Use the bookmarks on the left to navigate. Main manual is halfway down

Contents

Table of Contents ……. 1

Introduction and Safety Notice …….. 2

General Troubleshooting Information

Recommended Marine Shop Electrical Test Equipment and Tools ……. 3
Tricks to Testing with Minimal Test Equipment …….. 4
Voltage Drop Measurement……..…….…….…….…….…… 5
Johnson/Evinrude Model to Year Identification for 1980 and Up Engines ……. 5
Engine Wiring Cross Reference Chart……. 6
ABYC Color Chart ……. 7

Chrysler Troubleshooting

Battery CD Ignitions……..… 8
Magnapower II Ignitions…..…… 9
Capacitive Discharge Ignitions with Alternator…….. 10-12

Force Troubleshooting

Alternator Driven Ignitions (Prestolite)…….. 13-16
Alternator Driven Ignitions (Brunswick)…… 17-20

Johnson/Evinrude Troubleshooting

Battery CD Ignitions……..... 21-22
Alternator Driven Ignitions 1972-78 W/Screw Terminal Power Packs……..... 23-25
Alternator Driven Ignitions 1978-99…….. 26-31
60 Optical 6 Cylinder engines…… 32-35
60 Optical 4 Cylinder engines…… 36-39

Mercury Troubleshooting

Battery CD Ignitions W/Points…….. 40
Battery CD Ignitions W/O Points…….. 41-44
Alternator Driven Ignitions……..... 45-55

Mercury/Force CDM Ignitions System Troubleshooting

2 Cylinder CDM Ignitions ……..……. 56
3 Cylinder CDM Ignitions …….. 57
4 Cylinder CDM Ignitions ……..……. 58
6 Cylinder CDM Ignitions ……..…….. 59-60

Appendix

DVA (Peak Voltage) and Resistance Charts (Introduction)……. 61
Chrysler DVA and Resistance Charts……..…… 62
Force DVA and Resistance Charts……..……. 63
Johnson/Evinrude DVA and Resistance Charts ……..……. 64-65
OMC Sea Drive DVA and Resistance Charts …….. 66
Mercury DVA and Resistance Charts…….. 67-69
Yamaha DVA and Resistance Charts…….. 70-75
Glossary of Terms ……..…….. 76
CDI Technical Service Bulletin OMC 3 Cyl 60, 65 and 70 HP engines 77
Force Engine wiring diagrams …… 78-80
Johnson/Evinrude QuickStart Flywheel Trigger Magnet Orientation …… 81
OMC Stern Drive Electronic Shift Assist Applications and Wiring Diagrams …….. 82-84

Recommended Marine Shop Electrical Test Equipment and Tools

The following is a listing of tools available from CDI Electronics and recommended for testing late model engines:

Part Number	Description	Remarks/Use
511-9764	Neon Spark Tester	Sealed single cylinder has removable ground clamp can be used for running tests
511-9766	Sealed Spark Gap Tester	Allows for testing up to 8 cylinder for cranking tests. Sealed design reduces the chance of engine fire.
511-9770	Piercing Probes	Allows access to wires for testing without removing the connection. Tiny hole usually reseals itself.
511-9773 .	DVA (Peak Voltage)Adapter	Unit automatically compensates for polarity. Can be used with most quality Multimeters
511-9775	Load Resistor	Used to load the output of ignition modules when testing ignition coils.
518-33A	CDI 33 Meter Includes 511-9773 DVA Adapter	Meter has voltage, amperage, diode check and ohms DVA Adapter allows meter to read peak voltage
518-80TK	Fluke Temperature Adapter	Works with most digital Multimeters capable of reading millivolts.
520-ST80	DC Inductive Timing Light	DC Powered timing light with a very bright strobe light.
551-33GF	Gearcase Filler w/Check Valve	Universal design makes filling lower units easier. Check valve assembly helps prevent oil spills and makes filling easier.
551-34PV	Pressure/Vacuum Tester	Repairable metal combination unit does both vacuum and pressure testing.
551-5110	Flywheel Holder	Longer handle helps during use.
551-9765	Spark Plug Wire Puller	Grounded design reduces the chances of shocking.
553-2700	Amphenol Pin Tool Set	Set contains 1 each of 553-2697 (Insertion), 553-2698 (Pin Removal) and 553-2699 (Socket Removal)
553-9702	Sensor Gap Gauge Tool	Used to set the timer-base air gap on 1973-1978 OMC 3 and 4 cylinder engines with screw terminal power packs.
554-9706	Amp Pin Removal Tool	Used to remove the connector pins in the ignition system on Chrysler/Force engines using the Prestolite type ignitions. Also used on the Mercury TPI sensor connectors.
911-9783	Bullet Connector Kit	Contains 10 pieces each of the male, female and sleeves.
912-9708	Marine Terminal Kit	Contains 100+ pieces of hard to find terminals and heat shrink.
991-9705	Dielectric Grease	Use to keep water and corrosion out of connectors.
511-6996	Remote Starter For OMC	Used to replace the boat-side harness for engine testing, Fits most OMC engines 1969 to 2000.
511-7900	Remote Starter for Mercury	Used to replace the boat-side harness for engine testing, Fits most Mercury engines 1979 to 2000.
519-LB85	Load Bank	Used to load the battery when testing the battery charging output.

Optional Equipment

511-4017	OMC Optical Sensor Tester	Unique handheld tester that will efficiently test the optical ignition sensor.
511-0401	CDI 2 Cylinder Ignition Tester	New hand-held ignition tester generates high-voltage stator and low voltage trigger signals to test a variety of 2 cylinder ignition systems. Engine specific adapters are required. Includes 511-0402, 511-0403 and 511-0404 adapters.
520-ST84	Ferret Ultra Bright Timing Light	Ultra bright timing light is visible in bright sunlight. Also has a built-in tachometer for 2 and 4 stroke engines. This feature is a valuable diagnostic tool when troubleshooting ignition system problems.

Tricks to Testing with Minimal Test Equipment

All Engines

Please keep detailed records when you repair an engine. If an engine comes in with one cylinder not firing, mark which one on the work order/history.

Intermittent Firing: This problem can be very hard to isolate. A good inductive tachometer can be used to compare the RPM on all cylinders up through WOT (wide-open throttle). A significant difference in the RPM readings can help pinpoint a problem quickly.

Visually Check the Stator, Trigger, Rectifier/Regulator and Flywheel: Cracks, burned areas and bubbles in or on the components indicate a problem. If the battery charge windings on the stator are dark brown, black or burned on most or all of the posts, the rectifier/regulator is likely shorted as well. Any sign of rubbing on the outside of the stator indicates a problem in the upper or lower main bearings. A cracked trigger or outer charging magnets can cause many problems ranging from misfiring to no fire at all. Loose flywheel magnets can be dangerous, check the tightness of the bonding adhesive.

Rectifier/Regulators can cause problems ranging from a high-speed miss to a total shutdown. An easy check is to disconnect the stator leads to the rectifier (Make sure to insulate them) and retest. If the problem is gone – replace the rectifier/regulator.

Johnson/Evinrude

Open Timer Bases: When all cylinders fire with the spark plugs out, but will not with them installed, try re-gapping the sensors using P/N: 553-9702 Gap Gauge. (See the section on OMC ADI Ignitions page 22-24).

Engines with S.L.O.W. Features: If the customer is complaining that the engine won't rev up and shakes real bad, the S.L.O.W. function could be activating. If the engine is NOT overheating, a temperature sensor or VRO sensor failing early can cause this problem. Disconnect the TAN wires *at the power pack* and retest. If the engine performs normally, reconnect the tan wires one at a time until the problem recurs, then replace the last sensor you connected. Make sure that all of the TAN wires are located as far as possible from the spark plug wires. Also check the blocking diode in the engine harness.

Mercury 6 Cylinder Engines with ADI Ignitions

If more than one cylinder is not firing: Replace BOTH switch boxes unless you can pin the problem down to the trigger. Replacing just one switch box can result in damage to the engine if the remaining switch box on the engine has a problem in the bias circuit.

Always check the bias circuit: Disconnect the White/Black jumper between the switch boxes and check the resistance from the White/Black terminal on each switch box to engine ground. You should read 12-15,000 ohms on stock switch boxes, and 9,000-9,800 ohms on racing switch boxes. MAKE SURE THE READING IS THE SAME ON BOTH SWITCH BOXES! Any problem with the bias circuit and BOTH switch boxes must be replaced as a set.

No Fire on 1, 3, 5 or 2, 4, 6: Swap the stator leads from one switch box to the other. If the problem moves, replace the stator. If the problem remains on the same cylinders, replace the switch box. If the stator is replaced and the problem is still present, try another flywheel.

No Fire on One Cylinder: This can be caused by a defective blocking diode in the other switch box. Disconnect the White/Black jumper between the switch boxes and retest. If all cylinders are now firing, replace the switch box that was originally firing all three cylinders. To verify this condition, swap the trigger leads on the switch box that was originally firing all three cylinders. If the misfire moves to another cylinder, the switch box is bad.

Voltage Drop Measurement

Start by using a good digital auto-ranging voltmeter capable of reading 1/10th of a volt. The use of an auto-ranging meter will allow for more accurate testing without damaging the meter due to an incorrect range setting.

Remove the spark plug wires form the spark plugs and connect them to a spark gap tester and remove the emergency stop clip as well. This prevents the engine from starting and also reduces the chance of getting shocked by the ignition system.

The use of an ohmmeter to test a conductor or switch contact for their condition is not the best tool to use. In most cases, it is preferable to use a volt drop test to make sure the conductor, as well as the connection, is in good condition.

Before testing, remove and clean all battery cables and connection points.

Testing the Positive Battery Cable to the Engine

1. Select the DC Volts position on the meter.
2. Connect the Red (Positive) lead on the meter to the positive battery *POST*.
3. Connect the Black (Negative) lead on the meter to the starter solenoid terminal where the positive battery cable is connected.
4. Using a remote start switch, activate the starter solenoid to spin the engine and observe the reading on the meter. A reading above 0.6V indicates a bad cable or bad connection.
   (a) If the meter reads above 0.6V, move the Black lead on the meter to the positive battery cable terminal on the starter solenoid and retest. If the reading drops to below 0.6V, the cable connection is bad.
   (b) If the meter still reads above 0.6V, move the Black lead on the meter to the positive battery cable terminal on the battery and retest. If the reading drops to below 0.6V, the cable is bad or undersized.

Service Note: A bad power connection to the ignition or battery charging system can be found by connecting the Black lead on the meter to the power connection of the ignition system or charging system; then working your way back to the battery positive post. At no time should you see a reading above 1V.

Testing the Negative Battery Cable to the Engine

1. Select the DC Volts position on the meter.
2. Connect the Black (Negative) lead on the meter to the negative battery *POST*.
3. Connect the Red (Positive) lead on the meter to the engine block where the negative battery cable is connected.
4. Using a remote start switch, activate the starter solenoid to spin the engine and observe the reading on the meter. A reading above 0.6V is an indicator of a bad cable or bad connection.
   (a) If the meter reads above 0.6V, move the Red lead on the meter to the negative battery cable terminal on the engine block and retest. If the reading drops to below 0.6V, the cable connection is bad.
   (b) If the meter still reads above 0.6V, move the Red lead on the meter to the negative battery cable terminal on the battery and retest. If the reading drops to below 0.6V, the cable is bad or undersized.

A bad ground connection to the ignition and battery charging system can be found by connecting the Red lead on the meter to the ground connection of the ignition or battery charging system; then working your way back to the battery negative post. At no time should you see a reading above 1V.

Johnson/Evinrude Model to Year Identification for 1980 and newer Engines

"INTRODUCES"

I	N	T	R	O	D	U	C	E	S
1	2	3	4	5	6	7	8	9	0

Example: J150TTLCE would be a 1989 150 HP Johnson and aE175STEU would be a 1997 175 HP Evinruide.

Engine Wiring Cross Reference Chart for Most Outboards

Circuit	Mercury PRE- 1978	Mercury 1978 & UP	OMC	Yamaha	Force PRE- 1994	Force 1994 & UP	Suzuki
Power	Red	Red	Red	Red	Red	Red/Purple	White
Ign Switch	White	Purple	Purple	Yellow	Blue	Red/Blue	Gray
Eng Gnd	Black	Black	Black	Black	Black	Black	Black
Kill Circuit	Orange Salmon White	Blk/Yellow	Blk/Yellow	White	White	Blk/Yellow	Green Red Blue
Eng Start	Yellow	Yellow/Red	Yellow/Red	Brown	Yellow	Yellow/Red	Brown Yellow/Red
Tach	Brown	Gray	Gray	Green	Purple	Gray	Yellow
Battery Charge	Yellow/Red	Yellow Yellow/Blk	Yellow Yellow/Gry	Green	Yellow	Yellow Yellow/Blk	Yellow/Red
Stator CDI Power	Red White Blue(a)	Blue Blue/White Red Red/White Green/Wht Wht/Green	Brown Brown/Yel Brown/Blk Brown/Wht	Blue Brown Red Blk/Red	Blue Yellow Brown/Blue Brown/Yel	Blue Blue/White Red Red/White Green/Wht Wht/Green	Green Black/Red
Choke	Gray Blue	Yellow/Blk	Purple/Wht	Blue	Green	Yellow/Blk	Orange
Overheat Eng Temp	Tan	Tan	Tan (b) White/Blk(c)	Pink	Orange	Tan	Green/Yel

(a) Ignition Driver systems only, all others were battery driven systems.
(b) The stripe color on the Tan wire indicates the temperature at which the sensor trips.
(c) The White/Black wire is the cold engine temp indicator and shorts to Gnd at approx 105 deg F.

Blk = Black Wht = White Gry = Gray
Yel = Yellow Blk = Black

ABYC Recommended Boat Wiring Color Codes		
Color	**Function**	**Comments**
Yellow/Red Stripe (YR)	Engine Start Circuit	
Brown/Yellow Stripe (BY)	Bilge Blower	Alternate color is Yellow (Y)
Yellow Stripe (Y)	Bilge Blower	If used for DC negative, blower MUST be Brown/Yellow Stripe.
Dark Gray (Gy)	Navigation Lights	Fuse or Switch to lights
Dark Gray (Gy)	Tachometer	
Brown (Br)	Generator/Alternator	Charge Indicator Lights, Fuse or switch to pumps.
Orange (O)	Accessory Power	Ammeter to alternator output and accessory fuse or switches. Distribution Panel accessory switch.
Purple (Pu)	Ignition Instrument power	Ignition switch to coil and electrical instruments , Distribution Panel to electric instruments.
Dark Blue	Cabin and instrument lights	Fuse or switch to lights.
Light Blue (Lt Bl)	Oil Pressure	Oil sender to gauge.
Tan	Water Pressure	Temperature sender to gauge.
Pink (Pk)	Fuel Gauge	Fuel sender to gauge.
Green/White Stripe	Tilt/Trim down or in	Tilt and Trim circuits
Blue/White Stripe	Tilt/Trim up or out	Tilt and Trim circuits

Chrysler Troubleshooting

Points Type Ignitions with Amplifiers (Power packs)

(Preamps are electronic replacements for points)

A large proportion of the problems with the battery CD units are caused by low battery voltage or bad ground connections. Low voltage symptoms are weak fire or erratic firing of cylinders. Maintenance free batteries are NOT recommended for this application.
WARNING!! Battery reversal will cause severe damage to the CD module and rectifier.

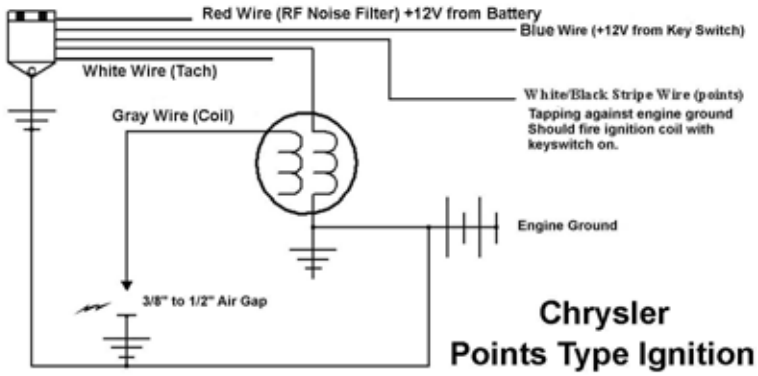
NOTE: The Chrysler CD modules are similar to the OMC CD modules with the exception of wire colors. The chart below will assist you as a general guideline for the Chrysler units:

Red	+12V from battery (RF Noise Filter)
Blue	+12V from the Key Switch
Gray	+ Terminal of ignition coil
White	OEM Tachometer signal
White/Black Stripe	Points or Preamp Module
Black	Engine ground

No Fire at All:

1. Clean all battery connections and engine grounds.
2. Make sure the CD module is grounded. Units using rubber shock mounts require a ground wire fastened from the pack to the engine block.
3. Connect a spark gap tester to the high tension lead coming from the ignition coil and set it to approximately ½". If it fires when you crank the engine over, there is a problem in the distributor cap, rotor button or spark plug wires.

Wiring Connection for Testing CD Module



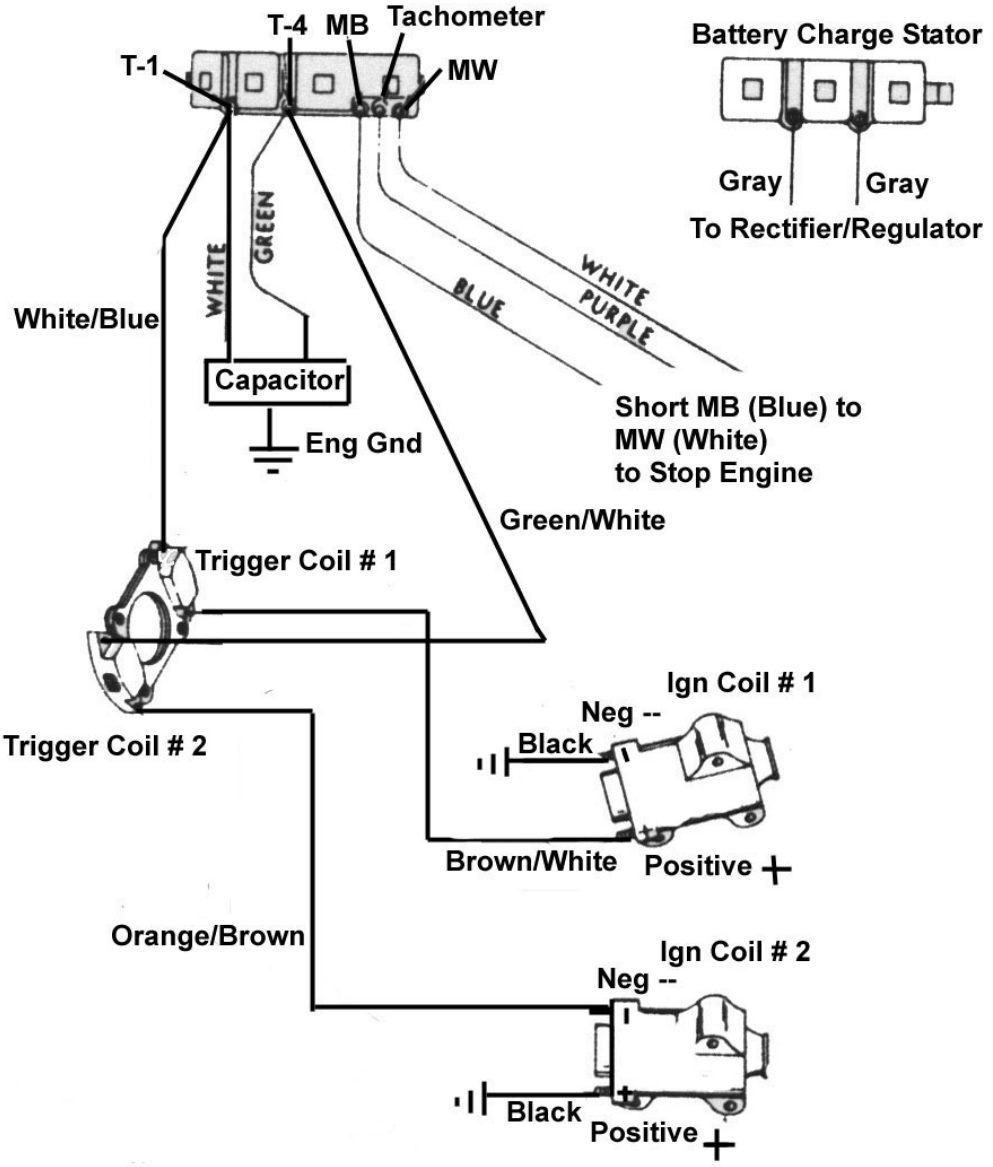
NOTE: Preamps are an electronic version of points and the ignition module will test the same for both.

4. Check voltage present on the blue wire at cranking. It MUST be at least 9½ volts. If not, the problem is likely in the harness, key switch, starter or battery.
5. Connect a DC voltmeter to the white/black wire (while it is connected to the distributor) and rotate the engine. There should be some fluctuation in the meter reading. If the reading is high, and fails to move up and down, there is definitely a problem inside the distributor. If the reading is low, disconnect the white/black wire from the distributor and with the key switch turned on, strike the white/black wire against engine ground. The unit should fire each time. If it does, then the CD module is usually good and the points (or Preamp) require checking. If the CD module fails to fire with this test, then the CD module is usually bad.
6. Check DVA voltage on the gray wire going to the coil, it should be approximately 200 volts at cranking. If the voltage is correct, replace the coil with another coil and retest or use a load resister if another coil is not available. A coil that is shorted internally will give a low reading. In this case replace the coil and retry.

After repairing the engine, check the battery voltage at approximately 3500 RPM, The MAXIMUM allowable voltage reading is 16 volts and the minimum is 12V. Running below 12V or over 16 volts will damage the ignition. Check for loose connections or a bad battery.

Magnapower II Systems

1. Disconnect the white and blue kill wires from the CD Module and retest. If the engine starts and runs, the key-switch or kill circuit is bad.
2. Connect a DC voltmeter from the kill wires to engine ground and turn the ignition switch on and off several times. At no time should you see battery voltage on the kill circuit.
3. Connect a spark gap tester to all cylinders and test with the spark plugs in and out. If the coils will not fire with the spark plugs in, check compression with the spark plugs removed from all cylinders. A blown head gasket on these engines can prevent the coils from firing with the spark plugs installed. This is caused by a hard to explain problem with the triggering circuit.
4. Crank the engine with the starter and then stop. Check the DVA voltage on terminals T1 and T4. You should read between 170 and 270 volts Positive on terminal T1 and between 170, and 270 volts Negative on terminal T4. (Remember that some DVA adapters are not polarized and will read the same regardless of the polarity). If there is a low reading on one of the terminals, disconnect the white/blue and green/white trigger wires, then retest. If the readings are now correct, one of the trigger modules is bad. A continued low reading may be caused by a bad capacitor. To test, use a couple of jumper wires and swap the green and white capacitor wires going to terminals T1 and T4. If the low reading remains on the same terminal, the CD is bad. If it moves when you move the capacitor wires, the capacitor is shorted.
5. Check to see if the ignition coils are wired correctly. The #1 coil on a two cylinder engine and the #1 & 2 cylinder on a four cylinder engine are wired as NEGATIVE GROUND. The #2 coil on a two cylinder engine and the #3 & 4 cylinder on a four cylinder engine are wired as POSITIVE GROUND.



Chrysler Troubleshooting

Capacitive Discharge Module with Alternator
(ADI – Alternator Driven Ignition)

General Troubleshooting

1. Disconnect the kill wires from the CD and connect a DC voltmeter between the kill wires and engine ground. Turn the ignition switch on and off several times. If, at any time, you see voltage appearing on the meter, there is a problem in the harness or ignition switch. At NO TIME SHOULD YOU SEE BATTERY VOLTAGE ON A KILL CIRCUIT.
2. Check the flywheel for a broken or loose magnet.
3. Check for broken wires and terminals, especially inside the plastic plug-in connectors. We recommend that you remove the pins from the connectors using the CDI **511-9706** pin removal tool and visually inspect them.
4. Visually inspect the stator for burned or discolored areas. If found, replace the stator. If the areas are on the battery charge windings, it indicates a possible problem with the rectifier.

IF NO FIRE ON ANY CYLINDER:

1. Disconnect all kill wires AT THE PACK.
2. Check for broken or bare wires on the unit, stator and trigger.
3. Using the CDI meter with the 511-9773 peak reading adapter, or CD-77 and 511-9770 piercing probes, measure DVA voltage of the stator between the output wire sets. With everything connected, reading's should be approximately 180 volts or more. Resistance readings between the stator wire sets range from 680 – 800 ohms (factory) and 400 – 500 (CDI/RAPAIR).
4. Disconnect the rectifier. If the engine fires, replace the rectifier.

NO FIRE OR INTERMITTENT ON ONE CYLINDER:

1. Check the stator resistance, you should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow (Note – On some two cylinder engines, the stator has two blue wires and no yellow wire. The stator will read from blue to blue). All stator wires should read open to engine ground.
2. Check the trigger resistance, trigger wire sets read approximately 50 ohms between the wire sets (DVA-5V or more), and open to engine ground.
3. If readings are good, disconnect kill wire from one pack. If the dead cylinder starts firing, the problem is likely the blocking diode in the opposite pack.

NO FIRE ON TWO CYLINDERS:

If two cylinders from the same CD unit will not fire, the problem is usually in the stator. Test per above.

ENGINE WILL NOT KILL:

Check kill circuit in the pack by using a jumper wire connected to the kill wire coming out of the pack and shorting it to ground. If this kills the pack, the kill circuit in the harness or on the boat is bad, possibly the ignition switch.

COILS ONLY FIRE WITH THE SPARK PLUGS OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the CDI meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine fires, replace the rectifier.

Two Cylinder Engines with Combination CD Module with Built-in Ignition Coils

NO FIRE OR INTERMITTENT ON ONE CYLINDER:

1. Check the stator resistance, you should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow (Note – On some two cylinder engines, the stator has two blue wires and no yellow wire. The stator will read from blue to blue). All stator wires should read open to engine ground.
2. Check the trigger resistance, trigger wire sets read approximately 50 ohms between the wire sets (DVA-5V or more), and open to engine ground.
3. If readings are good, disconnect kill wire from one pack. If the dead cylinder starts firing, the problem is likely the blocking diode in the opposite pack.

ENGINE WILL NOT SHUT OFF:

Check kill circuit in the pack by using a jumper wire connected to the kill wire coming out of the pack and shorting it to ground. If this kills the pack, the kill circuit in the harness or on the boat is bad, the ignition switch could also be bad.

Chrysler/Force Troubleshooting

Prestolite Capacitive Discharge Module with Alternator
(ADI – Alternator Driven Ignition)

Two Cylinder Engines Using a Separate Switch Box and Ignition Coils

1. Disconnect the stop wires from the CD and connect a DC voltmeter between the stop wires and engine ground, turn the ignition switch on and off several times. If, at any time, you see voltage appearing on the meter, there is a problem in the harness or ignition switch. At NO TIME SHOULD YOU SEE BATTERY VOLTAGE ON A STOP CIRCUIT.
2. Check the flywheel for a broken or loose magnet.
3. Check for broken wires and terminals, especially inside the plastic plug-in connectors. We recommend that you remove the pins from the connectors using the CDI **511-9706** pin removal tool and visually inspect them.
4. Visually inspect stator for burned or discolored areas. If found, replace the stator. If the areas are on the battery charge windings, it indicates a possible problem with the rectifier.

IF NO FIRE ON EITHER CYLINDER:

1. Disconnect all stop wires AT THE PACK.
2. Check for broken or bare wires on the ignition module, stator and trigger.
3. Using the CDI meter with the 511-9773 peak reading adapter, or CD-77 and 511-9770 piercing probes, measure DVA voltage of the stator between the output wire sets. With everything connected, reading's should be approximately 180 volts or more. Resistance readings between the stator wire sets ranges from 680 – 800 ohms (factory) and 250-350 ohms (CDI/RAPAIR).
4. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. Check the stator resistance, you should read 680-800 ohms (factory) and 400 – 500 (CDI/RAPAIR) DVA 180V or more from blue to yellow (Note – On some two cylinder engines, the stator has two blue wires and no yellow wire. The stator will read from blue to blue). All stator wires should read open to engine ground.
2. Check the trigger resistance, trigger wire sets read approximately 50 ohms between the wire sets (DVA-5V or more), and open to engine ground.
3. If readings are good, disconnect stop wire from one pack. If the dead cylinder starts sparking, the problem is likely the blocking diode in the opposite pack.

ENGINE WILL NOT STOP:

Check the stop circuit in the pack by using a jumper wire connected to the white stop wire coming out of the pack and shorting it to the white stop wire coming out of the other pack. If this stops all spark from the pack, the stop circuit in the engine harness or on the boat is bad, the ignition switch could also be bad.

COILS ONLY HAS SPARK WITH THE SPARK PLUGS OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the CDI meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

Three and Four Cylinder Engines Using Separate Switch Boxes and Ignition Coils

1. Check for broken wires and terminals, especially inside the plastic plug-in connectors. We recommend that you remove the pins from the connectors using the CDI **511-9706** pin removal tool and visually inspect them.
2. Check the flywheel for a broken or loose magnet.
3. Disconnect the stop wires from the CD and connect a DC voltmeter between the stop wires and engine ground, turn the ignition switch on and off several times. If, at any time, you see voltage appearing on the meter, there is a problem in the harness or ignition switch. At NO TIME SHOULD YOU SEE BATTERY VOLTAGE ON A STOP CIRCUIT.
4. Visually inspect stator for burned or discolored areas. If found, replace the stator. If the areas are on the battery charge windings, it indicates a possible problem with the rectifier.

IF NO SPARK ON ANY CYLINDER:

1. Disconnect stop wire AT THE PACK.
2. Check for broken or bare wires on the unit, stator and trigger.
3. Using the CDI meter with the 511-9773 peak reading adapter, or CD-77 and 511-9770 piercing probes, measure DVA voltage of the stator between the output wire sets. With everything connected, reading s should be approximately 180 volts or more. Resistance readings between the stator wire sets range from 680 – 800 ohms (factory) and 250-350 ohms (CDI/RAPAIR).
4. Disconnect the rectifier. If the engine has spark, replace the rectifier.

Chrysler/Force Troubleshooting

Capacitive Discharge Module with Alternator
(ADI – Alternator Driven Ignition)

Three and Four Cylinder Engines Using Separate Switch Boxes and Ignition Coils (Continued)

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. Check the stator and trigger resistance; the trigger wire sets should read approximately 50 ohms between the wire sets (DVA-5V or more), the stator should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow.
2. If readings are good, disconnect the stop wire from one pack. If the dead cylinder starts sparking, the problem is likely the blocking diode in the opposite pack.

NO SPARK ON TWO CYLINDERS:

If two cylinders from the same CD unit will not spark, the problem is usually in the stator. Test per above.

ENGINE WILL NOT SHUT OFF:

Check the stop circuit in the pack by using a jumper wire connected to the stop wire coming out of the pack and shorting it to ground. If this stops the pack from sparking, the stop circuit in the harness or on the boat is bad, the ignition switch could also be bad.

COILS ONLY HAS SPARK WITH THE SPARK PLUGS OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the Fluke meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

Pack #1 (Firing #1 and #2 Cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		White/Red (a)
	White/Green Stripe		White/Green Stripe
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue Stripe		Brown/Blue Stripe
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		White

Pack #3 (Firing #4 and #5 Cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		White/Red (a)
	White/Green Stripe		White/Green Stripe
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue Stripe		Brown/Blue Stripe
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		White

P Pack #2 (Firing #3 Cylinder)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		No Connection
	White/Green Stripe		No Connection
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue		No Connection (must be connected to the blue terminal on pack 1)
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		No Connection

(a) CDI replacement triggers do not have a connection for this wire from the power pack as the new trigger uses a common ground wire. This allows the wires going to the power pack from the trigger to be larger and more durable. The power pack uses that color as a ground wire for the trigger.

Color Code Cross Reference

FUNCTION	OLD	NEW
Trigger	Orange	White/Orange Stripe
Trigger	Green	White/Yellow Stripe
Trigger	Red	White/Red Stripe White/Green Stripe
Trigger	White/Green Stripe	White/Green Stripe
Stator	Blue	Brown/Blue Stripe
Stator	Yellow	Brown/Yellow Stripe
Pack Output to Coil	Orange	Orange/Blue
Pack Output to Coil	Red	Blue/Red
Ignition Coil	White	Orange/Blue
Stop Circuit	White	Black/Yellow

Force Troubleshooting

Prestolite ADI Ignitions 1984-1992

General

1. Check for broken wires and terminals, especially inside the plastic plug-in connectors. We recommend that you remove the pins from the connectors using the CDI **511-9706** pin removal tool and visually inspect them.
2. Check the flywheel for a broken or loose magnet.
3. Disconnect the stop wires from the CD and connect a DC voltmeter between the stop wires and engine ground, turn the ignition switch on and off several times. If, at any time, you see voltage appearing on the meter, there is a problem in the harness or ignition switch. At NO TIME SHOULD YOU SEE BATTERY VOLTAGE ON A STOP CIRCUIT.
4. Visually inspect stator for burned or discolored areas. If found, replace the stator. If the areas are on the battery charge windings, it indicates a possible problem with the rectifier.

IF THERE IS NO SPARK ON ANY CYLINDER:

1. Disconnect the stop wire AT THE PACK.
2. Check for broken or bare wires on the CD Module, stator and trigger.
3. Check the stator resistance and output using the CDI meter with the 511-9773 peak reading adapter and 511-9770 piercing probes, as follows:

Read Form	Read To	Resistance (OEM)	Resistance (CDI)	DVA (connected)	DVA (disconnected)
Yellow	Blue	680-850	250-350	180V or more	200 V or more
Yellow	Engine Gnd	Open	Open	180 V or more (a)	2 V or less (b)
Blue	Engine Gnd	Open	Open	180 V or more (a)	2 V or less (b)

NOTE: Remember that the stator may use Brown/Yellow or Brown/Black/Yellow for Yellow and Brown/Blue or Brown/Black/Blue for Blue.

(a) The DVA reading to engine ground is checking a circuit inside the power pack. If the readings are not fairly equal, swap the stator wires going to the power pack and recheck. If the low reading stays on the same wire from the stator, replace the stator. Otherwise, replace the power pack.

(b) Most meters will pick up a small amount of voltage due to inductive pick-up. As long as the voltage is very low, it will not indicate a problem.

4. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. Check the stator and trigger resistance; the trigger wire sets should read approximately 50 ohms between the wire sets (DVA-.5V or more), the stator should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow.
2. If readings are good, disconnect stop wire from one pack. If the dead cylinder starts sparking, the problem is likely the blocking diode in the opposite pack.

NO SPARK ON TWO CYLINDERS:

If two cylinders from the same CD unit have no spark, the problem is usually in the stator. Test per above.

ENGINE WILL NOT SHUT OFF:

Check the stop circuit in the pack by using a jumper wire connected to the stop wire coming out of the pack and shorting it to ground. If this stops the pack from sparking, the stop circuit in the harness or on the boat is bad, the ignition switch could also be bad.

COILS ONLY HAVE SPARK WITH THE SPARK PLUGS OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the CDI meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

Two Cylinder Engines using Combination CD Module with Built-in Ignition Coils (1984-88)

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. Check the stator resistance; you should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow (Note – On some two cylinder engines, the stator has two blue wires and no yellow wire. The stator will read from blue to blue). All stator wires should read open to engine ground.
2. Disconnect and check the trigger resistance; trigger wire sets read approximately 50 ohms between the wire sets (DVA-0.5V or more), and open to engine ground.
3. If readings are good, disconnect stop wire from one pack. If the dead cylinder starts sparking, the problem is likely the blocking diode in the opposite pack.

ENGINE WILL NOT SHUT OFF:

Check the stop circuit in the pack by using a jumper wire connected to the stop wire coming out of the pack and shorting it to ground. If this stops the pack from firing, the stop circuit in the harness or on the boat is bad. The ignition switch could also be bad.

Force Troubleshooting

Prestolite ADI Ignitions 1984-1992

Two Cylinder Engines Using Separate Switch Boxes and Ignition Coils

GENERAL:

1. Disconnect the stop wires from the CD and connect a DC voltmeter between the stop wires and engine ground, turn the ignition switch on and off several times. If, at any time, you see voltage appearing on the meter, there is a problem in the harness or ignition switch. At NO TIME SHOULD YOU SEE BATTERY VOLTAGE ON A STOP CIRCUIT.
2. Check the flywheel for a broken or loose magnet.
3. Check for broken wires and terminals, especially inside the plastic plug-in connectors. We recommend that you remove the pins from the connectors using the CDI **511-9706** pin removal tool and visually inspect them.
4. Visually inspect the stator for burned or discolored areas. If found, replace the stator. If the areas are on the battery charge windings, it indicates a possible problem with the rectifier.

IF THERE IS NO SPARK ON EITHER CYLINDER:

1. Disconnect all stop wires AT THE PACK.
2. Check for broken or bare wires on the switch box, stator and trigger.
3. Using the CDI meter with the 511-9773 peak reading adapter, or CD-77 and 511-9770 piercing probes, measure DVA voltage of the stator between the output wire sets. With everything connected, reading s should be approximately 180 volts or more. Resistance readings between the stator wire sets range from 680 – 800 ohms (factory) and 250-350 ohms (CDI/RAPAIR).
4. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

IF THERE IS NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. Check the stator resistance; you should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow (Note – On some two cylinder engines, the stator has two blue wires and no yellow wire. The stator will read from blue to blue). All stator wires should read open to engine ground.
2. Check the trigger resistance, trigger wire sets read approximately 50 ohms between the wire sets (DVA-0.5V or more), and open to engine ground.
3. If readings are good, swap the power pack output from the ignition coil that works to the one that does not. If the coil that had spark stops sparking, replace the power pack.

ENGINE WILL NOT SHUT OFF:

Check the stop circuit in the pack by using a jumper wire connected to the white stop wire coming out of the pack and shorting it to ground. If this stops all spark from the pack, the stop circuit in the harness or on the boat is bad. The ignition switch could also be bad.

NO SPARK UNLESS THE SPARK PLUGS ARE OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the CDI meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine now has spark, replace the rectifier.
3. Check for broken wires and terminals, especially inside the plastic plug-in connectors. We recommend that you remove the pins from the connectors using the CDI **511-9706** pin removal tool and visually inspect them.
4. Check the flywheel for a broken or loose magnet.
5. Disconnect the stop wires from the CD and connect a DC voltmeter between the stop wires and engine ground, turn the ignition switch on and off several times. If, at any time, you see voltage appearing on the meter, there is a problem in the harness or ignition switch. At NO TIME SHOULD YOU SEE BATTERY VOLTAGE ON A STOP CIRCUIT.
6. Visually inspect the stator for burned or discolored areas. If found, replace the stator. If the areas are on the battery charge windings, it indicates a possible problem with the rectifier.

Three and Four Cylinder Engines Using Separate Switch Boxes and Ignition Coils

NO SPARK ON ANY CYLINDER:

1. Disconnect the stop wire AT THE PACK.
2. Check for broken or bare wires on the unit, stator and trigger.
3. Using the CDI meter with the 511-9773 peak reading adapter, or CD-77 and 511-9770 piercing probes, measure DVA voltage of the stator between the output wire sets. With everything connected, reading s should be approximately 180 volts or more. Resistance readings between the stator wire sets range from 680 – 800 ohms (factory) and 250-350 ohms (CDI/RAPAIR).
4. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. Check the stator and trigger resistance; trigger wire sets should read approximately 50 ohms between the wire sets (DVA-0.5V or more), the stator should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow.
2. If readings are good, disconnect stop wire from one pack. If the dead cylinder starts sparking, the problem is likely the blocking diode in the opposite pack.

Force Troubleshooting

Prestolite ADI Ignitions 1984-1992

Three and Four Cylinder Engines Using Separate Switch Boxes and Ignition Coils (Continued)

NO SPARK ON TWO CYLINDERS:

If two cylinders from the same CD unit do not spark, the problem is usually in the stator. Test per above.

ENGINE WILL NOT SHUT OFF:

Check the stop circuit in the pack by using a jumper wire connected to the stop wire coming out of the pack and shorting it to ground. If this stops the pack from firing, the stop circuit in the harness or on the boat is bad. The ignition switch could also be bad.

COILS ONLY SPARK WITH THE SPARK PLUGS OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the CDI meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

Pack #1 (Firing #1 and #2 Cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		White/Red (a)
	White/Green Stripe		White/Green Stripe
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue Stripe		Brown/Blue Stripe
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		White

Pack #2 (Firing #3 and #4 Cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		White/Red (a)
	White/Green Stripe		White/Green Stripe
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue Stripe		Brown/Blue Stripe
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		White

Pack #2 (Firing #3 Cylinder)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		No Connection
	White/Green Stripe		No Connection
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue		No Connection (must be connected to the blue terminal on pack 1)
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		No Connection

(a) CDI replacement triggers do not have a connection for this wire from the power pack as the new trigger uses a common ground wire. This allows the wires going to the power pack from the trigger to be larger and more durable. The power pack uses that color as a ground wire for the trigger.

Color Code Cross Reference

FUNCTION	OLD	NEW
Trigger	Orange	White/Orange Stripe
Trigger	Green	White/Yellow Stripe
Trigger	Red	White/Red Stripe White/Green Stripe
Trigger	White/Green Stripe	White/Green Stripe
Stator	Blue	Brown/Blue Stripe
Stator	Yellow	Brown/Yellow Stripe
Pack Output to Coil	Orange	Orange/Blue
Pack Output to Coil	Red	Blue/Red
Ignition Coil	White	Orange/Blue
Stop Circuit	White	Black/Yellow

Sample Connection for a 4 Cylinder Using New Design CDI Trigger

Pack #1 (Firing #1 and #2 cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		No Connection
	White/Red		No Connection
	White/Green Stripe		White/Green Stripe
Pack:	Yellow	**Stator:**	Yellow
	Blue		Blue
Pack:	Orange/Blue	**Coil #1:**	White
Pack:	Blue/Red	**Coil #2:**	White

Pack #2 (Firing #3 and #4 cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow Stripe		No Connection
	White/Red		No Connection
	White/Green Stripe		White/Green Stripe
Pack:	Yellow	**Stator:**	Yellow
	Blue		Blue
Pack:	Orange/Blue	**Coil #3:**	White
Pack:	Blue/Red	**Coil #4:**	White

Force Troubleshooting

Prestolite ADI Ignitions 1984-1992

5 Cylinder Engines Using Separate Switch Boxes and Ignition Coils

IF THERE IS NO SPARK ON ANY CYLINDER:

1. Disconnect the stop wire AT THE PACK.
2. Check for broken or bare wires on the CD Modules, stator and trigger.
3. Check the stator resistance and output using the CDI meter with the 511-9773 peak reading adapter and 511-9770 piercing probes, as follows:

Read Form	Read To	Resistance (OEM)	Resistance (CDI)	DVA (connected)	DVA (disconnected)
Yellow	Blue	680-850	250-350	180V or more	200 V or more
Yellow	Engine Gnd	Open	Open	180 V or more (a)	2 V or less (b)
Blue	Engine Gnd	Open	Open	180 V or more (a)	2 V or less (b)

NOTE: Remember that the stator may use Brown/Yellow or Brown/Black/Yellow for Yellow and Brown/Blue or Brown/Black/Blue for Blue.

(a) The DVA reading to engine ground is checking a circuit inside the power pack. If the readings are not fairly equal, swap the stator wires going to the power pack and recheck. If the low reading stays on the same wire from the stator, replace the stator. Otherwise, replace the power pack.

(b) Most meters will pick up a small amount of voltage due to inductive pick-up. As long as the voltage is very low, it will not indicate a problem.

4. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. Check the stator and trigger resistance; the trigger wire sets should read approximately 50 ohms between the wire sets (DVA-.5V or more), the stator should read 680-800 ohms (factory) and 250-350 ohms (CDI/RAPAIR) DVA 180V or more from blue to yellow.
2. If readings are good, disconnect stop wire from one pack. If the dead cylinder starts sparking, the problem is likely the blocking diode in the pack you disconnected.

NO SPARK ON TWO CYLINDERS:

If two cylinders from the same CD unit have no spark, the problem is usually in the stator. Test per above.

ENGINE WILL NOT SHUT OFF:

Check the stop circuit in the pack by using a jumper wire connected to the stop wire coming out of the pack and shorting it to ground. If this stops the pack from sparking, the stop circuit in the harness or on the boat is bad, the ignition switch could also be bad.

COILS ONLY HAVE SPARK WITH THE SPARK PLUGS OUT:

Check for dragging starter or low battery causing slow cranking speed. DVA test stator and trigger.

HIGH SPEED MISS:

1. Using the CDI meter with the 511-9773 peak reading adapter, (or CD-77) and 511-9770 piercing probes, DVA check stator voltage to each pack at high speed. If it exceeds 400 volts, replace the pack.
2. Disconnect the rectifier. If the engine now has spark, replace the rectifier.

Connections: 5 Cylinder

Pack #1 (Firing #1 and #2 Cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		White/Red (a)
	White/Green Stripe		White/Green Stripe
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue Stripe		Brown/Blue Stripe
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		White

Pack #3 (Firing #4 and #5 Cylinders)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		White/Red (a)
	White/Green Stripe		White/Green Stripe
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	Brown/Blue Stripe		Brown/Blue Stripe
Pack:	Orange/Blue	**Coil:**	White
	Blue/Red		White

Pack #2 (Firing #3 Cylinder)

Pack:	White/Orange Stripe	**Trigger:**	White/Orange Stripe
	White/Yellow		White/Yellow (a)
	White/Red		No Connection
	White/Green Stripe		No Connection
Pack:	Brown/Yellow Stripe	**Stator:**	Brown/Yellow Stripe
	No Connection		Blue (must be connected to the blue terminal on pack 1)
Pack:	Orange/Blue	**Coil: #3**	White
	Blue /Red		No Connection

(a) CDI replacement triggers do not have a connection for this wire from the power pack as the new trigger uses a common ground wire. This allows the wires going to the power pack from the trigger to be larger and more durable. The power pack uses that color as a ground wire for the trigger.

Color Code Cross Reference

FUNCTION	OLD	NEW
Trigger	Orange	White/Orange Stripe
Trigger	Green	White/Yellow Stripe
Trigger	Red	White/Red Stripe White/Green Stripe
Trigger	White/Green Stripe	White/Green Stripe
Stator	Blue	Brown/Blue Stripe
Stator	Yellow	Brown/Yellow Stripe
Pack Output to Coil	Orange	Orange/Blue
Pack Output to Coil	Red	Blue/Red
Ignition Coil	White	Orange/Blue
Stop Circuit	White	Black/Yellow

Force Troubleshooting
Mercury Designed Ignitions
(1991-1996)

Two Cylinder Engines Using a Separate Switch Box and Ignition Coils

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire AT THE PACK and retest. If the engine's ignition fires, the stop circuit has a fault-check the key switch, harness and shift-switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine now has spark, replace the rectifier.
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
4. Check the stator resistance and DVA output as follows:

Black Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Blue/White	3250-3650	500-600	180V or more
Red	Red/White	75-90	28-32	25V or more

Red Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

Red Stator Adapter

WIRE	Read To	OEM RESISTANCE	DVA
Blue	Engine GND	OPEN	180V or more

NO SPARK OR INTERMITTANT SPARK ON ONE CYLINDER:

1. If the cylinders are only misfiring above an idle, connect an inductive Tachometer to each cylinder in turn and try to isolate the problem cylinder.
2. Check the trigger resistance and DVA output as shown below:

Wire Color	Check To (Wire Color)	Resistance	DVA Reading
Brown wire	White wire	800-1400	4V or more Connected
Brown wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no spark on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both places. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to each cylinder in turn and try to isolate the problem. A single cylinder dropping spark will likely be a bad switch box or ignition coil. All cylinders not sparking properly usually indicates a bad stator.
2. Connect a DVA meter between the stator's Blue wire and Blue/White wires. Perform a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs usually indicates a bad stator. (Read from Blue to Engine GND if the engine has a Red stator kit installed).
3. Connect a DVA meter between the stator's Red wire and Red/White wires. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than on the Blue wire reading indicates a bad stator.

High Speed Miss:

1. Connect an inductive Tachometer to each cylinder in turn and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under "*No spark or Intermittent spark on One Cylinder*".
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

Force Troubleshooting
Mercury Designed Ignitions
Three Cylinder Engines 1991-1996

Three Cylinder Engines Using a Single Switch Box and Three Ignition Coils

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire AT THE PACK and retest. If the engine's ignition now has spark, the stop circuit has a fault- check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to spark properly.
4. Check the stator resistance and DVA output as outlined below:

Black Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Engine GND	3250-3650	500-600	180V or more
Red	Engine GND	75-90	28-32	25V or more

Red Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

Red Stator Adapter (Not Available from CDI)

WIRE	Read To	OEM RESISTANCE	DVA
Blue	Engine GND	OPEN	180V or more

NO SPARK ON ONE OR MORE CYLINDERS:

1. If the cylinders are only misfiring above an idle, connect an inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Check the trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	White/Black	800-1400	4V or more Connected
White wire	White/Black	800-1400	4V or more Connected
Purple wire	White/Black	800-1400	4V or more Connected
Brown wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)
Purple wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no spark on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

4. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both places. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 3000-400 RPM:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A single cylinder dropping spark will likely be the switch box or ignition coil. All cylinders acting up usually indicate a bad stator.
2. Connect a DVA meter from the stator's blue wire to engine ground and do a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. (Check from the adapter's blue to engine ground if the engine has a red stator kit installed).
3. Connect a DVA meter to the Red wire. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than the blue wire reading indicates a bad stator.

HIGH SPEED MISS:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under "*No fire or Intermittent on One or More Cylinders*".
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

Four Cylinder Engines
(1991-1996)
Four Cylinder Engines Using a Single Switch Box and Four Ignition Coils

No Fire At All:

1. Disconnect the black/yellow stop wires AT THE PACK and retest. If the engine's ignition now has spark, the stop circuit has a fault-check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to spark properly.
4. Check the stator resistance and DVA output as given below:

Flywheel with Bolted in Magnets

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Blue/White	5000-7000	2200-2400	180V or more
Red	Red/White	125-155	45-55	25V or more

Flywheel with Glued-in Magnets

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Blue/White	3250-3650	500-600	180V or more
Red	Red/White	75-90	28-32	25V or more

Red Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

Red Stator Adapter

WIRE	Read To	OEM RESISTANCE	DVA
Blue	Blue	OPEN	180V or more
Blue (Each)	Ground	OPEN	180V or more

NO SPARK OR INTERMITTENT SPARK ON ONE OR MORE CYLINDERS:

1. If the cylinders are only acting up above an idle, connect an inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Check the trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Purple wire	White wire	800-1400	4V or more Connected
Brown wire	White/Black wire	800-1400	4V or more Connected
Purple wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)
Brown wire	Engine GND	Open	1V or more (*)
White/Black wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

Note: If #1 and #2, or #3 and #4 are misfiring, check the trigger as described above. The trigger uses two coils to spark four cylinders. #1 & 2 share one trigger coil and #3 & 4 share the other trigger coil. Also, the switch box is divided into two parts. The #1 and #2 cylinders spark on one half, and #3 and #4 spark on the other half of the switch box. If the trigger tests fine by the chart above, but you have two cylinders not sparking (either #1 and #2 or #3 and #4), the switch box or stator is bad.

3. If you have two cylinders not sparking (either #1 and #2 or #3 and #4), swap the stator leads end to end on the switch box (Red with red/white and blue with blue/white). If the problem moved to the other cylinders, the stator is bad. It the problem stayed on the same cylinders, the switch box is likely bad if the trigger tests within specifications.
4. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both terminals. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Four Cylinder Engines
(1991-1996)
Four Cylinder Engines Using a Single Switch Box and Four Ignition Coils (continued)

ENGINE WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. If two cylinders on the same end of the switch box are dropping out, the problem is likely going to be either the switch box or trigger. A single cylinder dropping spark will likely be the trigger, switch box or ignition coil. All cylinders misfiring usually indicate a bad stator.
2. Connect a DVA meter to the stator's blue wire and blue/white wires and do a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. (Note: Check between the adapter's blue wires if the engine has a red stator kit installed).
3. Connect a DVA meter between the Red wire and Red/White wire and do a running test. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than the reading on the blue wires indicates a bad stator.

HIGH SPEED MISS:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under "*No fire or Intermittent on One or More Cylinders*".
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

5 Cylinder with Single Switch Box
(1991-1992)

NOTE: This engine uses a battery powered inverter box to provide 250V power to the switch box. The inverter is in a 332-4797 CD module case. This unit is easily identified as the inverter has four terminals instead of the seven used on the 332-4797 CD module. The original stator's only function is to charge the battery. CDI Electronics offers a replacement for the inverter, which combines the functions of the inverter box with the stator. The stator has a high voltage output in addition to the battery charging output, allowing the inverter box to be removed.

NO SPARK ON ANY CYLINDER:

1. Check the red wire on the converter box from the battery at cranking; Minimum voltage is 9.5V.
2. Check the DVA voltage on the purple/white terminal on the converter box at cranking. A minimum of 0.3V is needed to trigger the inverter box. If the voltage is low, check the DVA voltage from the white/black trigger to the yellow, black, brown, white and purple trigger wires. If you read 4V or more, the inverter box is likely bad.
3. Check the DVA voltage on the blue terminal on the converter box at cranking, reading should be approximately 250V.
4. *CDI Electronics replacement stator only*: Check the DVA output and resistance from the blue wire to engine ground. You should read a minimum of 160V DVA and 80 ohms resistance.

NO SPARK ON ONE CYLINDER:

1. Check the DVA voltage from the white/black trigger to the yellow, black, brown, white and purple trigger wires. If you read 4V or more, the trigger is likely good.
2. Check the DVA voltage from the switch box. You should have the same reading on all of the Green Striped output wires to the ignition coils. If one cylinder reads low, swap the locations of the Green Striped wire not firing with one that has spark. If the problem moves, replace the power pack. If the no spark condition remains on the same cylinder, replace the ignition coil.

ALL CYLINDERS HAVE SPARK, BUT ENGINE WILL NOT RUN:

Disconnect the white/black wire from the switch box and check the resistance from the switch box's white/black wire to engine ground. The reading should be approximately 8400 ohms. A low reading indicates a bad bias circuit and the switch box needs to be replaced.

Johnson/Evinrude Troubleshooting

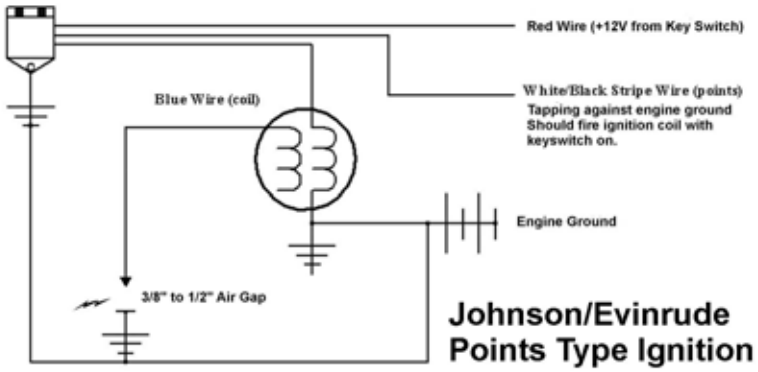
Battery CD Ignitions with Points

DUE TO THE CONSTRUCTION OF THE BATTERIES, NEITHER MAINTAINENCE FREE NOR LOW MAINTAINENCE BATTERIES ARE NOT RECOMMENDED FOR THIS APPLICATION!

1. Clean all battery connections and engine grounds.
2. Check wiring as follows:

Pack Wire Color	Function
Red or Purple	12V from key-switch
Blue	Positive to ignition coil
Black/White	To points
Black	Engine Ground

Engine Wiring Connections for Testing Ignition Module



3. Connect a spark gap tester to the high tension lead coming from the ignition coil and set it to approximately ½". When you crank the engine over, if it sparks while the spark gap tester is connected to the coil and does not spark through the spark plug wires – there is a problem in the distributor cap, rotor button or spark plug wires.
4. Check voltage present on the purple wire at cranking. It MUST be at least 9½ volts. If not, there is a problem in the harness, key switch, starter or battery.
5. Check DVA voltage on the blue wire going to the coil, it should be approximately 200 volts at cranking.
6. Disconnect the white/black points wire. Turn the ignition switch on and strike the white/black points wire against engine ground. The unit should spark each time. If it does, this usually means the CD module is good. Check the points, points plate and grounding wire for the points.
7. Connect a spark gap tester to the high-tension leads coming from the distributor cap and set the gap to approximately 7/16". Align the rotor with #1 spark plug wire. Turn the ignition switch on and strike the white/black points wire against engine ground. Only the #1 spark plug wire should spark. If another spark plug wire has spark, there is a problem in the distributor cap. Repeat the test for the other cylinders.
8. Check the battery voltage at approximately 3500-RPM, MAXIMUM reading allowable is 16 volts. Over 16 volts will damage the ignition. Check for loose connections or a bad battery.

Johnson/Evinrude

Prestolite Battery Ignitions with Pickup Sensors

DUE TO THE CONSTRUCTION OF THE BATTERIES, NEITHER MAINTAINENCE FREE NOR LOW MAINTAINENCE BATTERIES ARE NOT RECOMMENDED FOR THIS APPLICATION!

1. Clean all battery connections and engine grounds.
2. Check wiring as follows:

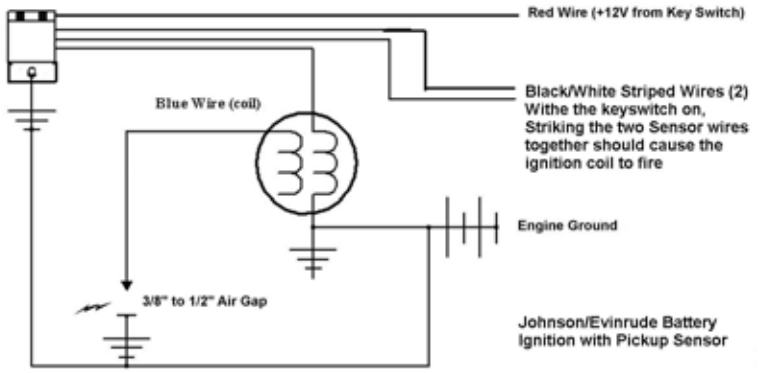
Except 1967

Pack Wire Color	Function
Red or Purple	12V from keyswitch
Blue	Positive to ignition coil
Black/White (2)	To trigger sensor
Black	Engine Ground
Green/Black*	Anti-reverse Spring

1967

Pack Wire Color	Function
Red or Purple	12V from keyswitch
Green	Positive to ignition coil
Blue (2)	To trigger sensor
Black	Engine Ground
Green/Black*	Anti-reverse Spring

* Some engines had this wire on the sensor plate.



3. Connect a spark gap tester to the high tension lead coming from the ignition coil and set it to approximately ½". When you crank the engine over, if it sparks while the spark gap tester is connected to the coil and does not spark through the spark plug wires – there is a problem in the distributor cap, rotor button or spark plug wires.
4. Check voltage present on the Purple (or Red) wire at cranking. It MUST be at least 9½ volts. If not, there is a problem in the harness, key switch, starter or battery.
5. Check DVA voltage on the Blue (or Green) wire going to the coil, it should be approximately 200 volts at cranking.
6. Disconnect the sensor wires. Turn the ignition switch on and strike the sensor wires together. The unit should fire each time. If it does, this usually means the CD module is good. Check the sensor and sensor air gap.
7. Make sure the triggering ring is the correct one for the type ignition being used. Phase II ignitions require the sensor with wide gaps between the lobes.



Phase One Rotor



Phase Two Rotor

8. Reset the sensor air gap to 0.020 in. If this allows the pack to fire, leave the gap at that setting.
9. Connect a spark gap tester to the high-tension leads coming from the distributor cap and set the gap to approximately 7/16". Align the rotor with #1 spark plug wire. Turn the ignition switch on and strike the sensor's wires together. Only the #1 spark plug wire should fire. If any of the other spark plug wires have fire, there is a problem in the distributor cap. Repeat the test for the other cylinders.
10. Check the battery voltage at approximately 3500-RPM, MAXIMUM reading allowable is 16 volts. Over 16 volts will damage the ignition. Check for loose connections or a bad battery.

Johnson/Evinrude Troubleshooting

Alternator Driven CD Ignitions 1972-1978

(With screw terminal type power packs)

Two Cylinder Engines

NO SPARK ON EITHER CYLINDER:

1. Disconnect the black yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault- check the key switch, harness and shift switch.
2. Check the stator resistance. You should read approximately 500 ohms from the brown wire to engine ground.
3. Check the DVA output from the stator. You should have a reading of at least 150V or more from the brown wire to engine ground (while connected to the pack).
4. Check the timer base's resistance from the black/white wire to the white/black wire. Reading should be 10-20 ohms (or 30-40 ohms for CDI Electronics 133-0875K1). Note: The original factory specifications was 8-14 ohms, this was changed around the mid 1970's in response to the change in SCR's triggering requirements.
5. Check the DVA output from the timer base. A reading of at least 0.5V or more from the black/white wire to the white/black (while connected to the pack) is needed to fire the pack. If the output is low, you may try to reset the air gap between the timer base sensor and the triggering magnet.

1. Loosen the two mounting screws on the sensor and the nut located in the epoxy on the outside of the heat shield of the timer base.
2. Slide the sensor in toward the crankshaft approximately 0.005" at a time.
3. Coat the face of the sensor with machinists bluing or equivalent.
4. Install the flywheel according to the service manual and crank the engine over.
5. Remove the flywheel and check to see if the trigging magnet struck the sensor face.
6. If the ignition fired, finger tight the nut on the outside of the heat shield and coat it with RTV.
7. If still no fire, slide the sensor in another 0.005" and repeat steps c through f.

6. Check the DVA voltage on each trigger wire to engine ground. You should have a reading of at least 150V or more from the black/white wire and the white/black wire to engine ground (while connected to the pack). If the reading is low, disconnect the trigger wires from the pack and recheck the terminals on the pack. If the voltage jumps up to an acceptable reading, the timer base may have a problem in it's internal wiring (A thin spot in the insulation on one wire).
7. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to spark properly.

NO SPARK ON ONE CYLINDER:

Either a faulty power pack or ignition coil normally causes this. Extremely rare causes include a weak trigger magnet in the flywheel or a timer base.

Three Cylinder Engines

NO SPARK ON ANY CYLINDER:

Note: If the ignition only sparks with the spark plugs out, the timer base is likely weak or the engine is not spinning fast enough. See # 6 and #8.

1. Disconnect the black yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault- check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine now sparks, replace the rectifier.
3. Check the stator resistance. Reading should be about 500 ohms from the brown wire to brown/yellow wire.
4. Check the DVA output from the stator. You should have a reading of at least 150V or more from the brown wire to the brown/yellow wire (while connected to the pack).
5. Check the timer base's resistance from the black/white wire to the white/black wires. Reading should be 10-20 ohms (or 30-40 ohms for CDI Electronics Blue Timer Bases).
6. Check the DVA output from the timer base. A reading of at least 0.5V or more is needed from the black/white wire to the white/black wires (while connected to the pack) to fire the pack. If the output is low, you may try to reset the air gap between the timer base sensor and the triggering magnet using a Sensor Gap Gauge (553-9702) or use the following procedure outlined below.
   a) Loosen the two mounting screws on the sensors and the nuts located in the epoxy on the outside of the heat shield of the timer base and slide the sensors in toward the crankshaft until the sensor touches the stop boss located at the base of the sensor mounting area. Tighten the mounting screws.
   b) Coat the face of the sensor with machinists bluing or equivalent and install the flywheel without the key and rotate the flywheel at least one full turn. Remove the flywheel and check to see if the trigging magnet struck the sensor face. If it did, back the sensor out approximately 0.005" and repeat steps C, D and E.
   c) If the ignition has spark, finger tight the nut on the outside of the heat shield and coat it with RTV.
   d) If still no spark, replace the sensor.

Johnson/Evinrude Troubleshooting

Alternator Driven CD Ignitions 1972-1978

(Three Cylinder Engines with screw terminal type power packs, continued)

7. Check the DVA voltage on the black/white wire to engine ground. You should have a reading of at least 150V or more (while connected to the pack). If the reading is low, disconnect the trigger wires from the pack and recheck the black/white terminal on the pack. If the voltage jumps up to an acceptable reading, the timer base may have a problem in the internal wiring (A thin spot in the insulation on one wire).
8. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to fire properly.

NO SPARK OR INTERMITTENT ON ONE OR MORE CYLINDERS:

1. Check the timer base resistance from the black/white wire to the white/black wires. Reading should be 10-20 ohms (or 30-40 ohms for CDI Electronics Blue Timer Bases) .
2. Check the DVA output from the timer base. A reading of at least 0.5V or more is needed from the black/white wire to the white/black wires (while connected to the pack) to fire the pack.
3. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Four Cylinder Engines

NO SPARK ON ANY CYLINDER:

(Note: If the engine has spark with the spark plugs out but not with them installed, the timer base is either weak or the engine is not spinning fast enough. See # 6 and #8.)

1. Disconnect the black yellow stop wire and retest. If the engines' ignition now has spark, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the stator resistance. You should read about 500 ohms from the brown wire to the brown/yellow wire.
4. Check the DVA output from the stator. You should have a reading of at least 150V or more from the brown wire to the brown/yellow wire (while connected to the pack).
5. Check the timer base resistance from the #1 to the #3 sensor wire, and from the #2 to the #4 sensor wire. Reading should be 10-20 ohms on each set (or 30-40 ohms for CDI Electronics Blue Timer Bases).
6. Check the DVA output from the timer base. A reading of at least 0.5V or more from the #1 sensor wire to the #3 sensor wire, and from the #2 sensor wire to the #4 sensor wire (while connected to the pack) is needed to fire the pack. If the output is low, you may try to reset the air gap between the timer base sensor and the triggering magnet using a Sensor Gap Gauge (553-9702) or use the following procedure:
   a) Loosen the two mounting screws on the sensors and the nuts located in the epoxy on the outside of the heat shield of the timer base.
   b) Slide the sensors in toward the crankshaft until the sensor touches the stop boss located at the base of the sensor mounting area. Tighten the mounting screws.
   c) Coat the face of the sensors with machinists bluing or equivalent.
   d) Install the flywheel without the key and rotate the flywheel at least one full turn.
   e) Remove the flywheel and check to see if the trigging magnet struck the face of the sensors. If it did, back the sensor out approximately 0.005” and repeat steps c, d and e.
   f) If the ignition fired, finger tight the nuts on the outside of the heat shield and coat them with RTV.
   g) If still no fire, replace the sensor.
7. Check the DVA voltage on each black/white wire to engine ground. You should have a reading of at least 150V or more (while connected to the pack). If the reading is low, disconnect the trigger wires from the pack and recheck the black/white terminals on the pack. If the voltage jumps up to an acceptable reading, the timer base may have a problem in the internal wiring (possibly a thin spot in the insulation on one wire).
8. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to fire properly.

Johnson/Evinrude Troubleshooting

Alternator Driven CD Ignitions 1972-1978

Four Cylinder Engines with screw terminal type power packs (Continued)

NO SPARK OR INTERMITTENT ON ONE OR MORE CYLINDERS:

Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

NO SPARK OR INTERMITTENT ON ONE BANK:

1. Check the timer base's resistance from the #1 to the #3 sensor wire, and from the #2 to the #4 sensor wire. Reading should be 10-20 ohms on each set (or 30-40 ohms for CDI Electronics Blue Timer Bases).
2. Check the DVA output from the timer base. A reading of at least 0.5V or more from the #1 to the #3 sensor wire, and from the #2 to the #4 sensor wire (while connected to the pack) is needed to have spark. If the output is low, you may try to reset the air gap between the timer base sensor and the triggering magnet using a sensor gap gauge or use the procedure outlined in the previous page.
3. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and connect a load resistor to that terminal. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Six Cylinder Engines

Note: If the engine has spark with the spark plugs out but not with them installed, the timer base is likely weak or the engine is not spinning fast enough. See # 6 and #8.

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault, check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the stator resistance. You should read about 500 ohms from the brown wire to the brown/yellow wire.
4. Check the DVA output from the stator. You should have a reading of at least 150V or more from the brown wire to the brown/yellow wire (while connected to the pack) on each bank.
5. Check the timer base's resistance from the white wire to the blue, green and purple wires. Reading should be 10-20 ohms (or 30-40 ohms for CDI Electronics Blue Timer Bases).
6. Check the DVA output from the timer base. A reading of at least 0.5V or more from the white wire to the blue, green and purple wires (while connected to the pack) is needed to fire the pack.
7. Check the DVA voltage on the white wire to engine ground. You should have a reading of at least 150V or more (while connected to the pack). If the reading is low, disconnect the trigger wires from the pack and recheck the white terminal on the pack. If the voltage jumps up to an acceptable reading, the timer base may have a problem in the internal wiring (possibly a thin spot in the insulation on one wire).
8. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.

NO SPARK OR INTERMITTENT ON ONE OR MORE CYLINDERS:

1. Check the timer bases resistance from the white wire to the blue, green and purple wires. Reading should be 10-20 ohms (or 30-40 ohms for CDI Electronics Blue Timer Bases).
2. Check the DVA output from the timer base. A reading of at least 0.5V or more from the white wire to the blue, green and purple wires (while connected to the pack) is needed to fire the pack.
3. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Johnson/Evinrude Troubleshooting

Alternator Driven CD Ignitions 1978-2006

Two Stroke/Except Direct Injected Engines

Two Cylinder Engines

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault-check the key switch, harness and shift switch.
2. Check the stator and trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550	150V or more Connected
Black/White wire	White/Black wire	15-42	0.6V or more Connected
Some engines use the following wiring on the trigger:			
White wire	Blue wire	15-42	0.6V or more Connected
White wire	Green wire	15-42	0.6V or more Connected

3. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to spark properly.
4. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the readings are low, disconnect the orange wires from the ignition coils and reconnect them to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

NO SPARK ON ONE CYLINDER:

Either a faulty power pack or ignition coil normally causes this problem. Rare cases include a weak trigger magnet in the flywheel or a timer base.

WILL NOT ACCELERATE BEYOND 3000 RPM:

1. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more, increasing with engine RPM until it reaches 300-400 volts. A sharp drop in voltage right before the miss becomes apparent will normally be caused by a bad stator. A drop on only one orange wire will normally be the power pack.
2. Check the stator resistance. If it reads approximately 900 ohms, replace it with the 500 ohm design.

Engines with S.L.O.W.

ENGINE WILL NOT ACCELERATE BEYOND 2500 RPM:

1. Use a temperature probe and verify that the engine is not overheating.
2. Disconnect the tan temperature wire from the pack and retest. If the engine now performs properly, replace the temperature switch.
3. Make sure the tan temperature switch wire is not located next to a spark plug wire.
4. Check the stator resistance. If it reads approximately 900 ohms, replace it with the 500 ohm design.

Three Cylinder Engines

(Except Quick Start Models)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault-check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the ignition now has spark, replace the rectifier.
3. Check the stator and trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550	150V or more Connected
White wire	Purple	38-42	0.6V or more Connected
White wire	Blue wire	38-42	0.6V or more Connected
White wire	Green wire	38-42	0.6V or more Connected

4. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to spark properly.

NO SPARK OR INTERMITTENT ON ONE OR MORE CYLINDERS:

1. Check the trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
White wire	Purple	38-42	0.6V or more Connected
White wire	Blue wire	38-42	0.6V or more Connected
White wire	Green wire	38-42	0.6V or more Connected

2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Johnson/Evinrude Troubleshooting
Alternator Driven CD Ignitions 1978-2006
(Three Cylinder Engines Continued…)

Models with S.L.O.W.

ENGINE WILL NOT ACCELERATE BEYOND 2500 RPM:

1. Use a temperature probe and verify that the engine is not overheating.
2. Disconnect the tan temperature wire from the pack and retest. If the engine now performs properly, replace the temperature switch.
3. Make sure the tan temperature switch wire is not located next to a spark plug wire.

Three Cylinder Engines
(Quick Start Models)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the ignition now has spark, replace the rectifier.
3. Check the stator and trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550	150V or more Connected
Orange wire	Orange/Black wire	450-550**	150V or more Connected
White wire	Purple	1.1M-2.4M ^^	0.6V or more Connected
White wire	Blue wire	1.1M-2.4M ^^	0.6V or more Connected
White wire	Green wire	1.1M-2.4M ^^	0.6V or more Connected

** NOTE: Some engines use a 50 or a 100 ohms power coil.

^^ This reading will vary according to the meter used. Do a comparison reading and if there is a difference of over 10%, replace the timer base. Typically, use the Red meter lead to the White wire and the Black wire to the other wires.

4. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to spark properly.

NO SPARK ON ONE OR MORE CYLINDERS:

1. Check the stator and trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550	150V or more Connected
Orange wire	Orange/Black wire	450-550**	150V or more Connected
White wire	Purple	1.1M-2.4M ^^	0.6V or more Connected
White wire	Blue wire	1.1M-2.4M ^^	0.6V or more Connected
White wire	Green wire	1.1M-2.4M ^^	0.6V or more Connected

** NOTE: Some engines use a 50 or a 100 ohms power coil.

^^ This reading will vary according to the meter used. Do a comparison reading and if there is a difference of over 10%, replace the timer base. Typically, use the Red meter lead to the White wire and the Black wire to the other wires.

2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 2500 RPM:

1. Use a temperature probe and verify that the engine is not overheating.
2. Disconnect the tan temperature wire from the pack and retest. If the engine now performs properly, replace the temperature switch.
3. Make sure the tan temperature switch wire is not located next to a spark plug wire.

Johnson/Evinrude Troubleshooting

Alternator Driven CD Ignitions 1978-2006

Four Cylinder Engines (Except Quick Start Models)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the stator and trigger resistance and DVA output as given below for both banks:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550	150V or more Connected
White wire	Blue wire	38-42	0.6V or more Connected
White wire	Green wire	38-42	0.6V or more Connected

4. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to fire properly.
5. Check the center hub triggering magnet in the flywheel for damage and tight fit.

NO SPARK OR INTERMITTENT ON ONE CYLINDER OR ONE BANK:

1. Check the stator and trigger resistance and DVA output as given below for both banks:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550	150V or more Connected
White wire	Blue wire	38-42	0.6V or more Connected
White wire	Green wire	38-42	0.6V or more Connected

NOTE: Also check the DVA readings to engine ground from each brown wire and compare the readings. If one wire reads low while connected to the pack, swap the connections and see if the low reading stays on the same stator wire. If it does, the stator is bad.

2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Johnson/Evinrude Troubleshooting

Alternator Driven CD Ignitions 1978-2006

Four Cylinder Engines (Quick Start Models)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire and retest. If the engine's ignition has spark, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the stator and trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	950-1100	150V or more Connected
Orange wire	Orange/Black wire	93-100**	150V or more Connected
White wire	Purple	35-55	0.6V or more Connected
White wire	Blue wire	35-55	0.6V or more Connected
White wire	Green wire	35-55	0.6V or more Connected
White wire	Pink	35-55	0.6V or more Connected
White wire	Purple/White	115-125	1.6V or more Connected
White wire	Blue/White	115-125	1.6V or more Connected
White wire	Green/White	115-125	1.6V or more Connected
White wire	Pink/White	115-125	1.6V or more Connected

** NOTE: Some engines use a 50 ohm power coil.

4. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to fire properly.

NO SPARK OR INTERMITTENT ON ONE OR MORE CYLINDERS:

1. Check the trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
White wire	Purple	35-55	0.6V or more Connected
White wire	Blue wire	35-55	0.6V or more Connected
White wire	Green wire	35-55	0.6V or more Connected
White wire	Pink	35-55	0.6V or more Connected

2. Disconnect the white/black temperature wire and retest. If all cylinders now fire, replace the timer base.
3. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 2500 RPM:

1. Use a temperature probe and verify that the engine is not overheating.
2. Disconnect the tan temperature wire from the pack and retest. If the engine now performs properly, replace the temperature switch.
3. Make sure the tan temperature switch wire is not located next to a spark plug wire.

Six Cylinder Engines
Without Quick Start

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wires and retest. If the engine's ignition has spark, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to spark properly.
3. Disconnect the yellow wires from the rectifier and retest. If the engine now has spark, replace the rectifier.
4. Check the center hub triggering magnet in the flywheel for damage and tight fit.

NO SPARK ON ONE BANK:

1. Check the stator and trigger resistance and DVA output as given below for each bank:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	450-550 (9 amp)	150V or more Connected
Brown wire	Brown/Yellow wire	900-1100 (35 amp)	150V or more Connected
White wire	Purple	15-42(a)	0.6V or more Connected
White wire	Blue wire	15-42(a)	0.6V or more Connected
White wire	Green wire	15-42(a)	0.6V or more Connected

(a) Use a comparison reading as the values for different years used different coils in the Timer-Base. As long as you have approximately the same ohm reading on all three tests and the correct output with the DVA meter, the Timer-Base should be good. The exception would be if the insulation is breaking down while the engine is running.

2. Check the DVA voltage to engine ground on the White Timer-Base wire while it is connected to the pack. You should see approximately the same reading as you do between the Brown & Brown/Yellow wires for that bank. A low reading usually indicates a bad Timer-Base.
3. Disconnect the Black/Yellow stop wire from one of the packs and retest. If the bank that had no fire now has spark, the pack that was appearing to fire correctly is faulty.

NO SPARK ON ONE CYLINDER:

1. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack or Timer-Base.
2. Check the Timer Base resistance and DVA output as given below for each cylinder:

Wire Color	Check to Wire Color	Resistance	DVA Reading
White wire	Purple wire	15-42(a)	0.6V or more Connected
White wire	Blue wire	15-42(a)	0.6V or more Connected
White wire	Green wire	15-42(a)	0.6V or more Connected

(a) Use a comparison reading as the values for different years used different coils in the Timer-Base. As long as you have approximately the same ohm reading on all three tests and the correct output with the DVA meter, the Timer-Base should be good.

3. Inspect the ignition coil for burned or discolored areas indicating arcing.
4. Swap the ignition coil with one that is sparking correctly.
5. Banks with the power packs and see if the problem moves. If fit does, replace the power pack. If not, replace the Timer-Base.

Six Cylinder Engines
Quick Start Models

Note: These engines usually have a 35 Amp battery charging capacity. Due to the size and weight of the flywheel magnets, it is highly recommended that you check to make sure both the triggering and charge magnets are still secure in the flywheel before you service the engine. A loose or broken magnet can be deadly to you or your pocketbook. It is a recommended you index the flywheel and check the timing on all cylinders when servicing these engines. Also check for static firing and intermittent spark.

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow kill wires AT THE PACK and retest. If the engine's ignition now has fire, the kill circuit has a fault-possibly the key switch, harness or shift switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine fires, replace the rectifier.
3. Check the stator and trigger resistance and DVA output as given below for each bank:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	900-1100 (35 amp)	150V or more Connected
Orange	Orange/Black	93-103 OEM	12-24V Connected
Orange	Orange/Black	45-55 CDI	12-24V Connected
White wire	Purple wire	(a)	0.6V or more Connected
White wire	Blue wire	(a)	0.6V or more Connected
White wire	Green wire	(a)	0.6V or more Connected
White wire	Purple wire 2nd connector	(a)	0.6V or more Connected
White wire	Blue wire 2nd connector	(a)	0.6V or more Connected
White wire	Green wire 2nd connector	(a)	0.6V or more Connected
White wire	Black/White wire 2nd connector	215-225	Not Applicable

(a) Use a comparison reading as different brands of meters will give different readings. The typical range is 1M to 5M ohms. As long as you have approximately the same ohm reading on all six tests and the correct output with the DVA meter, the Timer-Base should be good. The exception would be if one of the scr's inside the Timer-Base is breaking down while the engine is running. This can be found indexing the flywheel and checking the timing on all cylinders. If the readings are off, reverse the meter leads and retest to see if the readings are corrected.

4. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.

NO SPARK ON ONE CYLINDER:

1. Check the timer base's resistance and output (see NO SPARK ON ANY CYLINDER above).
2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 130V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack or Timer-Base.

NO SPARK ON ONE BANK:

1. Check the stator resistance and output (see NO SPARK ON ANY CYLINDER above).
2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one bank, disconnect the orange wires from the ignition coil for that bank and reconnect them to a load resistor. Retest. If the reading is now good, one or all of the ignition coils are likely bad. A continued low reading indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 2500 RPM :

1. Use a temperature probe and verify that the engine is not overheating.
2. Disconnect the tan temperature wire from the pack and retest. If the engine now performs properly, replace the temperature switch.
3. Make sure the tan temperature switch wire is not located next to a spark plug wire.
4. Disconnect the VRO sensor from the engine harness and retest. If the engine performs correctly, replace the VRO or sensor.

Eight Cylinder Engines
Quick Start Models

Note: These engines usually have a 35 Amp battery charging capacity. Due to the size and weight of the flywheel magnets, it is highly recommended that you check to make sure both the triggering and charge magnets are still secure in the flywheel before you service the engine. A loose or broken magnet can be deadly to you or your pocketbook. It is a recommended you index the flywheel and check the timing on all cylinders when servicing these engines. Also check for static firing and intermittent spark.

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow kill wires AT THE PACK and retest. If the engine's ignition now has fire, the kill circuit has a fault-possibly the key switch, harness or shift switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine fires, replace the rectifier.
3. Check the stator and trigger resistance and DVA output as given below for each bank:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	Brown/Yellow wire	900-1100 (35 amp)	150V or more Connected
Orange	Orange/Black	93-103 OEM	12-24V Connected
Orange	Orange/Black	40-55 CDI	12-24V Connected
White wire	Purple wire	(a)	0.6V or more Connected
White wire	Blue wire	(a)	0.6V or more Connected
White wire	Green wire	(a)	0.6V or more Connected
White wire	Pink wire	(a)	0.6V or more Connected
White wire	Purple wire 2nd connector	(a)	0.6V or more Connected
White wire	Blue wire 2nd connector	(a)	0.6V or more Connected
White wire	Green wire 2nd connector	(a)	0.6V or more Connected
White wire	Pink wire 2nd connector	(a)	0.6V or more Connected
White wire	Black/White wire 2nd connector	215-225	Not Applicable

(a) Use a comparison reading as different brands of meters will give different readings. The typical range is 1M to 5M ohms. As long as you have approximately the same ohm reading on all six tests and the correct output with the DVA meter, the Timer-Base should be good. The exception would be if one of the scr's inside the Timer-Base is breaking down while the engine is running. This can be found indexing the flywheel and checking the timing on all cylinders. If the readings are off, reverse the meter leads and retest to see if the readings are corrected.

4. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.

NO SPARK ON ONE CYLINDER:

1. Check the timer base's resistance and output (see NO SPARK ON ANY CYLINDER above).
2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 130V or more. If the reading is low on one cylinder, disconnect the orange wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack or Timer-Base.

NO SPARK ON ONE BANK:

1. Check the stator resistance and output (see NO SPARK ON ANY CYLINDER above).
2. Check the DVA output on the orange wires from the power pack while connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one bank, disconnect the orange wires from the ignition coil for that bank and reconnect them to a load resistor. Retest. If the reading is now good, one or all of the ignition coils are likely bad. A continued low reading indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 2500 RPM :

1. Use a temperature probe and verify that the engine is not overheating.
2. Disconnect the tan temperature wire from the pack and retest. If the engine now performs properly, replace the temperature switch.
3. Make sure the tan temperature switch wire is not located next to a spark plug wire.
4. Disconnect the VRO sensor from the engine harness and retest. If the engine performs correctly, replace the VRO or sensor.

Troubleshooting the Johnson/Evinrude 60° 6 Cylinder Ignition (OIS 2000) Carbureted 1991-2006 Model Years

Due to the differences in this ignition system, troubleshooting can be somewhat difficult if you are not familiar with the design. The other Johnson/Evinrude QuickStart ignitions use stator charge coils and a power coil to provide high voltage and power for the QuickStart and rev limiter circuits. They require a timer base for triggering and use separate magnets for the high voltage and triggering the timer base. The OIS 2000 Optical system uses the stator charge coils to provide high voltage for the firing of the ignition coils *and* a *power coil to provide power for the electronics, both inside the power pack and inside the sensor.* The other QuickStart models will run the engine without the power coil being connected (of course this will burn out the control circuits inside the power pack). The OIS 2000 ignition has to have the power coil supplying power in order to operate the QuickStart, S.L.O.W., rev limiter, and fire the coils beyond cranking speed. The optical sensor located on the top is fed power from the power pack and sends crankshaft position, cylinder location and direction of rotation back to the power pack. The pack is smart enough to know not to fire if the engine is not turning in the right direction. S.L.O.W. functions reduce the engine RPM to approximately 2500 when the engine over-heats or the no oil warning is activated. QuickStart (a 10° timing advance) activates as long as the engine RPM is below 1100, the engine temperature is below 105° F and the Yellow/Red wire from the starter solenoid is not feeding 12V DC to the power pack all of the time. QuickStart will also activate for 5-10 seconds each time the engine is started regardless of engine temperature. CDI Electronics (blue case with red sleeve) power packs have a built-in feature to compensate for a shorted cold sensor, allowing the engine to exit QuickStart after 5 minutes of running time regardless of the condition of the cold sensor. The CDI power pack also will not fire if the wrong encoder wheel (4 cylinder) is installed by mistake. At cranking speed the voltage from the stator may not be enough to operate the circuits inside the power pack. Therefore, battery voltage supplied via the yellow/red striped start wire. The extra voltage is needed in order for the optical sensor to operate correctly as low voltage from the battery and/or stator can cause intermittent or no fire at all. There are a couple of critical items you should be aware of on these engines. First, the spark plug wires have to be the Gray *inductive* resistor wires – these are NOT automotive wires. Secondly, the spark plugs should be the factory recommended QL78YC. Use of other spark plugs or wires can cause problems inside the power pack from RFI and MFI noise. CDI Electronics has the spark plug wires available as a set, P/N: 931-4921.

A breakthrough at CDI Electronics has allowed the use of microprocessor digital control circuits to handle the timing, QuickStart, S.L.O.W., rev limiter and data logging inside the power pack. This allows the timing to be set using a timing light, remote starter, spark gap tester, piston stop tool and a jumper wire. With these new digital power packs, you disconnect the port temperature switch/sensor leads and use a jumper wire to short the tan temperature sensor wire to engine ground. Once you have verified the timing pointer using a piston stop tool (Or a dial indicator), connect all spark plug wires to a spark gap tester, connect a remote starter to the engine and a timing light to # 1 spark plug wire. When you crank the engine over with the remote starter and check the timing, you should see the timing is set to approximately 4°-6° ATDC (After Top Dead Center). By advancing the throttle all the way and rechecking the timing for WOT (Wide Open Throttle), you should see approximately 19° - 20° BTDC (Before Top Dead Center) Without this timing feature built into the power pack, you will need the 511-4017 Timing Tool or the OEM version to set the timing for idle and WOT. Additional advantages offered by the digital circuitry include the ability to compensate for a bad temperature switch, a smoother rev limit, customized rev limiters and special timing curves.

Additional items to be aware of:

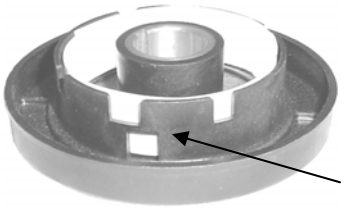
1. Early 150 and 175 HP engines did not have the tension washer on top of the sensor encoder wheel. This washer is required to keep the encoder locked in place. If it is missing, be sure to install the correct washer.
2. 1991 and 1992 engines did not have a shift interrupter switch. This resulted in hard shifting and required a conversion to resolve this problem.
3. The shift interrupter switch killed the fire on the starboard bank of cylinders from 1993 thru mid 1990's. By 1998, a change was made for the shift interrupter switch to kill the fire on the Port bank.
4. 1991 through late 1990's engines occasionally developed a crack in the water jacket allowing water into the intake at high speed. This typically resulted in # 1 cylinder ingesting water. You can usually see signs of this because the head looks like it has been steam cleaned inside the combustion chamber.
5. 1991 and 1992 engines came out with a Black sleeved power pack (P/N 584122) and stator (P/N 584109) and used a P/N 584265 sensor. In 1993 the power packs were changed to a Gray sleeve (Production) power pack (P/N 584910). The stator was changed to a Gray sleeve (P/N 584981) and the sensor was changed to P/N 584914. Engines with ignition problems had a service replacement power pack with a blue sleeve and a replacement sensor installed as a set. The Blue sleeved power pack was only available as a service replacement. The Gray sleeved stator could be used with all of the power packs, but the Black sleeved stator was to be used only with a Black sleeved power pack. The sensor P/N changed to 586343 in the late 1990's.

Troubleshooting the Johnson/Evinrude 60° 6 Cylinder Ignition (OIS 2000)
1991-2006 Model Years (Continued)

6. Some engines do not have the RFI/MFI noise shield between the ignition coils and the power pack. If it is missing, replace it.
7. The Gray inductive spark plug wires replaced the Black copper spark plug wires that were used on the early 1990's engines.
8. Originally the spark plugs were the QL82YC, but that recommendation was changed to the QL78YC for improved performance.

NO FIRE AT ALL:

1. Check the kill lanyard and key-switch position.
2. Verify the engine rotation (The engine needs to be turning in a clockwise direction).
3. Check the power pack and ignition coil ground wires for corrosion and tightness.
4. Connect a spark gap tester to all cylinders.
5. Disconnect the boat side harness and connect a remote starter unit. Check for spark. If the engine has spark, check the boat side harness's Black/Yellow wire for shorts to ground.
6. Disconnect the 5-pin connector on the port side of the power pack and see if the spark returns. If it does, use the CDI meter set to Ohms and see if the Black/Yellow wires are shorted to engine ground.
7. Check the battery voltage on the Yellow/Red striped wire while cranking the engine. If below 11 volts, charge the battery or check all battery cables.
8. Remove the sensor wheel and check for damage, especially where the top slots are located. Sometimes the wheels will break out where the windows overlap.



(This area is the most common breakout location)

9. Check the sensor eyes for dirt, grease, etc. If you have to clean it, use denatured alcohol and a Q-tip. Do not use any other cleaning agent because damage to the optical lens will occur.
10. Disconnect the voltage regulator/rectifier and retest. If the engine now has spark, replace the regulator/rectifier.
11. Using the Piercing Probes, check the resistance, then check the DVA voltage on the 6 pin stator connector while connected as follows:

Red Lead	Black Lead	Resistance	DVA Reading
Orange	Orange/Black	50-60 ohms	12 V or more
Brown	Brown/Yellow	450-600 ohms	150V or more
Brown/White	Brown/Black	450-600 ohms	150V or more

Note: Low readings on all checks indicate a possible problem with the flywheel magnets that require checking.

Service note: It is recommended that liquid neoprene be applied to the areas where the piercing probes were used.

12. If all the tests so far show good readings, check the DVA output from the power pack on the primary coil wires as follows:

Red Lead	Black Lead	DVA Reading
Orange/Blue	Engine Ground	130 V or more
Orange	Engine Ground	130 V or more
Orange/Green	Engine Ground	130 V or more

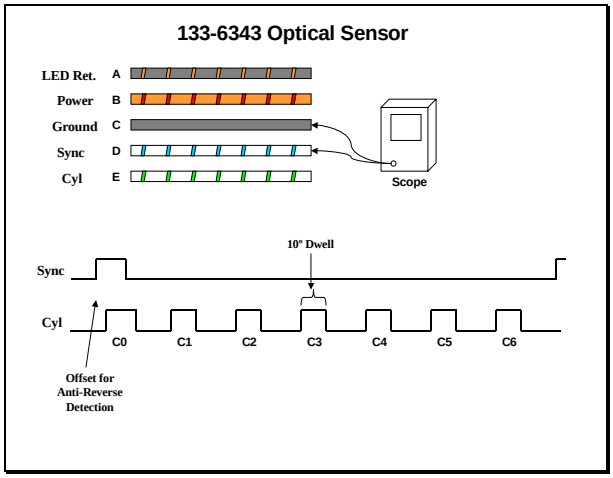
Note: If the DVA values are below these specifications, the power pack or sensor is likely bad.

13. Check the DVA voltage on the Black/Orange and Orange/Red sensors leads as follows:

Red Lead	Black Lead	DVA Reading
Orange/Red	Engine Ground	12 V or more
Black/Orange	Engine Ground	12 V or more

WARNING!! The Black/Orange wire should NEVER be shorted to engine ground as this will damage the sensor.

14. If an oscilloscope is available, check the white/blue (crank position signal) and white/green (cylinder position signal) sensor wires while connected to the sensor. With the engine cranking over, you should see a square toothed pattern on both wires. The white/blue wire should show 1 pulse per revolution and the white/green should show 7 pulses per revolution of the engine. See chart below.



a. Led Power – Black/Orange
b. Power – Orange Red
c. Ground – Black
d. Sync – White/Blue Stripe
e. Cyl – White/Green

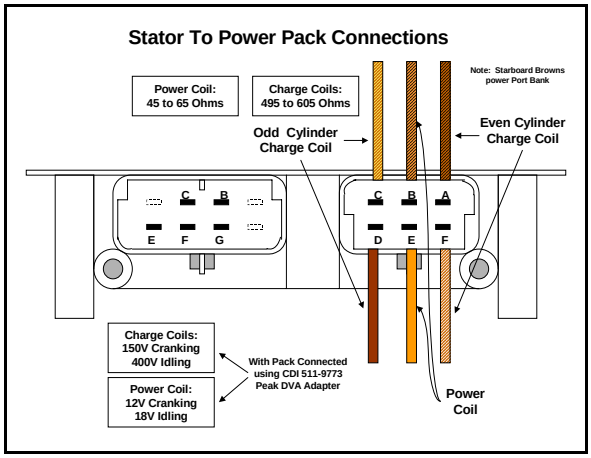
No Spark on One Bank of Cylinders:

1. Using the Piercing Probes and DVA adapter, check the resistance and DVA voltage for the bank without spark on the 6 pin stator connector while connected as follows:

Red Lead	Black Lead	Ohms Resistance	DVA	Bank/Cyl
Brown	Brown/Yellow	450-600 ohms	150V +	Stbd (1,3,5)
Brown/White	Brown/Black	450-600 ohms	150V +	Port (2,4,6)

NOTE: If the power pack has no spark on one bank and the readings are good, replace the power pack.

2. Disconnect the 5-pin connector on the port side of the power pack and see if the spark returns. If it does, use the CDI meter set to Ohms and see if the Black/Yellow or Black/Orange wire is shorted to engine ground. Check to see if the Shift Interrupter switch is located in the circuit where there is no spark.



6 Pin Connector

a) Brown/Black
b) Orange/Black
c) Brown/Yellow
d) Brown
e) Orange
f) Brown/White

Troubleshooting the Johnson/Evinrude 60° 6 Cylinder Ignition (OIS 2000)
1991-2006 Model Years (Continued)

High Speed Miss:

1. If the engine runs fine until you get above 4900 RPM and then starts missing, check the Orange to Orange/Black power coil wires with an oscilloscope (If available) or replace the pack. A breakdown inside the pack could cause RFI noise to activate the rev limiter for no apparent reason.
2. Using the Piercing Probes and DVA adapter, check the DVA voltage at the RPM where the problem is occurring while connected as follows:

Red Lead	Black Lead	DVA	Bank/Cylinder
Brown	Brown/Yellow	150V +	Starboard (1,3,5)
Brown/White	Brown/Black	150V +	Port (2,4,6)

NOTE: The readings should rapidly increase as the engine RPM increases and stabilize below 400 volts (voltage exceeding 400 V DVA indicates a bad pack). A sharp drop in voltage right before the miss becomes apparent usually indicates a bad stator charge coil.

3. Connect an inductive tachometer to the spark plug wires one at a time and compare the readings. If most of the cylinders show the same reading and one or two show different readings, check the primary wires with the inductive pickup to see if the readings are the same coming out of the power pack. A difference in readings between the primary and secondary coil wires usually indicate bad ignition wires. No difference indicates a bad power pack.

Will Not Rev Above Idle Speed or Only Has Spark as Long as the Starter Solenoid is Activated:

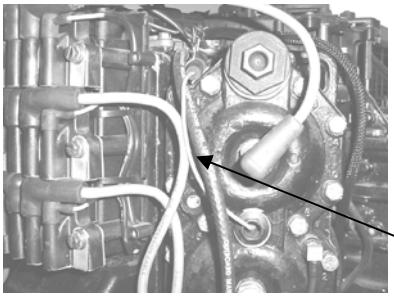
Using the Piercing Probes and DVA adapter, check the DVA voltage while connected as follows:

Red Lead	Black Lead	DVA
Orange	Orange/Black	11-24V

NOTE: The readings should rapidly increase as the engine RPM increases and stabilize below 24 volts (voltage exceeding 24 V DVA indicates a bad pack). A sharp drop in voltage right before the miss becomes apparent usually indicates a bad stator winding. A sharp drop in voltage when you let off of the starter solenoid indicates a bad power coil on the stator.

Engine Will Not Rev Above 2500 RPM *and Shakes Hard* (SLOW Activated):

1. Verify the engine is not actually over-heating by using a digital pyrometer.
2. Check the routing of the tan temperature wires, an example of a bad location is shown below. The tan wires have to be located as far away as possible from the spark plug wires.


(Unacceptable routing for the temp wire.)

3. Disconnect the temperature sensors and see if the engine performs normally. If it does, check both temperature sensors and replace the defective one.
4. If there is not any indication of a problem at this point, replace the power pack.

Engine stays in QuickStart All of the Time:

Check the Yellow/Red wire for 12 volts while the engine is running. You should only see voltage on this wire while the starter solenoid is engaged.

Troubleshooting the Johnson/Evinrude 60° 4 Cylinder Ignition (OIS 2000) Carbureted 1995-2006 Model Years

Due to the differences in this ignition system, troubleshooting can be somewhat difficult if you are not familiar with the design. The other Johnson/Evinrude QuickStart ignitions use stator charge coils and a power coil to provide high voltage and power for the QuickStart and rev limiter circuits. They require a timer base for triggering and use separate magnets for the high voltage and triggering the timer base. The OIS 2000 Optical system uses the stator charge coil to provide high voltage for the firing of the ignition coils *and* a *power coil to provide power for the electronics, both inside the power pack and inside the sensor.* The other QuickStart models will run the engine without the power coil being connected (of course this will burn out the control circuits inside the power pack). The OIS 2000 ignition has to have the power coil supplying power in order to operate the QuickStart, S.L.O.W., rev limiter, and fire the coils beyond cranking speed. The optical sensor located on the top is fed power from the power pack and sends crankshaft position, cylinder location and direction of rotation back to the power pack. The pack is smart enough to know not to fire if the engine is not turning in the right direction. S.L.O.W. functions reduce the engine RPM to approximately 2500 when the engine over-heats or the no oil warning is activated. QuickStart (a 10° timing advance) activates as long as the engine RPM is below 1100, the engine temperature is below 105° F and the Yellow/Red wire from the starter solenoid is not feeding 12V DC to the power pack all of the time. QuickStart will also activate for 5-10 seconds each time the engine is started regardless of engine temperature. CDI Electronics (blue case with red sleeve) power packs have a built-in feature to compensate for a shorted cold sensor, allowing the engine to come out of QuickStart after 5 minutes of running time regardless of the condition of the cold sensor. The CDI power pack will not fire if the wrong encoder wheel (6 cylinder) is installed by mistake.

At cranking speed the voltage from the stator may not be enough to operate the circuits inside the power pack, therefore there is battery voltage supplied from the starter solenoid via the yellow/red striped wire. The extra voltage is needed in order for the optical sensor to operate correctly as low voltage from the battery and/or stator can cause intermittent or no fire at all. There are a couple of critical items you should be aware of on these engines. First, the spark plug wires have to be the Gray *inductive* resistor wires – these are NOT automotive wires. Secondly, the spark plugs have to be the factory recommended QL78YC. Use of other spark plugs or wires can cause problems inside the power pack from RFI and MFI noise. CDI Electronics has the spark plug wires available as a set, P/N: 931-4921.

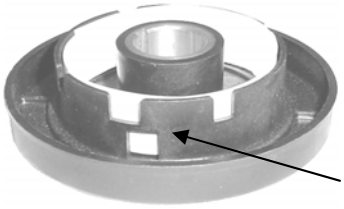
A breakthrough at CDI Electronics has allowed the use of microprocessor digital control circuits to handle the timing, QuickStart, S.L.O.W., rev limiter and data logging inside the power pack. This allows the timing to be set using a timing light, remote starter, spark gap tester, piston stop tool and a jumper wire. With these new digital power packs, you disconnect the port temperature switch/sensor leads and use a jumper wire to short the tan temperature sensor wire to engine ground. Once you have verified the timing pointer using a piston stop tool (Or a dial indicator), connect all spark plug wires to a spark gap tester, connect a remote starter to the engine and a timing light to # 1 spark plug wire. When you crank the engine over with the remote starter and check the timing, you should see the timing is set to approximately 4°-6° ATDC (After Top Dead Center). By advancing the throttle all the way and rechecking the timing for WOT (Wide Open Throttle), you should see approximately 19° - 21° BTDC (Before Top Dead Center) Without this timing feature built into the power pack, you would not be able to easily set the timing for idle or WOT without a optical diagnostic tool. Additional advantages offered by the digital circuitry include the ability to compensate for a bad temperature switch, a smoother rev limit, customized rev limiters and special timing curves.

Additional items to be aware of:

1. Some engines do not have the RFI/MFI noise shield between the ignition coils and the power pack. If it is missing, replace it.
2. Originally the spark plugs were the QL82YC, but that recommendation was changed to the QL78YC for improved performance.

NO FIRE AT ALL:

1. Check the kill lanyard and key-switch position.
2. Verify the engine rotation (The engine needs to be turning in a clockwise direction).
3. Check the power pack and ignition coil ground wires for corrosion and tightness.
4. Connect a spark gap tester to all cylinders.
5. Disconnect the boat side harness and connect a remote starter unit. Check for spark. If the engine has spark, check the boat side harness's Black/Yellow wire for shorts to ground.
6. Disconnect the 4-pin connector on the port side of the power pack and see if the spark returns. If it does, use the CDI meter set to Ohms and see if the Black/Yellow wires are shorted to engine ground.
7. Check the battery voltage on the Yellow/Red striped wire while cranking the engine. If below 11 volts, charge the battery or check all battery cables.
8. Remove the sensor wheel and check for damage, especially where the top slots are located. Sometimes the wheels will break out where the windows overlap.



(This area is the most common breakout location)

9. Check the sensor eyes for dirt, grease, etc. If you have to clean it, use denatured alcohol and a Q-tip. Do not use any other cleaning agent because damage to the optical lens will occur.
10. Disconnect the voltage regulator/rectifier and retest. If the engine now has spark, replace the regulator/rectifier.
11. Using the Piercing Probes, check the resistance, then check the DVA voltage on the 6 pin stator connector while connected as follows:

Red Lead	Black Lead	Resistance	DVA Reading
Orange	Orange/Black	50-60 ohms	12 V or more
Brown	Brown/Yellow	450-600 ohms	150V or more

Note: Low readings on all checks indicate a possible problem with the flywheel magnets that require checking.
Service note: It is recommended that liquid neoprene be applied to the areas where the piercing probes were used.

12. If all the tests so far show good readings, check the DVA output from the power pack on the primary coil wires as follows:

Red Lead	Black Lead	DVA Reading
Orange/Blue	Engine Ground	130 V or more
Orange/Green	Engine Ground	130 V or more

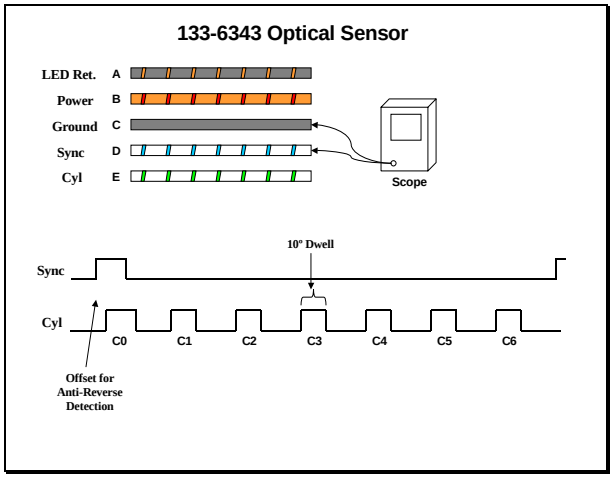
Note: If the DVA values are below these specifications, the power pack or sensor is likely bad.

13. Check the DVA voltage on the Black/Orange and Orange/Red sensors leads as follows:

Red Lead	Black Lead	DVA Reading
Orange/Red	Engine Ground	12 V or more
Black/Orange	Engine Ground	12 V or more

WARNING!! The Black/Orange wire should NEVER be shorted to engine ground as this will damage the sensor.

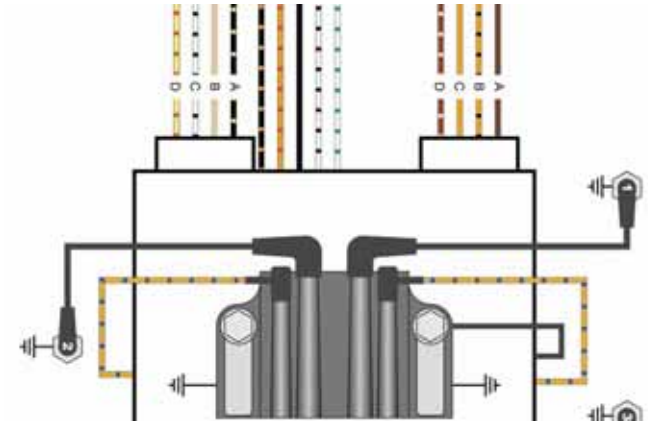
14. If an oscilloscope is available, check the white/blue (crank position signal) and white/green (cylinder position signal) sensor wires while connected to the sensor. With the engine cranking over, you should see a square toothed pattern on both wires. The white/blue wire should show 1 pulse per revolution and the white/green should show 7 pulses per revolution of the engine. See chart below.



f. Led Power – Black/Orange
g. Power – Orange Red
h. Ground – Black
i. Sync – White/Blue Stripe
j. Cyl – White/Green

No Spark on One Bank of Cylinders:

1. If the power pack has no spark on one bank and the readings are good, replace the power pack.
2. Disconnect the 4-pin connector on the port side of the power pack and see if the spark returns. If it does, use the CDI meter set to Ohms and see if the Black/Yellow wire is shorted to engine ground.
3. Check to see if the Shift Interrupter switch is shorted.



Port 4 Pin Connector	**Starboard 4 Pin Connector**
a) Black/Yellow	a) Brown
b) Tan	b) Orange/Black
c) White/Black	c) Orange
d) Yellow/Red	d) Brown/Yellow

High Speed Miss:

1. If the engine runs fine until you get above 4900 RPM and then starts missing, check the Orange to Orange/Black power coil wires with an oscilloscope (If available) or replace the pack. A breakdown inside the pack could cause RFI noise to activate the rev limiter for no apparent reason.
2. Using the Piercing Probes and DVA adapter, check the DVA voltage at the RPM where the problem is occurring while connected as follows:

Red Lead	Black Lead	DVA
Brown	Brown/Yellow	150V +

NOTE: The readings should rapidly increase as the engine RPM increases and stabilize below 400 volts (voltage exceeding 400 V DVA indicates a bad pack). A sharp drop in voltage right before the miss becomes apparent usually indicates a bad stator charge coil.

3. Connect an inductive tachometer to the spark plug wires one at a time and compare the readings. If most of the cylinders show the same reading and one or two show different readings, check the primary wires with the inductive pickup to see if the readings are the same coming out of the power pack. A difference in readings between the primary and secondary coil wires usually indicate a bad coil or bad ignition wires. No difference indicates a bad power pack.

Will Not Rev Above Idle Speed or Only Has Spark as Long as the Starter Solenoid is Activated:

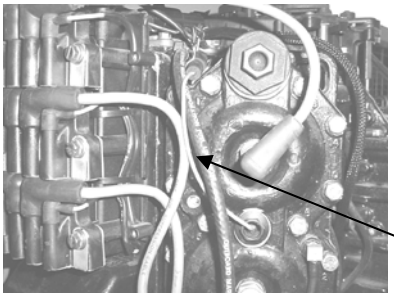
Using the Piercing Probes and DVA adapter, check the DVA voltage while connected as follows:

Red Lead	Black Lead	DVA
Orange	Orange/Black	11-24V

NOTE: The readings should rapidly increase as the engine RPM increases and stabilize below 24 volts (voltage exceeding 24 V DVA indicates a bad pack). A sharp drop in voltage right before the miss becomes apparent usually indicates a bad stator winding. A sharp drop in voltage when you let off of the starter solenoid indicates a bad power coil on the stator.

Engine Will Not Rev Above 2500 RPM *and Shakes Hard* (SLOW Activated):

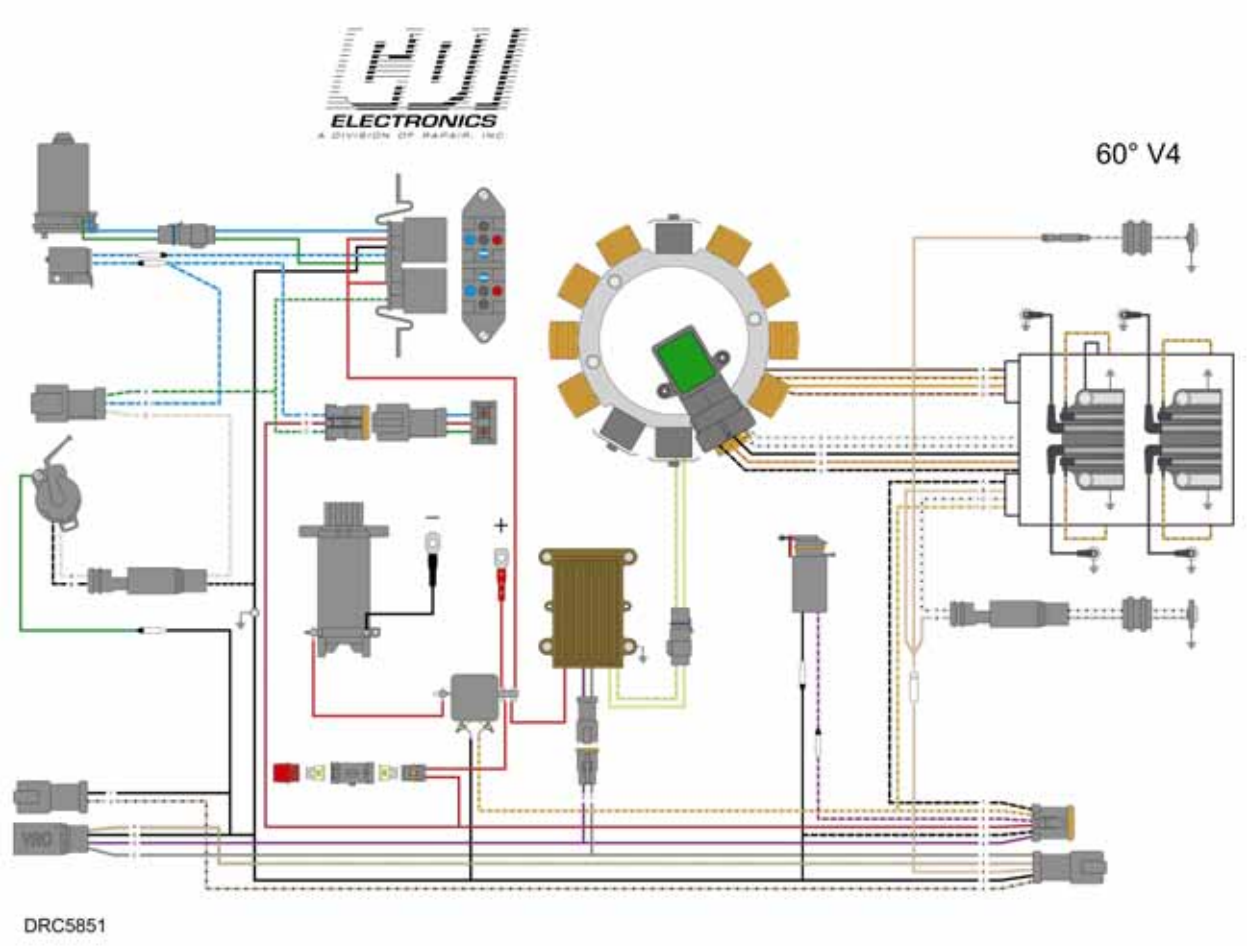
1. Verify the engine is not actually over-heating by using a digital pyrometer.
2. Check the routing of the tan temperature wires, an example of a bad location is shown below. The tan wires have to be located as far away as possible from the spark plug wires.



(Unacceptable routing for the temp wire.)

3. Verify the engine is not overheating and disconnect the Tan temperature sensor wire. If the engine performs normally, check both temperature sensors and replace the defective one.
4. If there is not any indication of a problem at this point, replace the power pack.

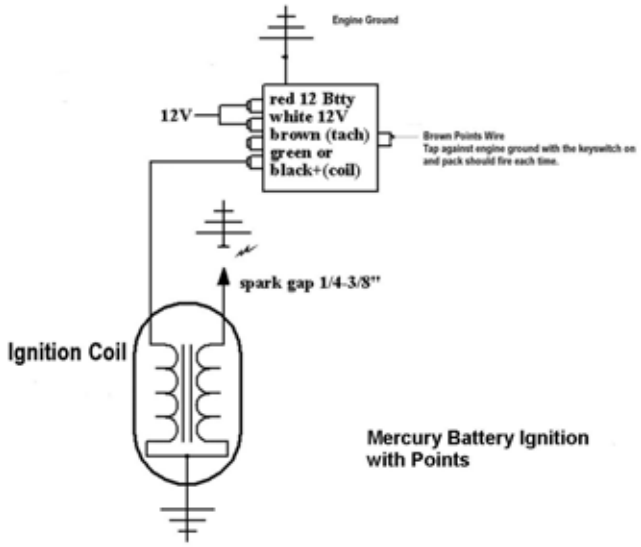
Engine stays in QuickStart All of the Time:
Check the Yellow/Red wire for 12 volts while the engine is running. You should only see voltage on this wire while the starter solenoid is engaged.



Mercury
Battery CD Ignitions with Points

1. SERVICE NOTE: Check the battery voltage at approximately 3500-RPM, MAXIMUM reading allowable is 16 volts. Over 16 volts will damage the ignition. Check for loose connections or a bad battery. ***Maintenance free batteries are NOT recommended for this application.*** A CD Tester (CDI Electronics P/N: 511-9701) can be used to test the CD module, distributor cap, rotor button and spark plug wires on the engine.

Engine Wiring Connection for Testing Ignition Module



2. Clean all battery connections and engine grounds.
3. Disconnect the mercury tilt switch and retest. If the ignition works properly, replace the mercury switch.
4. Connect a spark gap tester to the spark plug wires and check for fire on *all cylinders*. If some cylinders fire and not others, the problem is likely in the distributor cap, rotor button or spark plug wires.
5. Connect a spark gap tester to the high-tension lead coming from the ignition coil and set it to approximately 7/16". When you crank the engine over, if it fires while the spark gap tester is connected to the coil and does not fire through the spark plug wires – there is a problem in the distributor cap, rotor button or spark plug wires.
6. Check voltage present on the white and red terminals while at cranking. It MUST be at least 9½ volts. If not, there is a problem in the harness, key switch, starter battery cables or battery.
7. Check DVA voltage on the green wire going to the coil, it should be over 100 volts at cranking.
8. Disconnect the brown points wires. Turn the ignition switch on and strike one of the brown points wire against engine ground. The unit should fire each time. If the coil does fire, this means the CD module is usually good and the points, points plate and grounding wire for the points plate should be checked.
9. Connect a spark gap tester to the high-tension leads coming from the distributor cap and set the gap to approximately 7/16". Align the rotor with #1 spark plug wire. Turn the ignition switch on and strike the brown points wire against engine ground (Or use a CD Tester). Only the #1 spark plug wire should fire. If any other spark plug wire now has fire, there is a problem in the distributor cap. Repeat the test for the other cylinders.
10. Perform a voltage drop test after the engine is repaired to see if there is a problem with the voltage going to the CD module. At cranking and while the engine is running, use a DC voltmeter and put the black meter lead on the battery POS (+) *post* and the red meter lead on the positive battery cable at the starter solenoid. Keep the black lead on the battery post and shift the red meter lead to the positive post of the rectifier, then to the red and white terminals on the switch box. If you find a reading above 0.6V, there is a problem at the point where the voltage jumped up. For example, if the meter reads 0.4V until you get to the white terminal and then jumps to 2.3V on the white terminal –this indicates a problem in the key switch, or harness. Repeat the test for the negative battery post by putting the black meter lead on the battery NEG (-) *post* and the red meter lead on the negative battery cable terminal, then shifting to the engine block, rectifier base and case ground of the CD module.

Mercury

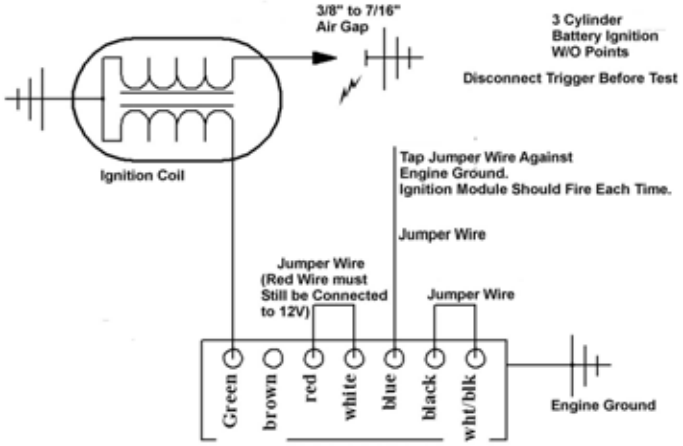
Battery CD Ignitions without Points

Three Cylinder Engines with 332-4796/393-4797 Battery Type Ignitions

Note: A CD Tester by CDI Electronics (511-9701) or Merc-o-Tronics can be used to test the CD module, distributor cap, rotor button and spark plug wires on the engine while the Trigger Tester by CDI can be used to test the distributor trigger.

SERVICE NOTE: Check the battery voltage at approximately 3500 RPM, MAXIMUM reading allowable is 16 volts and minimum is 12V. Running below 12V or over 16 volts will damage the ignition. Check for loose connections or a bad battery. ***Maintenance free batteries are NOT recommended for this application.***

Engine Wiring Connection for Testing Ignition Module



General:

1. Clean all battery connections and engine grounds.
2. Disconnect the mercury tilt switch and retest. If the ignition works properly, replace the mercury switch.
3. Connect a spark gap tester to the spark plug wires and check for fire on *all cylinders*. If some cylinders fire and not others, the problem is likely in the distributor cap, rotor button or spark plug wires.
4. Perform a voltage drop test after the engine is repaired to see if there is a problem with the voltage going to the CD module. At cranking and while the engine is running, use a DC voltmeter and put the black meter lead on the battery POS (+) *post* and the red meter lead on the positive battery cable at the starter solenoid. Keep the black lead on the battery post and shift the red meter lead to the positive post of the rectifier, then to the red and white terminals on the switch box. If you find a reading above 0.6V, there is a problem at the point where the voltage jumped up. For example, if the meter reads 0.4V until you get to the white terminal and then jumps to 2.3V on the white terminal –this indicates a problem in the key switch, or harness. Repeat the test for the negative battery post by putting the black meter lead on the battery NEG (-) *post* and the red meter lead on the negative battery cable terminal, then shifting to the engine block, rectifier base and case ground of the CD module.

NO SPARK ON ANY CYLINDER:

1. Connect a spark gap tester to the high-tension lead coming from the ignition coil and set it to approximately 7/16". When you crank the engine over, if it fires while the spark gap tester is connected to the coil and does not fire through the spark plug wires – there is a problem in the distributor cap, rotor button or spark plug wires.
2. Check the DC voltage present on the white and red terminals while at cranking. It MUST be at least 9½ volts. If not, there is a problem in the harness, key switch, starter battery cables or battery.
3. Check the DC voltage on the white/black trigger terminal while cranking, there must be at least 9V available with the trigger wire connected.
4. Check DVA voltage between the blue and black trigger wires (they must be connected to the switch box). You should read at least 3V. A low reading indicates a bad trigger.
5. Check DVA voltage on the green wire going to the coil, it should be over 100 volts at cranking.

ONLY HAS SPARK AS LONG AS THE STARTER IS ENGAGED:

This symptom usually indicates a bad trigger or low voltage.

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. Connect a spark gap tester to the high-tension leads coming from the distributor cap and set the gap to approximately 7/16". Use of a CD Tester is highly recommended.
2. Align the rotor with #1 spark plug wire. Disconnect the trigger wires and connect a jumper wire from the white/black trigger terminal to the black trigger terminal on the switch box.
3. Connect another jumper wire to the blue trigger terminal turn the ignition switch on. Strike the jumper wire from the blue terminal against engine ground – (DO NOT HOLD THE JUMPER AGAINST ENGINE GROUND). Only the #1 spark plug wire should fire. If any other spark plug wire now has fire, there is a problem in the distributor cap.
4. Repeat the test for the other cylinders.

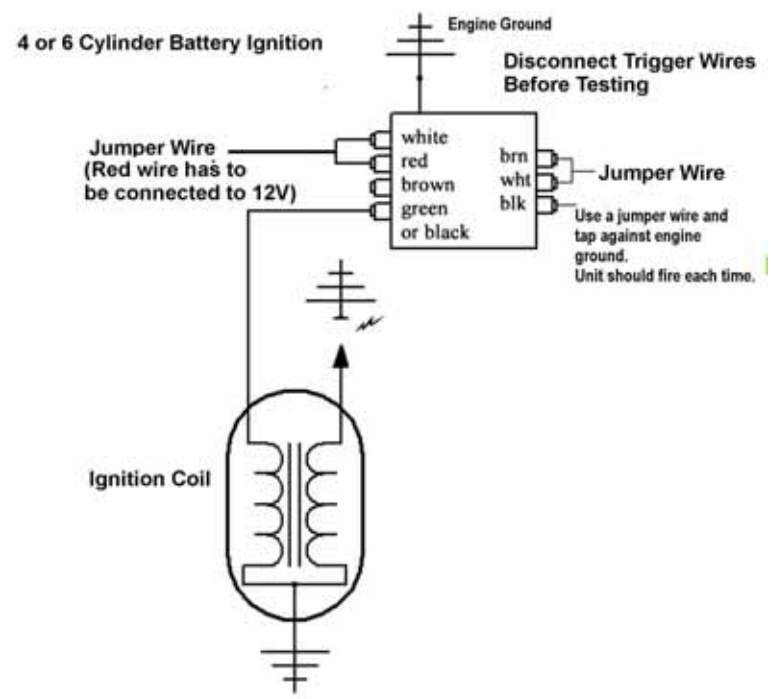
HIGH SPEED MISS:
Check the battery voltage on the red and white terminals of the switch box at high speed, the voltage should be between 12.5V and 16V DC. A reading outside this range will damage the CD module. If the readings are abnormal, perform the voltage drop test described above.

Four and Six Cylinder Engines with 332-2986/393-3736 Battery Type Ignitions

Note: A CD Tester like the one by CDI Electronics or Merc-o-Tronics can be used to test the CD module, distributor cap, rotor button and spark plug wires on the engine while the Trigger Tester by CDI can be used to test the distributor trigger.

SERVICE NOTE: Check the battery voltage at approximately 3500 RPM, MAXIMUM reading allowable is 16 volts and minimum is 12V. Running below 12V or over 16 volts will damage the ignition. Check for loose connections or a bad battery. ***Maintenance free batteries are NOT recommended for this application.***

Engine Wiring Connection for Testing Ignition Module



General:
1. Clean all battery connections and engine grounds.
2. Disconnect the mercury tilt switch and retest. If the ignition works properly, replace the mercury switch.
3. Connect a spark gap tester to the spark plug wires and check for fire on *all cylinders*. If some cylinders fire and not others, the problem is likely in the distributor cap, rotor button or spark plug wires.
4. Perform a voltage drop test after the engine is repaired to see if there is a problem with the voltage going to the CD module. At cranking and while the engine is running, use a DC voltmeter and put the black meter lead on the battery POS (+) *post* and the red meter lead on the positive battery cable at the starter solenoid. Keep the black lead on the battery post and shift the red meter lead to the positive post of the rectifier, then to the red and white terminals on the switch box. If you find a reading above 0.6V, there is a problem at the point where the voltage jumped up. For example, if the meter reads 0.4V until you get to the white terminal and then jumps to 2.3V on the white terminal –this indicates a problem in the key switch, or harness. Repeat the test for the negative battery post by putting the black meter lead on the battery NEG (-) *post* and the red meter lead on the negative battery cable terminal, then shifting to the engine block, rectifier base and case ground of the CD module.

NO SPARK ON ANY CYLINDER:
1. Connect a spark gap tester to the high-tension lead coming from the ignition coil and set it to approximately 7/16". When you crank the engine over, if it fires while the spark gap tester is connected to the coil and does not fire through the spark plug wires – there is a problem in the distributor cap, rotor button or spark plug wires.
2. Check the DC voltage present on the white and red terminals while at cranking. It MUST be at least 9½ volts. If not, there is a problem in the harness, key switch, starter battery cables or battery.
3. Check the DC voltage on the brown trigger terminal while cranking, there must be at least 9V available with the trigger wire connected.
4. Check DVA voltage between the white and black trigger wires (they must be connected to the switch box). You should read at least 3V. A low reading indicates a bad trigger.
5. Check DVA voltage on the green wire going to the coil, it should be over 100 volts at cranking.

ONLY HAS SPARK AS LONG AS THE STARTER IS ENGAGED:
This symptom usually indicates a bad trigger or low voltage.

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:
1. Connect a spark gap tester to the high-tension leads coming from the distributor cap and set the gap to approximately 7/16". (Use of a CD Tester is recommended).
2. Align the rotor with #1 spark plug wire. Disconnect the trigger wires and connect a jumper wire from the brown trigger terminal to the white trigger terminal.
3. Connect another jumper wire to the black trigger terminal turn the ignition switch on. Strike the jumper wire from the black terminal against engine ground – (DO NO HOLD THE JUMPER AGAINST ENGINE GROUND). Only the #1 spark plug wire should fire. If any other spark plug wire has fire, there is a problem in the distributor cap.
4. Repeat the test for the other cylinders.

HIGH SPEED MISS:
1. Check the battery voltage on the red and white terminals of the switch box at high speed, the voltage should be between 12.5V and 16V DC. A reading outside this range will damage the CD module. If the readings are abnormal, perform the voltage drop test described above.
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a high miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.

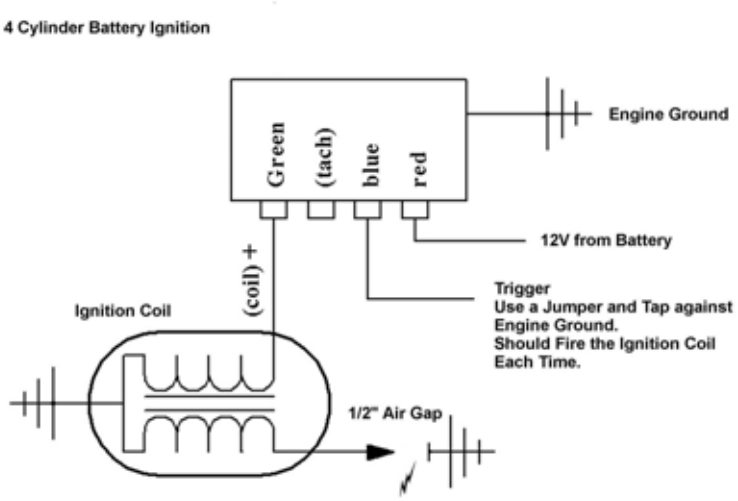
Four Cylinder Engines

1970-1971 Engines with 337-4406/337-4411 Ignitions

WARNING: Check the battery voltage at approximately 3500 RPM, MAXIMUM allowable reading is 16 volts and minimum is 12V. Running below 12V or over 16 volts will damage the ignition. Check for loose connections or a bad battery. Maintenance free batteries are NOT recommended for this application.

SERVICE NOTE: Due to problems associated with this system, it is recommended that the system be converted over to a 332-2986/393-3736 type system. (CDI Electronics offers a conversion kit, P/N – 114-2986K1)

Engine Wiring Connection for Testing Ignition 337-4411 Module



General:
1. Clean all battery connections and engine grounds.
2. Disconnect the mercury tilt switch and retest. If the ignition works properly, replace the mercury switch.
3. Connect a spark gap tester to the spark plug wires and check for fire on *all cylinders*. If some cylinders fire and not others, the problem is likely in the distributor cap, rotor button or spark plug wires.
4. Perform a voltage drop test after the engine is repaired to see if there is a problem with the voltage going to the CD module. At cranking and while the engine is running, use a DC voltmeter and put the black meter lead on the battery POS (+) *post* and the red meter lead on the positive battery cable at the starter solenoid. Keep the black lead on the battery post and shift the red meter lead to the positive post of the rectifier, then to the red and white terminals on the switch box. If you find a reading above 0.6V, there is a problem at the point where the voltage jumped up. For instance, if the meter reads 0.4V until you get to the white terminal and then jumps to 2.3V on the white terminal –this indicates a problem in the key switch, or harness. Repeat the test for the negative battery post by putting the black meter lead on the battery NEG (-) *post* and the red meter lead on the negative battery cable terminal, then shifting to the engine block, rectifier base and case ground of the CD module.

NO SPARK ON ANY CYLINDER:

1. If a mercury switch is connected to the switch box, disconnect it and retest. If you now have spark, replace the mercury switch.
2. Connect a spark gap tester to the high-tension lead coming from the ignition coil and set it to approximately 7/16". When you crank the engine over, if it fires while the spark gap tester is connected to the coil and does not fire through the spark plug wires – there is a problem in the distributor cap, rotor button or spark plug wires.
3. Check the DC voltage present on the white trigger wire and the red terminal of the switch box while cranking. It MUST be at least 9½ volts. If not, there is a problem in the harness, key switch, starter, battery cables or battery.
4. Check DVA voltage between the blue terminal and engine ground while cranking (The trigger wire must be connected to the switch box). You should read at least 9V.
5. Disconnect the wire from the blue terminal of the switch box and connect a jumper wire to the terminal. Strike the other end of the jumper wire against engine ground. The CD module should fire each time. Failure to fire usually indicates a bad CD module.
6. Check DVA voltage on the green wire going to the coil, it should be over 100 volts at cranking.

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. Connect a spark gap tester to the spark plug wires coming from the distributor cap and set the air gap to approximately 7/16".
2. Align the rotor with #1 spark plug wire. Disconnect the wire from the blue terminal of the switch box and connect a jumper wire to the terminal. Strike the other end of the jumper wire against engine ground. Only the #1 spark plug wire should fire. If any other spark plug wire has fire, there is a problem in the distributor cap.
3. Repeat the test for the other cylinders.

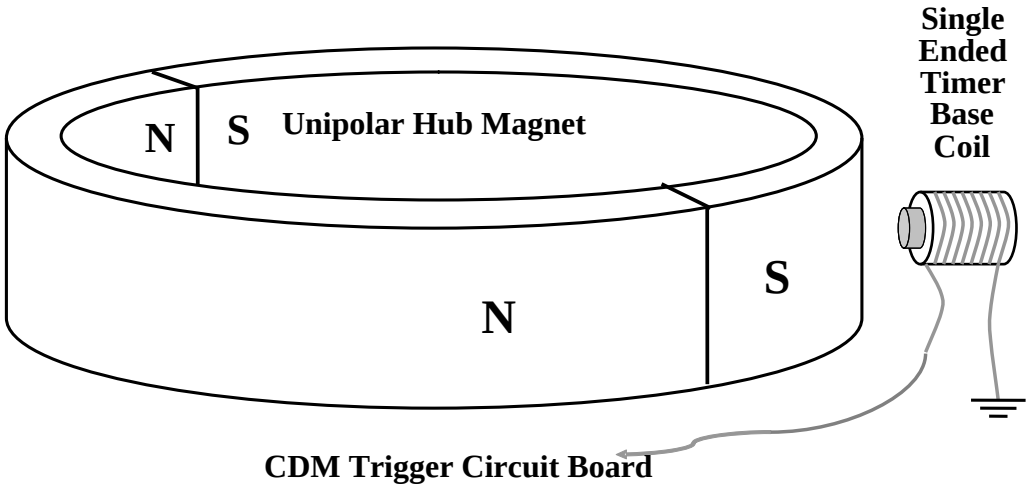
NOTICE: The 4 cylinder engines using the 332-3213 ignition module and belt driven ignition driver DO NOT USE BATTERY VOLTAGE. Connecting 12V to the Red terminal will destroy the module.

Mercury Trigger Magnets

THE FLYWHEELS WITH THESE MAGNET DESIGNS CANNOT BE INTERCHANGED!!!!

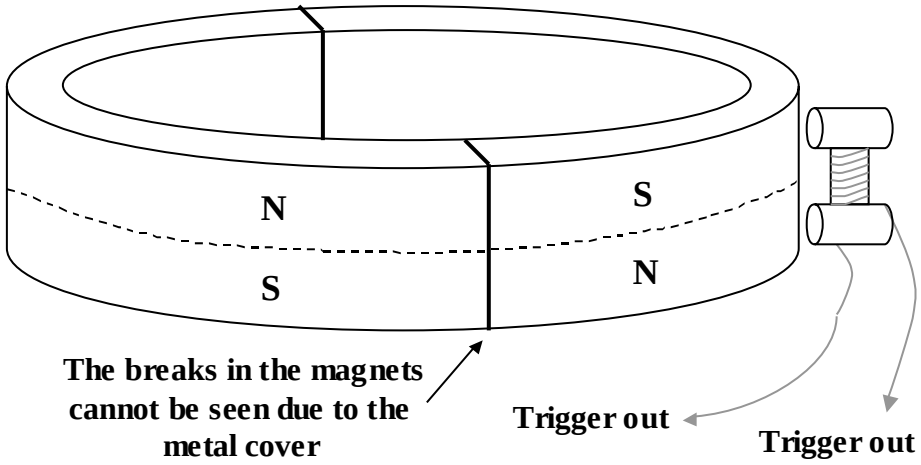
Mercury CDM Hub Magnet Design

1996 to 2006 2, 3 and 4 cylinder engines with CDM Modules



Mercury Hub Magnet Design

Push-Pull Trigger Coil Design (1978-1996 on 2, 3 and 4 Cyl engines All 1978-2005 L6, 2.0L, 2.4L and 2.5L engines)



Note that the design of the magnet for the push-pull is the same for the 3, 4 and 6 cylinder engines using standard ADI ignitions. The trigger magnet for the CDM modules is completely different.

Mercury

Alternator Driven Ignitions

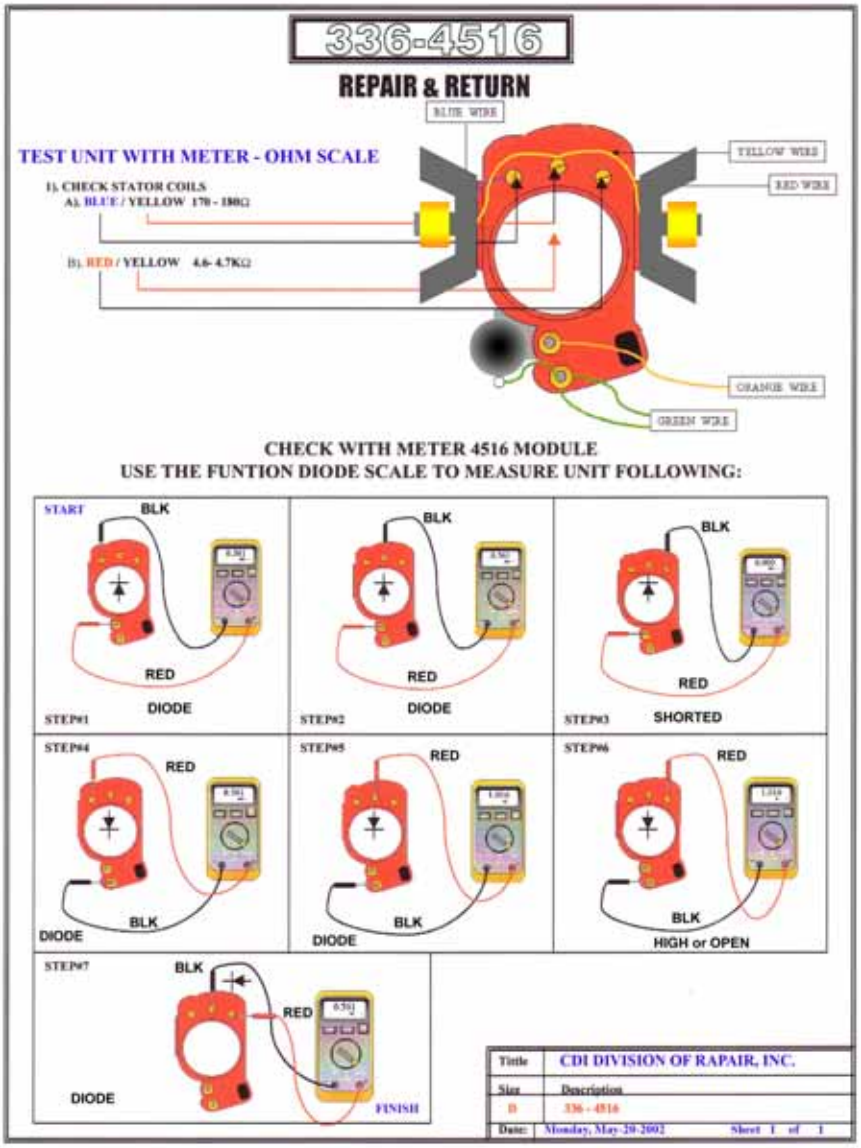
Two Cylinder Engines 1971-1975 (With Phase-Maker Ignition)

NO SPARK ON ONE OR BOTH CYLINDERS:

1. Disconnect the orange stop and retest. If the engine now has spark, the stop circuit has a fault.
2. Check the Stator resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Red wire	Yellow wire	320-550	Not Available
Blue wire	Yellow wire	3600-5500	Not Available
Green wire	Engine Ground	--	180V or more Connected

2. Disconnect the points wires (Brown and White) one at a time and retest. If the spark comes back on the one still connected when you disconnect one of them, the points or points wire is defective for the disconnected cylinder.
3. Disconnect the Green wires one at a time and retest If the spark comes back on one cylinder, the ignition coil not connected is defective. Remember that the coils must not be the Black or Blue coils (these coils are not isolated ground).
4. Test the 336-4516 module as follows:



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Two Cylinder Engines 1974-1985 (With the 336-3962 or 336-3996 Stator/Switch Box)

WARNING!! DO NOT START AND RUN THIS ENGINE ON A FLUSHING ATTACHMENT OR EAR MUFFS AND ACTIVATE THE STOP CIRCUIT. This system operates with the orange stop wire normally shorted to ground. When you activate the stop circuit, you open the orange's connection to ground. The resulting backlash into the stator may damage the electronics. You must use the choke to stop the engine. In the water, the back pressure from the exhaust will slow the engine quickly enough to prevent damage to the stator.

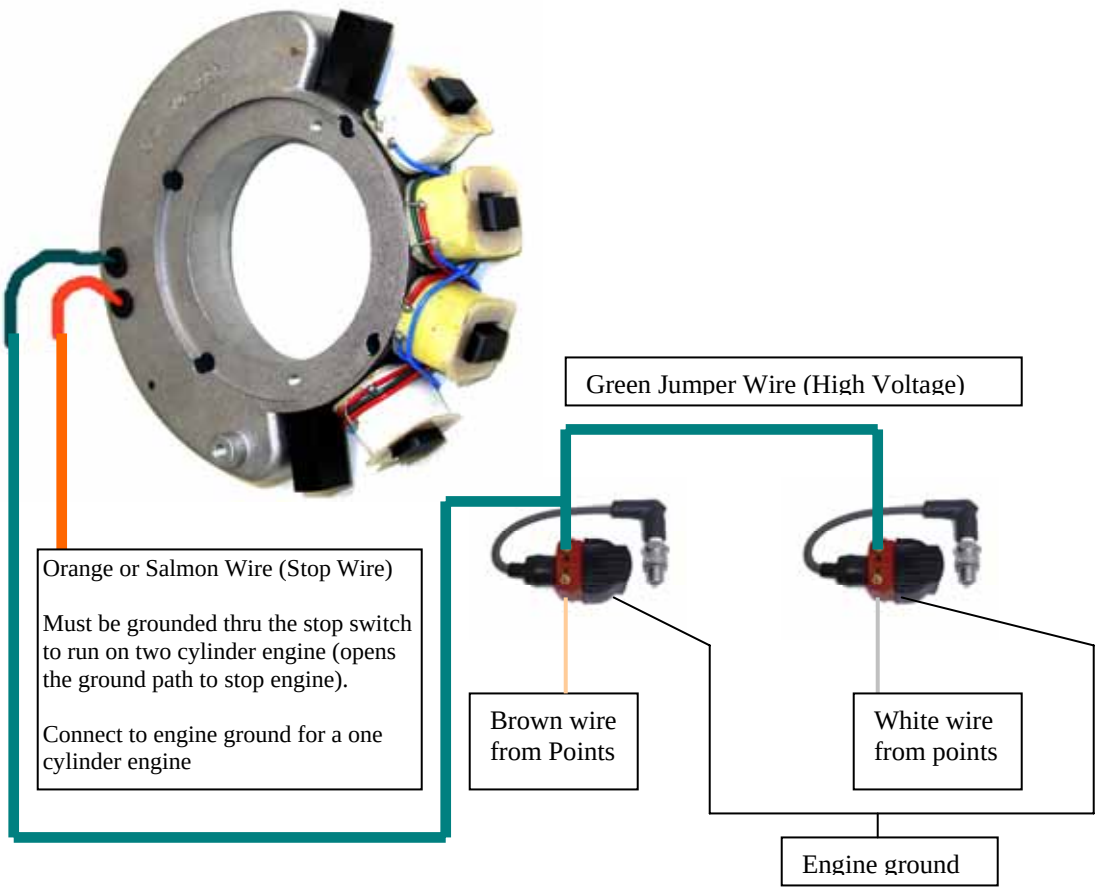
Note: The insulator blocks used with this stator are very important. You are strongly advised to closely inspect the points wires and insulator blocks for cracking or arcing. This system operates at a much higher voltage than the normal systems and what would be acceptable on other systems will cause arcing problems.

NO SPARK ON ANY CYLINDER:

1. Disconnect the Orange stop wire and retest. If the ignition system now has spark, the stop circuit has a problem.
2. Use a jumper wire and short the orange (Salmon) wire to ground. If the engine now has spark, replace the stop switch.
3. Disconnect the points wires from the ignition coils and connect a jumper wire to the negative side of the coils. Crank the engine and carefully tap the jumper to engine ground, if the coil sparks – check the points and points wires. If it fails to spark, inspect the ignition coil. You should have either a red, orange or green coil with a bare braided ground wire coming out of the backside of the coil. This bare braided ground wire MUST be connected to a clean engine ground. You cannot use a black or blue ignition coil.

NO SPARK ON ONE CYLINDER:

1. Disconnect the points wires from the ignition coils and swap them for a cranking test. Crank the engine over and see if the spark moves to a different coil. If it does, you have a problem in the points, points wire or insulator block for the cylinder not sparking.
2. If the spark remains on the same coil when you swap the points wires and it is the coil where the green wire is coming from the stator, remove the green jumper wire. Swap the green wire coming from the stator from one coil to the other coil. If the spark moves to the other coil, replace the green jumper wire connecting the two coils.
3. Check the ignition coil. You should have approximately 1,000 (1 K ohm) of resistance from the spark plug wire to engine ground.
4. Inspect the ignition coils. You should have either a red, orange or green coil with a bare braided ground wire coming out of the backside of the coil. This bare braided ground wire MUST be connected to a clean engine ground. You cannot use a black or blue ignition coil.



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Two Cylinder Engines 1974-1985 (With the 339-5287 or 339-6222 Switch Box)

NO SPARK ON ANY CYLINDER:

1. Disconnect the Orange stop wire and retest. If the ignition system now has spark, the stop circuit has a problem.
2. Check the stator and trigger resistance and DVA output:

WIRE	Read To	RESISTANCE	DVA
Orange	Engine GND	1600-1800 (800-900 per coil)	180V or more
Brown	White*	140-160	0.5V or more

Note: Some units had used a trigger that has 2 Brown wires instead of a Brown and White.

3. Inspect the ignition coils. You should have either a red, orange or green coil with a bare braided ground wire coming out of the backside of the coil. This bare braided ground wire MUST be connected to a clean engine ground. You cannot use a black or blue ignition coil.
4. Check the ignition coils as follows: Check resistance from + to – terminal reading should be 0.2-1.0 ohms and 800-1100 ohms from the high tension lead to engine ground. There should be no connection from the – terminal to engine ground.
5. Check the flywheel for broken magnets.

ENGINE HAS SPARK BUT WILL NOT RUN:

1. Index the flywheel and check the timing. If it is out by 180 degrees, swap the trigger wires to the switch box.
2. If the timing is off by any other degree, check the flywheel key.

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. Check the DVA output between the Green wire and Green/Whites from the switch box, also between the Blue and Blue/White wires while they are connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the wires from the ignition coil for that cylinder and reconnect them to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad switch box.
2. Connect an inductive tachometer to each cylinder and compare the RPM readings at the RPM where the problem is occurring. If only one cylinder is dropping out, swap the ignition coil locations and retest. If the problem follows a coil, replace the coil. If it stays on the same spark plug, replace the switch box.
3. Check the flywheel magnets to see if one has come loose and moved.

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Two Cylinder Engines 1974-1985 (With the 332-4911 or 332-4733 Switch Box)

NO SPARK ON ANY CYLINDER:

1. Disconnect the Orange (or Black/Yellow) stop wire and retest. If the ignition system now has spark, the stop circuit has a problem.
2. Check the stator and trigger resistance and DVA output:

WIRE	Read To	RESISTANCE	CDI RESISTANCE	DVA
Blue	Engine GND	3500-5500		180V or more
Red	Engine GND	450-550		20V or more
Brown	White*	140-160		0.5V or more

3. Check the flywheel for broken magnets.

ENGINE HAS SPARK BUT WILL NOT RUN:

1. Index the flywheel and check the timing. If it is out by 180 degrees, swap the trigger wires to the switch box.
2. If the timing is off by any other degree, check the flywheel key.

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. Check the DVA output from the switch box on the Green wires while they are connected to the ignition coils. You should have a reading of at least 150V or more. If the reading is low on one cylinder, disconnect the wires from the ignition coil for that cylinder and reconnect them to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad switch box.
2. Connect an inductive tachometer to each cylinder and compare the RPM readings at the RPM where the problem is occurring. If only one cylinder is dropping out, swap the ignition coil locations and retest. If the problem follows a coil, replace the coil. If it stays on the same spark plug, replace the switch box.
3. Check the flywheel magnets to see if one has come loose and moved.

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Two Cylinder Engines 1979-1996 (With the 332-7452 Switch Box)

NO SPARK ON ANY CYLINDER:

1. Disconnect the Black/Yellow stop wire and retest. If the ignition system now has spark, the stop circuit has a problem.
2. Check the stator and trigger resistance and DVA output:

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Black/Yellow	Engine GND	3250-3650	2200-2400	180V or more
Black/White	Engine GND	150-250	200-250	25V or more
Brown/Yellow	Brown/White	750-1400	925-1050	4V or more
Brown/Yellow	Engine GND	Open	Open	1V or more
Brown/White	Engine GND	Open	Open	1V or more

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both places. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad switch box.
2. Check the trigger resistance and DVA output as shown below:

Wire Color	Check To (Wire Color)	Resistance	DVA Reading
Brown wire	White wire	800-1400	4V or more Connected
Brown wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Connect a inductive tach to each cylinder and compare the RPM readings at the RPM where the problem is occurring. If only one cylinder is dropping out, swap the ignition coil locations and retest. If the problem follows a coil, replace the coil. If it stays on the same spark plug, replace the switch box.
4. Check the flywheel magnets to see if one has come loose and moved.

WILL NOT ACCELERATE BEYOUND 3000-4000 RPM:

1. Check the stator resistance and DVA output:

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Black/Yellow	Engine GND	3250-3650	2200-2400	180V or more
Black/White	Engine GND	150-250	200-250	25V or more

2. Connect a DVA meter to the Black/White wire/terminal and while under load, run the engine up to the RPM where the problem is occurring. The stator high speed voltage should increase with RPM. If the stator voltage falls off or if it does not increase with RPM, replace the stator.
3. Connect an inductive tach to each cylinder and compare the RPM readings at the RPM where the problem is occurring. If only one cylinder is dropping out, swap the ignition coil locations and retest. If the problem follows a coil, replace the coil. If it stays on the same spark plug, replace the switch box. If both cylinders become intermittent, replace the switch box.

Two Cylinder Engines 1994-1996 (With the 18495A4, A5, A6, A8, A11 or A13 Switch Box)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire AT THE PACK and retest. If the engine's ignition now has spark now, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
3. Check the stator resistance and DVA output as given below:

Black Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Blue/White	3250-3650	500-600	180V or more
Red	Red/White	75-90	28-32	25V or more

Red Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

Red Stator Adapter (Not Available from CDI)

WIRE	Read To	OEM RESISTANCE	DVA
Blue	Engine GND	OPEN	180V or more

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. If the cylinders are only misfiring above an idle, connect an inductive an Tachometer to each cylinder in turn and try to isolate the problem cylinder.
2. Check the trigger resistance and DVA output as shown below:

Wire Color	Check To (Wire Color)	Resistance	DVA Reading
Brown wire	White wire	800-1400	4V or more Connected
Brown wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both places. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to each cylinder in turn and try to isolate the problem. A single cylinder dropping fire will likely be the switch box or ignition coil. All cylinders misfiring usually indicate a bad stator.
2. Connect a DVA meter between the stator's blue wire and blue/white wires. Perform a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. (read the blue wire to engine ground if the engine has a red stator kit installed).
3. Connect a DVA meter between the stator's red wire and red/white wires. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than the reading on the blue wire indicates a bad stator.
4. If both cylinders become intermittent, replace the switch box.
5. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
6. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

Two Cylinder Engines 1994-1996 (With the 18495A9, A14, A16, A20, A21 or A30 Switch Box)

NOTE: This engine has a locked trigger arm. Therefore, the timing is controlled by the switch box and is adjusted according to the engine RPM. RPM limiting is done by retarding the timing at high RPM's. Where possible, it is recommended that the ignition system be changed over to either the newer type ignition or the older type of ignition.

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire AT THE PACK and retest. If the engine's ignition now has spark now, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
3. Check the stator resistance and DVA output as given below:

Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Black	2900-3500	2200-2600	180V or more connected
Red	Black	100-180	200-250	25V or more connected
Black	Eng Gnd	Open	Open	2V or more connected

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. If the cylinders are only misfiring above an idle, connect an inductive an Tachometer to each cylinder in turn and try to isolate the problem cylinder.
2. Check the trigger resistance and DVA output as shown below:

Wire Color	Check To (Wire Color)	Resistance	DVA Reading
Brown wire	White wire	800-1400	4V or more Connected
Brown wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both places. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

Two Cylinder Engines 1994-1996 (With the 18495A9, A14, A16, A20, A21 or A30 Switch Box)

(Continued)

WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to each cylinder in turn and try to isolate the problem. A single cylinder dropping fire will likely be the switch box or ignition coil. All cylinders misfiring usually indicate a bad stator.
2. Connect a timing light to #1 cylinder and verify that the timing is advancing. Also check to make sure the timing is not retarding too early.
3. Connect a DVA meter between the stator's blue wire and black wires. Perform a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. (read the blue wire to engine ground if the engine has a red stator kit installed).
4. Connect a DVA meter between the stator's red wire and black wires. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than the reading on the blue wire indicates a bad stator.
5. If both cylinders become intermittent, replace the switch box.
6. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
7. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

Two Cylinder Engines 1994-2006 (With the 855721A3 & A4 Switch Box)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire AT THE PACK and retest. If the engine's ignition now has spark now, the stop circuit has a fault-possibly the key switch, harness or shift switch.
2. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
3. Check the stator and trigger resistance and DVA output as given below:

WIRE	Read To	OEM Ohms	CDI Ohms	DVA
Green/White	White/Green	660-710	350-450	180V minimum connected
Green/White	Eng Gnd	Open	Open	None disconnected
White/Green	Eng Gnd	Open	Open	None disconnected
Brown/White	Brown/Yellow	850-1100	850-1100	4V minimum connected
Brown/White	Eng Gnd	Open	Open	None disconnected
Brown/Yellow	Eng Gnd	Open	Open	None disconnected

NO SPARK OR INTERMITTENT ON ONE CYLINDER:

1. If the cylinders are only misfiring above an idle, connect an inductive an Tachometer to each cylinder in turn and try to isolate the problem cylinder.
2. Check the trigger resistance and DVA output as shown below:

Wire Color	Check To (Wire Color)	Resistance	DVA Reading
Brown/White	Brown/Yellow	850-1100	4V minimum connected
Brown/White	Eng Gnd	Open	1V or more (*)
Brown/Yellow	Eng Gnd	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both places. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading indicates a bad power pack.

WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to each cylinder in turn and try to isolate the problem. A single cylinder dropping fire will likely be the switch box or ignition coil.
2. Connect a DVA meter between the stator's Green/White wire and White/Green wires. Perform a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs usually indicates a bad stator.
3. If both cylinders become intermittent, replace the switch box if the stator tests good.
4. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
5. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

Three Cylinder Engines

1976-1996

Three Cylinder Engines Using a Single Switch Box and Three Ignition Coils

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wire AT THE PACK and retest. If the engine's ignition now has spark, the stop circuit has a fault-check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
4. Check the stator resistance and DVA output as given below:

Flywheel with Bolted-in Magnets

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Engine GND	5800-7000	2200-2400	180V or more
Red	Engine GND	135-165	45-55	25V or more

Flywheel with Glued-in Magnets

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Engine GND	3250-3650	500-600	180V or more
Red	Engine GND	75-90	28-32	25V or more

Red Stator Kit

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more
Blue	Engine GND	OPEN		180V or more

NO SPARK OR INTERMITTENT SPARK ON ONE OR MORE CYLINDERS:

1. If the cylinders are only misfiring above an idle, connect a inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Check the trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Brown wire	White/Black	800-1400	4V or more Connected
White wire	White/Black	800-1400	4V or more Connected
Purple wire	White/Black	800-1400	4V or more Connected
Brown wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)
Purple wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both terminals. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading symptom indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A single cylinder dropping fire will likely be the switch box or ignition coil. All cylinders misfiring usually indicate a bad stator.
2. Connect a DVA meter to the stator's blue wire and engine ground and do a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. (blue to engine ground if the engine has a red stator kit installed).
3. Connect a DVA meter to the stator's red wire and engine ground and do a running test. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than the reading on the blue wire indicates a bad stator.

HIGH SPEED MISS:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder indicates a problem usually in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under "*No spark or Intermittent on One or More Cylinders*".
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.
4. Rotate the stator 1 bolt hole in either direction and retest.

WILL NOT IDLE BELOW 1500 RPM:

1. Check the Bias resistance from the Black/White terminal to engine ground. Reading should be 14-15,000 ohms.
2. Check for air leaks.

Four Cylinder Engines
(With Ignition Driver Distributors)

WARNING!! DO NOT CONNECT 12VDC TO THE IGNITION MODULE AS DC VOLTAGE WILL BURN OUT THE SWITCH BOX AND IGNITION DRIVER.

NO SPARK ON ANY CYLINDER:

1. Disconnect the orange stop wire AT THE PACK and retest. If the engine's ignition now has spark, the stop circuit has a fault-check the key switch, harness and mercury tilt switch.
2. Check the Ignition Driver resistance and DVA output:

Wire Color	Read to	Function	Resistance	DVA Reading
Red	White wire	Cranking Winding	400 ohms	180V+
Blue	White wire	High Speed Winding	10 Ohms	20V+
Green	Engine Gnd	Pack output	N/A	150V+
White	Common for Ignition Driver (DOES NOT CONNECT TO ENGINE GND)			

3. Check the cranking RPM. A cranking speed of less than 250-RPM will not allow the system to fire properly.

NO SPARK ON ONE OR MORE CYLINDERS:

If only one or two cylinders are not firing on this system, the problem is going to be either in the distributor cap or spark plug wires.

Four Cylinder Engines
1978-1996
Four Cylinder Engines Using a Single Switch Box and Four Ignition Coils

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wires AT THE PACK and retest. If the engine's ignition now has spark, the stop circuit has a fault-check the key switch, harness and mercury tilt switch.
2. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine now has spark, replace the rectifier.
3. Verify the correct flywheel is installed.
4. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
5. Check the stator resistance and DVA output as shown below:

Flywheel with Bolted-in Magnets

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Blue/White	5000-7000	2200-2400	180V or more
Red	Red/White	125-155	45-55	25V or more

Flywheel with Glued-in Magnets

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	Blue/White	3250-3650	500-600	180V or more
Red	Red/White	75-90	28-32	25V or more

Red Stator

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more
Blue	Blue	OPEN		180V or more
Blue (Each)	Ground	OPEN		180V or more

NO SPARK OR INTERMITTENT SPARK ON ONE OR MORE CYLINDERS:

1. If the cylinders are only misfiring above an idle, connect an inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Check the trigger resistance and DVA output as given below:

Wire Color	Check to Wire Color	Resistance	DVA Reading
Purple wire	White wire	800-1400	4V or more Connected
Brown wire	White/Black wire	800-1400	4V or more Connected
Purple wire	Engine GND	Open	1V or more (*)
White wire	Engine GND	Open	1V or more (*)
Brown wire	Engine GND	Open	1V or more (*)
White/Black wire	Engine GND	Open	1V or more (*)

(*) This reading can be used to determine if a pack has a problem in the triggering circuit. For instance, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

Note: If #1 and #2, or #3 and #4 are misfiring, check the trigger as described above. The trigger has two coils firing four cylinders. #1 & 2 share a trigger coil and #3 & 4 share a trigger coil. Also, the switch box is divided into two parts. The #1 and #2 cylinders are fired on one side and #3 and #4 are fired from the other side of the switch box. If the trigger tests are okay according to the chart above, but you have two cylinders not firing (either #1 and #2, or #3 and #4), the switch box or stator is bad.

3. If you have two cylinders not firing (either #1 and #2, or #3 and #4), switch the stator leads end to end on the switch box (red with red/white and blue with blue/white). If the problem moves to the other cylinders, the stator is bad. It the problem stayed on the same cylinders, the switch box is likely bad.
4. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both terminals. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading symptom indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. If two cylinders on the same end of the switch box are dropping out, the problem is likely going to be either the switch box or trigger. A single cylinder dropping fire will likely be the switch box or ignition coil. All cylinders misfiring usually indicate a bad stator.
2. Connect a DVA meter to the stator's blue wire and blue/white wires and do a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. (Check from blue to blue if the engine has a red stator kit installed).
3. Connect a DVA meter to the red wire and red/white wires and do a running test. The DVA voltage should show a smooth climb in voltage and remain high through the RPM range. A reading lower than the reading on the blue wires indicates a bad stator.

HIGH SPEED MISS:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder indicates a problem usually in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under "*No fire or Intermittent on One or More Cylinders*".
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

WILL NOT IDLE BELOW 1500 RPM:

1. Index the flywheel and check the timing on all cylinders. If the timing cannot be adjusted correctly or if the timing is off on one cylinder, replace the trigger.
2. Check for air leaks.
3. Check synchronization of the carburetors.

Inline 6 and V6 Carbureted Engines Using Dual Switch Boxes and Six Ignition Coils

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wires AT THE PACK and retest. If the engine's ignition has spark, the stop circuit has a fault-check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.

NO SPARK ON ONE BANK (3 OF 6 ON THE INLINE L-6):

1. Check the stator resistance and DVA output as shown below:

9 to 16 Amp Battery Charging Capacity

WIRE (Read to Engine ground)	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	5000-7000	2200-2400	180V or more
Blue/White	5000-7000	2200-2400	180V or more
Red	90-200	30-90	25V or more
Red/White	90-200	30-90	25V or more

40 Amp Battery Charging Capacity

WIRE (Read to Engine ground)	OEM RESISTANCE	CDI RESISTANCE	DVA
Blue	3200-4200	2200-2400	150V or more
Blue/White	3200-4200	2200-2400	150V or more
Red	90-140	90-110	20V or more
Red/White	90-140	90-110	20V or more

2. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both terminals on all cylinders. If the reading is low on one bank and the stator voltage is good, the switch box is usually bad. (Note: A final test to verify which component is bad is to swap the stator leads from one switch box to the other. If the problem moves, the stator is bad. If the same bank still does not fire, the switch box is usually bad.)
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.

NO SPARK OR INTERMITTENT SPARK ON ONE OR MORE CYLINDERS:

1. Connect a spark gap tester and verify which cylinders are misfiring. If the cylinders are only misfiring above an idle, connect an inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Check the trigger resistance and DVA output as shown below:

BLACK SLEEVE TO	YELLOW SLEEVE	Resistance	DVA Reading
Brown wire	White wire	800-1400	4V or more Connected
White wire	Purple wire	800-1400	4V or more Connected
Purple wire	Brown wire	800-1400	4V or more Connected

Service Note: You should get a high or open resistance reading to engine ground from each wire, but you will get a DVA reading of approximately 1-2 Volts. This reading can be used to determine if a pack has a problem in the triggering circuit. For example, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

3. Check the DVA output on the green wires from the switch box while connected to the ignition coils. Check the reading on the switch box terminal AND on the ignition coil terminal. You should have a reading of at least 150V or more at both terminals. If the reading is low on one cylinder, disconnect the green wire from the ignition coil for that cylinder and reconnect it to a load resistor. Retest. If the reading is now good, the ignition coil is likely bad. A continued low reading symptom indicates a bad power pack.

ENGINE WILL NOT ACCELERATE BEYOND 3000-4000 RPM:

1. Connect an inductive RPM meter to all cylinders and try to isolate the problem. If two or more cylinders on the same bank are dropping out, the problem is likely going to be either the stator or the switch box. A single cylinder dropping fire will likely mean the switch box or ignition coil is defective.
2. Check the stator resistance:

9 to 16 Amp Battery Charging Capacity

WIRE (Read to Engine ground)	OEM RESISTANCE	CDI RESISTANCE
Blue	5000-7000	2200-2400
Blue/White	5000-7000	2200-2400
Red	90-200	30-90
Red/White	90-200	30-90

40 Amp Battery Charging Capacity

WIRE (Read to Engine ground)	OEM RESISTANCE	CDI RESISTANCE
Blue	3400-4200	2200-2400
Blue/White	3400-4200	2200-2400
Red	90-140	90-110
Red/White	90-140	90-110

3. Connect a DVA meter to the Blue wire and do a running test. The DVA voltage should jump up to well over 200V and stabilize. A drop in voltage right before the problem occurs indicates a bad stator. Repeat for the blue/white wire and compare the readings.

WIRE (Read to Engine ground)	CRANKING	1000 RPM	3000 RPM
Blue	100-265	195-265	255-345
Blue/White	100-265	195-265	255-345
Red	25-50	120-160	230-320
Red/White	25-50	120-160	230-320
White/Black*	1-6	3-15	10-30

- This voltage is read with an analog DC volt meter – Not a DVA meter.

4. Check the trigger as follows:

WIRE	Read to	OEM RESISTANCE	CDI RESISTANCE	DVA @ CRANKING
Brown (Black Sleeve)	White (Yellow Sleeve)	1100-1400	800-1000	4V or more
White (Black Sleeve)	Purple (Yellow Sleeve)	1100-1400	800-1000	4V or more
Purple (Black Sleeve)	Brown (Yellow Sleeve)	1100-1400	800-1000	4V or more

Service Note: You should get a high or open resistance reading to engine ground from each wire, but you will get a DVA reading of approximately 1-2 Volts. This reading can be used to determine if a pack has a problem in the triggering circuit. For example, if you have no fire on one cylinder and the DVA trigger reading for that cylinder is low – disconnect the trigger wire and recheck the DVA output to ground from the trigger wire. If the reading stays low – the trigger is bad.

High Speed Miss:

1. Connect an inductive RPM meter to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under 'No fire or Intermittent on One or More Cylinders'.
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.

Two Cylinder Engines 1996-2006

Engines Using a Combination Switch Box and Ignition Coil (CDM Modules)

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wires from the harness and retest. If the engine's ignition sparks, the stop circuit has a fault- check the key switch, harness and shift switch.
2. Swap the White/Green and Green White stator wire and retest. If the problem moves to the other cylinder, the stator is likely bad.
3. Disconnect one CDM module at a time and using a set of piercing probes and jumper wires- short the stator and trigger wire in the CDM connector to engine ground. Retest. If the other module starts sparking, the CDM you unplugged is bad.
4. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine now has spark, replace the rectifier.
5. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to spark properly.
6. Check the stator resistance and DVA output as follows:

WIRE	Read to	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

7. Check the resistance of the CDM as follows:

	Red Meter Lead	Black Meter Lead	Reading
CDM Pin #	A	C	700-1300 Ohms
CDM Pin #	D	A	DIODE*
CDM Pin #	A	D	DIODE*
CDM Pin #	D	B	DIODE*
CDM Pin #	B	D	DIODE*
CDM Pin #	A	B	DIODE*
CDM Pin #	B	A	DIODE*
	High Tension Lead	A	700-1300 Ohms

* Diode readings are to be read one way, then reverse the leads and read again. You should get a low reading in one direction and a higher reading in the other.

NO SPARK OR INTERMITTENT SPARK ON ONE CYLINDER:

1. If the cylinders are only misfiring up above an idle, connect an inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Using a set of piercing probes, check the trigger DVA output as shown below:

Wire Color	Check To (Wire Color)	Resistance	DVA Reading
White wire	Engine GND	Open	1V or more
Brown wire	Engine GND	Open	1V or more

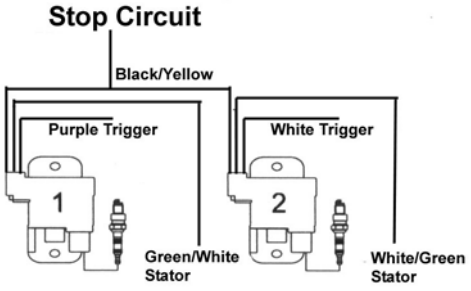
3. If # 1 is not sparking, swap the White/Green and Green White stator wire and retest. If the problem moves to the #2 cylinder, the stator is likely bad. If no change, swap locations with #2 and see if the problem moves. If it does, the module is bad. A continued no spark condition on the same cylinder indicates a bad trigger.
4. Check the resistance of the CDM as follows:

	Red Meter Lead	Black Meter Lead	Reading
CDM Pin #	A	C	700-1300 Ohms
CDM Pin #	D	A	DIODE*
CDM Pin #	D	B	DIODE*
CDM Pin #	A	B	DIODE*
	High Tension Lead	A	700-1300 Ohms

* Diode readings are to be read one way, then reverse the leads and read again. You should get a low reading in one direction and a higher reading in the other.

High Speed Miss:

1. Connect an inductive Tachometer to each cylinder in turn and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the trigger or CDM module.
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracked or broken magnets.



Three Cylinder Engines
1996-2006 Engines Using CDM Modules

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wires from the harness and retest. If the engine's ignition now sparks, the stop circuit has a fault- check the key switch, harness and shift switch.
2. Disconnect one CDM module at a time and see if the other modules start sparking. If they do, the module you just unplugged is bad.
3. If the bottom two CDM modules are not sparking, swap the connection between the top and middle cylinder. If the middle cylinder starts sparking, replace the top CDM.
4. Disconnect the yellow wires from the stator to the rectifier and retest. If the engine now has spark, replace the rectifier.
5. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to spark properly.
6. Check the stator resistance and DVA output as given below:

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

7. Check the resistance of the CDM as follows:

	Red Meter Lead	Black Meter Lead	Reading
CDM Pin #	A	C	700-1300 Ohms
CDM Pin #	D	A	DIODE*
CDM Pin #	A	D	DIODE*
CDM Pin #	D	B	DIODE*
CDM Pin #	B	D	DIODE*
CDM Pin #	A	B	DIODE*
CDM Pin #	B	A	DIODE*
	High Tension Lead	A	700-1300 Ohms

* Diode readings are to be read one way, then reverse the leads and read again. You should get a low reading in one direction and a higher reading in the other.

NO SPARK OR INTERMITTENT SPARK ON ONE OR MORE CYLINDERS:

1. If the cylinders are only misfiring above an idle, connect an inductive Tachometer to all cylinders and try to isolate the problem cylinders.
2. Using a set of piercing probes, check the trigger DVA output as shown below:

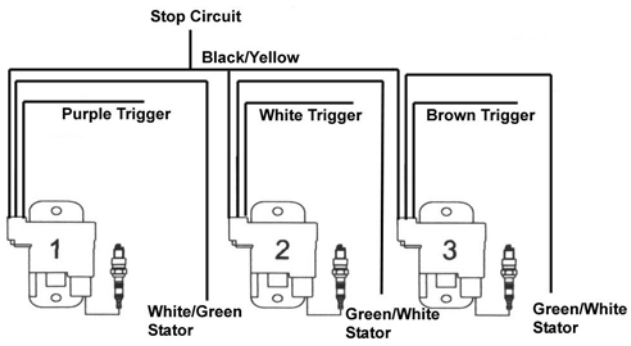
Wire Color	Check to Wire Color	Resistance	DVA Reading
Purple wire	Engine GND	Open	1V or more
White wire	Engine GND	Open	1V or more
Brown wire	Engine GND	Open	1V or more

NOTE: These triggers have the bias circuitry internally built-in, therefore you cannot measure the resistance like you can measure on the older engines.

3. If # 1 CDM module is not sparking, disconnect the #2 CDM module and see if the #1 CDM module starts sparking. If it does, the module you just unplugged is bad. If it does not, reconnect #2, then disconnect the #3 CDM module and see if the #1 module starts sparking. If it does, the module you just unplugged is bad.
4. If there is no spark ire on either # 2 or #3, swap locations with #1 and see if the problem moves. If it does, the module is bad. A continued no spark on the same cylinder indicates a bad trigger.

HIGH SPEED MISS:

1. Connect an inductive Tachometer to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder indicates a problem usually in the trigger or CDM module.
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.
4. Use the diagram below to help in locating the area where the problem may be. Remember a short in #1 can cause either #2 and #3 not to have spark. By the same reason, a problem in either #2 or #3 can cause #1 not to have spark.



Four Cylinder Engines
1996-2006 Engines Using CDM Modules

NO SPARK ON ANY CYLINDER:

1. Disconnect the black/yellow stop wires from the harness and RPM Limiter. Retest. If the engine's ignition has spark, the stop circuit has a fault-check the key switch, harness and shift switch.
2. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
3. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
4. Check the stator resistance and DVA output as given below:

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

5. Check the resistance of the CDM as follows:

	Red Meter Lead	Black Meter Lead	Reading
CDM Pin #	A	C	700-1300 Ohms
CDM Pin #	D	A	DIODE*
CDM Pin #	A	D	DIODE*
CDM Pin #	D	B	DIODE*
CDM Pin #	B	D	DIODE*
CDM Pin #	A	B	DIODE*
CDM Pin #	B	A	DIODE*
	High Tension Lead	A	700-1300 Ohms

Note: Diode readings are to be read one way, then reverse the leads and read again. You should get a low reading in one direction and a higher reading in the other.

NO SPARK OR INTERMITTENT SPARK ON ONE OR MORE CYLINDERS:

1. If the cylinders are only misfiring above an idle, connect an inductive RPM meter to all cylinders and try to isolate the problem cylinders.
2. Disconnect the CDM's one at a time and see if you get spark back on the problem cylinders.
3. Using a set of piercing probes, check the trigger DVA output as given below:

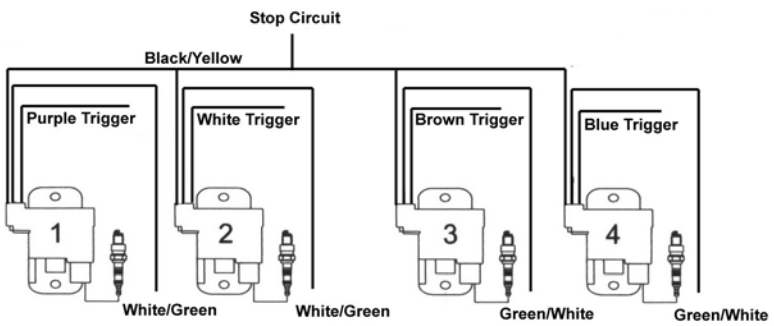
Wire Color	Check to Wire Color	Resistance	DVA Reading
Purple wire	Engine GND	Open	3V or more
White wire	Engine GND	Open	3V or more
Brown wire	Engine GND	Open	3V or more
White/Black wire	Engine GND	Open	3V or more

NOTE: These triggers have the bias circuitry internally built-in, therefore you cannot measure the resistance like you can measure on the older engines. In addition, these engines use four triggering coils versus the two triggering coils used on the older engines.

4. Disconnect one of the CDM modules that are firing one at a time and see if the dead CDM starts firing. If it does, the CDM you just unplugged is bad.

High Speed Miss:

1. Connect an inductive RPM meter to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the switch box or ignition coil. Occasionally a trigger will cause this same problem. Check the trigger as described above under "*No spark or intermittent spark on any cylinder*".
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.
4. Use the wiring diagram below as an aid in locating areas where problems may occur. Remember a short in either #1 or #2 can cause either # 3 and #4 not to have spark.



Six Cylinder Engines

1996-2005 2.0L and 2.5 L Engines Using CDM Modules

NO SPARK ON ANY CYLINDER:

1. Inspect the spark plug wires, boots and spark plugs. Check for chafing on the wiring and harnesses.
2. Clean and inspect CDM ground wire connection to engine ground
3. Disconnect the Black/Yellow stop wires from the harness and RPM Limiter. Retest. If the engine's ignition now has spark, the stop circuit has a fault-check the key switch, harness and shift switch. If there is still no spark, disconnect the CDM's one at a time and see if you get spark back on the other cylinders. A shorted stop circuit in one CDM will prevent ALL cylinders from sparking.
4. Disconnect the yellow wires from the rectifier and retest. If the engine has spark, replace the rectifier.
5. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
6. Check the stator resistance and DVA output as given below:

WIRE	Read To	OEM RESISTANCE	CDI RESISTANCE	DVA
White/Green	Green/White	500-700	500-600	180V or more

7. Check the resistance of each of the CDM's as follows:

	Red Meter Lead	Black Meter Lead	Reading
CDM Pin #	A	C	700-1300 Ohms
CDM Pin #	D	A	DIODE*
CDM Pin #	A	D	DIODE*
CDM Pin #	D	B	DIODE*
CDM Pin #	B	D	DIODE*
CDM Pin #	A	B	DIODE*
CDM Pin #	B	A	DIODE*
	High Tension Lead	A	700-1300 Ohms

Note: Diode readings are to be read one way, then reverse the leads and read again. You should get a low reading in one direction and a higher reading in the other.

NO SPARK OR INTERMITTENT SPARK ON ONE OR TWO CYLINDERS:

1. Inspect the spark plug wires, boots and spark plugs. Check for chafing on the wiring and harnesses
2. Clean and inspect CDM ground wire connection to engine ground.
3. If the cylinders are only misfiring above an idle, connect an inductive RPM meter to all cylinders and try to isolate the problem cylinders.
4. Using a set of piercing probes, check the trigger Resistance and DVA output as given below:

Wire Color	Check to Wire Color	OEM Resistance	CDI Resistance	DVA Reading
Purple wire	Blue	1100-1400	850-1050	4V or more
White wire	Red	1100-1400	850-1050	4V or more
Brown wire	Yellow	1100-1400	850-1050	4V or more

High Speed Miss:

1. Connect an inductive RPM meter to all cylinders and try to isolate the problem. A high variance in RPM on one cylinder usually indicates a problem in the CDM module.
2. Perform a high-speed shutdown and read the spark plugs. Check for water. A crack in the block can cause a miss at high speed when the water pressure gets high, but a normal shutdown will mask the problem.
3. Remove the flywheel and check the triggering and charge coil flywheel magnets for cracks or broken magnets.
4. Index the flywheel and check the timing on ALL cylinders. On carbureted models, the control module rev limi function starts to retard timing in sequence (2, 3, 4, 5, 6, 1) at 5800-6000 RPM. The control module will retard the timing each cylinder up to 30 degrees (starting with #2) and then stop firing that cylinder if the RPM is still above the limit. It will continue to retard, then shut down each cylinder until the engine drops below the limit.

NO SPARK OR INTERMITTENT SPARK ON #1, #2 and #3 OR #4, #5 and #6 CYLINDERS:

1. Check the cranking RPM. A cranking speed less than 250-RPM will not allow the system to fire properly.
2. Disconnect the CDM's one at a time and see if you get spark back on the problem cylinders.
3. Check the stator resistance and DVA output as given below:

WIRE	Read To	OEM	CDI	DVA
White/Green	Green/White	500-700 ohms	500-600 ohms	180V or more connected
White/Green	Engine Gnd	Open	Open	180V or more connected
White/Green	Engine Gnd	Open	Open	Less than 2 V disconnected
Green/White	Engine Gnd	Open	Open	180V or more connected
Green/White	Engine Gnd	Open	Open	Less than 2 V disconnected

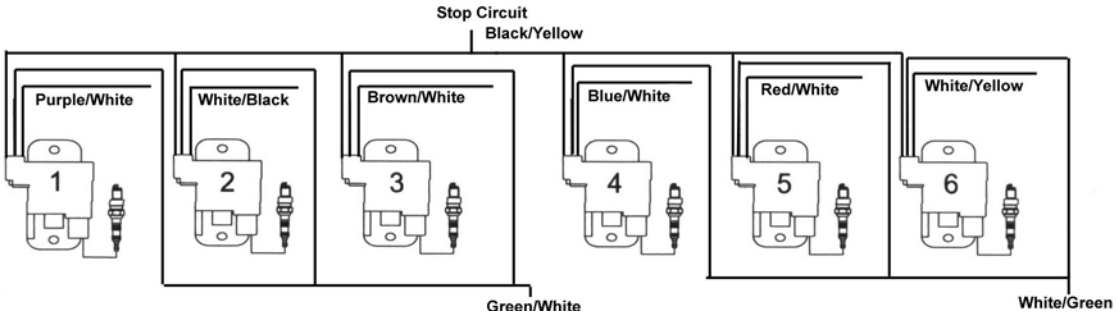
3. Using a set of piercing probes, check the trigger Resistance and DVA output as given below:

Wire Color	Check to Wire Color	OEM Resistance	CDI Resistance	DVA Reading
Purple wire	Blue	1100-1400	850-1050	4V or more
White wire	Red	1100-1400	850-1050	4V or more
Brown wire	Yellow	1100-1400	850-1050	4V or more

4. Using a set of piercing probes, check the trigger voltage going to the CDM's:

Wire Color	Check to Wire Color	OEM Resistance	CDI Resistance	DVA Reading
Purple wire	Engine GND	Open	Open	3V or more
White wire	Engine GND	Open	Open	3V or more
Brown wire	Engine GND	Open	Open	3V or more
Blue wire	Engine GND	Open	Open	3V or more
Red wire	Engine GND	Open	Open	3V or more
Yellow wire	Engine GND	Open	Open	3V or more

5. The connection guide below will assist you in locating areas where problems can occur. Remember a short in either #1, #2 or #3 can cause either # 4, #5 and #6 not to have spark.



CDI ELECTRONICS

(DVA) PEAK READING VOLTAGE AND RESISTANCE CHARTS

NOTICE: These charts were compiled using the CDI 511-9773 Peak Adapter with a shielded Digital Multimeter.

NOTE: The resistance readings are given for a room temperature of 68°F. Higher temperatures will cause a slightly higher resistance reading.
DVA readings should always be taken with everything hooked up with the exception of the kill circuit.

The CDI peak reading voltage adapter is specifically designed to work with shielded Digital Multimeters. This adapter will simplify the testing of electronic ignition systems, stators, sensors and charging systems. The DVA readings will be approximately the same as any other DVA meter and the specifications listed in the service manuals can be followed without problems (Hopefully a little easier to you).

The CDI piercing probe set (511-9770) and the pack load resister (511-9775) are highly recommended for use with this adapter.

INSTRUCTIONS

1. Plug the adapter into the shielded Digital Multimeter with the (+) rib side pin in the (V, Ohms) jack and the other pin in the (COM) jack.
2. Set the digital voltmeter to DC Volts (the purpose of the adapter is to convert and *store* the voltage so that it can be read by a meter).
3. Connect the probes to the component to be measured.

*NOTE: The adapter will **automatically compensate for polarity** and all readings will be peak voltage.*

See the following pages for readings of Chrysler, Force, Mercury, OMC (Johnson/Evinrude), OMC Sea Drive and Yamaha engines. Other ignitions can be tested using test results given by the manufacturer of the equipment or by comparing a known good system to a suspect one. Please forward any additional readings you would like to have included in future printings.

Chrysler

DVA (PEAK READING) and RESISTANCE CHARTS

		Model	Ignition	Stator	Stator	Stator	Trigger	Trigger	Trigger	Ignition Coil	
HP	**Year**	Type	**Part**		**DVA**	**Reading**		**DVA**	**Reading**	**Primary**	**Output**
			Number	**Ohms**	**Output**	**Colors**	**Ohms**	**Output**	**Colors**	**Ohms**	
7.5	1972	BOC/B1D /HOC/H1D	525475	680-850 300-400*	180V+	Blue - Blue	48-52	0.5V+	Orange to Grn Red to Wht/Grn	N/A	125-140
7.5	1977	BOC/B1C /HOC/H1C	525475	680-850 300-400*	180V+	Blue - Blue	48-52	0.5V+	Orange to Grn Red to Wht/Grn	N/A	125-140
7.5	1979- 1984	All Models	525475	680-850 300-400*	180V+	Blue - Blue	48-52	0.5V+	Orange to Grn Red to Wht/Grn	N/A	125-140
8	1982	82H8J -87H8A	525475	680-850 300-400*	180V+	Blue - Blue	48-52	0.5V+	Orange to Grn Red to Wht/Grn	N/A	125-140
9.9	1979- 1984	A, B	510301 116- 0301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
10	1976- 1978	W/CD & Alternator	510301 116- 0301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
12	1979	W/CD & Alternator	510301 116- 0301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
15	1976 - 1984	W/CD & Alternator	510301 116- 0301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
20	1979 - 1981	W/CD & Alternator	529301 116- 9301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
25	1983 - 1984	W/CD & Alternator	529301 116- 9301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
30	1979 - 1982	W/CD & Alternator	529301 116- 9301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
35	1978 - 1984	W/CD & Alternator	529301 116- 9301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
55	1977 - 1980	W/Magna-power II	474301- 1	Not Applicable	180V+	T1 & T4 to Eng Gnd	Open	0.5V+	Between Terminals	0.2-1.0	200- 2000
55	1981 - 1983	All Models	475301 116- 5301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
60	1984	All Models	475301 116- 5301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
65	1977 - 1978	W/Magna-power II	474301- 1	Not Applicable	180V+	T1 & T4 to Eng Gnd	Open	0.5V+	Between Terminals	0.2-1.0	200- 2000
80	1983 - 1984	W/CD & Alternator	475301 116- 5301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
90	1983 - 1984	W/CD & Alternator	475301 116- 5301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
105	1976	BD/BE/HA/HD/HE	474301- 1	Not Applicable	180V+	T1 & T4 to Eng Gnd	Open	0.5V+	Between Terminals	0.2-1.0	200- 2000
115	1983 - 1984	W/CD & Alternator	475301 116- 5301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
120	1976	BD/BE/HD/HE	474301- 1	Not Applicable	180V+	T1 & T4 to Eng Gnd	Open	0.5V+	Between Terminals	0.2-1.0	200- 2000
125	1981 - 1982	W/CD & Alternator	475301 116- 5301*	680-850 300-400*	180V+	Blue - Yellow	48-52	0.5V+	Orange to Grn Red to Wht/Grn	0.2-1.0	800- 1100
135	1976	BD/BE/ HD/HE	474301- 1	Not Applicable	180V+	T1 & T4 to Eng Gnd	Open	0.5V+	Between Terminals	0.2-1.0	200- 2000

Grn = Green

Wht/Grn = White/Green Stripe

* Indicates a part manufactured by CDI Electronics

FORCE

DVA (Peak Reading) Voltage and Resistance Chart

		Model	Ignition	Stator					Sensor			Ignition Coil	
HP	Year	Serial #	Part	Ohms		DVA		Reading		DVA	Reading	Input	Output
			Number	Low Spd	Hi Spd	Low Spd	Hi Spd	Colors(a)	Ohms	Output	Colors(b)	Ohms	
35	1987-1991	All Models	529301 116-9301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	N/A	125-140
50	1988	A, B, C	658475	680-850 300-400*		180V+		Blue - Blue	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	N/A	125-140
50	1988	D	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	N/A	125-140
50	1989-1992	All Models	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	N/A	125-140
50	1992-1995	OE009500-OE138599	18495 114-4953*	3250-3650 2200-2400*	75-90 28-32*	180V+	20V+	Blue and Red to Engine Gnd	800-1400	5V+	Wht/Blk to Brown, White and Purple	0.2-1.0	800-1100
50	1996-1997	OE138600-OE283999	827509 114-7509	500-700 400-600*		180V+		Green/White to White/Green	Open	1.5V+	Gnd to Wht/Blk at CDM	N/A	800-1100
60	1985	All Models	475301 116-5301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	800-1100
70	1991-1992	OE000001-OE009499	332-7778 114-7778*	3250-3650 2200-2400*	75-90 28-32*	180V+	20V+	Blue and Red to Engine Gnd	800-1400	5V+	Wht/Blk to Brown, White and Purple	0.2-1.0	800-1100
70	1993-1995	OE009500-OE138599	18495 114-4953*	3250-3650 2200-2400*	75-90 28-32*	180V+	20V+	Blue and Red to Engine Gnd	800-1400	5V+	Wht/Blk to Brown, White and Purple	0.2-1.0	800-1100
70	1996-1999	OE138600-OE369299	827509 114-7509	500-700 400-600*		180V+		Green/White to White/Green	Open	1.5V+	Gnd to Wht/Blk , Wht/Yel, Blue/Wht	N/A	900-1100 2100-2400*
75	1996-1999	OE138600-OE369299	827509 114-7509	500-700 400-600*		180V+		Green/White to White/Green	Open	1.5V+	Gnd to Wht/Blk , Wht/Yel, Blue/Wht	N/A	900-1100 2100-2400*
85	1983	856XL	475301 116-5301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	800-1100
85	1984-1989	All Models	475301 658301 116-5301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	200-2000
90	1990	All Models	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	800-1100
90	1991	B & D	332-7778 114-7778*	3250-3650 2200-2400*	75-90 28-32*	180V+	20V+	Blue and Red to Engine Gnd	800-1400	5V+	Wht/Blk to Brown, White and Purple	0.2-1.0	800-1100
90	1991	A, C & E	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	200-2000
90	1991-1995	OE000001-OE138599	332-7778 18495 114-7778 114-4953*	3250-3650 2200-2400*	75-90 28-32*	180V+	20V+	Blue and Red to Engine Gnd	800-1400	5V+	Wht/Blk to Brown, White and Purple	0.2-1.0	800-1100
90	1996-1999	OE138600-OE369299	827509 114-7509	500-700 400-600*		180V+		Green/White to White/Green	Open	1.5V+	Gnd to Wht/Blk , Wht/Yel, Blue/Wht	N/A	900-1100 2100-2400*
120	1990-1994	OE000001-OE0093669	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	200-2000
120	1996-1999	OE138600-OE369299	827509 114-7509	500-700 400-600*		180V+		Green/White to White/Green	Open	1.5V+	Gnd to Wht/Blk , Wht/Yel, Blue/Wht, Brn/Wht	N/A	900-1100 2100-2400*
120 L Drive	1990	A, B, C	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	200-2000
120 L Drive	1991-1992	B & D	332-5772 114-5772	3250-3650 2200-2400*	75-90 28-32*	180V+	20V+	Blue to Bl/Wht Red to Red/Wht	800-1400	5V+	Brown to Wht/Blk Purple to White	0.2-1.0	800-1100
125	1983-1989	All Models	475301 658301 116-5301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	800-1100
150	1989-1991	89A, 90C, 90D, 91A	658301 116-8301*	680-850 300-400*		180V+		Blue - Yellow (b)	48-52	0.5V+	Orange to Grn Red to Wht/Grn (a)	0.2-1.0	800-1100
150	1991-1992	OE000001-OE093699	332-817323 116-7323*	Not Applicable 12V Inverter		225-300V		Blue - Eng Gnd	800-1400	5V+	Wht/Blk to Brn, Blk, Wht, Pur & Yel	0.2-1.0	800-1100

* Indicates a part manufactured by CDI Electronics

(a) Some units use White/Orange stripe to White/Yellow and White/Red to White/Green. Also, some have additional black stripes

(b) Some units use Brown/Yellow stripe for Yellow and Brown/Blue for Blue. Also, some have additional black stripes

Johnson & Evinrude Outboard

DVA (Peak Voltage) and Resistance Chart

HP	Year	Ignition	Stator						Trigger		
		Part	Chg	Power	Chg	Power	Chg	Power		DVA	Reading
		Number	Ohms Reading		DVA Output		Read	Color	Ohm	Out	Colors
4-55	1971-1977	Power Pack 2	450-600	N/A	150V+	N/A	Brown to Engine Gnd	N/A	10-20	0.5V+	White/Black to Black/White
4-60	1978-1988	CD2	450-600	N/A	150V+	N/A	Brown to Brown/Yellow	N/A	35-55	0.5V+	White/Black to Black/White
4-55	1989-1993	CD2 - USL	450-950	N/A	150V+	N/A	Brown to Brown/Yellow	N/A	N/A	N/A	N/A
4-55	1989-1993	CDI Elect-USL Repl*	450-600	N/A	150V+	N/A	Brown to Brown/Yellow	N/A	35-55	0.5V+	White/Black to Black/White
5-60	1992-2000	CD2 W/SLOW	450-600	N/A	150V+	N/A	Brown to Brown/Yellow	N/A	35-55	0.5V+	White/Black to Black/White
5-60	1992-2005	CD2 SL	500-700	450-600	150V+	12-24V	Brown to Brown/Yellow	Org to Org/Blk	35-55	0.5V+	White/Black to Black/White
25-35 Elect Start	1995-1997	CD3 OPTICAL	720-880	52-62	150V+	12V+	Brown to Brown/Yellow	Org to Org/Blk	N/A	N/A	N/A
25-35 Man Start	1995-1997	CD3 OPTICAL	1010-1230	76-92	150V+	12V+	Brown to Brown/Yellow	Org to Org/Blk	N/A	N/A	N/A
60	1986-1989	CD3	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Blue/Pur/Grn
60	1989-1992	CD3 W/SLOW	450-600	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Blue/Pur/Grn
60	1993-2000	CD3 Looper	500-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
65 - 70	1972-1978	Power Pack 3	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	10-20	0.5V+	Black/White to White/Blacks
65	1989	CD3 W/SLOW	450-600	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Blue/Pur/Grn
65	1992-1995	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
65 COMM	1984-1988	CD3	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
65 COM Elect Start	1989-1992	CD3	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
65 COM Man Start	1989-1992	CD3 W/SLOW	500-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn
65 COM	1992-1995	CD3 W/SLOW	500-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn
70	1979-1988	CD3	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
70	1989-1997	CD3 W/SLOW	450-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn
80	1992-1996	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
85 - 140	1973-1977	Power Pack 4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	10 - 20	0.5V+	#1 to #3 and #2 to #4
85	1979-1983	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
85	1991-1995	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
88	1987-1996	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
90	1984-1997	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
90 - 115 OPTICAL	1995-2006	CD4AL	450-600	50-60	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	N/A	N/A	N/A
100	1990-1994	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk

N/A = Not Applicable
Sec = Secondary
Org/Blk = Orange/Black Stripe
Pk = Pink

*Part Manufactured by CDI Electronics
Pri = Primary
Blk = Black
Pur = Purple

COMM = Commercial
Gnd = Ground
Bl = Blue

NOTE: Ignition Coils will read 0.2 to 1.0 ohms on the Primary and 200-400 ohms on the secondary windings

NOTICE: ALL DVA READINGS ARE TO BE TAKEN WITH ALL WIRING CONNECTED EXCEPT THE STOP CIRCUIT.

Johnson & Evinrude Outboard

DVA (Peak Voltage) and Resistance Chart

HP	Year	Ignition	Stator						Trigger		
		Part	Chg	Power	Chg	Power	Chg	Power		DVA	Reading
		Number	Ohms Reading		Min DVA Output		Read	Color	Ohm	Out	Colors
100 COMM	1984-1997	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
105 JET OPTICAL	1994-2000	CD6AL	450-600	50-60	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	N/A	N/A	N/A
110	1986-1989	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
112	1994-1996	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
115	1978-1997	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
120-140 10 AMP	1985-1999	CD4	450-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
120-140 35 AMP	1985-1994	CD4	735-935	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
125	1991-1994	CD4	450-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
125 COMM	1989-1994	CD4	450-700	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
130	1994-2000	CD4AL	450-700	450-600 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
140	1978-1984	CD4	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn/Pk
150 - 235	1977-1978	Power Pack 3/6	450-600	N/A	150V+	N/A	Brown to Engine Gnd	N/A	10-20	0.5V+	Black/White to White/Blacks
150 - 185 10 AMP	1979-1988	CD3/6	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
150 - 185 35 AMP	1984-1988	CD3/6	735-935	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
150 - 175 10 AMP	1989-1991	CD3/6	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
150 - 175 35 AMP	1989-1991	CD3/6	735-935	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
150 - 175 OPTICAL	1992-2005	CD6AL	735-935	50-60	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	N/A	N/A	N/A
155 10 AMP	1984-1992	CD6	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
155 35 AMP	1984-1992	CD6	735-935	90-110	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
155 Turbojet	1995	CD6	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
185	1990-1994	CD6	735-935	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
200 - 235	1979-1983	CD3/6	450-600	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
200 - 225	1986-1987	CD3/6	735-935	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
200 - 225	1988-2000	CD6	735-935	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
235	1984-1985	CD3/6	735-935	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
250	1991-2000	CD6	735-935	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
275	1985-1987	CD4/8	735-935	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
275	1988-1989	CD8	735-935	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn
300	1985-1987	CD4/8	735-935	N/A	150V+	N/A	Brown to Brown/yellow	N/A	35-45	0.5V+	Wht to Bl/Pur/Grn
300	1988-1995	CD8	735-935	90-100 40-50*	150V+	12V+	Brown to Brown/yellow	Org to Org/Blk	Open	0.5V+	Wht to Bl/Pur/Grn

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*Part Manufactured by CDI Electronics
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COMM = Commercial
Gnd = Ground
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NOTE: Ignition Coils will read 0.2 to 1.0 ohms on the Primary and 200-400 ohms on the secondary windings

NOTICE: ALL DVA READINGS ARE TO BE TAKEN WITH ALL WIRING CONNECTED EXCEPT THE STOP CIRCUIT.

OMC Sea Drive

DVA (Peak Reading) Voltage and Resistance Chart

Engine	Year	Ignition	Stator						Trigger			Ignition Coil	
		Part	Charge Coil			Power Coil			Reading			Pri	Sec
		Number	Color	Ohms	DVA	Color	Ohms	DVA	Colors	Ohm	DVA	Ohm Reading	
2.5/2.6L 'S'	1982	582138 113-2138*	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
1.6L 'S'	1983	582125 113-2125	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Grn	35-45	0.5V+	0.2-1.0	200-400
2.6L 10AMP 1AA/2BA/2B B	1983	582556 113-2556	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
2.5L 35AMP 1AA/2BA/2B B	1983	582138 113-2138	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1984	582125 113-2125	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Grn	35-45	0.5V+	0.2-1.0	200-400
2.5/2.6L V6	1984	582556 113-2556	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1985	582811 113-2811	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Grn	35-45	0.5V+	0.2-1.0	200-400
2.5/2.6L V6	1985	582651 113-2651	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1986	583110 113-3110	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Grn	35-45	0.5V+	0.2-1.0	200-400
2.6L V6	1986	583114 113-3114	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1987	583110 113-3110	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Grn	35-45	0.5V+	0.2-1.0	200-400
1.8L V4 'S'	1987	583101 113-3101	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
2.7L V6	1987	583605 113-3605	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn	35-45	0.5V+	0.2-1.0	200-400
3.6L V8	1987	583101 113-3101	Brown to Brown/yellow	735-935	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1988	583101 113-3101	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
2.0L V4 'S'	1988	584041 113-4041	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
3.0L V6 'S'	1988	584037 113-4037	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn	Open	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1989	583030 113-3030	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
2.0L V4 'S'	1989	584041 113-4041	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
3.0L V6 'S'	1989	584037 113-4037	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn	Open	0.5V+	0.2-1.0	200-400
4.0L V8 'S'	1989	584035	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn/PK	Open	0.5V+	0.2-1.0	200-400
1.6L V4 'S'	1990	584028 113-4028	Brown to Brown/yellow	450-600	150V+	N/A	N/A	N/A	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
2.0L V4 'S'	1990	584041 113-4041	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn/PK	35-45	0.5V+	0.2-1.0	200-400
3.0L V6 'S'	1990	584037 113-4037	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn	Open	0.5V+	0.2-1.0	200-400
4.0L V8 'S'	1990	584035	Brown to Brown/yellow	735-935	150V+	Org to Org/Blk	90-110 40-55*	12V+	Wht to Bl/Pur/Grn/PK	Open	0.5V+	0.2-1.0	200-400

N/A = Not Applicable

*Part Manufactured by CDI Electronics

COMM = Commerical

Pri = Primary

Sec = Secondary

Gnd = Ground

Bl = Blue

Blk = Black

Grn = Green

Org = Orange

Org/Blk = Orange/Black Stripe

Pk = Pink

Pur = Purple

Wht = White

Mercury

DVA (Peak Reading) Voltage and Resistance Chart

Please note that all DVA readings are minimum voltages measured at cranking speed, not while the engine is running.

		Model	Ignition	Stator					Trigger			Ignition Coil	
HP	Year	Serial #	Part	Ohms		DVA		Reading		DVA	Reading	Primary	Output
			Number	Low Spd	Hi Sp	Low	Hi	Colors	Ohms	Out	Colors	Ohms	
4	1972-1975	3296137 - 4107219	336-4516	3600-5500	450-550	180V+		Green to Eng Gnd	N/A	N/A	Points Brn & Wht	0.2-1.0	800-1100
4	1976-1980	9075839 - 5595531	339-6222 114-6222	1600-1800 (800-900 per coil)		180V+		Orange to Eng Gnd	140-160	0.5V+	Brn to Brn or Brn to Wht	0.2-1.0	800-1100
4/4.5	1980-1989	5595532 - A855096	336-4516	3600-5500	450-550	180V+		Green to Engine Gnd	N/A	N/A	Points Brown & White	0.2-1.0	800-1100
6/8/9.9/10	1986-1996	A197112 - OG289100	332-7452 114-7452K1	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
6/8/10/15/20/25	1995-2006	OG760299 -1B000001	855713 114-5713	370-445		180V+		Green/White to White/Green	650-850	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
9.8/20	1972-1973	3226958-37956658	336-4516	3600-5500	450-550	180V+		Green to Engine Gnd	N/A	N/A	Points Brown & White	0.2-1.0	800-1100
9.8	1974-1985	3795659-5206549	339-6222 114-6222	1600-1800 (800-900 per coil)		180V+		Orange to Eng Gnd	750-1400	0.5V+	Brn to Brn or Brn to Wht	0.2-1.0	800-1100
15 20 25	1988-1993	OB238464-OG044365	332-7452 114-7452K1	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
15 20 25	1994-1996	OG044027 - OG437999	18495A30 114-4952K1	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blue to Black Red to Black	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
15/20	1996-1997	OG438000 - OG760299	332-7452 114-7452K1	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
18/20 25 XD	1979-1987	5837437-OB114230	332-7452A3 114-7452A3	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
20	1973-1977	3537531-4709592	332-4911 114-4911	3500-5500	450-550	180 V+	20V+	Blue and Red to Engine Gnd	N/A	N/A	Brn to Wht	0.2-1.0	800-1100
20/25	1980-1993	5705532-OG044026	332-7452 114-7452K1	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
35	1984-1989	6445653-OB393190	332-7452 114-7452K1	3200-3800 2200-2600*	120-180 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
40	1970-1971	2874704-3336237	332-4172 332-4172	3200-3800 2200-2600*	45-55 45-55*	180 V+	20V+	Blue and White to Engine Gnd	750-1400	0.5V+	Brn to Wht	0.2-1.0	800-1100
40	1972-1981	3336258 - 5823917	338-4733 332-4911 338-4733 114-4911	5000-7000 2200-2500*	180-220 45-55*	180 V+	20V+	Blue to Eng Gnd Red to Eng Gnd	750-1400	0.5V+	Brn/Wht to Brn/Yellow	0.2-1.0	800-1100
40	1982-1984	5283918-6999999	332-7452 114-7452K1	3200-3800 2200-2600*	150-200 225-300*	180 V+	20V+	Blk/Yel (LS) Blk/Wht(HS) to Eng Gnd	750-1400	0.5V+	Brn/Yel to Brn/Wht	0.2-1.0	800-1100
40-45 4 CYL NOTE 2	1989-1996	C159200-OG291031	332-5772 114-5772	3250-3650 2200-2400*	75-90 28-32*	180 V+	20V+	Blue to Bl/Wht Red to Red/Wht	750-1400	4V+	Brn to Wht/Blk Purple to White	0.2-1.0	800-1100
45-80 3 CYL NOTE 3	1989-1996	C159200-OG291031	18495 114-4953	3250-3650 500-700*	75-90 28-32*	180 V+	20V+	Blue to Eng Gnd Red to Eng Gnd	750-1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2-1.0	800-1100
40-125	1997-2001	OG531301 - OG980599	827509 114-7509	660-710 450-600*		180V+		Green/White to White/Green	Open	0.5V+	Gnd to Wht/Blk, Wht/Yel, Blue/Wht	N/A	900-1100 2100-2400
50	1970-1975	2858814-4357639	333-3213	380-420	9-11	180 V+	20V+	Red to White Blue to White	Ignition Driver	N/A	Not Applicable	Does not apply	Does not apply
50	1976-1985	4357640-6586624	332-5772 114-5772	5800-7000 2200-2400*	135-165 30-90*	180 V+	20V+	Blue to Blue/Wht Red to Red/Wht	800-1400	4V+	Brn to Wht/Blk Purple to White	0.2-1.0	800-1100
50	1985-1990	6586625-OD000749	332-7778 114-7778	3250-3650 2200-2400*	75-90 28-32*	180 V+	20V+	Blue to Eng Gnd Red to Eng Gnd	800-1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2-1.0	800-1100
50-60	1991-1996	OD000750-OG589999	19052 114-9052	3250-3650 500-700*	75-90 28-32*	180 V+	20V+	Blue to Gnd Red to Gnd	800-1400	4V+	Wht/Blk to Brn, Wht, Pur	0.2-1.0	800-1100

Mercury

DVA (Peak Reading) Voltage and Resistance Chart

Please note that all DVA readings are minimum voltages measured at cranking speed, not while the engine is running.

50-60 65 Jet	1997- 2001	OG590000- OG980600	827509 114-7509	660-710 450-600*		180V+		Green/White to White/Green	Open	1.5V +	Gnd to Wht/Blk, Wht/Yel, Blue/Wht	N/A	900- 1100 2100- 2400
65	1968	2309311- 2452709	333-3213	380-420	9-11	180V+	20V +	Red to White Blue to White	Ignition Driver	N/A	Not Applicable	N/A	N/A
65	1976- 1979	4382057- 4571651	332-7778 114-7778	3250-3650 2200- 2400*	75-90 28-32*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Pur	0.2- 1.0	800- 1100
65	1994- 1996	OD283222- OG437999	18495 114-4953	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Pur	0.2- 1.0	800- 1100
65 Jet	1992- 1995	OE009500- OE138599	18495 114-4953	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Pur	0.2- 1.0	800- 1100
70	1977- 1993	4571652- OD283221	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2- 1.0	800- 1100
75	1984- 1988	643901- OB279480	332-5772 114-5772	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Bl/Wht Red to Red/Wht	800- 1400	4V+	Brn to Wht/Blk Purple to White	0.2- 1.0	800- 1100
80	1978- 1983	4831999- 6432900	332-5772 114-5772	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Bl/Wht Red to Red/Wht	800- 1400	4V+	Brn to Wht/Blk Purple to White	0.2- 1.0	800- 1100
80	1987- 1988	OA966142- OB209468	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2- 1.0	800- 1100
90 Inline 6	1979- 1986	5299506- OB110053	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd. Red to Gnd Red/Wht to Gnd	800- 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
90 3 CYL NOTE 2	1987- 1992	OA996142- OC221999	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2- 1.0	800- 1100
90 3 CYL NOTE 3	1989- 1996	OC222000- OG437999	18495 114-4953	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2- 1.0	800- 1100
90 Sport Jet	1995- 1997	OE141089- OE315900	18495 114-4953	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Eng Gnd Red to Eng Gnd	800- 1400	4V+	Wht/Blk to Brn, Wht and Purple	0.2- 1.0	800- 1100
100	1988- 1996	OB209468- OG437999	332-5772 114-5772	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Bl/Wht Red to Red/Wht	800- 1400	4V+	Brn to Wht/Blk Purple to White	0.2- 1.0	800- 1100
105 Jet	1992- 1996	OD082000- OG840500	332-7778 114-7778	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd Red to Gnd Red/Wht to Gnd	800- 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
115 6 Cyl	1979- 1989	5314656- OC09999	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd Red to Gnd Red/Wht to Gnd	800- 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
115/125 4 Cyl	1989- 1996	OC10000- OG437999	332-5772 114-5772	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Bl/Wht Red to Red/Wht	800- 1400	4V+	Brn to Wht/Blk Purple to White	0.2- 1.0	800- 1100
120 Sport Jet	1995	OE080400- OE141088	332- 826866 114-6866	3250-3650 500-700*	75-90 28-32*	180V+	20V +	Blue to Bl/Wht Red to Red/Wht	800- 1400	4V+	Brn to Wht/Blk Purple to White	0.2- 1.0	800- 1100
120 Sport Jet	1996- 2000	OE141089- OE384499	827509 114-7509	500-700 400-600*		180V+		Green/White to White/Green	Open	1.5V +	Gnd to Wht/Blk, Wht/Yel, Blue/Wht, Brn/Wht	N/A	900- 1100 2100- 2400
135-200 6 CYL 9-15 AMP	1978- 1985	4868998- OA904646	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd Red to Gnd Red/Wht to Gnd	800- 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
135-275 2.0L,2.4L 16 AMP	1985- 1988	OA904647- OC100860	332-7778 114-7778	5800-7000 2200- 2400*	135- 165 30-90*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd Red to Gnd Red/Wht to Gnd	800- 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
175/210 Sport Jet 16 AMP	1997- 2005	398-9873 174-9873-16	18495 114-4953	1000-1600 450-600*	75-90 28-32*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd Red to Gnd Red/Wht to Gnd	800- 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
135-275 2.0L, 2.4L 2.5L 40 AMP	1989- 2005	OC100861- OG840500	332-7778 114-7778	3200-4200 2100- 2400*	90-140 28-32*	180V+	20V +	Blue to Gnd Bl/Wht to Gnd Red to Gnd Red/Wht to Gnd	1100 - 1400	4V+	NOTE 1	0.2- 1.0	800- 1100
225 Carb 250 EFI 3.0L	1996- 2004	OD280813- OG840500	827509 114-7509	900-1100		180V+		Green/White to White/Green	Open	1.5V +	Gnd to Wht/Blk , Wht/Yel, Blue/Wht, Brn/Wht, Red/Wht, Pur/Wht	N/A	900- 1100 2100- 2400

Gnd = Engine ground
Bl/Wht = Blue/White

Blk = Black
Wht/Blk = White/Black

Blk/Wht = Black/White Stripe
Brn/Yel = Brown/Yellow Stripe

* Manufactured by CDI Electronics
Red/Wht = Red/White
Blk/Yel = Black/Yellow Stripe

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MDL	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					LS	HS	LS	HS	HS	LS	Ohms	DVA			Pri	Sec	
2	1984-2004	1	2		320-390				Brown to Gnd		N/A	N/A	N/A		0.21	3.2K	
2.5	2003-2004	1	4	F											.56-.84	11.6 K - 17.4 K	4-6 K
3	1984-2002	1	2		250-300		100		Brown to BLK		30-36 LS 280-340 HS		Red/White to BLK Green/Wht to BLK		0.1	2.6 K	
4	1984-1999	1	2		250-300		100		Brown to BLK		30-36 LS 280-340 HS		White/Red to BLK White/Grn to BLK		0.1	3.1 K	None
4	1999-2004	1	2				126		TCI to Gnd						.56-.84	11.6 K - 17.4 K	4.9-5.1 k
5	1984-2002	1	2		250-300		100		Brown to BLK		30-36 LS 280-340 HS		White/Red to BLK White/Grn to BLK		0.3	3.1 K	None
6	1984-2000	2	2		81-99		100		Brown to BLK		92-111		White/Red to Blk		0.1	3.5 K	None
6/8	2001-2004	2	4	F	81-99		100		Brown to BLK		92-111		White/Red to Blk		0.1	7.8 K	None
8	1986-2004	2	2		81-99		100		Brown to BLK		92-111		White/Red to Blk		0.3	3.5 K	None
9.9	1984-1992	2	2		81-99		100		Brown to BLK		92-111		White/Red to Blk		0.3	3.5 K	None
9.9	1993-1995	2	2		81-99		100		Brown to BLK		92-111		White/Red to Blk		0.3	5.4 K	None
9.9/15	1996-2004	2	2		280-340		105		Brown to BLK		396-484		White/Red to Blk		0.6	2.1 K	None
9.9	1984-1990	2	4	F/FT/T	300-400		90		Brown to Blue		280-340	2.5	White/Red to Blk		0.5	3.4 K	None
9.9	1991-2004	2	4	F/FT/T	300-400		90		Brown to Blue		280-340	2.5	White/Red to Blk		0.5	4.1K	None
15	1984-1995	2	2		81-99				Brown to BLK		92-111		White/Red to Blk		0.3	5.4 K	None
15	1998-2004	2	4	F	272-408		135		Brown to Blue		234-348	4	White/Red to Blk	115	0.5	4.91 K	None
20	1996-1997	2	2		340-420		125		Brown to Blue		310-390	5.5	White/Red to Blk White/Blk to Blk	105	0.5	3.2 K	None
25	1984-1987	2	2		120-150		190		Brown to Blue		12-16	5	White/Red to Blk White/Blk to Blk	210	0.5	3.5 K	None
25	1988-1993	2	2		200-275		190		Brown to BLK		90-120	5	White/Red to Blk White/Blk to Blk	210	0.5	3.5 K	None
25	1994-2004	2	2		340-420		125		Brown to Blue		310-390	5.5	White/Red to Blk White/Blk to Blk	105	0.5	3.2 K	None
25	1996-2002	3	2		340-420		175		Brown to Blue		310-390	4	White/Red to Blk White/Blk to Blk White/Grn to Blk	135	0.5	6.3 K	None
25	1990-1992	2	2	C	200-275		190		Brown to BLK		90-120	5	White/Red to Blk	210	0.5	3.5 K	None
25	1993-1995	2	2	C	200-275		190		Brown to BLK		90-120	5	White/Red to Blk	210	0.5	5.4 K	None
25	1996-1997	2	2	C	200-275		190		Brown to BLK		90-120	5	White/Red to Blk	210	0.5	8.5 K	None
25	1998-2004	2	4	F	660-710		190		Grn/Wht to Wht/Grn		300-350	6	Red to Wht	100	0.5	4.1 K	None
30	1984-1986	2	2		120-150		190		Brown to Blue		12-16	5	White/Red to Blk	210	0.5	3.5 K	None
30	1987-2002	3	2		280-330		175		Brown to Blue		310-390	4	White/Red to Blk White/Blk to Blk White/Grn to Blk	135	0.5	6.3K	None
30	1989-1992	2	2	C	120-150		190		Brown to Blk		12-16	5	White/Red to Blk	210	0.5	3.5 K	None
30	1993-1996	2	2	C	400-490		125		Brown to Blue		310-390	4	White/Red to Blk White/Blk to Blk	105	0.5	3.2 K	None
30	1997	2	2	C	340-420		125		Brown to Blue		310-390	4	White/Red to Blk White/Blk to Blk	105	0.5	3.2 K	None

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MD L	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					L S	HS	LS	HS	HS	LS	Ohms	DVA			Primary	Sec	
30	2001-2004	2	4	F	600-720		193		Grn/Wht to Wht/Grn		270-330	6	White/Red to Blk	151	0.5	4.1 K	None
40/50	1984-1988	3	2		180-250		175		Brown to Blue		310-390	4	White/Red, White/Blk, White/Grn to Blk	135	0.5	6.3K	
40/50	1989-1994	3	2		280-330		200		Brown to Blue		180-220	4	White/Red, White/Blk, White/Grn to Blk	175	0.5	3.2 K	None
40/50	1995-2004	3	2		400-510		145		Brown to Blue		180-240	3	White/Red, White/Blk, White/Grn to Blk	125	0.5	3.2 K	None
40	1989-1997	2	2	C	120-140		125		Brown to Blue		12-16	5.5	White/Red to Blk	115	0.5	3.5 K	None
40	1998-2002	3	2	C	400-510		145		Brown to Blue		180-220	4	White/Red, White/Blk, White/Grn to Blk	125	0.5	3.2 K	None
40	1999	4	4	F	300-380		140		Brown to Blue		375-475	7	Red//Wht to White/Blk	105	0.5	4.1 K	4-6 K
40	2000-2004	3	4	F	600-710		193		Grn/Wht to Wht/Grn		270-330	6	Red//Wht to Blk	151	0.5	2.7-3.7K	4-6 K
48	1995-2000	2	4	E	81-99				Brown to BLK		92-111		White/Red to Blk		0.3	5.4K	None
50	1999-2002	3	2	C	420-510		145		Brown to Blue		180-240	3	White/Red, White/Blk, White/Grn to Blk	125	0.5	3.2 K	None
50	1995-2000	4	4	F	300-380		137		Brown to Blue		375-475	3.5	Red//Wht to White/Blk	150	0.5	4.1 K	3.8-5.7 K
50	1996-2000	4	4	F	300-380		137		Brown to Blue		375-475	3.5	Red//Wht to White/Blk	150	0.5	4.1 K	3.8-5.7 K
50	2001-2004	4	4	F	272-408		144		Brown to Blue		396-594	6.3	Red//Wht to White/Blk	126	0.078-0.106	3.5-4.7 K	3.8-5.7 K
55	1989-1994	2	2	C	200-260		135		Brown to Blue		70-88 23-29	2	White/Red, White/Blk, Yel to Blk	150	0.5	3.1 K	None
55	1995	2	2	C	200-260		135		Brown to Blue		280-360	2	White/Red, White/Blk to Blk	150	0.5	3.1 K	None
60	1991-2000	3	2		145-190		140		Brown to Blue		110-150	2.5	White/Red, White/Blk, White/Grn to Blk	100	0.5	3.2 K	None
60	1992-1999	2	2	P	150-190		120		Brown to Blue		270-330	2.5	White/Red to White/Blk	105	0.5	4.1 K	None
60	1996-2002	2	2	C	150-190		120		Brown to Blue		270-330	2.5	White/Red to White/Blk	105	0.5	4.1 K	None
60	2001-2004	3	2		150-190		150		Brown to Blue		270-330	2.5	White/Red to White/Blk	105 on #1 & #3 at idle (0 on #2), 145 on all at 1500 RPM	0.5	4.1 K	None
60	2002-2004	4	4	F/T	272-408		144		Brown to Blue		396-594	6.3	Red//Wht to White/Blk	126	0.078-0.106	3.5-4.7 K	3.8-5.7 K
70	1984-1991	3	2		145-190		140		Brown to Blue		110-150	2.5	White/Red, White/Blk, White/Grn to Blk	100	0.5	3.2 K	
70	1992-2004	3	2		150-190		150		Brown to Blue		270-330	2.5	White/Red to White/Blk	105 on #1 & #3 at idle (0 on #2), 145 on all at 1500 RPM	0.5	4.1 K	None

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MDL	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					L Spd	HSpd	LS	HS	HS	LS	Ohms	DVA			Primary	Sec	
75	1994-1996	3	2	C	900-1100	105-140	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to Wht/Yel Wht/Grn to Wht/Blk	95	0.5	4.5K	
75	1998-1999	3	2	C	191-288	64-96	55	90	Brn to Red	Blue to Red	241-362	7	White/Red to White/Blk	105 on #1 & #3 at idle (0 on #2), 145 on all at 1500 RPM	0.5	4.0 K	None
75	1995-1996	3	2	E	900-1100	105-140	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Grn Wht/Blk to Wht/Grn	95	0.5	4.8K	None
75	1996-1999	3	2	P	900-1100	105-140	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	4.8 K	None
75	1997-2000	3	2	E	480-600	50-70	105	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Grn Wht/Blk to Wht/Grn	105	0.5	4.1K	None
75/90	2003-2004	4	4	F	?	?	?	?	?	?	396-594	2.7	White/Red to Blk White/Blk to Blk	107	0.5	4.1 K	#1 - 7.6K #2 - 5.6 K #3 - 6.3 K #4 - 7.2 K
80	1997	3	2	C	220-270	70-90	100	60	Brn to Red	Blue to Red	241-362	5	White/Red to Wht/Blk	130	0.5	4.1 K	None
80/100	1999-2002	4	4	F	?	?	?	?	?	?	396-594	2.7	White/Red to Blk White/Blk to Blk	107	0.5	4.1 K	#1 - 7.6K #2 - 5.6 K #3 - 6.3 K #4 - 7.2 K
85	1989-1996	4	2	C	900-1100	105-140	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	4.8 K	None
90	1984-1989	4	2		765-935	105-135	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	2.5 K	None
90	1990-1991	4	2		900-1100	105-140	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	4.8 K	None
90	1992-2004	3	2		220-270	70-90	100	60	Brn to Red	Blue to Red	241-362	5	White/Red to White/Blk	130	0.5	4.1 K	None
115	1984-1988	4	2	B/P/S	625-820	62-79	160	45	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	3.8 K	None
115	1994-2000	4	2	C	900-1100	105-140	85	45	Brn to Blue	Blue to Blk/Red	320-400	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	2.5 K	4-6 K
115	2000-2004	4	4	F	?	?	?	?	?	?	?	3	White/Red to Blk White/Blk to Blk	5			None

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MDL	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					L Spd	HSpd	LS	HS	HS	LS	Ohms	DVA			Primary	Sec	
130	1984-1989	4	2		900-1100	105-140	85	45	Brn to Blue	Red to Blue	290-370	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	95	0.5	4.8 K	None
130	1990-2003	4	2		625-820	62-79	160	45	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to White/Yel Wht/Grn to Wht/Blk	125	0.5	3.8 K	4-6 K
150/175	1984-1989	6	2		900-1100	21-27	75	14	Brn to Red	Blue to Blk/Red	280-460	1.6	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	105	0.5	2.5 K	4-6 K
150/175	1990-1995	6	2		660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	2	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	105	0.5	3.8 K	4-6 K
150	1996-2004	6	2	D/L/P/S	660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	3	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	130	0.5	4.1 K	5 K
150	1996-1999	6	2	C	460-620	70-90	90	30	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	65	0.5	4.1 K	None
150	1999-2003	6	2	DX/SX/VX	224-336		110		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red to Blk Wht/Grn to Blk Wht/Blk to Blk Wht/Blue to Blk Wht/Yel to Blk Wht/Brn to Blk	100	0.5	2.72 - 3.68 K	None
150	1999-2002	6	2	LX/PX	224-336		110		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red to Blk Wht/Grn to Blk Wht/Blk to Blk Wht/Blue to Blk Wht/Yel to Blk Wht/Brn to Blk	100	0.5	2.72 - 3.68 K	None
150	1994-1995	6	2	P	660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	65	0.5	3.8 K	None
150	2000-2004	6	2	Z/LZ/VZ	CDI OUTPUT		140		Blk/Org, Blk/Yel, Blk/Blue, Blk/Grn, Blk/Wht to Red/Yel		?	5	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	140			4-6 k
150	2004	6	4	F/LF	ECM OUTPUT		260		Blk/Org to Blk Blk/Wht to Blk		459-561	3.5	White/Red to Blk White/Blk to Blk	260	1.53-2.07	12.5 - 16.91 K	None

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MDL	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					L Spd	HSpd	LS	HS	HS	LS	Ohms	DVA			Primary	Sec	
175	1996-2000	6	2		660-820	62-79	140	40	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	130	0.5	4.1 K	5 K
175	2001-2004	6	2	Z/VZ	CDI OUTPUT		140		Blk/Org, Blk/Yel, Blk/Blue, Blk/Grn, Blk/Wht to Red/Yel		?	5	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	140			4-6 K
200	1984-1989	6	2		900-1100	21-27	75	14	Brn to Red	Blue to Blk/Red	280-460	1.6	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	105	0.5	2.5 K	
200	1990-1995	6	2		660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	105	0.5	3.8 K	None
200	1991-1995	6	2	P	660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	2	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	105	0.5	3.8 K	None
200	1996-1999	6	2	L/P/S	660-820	62-79	140	40	Brn to Red	Blue to Blk/Red	280-460	2.5	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	130	0.5	4.1 K	5 K
200	1998	6	2	V	224-336		115		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7 - 3.6 K	5 K
200	2002-2004	6	4	F	CDI OUTPUT		252		Blk/Org, Blk/Yel, Blk/Wht to Red/Yel		459-561	5.3	Wht/Red to Blk Wht/Grn to Blk Wht/Blk to Blk	252	1.5-1.9	19.6 - 35.4 K	None
200	1999-2002	6	2	LX	CDI OUTPUT		140		Blk/Org, Blk/Yel, Blk/Blue, Blk/Grn, Blk/Wht to Red/Yel		?	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	140			4-6 K
200	1999-2004	6	2	SX	CDI OUTPUT		100		Blk/Org, Blk/Yel, Blk/Blue, Blk/Grn, Blk/Wht to Red/Yel		?	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100			4-6 K
200	1999-2004	6	2	V/VX	224-336		115		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7-3.6 k	5 K

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MDL	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					L Spd	HSpd	LS	HS	HS	LS	Ohms	DVA			Primary	Sec	
200	2000-2004	6	2	LZ/Z HPDI	CDI OUTPUT		140		Blk/Org, Blk/Yel, Blk/Blue, Blk/Grn, Blk/Wht to Red/Yel		?	5	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	140	0.5		4-6 K
220	1984-1986	6	2		900-1100	21-27	75	14	Brn to Red	Blue to Blk/Red	280-460	1.6	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	58	0.5	2.5 K	5 K
225	1984-1989	6	2		900-1100	21-27	75	14	Brn to Red	Blue to Blk/Red	280-460	1.6	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	58	0.5	2.5 K	5 K
225	1990-1995	6	2	L/HP	660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	2	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	105	0.5	3.8 K	5 K
225	1996-1997	6	2	L/HP	660-820	62-79	145	40	Brn to Red	Blue to Blk/Red	280-460	2	Wht/Red to Wht/Grn Wht/Blk to Wht/Blue Wht/Yel to Wht/Brn	130	0.5	4.1 K	5 K
225	1994-1995	6	2	X/HP U/HP	224-336	224-336	90	90	Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7 K	5 K
225	2002-2004	6	4	F	CDI OUTPUT		252		Blk/Org to Red/Yel Blk/Yel to Red/Yel Blk/Wht to Red/Yel		459-561	5.3	Wht/Red to Blk Wht/Grn to Blk Wht/Blk to Blk	252	1.5-1.9	19.6-35.4 k	None
225	1996-2002	6	2	S/X/U L/LX/SX	224-336		115		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7 K	5 K
225	1998-2004	6	2	VX	224-336		115		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7 K	5 K
225	2003-2004	6	2	VZ HPDI	224-336		160		Red to Blk/Wht		294-398	3.5	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	160	1.87-2.53	8.93-12.08 K	None
250	1990-1996	6	2		224-336		90		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7 K	5 K
250	1997-2002	6	2		224-336		115		Brn to Red	Blue to Blk/Red	294-398	3	Wht/Red, Wht/Grn, Wht/Blk, Wht/Blue, Wht/Yel , Wht/Brn to Blk	100	0.5	2.7 K	5 K

YAMAHA DVA and RESISTANCE CHARTS

HP	YEAR	# Cyl	STK	MDL	STATOR						TRIGGER			CDI Out	IGNITION COIL		SPK PLG
					OHMS		DVA		CHECK POINTS		OHMS	DVA	CHECK POINTS		OHMS +/- 10%		CAP
					L Spd	HSpd	LS	HS	HS	LS	Ohms	DVA			Primary	Sec	
250	2003-2004	6	2	HPDI	CDI OUTPUT		160		Red to Blk/Wht		294-398	3.5	Wht/Red to Blk Wht/Grn to Blk Wht/Blk to Blk Wht/Blue to Blk Wht/Yel to Blk Wht/Brn to Blk	140	1.87-2.53	8.93-12.08 K	None
300	2004	6	2	LZ/VZ/Z HPDI	CDI OUTPUT		265		Red to Blk/Wht		294-398	3.5	Wht/Red to Blk Wht/Grn to Blk Wht/Blk to Blk Wht/Blue to Blk Wht/Yel to Blk Wht/Brn to Blk	265	1.36-1.84	7.31 - 9.89 K	None

Glossary of Terms

ADI – **Alternator Driven Ignition**, consists of a flywheel, stator, trigger and ignition module.

ADTC - **After Top Dead Center** Reference on ignition timing.

BTDC - **Before Top Dead Center** Reference on ignition timing.

CD Ignition – **Capacitive Discharge Ignition**. The capacitor stores the power developed by a stator or inverter and uses a SCR to deliver the power to the ignition coil.

CDM – **Capacitive Discharge Module**. The CDM is a combination of the switch box and ignition coil.

Crank - Refers to the engine being turned over with the starter, not running. Spark plug wires are usually connected to a spark gap tester.

DVA – **Direct Voltage Adapter**. Also known as Peak voltage. The term refers to the peak voltage as read by a specialized meter or a multimeter using a adapter to convert the peak voltage in the ignition system to a DC value. Regular meters cannot read the voltages due to the frequency and duration of the pulses in the system.

Power Pack – Term used by Johnson/Evinrude for the ignition module.

RPM – **Revolutions per minute**. The number of times the engine rotates in one minute.

S.L.O.W. – **Speed Limiting Oil Warning** system. Limits the RPM of the engine to approximately 2500 RPM in order to reduce the damage to the engine caused by a no oil or overheat condition.

Spark Tester - Device used to check for spark from the ignition coil to the spark plug. Testers are normally available in 1, 4, 6 and 8 cylinder configurations.

Switch Box – Term used for Force, Mariner and Mercury ignition modules.

W.O.T. – **Wide Open Throttle**.

CDI ELECTRONICS
OUTBOARD SERVICE BULLETIN

12/06/2003 **CDI Bulletin # 2276 Rev.1**

Models affected: Johnson/Evinrude 60 HP 1986 (CE) through 1994 (ER)
Johnson/Evinrude 65 HP 1987 (CU) through 1994 (ER)
Johnson/Evinrude 70 HP 1989 (CD) through 1994 (ER)

Problem:

The engine and electrical system can become damaged by overheating when air is trapped in the upper half of the cooling system. Trapped air can cause the upper cylinder or regulator/rectifier to overheat, resulting in damage to the piston or regulator (also damaging the stator). Air can become trapped when:

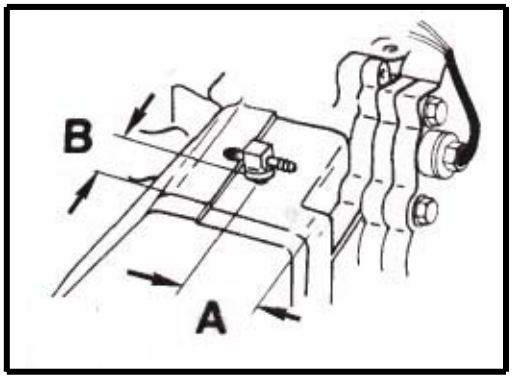
1. The engine is idling with a blocked or restricted thermostat bypass hole.
2. The engine is operated in aerated water, such as a pontoon or deck boat wakes.

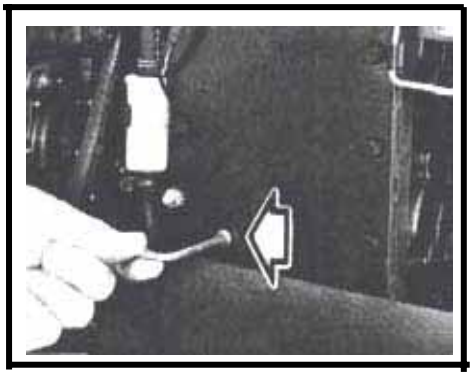
SOLUTION:

Relocate the water pump indicator outlet tee (for the pee tube) from the side of the engine block to the top of the engine cylinder block. This allows air to be vented from the top of the cooling system and helps ensure an adequate water level when idling.

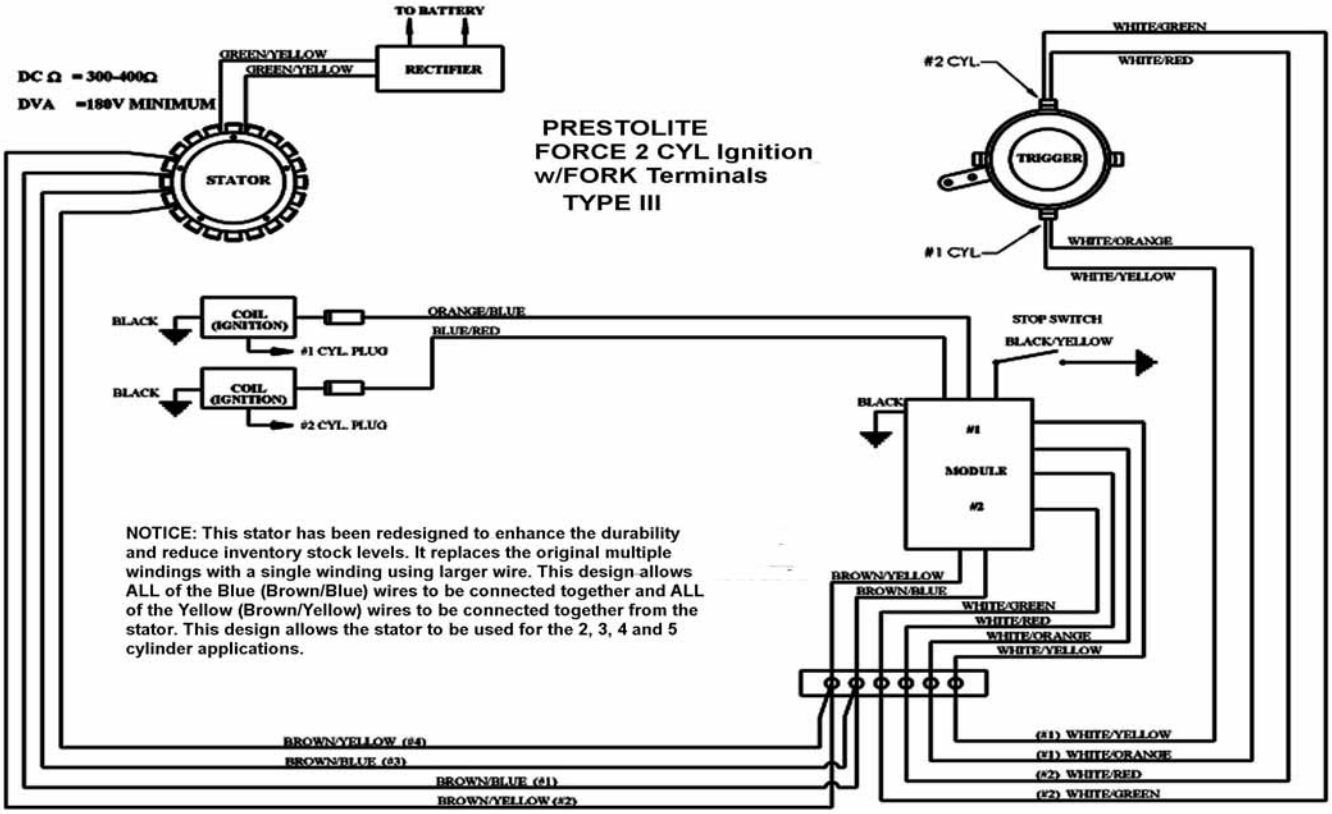
If the engine does not have a threaded hole located in the top of the cylinder block, please follow the steps below:

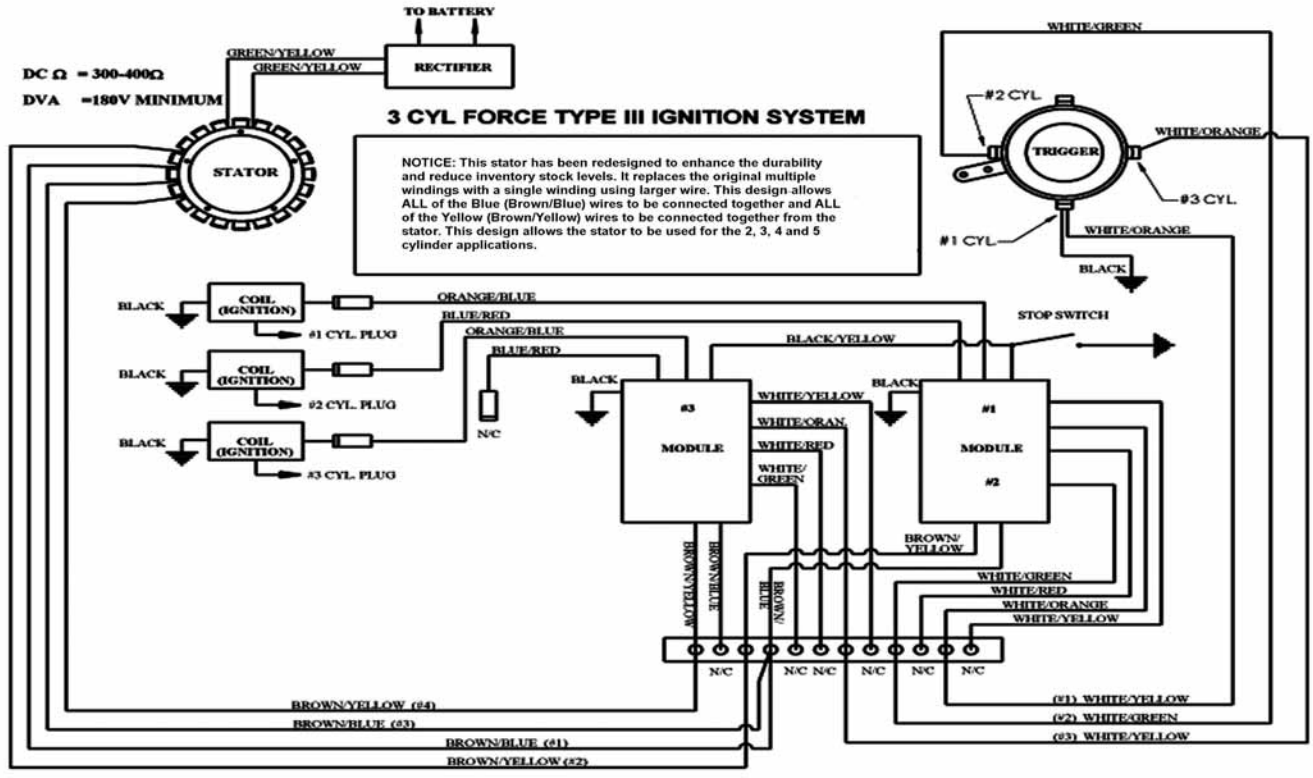
1. Remove the indicator hose from the outlet tee and discard.
2. Remove the outlet tee.
3. Install a 1/8th inch NPT brass or aluminum pipe plug into the hole where the tee was located (use gel-seal on the threads). (See fig. 1)
4. Measure 2 inches forward from the rear corner of the exhaust manifold cover (ref "A") and 1-3/8th inches from the exhaust cover gasket (Ref to "B"). Mark the intersection with a center punch. (See fig. 2).
5. Mark an 11/32nd (Letter "R") drill bit ½ inch from the tip (to prevent damage to the water jacket) as a depth gauge. Grease the tip and drill a hole through the casting. The grease will help prevent shavings from entering the cooling system.
6. Grease the tip of an 1/8th NPT tap and thread the hole.
7. Apply gel-seal to the threads of the original tee and install it in the hole you just tapped. Position the tee so that the indicator nipple is facing the back of the engine.
8. Install a new piece of 3/16th hose (19 inches long) from the tee to the indicator.



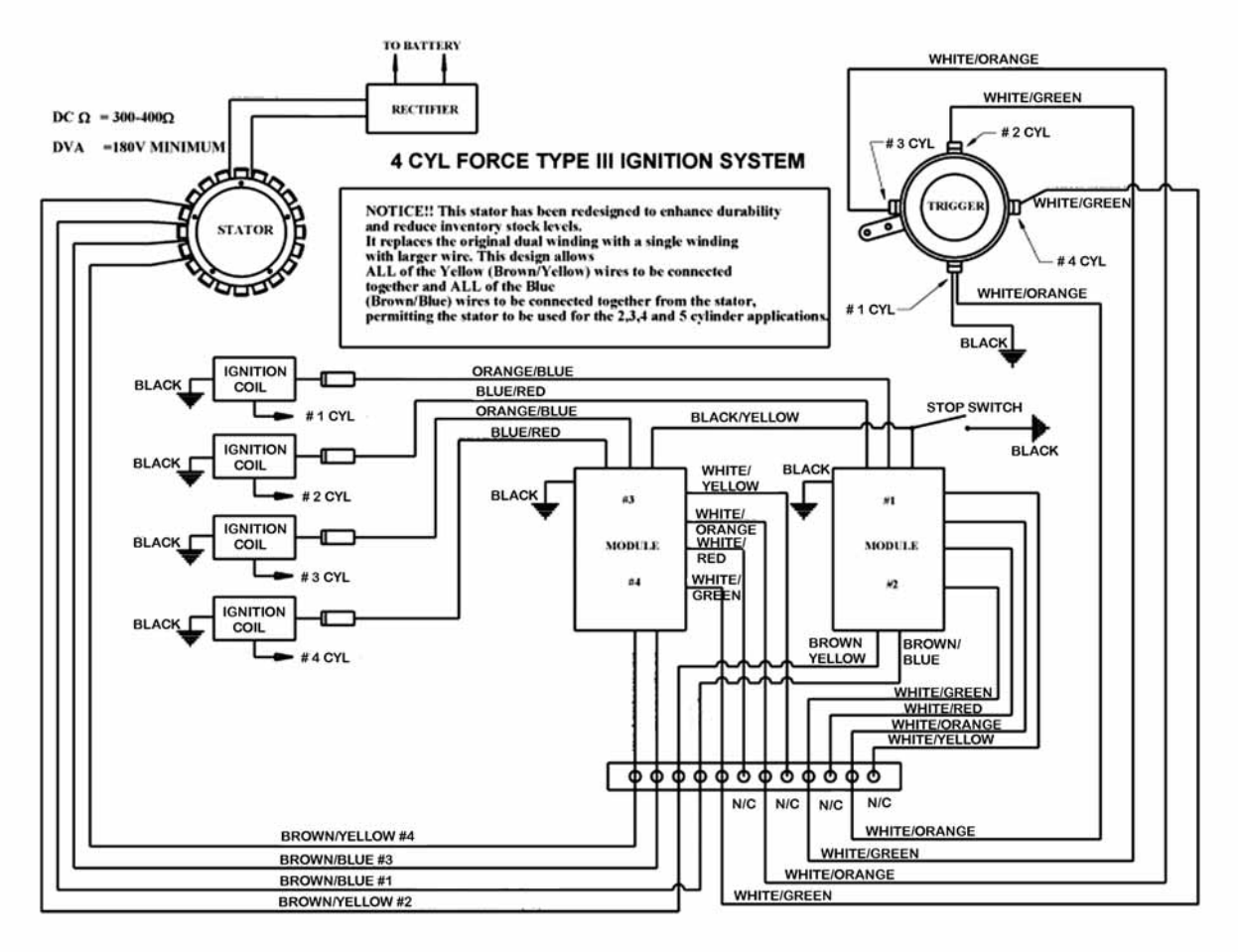


Modified Engine Wiring Diagrams for CDI Electronics Components

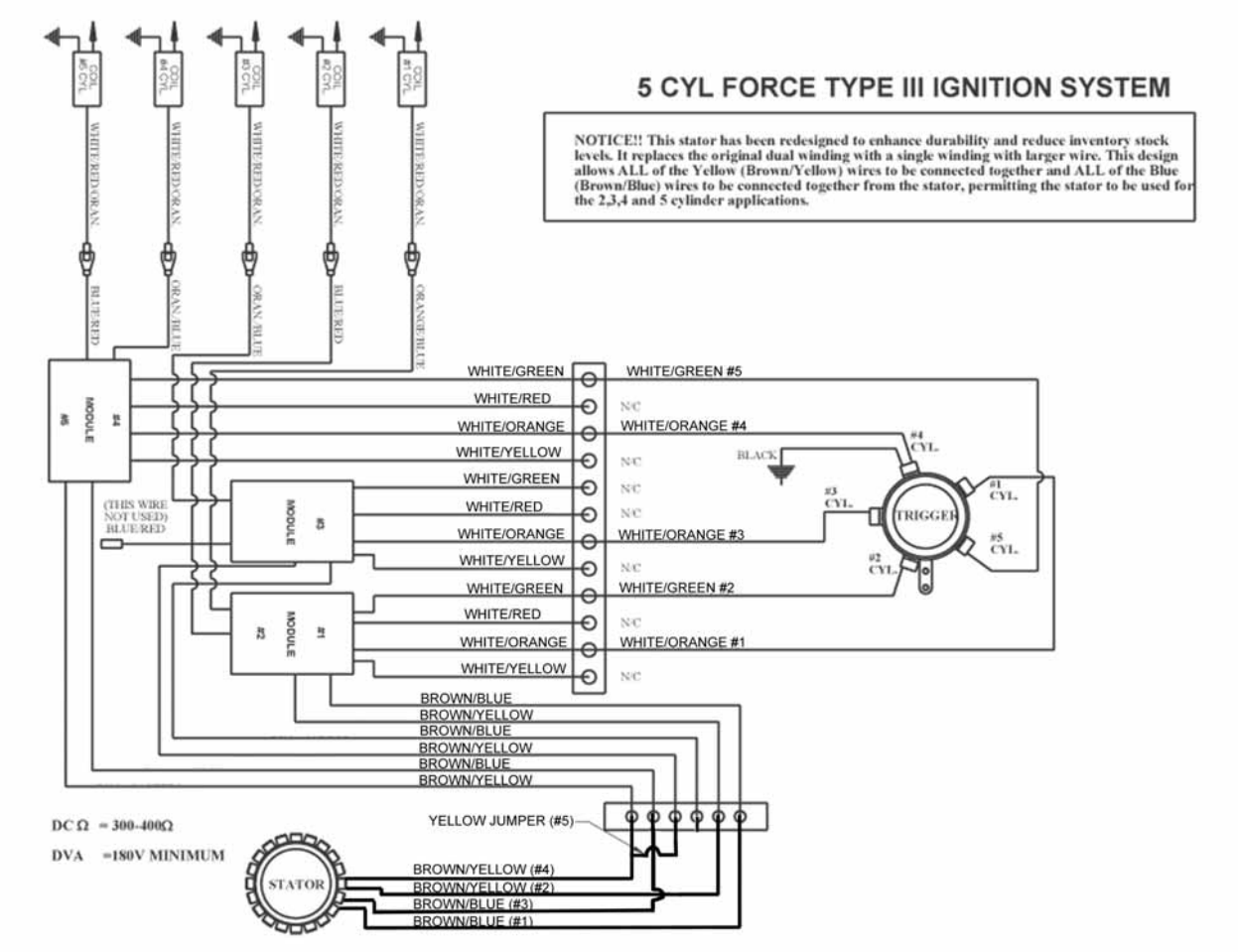




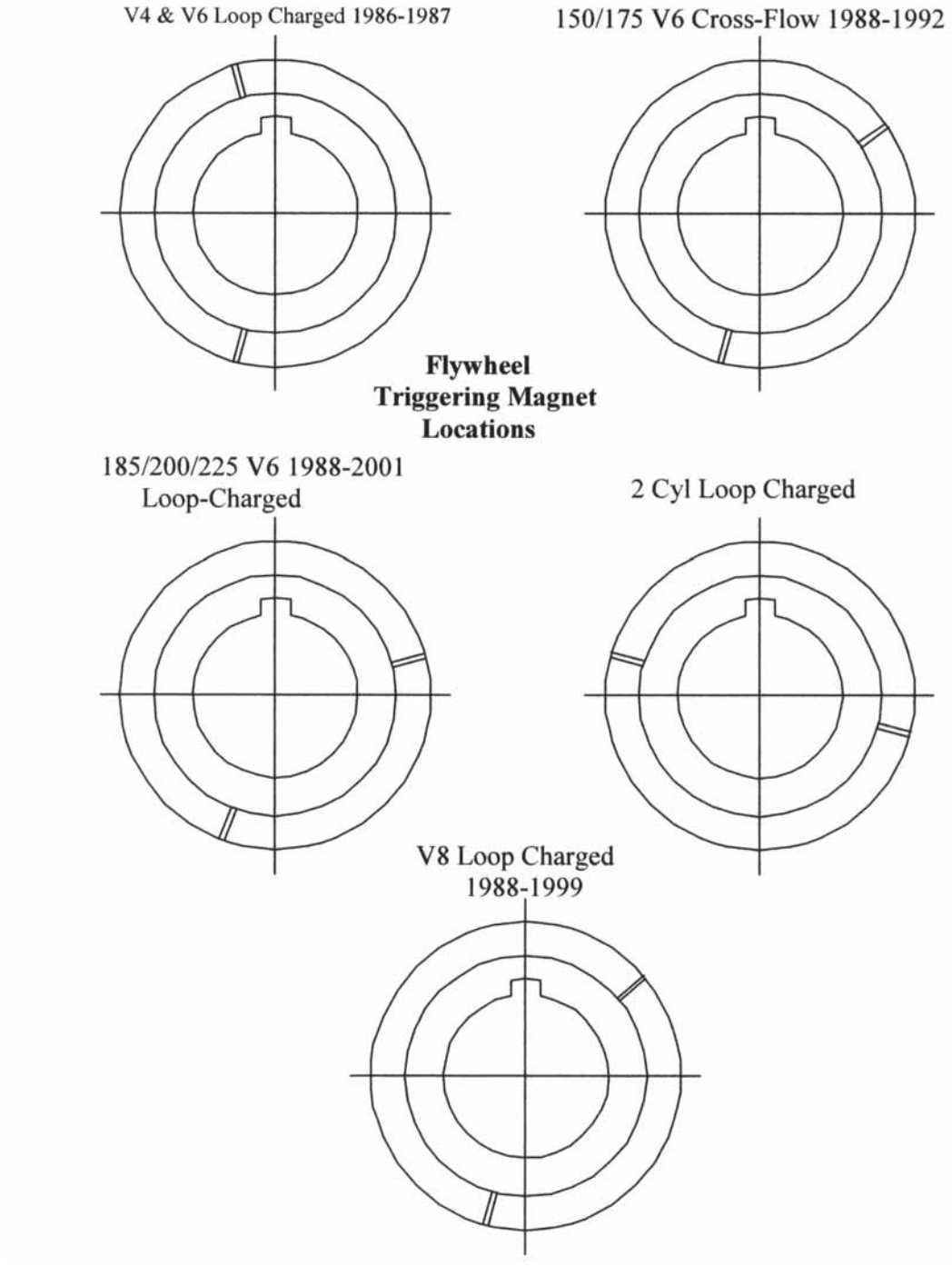
Modified Engine Wiring Diagrams for CDI Electronics Components



Modified Engine Wiring Diagrams for CDI Electronics Components

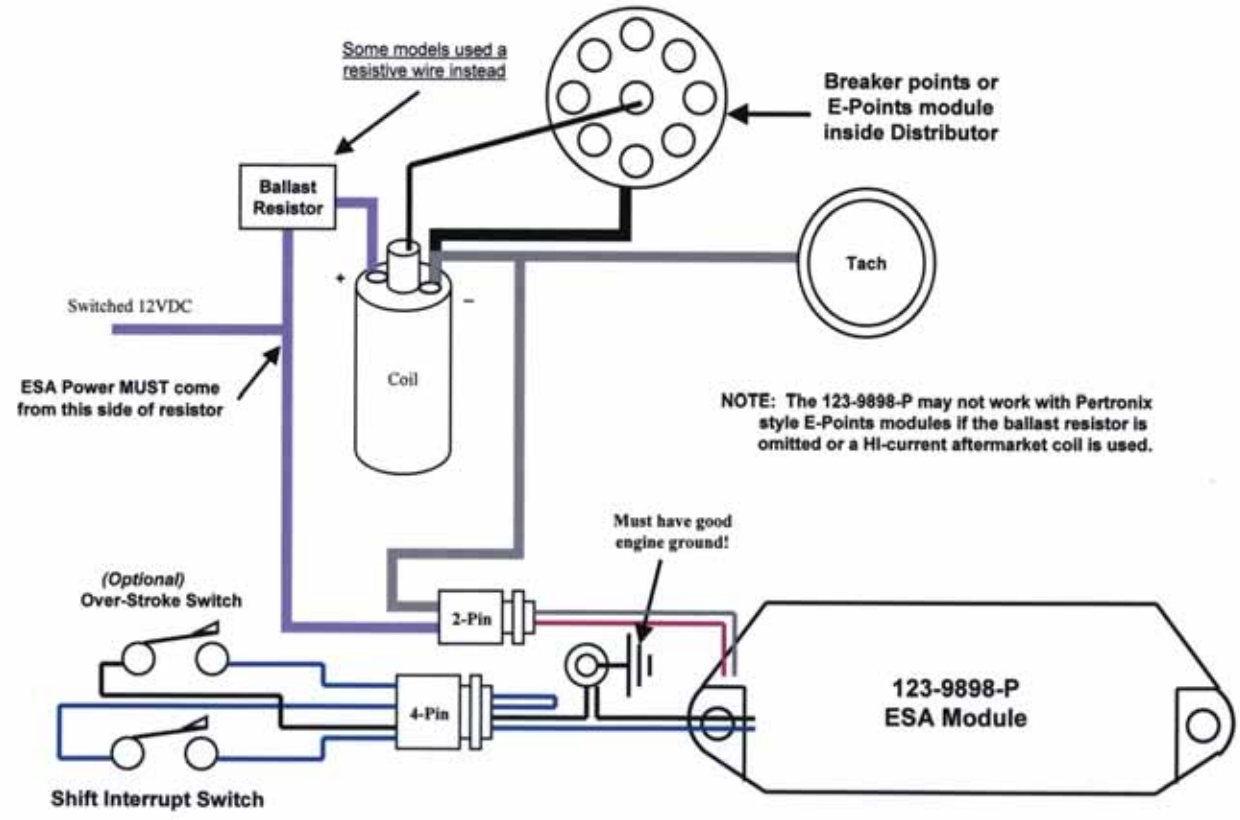


This drawing is to be used to determine if the flywheel sensor magnet has moved from it's original location only.



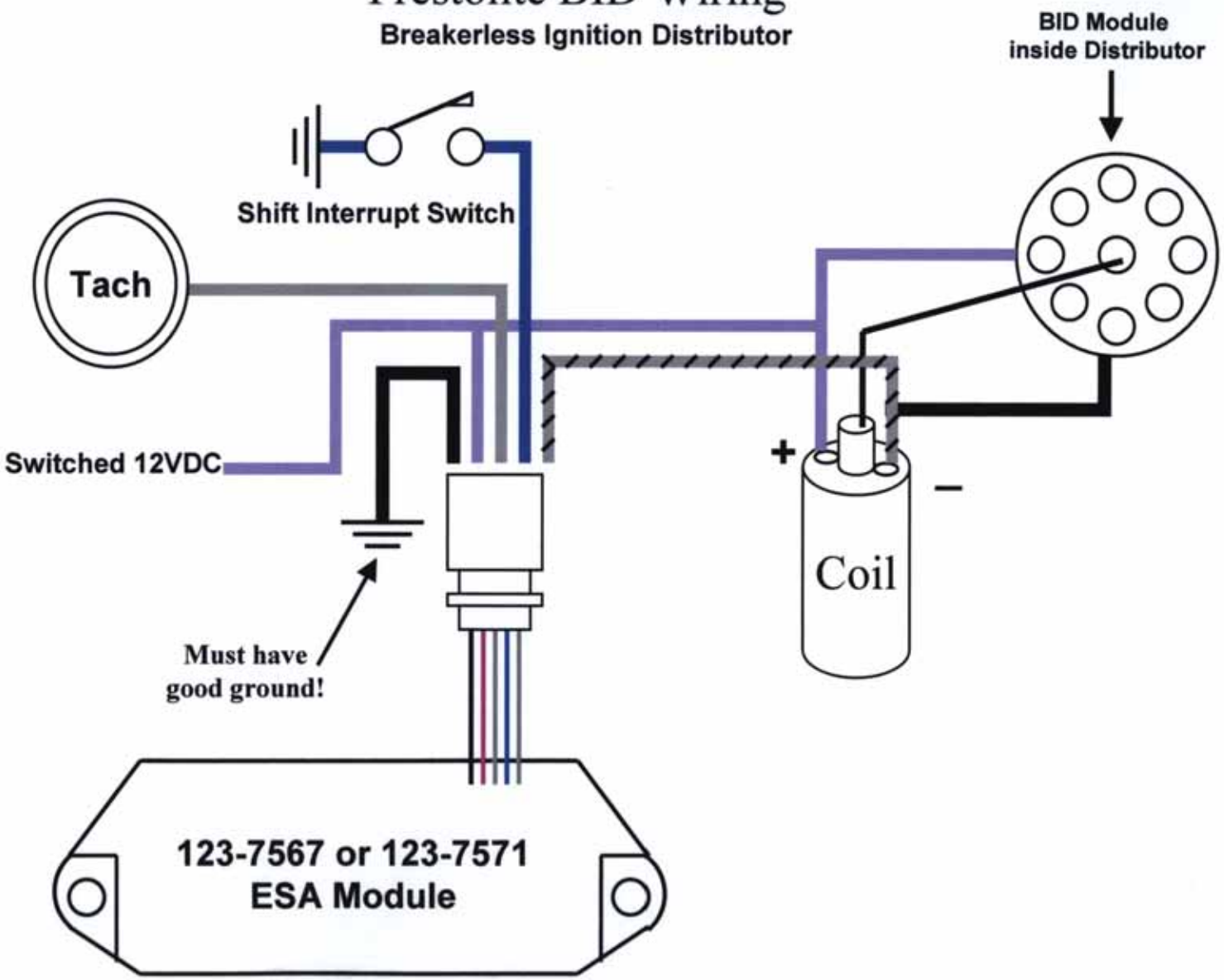
OMC Shift Assist (ESA) Applications					
OMC P/N	Ignition	CDI P/N	Superceded to	Application	Years
982749	Points	123-9898-P*		5.0, 5.7L V8	82 - 85
982755	Points	123-9898-P*		2.5, 3.0L V4	82 - 85
982774	Points	123-9898-P*		3.8, 4.3L V6	82 - 85
984036	Points	123-9898-P*	986342	4.3L V6	86 - 88
984276	Points	123-9898-P*	984730	5.0, 5.7L V8	86 - 88
984281	Points	123-9898-P*	985902	2.3, 2.5, 3.0L I4	86 - 88
984730	Points	123-9898-P*		3.5, 4.6, 5.0, 5.8L V8	89 -90
984730	Points	123-9898-P*		3.5, 4.6L V6, 7.5L V8	87 - 88
984740	Points	123-9898-P*		No data	
985902	Points	123-9898-P*	987740	2.3 3.0 I4, 2.6, 4.3L V6	89 - 90
986342	Points	123-9898-P*	987740	4.3L V6	86 - 88
986610	Delco EST	123-7878	987396	3.0, 3,0L HO I4	90
986837	Points	123-9898-P*		5.7L V8	90
987396	Delco EST	123-7878	987878	3.0, 3,0L HO I4	90 - ?
987564	Prestolite BID	123-7571		5.0, 5.8L V8	92 - 93
987566	Delco EST	123-7566		3.0, 3,0L HO I4	92 -93
987567	Prestolite BID	123-7567		4.3L V6	92 -93
987571	Prestolite BID	123-7571		5.7L V8	91 - 93
987738	Points	123-9898-P*		No data	
987739	Points	123-9898-P*		No data	
987740	Points	123-9898-P*		4.3L V6	86-91
987874	Delco EST	123-7566		3.0, 3,0L HO I4	
987878	Delco EST	123-7878		3.0, 3,0L HO I4	
* Also works with electronic points modules (Pertronix)					

Breaker Points Wiring



Prestolite BID Wiring

Breakerless Ignition Distributor



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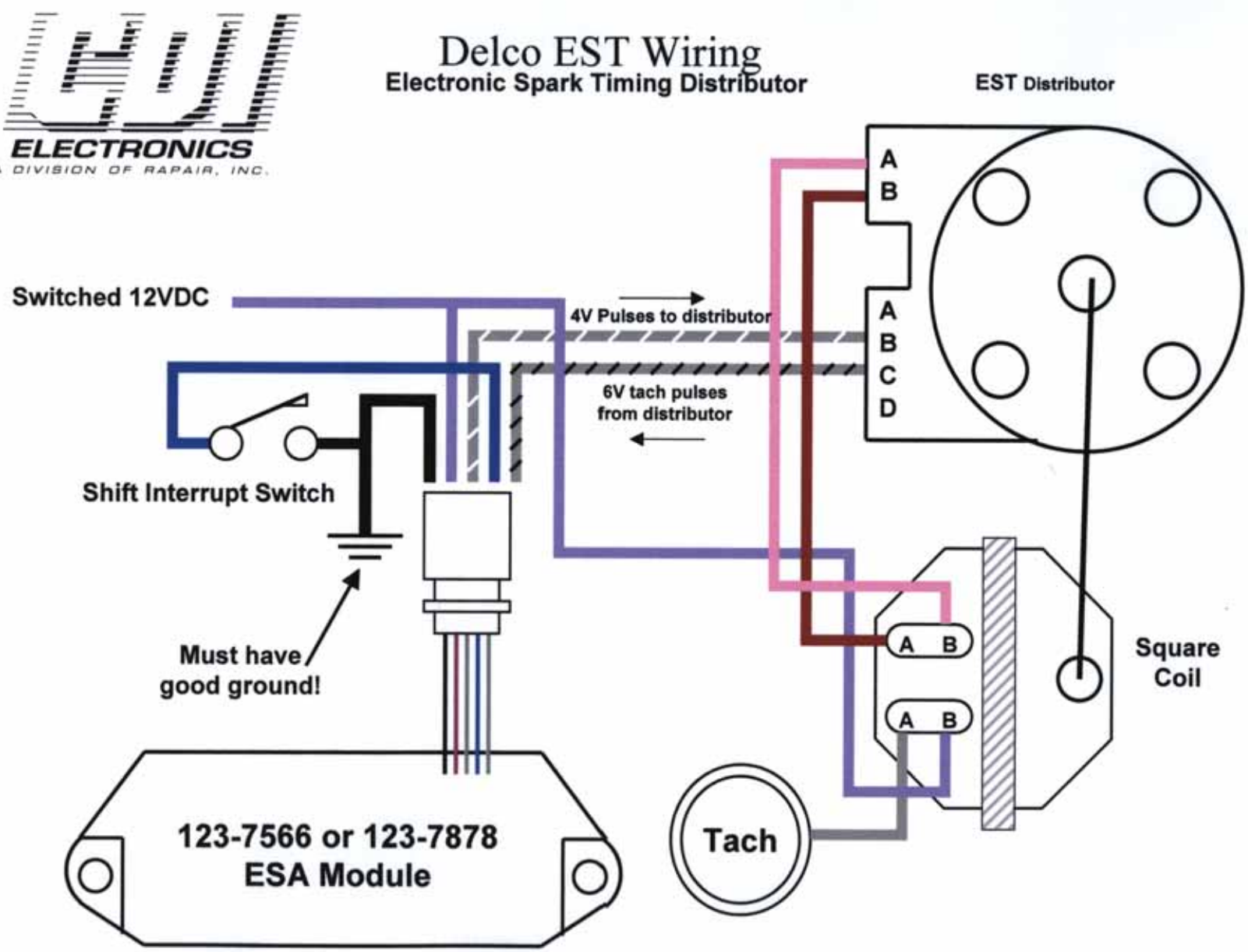
Delco EST Wiring

Electronic Spark Timing Distributor



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ENGINE FINDER

The following listings contain all engines covered in this manual

Model/Engine	Year
45 hp, 4 cyl, 2-stroke	1986 - 1989
50 hp, 3 cyl, 2-stroke	1986 - 1989
50 hp, 4 cyl, 2-stroke	1982 - 1985
60 hp, 3 cyl, 2-stroke	1984 - 1989
70 hp, 3 cyl, 2-stroke	1980 - 1983
75 hp, 3 cyl, 2-stroke	1987 - 1989
75 hp, 4 cyl, 2-stroke	1984 - 1986
80 hp, 4 cyl, 2-stroke	1978 - 1983
85 hp, 4 cyl, 2-stroke	1977
90 hp, 3 cyl, 2-stroke	1987 - 1989
90 hp, 6 cyl, 2-stroke	1979 - 1986
100 hp, 4 cyl, 2-stroke	1988 - 1989
115 hp, 4 cyl, 2-stroke	1989
115 hp, 6 cyl, 2-stroke	1978 - 1988
135 hp, V6, 2-stroke	1986 - 1989
140 hp, 6 cyl, 2-stroke	1978 - 1980
150 hp, V6, 2-stroke	1980 - 1989
175 hp, V6, 2-stroke	1979 - 1980
175 hp, V6, 2-stroke	1985 - 1989
200 hp, V6, 2-stroke	1980 - 1989
220 EFI, V6, 2-stroke	1987 - 1988

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TABLE OF CONTENTS

1 SAFETY

INTRODUCTION 1-1
CLEANING, WAXING, & POLISHING 1-1
CONTROLLING CORROSION 1-2
PROPELLERS 1-2
FUEL SYSTEM 1-7
LOADING 1-9
HORSEPOWER 1-10
FLOTATION 1-10
EMERGENCY EQUIPMENT 1-12
COMPASS 1-14
ANCHORS 1-16
MISCELLANEOUS EQUIPMENT 1-17
BOATING ACCIDENT REPORTS 1-18
NAVIGATION 1-18

2 TUNING

INTRODUCTION 2-1
TUNE-UP SEQUENCE 2-2
COMPRESSION CHECK 2-2
SPARK PLUG INSPECTION 2-3
IGNITION SYSTEM 2-4
TIMING AND SYNCHRONIZING 2-4
ELECTRICAL POWER SUPPLY 2-5
CARBURETOR ADJUSTMENT 2-6
ELECTRONIC FUEL INJECTION 2-9
FUEL PUMPS 2-9
OIL INJECTION 2-10
CRANKING MOTOR AND SOLENOID 2-10
INTERNAL WIRING HARNESS 2-11
WATER PUMP CHECK 2-11
PROPELLER 2-12
LOWER UNIT 2-13
BOAT TESTING 2-14

3 MAINTENANCE

INTRODUCTION 3-1
OUTBOARD SERIAL NUMBERS 3-2
LUBRICATION - COMPLETE UNIT 3-2
PRE-SEASON PREPARATION 3-4
FIBERGLASS HULLS 3-8
BELOW WATERLINE SERVICE 3-9
SUBMERGED ENGINE SERVICE 3-9
PROPELLER SERVICE 3-12
POWER TRIM/TILT 3-13
INSIDE THE BOAT 3-15
LOWER UNIT 3-15
WINTER STORAGE 3-16

4 FUEL

INTRODUCTION 4-1
GENERAL CARBURETION INFORMATION 4-2
CARBURETOR IDENTIFICATION 4-4
FUEL SYSTEM 4-5
Leaded Gasoline & Gasohol 4-6
Removing Fuel From System 4-6
TROUBLESHOOTING
MODELS W/O EFI 4-7
"Sour" Fuel 4-7
Fuel Pump Test 4-9
Fuel Line Test 4-11
Rough Engine Idle 4-11
Excessive Fuel Consumption 4-11
Engine Surge 4-12
Anti-Syphon Valve 4-12
ENRICHENER SYSTEM 4-12
"2+2" SYSTEM 4-13

CARBURETOR "A" - "MERCARB" WITH OR WITHOUT INTEGRAL FUEL PUMP 4-14
Removal & Disassembling 4-15
Cleaning & Inspecting 4-18
Assembling & Installation 4-20
Adjustments 4-23

CARBURETOR "B" CENTER SQUARE BOWL 4-23
Removal & Disassembling 4-23
Cleaning & Inspecting 4-26
Assembling & Installation 4-28
Adjustments 4-32

CARBURETOR "C" - WME SERIES 4-33
Removal & Disassembling 4-33
Cleaning & Inspecting 4-36
Assembling & Installation 4-37
Adjustments 4-39

CARBURETOR "D" SIDE BOWL AND BACK DRAG 4-39
Removal & Disassembling 4-39
Cleaning & Inspecting 4-42
Assembling & Installation 4-44
Adjustments 4-48

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4 FUEL (Continued)

CARBURETOR "E" V6 POWERHEADS
- DUAL FLOAT CENTER BOWL 4-49
- Removal & Disassembling 4-49
- Cleaning & Inspecting 4-51
- Assembling & Installation 4-53
- Adjustments 4-57

FUEL PUMP
- Theory of Operation 4-57
- Pump Pressure Check 4-58
- Pump Removal 4-58
- Cleaning & Inspecting 4-59
- Assembling 4-59

ELECTRONIC FUEL INJECTION 4-61
EFI SYSTEM DESCRIPTION 4-61
TROUBLESHOOTING EFI 4-69
MAINTENANCE -- EFI FUEL SYS. 4-76
- Leaded Gasoline & Gasohol 4-76
- Removing Fuel From System 4-77

SERVICING EFI 4-78
- Intake Manifold and Fuel Injectors 4-78
- Secondary Fuel Filter 4-89
- Fuel Pressure Regulator and Vapor Separator 4-91
- Throttle Sensor 4-95

5 OIL INJECTION

INTRODUCTION 5-1
AUTO BLEND
- Description 5-2
- Operation 5-3
- Troubleshooting 5-3
- System Storage 5-6
- Preparation for Use 5-6

ADVANCED OIL INJECTION
- Description 5-7
- Operation 5-10
- Filling System 5-11
- Bleeding System 5-11
- Oil Pump Adjustment 5-12
- Troubleshooting 5-12
- Servicing 5-12
  - Removal 5-15
  - Disassembling 5-16
  - Cleaning and Inspecting 5-17
  - Assembling 5-19
  - Installation 5-22

6 IGNITION

INTRODUCTION 6-1
SPARK PLUG EVALUATION 6-1

THUNDERBOLT -- DISTRIBUTOR CD -- POINTLESS
- Description 6-3
- Troubleshooting 6-2
- Servicing 6-7
- Distributor Removal 6-7
- Cleaning & Inspecting 6-8
- Distributor Assembling 6-8

THUNDERBOLT -- FLYWHEEL -- CD -- COIL PER CYLINDER
- Description 6-11
- Troubleshooting 6-11
- Servicing 6-19
  - Removal 6-19
  - Cleaning and Inspecting 6-21
  - Assembling 6-22

IDLE STABILIZER AND SPARK ADVANCE MODULES 6-23
- Operation 6-24
- Troubleshooting 6-24

7 TIMING AND SYNCHRONIZING

INTRODUCTION & PREPARATION 7-1
IGNITION TIMING & CARB. SYNCH. 7-3
IDLE STABILIZER AND SPARK ADVANCE MODULES 7-6

4-CYLINDER POWERHEADS
- MODEL 50HP - 1982-85
- MODEL 45HP - SINCE 1986 7-6

3-CYLINDER POWERHEADS
- MODEL 50HP - SINCE 1986
- MODEL 60HP - SINCE 1984
- MODEL 70HP - 1980-83 7-8

4-CYLINDER POWERHEADS
- MODEL 75HP - 1984-86
- MODEL 80HP - 1978-83
- MODEL 85HP - 1977 Only 7-10

3-CYLINDER POWERHEADS
- MODEL 75HP - SINCE 1987
- MODEL 90HP - SINCE 1987 7-11

4-CYLINDER POWERHEADS
- MODEL 100HP - SINCE 1988
- MODEL 115HP - SINCE 1989 7-14

6-CYLINDER IN-LINE POWERHEADS WITH DISTRIBUTOR
- MODEL 90HP
- MODEL 115HP
- MODEL 140HP 7-16

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6-CYLINDER IN-LINE
POWERHEADS WITHOUT
DISTRIBUTOR
MODEL 90HP
MODEL 115HP
MODEL 140HP 7-18

V6 POWERHEADS WITHOUT EFI
MODEL 175HP
S/N 4838074 to 6618750 7-21

MODEL 150HP
S/N 5203428 AND BELOW
MODEL 200HP
S/N 5363917 AND BELOW 7-24

MODEL 135HP
MODEL 150HP
S/N 5203429 AND ABOVE
MODEL 175 HP
S/N 6618751 AND ABOVE
MODEL 200HP
S/N 5363918 TO 6073191 7-27

MODEL 200HP
S/N 6073192 AND ABOVE 7-30

V6 POWERHEADS WITH EFI 7-33

8 POWERHEAD

CHAPTER ORGANIZATION 8-1
GENERAL POWERHEAD
INFORMATION 8-2
COOLING LECTURE 8-4
CYLINDER DRAIN SYSTEM 8-6
REMOVAL AND DISASSEMBLING
ORIGINAL DESIGN IN-LINE
POWERHEADS
MODEL 45 4-CYL. 1986 & ON
MODEL 50 4-CYL. 1982-85
MODEL 50 3-CYL. 1986 & ON
MODEL 60 3-CYL. 1984 & ON
MODEL 70 3-CYL. 1980-83
MODEL 75 4-CYL. 1984-86
MODEL 80 4-CYL. 1978-83
MODEL 85 4-CYL. 1977
MODEL 90 L6 1978-86
MODEL 115 L6 1978-88
MODEL 140 L6 1978-80 8-8
Removal 8-9
Disassembling 8-10
Assembling 8-14
Installation 8-27

REDESIGNED IN-LINE
POWERHEADS

MODEL 75 3-CYL. 1988 & ON
MODEL 90 3-CYL. 1988 & ON
MODEL 100 4-CYL. 1988 & ON
MODEL 115 4-CYL. 1989 & ON 8-29
Removal 8-29
Disassembling 8-32
Assembling 8-46
Installation 8-58

V6 POWERHEAD
Removal 8-62
Disassembling 8-63
Assembling 8-74
Installation 8-90

CLEANING AND INSPECTING
ALL MODELS 8-95
Thermostat Service 8-95
Reed Block Service 8-96
Crankshaft Service 8-98
End Cap Bearings 8-99
Connecting Rod Service 8-100
Piston Service 8-102
Ring End Gap 8-103
Cylinder Block Service 8-104
Honing Procedures 8-105

9 ELECTRICAL

INTRODUCTION 9-1
BATTERIES 9-1
JUMPER CABLES 9-5
GAUGES AND HORNS 9-7
Temperature Gauges 9-8
Warning Lights 9-8
Fuel Gauges 9-9
Tachometer 9-11
Horns 9-11
ELECTRICAL SYSTEM
GENERAL INFORMATION 9-12
CHARGING CIRCUIT SERVICE 9-13
Troubleshooting 9-14
Rectifier Removal 9-15
Rectifier Installation 9-17
STATOR SERVICE 9-17
Removal 9-18
Installation 9-18
CHOKE CIRCUIT 9-19
ENRICHENER SYSTEM 9-20
CRANKING MOTOR CIRCUIT
Description & Operation 9-22
Troubleshooting 9-23
Removal 9-27

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9 ELECTRICAL (Continued)

Disassembling - Pinion Gear with Rubber Cushion 9-28
Assembling 9-28
Disassembling - Pinion Gear with Snap Ring or Nut 9-29
Assembling 9-30
Disassembling - Pinion Gear with Top Spring 9-31
Assembling 9-32
CRANKING MOTOR REPAIR 9-32
Disassembling 9-33
Testing Parts 9-34
Cleaning & Inspecting 9-36
Assembling a Bosch 9-41
Assembling a Delco Remy 9-41
Assembling a Prestolite 9-46

10 TRIM/TILT

INTRODUCTION 10-1
CHAPTER ORGANIZATION 10-2
MECHANICAL TILT PIN 10-2

SYSTEM "A" -- TWO TRIM/TILT CYLINDERS
Description and Operation 10-3
Special Instructions 10-5
Bleeding System "A" 10-6
Troubleshooting 10-7
Cleaning and Inspecting 10-9
System "A" Service 10-12
Pump Service 10-14
Electric Motor Service 10-17

SYSTEM "B" -- TWO TRIM CYLINDERS -- ONE TILT CYLINDER
Description and Operation 10-21
Bleeding System "B" 10-22
Flushing 10-23
Troubleshooting 10-24
System "B" Service 10-31
Preliminary Tasks 10-31
Removal 10-33
Component Service 10-34
Manual Release Valve 10-34
Oil Reservoir Cover 10-35
Trim Cylinder 10-35
Tilt Cylinder 10-36
Electric Motor 10-36
Cleaning and Inspecting 10-37
Assembling & Installation 10-38

SYSTEM "C" -- ONE TRIM/TILT CYLINDER
Description and Operation 10-53
Bleeding System "C" 10-54
Troubleshooting 10-54
System "C" Service 10-55
Pump Removal & Service 10-55
Cylinder Service 10-55

11 LOWER UNIT

DESCRIPTION 11-1
CHAPTER COVERAGE 11-1
TROUBLESHOOTING 11-5
LOWER UNIT REMOVAL
ALL UNITS 11-6
Propeller Removal 11-7
WATER PUMP SERVICE
Removal and Disassembling
High Pressure Type Pump 11-9
High Volume Type Pump 11-10

SERVICING CAM-SHIFT TYPE I UNITS MATCHED WITH EARLY 3-, 4-CYLINDER, L6 AND V6 POWERHEADS TO ABOUT 1979 11-12
Removal 11-12
Bearing Carrier and Propeller Shaft 11-13
Driveshaft & Bearing 11-14
Forward Gear & Bearing 11-16
Disassembling
Bearing Carrier 11-17
Propeller Shaft 11-18
Driveshaft 11-18
Assembling
Lower Driveshaft Bearing 11-23
Shift Shaft 11-23
Bearing Carrier 11-24
Forward Gear & Bearing 11-25
Forward Bearing Race 11-26
Driveshaft 11-27
Shimming & Backlash
Pinion Gear Depth 11-29
Forward Gear Backlash 11-30
Reverse Gear Backlash 11-34
Assembling & Installation
Bearing Carrier 11-33

SERVICING CAM-SHIFT TYPE II UNITS MATCHED WITH LATE 3-, 4-CYLINDER, AND L6 POWERHEADS FROM ABOUT 1980 11-35

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Removal and Disassembling
- Bearing Carrier 11-36
- Propeller Shaft 11-37
- Shift Shaft 11-38
- Pinion Gear 11-39
- Driveshaft 11-39
- Forward Gear 11-40
- Pinion Gear Bearing Race 11-41
- Forward Bearing Race 11-41
- Driveshaft Bearing 11-41

Assembling and Installation
- Driveshaft Bearing 11-44
- Pinion Gear Bearing Race 11-45
- Forward Bearing Race 11-45
- Shift Shaft 11-46
- Forward Gear 11-46
- Driveshaft 11-47
- Pinion Gear 11-47
- Propeller Shaft 11-48
- Bearing Carrier 11-49

Pinion Gear Depth 11-50
Forward Gear Backlash 11-51

SERVICING E-Z SHIFT MODELS SINCE ABOUT 1979
Special Words 11-53
Removal
- Bearing Carrier 11-53
- Propeller Shaft 11-55
- Driveshaft & Bearing 11-56
- Separate Forward Gear from Bearing 11-60

Disassembling
- Driveshaft 11-60
- Separate Reverse Gear from Bearing Carrier 11-61

Assembling & Installation
- Lower Driveshaft Bearing 11-61
- Bearing Carrier 11-61
- Forward Gear & Bearing 11-64
- Forward Bearing Race 11-65
- Propeller Shaft 11-66
- Driveshaft 11-71

Shimming
- Pinion Gear Depth 11-75
- Forward Gear Backlash 11-76
- Alpha Drive 11-78

WATER PUMP ASSEMBLING AND INSTALLATION 11-81
High Pressure Type Pump 11-81
- Shimming (Certain Units) 11-81

High Volume Type Pump 11-85

CLEANING AND INSPECTING ALL UNITS 11-86

LOWER UNIT INSTALLATION
- Filling Lower Unit 11-88
- Assembling & Installation 11-89
- Propeller Installation 11-92

12 REMOTE CONTROLS

INTRODUCTION 12-1
COMMANDER CONTROL BOX
- Removal & Disassembling 12-2
- Cleaning & Inspecting 12-9
- Assembling & Installation 12-11

13 HAND REWIND STARTER

INTRODUCTION 13-1

TYPE **"A"** (See Introduction) 13-2
- Removal and Disassembling 13-2
- Cleaning and Inspecting 13-4
- Assembling and Installation 13-6

TYPE **"B"** (See Introduction) 13-6
- Removal and Disassembling 13-13
- Cleaning and Inspecting 13-16
- Assembling and Installation 13-17

APPENDIX

METRIC CONVERSION CHART A-1
ENGINE SPECIFICATIONS AND TUNE-UP ADJUSTMENTS A-2
REED STOP OPENING A-10
PISTON AND CYLINDER SPECS. A-11
LOWER UNIT BACKLASH TABLE A-12
LOWER UNIT OIL CAPACITY AND GEAR CHART A-13
CARBURETOR JET SIZE/ ELEVATION CHARTS A-14

WIRE IDENTIFICATION DWGS.
- Ignition Systems A-17 thru A-24
- Type "B" Trim/Tilt A-25
- Type "C" Trim/Tilt A-26
- Commander Control Box A-27

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1
SAFETY

1-1 INTRODUCTION

In order to protect the investment for the boat and outboard, they must be cared for properly while being used and when out of the water. Always store the boat with the bow higher than the stern and be sure to remove the transom drain plug and the inner hull drain plugs. If any type of cover is used to protect the boat, be sure to allow for some movement of air through the hull. Proper ventilation will assure evaporation of any condensation that may form due to changes in temperature and humidity.

1-2 CLEANING, WAXING, AND POLISHING

Any boat should be washed with clear water after each use to remove surface dirt and any salt deposits from use in salt water. Regular rinsing will extend the time between waxing and polishing. It will also give you "pride of ownership", by having a sharp looking piece of equipment. Elbow grease, a mild detergent, and a brush will be required to remove stubborn dirt, oil, and other unsightly deposits.

Stay away from harsh abrasives or strong chemical cleaners. A white buffing com-



A clean boat, properly tuned outboard unit, and attention to sensible safety practices are what make: "The worst day fishin' better than the best day workin'."

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pound can be used to restore the original gloss to a scratched, dull, or faded area. The finish of your boat should be thoroughly cleaned, buffed, and polished at least once each season. Take care when buffing or polishing with a marine cleaner not to overheat the surface you are working, because you will burn it.

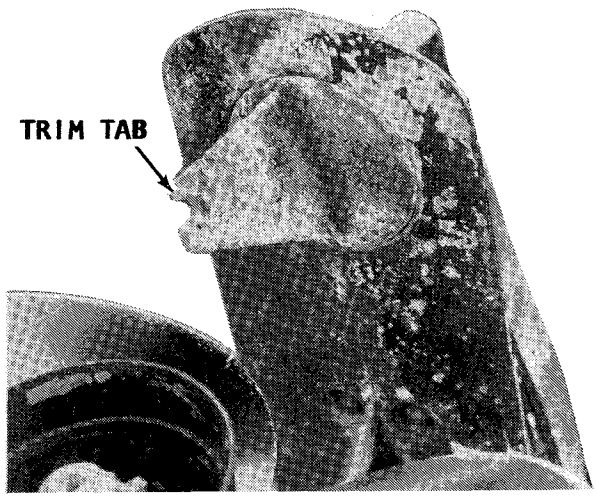
1-3 CONTROLLING CORROSION

Since man first started out on the water, corrosion on his craft has been his enemy. The first form was merely rot in the wood and then it was rust, followed by other forms of destructive corrosion in the more modern materials. One defense against corrosion is to use similar metals throughout the boat. Even though this is difficult to do in designing a new boat, particularly the undersides, similar metals should be used whenever and wherever possible.

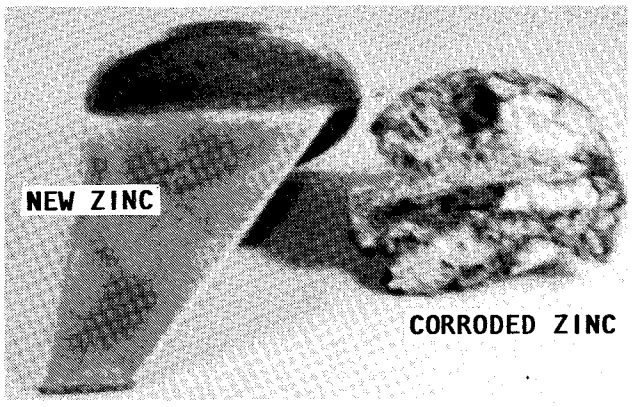
A second defense against corrosion is to insulate dissimilar metals. This can be done by using an exterior coating of Sea Skin or by insulating them with plastic or rubber gaskets.

Using Zinc

The proper amount of zinc attached to a boat is extremely important. The use of too much zinc can cause wood burning by placing the metals close together and they become "hot". On the other hand, using too small a zinc plate will cause more rapid deterioration of the metal you are trying to protect. If in doubt, consider the fact that it is far better to replace the zincs than to replace planking or other expensive metal parts from having an excess of zinc.



Zinc installation also used as the trim tab. The tab assists the helmsperson to maintain a true course without "fighting" the wheel.



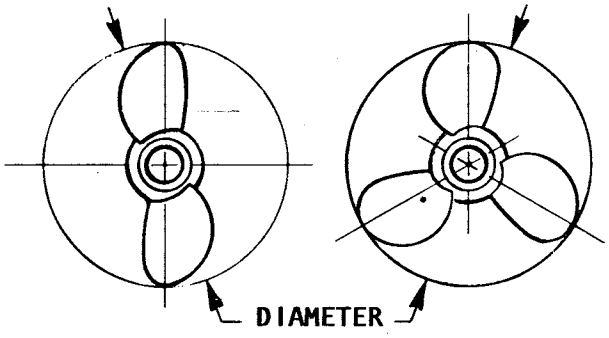
A new trim tab zinc, left, and a corroded zinc, right. An excellent example of the inexpensive zinc saving more costly parts of the outboard unit.

When installing zinc plates, there are two routes available. One is to install many different zincs on all metal parts and thus run the risk of wood burning. Another route, is to use one large zinc on the transom of the boat and then connect this zinc to every underwater metal part through internal bonding. Of the two choices, the one zinc on the transom is the better way to go.

Small outboard engines have a zinc plate attached to the cavitation plate. Therefore, the zinc remains with the engine at all times.

1-4 PROPELLERS

As you know, the propeller is actually what moves the boat through the water. This is how it is done. The propeller operates in water in much the manner as a wood screw does in wood. The propeller "bites" into the water as it rotates. Water passes between the blades and out to the rear in the shape of a cone. The propeller "biting" through the water in much the same manner as a wood auger is what propels the boat.



Diameter and pitch are the two basic dimensions of a propeller. The diameter is measured across the circumference of a circle scribed by the propeller blades, as shown.

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Diameter and Pitch

Only two dimensions of the propeller are of real interest to the boat owner: the diameter and the pitch. These two dimensions are stamped on the propeller hub and always appear in the same order: the diameter first and then the pitch. For instance, the number 15-19 stamped on the hub, would mean the propeller had a diameter of 15 inches with a pitch of 19.

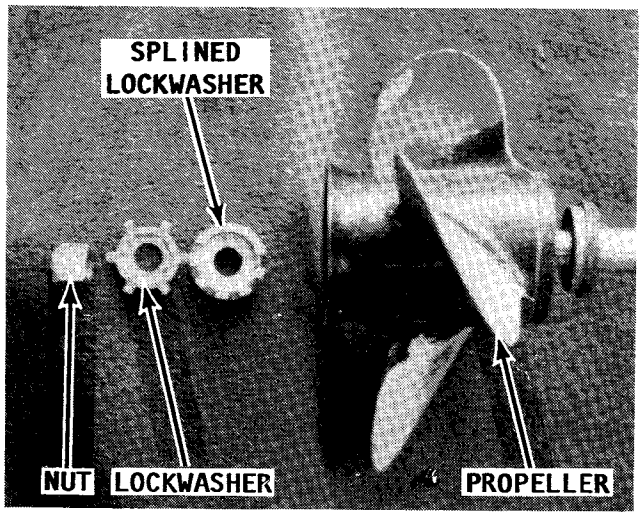
The diameter is the measured distance from the tip of one blade to the tip of the other as shown in the accompanying illustration.

The pitch of a propeller is the angle at which the blades are attached to the hub. This figure is expressed in inches of water travel for each revolution of the propeller. In our example of a 15-19 propeller, the propeller should travel 19 inches through the water each time it revolves. If the propeller action was perfect and there was no slippage, then the pitch multiplied by the propeller rpms would be the boat speed.

Most outboard manufacturers equip their units with a standard propeller with a diameter and pitch they consider to be best suited to the engine and the boat. Such a propeller allows the engine to run as near to the rated rpm and horsepower (at full throttle) as possible for the boat design.

The blade area of the propeller determines its load-carrying capacity. A two-blade propeller is used for high-speed running under very light loads.

A four-blade propeller is installed in boats intended to operate at low speeds under very heavy loads such as tugs, barges, or large houseboats. The three-blade propeller is the happy medium covering the wide range between the high performance units and the load carrying workhorses.



Typical attaching hardware for a propeller.

Propeller Selection

There is no standard propeller that will do the proper job in very many cases. The list of sizes and weights of boats is almost endless. This fact coupled with the many boat-engine combinations makes the propeller selection for a specific purpose a difficult job. In fact, in many cases the propeller is changed after a few test runs. Proper selection is aided through the use of charts set up for various engines and boats. These charts should be studied and understood when buying a propeller. However, bear in mind, the charts are based on average boats with average loads, therefore, it may be necessary to make a change in size or pitch, in order to obtain the desired results for the hull design or load condition.

Propellers are available with a wide range of pitch. Remember, a low pitch takes a smaller bite of the water than the high pitch propeller. This means the low pitch propeller will travel less distance through the water per revolution. The low

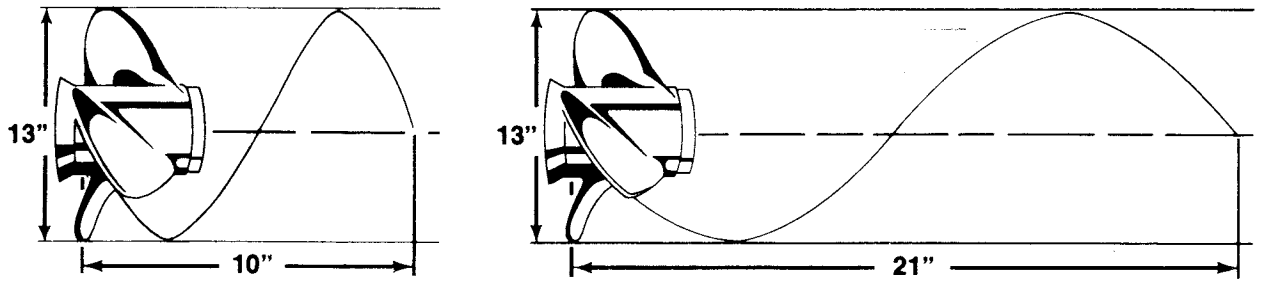


Diagram to explain the pitch dimension of a propeller. The pitch is the theoretical distance a propeller would travel through water if there were no friction.

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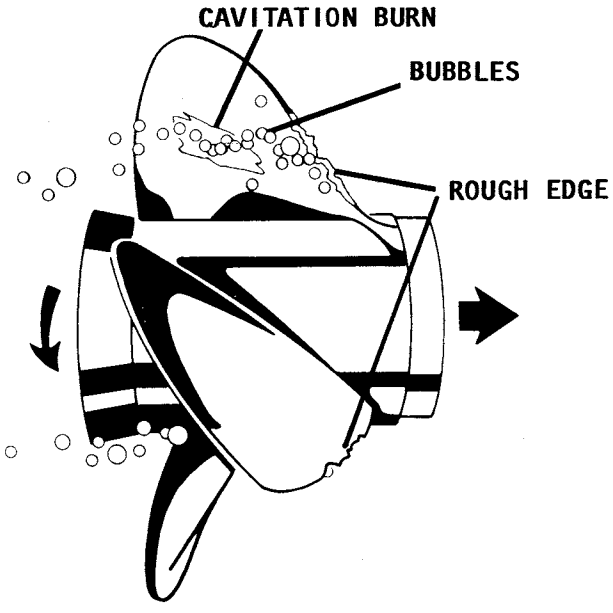
pitch will require less horsepower and will allow the engine to run faster.

All engine manufacturers design their units to operate with full throttle at, or slightly above, the rated rpm. If you run your engine at the rated rpm, you will increase spark plug life, receive better fuel economy, and obtain the best performance from your boat and engine. Therefore, take time to make the proper propeller selection for the rated rpm of your engine at full throttle with what you consider to be an average load. Your boat will then be correctly balanced between engine and propeller throughout the entire speed range.

A reliable tachometer must be used to measure engine speed at full throttle to ensure the engine will achieve full horsepower and operate efficiently and safely. To test for the correct propeller, make your run in a body of smooth water with the lower unit in forward gear at full throttle. If the reading is above the manufacturer's recommended operating range, you must try propellers of greater pitch, until you find the one that allows the engine to operate continually within the recommended full throttle range.

If the engine is unable to deliver top performance and you feel it is properly tuned, then the propeller may not be to blame. Operating conditions have a marked effect on performance. For instance, an engine will lose rpm when run in very cold water. It will also lose rpm when run in salt water as compared with fresh water. A hot, low-barometer day will also cause your engine to lose power.



Cavitation (air bubbles) formed at the propeller. Manufacturers are constantly fighting this problem, as explained in the text.

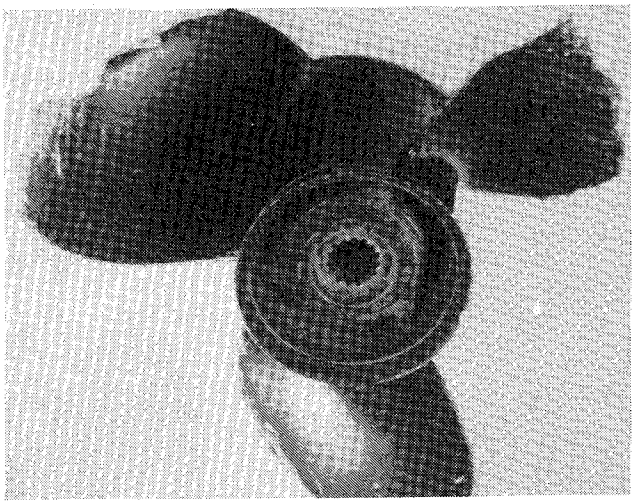
Cavitation

Cavitation is the forming of voids in the water just ahead of the propeller blades. Marine propulsion designers are constantly fighting the battle against the formation of these voids due to excessive blade tip speed and engine wear. The voids may be filled with air or water vapor, or they may actually be a partial vacuum. Cavitation may be caused by installing a piece of equipment too close to the lower unit, such as the knot indicator pickup, depth sounder, or bait tank pickup.

Vibration

Your propeller should be checked regularly to be sure all blades are in good condition. If any of the blades become bent or nicked, this condition will set up vibrations in the drive unit and the motor. If the vibration becomes very serious it will cause a loss of power, efficiency, and boat performance. If the vibration is allowed to continue over a period of time it can have a damaging effect on many of the operating parts.

Vibration in boats can never be completely eliminated, but it can be reduced by keeping all parts in good working condition and through proper maintenance and lubrication. Vibration can also be reduced in



Example of a damaged propeller. This unit should have been replaced long before this amount of damage was sustained.

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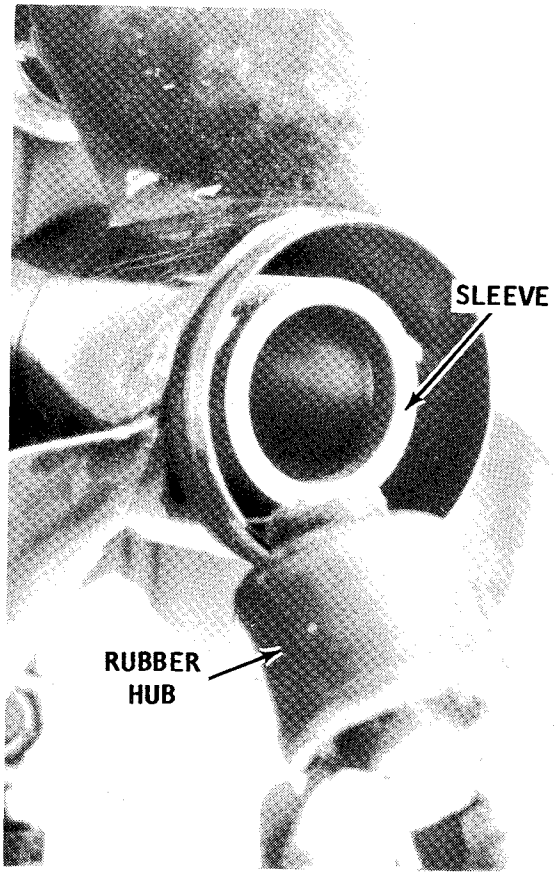
some cases by increasing the number of blades. For this reason, many racers use two-blade props and luxury cruisers have four- and five-blade props installed.

Shock Absorbers

The shock absorber in the propeller plays a very important role in protecting the shafting, gears, and engine against the shock of a blow, should the propeller strike an underwater object. The shock absorber allows the propeller to stop rotating at the instant of impact while the power train continues turning.

How much impact the propeller is able to withstand, before causing the shock absorber to slip, is calculated to be more than the force needed to propel the boat, but less than the amount that could damage any part of the power train. Under normal propulsion loads of moving the boat through the water, the hub will not slip. However, it will slip if the propeller strikes an object with a force that would be great enough to stop any part of the power train.

If the power train was to absorb an impact great enough to stop rotation, even for an instant, something would have to give and be damaged. If a propeller is subjected to repeated striking of underwater objects, it would eventually slip on its clutch hub under normal loads. If the propeller should start to slip, a new shock absorber/cushion hub would have to be installed.



Rubber hub removed from the propeller because the hub was slipping in the propeller.

Propeller Rake

If a propeller blade is examined on a cut extending directly through the center of the hub, and if the blade is set vertical to the propeller hub, as shown in the accompanying illustration, the propeller is said to have a zero degree (0°) rake. As the blade slants back, the rake increases. Standard propellers have a rake angle from 0° to 15°.

A higher rake angle generally improves propeller performance in a cavitating or ventilating situation. On lighter, faster boats, higher rake often will increase performance by holding the bow of the boat higher.

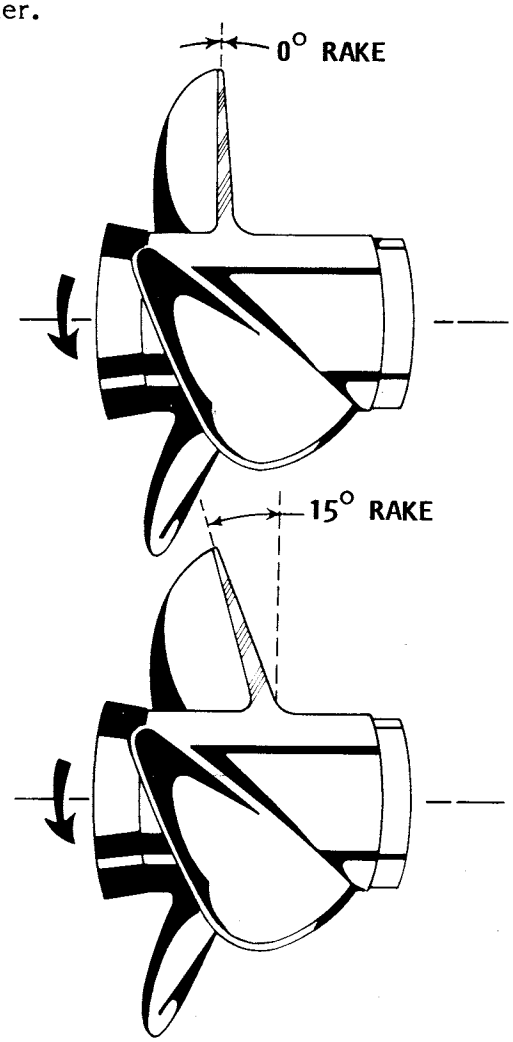


Illustration depicting the rake of a propeller, as explained in the text.

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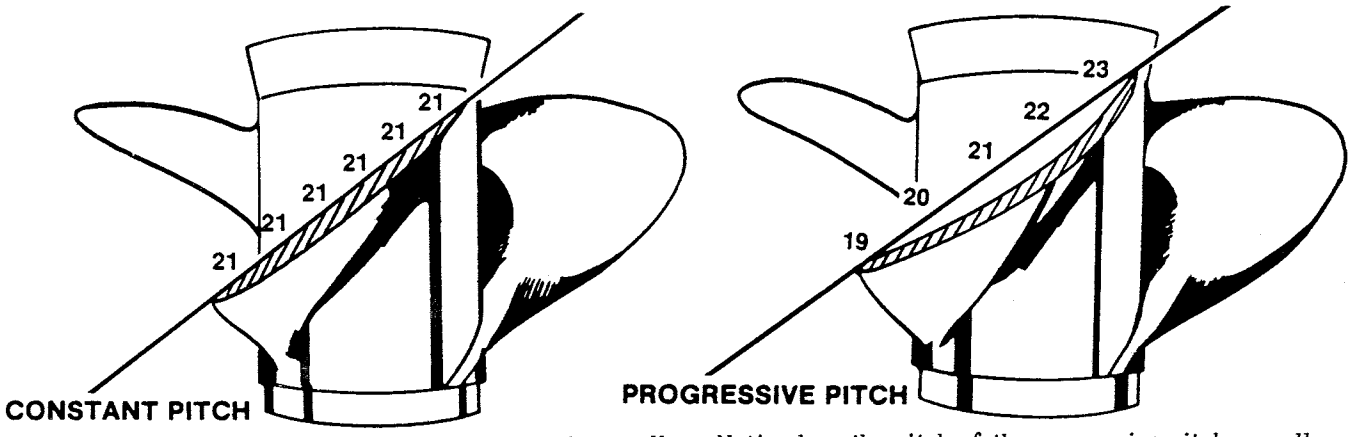


Comparison of a constant and progressive pitch propeller. Notice how the pitch of the progressive pitch propeller, right, changes to give the blade more thrust and therefore, the boat more speed.

Progressive Pitch

Progressive pitch is a blade design innovation that improves performance when forward and rotational speed is high and/or the propeller breaks the surface of the water.

Progressive pitch starts low at the leading edge and progressively increases to the trailing edge, as shown in the accompanying illustration. The average pitch over the entire blade is the number assigned to that propeller. In the illustration of the progressive pitch, the average pitch assigned to the propeller would be 21.

Cupping

If the propeller is cast with an edge curl inward on the trailing edge, the blade is said to have a cup. In most cases, cupped blades improve performance. The cup helps the blades to **"HOLD"** and not break loose, when operating in a cavitating or ventilating situation.

The cup has the effect of adding to the propeller pitch. Cupping usually will reduce full-throttle engine speed about 150 to 300 rpm below the same pitch propeller without a cup to the blade. A propeller repair shop is able to increase or decrease the cup on the blades. This change, as explained, will alter engine rpm to meet specific operating demands. Cups are rapidly becoming standard on propellers.

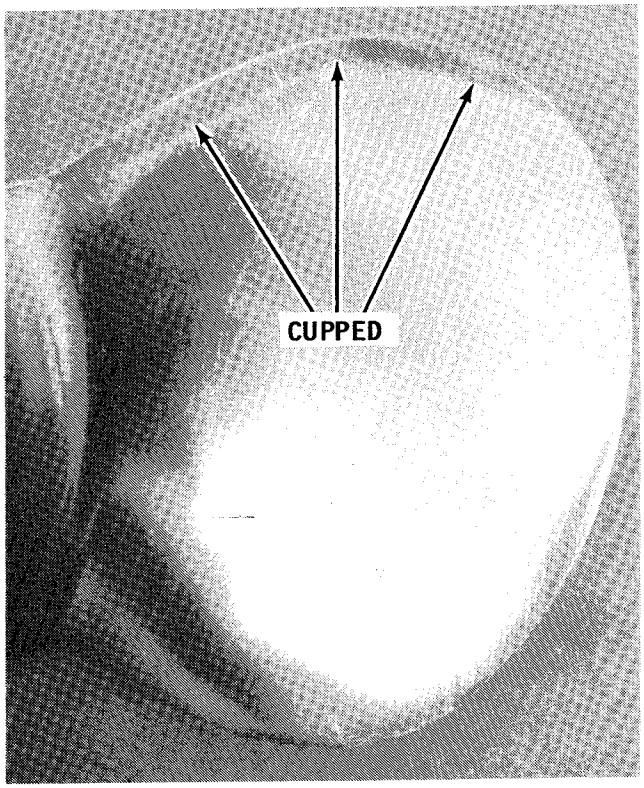
In order for a cup to be the most effective, the cup should be completely concave (hollowed) and finished with a sharp corner. If the cup has any convex rounding, the effectiveness of the cup will be reduced.

Rotation

Propellers are manufactured as right-hand rotation (RH), and as left-hand rotation (LH). The standard propeller for outboard units is RH rotation.

A right-hand propeller can easily be identified by observing it as shown in the accompanying illustration. Observe how the blade of the right-hand propeller slants from the lower left to upper right. The left-hand propeller slants in the opposite direction, from lower right to upper left.

When the RH propeller is observed rotating from astern the boat, it will be rotating clockwise when the engine is in forward gear. The left-hand propeller will rotate counterclockwise.



Propeller with a "cupped" leading edge. "Cupping" gives the propeller a better "hold" in the water.

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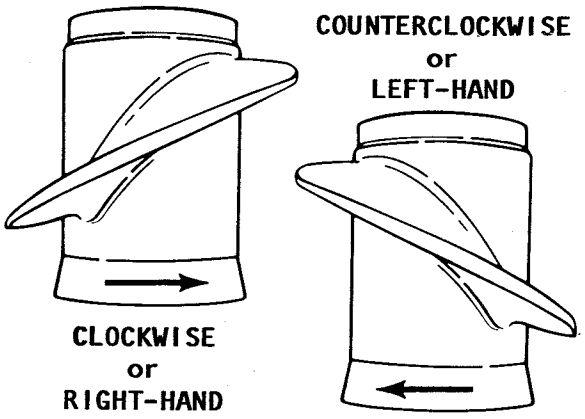


Right- and left-hand propellers showing how the angle of the blades is reversed. Right-hand propellers are by far the most popular for outboard units.

1-5 FUEL SYSTEM

With Built-in Fuel Tank

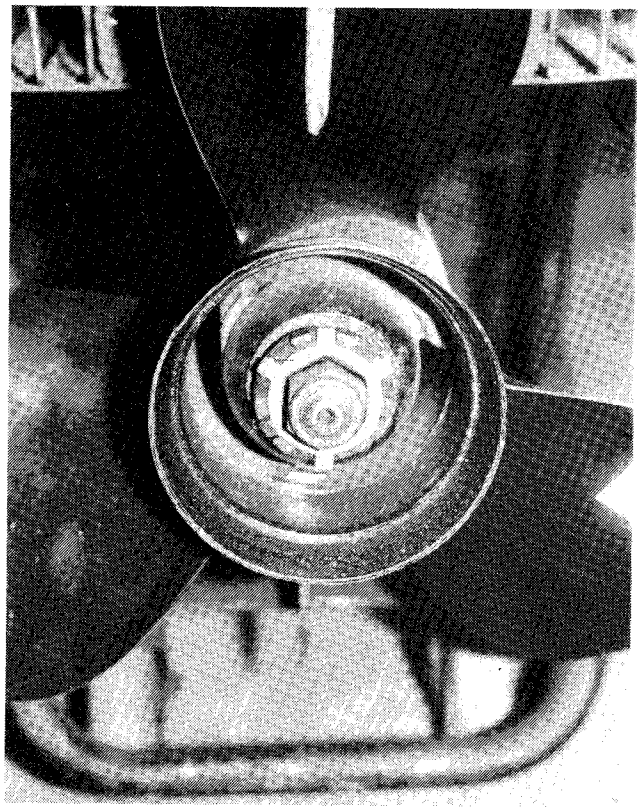
All parts of the fuel system should be selected and installed to provide maximum service and protection against leakage. Reinforced flexible sections should be installed in fuel lines where there is a lot of motion, such as at the engine connection. The flaring of copper tubing should be annealed after it is formed as a protection against hardening.

CAUTION: Compression fittings should **NOT** be used because they are so easily overtightened, which places them under a strain and subjects them to fatigue. Such conditions will cause the fitting to leak after it is connected a second time.

The capacity of the fuel filter must be large enough to handle the demands of the engine as specified by the engine manufacturer.

A manually-operated valve should be installed if anti-siphon protection is not provided. This valve should be installed in the fuel line as close to the gas tank as possible. Such a valve will maintain anti-siphon protection between the tank and the engine.

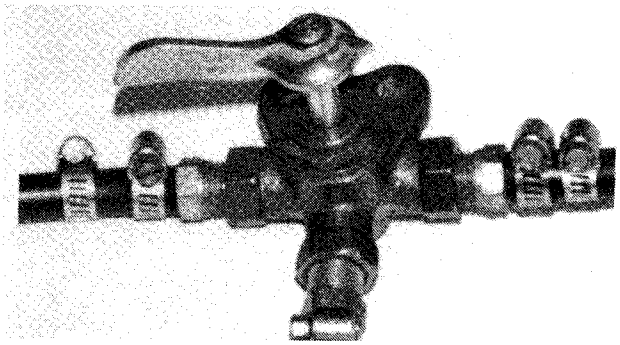
The supporting surfaces and hold-downs must fasten the tank firmly and they should be insulated from the tank surfaces. This insulation material should be non-abrasive and nonabsorbent material. Fuel tanks installed in the forward portion of the boat should be especially well secured and protected because shock loads in this area can be as high as 20 to 25 g's ("g" equals force of gravity).



Typical propeller exhaust hub. This arrangement of exhaust gases passing through the hub results in a much quieter engine operation and the fumes are buried far behind the boat.

Taking On Fuel

The fuel tank of the boat should be kept full to prevent water from entering the system through condensation caused by temperature changes. Water droplets forming is one of the greatest enemies of the fuel system. By keeping the tank full, the air space in the tank is kept to an absolute minimum and there is no room for moisture to form. It is a good practice not to store



A three-position valve permits fuel to be drawn from either of two tanks or shut off completely. Such an arrangement prevents accidental siphoning of fuel from the tank. The inside diameter of the valve should be at 5/16" (7.94mm).

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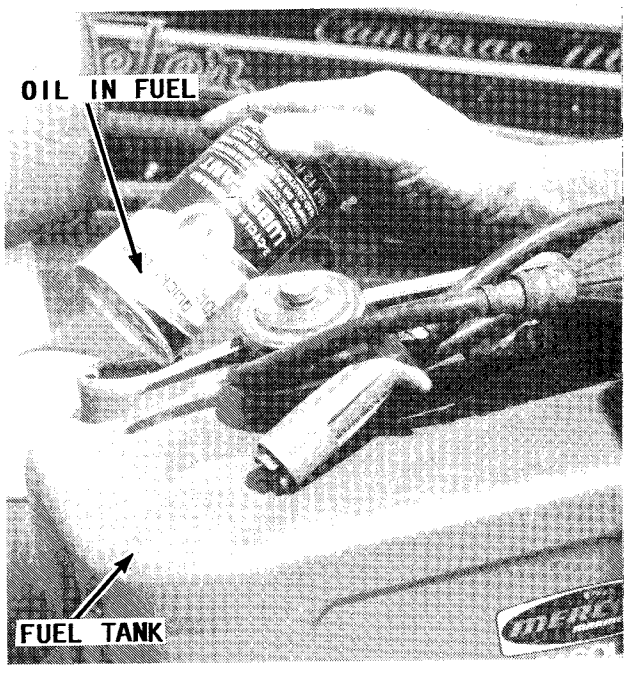
fuel in the tank over an extended period, say for six months. Today, fuels contain ingredients that change into gums when stored for any length of time. These gums and varnish products will cause carburetor problems and poor spark plug performance. An additive (Sta-Bil) is available and can be used to prevent gums and varnish from forming.

Static Electricity

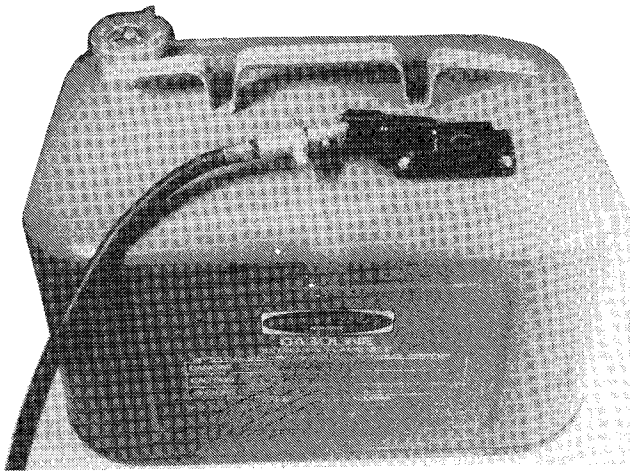
In very simple terms, static electricity is called frictional electricity. It is generated by two dissimilar materials moving over each other. One form is gasoline flowing through a pipe or into the air. Another form is when you brush your hair or walk across a synthetic carpet and then touch a metal object. All of these actions cause an electrical charge. In most cases, static electricity is generated during very dry weather conditions, but when you are filling the fuel tank on a boat it can happen at any time.

Fuel Tank Grounding

One area of protection against the build-up of static electricity is to have the fuel tank properly grounded (also known as bonding). A direct metal-to-metal contact from the fuel hose nozzle to the water in which the boat is floating. If the fill pipe is made of metal, and the fuel nozzle makes a good contact with the deck plate, then a good ground is made.



Any tank should contain some fuel when taking on fuel before oil is added. Just a little fuel will prevent the oil from accumulating on the bottom surface of the tank.



An approved fuel tank equipped with a quick-disconnect fitting. This type arrangement is handy when the tank must be removed from the boat to obtain fuel.

As an economy measure, some boats use rubber or plastic filler pipes because of compound bends in the pipe. Such a fill line does not give any kind of ground and if your boat has this type of installation and you do not want to replace the filler pipe with a metal one, then it is possible to connect the deck fitting to the tank with a copper wire. The wire should be 8 gauge or larger.

The fuel line from the tank to the engine should provide a continuous metal-to-metal contact for proper grounding. If any part of this line is plastic or other non-metallic material, then a copper wire must be connected to bridge the non-metal material. The power train provides a ground through the engine and drive shaft, to the propeller in the water.

Fiberglass fuel tanks pose problems of their own. Fortunately, this material has almost totally disappeared as a suitable substance for fuel tanks. If, however, the boat you are servicing, does have a fiberglass tank, or one is being installed, or repaired, it is almost mandatory that you check with the Coast Guard Recreational Boating Standards Office in your district before proceeding with any work. The new standards are very specific and the Coast Guard is extremely rigid about enforcing the regulations.

Anything you can feel as a "shock" is enough to set off an explosion. Did you know that under certain atmospheric con-

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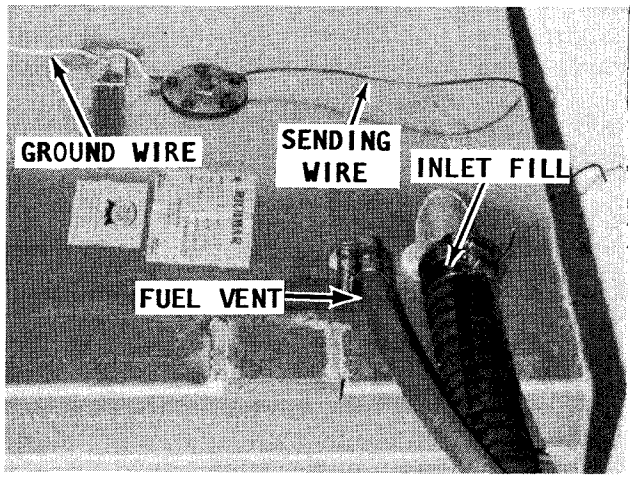


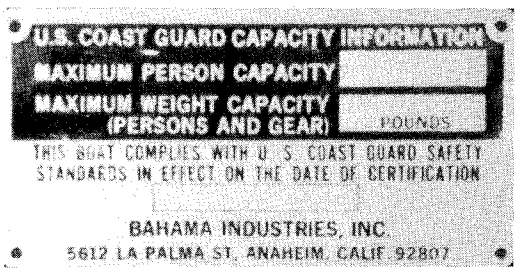
A fuel tank properly grounded to prevent static electricity. Static electricity could be extremely dangerous when taking on fuel.

ditions you can cause a static explosion yourself, particularly if you are wearing synthetic clothing. It is almost a certainty you could cause a static spark if you are **NOT** wearing insulated rubber-soled shoes.

As soon as the deck fitting is opened, fumes are released to the air. Therefore, to be safe you should ground yourself before opening the fill pipe deck fitting. One way to ground yourself is to dip your hand in the water overside to discharge the electricity in your body before opening the filler cap. Another method is to touch the engine block or any metal fitting on the dock which goes down into the water.

1-6 LOADING

In order to receive maximum enjoyment, with safety and performance, from your boat, take care not to exceed the load capacity given by the manufacturer. A plate attached to the hull indicates the U.S. Coast Guard capacity information in pounds for persons and gear. If the plate states the maximum person capacity to be 750 pounds and you assume each person to weigh an average of 150 lbs., then the boat could carry five persons safely. If you add another 250 lbs. for motor and gear, and the maximum weight capacity for persons and gear is 1,000 lbs. or more, then the five persons and gear would be within the limit.



U.S. Coast Guard plate affixed to all new boats. When the blanks are filled in, the plate will indicate the Coast Guard's recommendations for persons, gear, and horsepower to ensure safe operation of the boat. These recommendations should not be exceeded, as explained in the text.

Try to load the boat evenly port and starboard. If you place more weight on one side than on the other, the boat will list to the heavy side and make steering difficult. You will also get better performance by placing heavy supplies aft of the center to keep the bow light for more efficient planing.

Clarification

Much confusion arises from the terms, certification, requirements, approval, regulations, etc. Perhaps the following may clarify a couple of these points.

1- The Coast Guard does not approve boats in the same manner as they "Approve" life jackets. The Coast Guard applies a formula to inform the public of what is safe for a particular craft.

2- If a boat has to meet a particular regulation, it must have a Coast Guard certification plate. The public has been led to believe this indicates approval of the Coast Guard. Not so.

3- The certification plate means a willingness of the manufacturer to meet the Coast Guard regulations for that particular craft. The manufacturer may recall a boat if it fails to meet the Coast Guard requirements.

4- The Coast Guard certification plate, see accompanying illustration, may or may not be metal. The plate is a regulation for the manufacturer. It is only a warning plate and the public does not have to adhere to the restrictions set forth on it. Again, the plate sets forth information as to the Coast Guard's opinion for safety on that particular boat.

5- Coast Guard Approved equipment is equipment which has been approved by the Commandant of the U.S. Coast Guard and has been determined to be in compliance with Coast Guard specifications and regulations relating to the materials, construction, and performance of such equipment.

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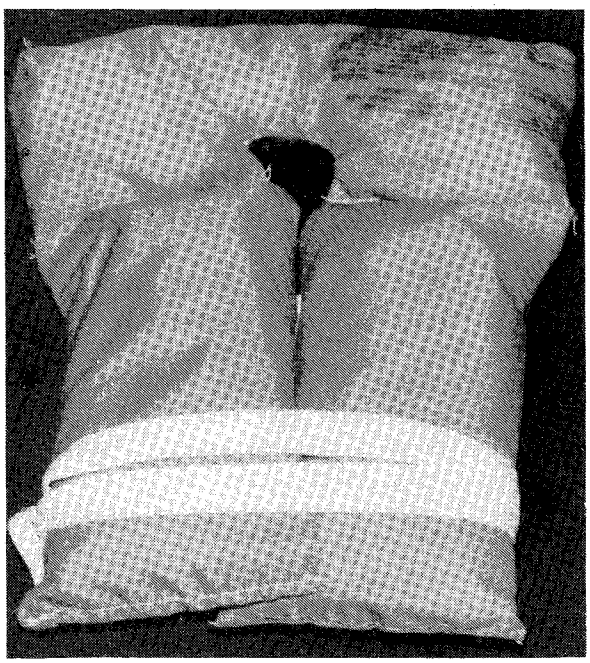
1-7 HORSEPOWER

The maximum horsepower engine for each individual boat should not be increased by any great amount without checking requirements from the Coast Guard in your area. The Coast Guard determines horsepower requirements based on the length, beam, and depth of the hull. **TAKE CARE NOT** to exceed the maximum horsepower listed on the plate or the warranty, and possibly the insurance, on the boat may become void.

1-8 FLOTATION

If your boat is less than 20 ft. overall, a Coast Guard or BIA (Boating Industry of America), now changed to NMMA (National Marine Manufacturers Association), requirement is that the boat must have buoyant material built into the hull (usually foam) to keep it from sinking if it should become swamped. Coast Guard requirements are mandatory but the NMMA is voluntary.

"Kept from sinking" is defined as the ability of the flotation material to keep the boat from sinking when filled with water and with passengers clinging to the hull. One restriction is that the total weight of the motor, passengers, and equipment aboard does not exceed the maximum load capacity listed on the plate.



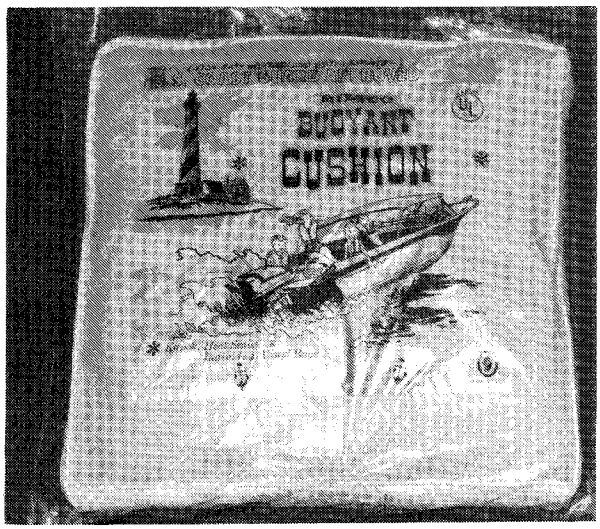
*Type I PFD Coast Guard approved life jacket. This type flotation device provides the greatest amount of buoyancy. **NEVER** use them for cushions or other purposes.*

Life Preservers --Personal Flotation Devices (PFDs)

The Coast Guard requires at least one Coast Guard approved life-saving device be carried on board all motorboats for each person on board. Devices approved are identified by a tag indicating Coast Guard approval. Such devices may be life preservers, buoyant vests, ring buoys, or buoyant cushions. Cushions used for seating are serviceable if air cannot be squeezed out of it. Once air is released when the cushion is squeezed, it is no longer fit as a flotation device. New foam cushions dipped in a rubberized material are almost indestructable.

Life preservers have been classified by the Coast Guard into five type categories. All PFDs presently acceptable on recreational boats fall into one of these five designations. All PFDs **MUST** be U.S. Coast Guard approved, in good and serviceable condition, and of an appropriate size for the persons who intend to wear them. Wearable PFDs **MUST** be readily accessible and throwable devices **MUST** be immediately available for use.

Type I PFD has the greatest required buoyancy and is designed to turn most **UNCONSCIOUS** persons in the water from a face down position to a vertical or slightly



A Type IV PFD cushion device intended to be thrown to a person in the water. If air can be squeezed out of the cushion, it is no longer fit for service as a PFD.

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backward position. The adult size device provides a minimum buoyancy of 22 pounds and the child size provides a minimum buoyancy of 11 pounds. The Type I PFD provides the greatest protection to its wearer and is most effective for all waters and conditions.

Type II PFD is designed to turn its wearer in a vertical or slightly backward position in the water. The turning action is not as pronounced as with a Type I. The device will not turn as many different type persons under the same conditions as the Type I. An adult size device provides a minimum buoyancy of 15½ pounds, the medium child size provides a minimum of 11 pounds, and the infant and small child sizes provide a minimum buoyancy of 7 pounds.

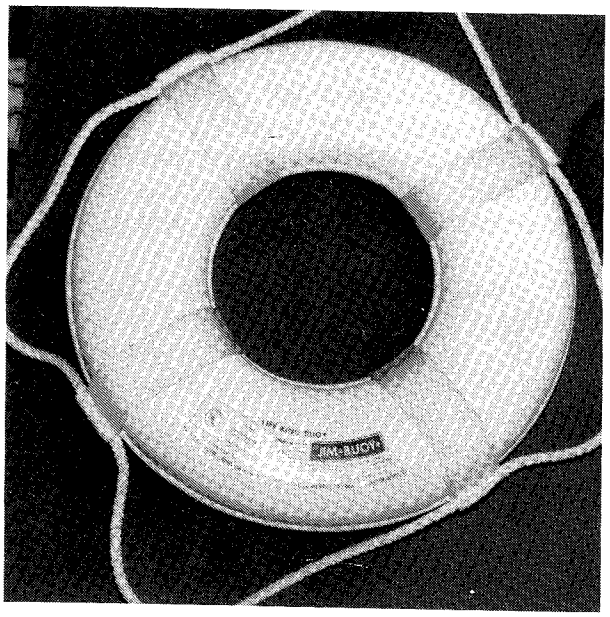
Type III PFD is designed to permit the wearer to place himself (herself) in a vertical or slightly backward position. The Type III device has the same buoyancy as the Type II PFD but it has little or no turning ability. Many of the Type III PFD are designed to be particularly useful when water skiing, sailing, hunting, fishing, or engaging in other water sports. Several of this type will also provide increased hypothermia protection.

Type IV PFD is designed to be thrown to a person in the water and grasped and held by the user until rescued. It is **NOT** designed to be worn. The most common Type IV PFD is a ring buoy or a buoyant cushion.

Type V PFD is any PFD approved for restricted use.

Coast Guard regulations state, in general terms, that on all boats less than 16 ft. overall, one Type I, II, III, or IV device shall be carried on board for each person in the boat. On boats over 26 ft., one Type I, II, or III device shall be carried on board for each person in the boat **plus** one Type IV device.

It is an accepted fact that most boating people own life preservers, but too few actually wear them. There is little or no excuse for not wearing one because the modern comfortable designs available today do not subtract from an individual's boating pleasure. Make a life jacket available to your crew and advise each member to wear it. If you are a crew member ask your skipper to issue you one, especially when boating in rough weather, cold water, or when running at high speed. Naturally, a life jacket should be a must for non-swimmers any time they are out on the water in a boat.



Type IV ring buoy also designed to be thrown to a person in the water. On ocean cruisers, this type device usually has a weighted pole with flag and light attached to the buoy.



Moisture-protected flares should be carried on board for use as a distress signal.

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1-9 EMERGENCY EQUIPMENT

Visual Distress Signals
The Regulation

Since January 1, 1981, Coast Guard Regulations require all recreation boats when used on coastal waters, which includes the Great Lakes, the territorial seas and those waters directly connected to the Great Lakes and the territorial seas, up to a point where the waters are less than two miles wide, and boats owned in the United States, when operating on the high seas, to be equipped with visual distress signals.

The only exceptions are during daytime (sunrise to sunset) for:

Recreational boats less than 16 ft. (5 meters) in length.

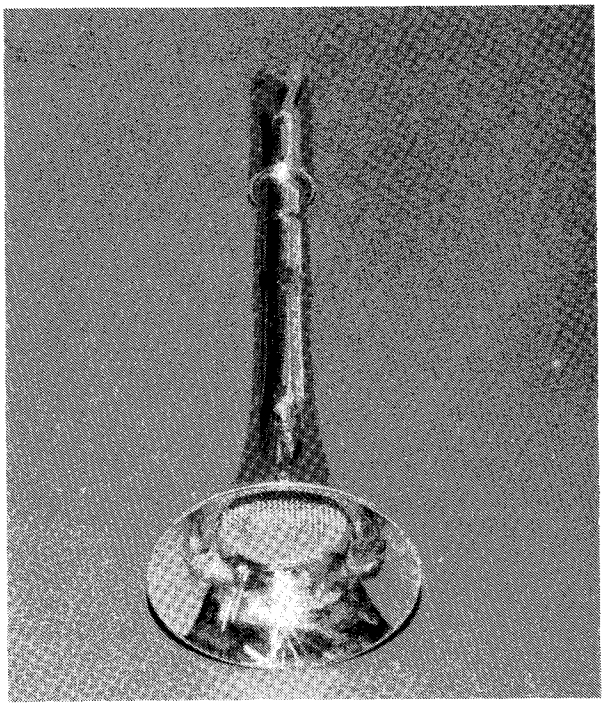
Boats participating in organized events such as races, regattas or marine parades.

Open sailboats not equipped with propulsion machinery and less than 26 ft. (8 meters) in length.

Manually propelled boats.

The above listed boats need to carry night signals when used on these waters at night.

Pyrotechnic visual distress signaling devices **MUST** be Coast Guard Approved, in serviceable condition and stowed to be readily accessible. If they are marked with a date showing the serviceable life, this date must not have passed. Launchers, produced before Jan. 1, 1981, intended for use with approved signals are not required to be Coast Guard Approved.



A sounding device should be mounted close to the helmsperson for use in sounding an emergency alarm.

USCG Approved pyrotechnic visual distress signals and associated devices include:

Pyrotechnic red flares, hand held or aerial.

Pyrotechnic orange smoke, hand held or floating.

Launchers for aerial red meteors or parachute flares.

Non-pyrotechnic visual distress signaling devices must carry the manufacturer's certification that they meet Coast Guard requirements. They must be in serviceable condition and stowed so as to be readily accessible.

This group includes:

Orange distress flag at least 3 x 3 feet with a black square and ball on an orange background.

Electric distress light -- not a flashlight but an approved electric distress light which **MUST** automatically flash the international **SOS** distress signal (. . . - - - . . .) four to six times each minute.

Types and Quantities

The following variety and combination of devices may be carried in order to meet the requirements.

1- Three hand-held red flares (day and night).

2- One electric distress light (night only).

3- One hand-held red flare and two parachute flares (day and night).

4- One hand-held orange smoke signal, two floating orange smoke signals (day) and one electric distress light (day and night).

If young children are frequently aboard your boat, careful selection and proper stowage of visual distress signals becomes especially important. If you elect to carry pyrotechnic devices, you should select those in tough packaging and not easy to ignite should the devices fall into the hands of children.

Coast Guard Approved pyrotechnic devices carry an expiration date. This date can **NOT** exceed 42 months from the date of manufacture and at such time the device can no longer be counted toward the minimum requirements.

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SPECIAL WORDS

In some states the launchers for meteors and parachute flares may be considered a firearm. Therefore, check with your state authorities before acquiring such a launcher.

First Aid Kits

The first-aid kit is similar to an insurance policy or life jacket. You hope you don't have to use it but if needed, you want it there. It is only natural to overlook this essential item because, let's face it, who likes to think of unpleasantness when planning to have only a good time. However, the prudent skipper is prepared ahead of time, and is thus able to handle the emergency without a lot of fuss.

Good commercial first-aid kits are available such as the Johnson and Johnson "Marine First-Aid Kit". With a very modest expenditure, a well-stocked and adequate kit can be prepared at home.

Any kit should include instruments, supplies, and a set of instructions for their use. Instruments should be protected in a watertight case and should include: scissors, tweezers, tourniquet, thermometer, safety pins, eye-washing cup, and a hot water bottle. The supplies in the kit should include: assorted bandages in addition to the various sizes of "band-aids", adhesive tape, absorbent cotton, applicators, petroleum jelly, antiseptic (liquid and ointment), local ointment, aspirin, eye ointment, antihistamine, ammonia inhalent, sea-sickness pills, antacid pills, and a laxative. You may want to consult your family physician about including antibiotics. Be sure your kit contains a first-aid manual because even though you have taken the Red Cross course, you may be the patient and have to rely on an untrained crew for care.



An adequately stocked first aid kit should be on board for the safety of crew and guests.

Fire Extinguishers

All fire extinguishers must bear Underwriters Laboratory (UL) "Marine Type" approved labels. With the UL certification, the extinguisher does not have to have a Coast Guard approval number. The Coast Guard classifies fire extinguishers according to their size and type.

Type B-I or B-II Designed for extinguishing flammable liquids. Required on all motorboats.

The Coast Guard considers a boat having one or more of the following conditions as a "boat of closed construction" subject to fire extinguisher regulations.

1- Inboard engine or engines.

2- Closed compartments under thwarts and seats wherein portable fuel tanks may be stored.

3- Double bottoms not sealed to the hull or which are not completely filled with flotation materials.

4- Closed living spaces.

5- Closed stowage compartments in which combustible or flammable material is stored.

6- Permanently installed fuel tanks.

Detailed classification of fire extinguishers is by agent and size:



A suitable fire extinguisher should be mounted close to the helmsperson for emergency use.

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B-I contains 1-1/4 gallons foam, 4 pounds carbon dioxide, 2 pounds dry chemical, and 2-1/2 pounds freon.

B-II contains 2-1/2 gallons foam, 15 pounds carbon dioxide, and 10 pounds dry chemical.

The class of motorboat dictates how many fire extinguishers are required on board. One B-II unit can be substituted for two B-I extinguishers.

Dry chemical fire extinguishers without gauges or indicating devices must be weighed and tagged every 6 months. If the gross weight of a carbon dioxide (CO_2) fire extinguisher is reduced by more than 10% of the net weight, the extinguisher is not acceptable and must be recharged.

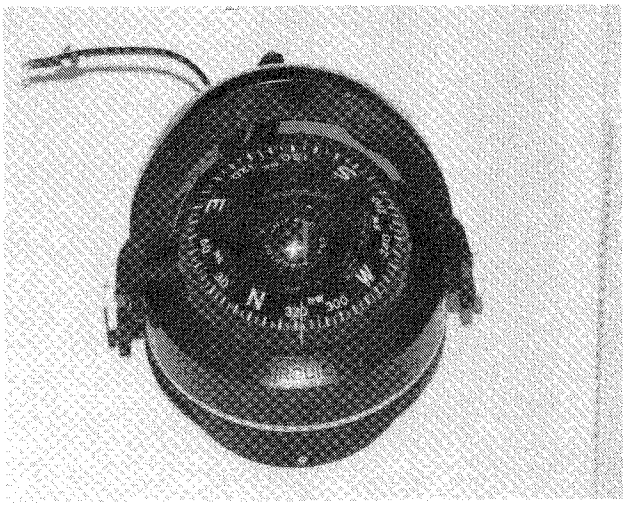
READ labels on fire extinguishers. If the extinguisher is U.L. listed, it is approved for marine use.

DOUBLE the number of fire extinguishers recommended by the Coast Guard, because their requirements are a bare **MINIMUM** for safe operation. Your boat, family, and crew, must certainly be worth much more than "bare minimum".

1-10 COMPASS

Selection

The safety of the boat and her crew may depend on her compass. In many areas weather conditions can change so rapidly that within minutes a skipper may find himself "socked-in" by a fog bank, a rain squall, or just poor visibility. Under these conditions, he may have no other means of keeping to his desired course except with the compass. When crossing an open body of water, his compass may be the only means of making an accurate landfall.



Do not hesitate to spend a few extra dollars for a good, reliable compass. If in doubt, seek advice from fellow boaters.

During thick weather when you can neither see nor hear the expected aids to navigation, attempting to run out the time on a given course can disrupt the pleasure of the cruise. The skipper gains little comfort in a chain of soundings that does not match those given on the chart for the expected area. Any stranding, even for a short time, can be an unnerving experience.

A pilot will not knowingly accept a cheap parachute. A good boater should not accept a bargain in lifejackets, fire extinguishers, or compass. Take the time and spend the few extra dollars to purchase a compass to fit your expected needs. Regardless of what the salesman may tell you, postpone buying until you have had the chance to check more than one make and model.

Lift each compass, tilt and turn it, simulating expected motions of the boat. The compass card should have a smooth and stable reaction.

The card of a good quality compass will come to rest without oscillations about the lubber's line. Reasonable movement in your hand, comparable to the rolling and pitching of the boat, should not materially affect the reading.

Installation

Proper installation of the compass does not happen by accident. Make a critical check of the proposed location to be sure compass placement will permit the helmsman to use it with comfort and accuracy. First, the compass should be placed directly in front of the helmsman and in such a position that it can be viewed without body stress as he sits or stands in a posture of relaxed alertness. The compass should be in the helmsman's zone of comfort. If the compass is too far away, he may have to bend forward to watch it; too close and he must rear backward for relief.

Second, give some thought to comfort in heavy weather and poor visibilty conditions during the day and night. In some cases, the compass position may be partially determined by the location of the wheel, shift lever, and throttle handle.

Third, inspect the compass site to be sure the instrument will be at least two feet

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from any engine indicators, bilge vapor detectors, magnetic instruments, or any steel or iron objects. If the compass cannot be placed at least two feet (six feet would be better) from one of these influences, then either the compass or the other object must be moved, if first order accuracy is to be expected.

Once the compass location appears to be satisfactory, give the compass a test before installation. Hidden influences may be concealed under the cabin top, forward of the cabin aft bulkhead, within the cockpit ceiling, or in a wood-covered stanchion.

Move the compass around in the area of the proposed location. Keep an eye on the card. A magnetic influence is the only thing that will make the card turn. You can quickly find any such influence with the compass. If the influence can not be moved away or replaced by one of non-magnetic material, test to determine whether it is merely magnetic, a small piece of iron or steel, or some magnetized steel. Bring the north pole of the compass near the object, then shift and bring the south pole near it. Both the north and south poles will be attracted if the compass is demagnetized. If the object attracts one pole and repels the other, then the compass is magnetized. If your compass needs to be demagnetized, take it to a shop equipped to do the job **PROPERLY.**

After you have moved the compass around in the proposed mounting area, hold it down or tape it in position. Test everything you feel might affect the compass and cause a deviation from a true reading. Rotate the wheel from hard over to hard over. Switch on and off all the lights, radios, radio direction finder, radio telephone, depth finder and the shipboard intercom, if one is installed. Sound the electric whistle, turn on the windshield wipers, start the engine (with water circulating through the engine), work the throttle, and move the gear shift lever. If the boat has an auxiliary generator, start it.

If the card moves during any one of these tests, the compass should be relocated. Naturally, if something like the windshield wipers causes a slight deviation, it may be necessary for you to make a different deviation table to use only when certain pieces of equipment are operating. Bear in mind, following a course that is only off a degree or two for several hours can make considerable difference at the end, putting you on a reef, rock, or shoal.

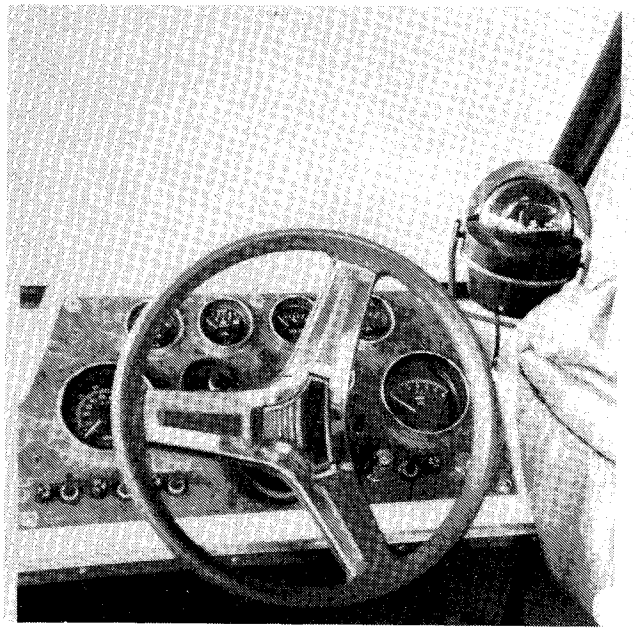
Check to be sure the intended compass site is solid. Vibration will increase pivot wear.

Now, you are ready to mount the compass. To prevent an error on all courses, the line through the lubber line and the compass card pivot must be exactly parallel to the keel of the boat. You can establish the fore-and-aft line of the boat with a stout cord or string. Use care to transfer this line to the compass site. If necessary, shim the base of the compass until the stile-type lubber line (the one affixed to the case and not gimbaled) is vertical when the boat is on an even keel. Drill the holes and mount the compass.

Magnetic Items After Installation

Many times an owner will install an expensive stereo system in the cabin of his boat. It is not uncommon for the speakers to be mounted on the aft bulkhead up against the overhead (ceiling). In almost every case, this position places one of the speakers in very close proximity to the compass, mounted above the ceiling.

As we all know, a magnet is used in the operation of the speaker. Therefore, it is very likely that the speaker, mounted almost under the compass in the cabin will have a very pronounced affect on the compass accuracy.



The compass is a delicate instrument and deserves respect. It should be mounted securely and in position where it can be easily observed by the helmsperson.

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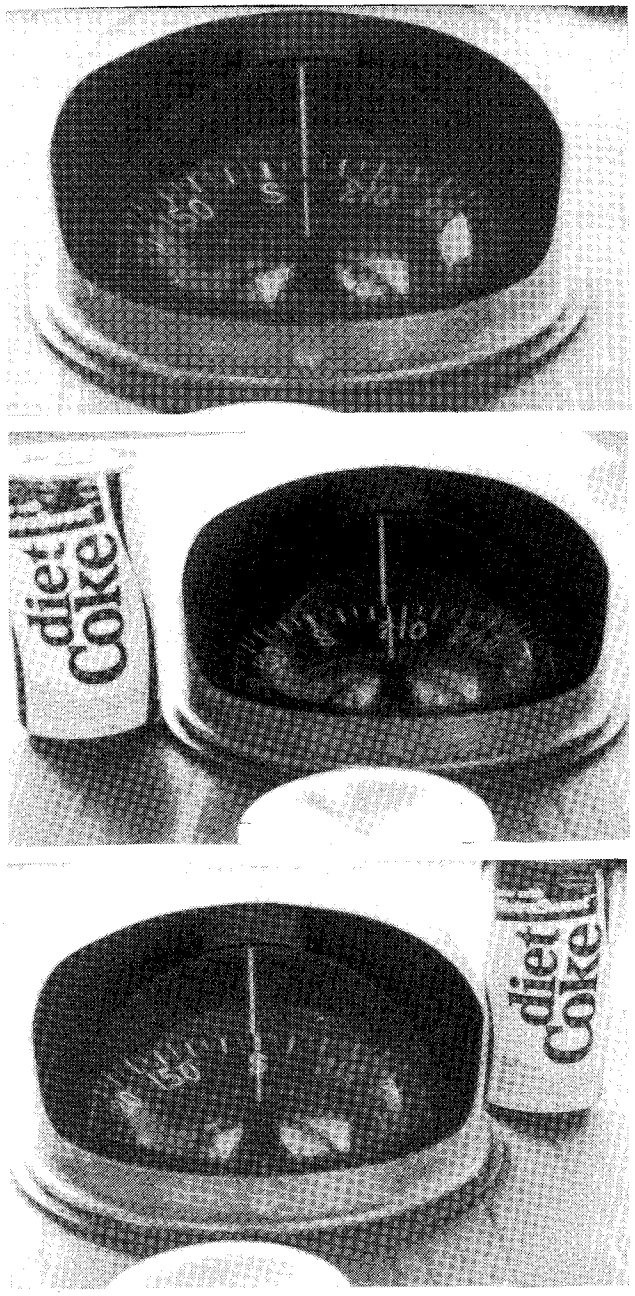
Consider the following test and the accompanying photographs as prove of the statements made.

First, the compass was read as 190 degrees while the boat was secure in her slip.

Next a full can of diet coke in an **aluminum** can was placed on one side and the compass read as 204 degrees, a good 14 degrees off.

Next, the full can was moved to the opposite side of the compass and again a reading was observed. This time as 189 degrees, 11 degrees off from the original reading.



"Innocent" objects close to the compass, such as diet coke in an aluminum can, may cause serious problems and lead to disaster, as these three photos and the accompanying text prove.

Finally the contents of the can were consumed, the can placed on both sides of the compass with **NO** affect on the compass reading.

Two very important conclusions can be drawn from these tests.

1- Something must have been in the contents of the can to affect the compass so drastically.

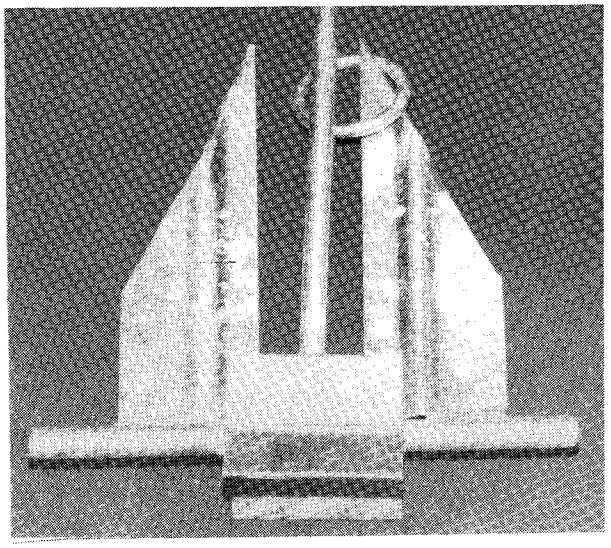
2- Keep even "innocent" things clear of the compass to avoid any possible error in the boat's heading.

REMEMBER, a boat moving through the water at 10 knots on a compass error of just 5 degrees will be almost 1.5 miles off course in only **ONE** hour. At night, or in thick weather, this could very possibly put the boat on a reef, rock, or shoal, with disastrous results.

1-11 ANCHORS

One of the most important pieces of equipment in the boat next to the power plant is the ground tackle carried. The engine makes the boat go and the anchor and its line are what hold it in place when the boat is not secured to a dock or on the beach.

The anchor must be of suitable size, type, and weight to give the skipper peace of mind when his boat is at anchor. Under certain conditions, a second, smaller, lighter anchor may help to keep the boat in a favorable position during a non-emergency daytime situation.



*The weight of the anchor **MUST** be adequate to secure the boat without dragging.*

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In order for the anchor to hold properly, a piece of chain must be attached to the anchor and then the nylon anchor line attached to the chain. The amount of chain should equal or exceed the length of the boat. Such a piece of chain will ensure that the anchor stock will lay in an approximate horizontal position and permit the flutes to dig into the bottom and hold.

1-12 MISCELLANEOUS EQUIPMENT

In addition to the equipment you are legally required to carry in the boat and those previously mentioned, some extra items will add to your boating pleasure and safety. Practical suggestions would include: a bailing device (bucket, pump, etc.), boat hook, fenders, spare propeller, spare engine parts, tools, an auxiliary means of propulsion (paddle or oars), spare can of gasoline, flashlight, and extra warm clothing. The area of your boating activity, weather conditions, length of stay aboard your boat, and the specific purpose will all contribute to the kind and amount of stores you put aboard. When it comes to personal gear, heed the advice of veteran boaters who say, "Decide on how little you think you can get by with, then cut it in half".

Bilge Pumps

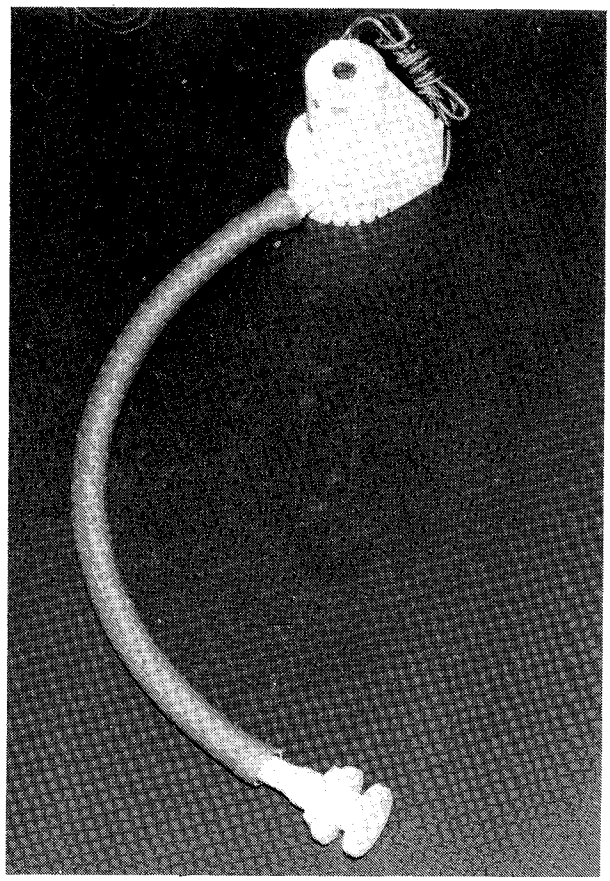
Automatic bilge pumps should be equipped with an overriding manual switch. They should also have an indicator in the operator's position to advise the helmsman when the pump is operating. Select a pump that will stabilize its temperature within the manufacturer's specified limits when it is operated continuously. The pump motor should be a sealed or arcless type, suitable for a marine atmosphere. Place the bilge pump inlets so excess bilge water can be removed at all normal boat trims. The intakes should be properly screened to prevent the pump from sucking up debris from the bilge. Intake tubing should be of a high quality and stiff enough to resist kinking and not collapse under maximum pump suction condition if the intake becomes blocked.

To test operation of the bilge pump, operate the pump switch. If the motor does not run, disconnect the leads to the motor. Connect a voltmeter to the leads and see if voltage is indicated. If voltage is not indicated, then the problem must be in a blown fuse, defective switch, or some other area of the electrical system.

If the meter indicates voltage is present at the leads, then remove, disassemble, and inspect the bilge pump. Clean it, reassemble, connect the leads, and operate the switch again. If the motor still fails to run, the pump must be replaced.

To test the bilge pump switch, first disconnect the leads from the pump and connect them to a test light.

Next, hold the switch firmly against the mounting location in order to make a good ground. Now, tilt the opposite end of the switch upward until it is activated as indicated by the test light coming on or the ohmmeter showing continuity. Finally, lower the switch slowly toward the mounting position until it is deactivated. Measure the distance between the point the switch was activated and the point it was deactivated. For proper service, the switch should deactivate between 1/2-inch and 1/4-inch from the planned mounting position. **CAUTION: The switch must never be mounted lower than the bilge pump pickup.**



The bilge pump line must be cleaned frequently to ensure the bilge pump will be able to do its job in an emergency.

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1-13 BOATING ACCIDENT REPORTS

New federal and state regulations require an accident report to be filed with the nearest State boating authority within 48 hours if a person is lost, disappears, or is injured to the degree of needing medical treatment beyond first aid.

Accidents involving only property or equipment damage **MUST** be reported within 10 days if the damage is in excess of $200. Some states require reporting of accidents with property damage less than $200 or total boat loss.

A **$500 PENALTY** may be assessed for failure to submit the report.

WORD OF ADVICE

Take time to make a copy of the report to keep for your records or for the insurance company. Once the report is filed, the Coast Guard will not give out a copy, even to the person who filed the report.

The report must give details of the accident and include:

1- The date, time, and exact location of the occurrence.

2- The name of each person who died, was lost, or injured.

3- The number and name of the vessel.

4- The names and addresses of the owner and operator.

If the operator cannot file the report for any reason, each person on board **MUST** notify the authorities, or determine that the report has been filed.

1-14 NAVIGATION

Buoys

In the United States, a buoyage system is used as an assist to all boaters of all size craft to navigate our coastal waters and our navigable rivers in safety. When properly read and understood, these buoys and markers will permit the boater to cruise with comparative confidence that he will be able to avoid reefs, rocks, shoals, and other hazards.

In the spring of 1983, the Coast Guard began making modifications to U.S. aids to navigation in support of an agreement sponsored by the International Associaiton of Lighthouse Authorities (IALA) and signed by representatives from most of the maritime nations of the world. The primary purpose of the modifications is to improve safety by making buoyage systems around the world more alike and less confusing.

Lights

The following information regarding lights required on boats between sunset and sunrise or during restricted visibility is taken directly from a U.S. Coast Guard publication dated 1984.

The terms **"PORT"** and **"STARBOARD"** are used to refer to the left and right side of the boat, when looking forward. One easy way to remember this basic fundamental is to consider the words "port" and "left" both have four letters and go together.

Waterway Rules

On the water, certain basic safe-operating practices must be followed. You should learn and practice them, for to **know**, is to be able to handle your boat with confidence and safety. Knowledge of what to do, and not do, will add a great deal to the enjoyment you will receive from your boating investment.

Rules of the Road

The best advice possible and a Coast Guard requirement for boats over 39' 4" (12 meters) since 1981, is to obtain an official copy of the "Rules of the Road", which includes Inland Waterways, Western Rivers, and the Great Lakes for study and ready reference.

The following two paragraphs give a **VERY** brief, condensed, and abbreviated -- synopsis of the rules. They should not be considered in any way as covering the entire subject.

Powered boats must yield the right-of-way to all boats without motors, except when being overtaken. When meeting another boat head-on, keep to starboard, unless you are too far to port to make this practical. When overtaking another boat, the right-of-way belongs to the boat being overtaken. If your boat is being passed, you must maintain course and speed.

When two boats approach at an angle and there is danger of collision, the boat to port must give way to the boat to starboard. Always keep to starboard in a narrow channel or canal. Boats underway must stay clear of vessels fishing with nets, lines, or trawls. (Fishing boats are not allowed to fish in channels or to obstruct navigation.)

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2
TUNING

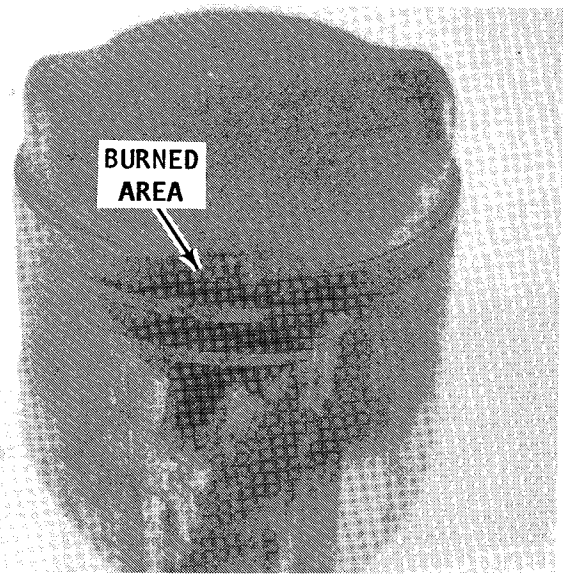
2-1 INTRODUCTION

The efficiency, reliability, fuel economy and enjoyment available from engine performance are all directly dependent on having it tuned properly. The importance of performing service work in the sequence detailed in this chapter cannot be over emphasized. Before making any adjustments, check the specifications in the Appendix. **NEVER** rely on memory when making critical adjustments.

Before beginning to tune any engine, check to be sure the engine has satisfactory compression. An engine with worn or broken piston rings, burned pistons, or scored cylinder walls, cannot be made to perform properly no matter how much time and expense is spent on the tune-up. Poor compression must be corrected or the tune-up will not give the desired results.

A practical maintenance program that is followed throughout the year, is one of the best methods of ensuring the engine will give satisfactory performance at any time.

The extent of the engine tune-up is usually dependent on the time lapse since the last service. A complete tune-up of the entire engine would entail almost all of the work outlined in this manual. A logical sequence of steps will be presented in general terms. If additional information or



Damaged piston, probably caused by inaccurate fuel mixture, or improper timing.



A clean exterior engine appearance reflects this owner's pride in his unit. Keeping the interior well-lubricated and properly tuned will give him/her the enjoyment deserved for the investment.

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detailed service work is required, the chapter containing the instructions will be referenced.

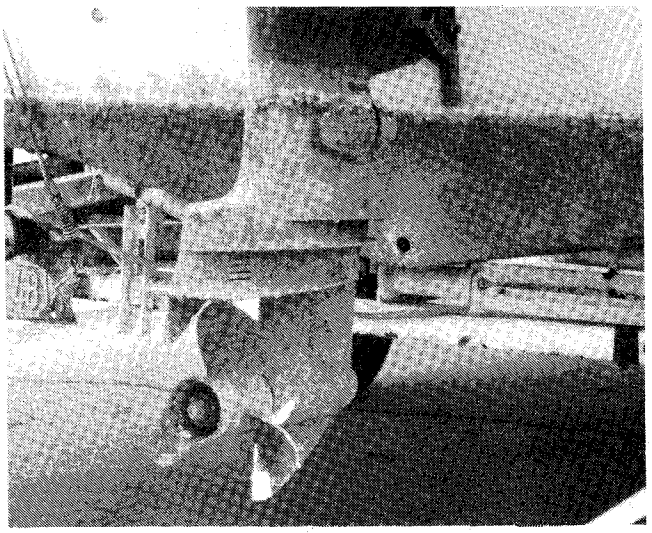
Each year higher compression ratios are built into modern outboard engines and the electrical systems become more complex, especially with electronic (capacitor discharge) units. Therefore, the need for reliable, authoritative, and detailed instructions becomes more critical. The information in this chapter and the referenced chapters fulfill that requirement.

2-2 TUNE-UP SEQUENCE

During a major tune-up, a definite sequence of service work should be followed to return the engine to the maximum performance desired. This type of work should not be confused with attempting to locate problem areas of "why" the engine is not performing satisfactorily. This work is classified as "trouble shooting". In many cases, these two areas will overlap, because many times a minor or major tune-up will correct the malfunction and return the system to normal operation.

The following list is a suggested sequence of tasks to perform during the tune-up service work. The tasks are merely listed here. Generally procedures are given in subsequent sections of this chapter. For more detailed instructions, see the referenced chapter.

1- Perform a compression check of each cylinder. See Chapter 6.



A boat and lower unit covered with marine growth. Such a condition is a serious hinderance to performance and cannot be corrected by tuning the powerhead.

2- Inspect the spark plugs to determine their condition. Test for adequate spark at the plug. See Chapter 6.

3- Start the engine in a body of water and check the water flow through the powerhead, See Chapter 11.

4- Check the gear oil in the lower unit. See Chapter 11.

5- Check the carburetor adjustments and the need for an overhaul. See Chapter 4.

6- Check the fuel pump for adequate performance and delivery. See Chapter 4.

7- Make a general inspection of the ignition system. See Chapter 6.

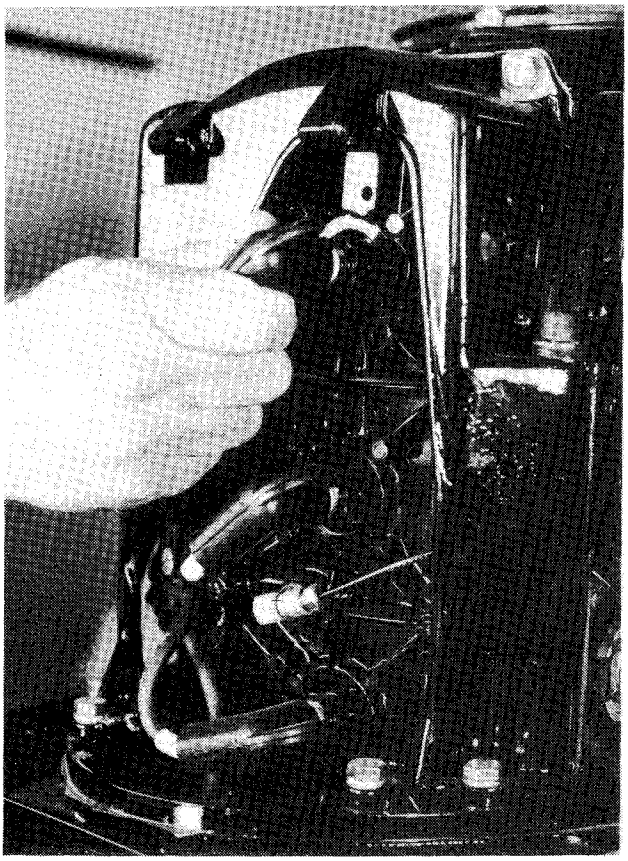
8- Test the cranking motor and the solenoid. See Chapter 9.

9- Check the internal wiring.

10- Check the timing and synchronization. See Chapter 7.

2-3 COMPRESSION CHECK

A compression check is extremely important, because an engine with low or uneven compression between cylinders **CAN-**



Removing the spark plugs for inspection. Worn plugs are one of the major contributing factors to poor engine performance.

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NOT be tuned to operate satisfactorily. Therefore, it is essential that any compression problem be corrected before proceeding with the tune-up procedure. See Chapter 8.

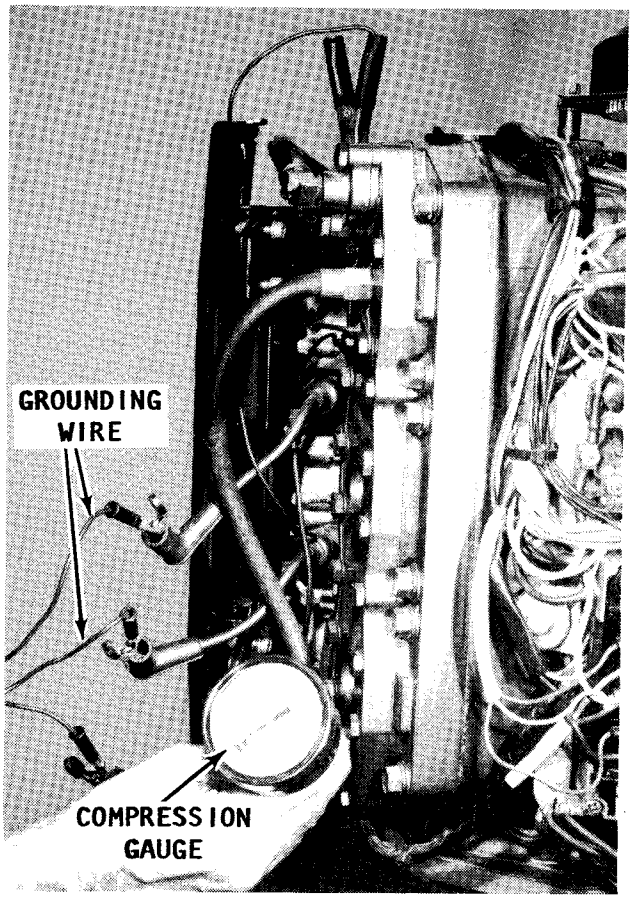
If the powerhead shows any indication of overheating, such as discolored or scorched paint, inspect the cylinders visually thru the transfer ports for possible scoring. It is possible for a cylinder with satisfactory compression to be scored slightly. Also, check the water pump. The overheating condition may be caused by a faulty water pump.

Checking Compression

Remove the spark plug wires. **ALWAYS** grasp the molded cap and pull it loose with a twisting motion to prevent damage to the connection. Remove the spark plugs and keep them in **ORDER** by cylinder for evaluation later. Ground the spark plug leads to the engine to render the ignition system inoperative while performing the compression check.

Insert a compression gauge into the No. 1, top, spark plug opening. Crank the powerhead, with the cranking motor, thru at least 4 complete revolutions of the crankshaft, with the throttle at the wide-open position, to obtain the highest possible reading. Record the highest reading. Repeat the test and record the compression for each cylinder. A variation between cylinders is far more important than the actual readings. A variation of more than 15 psi between cylinders indicates the lower compression cylinder is defective. The problem may be worn, broken, or sticking piston rings, scored pistons or worn cylinders.

Use of an engine cleaner will help to free stuck rings and to dissolve accumulated carbon. Follow the directions on the can.



All spark plugs should be "grounded" while making compression tests. This action will prevent placing an extra load on the ignition coil.

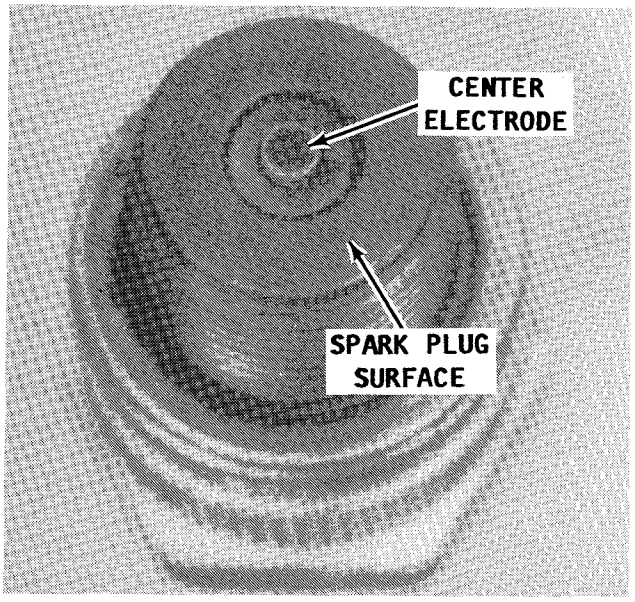
2-4 SPARK PLUG INSPECTION

All spark plugs installed on powerheads covered in this manual are of the non-adjustable surface gap type, as shown in the accampanying illustration.

The spark plugs should be replaced if the center electrode has burned back more than 1/32" (0.8mm) below the spark plug surface.

Inspect each spark plug for badly worn electrodes, glazed, broken, blistered, or lead fouled insulators. Replace all plugs, if one shows signs of excessive wear.

Make an evaluation of the cylinder performance by comparing the spark condition with those shown in Chapter 6. Check each spark plug to be sure they are all of the same manufacturer and have the same heat range rating.



Example of a non-adjustable surface gap spark plug operated under favorable conditions.

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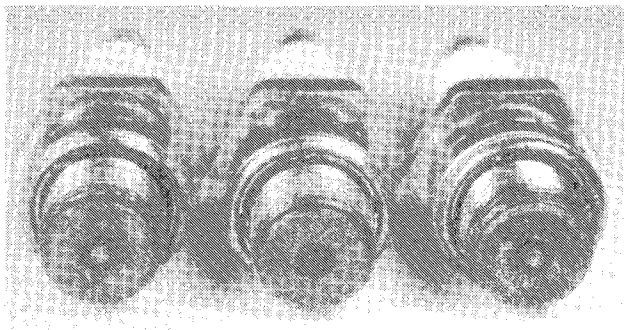


After removal, the spark plugs should be kept in order to permit a proper diagnosis to be made of how each cylinder has been operating.

Inspect the threads in the spark plug opening of the block, and clean the threads before installing the plug.

When purchasing new spark plugs, **ALWAYS** ask the marine dealer if there has been a spark plug change for the engine being serviced.

Crank the powerhead through several revolutions to blow out any material which might have become dislodged during cleaning.

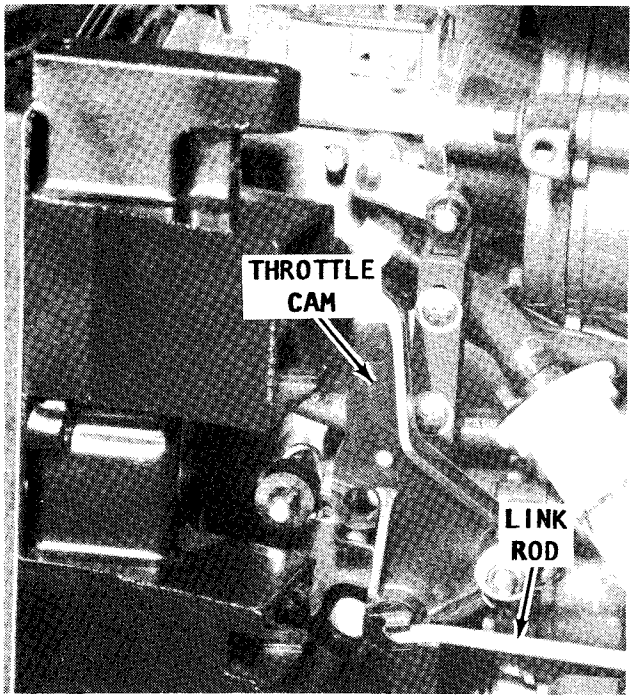
Install the spark plugs and tighten them to a torque value of 20ft lbs (26Nm). **ALWAYS** use a new gasket and wipe the seats in the block clean. The gasket must be fully compressed on clean seats to complete the heat transfer process and to provide a gas tight seal in the cylinder. If the torque value is too high, the heat will dissipate too rapidly. Conversely, if the torque value is too low, heat will not dissipate fast enough.

2-5 IGNITION SYSTEM

Two different ignition systems are used on the powerheads covered in this manual. Each system is easily recognized. One system has a distributor. Only a few early 90, 115, and 140hp 6-cylinder in-line powerheads have the distributor ignition.

Instead of a distributor, the new ignition system is labeled, Thunderbolt Flywheel CD Ignition. Almost all the powerheads covered in this manual have the new distributorless ignition system. The majority of ignition components for this new ignition system are housed under the flywheel.

The Thunderbolt Flywheel C.D. system has an ignition coil for each cylinder. The Thunderbolt Pointless Distributor C.D. system has only one coil which serves all cylinders. If powerhead performance is less than expected, and the ignition is diagnosed as the problem area, refer to Chapter 6 for detailed service procedures.

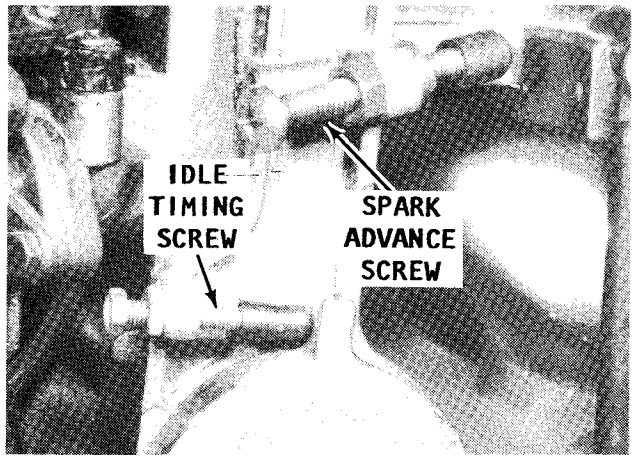


*The fuel and ignition systems on any powerhead **MUST** be properly synchronized before maximum performance can be obtained from the unit.*

To properly time and synchronize the ignition system with the fuel system, see Chapter 7.

2-6 TIMING AND SYNCHRONIZING

Correct timing and synchronization are essential to efficient engine operation. An engine may be in apparent excellent mechanical condition, but perform poorly, unless the timing and synchronization have been adjusted precisely, according to the Specifications in the Appendix. To time and synchronize the engine, see Chapter 7.



Typical location for some of the major adjustment points to synchronize and time a V6 powerhead.

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2-7 ELECTRICAL POWER SUPPLY

Inspect and service the battery, cables and connections. Check for signs of corrosion. Inspect the battery case for cracks or bulges, dirt, acid, and electrolyte leakage. Check the electrolyte level in each cell.

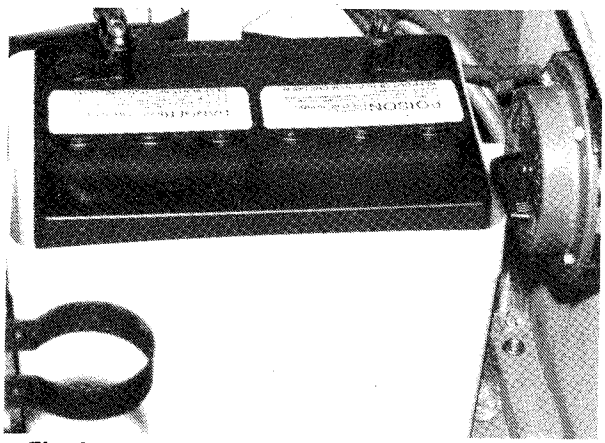
Fill each cell to the proper level with distilled water or water passed thru a demineralizer.

Clean the top of the battery. The top of a 12-volt battery should be kept especially clean of acid film and dirt, because of the high voltage between the battery terminals. For best results, first wash the battery with a diluted ammonia or baking soda solution to neutralize any acid present. Flush the solution off the battery with clean water. Keep the vent plugs tight to prevent the neutralizing solution or water from entering the cells.

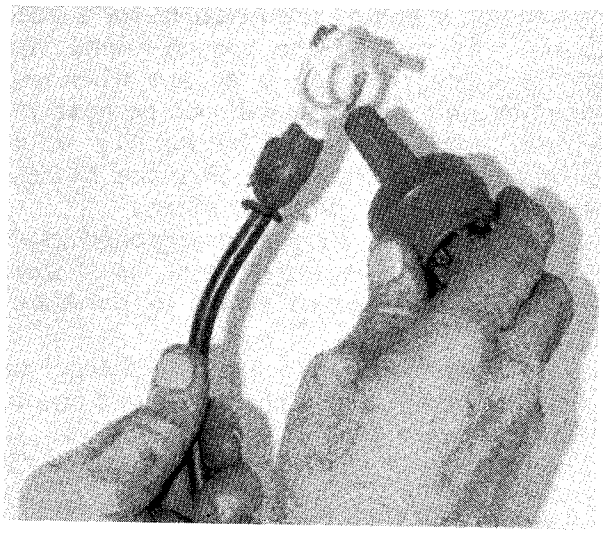
Check to be sure the battery is fastened securely in position. The hold-down device should be tight enough to prevent any movement of the battery in the holder, but not so tight as to place a strain on the battery case.

If the battery posts or cable terminals are corroded, the cables should be cleaned separately with a baking soda solution and a wire brush. Apply a thin coating of Multipurpose Lubricant to the posts and cable clamps before making the connections. The lubricant will help to prevent corrosion.

If the battery has remained under-charged, check for high resistance in the charging circuit. If the battery appears to be using too much water, the battery may be defective, or it may be too small for the job.



*The battery **MUST** be located near the engine in a well-ventilated area. It must be secured in such a manner to allow absolutely no movement in any direction under the most violent action of the boat.*

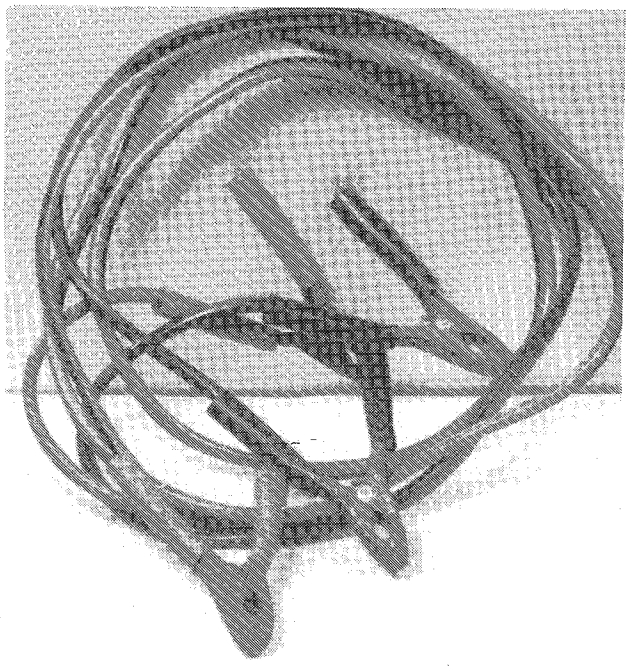


An inexpensive brush should be purchased and used to clean battery cable terminals and the battery posts. Clean posts and terminals will ensure proper service.

Jumper Cables

If booster batteries are used for starting an engine the jumper cables must be connected correctly and in the proper sequence to prevent damage to either battery, or the rectifier diodes.

ALWAYS connect a cable from the positive terminals of the dead battery to the positive terminal of the good battery **FIRST. NEXT,** connect one end of the other cable to the negative terminals of the good battery



*Common set of jumper cables for use with a second battery to crank and start the engine. **EXTREME** care should be exercised when using a second battery, as explained in the text.*

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and the other end of the **ENGINE** for a good ground. By making the ground connection on the engine, if there is an arc when you make the connection it will not be near the battery. An arc near the battery could cause an explosion, destroying the battery and causing serious personal injury.

DISCONNECT the battery ground cable before replacing an alternator or before connecting any type of meter to the alternator.

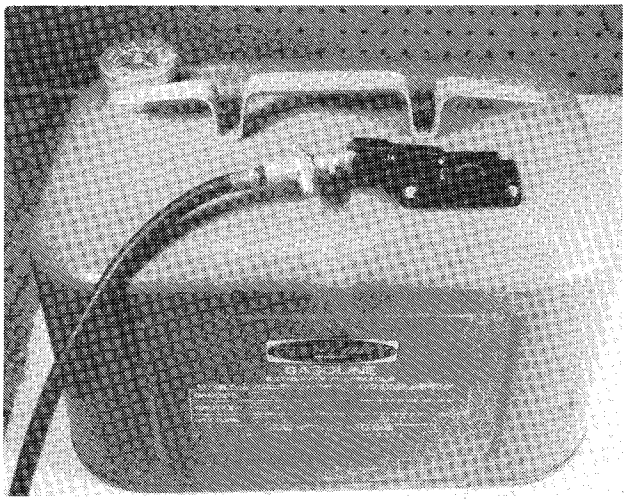
If it is necessary to use a fast-charger on a dead battery, **ALWAYS** disconnect one of the boat cables from the battery first, to prevent burning out the diodes in the rectifier.

NEVER use a fast charger as a booster to start the engine because the diodes in the rectifier will be **DAMAGED.**

Alternator Charging

When the battery is partially discharged, the ammeter should change from discharge to charge between 800 to 1000 rpm for all models. If the battery is fully-charged, the rpm will be a little higher.

With the engine running, increase the throttle until the rpm is approximately 5200 rpm. The ammeter reading should meet the Alternator Specifications in the Appendix. With a fully-charged battery the ammeter reading will be a bit lower because of the self-regulating characteristics of the generating systems. Before disconnecting the ammeter, reconnect the red harness lead to the positive battery terminal and install the wing nut.



An ideal fuel tank and fuel line arrangement for an outboard unit. The tank should be kept clean and well secured in the boat. The quick-disconnect device affords easy removal for filling and safety.

2-8 CARBURETOR ADJUSTMENT

Fuel and Fuel Tanks

Take time to check the fuel tank and all of the fuel lines, fittings, couplings, valves, flexible tank fill and vent. Turn on the fuel supply valve at the tank. If the gas was not drained at the end of the previous season, make a careful inspection for gum formation. When gasoline is allowed to stand for long periods of time, particularly in the presence of copper, gummy deposits form. This gum can clog the filters, lines, and passageway in the carburetor.

If the condition of the fuel is in doubt, drain, clean, and fill the tank with fresh fuel.

Fuel pressure at the top carburetor should be checked whenever a lack of fuel volume at the carburetor/s is suspected.

Check other than Mariner fuel tank for the following:

1- Adequate air vent in the fuel cap.
2- Fuel line of sufficient size, should be 5/16" to 3/8".
3- Filter on the end of the pickup is too small or is clogged.
4- Fuel pickup tube is too small.



Quicksilver Gasoline Stabilizer and Conditioner may be used to keep the gasoline in the tank fresh. Such an additive will prevent the fuel from "souring" for up to twelve months.

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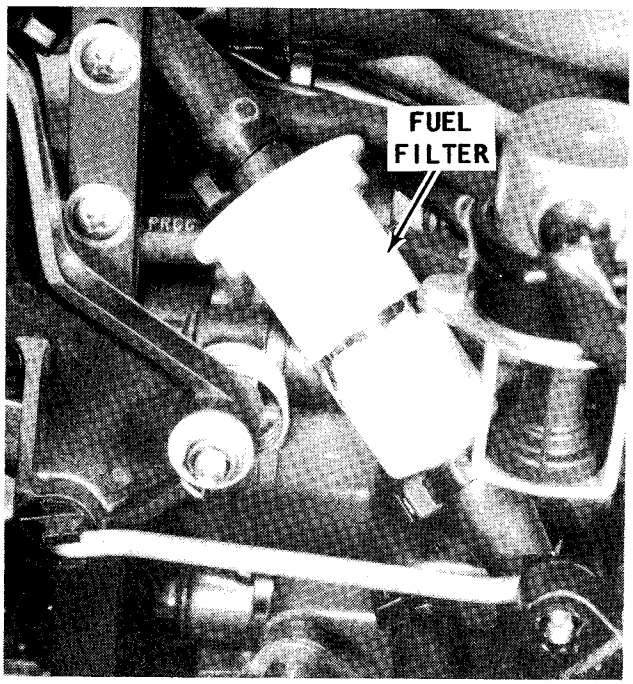
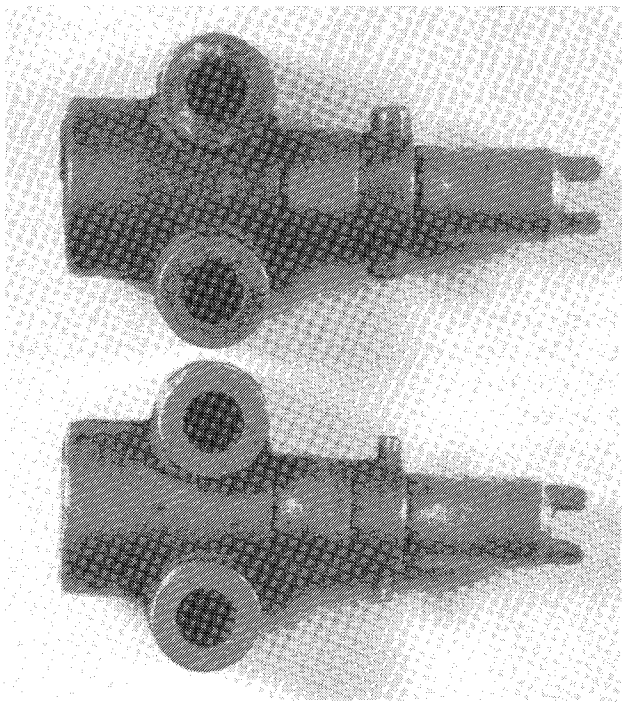


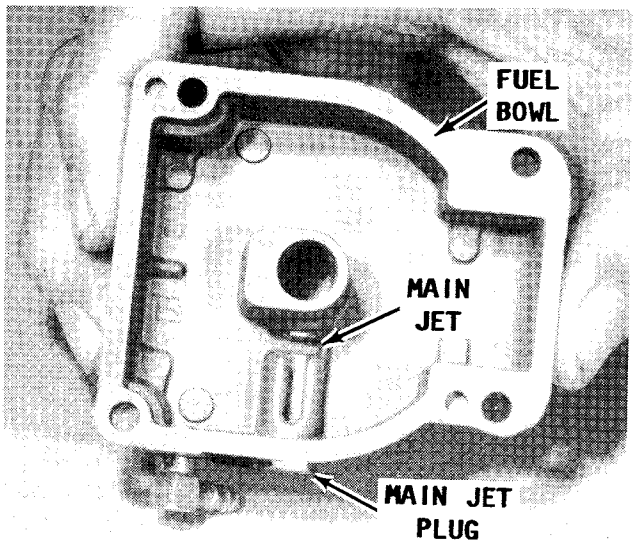
In-line fuel filter installed on a late model V6 powerhead.

High-speed Adjustment

The high-speed (main) jet is fixed at the factory and is **NOT** adjustable. However, larger or smaller jets may be installed for different elevations.



A worn fuel coupling, bottom, compared with a new one, top. Notice how the pins on the worn coupling are smaller and tapered. For the modest cost involved and to ensure a proper connection, the coupling and line should be replaced if there is any sign of excessive wear.



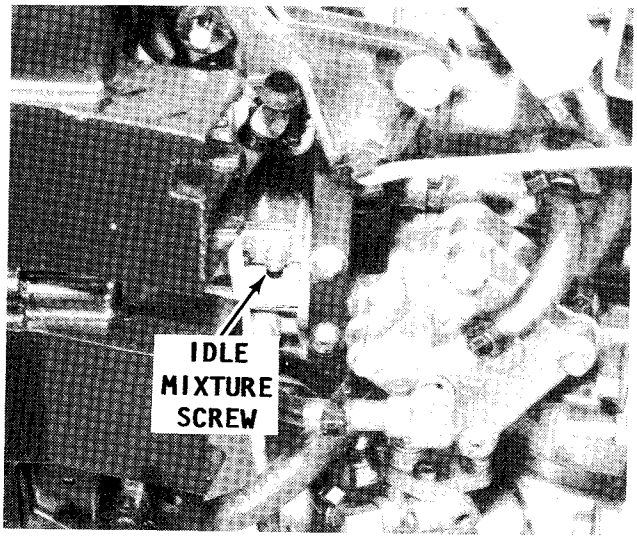
Removal of the main jet plug located externally on the float bowl reveals an access passage to the main jet. The main jet can be changed without removing the carburetor from the powerhead. Not all carburetors have this feature.

Idle Mixture Adjustment

The idle mixture and idle speed are set at the factory. Due to local conditions, it may be necessary to adjust the carburetor while the engine is running in a test tank or with the boat in a body of water. For maximum performance, the idle mixture and the idle rpm should be adjusted under actual operating conditions.

Set the idle mixture screw at the specified number of turns open from a lightly seated position.

Start the powerhead and allow it to warm to operating temperature.



Location of the idle mixture screw on a late model 3-cylinder powerhead. The two lower carburetors on some late model 4-cylinder powerheads are not equipped with idle mixture screws.

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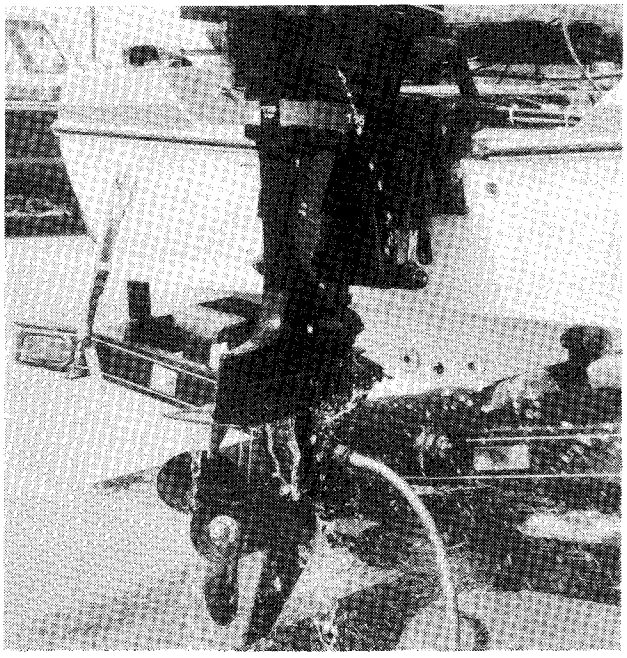
CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

NEVER, AGAIN NEVER, operate the powerhead at high speed with a flush device attached. The powerhead operating at high speed with such a device attached, would **RUNAWAY** from lack of a load on the propeller shaft, causing extensive damage.

With the engine running in forward gear, slowly turn the idle mixture screw **COUNTERCLOCKWISE** until the affected cylinders start to load up or fire unevenly, due to an over-rich mixture. Slowly turn the idle mixture screw **CLOCKWISE** until the cylinders fire evenly and engine rpm increases. Continue to slowly turn the screw **CLOCKWISE** until too lean a mixture is obtained and the rpms fall off and the engine begins to misfire. Now, set the idle mixture screw one-quarter (1/4) turn out (counterclockwise) from the lean-out position. This adjustment will result in an approximate true setting. A too-lean setting is a major cause of hard starting a cold engine. It is better to have the adjustment on the rich side rather than on the lean side. Stating it another way, do not make the adjustment any leaner than necessary to obtain a smooth idle.



*Using a flush attachment and garden hose while operating the engine at idle speed. **NEVER** operate the engine in gear or above idle speed with such a device.*

If the engine hesitates during acceleration after adjusting the idle mixture, the mixture is too lean. Enrich the mixture slightly, by turning the adjustment screw inward until the engine accelerates correctly.

Loosen the locknut and adjust the idle stop screw on the stop bracket until the engine idles at the recommended rpm in forward gear. The manufacturer's suggested range is 600-700 rpm. Tighten the locknut to hold the adjustment.

ENRICHENER SYSTEM

Most of the powerheads covered in this manual, are equipped with an enrichener system, replacing the traditional choke system.

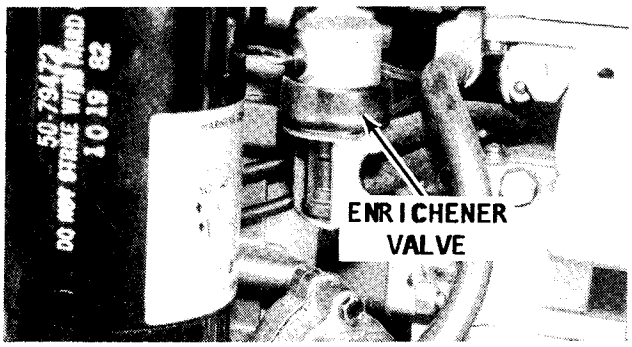
An electrically operated enrichener valve mounted on the port side of the powerhead, as shown in the accompanying illustration, is supplied with fuel via a fuel line from the float bowl of the top carburetor.

When the ignition key is rotated to the **ON** position and pushed inward to start a cold powerhead, the enrichener system is energized. Fuel is then fed to all cylinders through short hoses and fittings at the intake manifold close to the carburetor mounting flanges.

As soon as the ignition key is released, electrical current to the system is cutoff; the valve closes; and fuel through the valve stops. For more information, see Chapter 9.

Repairs and Adjustments

For detailed procedures to disassemble, clean, assemble, and adjust the carburetor, see the appropriate section in Chapter 4 for the carburetor type on the engine being serviced.



Most larger late model powerheads are equipped with an enrichener valve in place of a starboard choke circuit.

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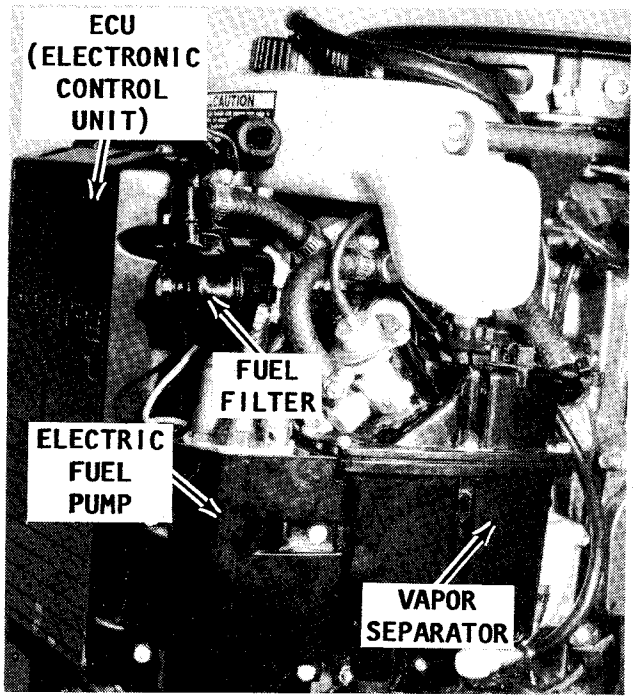
2-9 ELECTRONIC FUEL INJECTION (EFI)

Some late model V6 powerheads are equipped with an Electronic Fuel Injection (EFI) system. This fuel distribution system is computer controlled. Five different sensors provide the computer with information on rpm, throttle setting, manifold air temperature, powerhead temperature and manifold pressure -which automatically adjusts to barometeric pressure. The EFI fuel system includes the fuel tank, an anti-syphon valve, a mechanical fuel pump, an electric "booster" fuel pump, a primary fuel filter, a secondary fuel filter, a vapor separator, a fuel pressure regulator, and an injector fuel rail supporting six fuel injectors. The electronic control system for the fuel system includes the six fuel injectors (each a mini solenoid), five sensors and an Electronic Control Unit (ECU) - a "black box".

A computer housed in the Electronic Control Unit (ECU) accepts data from a number of sensors. Based on the information received, the ECU signals each fuel injector to inject a precise and correct amount of fuel.

A fuel injection system must provide the correct air/fuel ratio for all powerhead loads, rpm, and temperature conditions. Exhaustive coverage of EFI is presented in Chapter 4.



The EFI (electronic fuel injection), installed on a V6 powerhead with some of the system components identified.

2-10 FUEL PUMPS

Many times, a defective fuel pump diaphragm is mistakinly diagnosed as a problem in the ignition system. The most common problem is a tiny pin-hole in the diaphragm. Such a small hole will permit gas to enter the crankcase and wet foul the spark plug at idle-speed. During high-speed operation, gas quantity is limited, the plug is not fouled and will therefore fire in a satisfactory manner.

If the fuel pump fails to perform properly, an insufficient fuel supply will be delivered to the carburetor. This lack of fuel will cause the engine to run lean, lose rpm or cause piston scoring.

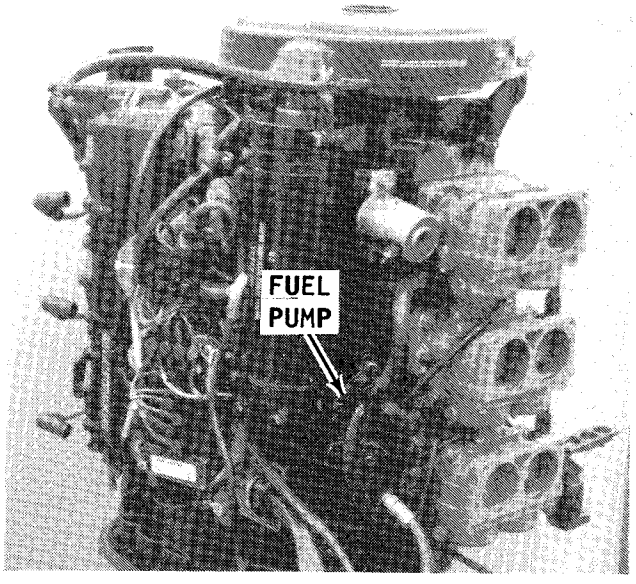
When a fuel pressure gauge is added to the system, it should be installed at the end of the fuel line leading to the upper carburetor. To ensure maximum performance, the fuel pressure must be 2 psi or more at full throttle.

Tune-up Task

Remove the fuel filter on the carburetor. Wash the parts in solvent and then dry them with compressed air. Install the clean element. A fuel pump pressure test should be made any time the engine fails to perform satisfactorily at high speed.

NEVER use liquid Neoprene on fuel line fittings. Always use Permatex when making fuel line connections. Permatex is available at almost all marine and hardware stores.

To service the fuel pump, see Chapter 4.



Typical separate fuel pumps installed on the powerheads covered in this manual.

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2-11 OIL INJECTION

Two different oil injection systems are used on the powerheads covered in this manual.

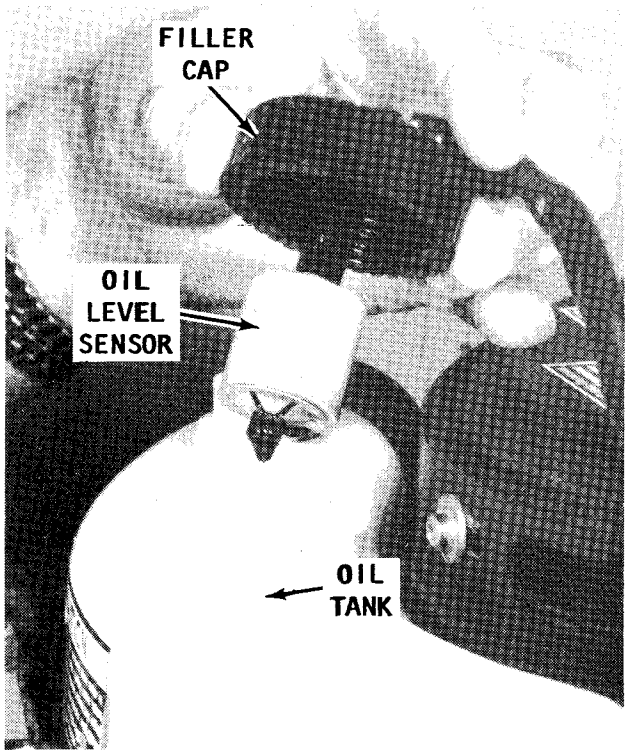
"Auto Blend"

Mercury/Mariner engineers designed and developed their oil injection system to "blend" the correct amount of oil with the fuel prior to delivery to the carburetor/s. Therefore, the trade name used is "Auto Blend", because the blending is accomplished automatically for all powerhead demands and conditions.

Fuel from the tank moves to the "Auto Blend" unit where it mixes with the oil and is then pumped to the powerhead.

Advanced Oil Injection

Since 1984 a new oil injection system has been installed on the larger powerheads, with the exception of the 6-cylinder in-line units. The oil pump and an oil reservoir are mounted on the powerhead. The pump is driven by a worm gear directly off the crankshaft. Oil is pumped just a short distance to an oil/fuel mixing chamber and then routed to the carburetor/s or to the vapor separator on an electronic fuel injection system.



Adding oil to the powerhead mounted oil tank on a V6 powerhead with "advanced" oil injection.

2-12 CRANKING MOTOR AND SOLENOID

Cranking Motor Test

Check to be sure the battery has at least a 90-ampere rating and is fully charged. Would you believe, many cranking motors are needlessly disassembled, when the battery is actually the culprit.

Lubricate the pinion gear and screw shaft with No. 10 oil.

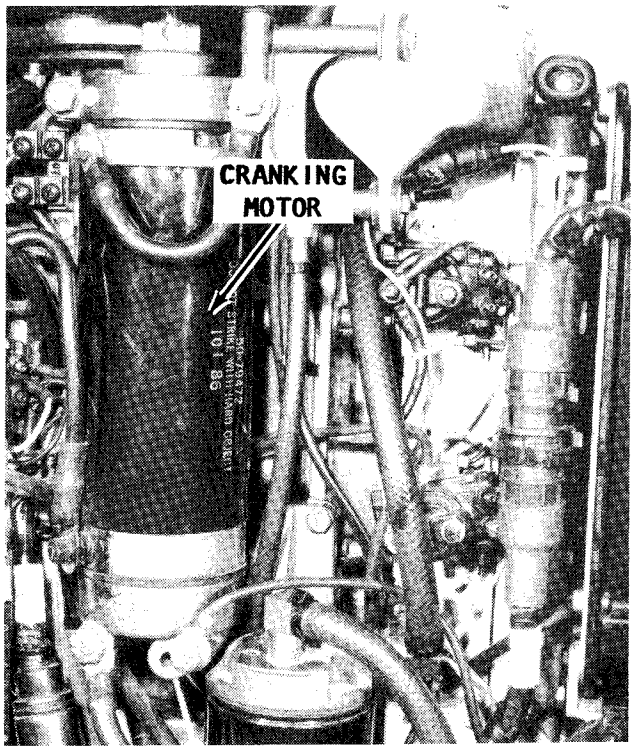
Connect one lead of a voltmeter to the positive terminal of the cranking motor. Connect the other meter lead to a good ground on the powerhead.Check the battery voltage under load by turning the ignition switch to the **START** position and observing the voltmeter reading.

If the reading is 9-1/2 volts or greater, and the cranking motor fails to operate, repair or replace the unit. See Chapter 9.

Solenoid Test

An ohmmeter is required for this test. Select the Rx1000 ohm scale. Calibrate the meter by making contact with the meter leads to each other, and then rotating the calibration knob on the meter until the needle indicates zero ohms. Separate the meter leads.

Make contact with the Red meter lead



A heavy duty Prestolite cranking motor mounted on a larger horsepower powerhead.

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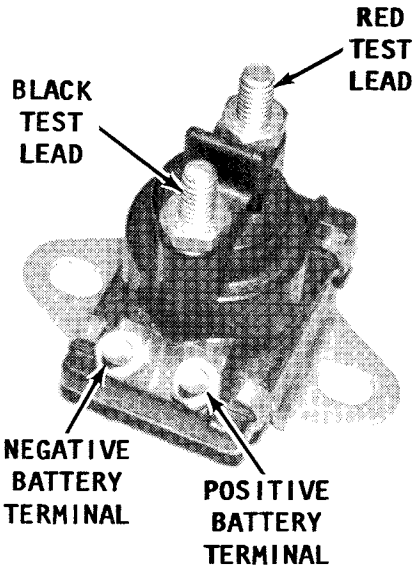


Hookup to test the newer style starter relay, as explained in the text.

to one of the large terminals on the solenoid. Make contact with the Black meter lead to the other large solenoid terminal. **NEVER** connect the battery leads to the large terminals of the solenoid, or the meter will be damaged.

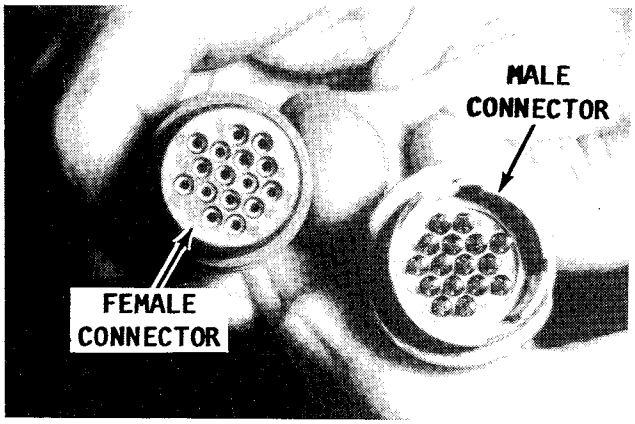
Using battery jumper leads, connect the positive lead from the positive terminal of the battery to the the small **"S"** terminal of the solenoid. Connect the negative lead to the negative battery terminal and the **"I"** terminal of the solenoid. If the meter needle indicates continuity, the solenoid is serviceable. If the meter fails to indicate continuity, the solenoid if defective and **MUST** be replaced.

2-13 INTERNAL WIRING HARNESS

Check the internal wiring harness if problems have been encountered with any of the electrical components. Check for frayed or chafed insulation and/or loose connections between wires and terminal connections.

Check the harness connector for signs of corrosion. Inspect the electrical "prongs" to be sure they are not bent or broken. If the harness shows any evidence of the foregoing problems, the problem must be corrected before proceeding with any harness testing.

Verify that the "prongs" of the harness connector are clean and free of corrosion. Convince yourself that a good electrical



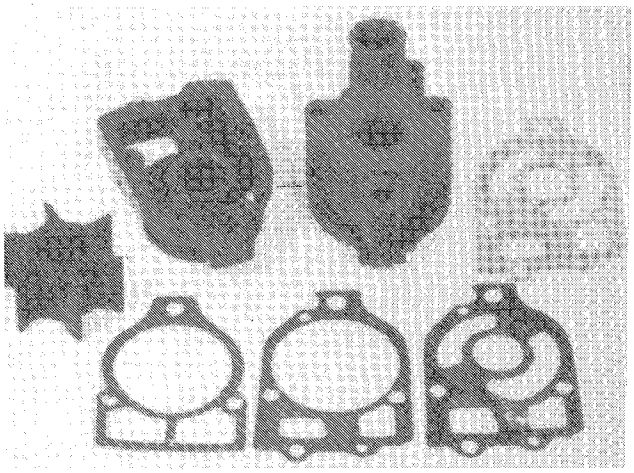
Close look at the female and male connectors of a main engine harness plug. This type plug can only be connected the proper way with the pins indexing correctly.

connection is being made between the harness connector and the remote control harness.

2-14 WATER PUMP CHECK

FIRST A GOOD WORD: The water pump **MUST** be in very good condition for the engine to deliver satisfactory service. The pump performs an extremely important function by supplying enough water to properly cool the engine. Therefore, in most cases, it is advisable to replace the complete water pump assembly at least once a year, or anytime the lower unit is disassembled for service.

Sometimes during adjustment procedures, it is necessary to run the engine with a flush device attached to the lower unit. **NEVER** operate the engine over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no-load condition on the propeller. A "runaway"



Major parts included in a water pump kit, available at the local marine dealer at modest cost.

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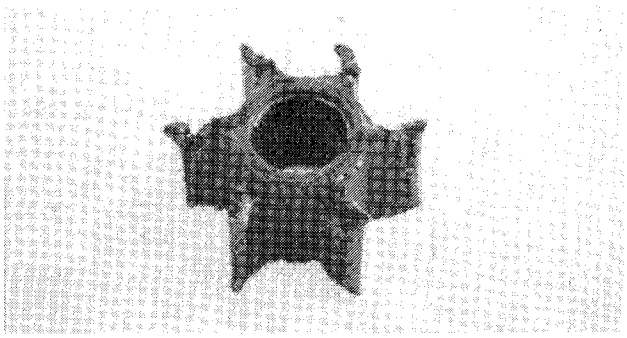

Worn water pump impeller, unfit for service.

engine could be severely damaged. As the name implies, the flush device is primarily used to flush the engine after use in salt water or contaminated fresh water. Regular use of the flush device will prevent salt or silt deposits from accumulating in the water passage-way. During and immediately after flushing, keep the motor in an upright position until all of the water has drained from the drive shaft housing. This will prevent water from entering the power head by way of the drive shaft housing and the exhaust ports, during the flush. It will also prevent residual water from being trapped in the drive shaft housing and other passageways.

Most outboard engines have water exhaust ports which deliver a tattle-tale stream of water, if the water pump is functioning properly during engine operation. Water pressure at the cylinder block should be checked if an overheating condition is detected or suspected.

To test the water pump, the lower unit **MUST** be placed in a test tank or the boat moved into a body of water. The pump must now work to supply a volume to the engine. A tattle-tale stream of water should be visible from the ports.

A water pressure kit is available from the local marine dealer for use with the larger horsepower engines. This kit will indicate the amount of water pressure the pump is delivering to the engine at all times. The first time the pressure indicator falls off, the pump should be serviced. To install the kit, simply connect the necessary fitting and water pressure hose onto the cylinder block. Place the water pressure gauge in a convenient position for viewing while operating the boat. Water pressure at full throttle under any boat operating condition, such as sharp turns, or other quick maneuvers, **MUST** be 5 psi or more.

Lack of adequate water supply from the water pump thru the engine will cause any number of power head failures, such as stuck rings, scored cylinder walls, burned pistons, etc.



A water pressure gauge kit available from the local marine dealer. All necessary parts and fittings to complete the installation, are included in the package.

2-15 PROPELLER

Inspect the propeller blades for nicks, cracks, or bent condition. If the propeller is damaged, the local marine dealer can make repairs or send it out to a shop specializing in such work.

Check with the local marine dealer, or a propeller shop for the recommended size



Damage was caused to this unit when the propeller struck an underwater object. If the propeller should suffer this much abuse, the propeller shaft should be carefully checked.

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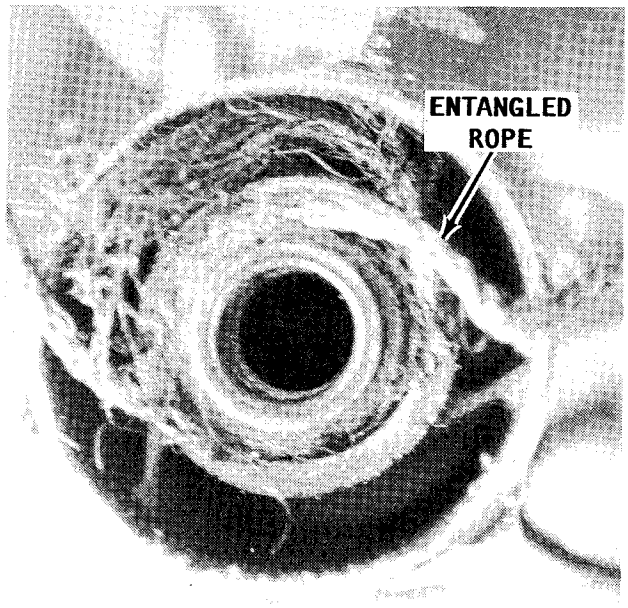
and pitch for a particular size engine, boat, and intended operation. The correct propeller should be installed on the engine to enable operation at the upper end of the factory recommended rpm.

If the powerhead rpm is below the rated rpm range, use a smaller or less pitch propeller. The reason for adjusting to the "high" side of the rpm range is to compensate if a heavier load is carried in the boat, the wide open throttle (WOT) rpm will not drop substantially. If the powerhead rpm is above the recommended rpm, try a higher pitch propeller or the same pitch cupped. See Chapter 1 for explanation of propeller terms, pitch, diameter, cupped, etc. One size smaller propeller usually gives best performance for water skiing.

For a dual engine installation, the next higher pitch propeller may prove the most satisfactory arrangement for water skiing.

Remove the propeller and the thrust hub. Check the propeller shaft seal to be sure it is not leaking. Check the area just forward of the seal to be sure a fish line is not wrapped around the shaft.

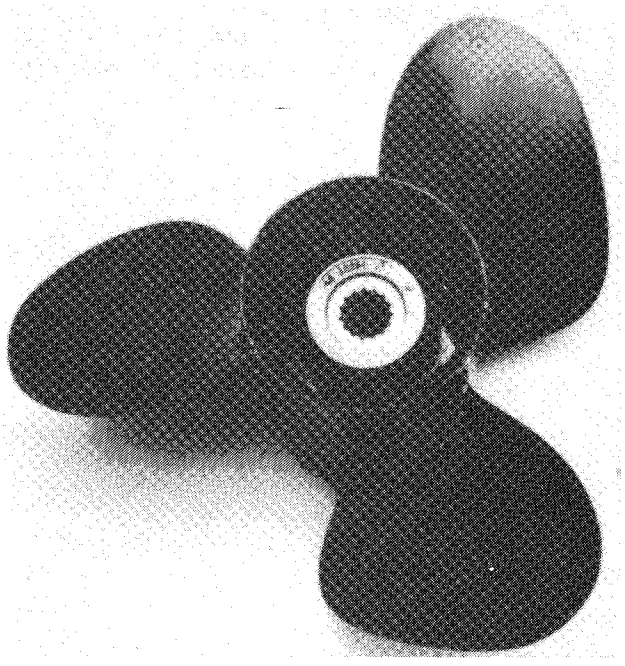


This rope became entangled behind the propeller around the propeller shaft. The propeller should be removed periodically and this area checked for foreign material.

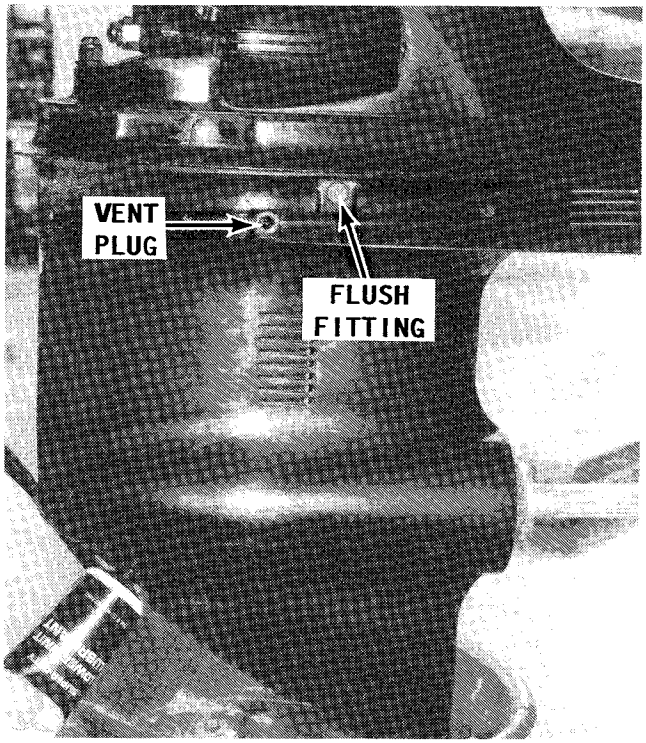
2-16 LOWER UNIT

NEVER remove the vent or filler plugs when the lower unit is hot. Expanded lubricant would be released through the plug hole. Check the lubricant level after the unit has been allowed to cool. Add only Super-Duty Gear Lubricant. **NEVER** use regular automotive-type grease in the lower unit, because it expands and foams too much. Outboard lower units do not have provisions to accommodate such expansion.

If the lubricant appears milky brown, or if large amounts of lubricant must be added to bring the lubricant up to the full mark, a



New propeller ready for installation and service.



*Filling the lower unit with new lubricant. Notice the unit is filled through the lower plug, but the upper plug **MUST** be removed to allow trapped air to escape.*

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thorough check should be made to determine the cause of the loss.

Draining Lower Unit

Remove the **FILL** plug from the lower end of the gear housing on the port side and the **VENT** plug just above the anti-cavitation plate.

Filling Lower Unit

Position the drive unit approximately vertical and without a list to either port or starboard. Insert the lubricant tube into the **FILL/DRAIN** hole at the bottom plug hole, and inject lubricant until the excess begins to come out the **VENT** hole. Install the **VENT** plug first then replace the **FILL** plug with **NEW** gaskets. Check to be sure the gaskets are properly positioned to prevent water from entering the housing.

For detailed lower unit service procedures, see Chapter 11. For lower unit lubrication capacities, see the Appendix.

2-17 BOAT TESTING

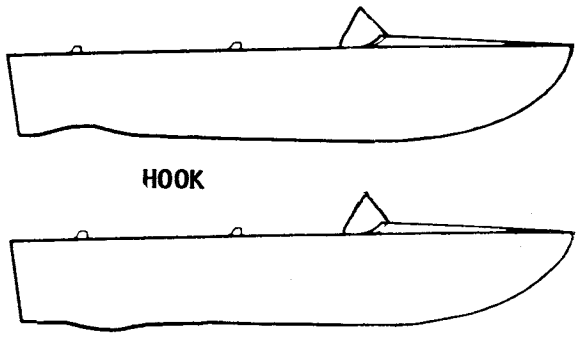
Hook and Rocker

Before testing the boat, check the boat bottom carefully for marine growth or evidence of a "hook" or a "rocker" in the bottom. Either one of these conditions will greatly reduce performance.

Performance

Mount the motor on the boat. Install the remote control cables and check for proper adjustment.

Make an effort to test the boat with what might be considered an average gross load. The boat should ride on an even keel, without a list to port or starboard. Adjust the motor tilt angle, if necessary, to permit the bow to ride slightly higher than the stern. If heavy supplies are stowed aft of the center, the bow will be light and the boat will "plane" more efficiently. For this test the boat must be operated in a body of water.



Boat performance will be drastically impaired, if the bottom is damaged by a dent (hook) or bulge (rocker).

If the motor is equipped with an adjustable trim tab, the tab should be adjusted to permit boat steerage in either direction with equal ease.

Check the engine rpm at full throttle. The rpm should be within the Specifications in the Appendix. If the rpm is not within specified range, a propeller change may be in order. A higher pitch propeller will decrease rpm, and a lower pitch propeller will increase rpm.

For maximum low speed engine performance, the idle mixture and the idle rpm should be readjusted under actual operating conditions.

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3
MAINTENANCE

3-1 INTRODUCTION

GOOD WORDS: The authors estimate 75% of engine repair work can be directly or indirectly attributed to lack of proper care for the engine. This is especially true of care during the off-season period. There is no way on this green earth for a mechanical engine, particularly an outboard motor, to be left sitting idle for an extended period of time, say for six months, and then be ready for instant satisfactory service.

Imagine, if you will, leaving your automobile for six months, and then expecting to turn the key, have it roar to life, and be able to drive off in the same manner as a daily occurrence.

It is critical for an outboard engine to be run at least once a month, preferably, in the water, but if this is not possible, then a flush attachment **MUST** be connected to the lower unit.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

NEVER, AGAIN NEVER, operate the engine at high speed with a flush device attached. The engine, operating at high speed with such a device attached, would **RUNAWAY** from lack of load on the propeller, causing extensive damage.

At the same time, the shift mechanism should be operated through the full range several times and the steering operated from hard-over to hard-over.

Only through a regular maintenance program can the owner expect to receive long life and satisfactory performance at minimum cost.

The material presented in this chapter is divided into five general areas.

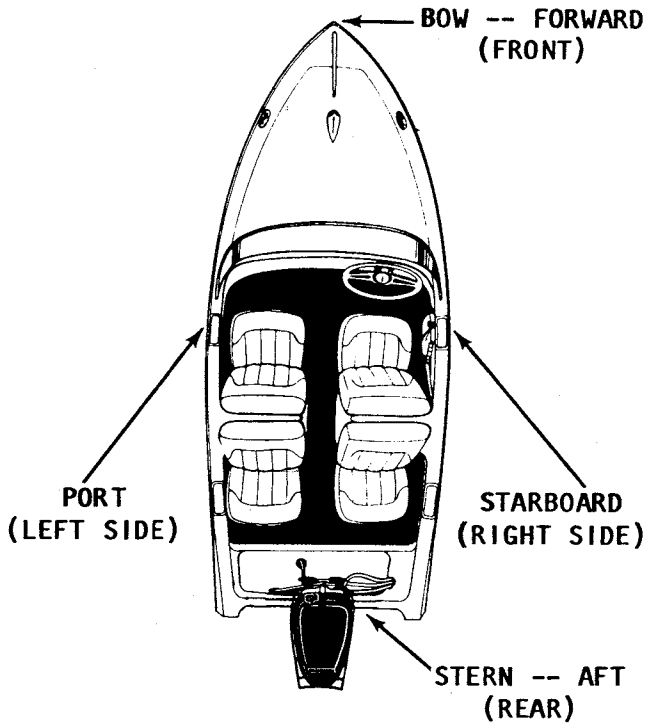
1- General information every boat owner should know.

2- Maintenance tasks that should be performed periodically to keep the boat operating at minimum cost.

3- Care necessary to maintain the appearance of the boat and to give the owner that "Pride of Ownership" look.

4- Winter storage practices to minimize damage during the off-season when the boat is not in use.

In nautical terms, the front of the boat is the **bow;** the rear is the **stern;** the right side, when facing forward, is the **starboard**



Common terminology used throughout the world for reference designation on boats of all sizes. These are the terms used in this book.

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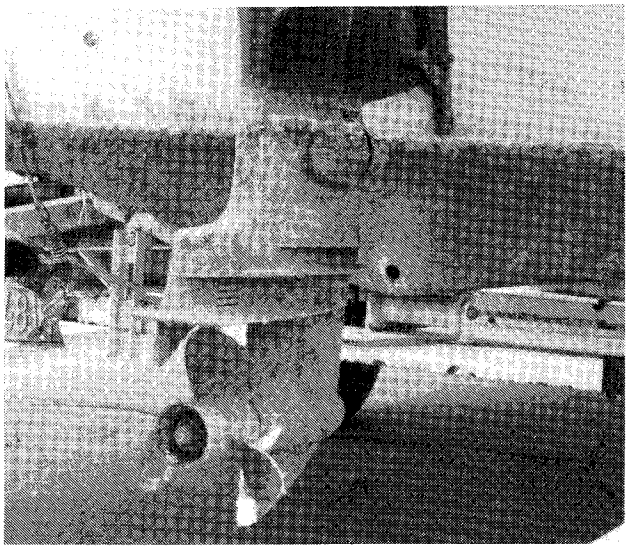
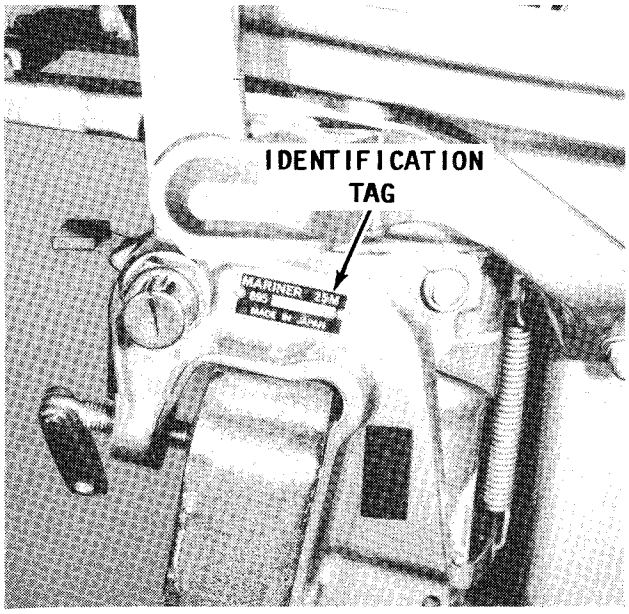


Example of a fouled boat bottom and lower outboard unit. Such condition should be corrected for maximum performance.

side; and the left side is the **port** side. All directional references in this manual use this terminology. Therefore, the direction from which an item is viewed is of no consequence, because **starboard** and **port** **NEVER** change no matter where the individual is located.

3-2 OUTBOARD SERIAL NUMBERS

The engine serial numbers are the manufacturer's key to engine changes. These numbers identify the year of manufacture, the qualified horsepower rating, and the parts book identification. If any correspondence or parts are required, the engine serial number **MUST** be used or proper identification is not possible. The accompanying illustration will be very helpful in locating the engine identification tag for the various models.



Typical location of the identification tag on a small horsepower outboard unit.

ONE MORE WORD:

The serial number establishes the year in which the engine was produced and not necessarily the year of first installation.

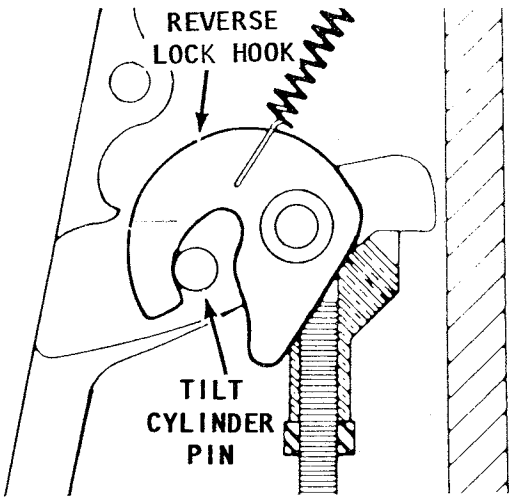
Two serial number locations are used on each of the outboard units covered in this manual. The most accessible location is on the serial/instruction plate on the swivel bracket. The other location is on the engine cylinder block.

3-3 LUBRICATION - COMPLETE UNIT

As with every type mechanical invention with moving parts, lubrication plays a prominent role in operation, enjoyment, and longevity of the unit.

If an outboard unit is operated in salt water the frequency of applying lubricant to fittings is usually cut in half for the same fitting if the unit is used in fresh water. The few minutes involved in moving around the outboard applying lubricant and at the same time making a visual inspection of its general condition will pay in rich rewards with years of continued service.

It is not uncommon to see outboard units well over 20-years of age moving a boat through the water as if the unit had recently been purchased from the current line of models. An inquiry with the proud owner



The under surface of the reverse lock hook should be lubricated where it contacts the tilt cylinder pin.

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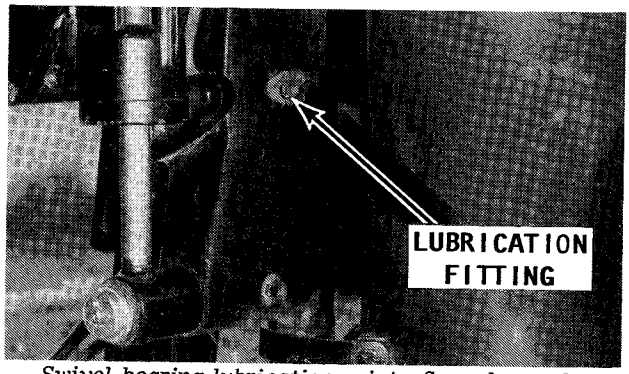
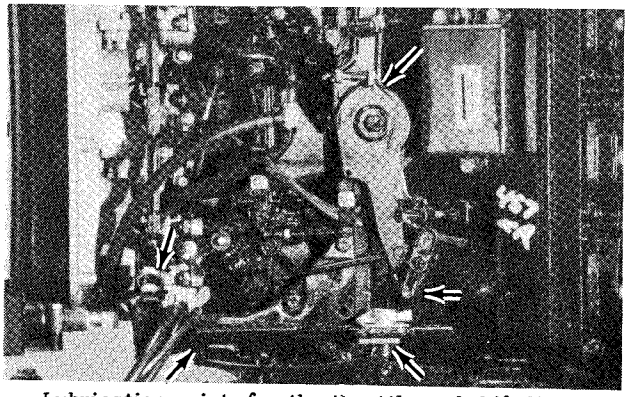


Swivel bearing lubrication point. Some larger horsepower units have two such points.



Lubrication points for the throttle and shift linkage.

LUBRICATION POINT/FREQUENCY CHART

DESCRIPTION	LUBRICANT	FREQUENCY FRESH WATER	FREQUENCY SALT WATER
Ride-Guide steering cable	Multipurpose Lubricant	Every 60 days	Every 30 days
Throttle linkage and throttle cable			
Upper shift shaft			
Lube fitting in power trim cylinder			
Reverse lock lever			
Shift linkage and shift cable			
Steering link rod pivot points	SAE 30W engine oil		
Clamp screws	Anti-Corrosion Lubricant		
Propeller shaft	Perfect Seal	Once in season	Every 60 days
Gear Housing	Super-Duty Lubricant	After 10 days then ea. 30 days	After 10 days then ea. 30 days
Tilt lock lever	Multipurpose Lubricant	Every 60 days	Every 30 days
Cranking motor pinion gear	SAE 10W Engine oil	Once ea. season	Once ea. season

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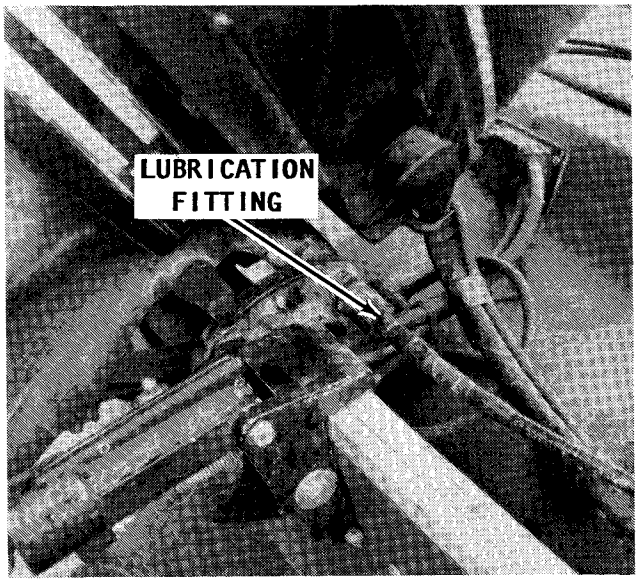
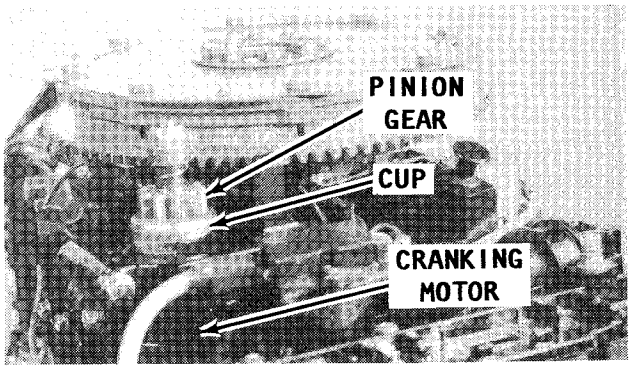
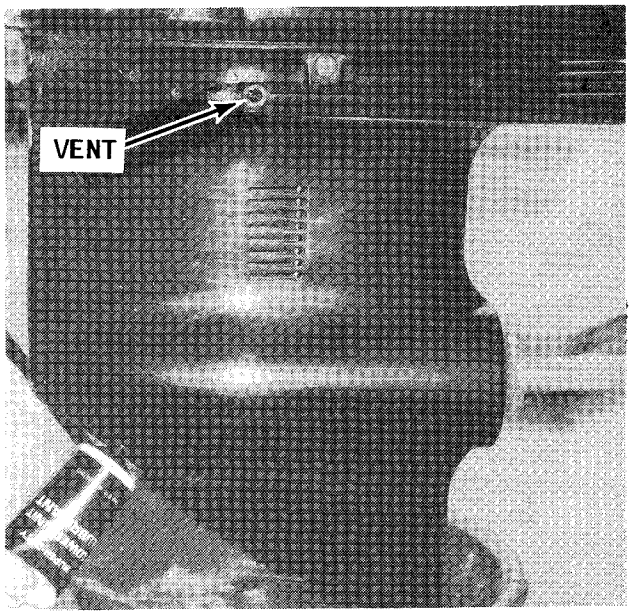


Steering cable lubrication fitting. This point should be serviced after each outing to force water from the cable shaft.



The outer surface of the cup below the pinion gear and the gear should be lubricated periodically.



Filling the lower unit with approved gear lubricant through the drain plug opening. The vent plug must be "cracked" open slightly to permit trapped air to escape.

will undoubtedly reveal his main credit for its performance to be regular periodic maintenance.

The following chart can be used as a guide to periodic maintenance while the outboard is being used during the season. The pictures numbers reference in the chart are keyed to the illustrations in this section.

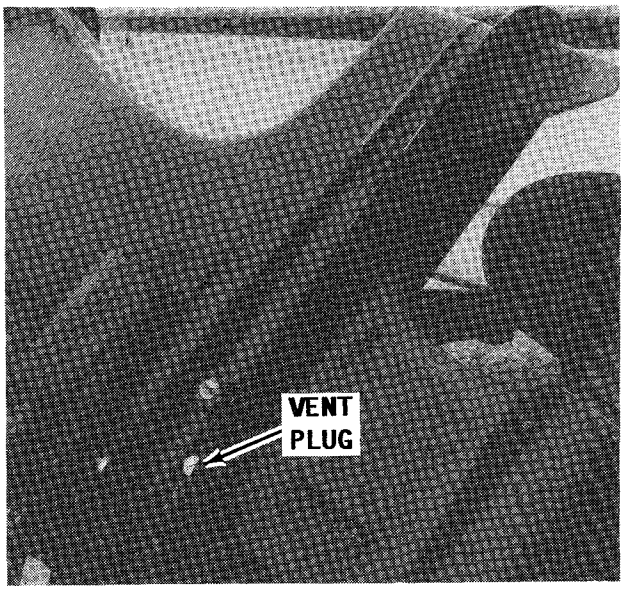
In addition to the normal lubrication listed in the lubrication chart, the prudent owner will inspect and make checks on a regular basis as listed in the accompanying chart.

3-4 PRE-SEASON PREPARATION

Satisfactory performance and maximum enjoyment can be realized if a little time is spent in preparing the outboard unit for service at the beginning of the season. Assuming the unit has been properly stored, as outlined in Section 3-12, a minimum amount of work is required to prepare the unit for use.

The following steps outline an adequate and logical sequence of tasks to be performed before using the outboard the first time in a new season.

1- Lubricate the outboard according to the manufacturer's recommendations. Refer to the lubrication chart on Page 3-3. Remove, clean, inspect, adjust, and install the spark plugs with new gaskets (if they require gaskets). Make a thorough check of



The upper vent plug should be removed periodically and the opening cleaned with a piece of wire. The oil level should be close to the vent hole. Any indication of a "milky" color to the oil means water in the lubricant.

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INSPECTION AND CHECKS

Item or Area to be Checked	Every 30 Days	Every 60 Days	Once In Season	Twice In Season
Lubricant level in lower unit	X			
Lubricant level in Power Trim/Tilt		X		
Clean battery terminals				X
Spark plugs & leads			X	
Clean fuel filter/s			X	
Fuel filter on oil injection unit		X		
Fuel filter at fuel tank			X	
All fuel lines and connections				X
Complete outboard -- damaged parts			X	
Breaker points			X	
Propeller for damage		X		
Clean outboard -- touch-up paint			X	

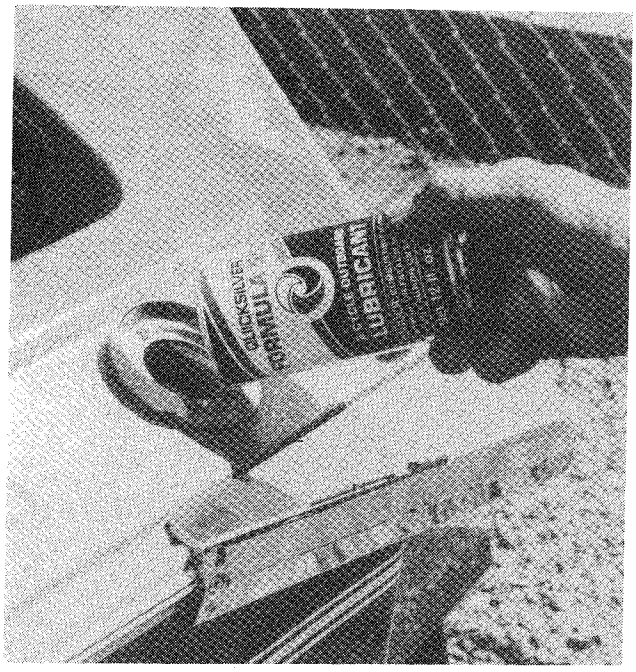
SPECIAL WORDS

Time for inspection, checks, and maintenance can almost be cut in half, if the unit is operated in salt water.

the ignition system. This check should include: ignition coil/s, stator assembly, condition of the wiring, and the battery electrolyte level and charge.

2- If a built-in fuel tank is installed, take time to check the gasoline tank and all of the fuel lines, fittings, couplings, valves, flexible tank fill and vent. Turn on the fuel supply valve at the tank. If the fuel was not drained at the end of the previous season, make a careful inspection for gum formation. If a six-gallon fuel tank is used, take the same action. When gasoline is allowed to stand for long periods of time, particularly in the presence of copper, gummy deposits form. This gum can clog the filters, lines, and passageways in the carburetor. See Chapter 4, Fuel System Service.

3- Check the oil level in the lower unit by first removing the vent screw on the port side just above the anti-cavitation plate. Insert a short piece of wire into the hole and check the level. Fill the lower unit according to procedures outlined in Section 3-11.



Adding approved oil to the fuel in a permanent fuel tank installation. The oil should be carefully measured and added in the proportions recommended by the manufacturer.

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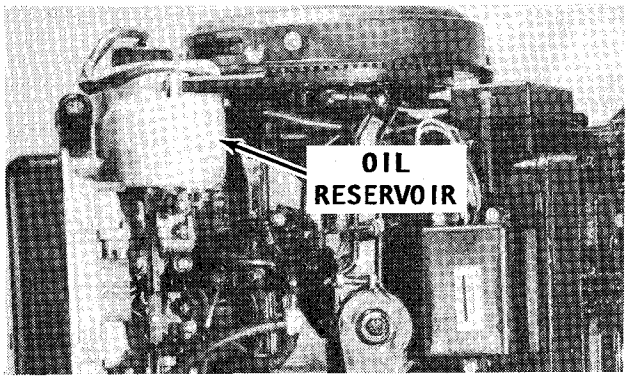


Typical oil injection system installed on a late model V6 powerhead. The remote tank, installed in the boat is not shown.

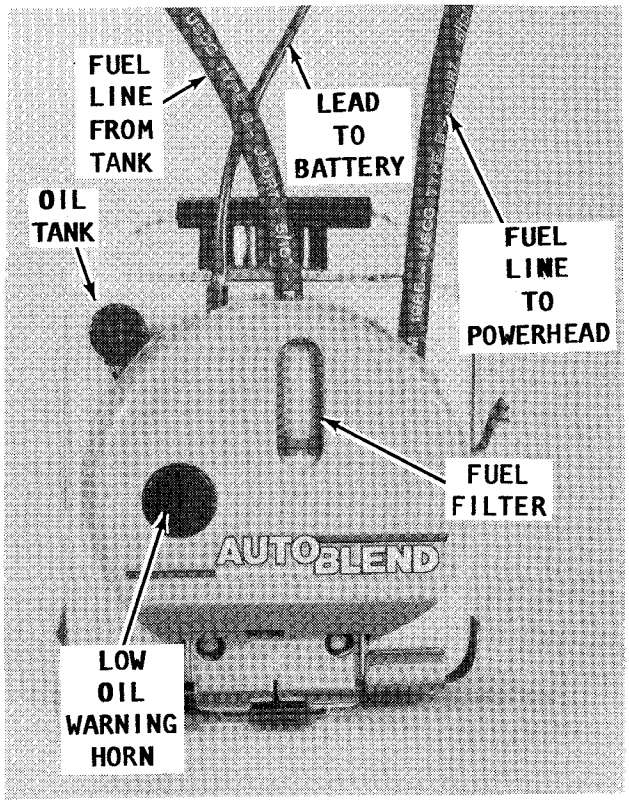
UNITS WITH OIL INJECTION

Units With Advanced Oil Injection

No pre-season preparation is necessary.

Units With "Auto Blend"

4- Remove the front cover of the unit by simultaneously pushing in on the cutaway tabs located on both sides of the cover, and at the same time pulling the cover away from the unit. Check to be sure the fuel drain plug is tight. Replace the front cover by aligning the cover openings on both sides of the unit, and then pushing in on the cover until it snaps into place.



Exterior view of an Autoblend oil injection unit connected and ready for the season's operation.

Next, fill the oil tank with 2-cycle outboard oil with a BIA rating of TC-W. Tighten the fill cap securely.

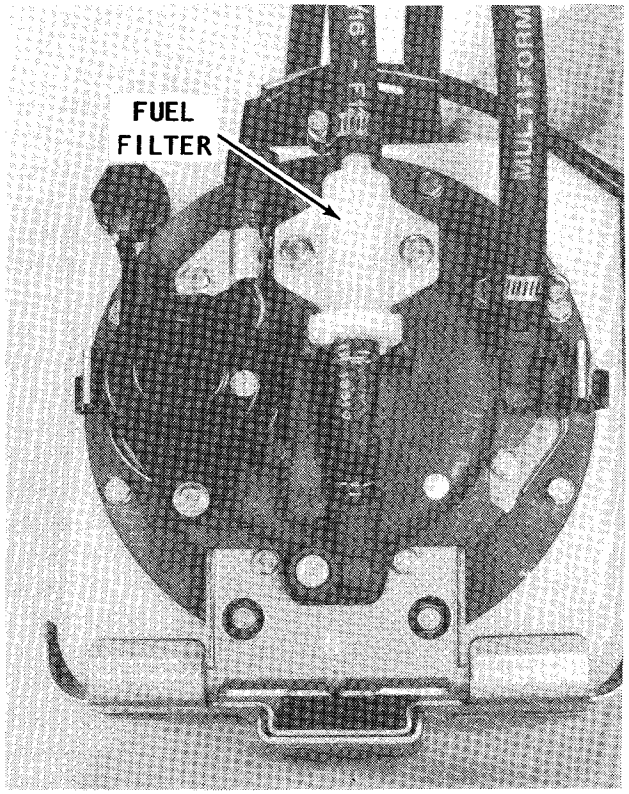
Remove any plugs in the fuel lines, and then connect the hoses to the fuel tank and the powerhead. Remember, the squeeze bulb **MUST** be in the hose between the oil injection unit and the fuel pump on the powerhead.

Connect the low oil warning wire harness to the battery. Connect the **RED** lead to the positive battery terminal and the **BLACK** lead to the negative battery terminal.

Check to be sure the low oil warning system is functioning correctly. First, verify the tank is full of oil, and then the fill cap is tightened securely. Now, turn the oil injection unit upside down. This position will allow the float to activate the horn.

If the horn sounds, immediately turn the unit rightside up and position it in the mounting bracket. Secure it in place with the strap and Velcro material.

If the horn does not sound, check the 0.5 amp fuse in the fuse holder of the positive battery lead. Check both the battery connections and the charge condition of the battery.



Autoblend oil injection unit with the plastic cover removed, ready for a pre-season check or maintenance.

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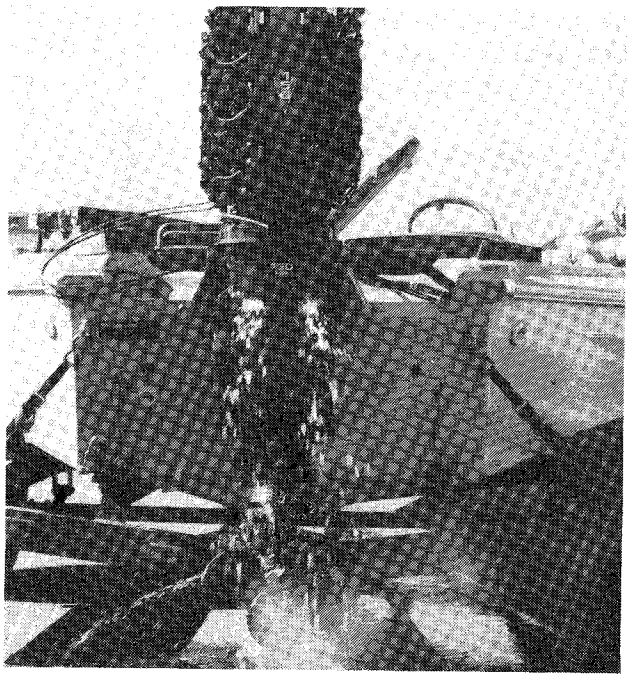
GOOD WORDS

The manufacturer recommends the fuel filter be replaced at the start of each season or at least once a year. The manufacturer also recommends oil be added to the fuel tank at the ratio of 50:1 for the first 6-gallons of fuel used after the unit is brought out of storage. The oil in the fuel tank plus the 50:1 oil mixture in the oil injection unit will deliver a mixture of 25:1 to the powerhead. This ratio will **ENSURE** adequate lubrication of moving parts which have been drained of oil during the storage period.

ALL UNITS

5- Close all water drains. Check and replace any defective water hoses. Check to be sure the connections do not leak. Replace any spring-type hose clamps, if they have lost their tension, or if they have distorted the water hose, with band-type clamps.

6- The engine can be run with the lower unit in water to flush it. If this is not practical, a flush attachment may be used. This unit is attached to the water pick-up in the lower unit. Attach a garden hose, turn on the water, allow the water to flow into the engine for awhile, and then run the engine.



Flushing with a flush attachment connected to the lower unit. The powerhead should ***NEVER*** *be run above idle speed with this type device attached.*

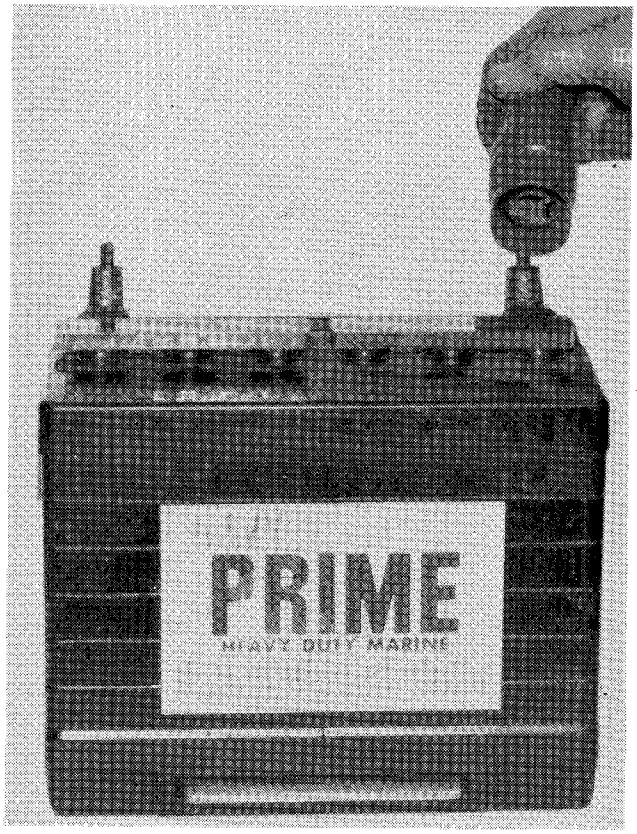
CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Check the exhaust outlet for water discharge. Check for leaks. Check operation of the thermostat.

7- Check the electrolyte level in the battery and the voltage for a full charge. Clean and inspect the battery terminals and cable connections. **TAKE TIME** to check the polarity, if a new battery is being installed. Cover the cable connections with grease or special protective compound as a prevention to corrosion formation. Check all electrical wiring and grounding circuits.

8- Check all electrical parts on the engine and lower portions of the hull to be sure they are not of a type that could cause ignition of an explosive atmosphere. Rubber caps help keep spark insulators clean and reduce the possibility of arcing. Starters, generators, distributors, alternators, electric fuel pumps, voltage regulators, and



An inexpensive two-part tool will do an excellent job of cleaning the battery terminals and the inside of the cable connectors.

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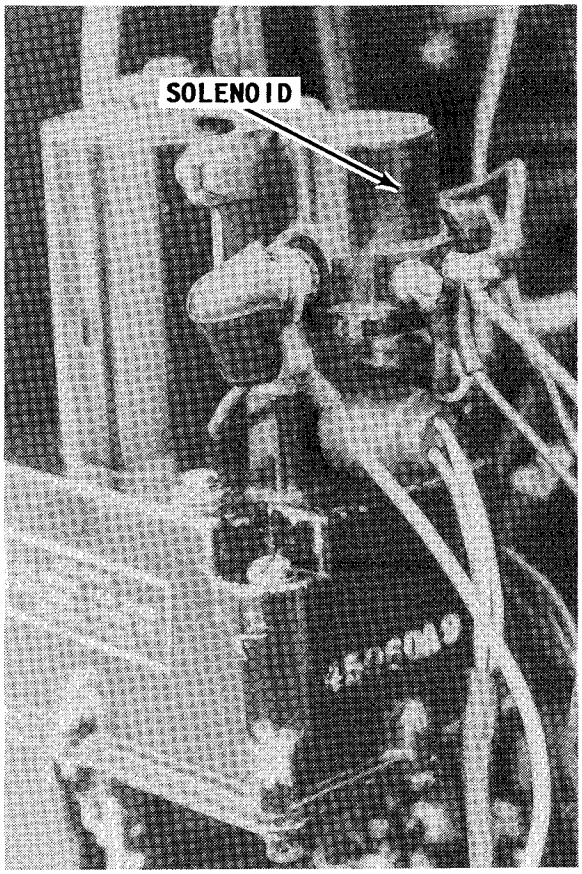
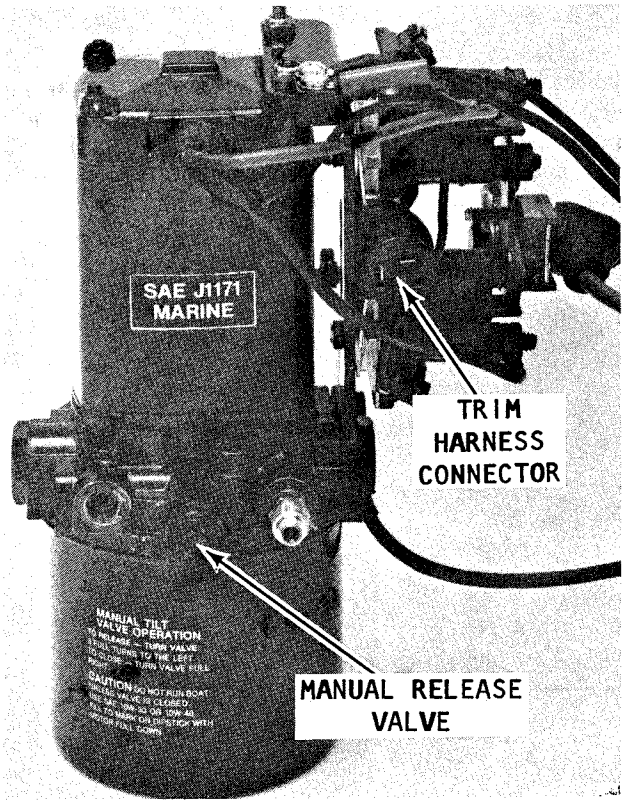


Typical early model power trim/tilt pump installation with one solenoid.



Typical late model trim/tilt up and down solenoids installed on the pump motor.

high-tension wiring harnesses should be of a marine type that cannot cause an explosive mixture to ignite.

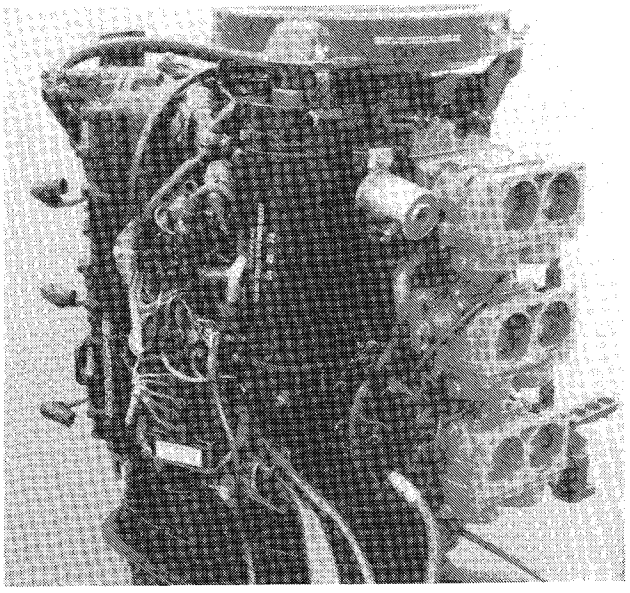
ONE FINAL WORD

Before putting the boat in the water, **TAKE TIME** to **VERIFY** the drain plugs are installed. Countless number of boating excursions have had a very sad beginning because the boat was eased into the water only to have the boat begin to fill with the "wet stuff" from the river, lake, reservoir, etc.

3-5 FIBERGLASS HULLS

Fiberglass-reinforced plastic hulls are tough, durable, and highly resistant to impact. However, like any other material they can be damaged. One of the advantages of this type of construction is the relative ease with which it may be repaired. Because of its break characteristics, and the simple techniques used in restoration, these hulls have gained popularity throughout the world. From the most congested urban marina, to isolated lakes in wilderness areas, to the severe cold of far off northern seas, and in sunny tropic remote rivers of primative islands or continents, fiberglass boats can be found performing their daily task with a minimum of maintenance.

A fiberglass hull has almost no internal stresses. Therefore, when the hull is broken or stove-in, it retains its true form. It will not dent to take an out-of-shape set. When the hull sustains a severe blow, the impact



Remember to check even the most obvious electrical connections, at the beginning of each season.

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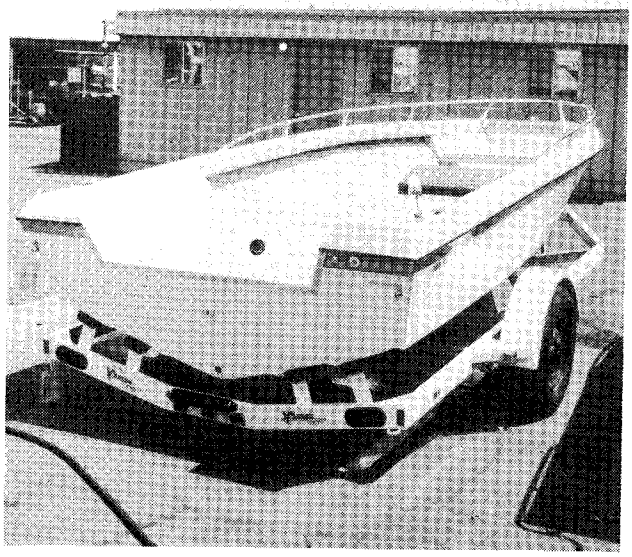
will be either absorbed by deflection of the laminated panel or the blow will result in a definite, localized break. In addition to hull damage, bulkheads, stringers, and other stiffening structures attached to the hull may also be affected and therefore, should be checked. Repairs are usually confined to the general area of the rupture.

3-6 BELOW WATERLINE SERVICE

A foul bottom can seriously affect boat performance. This is one reason why racers, large and small, both powerboat and sail, are constantly giving attention to the condition of the hull below the waterline.

In areas where marine growth is prevalent, a coating of vinyl, anti-fouling bottom paint should be applied. If growth has developed on the bottom, it can be removed with a solution of muriatic acid applied with a brush or swab and then rinsed with clear water. **ALWAYS** use rubber gloves when working with muriatic acid and **TAKE EXTRA CARE** to keep it away from your face and hands. The **FUMES ARE TOXIC.** Therefore, work in a well-ventilated area, or if outside, keep your face on the windward side of the work.

Barnacles have a nasty habit of making their home on the bottom of boats which have not been treated with anti-fouling paint. Actually they will not harm the fiberglass hull, but can develop into a major nuisance.



New boat in a dealer's lot ready for installation of an outboard unit to give its owner a "fun day" on the water.

If barnacles or other crustaceans have attached themselves to the hull, extra work will be required to bring the bottom back to a satisfactory condition. First, if practical, put the boat into a body of fresh water and allow it to remain for a few days. A large percentage of the growth can be removed in this manner. If this remedy is not possible, wash the bottom thoroughly with a high-pressure fresh water source and use a scraper. Small particles of hard shell may still hold fast. These can be removed with sandpaper.

3-7 SUBMERGED ENGINE SERVICE

A submerged engine is always the result of an unforeseen accident. Once the engine is recovered, special care and service procedures **MUST** be closely followed in order to return the unit to satisfactory performance.

NEVER, again we say **NEVER** allow an engine that has been submerged to stand more than a couple hours before following the procedures outlined in this section and making every effort to get it running. Such delay will result in serious internal damage. If all efforts fail and the engine cannot be started after the following procedures have been performed, the engine should be disassembled, cleaned, assembled, using new gaskets, seals, and O-rings, and then started as soon as possible.

Submerged engine treatment is divided into three unique problem areas: Submersion in salt water; submerged engine while running; and a submerged engine in fresh water, including special instructions.

The most critical of these three circumstances is the engine submerged in salt water, with submersion while running a close second.

Salt Water Submersion

NEVER attempt to start the engine after it has been recovered. This action will only result in additional parts being damaged and the cost of restoring the engine increased considerably. If the engine was submerged in salt water the complete unit **MUST** be disassembled, cleaned, and assembled with new gaskets, O-rings, and seals. The corrosive effect of salt water can only be eliminated by the complete job being properly performed.

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Submerged While Running Special Instructions

If the engine was running when it was submerged, the chances of internal engine damage is greatly increased. After the engine has been recovered, remove the spark plugs to prevent compression in the cylinders. Make an attempt to rotate the crankshaft with the rewind starter or the flywheel. On larger horsepower engines without a rewind starter, use a socket wrench on the flywheel nut to rotate the crankshaft. If the attempt fails, the chances of serious internal damage, such as: bent connecting rod, bent crankshaft, or damaged cylinder, is greatly increased. If the crankshaft cannot be rotated, the powerhead must be completely disassembled.

CRITICAL WORDS

Never attempt to start powerhead that has been submerged. If there is water in the cylinder, the piston will not be able to compress the liquid. The result will most likely be a bent connecting rod.

Submerged Engine — Fresh Water

SPECIAL WORD: As an aid to performing the restoration work, the following steps are numbered and should be followed in sequence. However, illustrations are not included with the procedural steps because the work involved is general in nature.

1- Recover the engine as quickly as possible.

2- Remove the cowl and the spark plugs.

3- Remove the carburetor float bowl cover, or the bowl. On units equipped with EFI, remove and drain the vapor separator.

4- Flush the outside of the engine with fresh water to remove silt, mud, sand, weeds, and other debris. **DO NOT** attempt to start the engine if sand has entered the powerhead. Such action will only result in serious damage to powerhead components. Sand in the powerhead means the unit must be disassembled.

CRITICAL WORDS

Never attempt to start powerhead that has been submerged. If there is water in the cylinder, the piston will not be able to compress the liquid. The result will most likely be a bent connecting rod.

5- Remove as much water as possible from the powerhead. Most of the water can be eliminated by first holding the engine in



Two Quicksilver products available for normal maintenance use and to restore an engine after it has been submerged.

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a horizontal position with the spark plug holes **DOWN,** and then cranking the powerhead with the rewind starter or with a socket wrench on the flywheel nut. Rotate the crankshaft through at least 10 complete revolutions. If you are satisfied there is no water in the cylinders, proceed with Step 6 to remove moisture.

6- Alcohol will absorb moisture. Therefore, pour alcohol into the carburetor throat and again crank the powerhead.

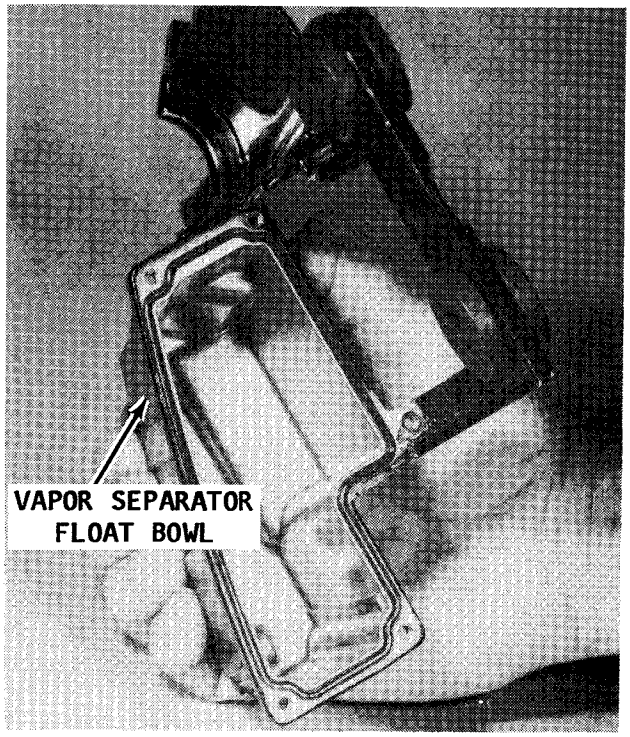
7- Rotate the outboard in the horizontal position until the spark plug openings are facing **UPWARD.** Pour alcohol into the spark plug openings and again rotate the crankshaft.

8- Rotate the outboard in the horizontal position until the spark plug openings are again facing **DOWN.** Pour engine oil into the carburetor throat and, at the same time, rotate the crankshaft to distribute oil throughout the crankcase.

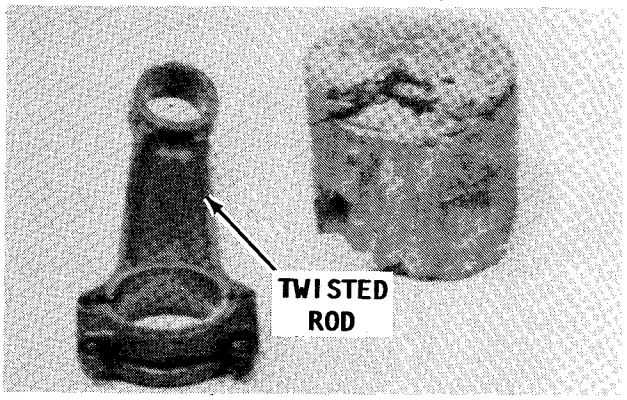
9- Rotate the outboard in the horizontal position until the spark plug holes are again facing **UPWARD.** Pour approximately one teaspoon of engine oil into each spark plug opening. Rotate the crankshaft to distribute the oil in the cylinders.

10- Install and connect the spark plugs.

11- Install the carburetor float bowl cover, or the bowl.



The vapor separator -- installed only on powerheads equipped with EFI — must be drained if the powerhead was submerged.

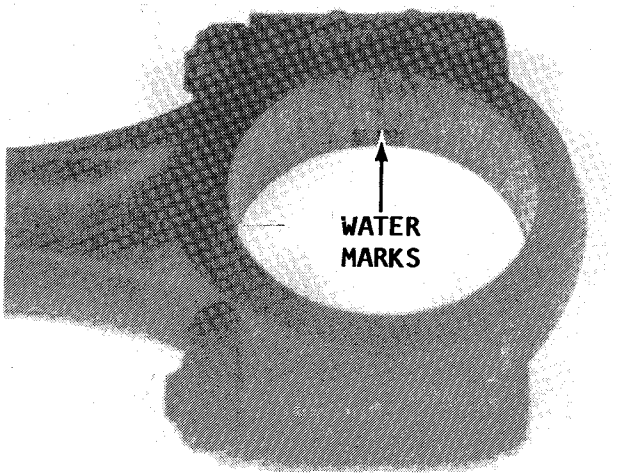


Damaged rod and piston caused when the powerhead was submerged while running.

12- Obtain **FRESH** fuel and attempt to start the engine. If the powerhead will start, allow it to run for approximately an hour to eliminate any unwanted moisture remaining in the powerhead.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

13- If the powerhead fails to start, determine the cause, electrical or fuel, correct the problem, and again attempt to get it running. **NEVER** allow a powerhead to remain unstarted for more than a couple hours without following the procedures in this section and attempting to start it. If attempts to start the powerhead fail, the unit should be disassembled, cleaned, assembled, using new gaskets, seals, and O-rings, just as **SOON** as possible.



Damaged rod and rod cap unfit for further service. The needle bearing water marks shown were caused from water entering the powerhead.

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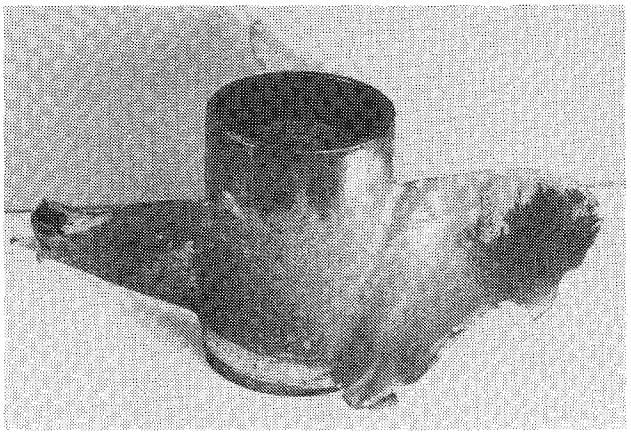
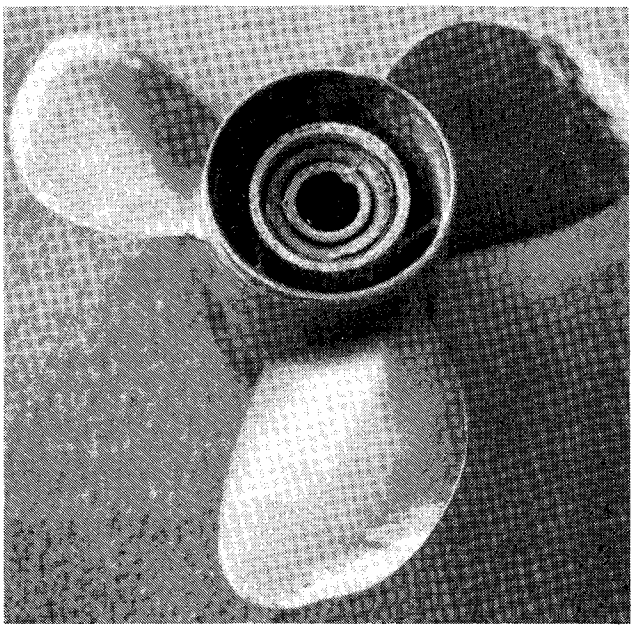


This propeller is damaged beyond repair. Even the best "Prop Shop" could not restore it for satisfactory service.

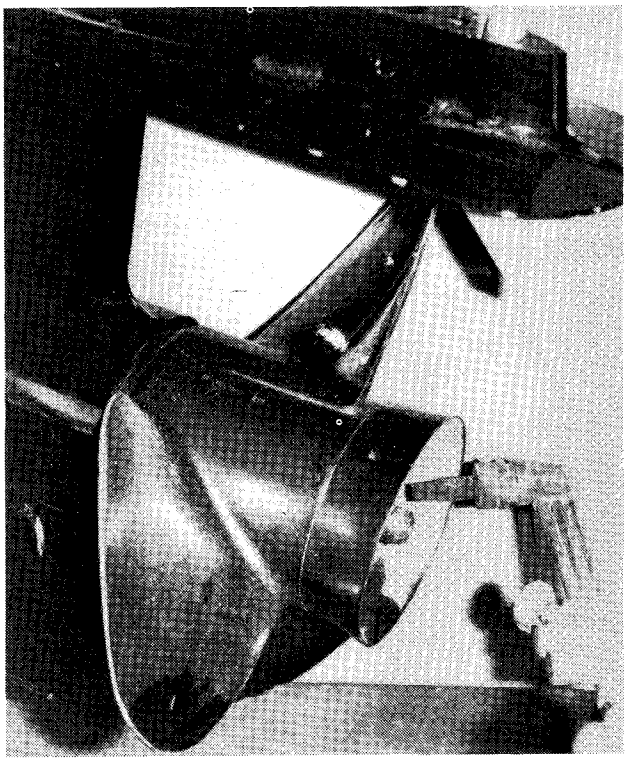
3-8 PROPELLER SERVICE

The propeller should be checked regularly to be sure all the blades are in good condition. If any of the blades become bent or nicked, this condition will set up vibrations in the motor. Remove and inspect the propeller. Use a file to trim nicks and burrs. **TAKE CARE** not to remove any more material than is absolutely necessary. For a complete check, take the propeller to your marine dealer where the proper equipment and knowledgeable mechanics are available to perform a proper job at modest cost.

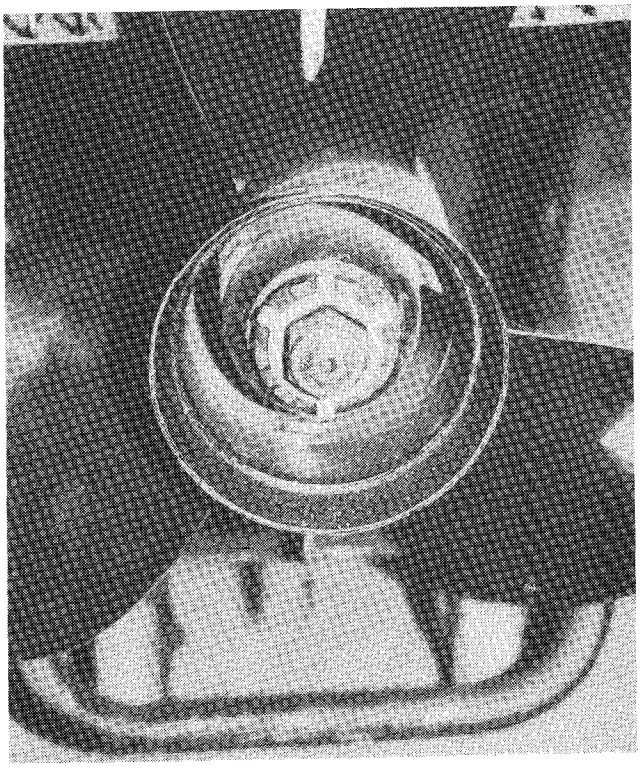


This slightly damaged propeller can be reconditioned in a "Prop Shop", and then returned to service.

Inspect the propeller shaft to be sure it is still true and not bent. If the shaft is not perfectly true, it should be replaced.



If an antiseizing compound was not used when the propeller was installed the last time, drastic measures may be required to remove the propeller from the shaft.



Close on view of a propeller properly installed. All parts are in place and the tab of the tab washer has been bent into the locking position. The unit is ready to move the boat through the water for its owner.

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Install the thrust hub. Coat the propeller shaft splines with Perfect Seal No. 4, and the rest of the shaft with a good grade of anti-corrosion lubricant. Install the propeller, and then the splined washer, tab washer, and propeller nut.

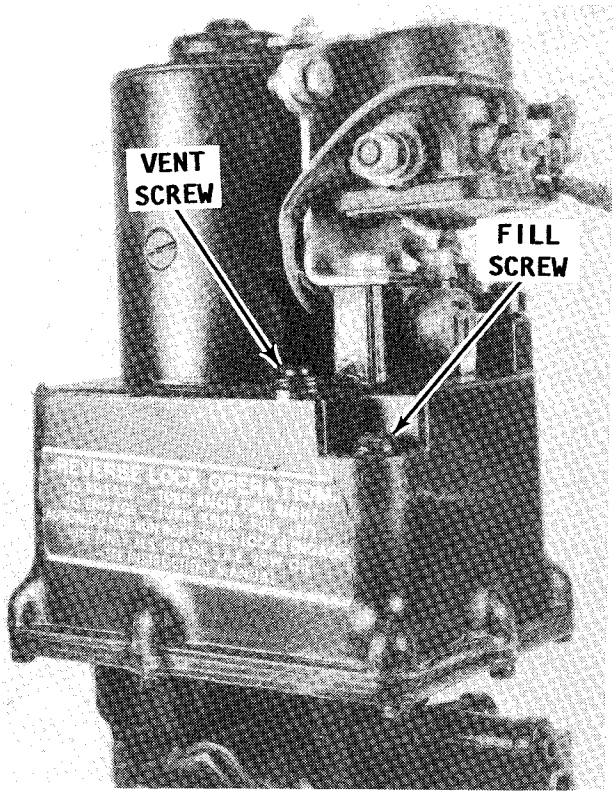
Position a block of wood between the propeller and the anti-cavitation tab to keep the propeller from turning. Tighten the propeller nut to a torque value of 35-45 ft. lbs (47.6-61.2 Nm). Adjust the nut to fit the tab lock space. Bend three of the tab washer tabs into the spline washer using a punch and hammer. The tabs will prevent the nut from backing out.

3-9 POWER TRIM/TILT

Check the power trim/tilt system for proper operation.

Units with One Trim/Tilt Cylinder

Lower the outboard unit to the full **DOWN** position. Check the oil level in the pump reservoir and be sure the vent screw is left **OPEN.** By the term "open", the manufacturer suggests backing the screw out 1-1/2 turns from the seated position.



*Overall exterior view of an early model Power Trim/Tilt unit. Use **ONLY** the manufacturer's recommended oil.*

CAUTION

The Fill/Vent screw must be OPEN, backed out 1-1/2 turns from the seated position to vent the pump reservoir.

Units with Two Trim/Tilt Cylinders

Raise the outboard unit to the full **UP** position, and then engage the tilt lock lever.

WARNING

TRIM SYSTEM IS PRESSURIZED! DO NOT REMOVE FILL SCREW UNLESS OUTBOARD UNIT IS IN CORRECT POSITION.

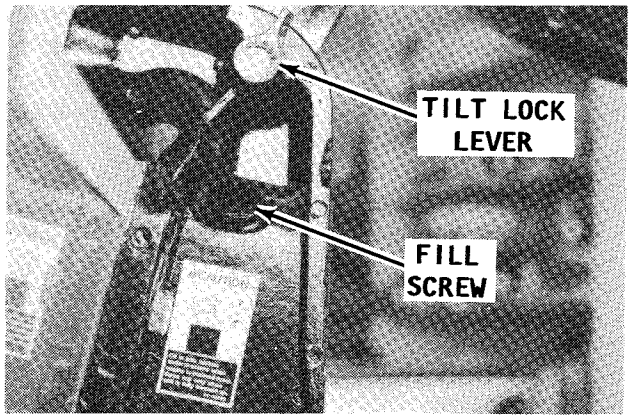
If the trim/tilt pump and motor are installed in the boat, the outboard unit **MUST** be in the full **DOWN** position.

If the trim/tilt pump and motor are installed between the clamp brackets, the outboard unit **MUST** be in the full **UP** position.

TIGHTEN FILL SCREW SECURELY BEFORE MOVING OUTBOARD.

Slowly remove **Fill** screw on the pump reservoir and check the oil level in the pump. The oil level should be at the bottom of the fill screw threads. Replenish as necessary with SAE 10W-30 motor oil. In tropical areas, single viscosity SAE 30W motor oil may be used. Do not overfill. See Chapter 10 for detailed instructions to bleed and flush the system.

Tighten the fill screw securely. The vent screw will always stay open to vent the pump reservoir.



*The pump reservoir of late model power trim/tilt units is behind the port clamp bracket. The system is pressurized. Therefore, the fill screw **MUST NEVER** be loosened or removed unless the outboard unit is in the correct position. If the pump and motor are mounted in the boat, the outboard **MUST** be in the **DOWN** position. If the pump and motor are mounted between the clamp brackets, the outboard **MUST** be in the full **UP** position.*

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Units with Two Trim Cylinders and One Tilt Cylinder

Raise the outboard unit to the full up position. Engage the tilt lock lever.

WARNING

TRIM SYSTEM IS PRESSURIZED! DO NOT REMOVE FILL SCREW UNLESS OUTBOARD UNIT IS IN CORRECT POSITION.

The outboard unit **MUST** be in the full UP position.

TIGHTEN FILL SCREW SECURELY BEFORE MOVING OUTBOARD.

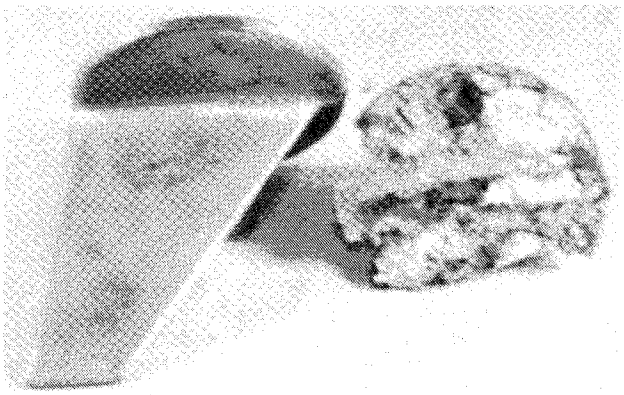
SLOWLY open the fill screw in the port clamp bracket and check the level of fluid. The fluid should be visible through the fill screw opening. Add Automatic Transmission Fluid, as required. See Chapter 10 for detailed instructions to bleed or flush the system. Tighten the screw **SECURELY.**

ALL Units

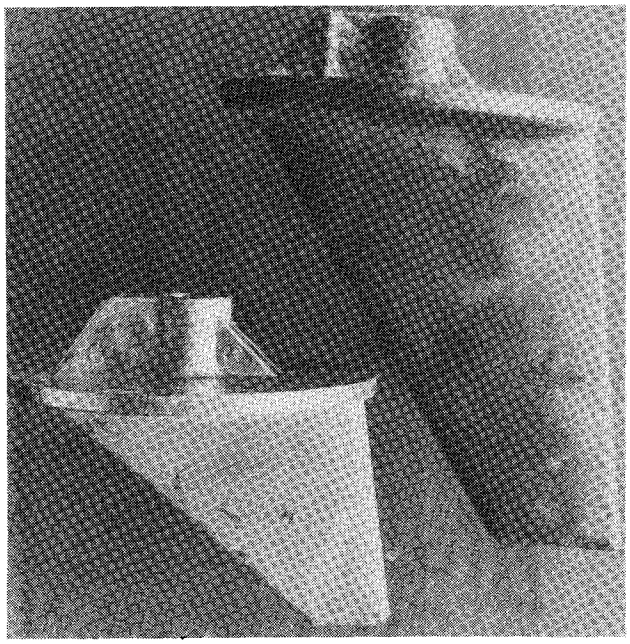
Check to be sure all connections are secure. Check and adjust the shift and throttle cables. Lubricate all external lubrication points with Multipurpose Lubricant. Check and clean the water intake opening.

Trim Tabs

Check the trim tab and the anodic heads. Replace them, if necessary. The trim tab must make a good ground inside the lower unit. Therefore, the trim tab and the cavity **MUST NOT** be painted. In addition to trimming the boat, the trim tab acts as a zinc electrode to prevent electrolysis from acting on more expensive parts. It is normal for the tab to show signs of erosion. The tabs are inexpensive and should be replaced frequently.



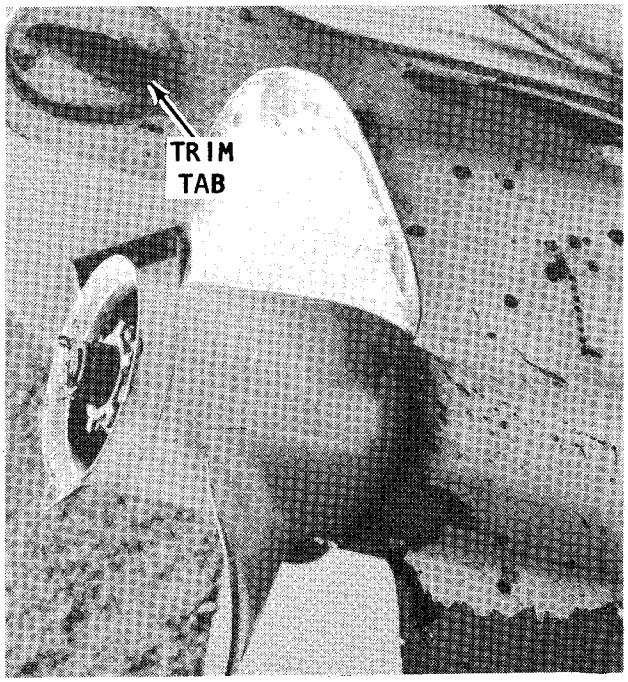
A new trim tab (left), and a badly deteriorated tab (right). Actually, such extensive erosion of the tab suggests a possible electrolysis problem.



Two types of trim tab used on the outboard units covered in this manual.

Clean the exterior surface of the unit thoroughly. Inspect the finish for damage or corrosion. Clean any damaged or corroded areas, and then apply primer and matching paint.

Check the entire unit for loose, damaged, or missing parts.



The propeller and skeg on this outboard unit are in good condition because the trim tab zinc did its job of protecting expensive parts.

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3-10 INSIDE THE BOAT

The following points may be lubricated with Quicksilver Multipurpose Lubricant:

a- Steering cable end next to the hand nut. **DO NOT** over-lubricate the cable.

b- Steering arm pivot socket.

c- Exposed shaft of the cable passing through the cable guide tube.

d- Steering link rod to the steering cable.

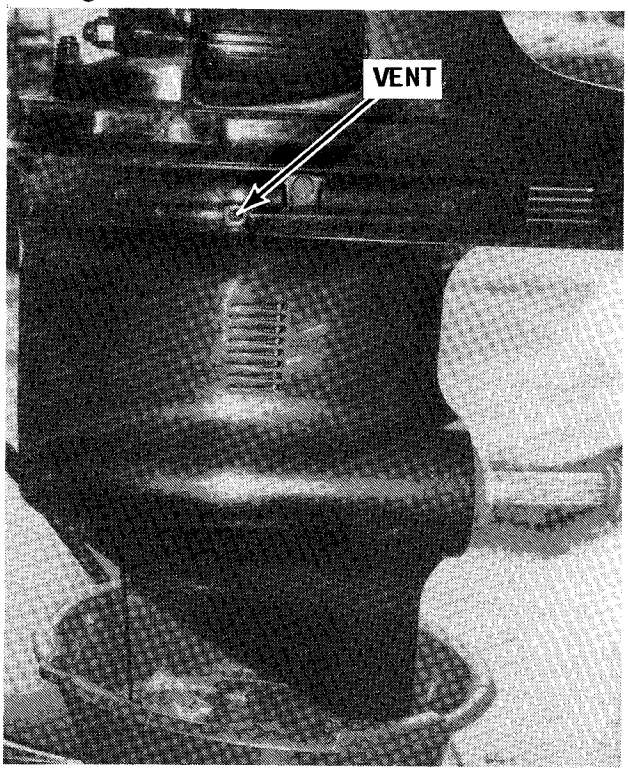
3-11 LOWER UNIT

Draining Lower Unit

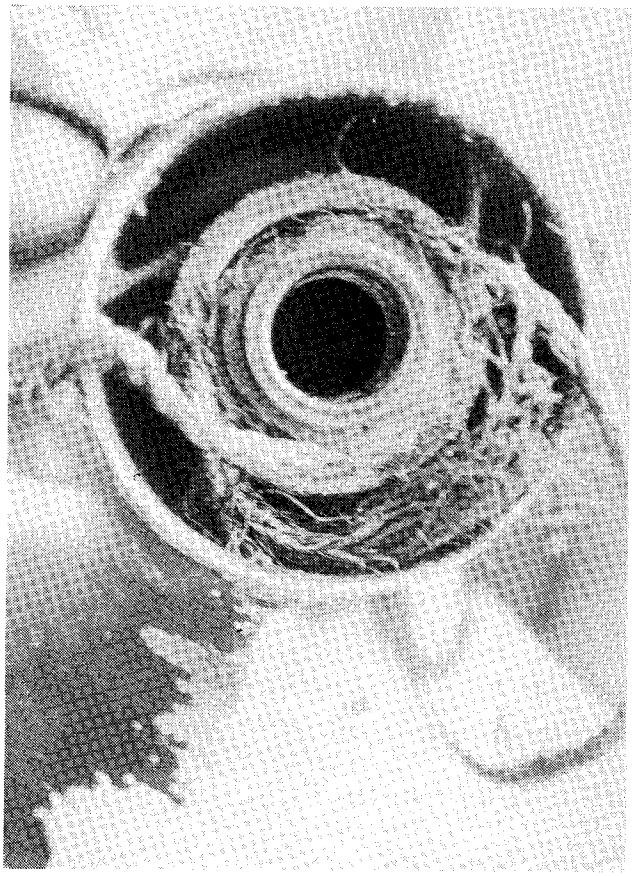
Remove the **FILL** plug from the lower end of the gear housing on the port side and the **VENT** plug just above the anti-cavitation plate.

NEVER remove the vent or filler plugs when the drive unit is hot. Expanded lubricant would be released through the plug hole. Check the lubricant level after the unit has been allowed to cool. Add only Super-Duty Gear Lubricant. **NEVER** use regular automotive-type grease in the lower unit because it expands and foams too much. Lower units do not have provisions to accommodate such expansion.

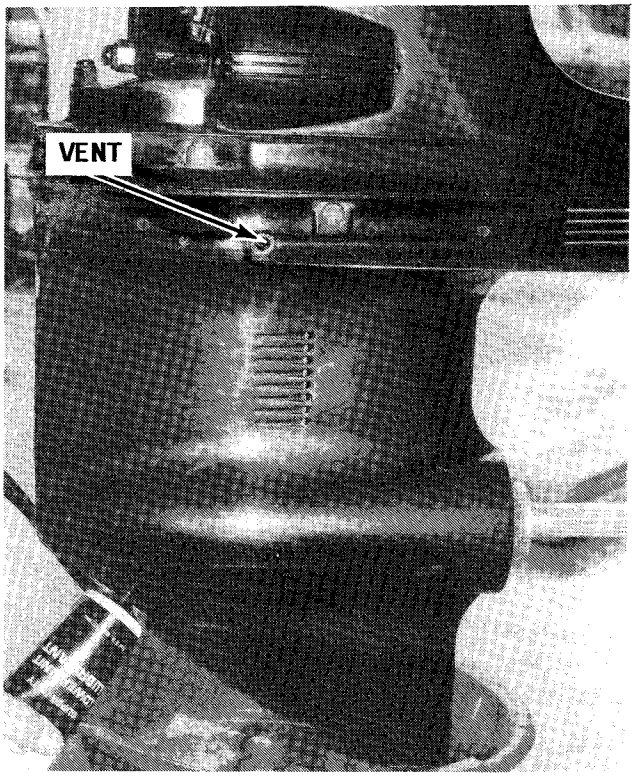
If the lubricant appears milky brown, or if large amounts of lubricant must be added



While draining oil, watch closely for a "milky" color indicating water in the lower unit. ***BAD NEWS!***



Excellent view of rope and fish line entangled behind the propeller. Entangled fish line can actually cut through the seals, allowing water to enter and oil to escape the lower unit.



Filling the lower unit with approved lower unit lubricant. Be sure the vent screw has been removed.

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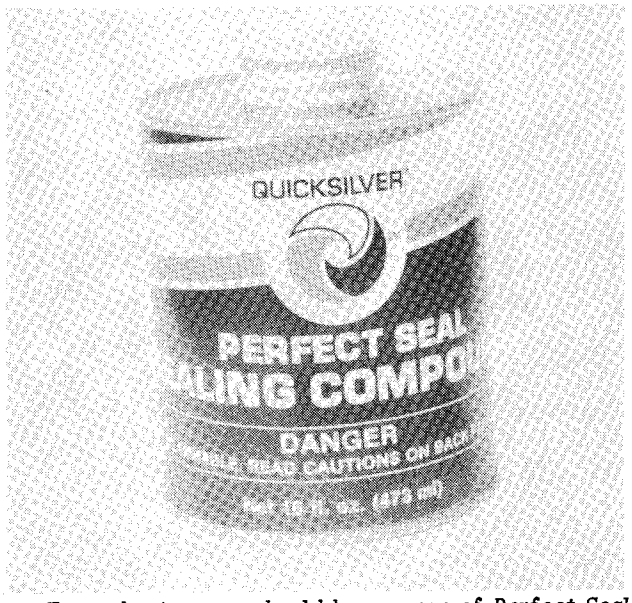


Every boat owner should have a can of Perfect Seal Sealing Compound ready for use when installing the propeller. This product will prevent the propeller splines seizing with the propeller shaft splines.

to bring the lubricant up to the full mark, a thorough check should be made to determine the cause of the loss.

Filling Lower Unit

Position the drive unit approximately vertical and without a list to either port or starboard. Insert the lubricant tube into the **FILL/DRAIN** hole at the bottom plug hole, and inject lubricant until the excess begins to come out the **VENT** hole. Install the **VENT** and **FILL** plugs with **NEW** gaskets. Check to be sure the gaskets are properly positioned to prevent water from entering the housing.

See the Appendix for lower unit capacities.



Manufacturer recommended lubricants and additives will not only keep the unit within the limits of the warranty, but will be a major contributing factor to dependable performance and reduced maintenance cost.

3-12 WINTER STORAGE

Taking extra time to store the boat properly at the end of each season, will increase the chances of satisfactory service at the next season. **REMEMBER,** idleness is the greatest enemy of an outboard motor. The unit should be run on a monthly basis. The boat steering and shifting mechanism should also be worked through complete cycles several times each month. The owner who spends a small amount of time involved in such maintenance will be rewarded by satisfactory performance, and greatly reduced maintenance expense for parts and labor.

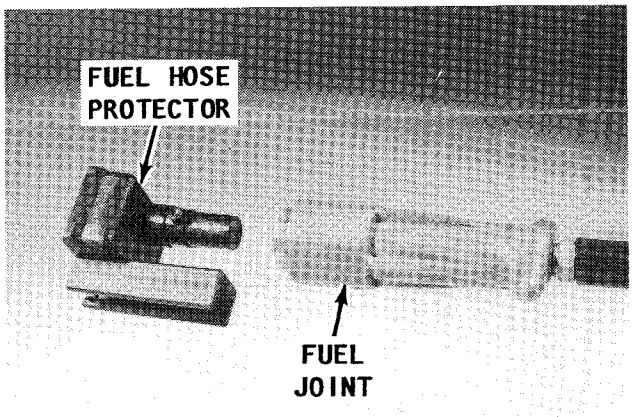
Proper storage involves adequate protection of the unit from physical damage, rust, corrosion, and dirt.

The following steps provide an adequate maintenance program for storing the unit at the end of a season.

1- Remove the cowl. Start the engine and allow it to warm to operating temperature.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Disconnect the fuel line from the engine and allow the unit to run at **LOW** rpm and, at the same time, inject about 4 ounces of Quicksilver Storage Seal through each carburetor throat. Allow the engine to run until it shuts down from lack of fuel, indicating the caburetors are dry of fuel.



A Kleen-Klip fuel hose protector, available at marine dealers and used on the end of a disconnected fuel line, will keep the fitting free of almost any type contamination and most damage.

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2- Drain the fuel tank and the fuel lines. Pour approximately one quart (0.96 liters) of benzol (benzine) into the fuel tank, and then rinse the tank and pickup filter with the benzol. Drain the tank. Store the fuel tank in a cool dry area with the vent **OPEN** to allow air to circulate through the tank. **DO NOT** store the fuel tank on bare concrete. Place the tank to allow air to circulate around it.

3- Clean the carburetor fuel filters with benzol, see Chapter 4, Carburetor Repair Section.

4- Drain, and then fill the lower unit with Super-Duty Lower Unit Gear Lubricant, as outlined in Section 3-11.

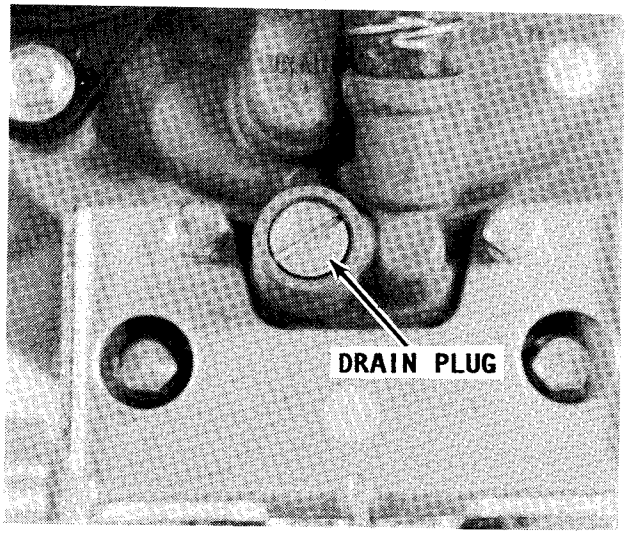
5- Lubricate the throttle and shift linkage. Lubricate the swivel pin and the tilt tube with Multipurpose Lubricant, or equivalent.

Clean the outboard unit thoroughly. Coat the powerhead with Corrosion and Rust Preventative spray. Install the cowl, and then apply a thin film of fresh engine oil to all painted surfaces.

Remove the propeller. Apply Perfect Seal or a waterproof sealer to the propeller shaft splines, and then install the propeller back in position.

STORAGE FOR MODELS WITH ADVANCE OIL INJECTION

Oil may remain in the oil reservoir and in the remote oil tank during storage without any harmful effects.



Before storing the Autoblend oil injection unit, the drain plug must be removed and any fuel in the tank allowed to drain. Draining time may be almost five full minutes.

STORAGE FOR MODELS WITH AUTO BLEND OIL INJECTION

Proper storage procedures are **CRITICAL** to ensure efficient operation when the unit is again placed in service.

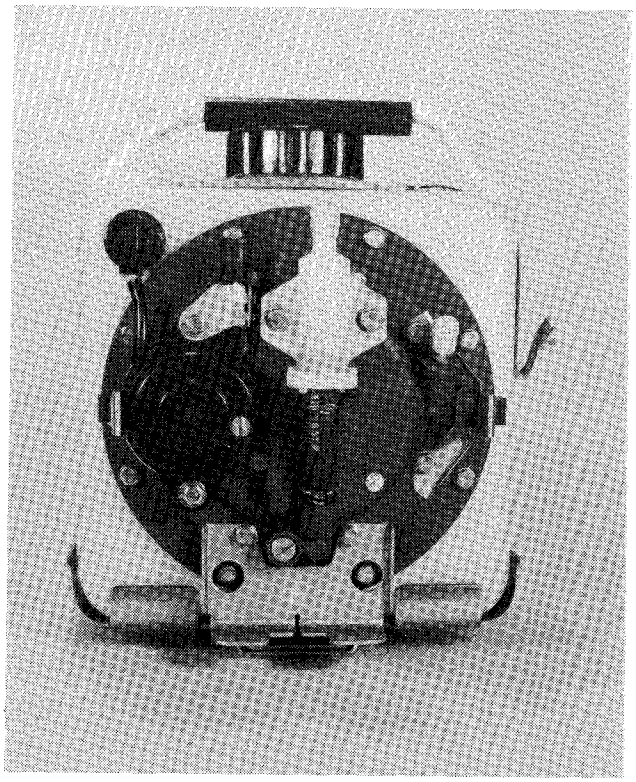
First, disconnect the battery leads from the battery.

Next, disconnect and plug the fuel lines at the fuel tank and powerhead.

Now, drain all fuel from the oil injection unit. Remove the front cover of the unit by simultaneously pushing in on the cutaway tabs located on both sides of the cover, and at the same time pulling the cover away from the unit. Remove the drain plug and allow at least 5-minutes for all fuel to drain from the pump. Install the drain plug and tighten it securely.

CRITICAL WORDS

All fuel **MUST** be drained from the oil injection fuel "pump". The percentage of alcohol in modern fuels seems to increase each year. This alcohol in the fuel is a definite enemy of the diaphragm in the "pump". Therefore, if any fuel is left in the "pump" during storage the diaphragm will most likely be damaged.



An oil injection unit removed from the boat and ready for storage. The fuel has been drained and both the inlet and outlet lines have been plugged.

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Install the front cover by aligning the cover openings on both sides of the unit, and then pushing in on the cover until it snaps into place.

Oil may remain in the oil injection tank during storage without any harmful effects.

FINAL WORDS: Be sure all drain holes in the gear housing are open and free of obstruction. Check to be sure the **FLUSH** plug has been removed to allow all water to drain. Trapped water could freeze, expand, and cause expensive castings to crack.

ALWAYS store the outboard unit off the boat with the lower unit below the powerhead to prevent any water from being trapped inside.

BATTERY STORAGE

Remove the batteries from the boat and keep them charged during the storage period. Clean the batteries thoroughly of any dirt or corrosion, and then charge them to full specific gravity reading. After they are fully charged, store them in a clean cool dry place where they will not be damaged or knocked over.

NEVER store the battery with anything on top of it or cover the battery in such a manner as to prevent air from circulating around the filler caps. All batteries, both new and old, will discharge during periods of storage, more so if they are hot than if they remain cool. Therefore, the electrolyte level and the specific gravity should be checked at regular intervals. A drop in the specific gravity reading is cause to charge them back to a full reading.

In cold climates, **EXERCISE CARE** in selecting the battery storage area. A fully-charged battery will freeze at about 60 degrees below zero. A discharged battery, almost dead, will have ice forming at about 19 degrees above zero.

ALWAYS remove the drain plug and position the boat with the bow higher than the stern. This will allow any rain water and melted snow to drain from the boat and prevent "trailer sinking". This term is used to describe a boat that has filled with rain water and ruined the interior, because the plug was not removed or the bow was not high enough to allow the water to drain properly.

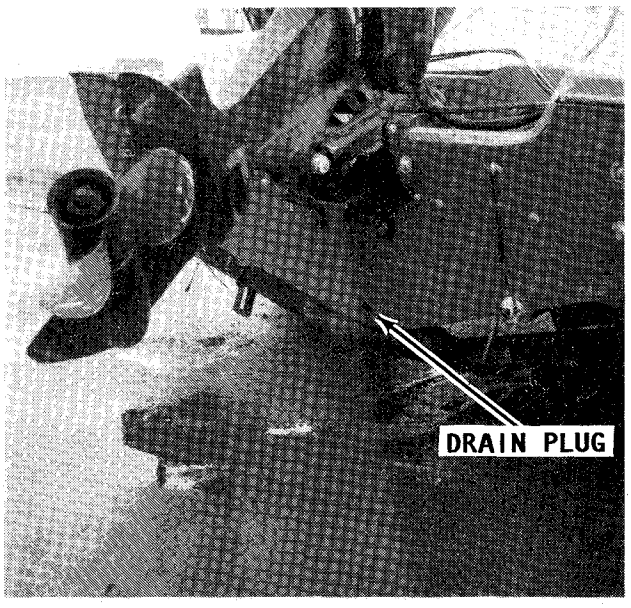
ONE FINAL WORD

Let us say again: Before putting the boat in the water, take time to verify the drain plug is installed. One good way to safeguard against forgetting the plug is to tie the plug to the steering wheel the moment it is removed for storage or the trip home on a trailer.

Keep the shift shaft shifting, the trim tab trimmed, the fuel pump pumping, the spark plugs sparking, and the pistons -- well, keep them working too.



Manufacturer's approved paint products to dress the outboard unit and give a special "pride of ownership" look. After the paint (left), is used, the leveler (right) can be applied for a smooth professional finish.



*When storing the boat during the off season, check to be **SURE** the bow is higher than the stern and the drain plug is **REMOVED**. Any rain water or snow melt will then move aft and out the opening.*

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4
FUEL

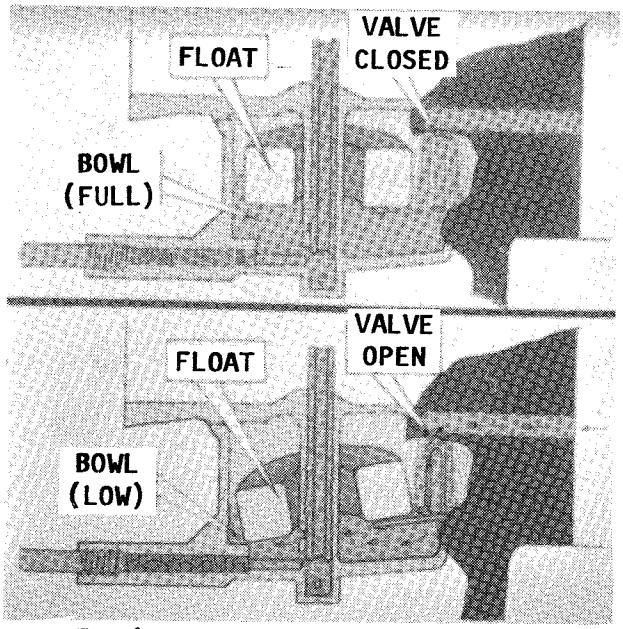
4-1 INTRODUCTION

The carburetion, fuel injection and ignition principles of two-cycle engine operation **MUST** be understood in order to perform a proper tune-up on an outboard motor.

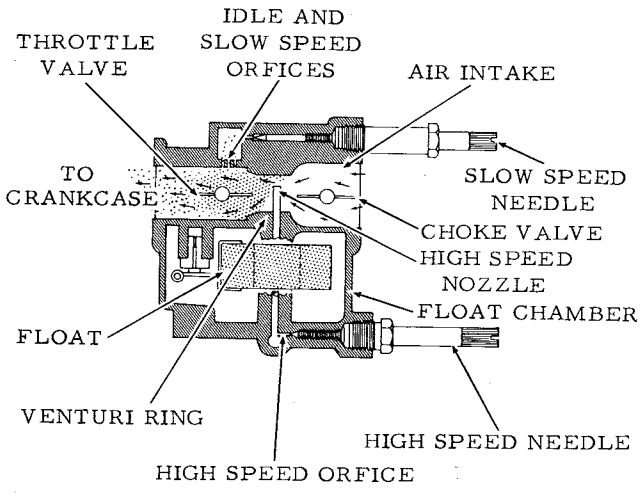
If you have any doubts concerning your understanding of two-cycle engine operation, it would be best to study the Introduction section in the first portion of Chapter 8, before tackling any work on the fuel system.

On all models, **EXCEPT** some late model V6 units equipped with electronic fuel injection (EFI), the fuel system includes the fuel tank, fuel pump, fuel filters, an anti-syphon valve, carburetors, a squeeze bulb, and the associated parts to connect it all together. Regular maintenance of the fuel system to obtain maximum performance, is limited to changing the fuel filter at regular intervals and using fresh fuel.

Some late model V6 powerheads are equipped with state-of-the-art Electronic Fuel Injection (EFI). This fuel distribution system is computer controlled. Five different sensors provide the computer with information on rpm, throttle setting, manifold air temperature, powerhead temperature and manifold pressure -which automatically adjusts to barometric pressure. The EFI fuel system includes the fuel tank, an anti-syphon valve, a mechanical fuel pump, an electric "booster" fuel pump, a primary fuel filter, a secondary fuel filter, a vapor separator, a fuel pressure regulator, and an injector fuel rail supporting six fuel injectors. The electronic control system for the fuel system includes the six fuel injectors (each a mini solenoid), five sensors and an Electronic Control Unit (ECU) - a "black box".



Fuel flow principle of a modern carburetor.



Fuel flow through the venturi, showing principle and related parts controlling intake and outflow.

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CHAPTER COVERAGE

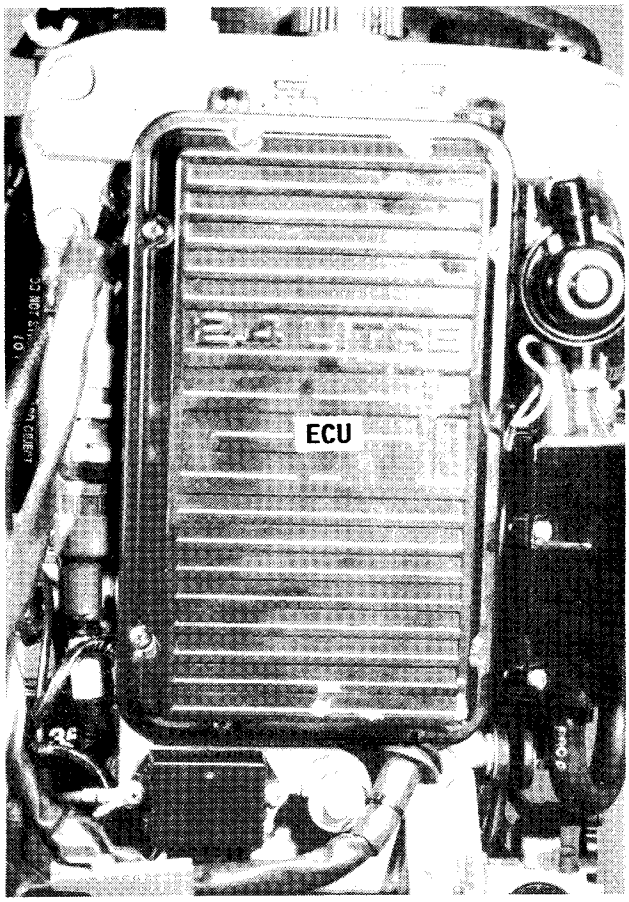
Sections 4-2 thru 4-13 apply to all powerhead models **EXCEPT** late model V6 powerheads with EFI.

Sections 4-14 thru 4-16 apply only to the late model V6 powerheads equipped with EFI.

Because the EFI system is so different from a carburetor fuel system, the following sections apply to only one system, with one exception. The section covering the fuel pump operated by crankcase vacuum applies to both the carburetor system and the EFI system.

4-2 GENERAL INFORMATION ALL MODELS EQUIPPED WITH CARBURETION

The carburetor is merely a metering device for mixing fuel and air in the proper proportions for efficient engine operation. At idle speed, an outboard engine requires a mixture of about 8 parts air to 1 part fuel. At high speed or under heavy duty service, the mixture may change to as much as 12 parts air to 1 part fuel.



Powerheads equipped with EFI have an on board "Black Box" computer.

Float Systems

A small chamber in the carburetor serves as a fuel reservoir. A float valve admits fuel into the reservoir to replace the fuel consumed by the engine. If the carburetor has more than one reservoir, the fuel level in each reservoir (chamber) is controlled by identical float systems.

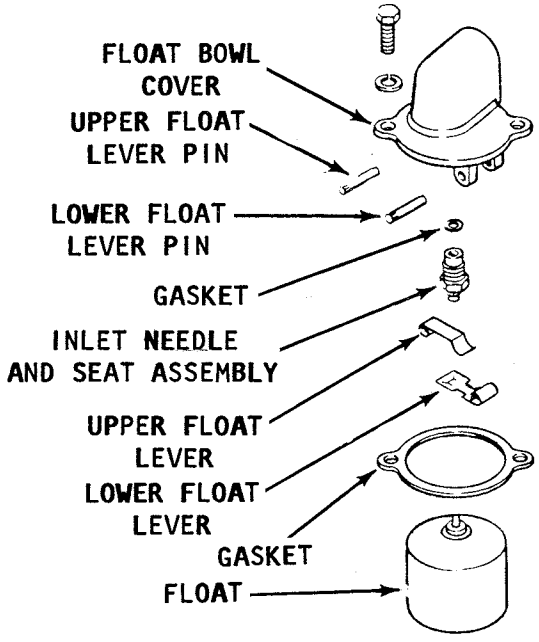
Fuel level in each chamber is extremely critical and must be maintained accurately. Accuracy is obtained through proper adjustment of the floats. This adjustment will provide a balanced metering of fuel to each cylinder at all speeds.

Following the fuel through its course, from the fuel tank to the combustion chamber of the cylinder, will provide an appreciation of exactly what is taking place. In order to start the engine, the fuel must be moved from the tank to the carburetor by a squeeze bulb installed in the fuel line. This action is necessary because the fuel pump does not have sufficient pressure to draw fuel from the tank during cranking before the powerhead starts.

After the powerhead starts, the fuel passes through the pump to the carburetor. All systems have some type of filter installed somewhere in the line between the tank and the carburetor.

On units equipped with oil injection, the fuel mixes with oil from the injection pump before moving on to the top carburetor.

At the carburetor, the fuel passes through the inlet passage to the needle and



Exploded view of a single float system.

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seat, and then into the float chamber (reservoir). A float in the chamber rides up and down on the surface of the fuel. After fuel enters the chamber and the level rises to a predetermined point, a tang on the float closes the inlet needle and the flow entering the chamber is cutoff. When fuel leaves the chamber as the engine operates, the fuel level drops and the float tang allows the inlet needle to move off its seat and fuel once again enters the chamber. In this manner a constant reservoir of fuel is maintained in the chamber to satisfy the demands of the engine at all speeds.

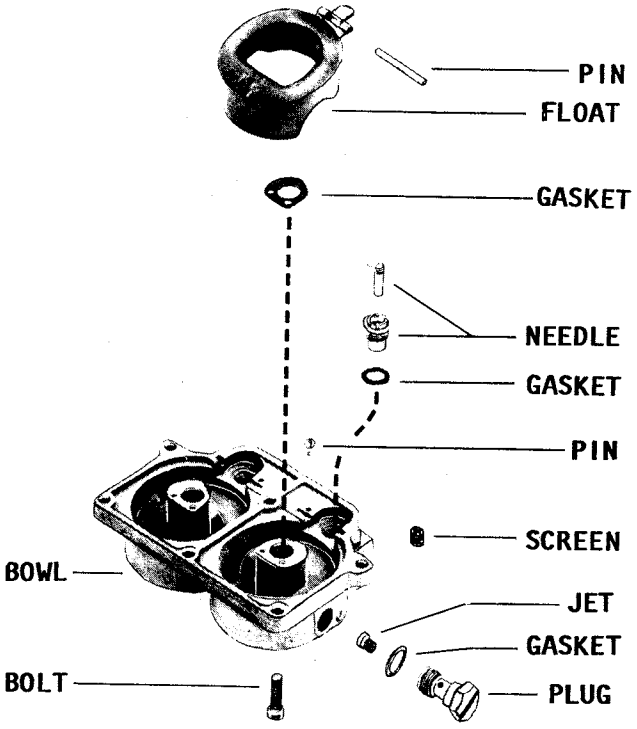
A fuel chamber vent hole is located near the top of the carburetor body to permit atmospheric pressure to act against the fuel in each chamber. This pressure assures an adequate fuel supply to the various operating systems of the engine.

Air/Fuel Mixture

A suction effect is created each time the piston moves upward in the cylinder. This suction draws air through the throat of the carburetor. A restriction in the throat, called a venturi, controls air velocity and has the effect of reducing air pressure at this point.

The difference in air pressures at the throat and in the fuel chamber, causes the fuel to be pushed out of metering jets extending down into the fuel chamber. When the fuel leaves the jets, it mixes with the air passing through the venturi. This fuel/air mixture should then be in the proper proportion for burning in the cylinders for maximum engine performance.

In order to obtain the proper air/fuel mixture for all engine speeds, high and low speed jets are provided. These jets have adjustable needle valves which are used to compensate for changing atmospheric conditions. In almost all cases, the high-speed circuit has fixed high-speed jets that are not adjustable.



Exploded view of a double float system carburetor.

Metering Jets

All carburetors on V6 models, are provided with three sets of jets, as shown in the accompanying illustration. The three jet sets consist of a pair of main jets, a pair of vent jets, and a pair of idle jets.

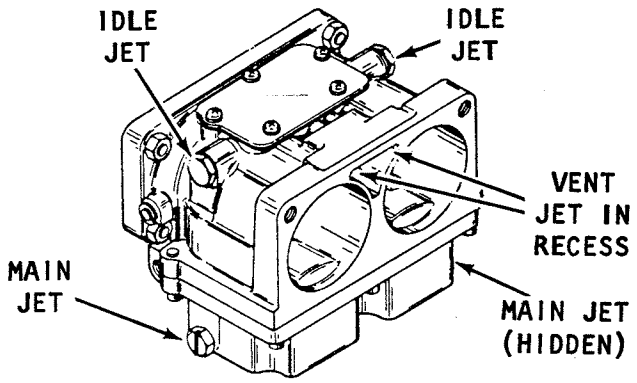
All jets are easily accessible to facilitate changes for whatever reason. Therefore, the carburetors on all V6 powerheads covered in this manual **DO NOT** have any external adjustment screws. All metering is accomplished through the jets.

Main Jets

The main jets, located on each side of the fuel bowl, actually meter the fuel entering the venturi. A jet with a small orifice will provide a lean air/fuel mixture. A jet with a large orifice will provide a rich air/fuel mixture.

Vent Jets

The vent jets, located at the carburetor throat, lower atmospheric pressure at the fuel bowl, resulting in improved fuel economy. As with the main jets, the smaller the orifice -- the leaner the mixture; the larger



Line drawing to indicate location of the jets on Carburetor "E".

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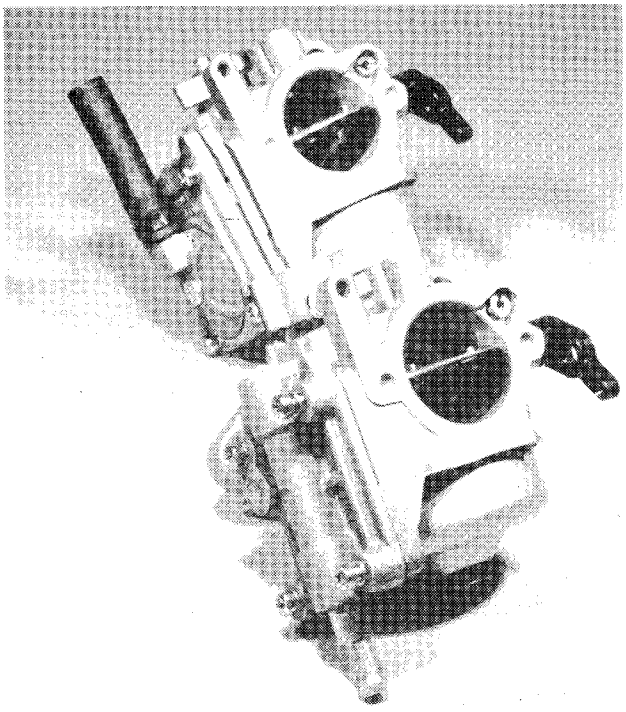
the orifice -- the richer the mixture. On some V6 models, the manufacturer calls for different size vent jets for the center and bottom carburetor from those recommended for the top carburetor. The manufacturer takes one further step by calling for different size jets on the starboard and port sides of the carburetor. Check the Jet Size Chart in the Appendix very **CAREFULLY.**

Idle Jets

The set of idle jets, located on either side of the mixing chamber cover, meter air flow. Their operating principle is opposite to the main and vent jets. The smaller the orifice -- the richer the mixture; the larger the orifice -- the leaner the mixture.

If two cylinders of the powerhead share a common carburetor, and the powerhead is equipped with vertically mounted reed blocks, the jets installed on the starboard side of the carburetor supply fuel to the **STARBOARD** cylinder. Likewise, the jets on the port side supply fuel to the **PORT** cylinder.

If the powerhead is equipped with horizontal reed blocks, the jets installed on the starboard side of the carburetor supply fuel to the **PORT** cylinder; and the jets installed on the port side supply fuel to the **STARBOARD** cylinder.



*Tillotson/Walbro "Mercarb" carburetor with or without integral fuel pump. These units are identified as Carburetor **"A"** in the text and Appendix.*

Engine operation at sea level compared with performance at high altitudes is quite noticeable. A jet/altitude chart is provided in the Appendix for operation from sea level to above 7500 ft (2,300m).

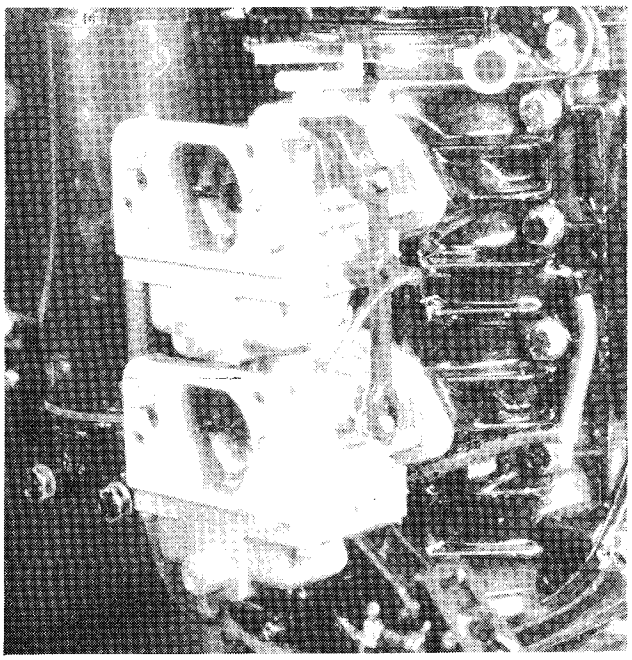
4-3 CARBURETOR IDENTIFICATION

Five, yes, **FIVE** different carburetors have been used on the powerheads covered in this manual. Complete detailed procedures for each carburetor are outlined in a separate section of this chapter. To determine which carburetor is installed on the powerhead being serviced, check the table in the Appendix, under outboard model and manufactured year. The carburetor identification used in the Appendix and throughout this book and service procedures for each are as follows:

"A" Tillotson/Walbro "Mercarb", with or without integral fuel pump -- installed on 45 and 50hp powerheads, covered in Section 4-8, beginning on Page 4-14.

"B" Center Square Bowl -- installed on 50, 60, 70hp 3-Cylinder and 75, 80, and 85hp 4-Cylinder in-line powerheads, covered in Section 4-9, beginning on Page 4-23.

"C" Series WME Center Square Bowl -- installed on 75 and 90hp 3-Cylinder and 100 and 115hp 4-Cylinder in-line powerheads, covered in Section 4-10, beginning on Page 4-33.



*Center square bowl carburetors identified as Carburetor **"B"** in the text and Appendix.*

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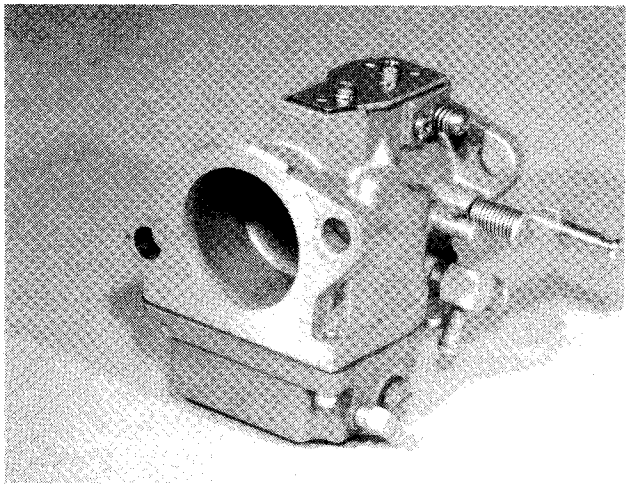


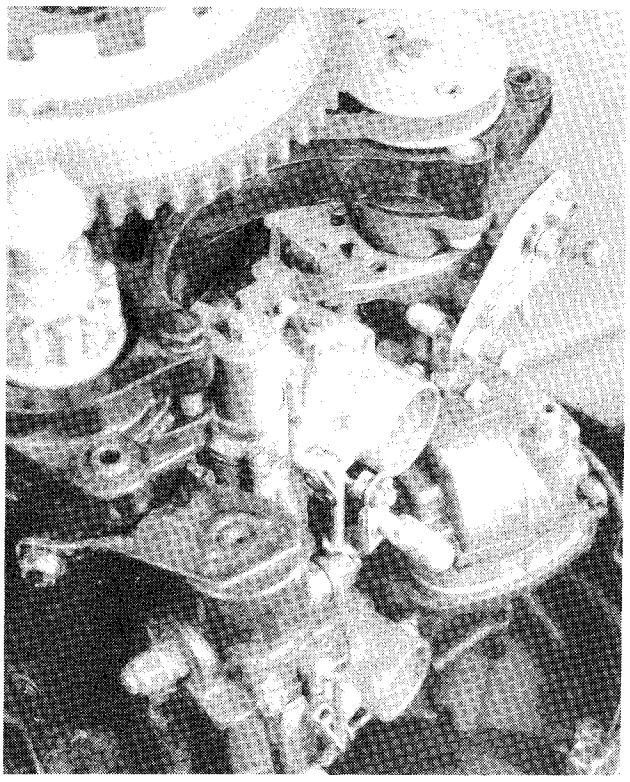
Series WME center square bowl carburetors identified as Carburetor "C" in the text and Appendix.

"D" Side Bowl and Back Drag -- installed on 90, 115 and 140hp 6-Cylinder in-line powerheads, covered in Section 4-11, beginning on Page 4-39.

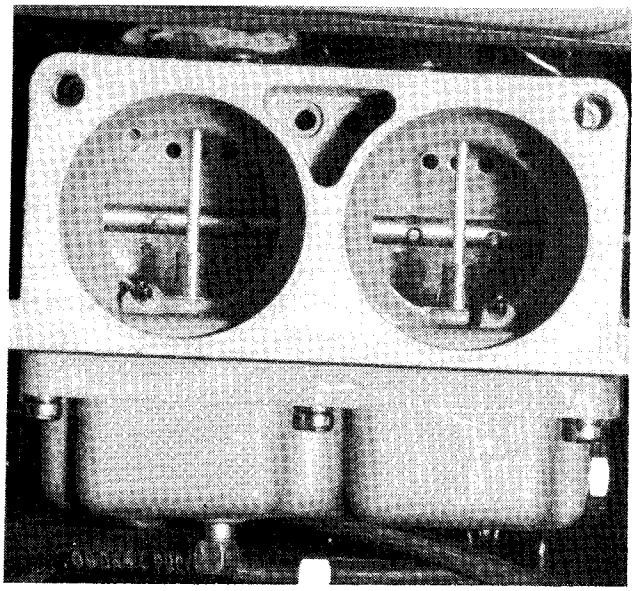
"E" Dual Float Center Bowl -- installed on V6 powerheads, covered in Section 4-12, beginning on Page 4-49.

Service procedures for the fuel pump are outlined in Section 4-13, beginning on Page 4-57.

The **EFI** system is covered in detail in Section 4-14, beginning on Page 4-61.



Side bowl, back drag carburetor identified as Carburetor "D" in the text and Appendix.



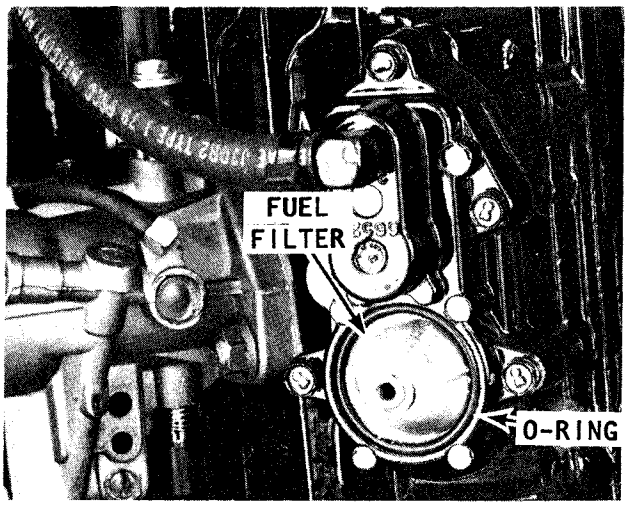
Dual float center bowl carburetor identified as Carburetor "E" in the text and Appendix.

4-4 FUEL SYSTEM

On carbureted models, regular maintenance of the fuel system, to obtain maximum performance, is normally limited to changing the fuel filters at regular intervals and using fresh good quality fuel.

Even with the high price of fuel, removing gasoline that has been standing unused over a long period of time, is still the easiest and least expensive preventive maintenance possible. In most cases this old gas can be used without harmful effects in an automobile using regular gasoline.

If a sudden increase in gas consumption is noticed, or if the engine does not perform properly, a carburetor overhaul, including



Typical fuel filter location on the powerheads covered in this manual.

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boil-out, or replacement of the fuel pump may be required.

LEADED GASOLINE AND GASOHOL

The manufacturer of the units covered in this manual recommends the powerheads be operated using either regular unleaded or regular leaded gasoline having a minimum octane rating of 86 or higher for all models with standard CDI ignition.

In the United States, the Environmental Protection Agency (EPA) has slated a proposed national phase-out of leaded fuel, "Regular" gasoline, by 1988. Lead in gasoline boosts the octane rating (energy). Therefore, if the lead is removed, it must be replaced with another agent. Unknown to the general public, many refineries are adding alcohol in an effort to hold the octane rating.

Alcohol in gasoline can have a deteriorating effect on certain fuel system parts. Seals can swell, pump check valves can swell, diaphragms distort, and other rubber or neoprene composition parts in the fuel system can be affected.



A lead substitute additive can help prevent detonation when unleaded gasoline is used for an outboard fuel.

Since about 1981, all manufacturers have made every effort to use materials that will resist the alcohol being added to fuels.

Fuels containing alcohol will slowly absorb moisture from the air. Once the moisture content in the fuel exceeds about 1%, it will separate from the fuel taking the alcohol with it. This water/alcohol mixture will settle to the bottom of the fuel tank. The engine will fail to operate. Therefore, storage of this type of gasoline for use in marine engines is not recommended for more than just a few days.

One temporary, but aggravating, solution to increase the octane of "unleaded" fuel is to purchase some aviation fuel from the local airport. Add about 10 to 15 percent of the tank's capacity to the unleaded fuel.

REMOVING FUEL FROM THE SYSTEM

For many years there has been the widespread belief that simply shutting off the fuel at the tank and then running the powerhead until it stops is the proper procedure before storing the engine for any length of time. Right? **WRONG.**

It is **NOT** possible to remove all of the fuel in the system by operating the powerhead until it stops. Some fuel is trapped in the float chamber and other passages and in the line leading to the carburetor. The **ONLY** guaranteed method of removing **ALL** of the fuel is to take the time to remove the carburetor, and drain the fuel.

If the powerhead is operated with the fuel supply shut off until it stops, the fuel and oil mixture inside the block is removed, leaving bearings, pistons, rings, and other parts with little protective lubricant, during long periods of storage.

Proper procedure involves: Shutting off the fuel supply at the tank; disconnecting the fuel line at the tank; operating the powerhead until it begins to run **ROUGH;** then shutting down the powerhead which will leave some fuel/oil mixture inside.

The final step includes removing and draining the carburetor. By disconnecting the fuel supply, all **SMALL** passages are cleared of fuel even though some fuel is left in the carburetor. A light oil should be put in the combustion chamber as instructed in the Owner's Manual. Some of the carburetors covered in this manual are equipped with a drain plug on the base of the fuel

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bowl which should be removed to drain the fuel from the carburetor.

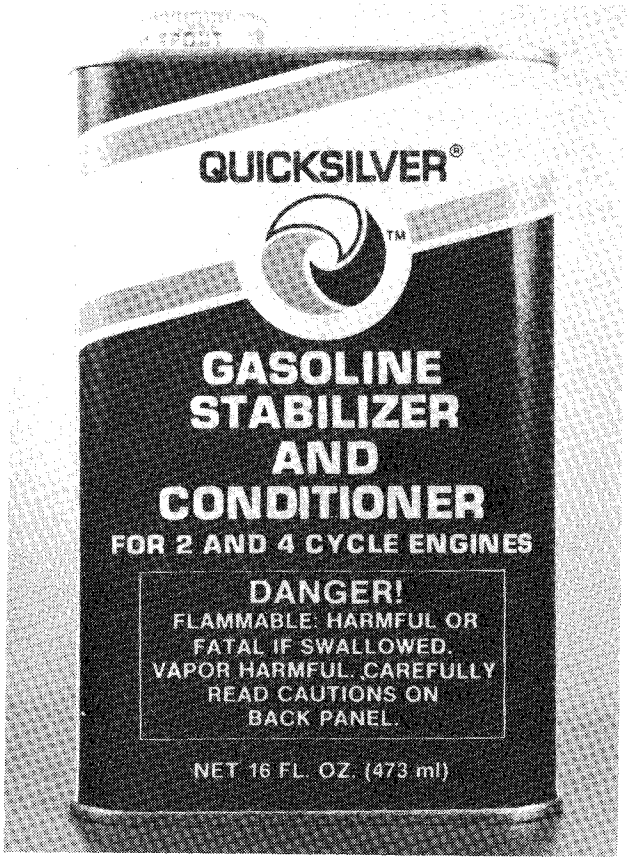
For short periods of storage, simply running the carburetor dry may help prevent severe gum and varnish from forming in the carburetor. This is especially true during hot weather.

4-5 TROUBLESHOOTING MODELS NOT EQUIPPED WITH EFI

The following paragraphs provide an orderly sequence of tests to pinpoint problems in the system. It is very rare for the carburetor by itself to cause failure of the engine to start.

FUEL PROBLEMS

Many times fuel system troubles are caused by a plugged fuel filter, a defective fuel pump, or by a leak in the line from the fuel tank to the fuel pump. A defective choke may also cause problems. **WOULD YOU BELIEVE,** a majority of starting troubles which are traced to the fuel system are the result of an empty fuel tank or aged "sour" fuel.



Quicksilver Gasoline Stabilizer and Conditioner may be used to prevent the fuel from "souring" for up to twelve full months.

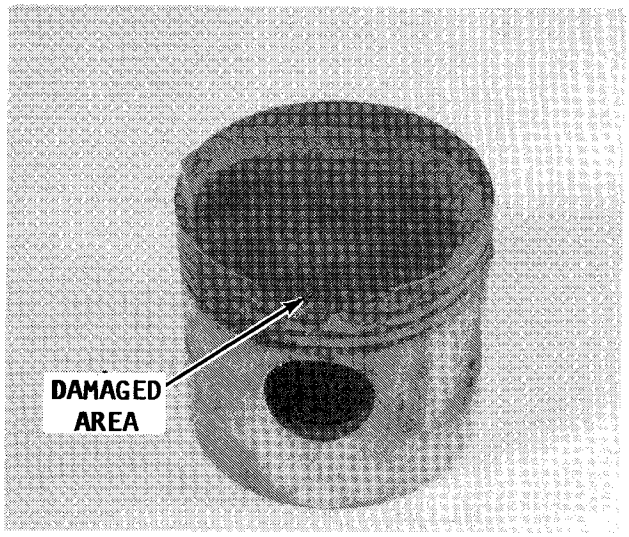
If a sudden increase in gas consumption is noticed, or if the powerhead does not perform properly, a carburetor overhaul, including boil-out, or replacement of the fuel pump may be required.

"SOUR" FUEL

Under average conditions (temperate climates), fuel will begin to breakdown in about four months. A gummy substance forms in the bottom of the fuel tank and in other areas. The filter screen between the tank and the carburetor and small passages in the carburetor will become clogged. The gasoline will begin to give off an odor similar to rotten eggs. Such a condition can cause the owner much frustration, time in cleaning components, and the expense of replacement or overhaul parts for the carburetor.

Even with the high price of fuel, removing gasoline that has been standing unused over a long period of time is still the easiest and least expensive preventive maintenance possible. In most cases, this old gas can be used without harmful effects in an automobile using regular gasoline.

The gasoline preservative additive Quicksilver Fuel Conditioner and Stabilizer for 2 and 4 cycle engines, will keep the fuel "fresh" for up to twelve months. If this particular product is not available in your area, other similar additives are produced under various trade names.



Damaged piston, possibly caused by insufficient oil mixed with the fuel; using too-low an octane fuel; or using fuel that has "soured" (stood too long without a preservative added).

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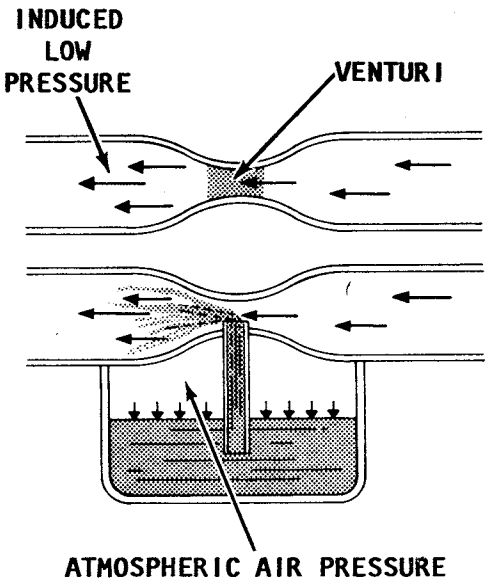
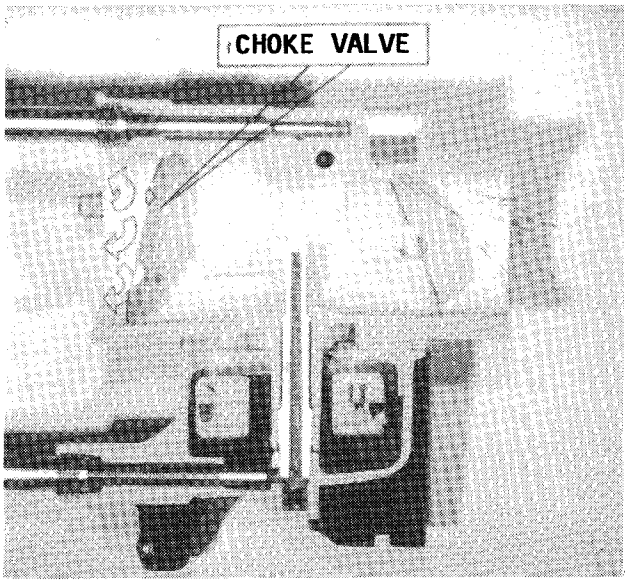


Air flow principle of a modern carburetor.

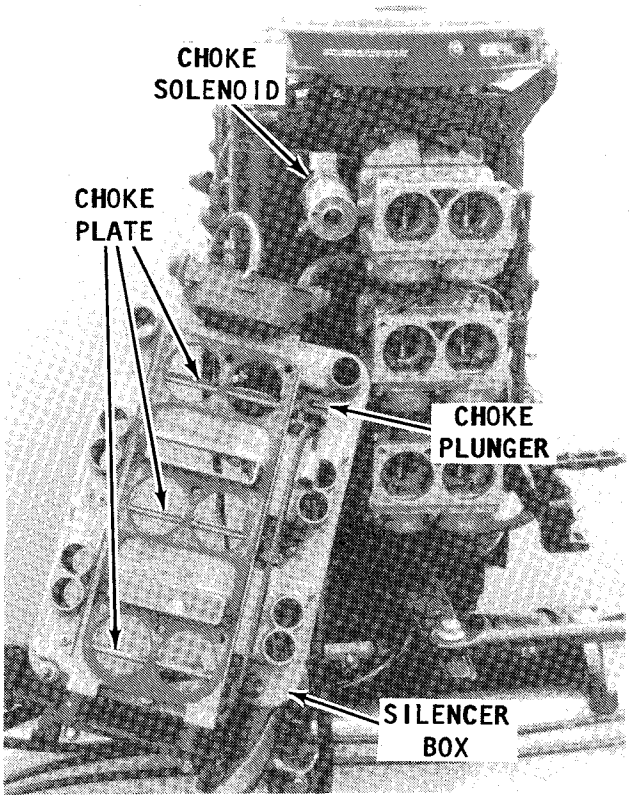


Choke valve location in the carburetor venturi. The choke valve on most carburetors covered in this manual is located in front of the venturi.

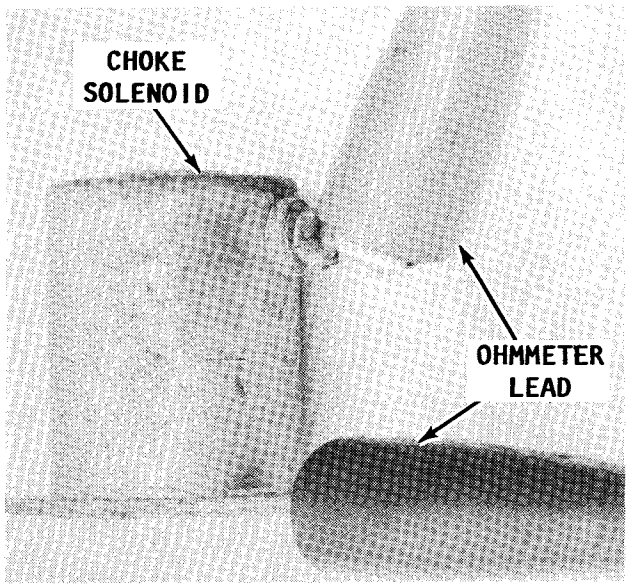
Choke Problems

When the engine is hot, the fuel system can cause starting problems. After a hot engine is shut down, the temperature inside the fuel bowl may rise to 200°F and cause the fuel to actually boil and vaporize in the bowl. All carburetors are vented to allow this gas or pressure to escape to the atmosphere. Sometimes, if a hot engine is restarted, a condition known as "vapor lock" may exist causing the engine to stall. The vaporized fuel escapes through the vents in the float bowl and starves the engine of fuel. As soon as sufficient fuel cooling takes place, the engine in most cases, can be started, but will stall again once the temperature rises to vaporize the fuel.

One solution to a "vapor lock" condition is patience -- wait for the powerhead to cool down to a normal operating temperature.



Typical choke linkage arrangement for a multiple carburetor installation.



A choke solenoid may be tested with an ohmmeter. If the meter indicates continuity, the solenoid is satisfactory for further service. If continuity is not indicated, the unit cannot be repaired, it must be replaced.

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If the choke should stick in the open position, the engine will be hard to start. If the choke should stick in the closed position, the engine will flood making it very difficult to start.

In order for this raw fuel to vaporize enough to burn, considerable air must be added to lean out the mixture. Therefore, the only remedy is to remove the spark plugs; ground the leads; crank the engine about 10 times; clean the plugs; install the plugs again; and start the engine.

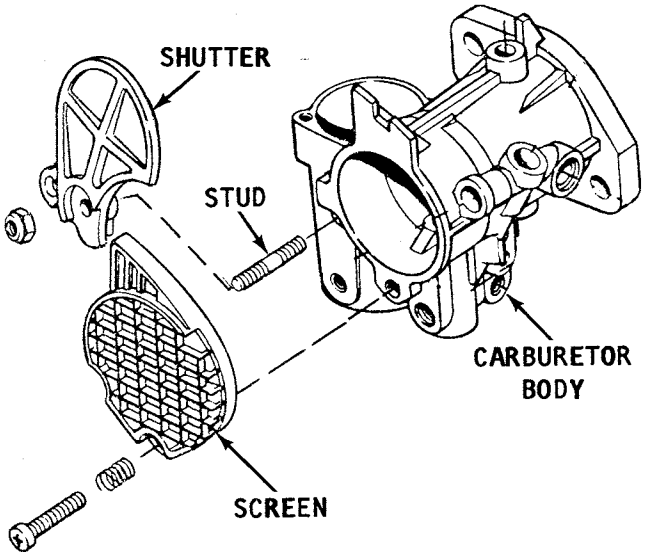
If the needle valve and seat assembly is leaking, an excessive amount of fuel may enter the intake manifold in the following manner: After the engine is shut down, the pressure left in the fuel line will force fuel past the leaking needle valve. This extra fuel will raise the level in the fuel bowl and cause fuel to overflow into the intake manifold.

A continuous overflow of fuel into the intake manifold may be due to a sticking inlet needle or to a defective float which would cause an extra high level of fuel in the bowl and overflow into the intake manifold.

FUEL PUMP TEST

CAUTION

Gasoline will be flowing in the engine area during this test. Therefore, guard against fire by grounding the high-tension wire to prevent any chance of a spark.



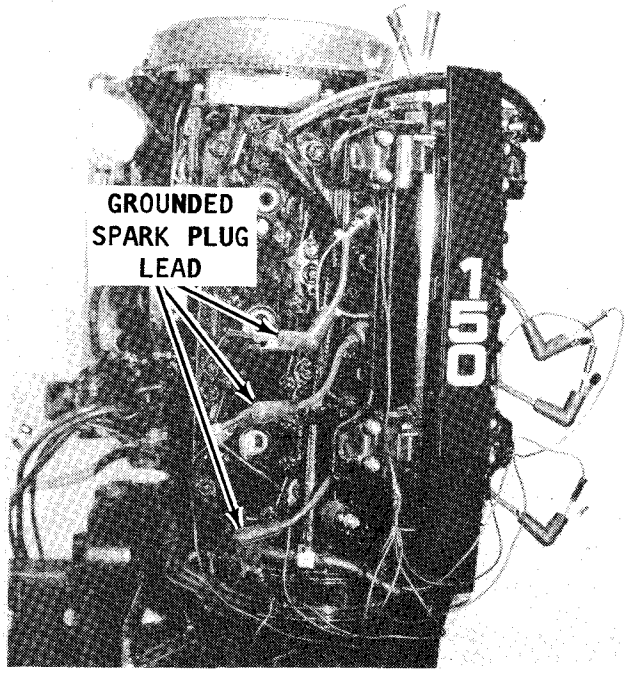
Exploded drawing of a mechanical choke with a shutter. The shutter slides across the carburetor intake to restrict the flow of air, thus enriching the mixture.

The high-tension wire between the coils and the distributor can be grounded by either pulling it out of each coil and grounding it, or by connecting a jumper wire from the primary (distributor) side of the ignition coil to a good ground. An alternate safety method, and perhaps a better one, is to ground each spark plug lead. Disconnect the fuel line at the top carburetor. Place a suitable container over the end of the fuel line to catch the fuel discharged. Now, squeeze the primer bulb and observe if there is satisfactory flow of fuel from the line.

If there is no fuel discharged from the line, the check valve in the squeeze bulb may be defective, or there may be a break or obstruction in the fuel line.

If there is a good fuel flow, then crank the engine. If the fuel pump is operating properly, a healthy stream of fuel should pulse out of the line.

Continue cranking the engine and catching the fuel for about 15 pulses to determine if the amount of fuel decreases with each pulse or maintains a constant amount. A decrease in the discharge indicates a restriction in the line. If the fuel line is plugged, the fuel stream may stop. If there is fuel in the fuel tank but no fuel flows out of the fuel line while the powerhead is being cranked, the problem may be in one of four areas:



*Grounding the spark plug leads to the powerhead in preparation to making fuel flow tests. The grounding is **NECESSARY** to prevent a spark from igniting fuel vapors or fuel being handled in the open.*

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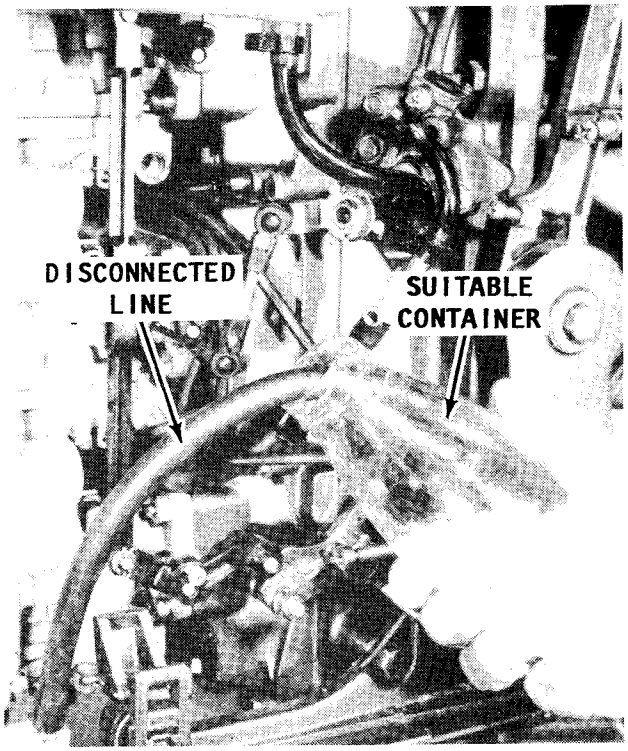
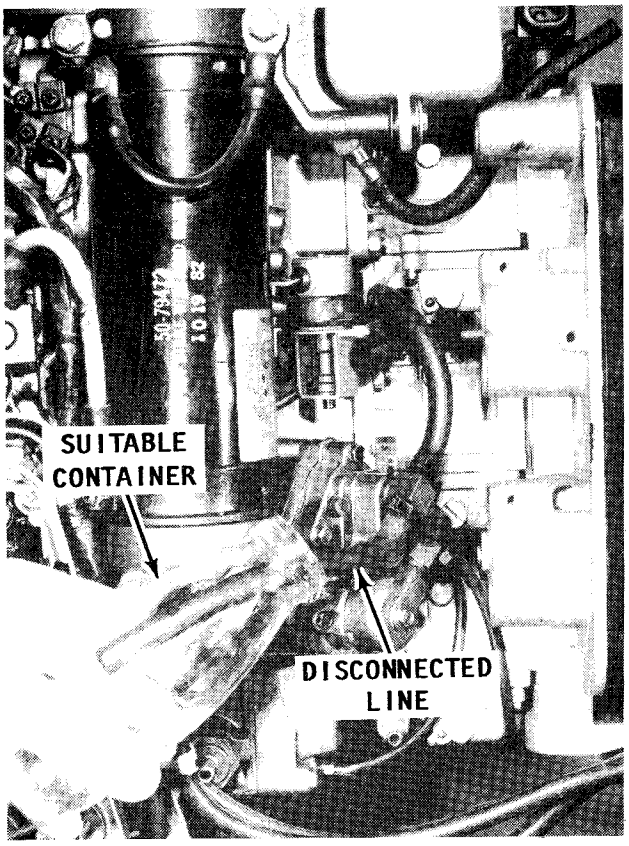


*Testing the fuel pickup in the fuel tank **AND** operation of the squeeze bulb by observing fuel flow from the line disconnected at the fuel pump and discharged into a suitable container.*



Working the squeeze bulb and observing the fuel flow from the line disconnected at the carburetor and discharged into a suitable container. This verifies fuel flow through the fuel pump.

1- The line from the fuel pump to the carburetor may be plugged as already mentioned.

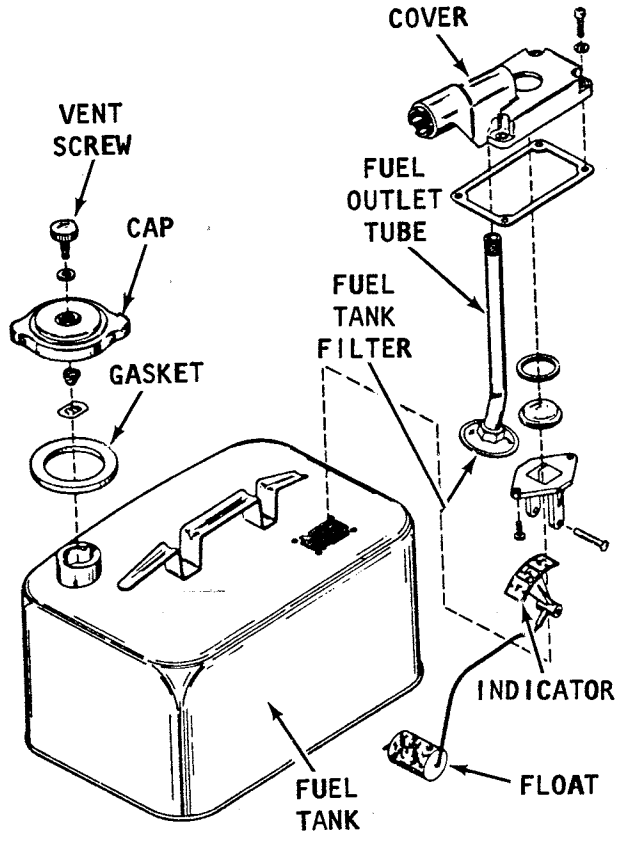
2- The fuel pump may be defective.

3- The line from the fuel tank to the fuel pump may be plugged; the line may be leaking air; or the squeeze bulb may be defective.

4- If the engine does not start even though there is adequate fuel flow from the fuel line, the fuel filter in the carburetor inlet may be plugged or the fuel inlet needle valve and the seat may be gummed together and prevent adequate fuel flow.

FUEL LINE TEST

On most installations, the fuel line is provided with quick-disconnect fittings at the tank and at the engine. If there is reason to believe the problem is at the quick-disconnects, the hose ends should be replaced as an assembly. For a small additional expense, the entire fuel line can be replaced, thus eliminating this area as a problem source for many future seasons.



Exploded drawing of the fuel tank and associated parts. If fuel volume at the carburetors is a problem, the filter in the fuel outlet tube may be clogged.

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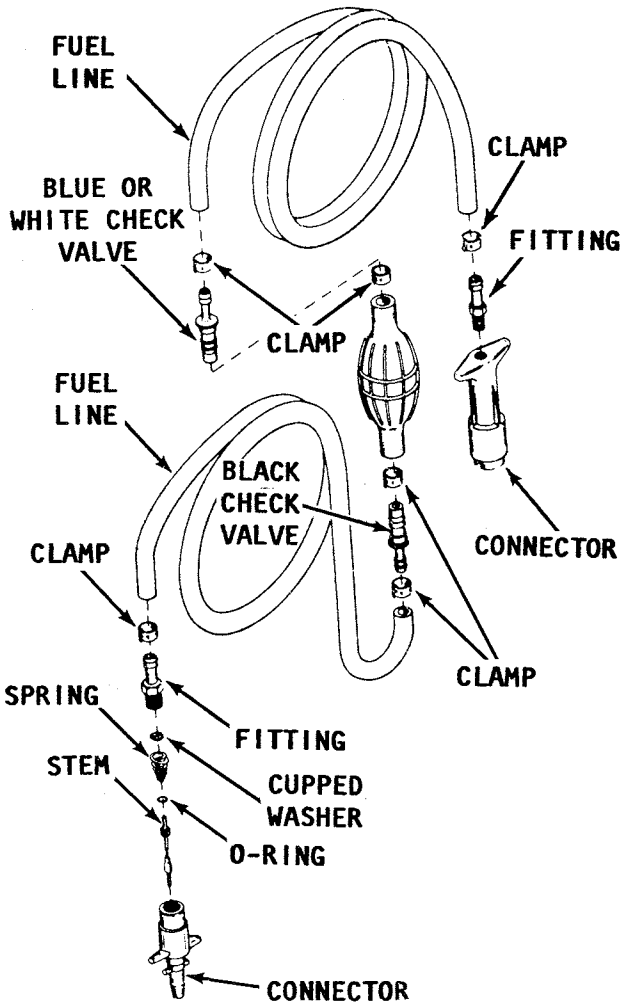
The primer squeeze bulb can be replaced in a short time. First, cut the hose line as close to the old bulb as possible. Slide a small clamp over the end of the fuel line from the tank. Next, install the **SMALL** end of the check valve assembly into this side of the fuel line. The check valve always goes towards the fuel tank. Place a large clamp over the end of the check valve assembly. Use Primer Bulb Adhesive when the connections are made. Tighten the clamps. Repeat the procedure with the other side of the bulb assembly and the line leading to the engine.

ROUGH ENGINE IDLE

If an engine does not idle smoothly, the most reasonable approach to the problem is to perform a tune-up to eliminate such areas as: defective points; faulty spark plugs; and timing out of adjustment.



Exploded drawing of a typical fuel line and primer bulb with major parts identified.

Other problems that can prevent an engine from running smoothly include: An air leak in the intake manifold; uneven compression between the cylinders; and sticky or broken reeds.

Of course any problem in the carburetor affecting the air/fuel mixture will also prevent the engine from operating smoothly at idle speed. These problems usually include: Too high a fuel level in the bowl; a heavy float; leaking needle valve and seat; defective automatic choke; and improper adjustments for idle mixture or idle speed.

EXCESSIVE FUEL CONSUMPTION

Excessive fuel consumption can be the result of any one of three conditions, or a combination of all three.

1- Inefficient engine operation.

2- Faulty condition of the hull, including excessive marine growth.

3- Poor boating habits of the operator.

If the fuel consumption suddenly increases over what could be considered normal, then the cause can probably be attributed to the engine or boat and not the operator.

Marine growth on the hull can have a very marked effect on boat performance. This is why sail boats always try to have a haul-out as close to race time as possible. While you are checking the bottom take note of the propeller condition. A bent blade or other damage will definitely cause poor boat performance.

If the hull and propeller are in good shape, then check the fuel system for possible leaks. Check the line between the fuel pump and the carburetor while the engine is running and the line between the fuel tank and the pump when the engine is not running. A leak between the tank and the pump many times will not appear when the engine is operating, because the suction created by the pump drawing fuel will not allow the fuel to leak. Once the engine is turned off and the suction no longer exists, fuel may begin to leak.

If a minor tune-up has been performed and the spark plugs, points, and timing are properly adjusted, then the problem most likely is in the carburetor and an overhaul is in order. Check the needle valve and seat for leaking. In an effort to conserve fuel, use extra care when making any adjustments affecting the fuel consumption, such as the float level or automatic choke.

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ENGINE SURGE

If the engine operates as if the load on the boat is being constantly increased and decreased, even though an attempt is being made to hold a constant engine speed, the problem can most likely be attributed to the fuel pump, or a restriction in the fuel line between the tank and the carburetor.

Operational description and service procedures for the fuel pump are given in Section 4-11.

ANTI-SYPHON VALVE

WORDS ON REQUIREMENT

At press time, in the United States, there is no governmental regulation requiring an outboard motor to be equipped with an anti-syphon valve. However, boats complying with the Boating Industry Association (BIA) Certification Program, vessels with permanently installed fuel tanks are required to have an anti-syphon valve. Bear in mind, the BIA sets a standard which is not subject to enforcement by any government agency.

An anti-syphon valve is considered an "After Market" item, not installed by the factory. Many people consider such a device to be a safety item, but more often than not, the valve may cause more problems in the fuel delivery system than they solve.

If the valve becomes the least bit clogged with debris or a too small valve is installed in the fuel line, or the spring is too stout, a pressure drop may develop from one side of the valve to the other. A pressure drop across the anti-syphon valve can cause poor powerhead performance and possible damage.

A defective or poorly operating anti-syphon valve may cause one or more of the following problems:

Inadequate fuel pump pressure.

Loss of power at the powerhead.

Powerhead surge at high speed rpm.

Piston dome erosion due to preignition or detonation.

Poor powerhead performance during acceleration -- unit falters or cuts out completely.

Powerhead fails to operate smoothly -- runs "rough".

Powerhead cannot be started.

Checking Anti-Syphon Valve

If troubleshooting should indicate the anti-syphon valve is at fault, attempt to operate the powerhead with a separate fuel source. In other words, the valve is physically bypassed.

If the valve proves to be the source of the problem, either remove the valve from the fuel line or replace the valve with a solenoid operated fuel shutoff valve.

4-6 ENRICHENER SYSTEM

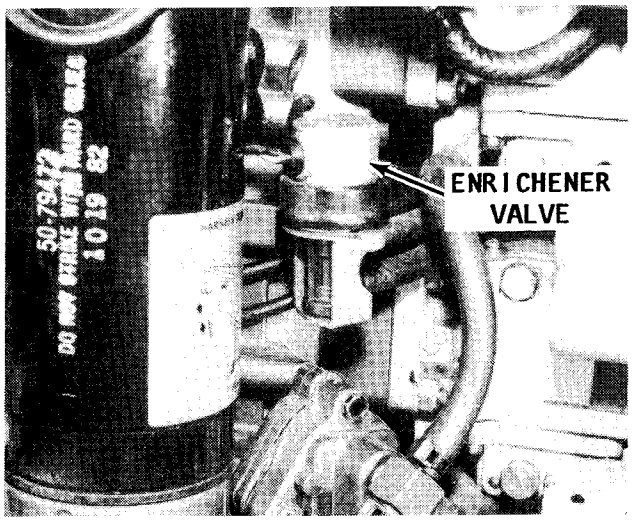
Almost all powerheads covered in this manual are equipped with an enrichener system, replacing the traditional choke system.

An electrically operated enrichener valve mounted on the port side of the powerhead, as shown in the accompanying illustration, is supplied with fuel via a fuel line from the float bowl of the top (No. 1) carburetor.

When the ignition key is rotated to the **ON** position and pushed inward to start a cold powerhead, the enrichener system is energized. Fuel is then fed to all cylinders through short hoses and fittings at the intake manifold close to the carburetor mounting flanges.

As soon as the ignition key is released, electrical current to the system is cutoff; the valve closes; and fuel through the valve stops.

Troubleshooting the enrichener system is described in Chapter 9, beginning on Page 9-20.



An enrichener valve mounted on the port side of the powerhead replaces the choke circuit on other powerheads.

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SPECIAL WORDS

Carburetor "B" installed on 50, 60, and 70hp 3-Cylinder powerheads and the same carburetor installed on 75, 80, and 85hp 4-Cylinder powerheads is equipped with an "enrichment" valve.

This type carburetor is equipped with a choke solenoid but not a choke shutter valve in the carburetor throat. An enrichment valve performs the same function as the choke shutter and is linked to the choke solenoid. The enrichment valve is a mechanical valve and should not be confused with an enrichener valve which is an electrically operated valve installed on larger horsepower late model powerheads.

4-7 2+2 SYSTEM WITH ACCELERATOR PUMP 100HP AND 115HP 4-CYLINDER POWERHEADS

A 4-cylinder powerhead normally operates on all four cylinders. However, on the 100hp and 115hp 4-cylinder powerhead, the manufacturer introduced a **2+2** concept. The principle of the **2+2** is to restrict the flow of fuel to the No. 3 and No. 4 cylinders, while the powerhead is idling. By restricting the fuel flow, the mixture of air/fuel becomes so lean it will not ignite and burn in the cylinders. With this arrangement, the No. 1 and No. 2 cylinders continue to operate in the normal manner, at idle speed, while the No. 3 and No. 4 cylinder are "along for the ride".

The firing order for this powerhead is 1-3-2-4. Therefore, at idle speed, every other cylinder fires to provide smooth operation and fuel economy. To meet the demand for sudden acceleration, a mechanical accelerator pump is built into the **2+2** system.

Fuel Flow

The fuel flow circuit for a powerhead equipped with the **2+2** system is slightly different from normal fuel flow on other powerheads.

Fuel is drawn from the fuel tank through typical hose and hose connection joints by the fuel pump. Fuel is then routed from the pump through a large fuel filter to the No. 1 and No. 2 carburetors. This supply line also feeds the No. 3 and No. 4 carburetors.

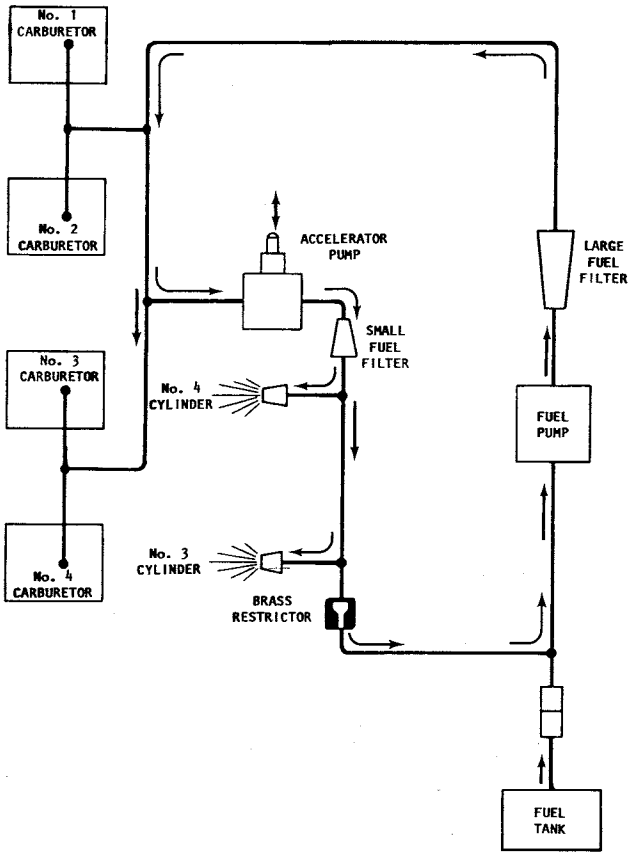
A tee fitting between the No. 2 and No. 3 carburetors routes fuel to an accelerator pump for the **2+2** system. From the accelerator pump, fuel is forced at a higher pressure through a small fuel filter, and then on to the No. 3 and No. 4 cylinders.

Two spring loaded check valves, one for the No. 3 and the other for the No. 4 cylinder are installed in the cylinder block transfer ports. These valves only unseat at the higher fuel pressure and permit fuel to be sprayed into the two lower cylinders, from the injector nozzles at the transfer ports. This additional fuel will meet an acceleration demand.

Excess fuel not used by the two lower cylinders is routed back to the normal fuel line through a brass restrictor which reduces fuel pressure before it is returned to the normal fuel circuit, as indicated on the accompanying flow diagram.

Carburetor Identification

All four carburetors are identical, except for a slight design modification on the two lower carburetors. The off-idle progression holes for these two lower carburetors have been relocated further from the powerhead. The end result of this new carburetor design is to delay the activation of the off-idle circuit until the throttle plate is moved to a position correspond-



The acceleration pump and fuel flow circuit for the 2+2 fuel system, explained in the text.

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ing to 1800 rpm. At powerhead speeds above 1800 rpm, the two lower carburetors function normally.

The upper carburetors have adjustable idle mixture screws. The idle mixture screw on the two lower carburetors is replaced with a premanently installed plug.

Therefore, anytime a carburetor is removed from the powerhead, the location **MUST** be identified to **ENSURE** it is installed back in its original position.

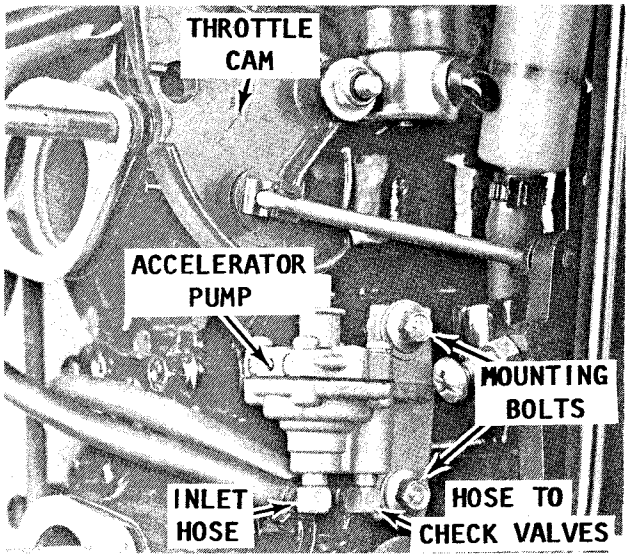
As explained earlier, while the powerhead is operating at speeds below 1800 rpm, only No. 1 and No. 2 cylinders fire normally. Cylinders No. 3 and No. 4 are supplied with a too lean air/fuel mixture to burn. However, this mixture does contain sufficient oil for adequate cylinder lubrication.

Acceleration

The purpose of the accelerator pump is to satisfy the increased demand for fuel for quick acceleration. The accelerator pump is a mechanically operated device, located on the starboard side of the powerhead, and is **NOT** any part of the carburetor accelerator circuit bearing the same name.

The accelerator pump has an exposed plunger shaft on top. The end of this short shaft rides under the throttle cam. Therefore, the action of the pump is directly dependent on throttle position.

When the operator demands a sudden quick acceleration from idle speed below 1800 rpm, the accelerator pump plunger is depressed one time by action of the throttle cam.



The accelerator pump of the 2+2 fuel system is mounted on the starboard side of the powerhead.

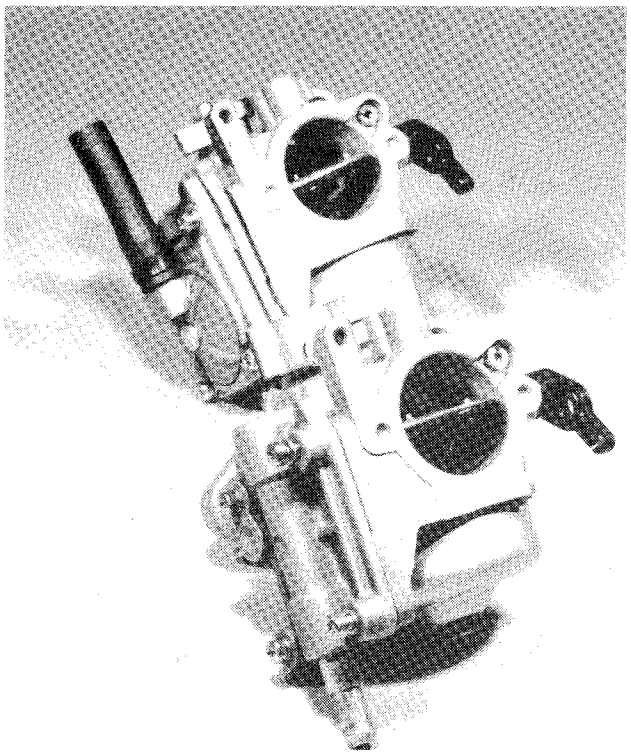
4-8 TILLOTSON/WALBRO "MERCARB" WITH OR WITHOUT INTEGRAL FUEL PUMP REFERENCED CARBURETOR "A" IN APPENDIX

This section provides complete detailed procedures for removal, disassembly, cleaning and inspecting, assembling including bench adjustments, installation, and operating adjustments for the Tillotson/Walbro "Mercarb" carburetor. This unit is identified as Carburetor **"A"** in the Appendix. Carburetor **"A"** may or may not have an integral fuel pump.

The accompanyng illustration shows the two versions of this carburetor. One is installed with an integral fuel pump. The other has a cover in place of the integral fuel pump. The version without the pump is fed by a crankcase vacuum operated fuel pump. One minor difference is an economizer jet installed on the front face of the carburetor. Not all type **"A"** carburetors have the economizer jet.

The service procedures are identical for both carburetors once the integral fuel pump or cover plate has been removed.

To synchronize the fuel and ignition systems, see Chapter 7.



Tillotson/Walbro "Mercarb" carburetor with or without integral fuel pump. These units are identified as Carburetor "A" and are serviced in this section.

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REMOVAL AND DISASSEMBLING CARBURETOR "A"

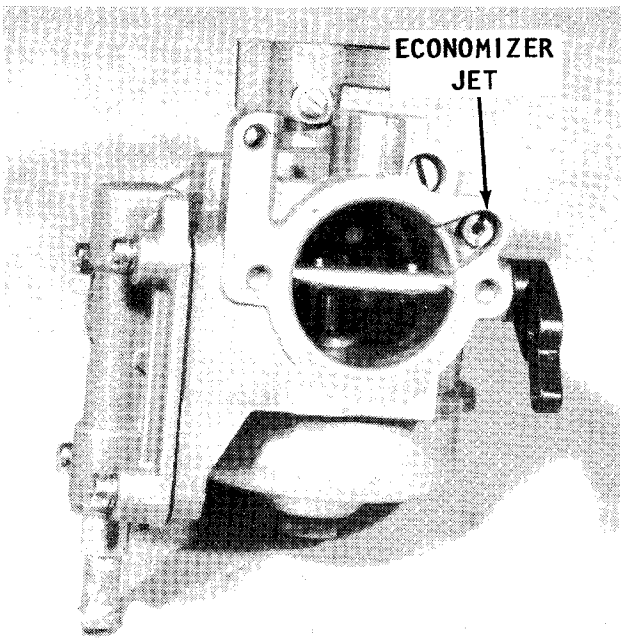
Check to be sure the carburetor/s being serviced are identified as Carburetor **"A"** from the Appendix and the illustrations at the beginning of this chapter. Only by proper carburetor identification can the reader be assured the correct procedures are being followed.

PRELIMINARY TASKS

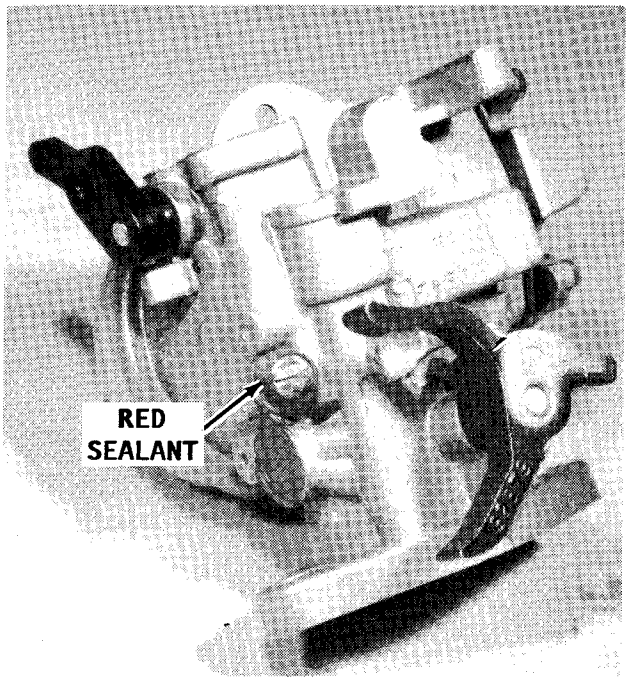
Remove the battery leads from the battery terminals. Remove the front engine cover. Take off the wrap around cowl cover. Remove the air box.

Take time to identify each carburetor to ensure each will be installed back in its original position.

Disconnect the choke and throttle linkage from each carburetor. Disconnect the fuel line from the powerhead. Remove the hose clamps on each fuel line to each carburetor. Remove the fuel line from each carburetor. Remove the attaching nuts securing each carburetor to the intake manifold. Remove each carburetor from the powerhead. Apart from the specific differences mentioned at the beginning of this section, the carburetors are identical. Therefore, the following procedures are to be repeated for each carburetor. Any differences affecting service procedures, are clearly identified.



The location of the economizer (vent) jet on Carburetor ***"A"****.*

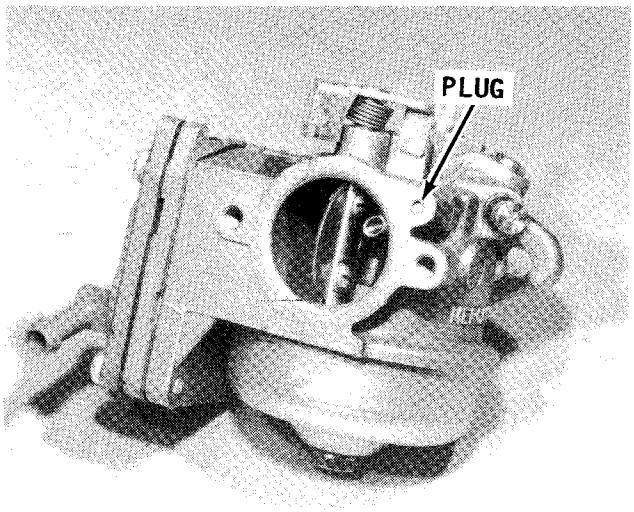


Red sealant applied to screws or plugs are the manufacturer's method of giving the message: ***"DO NOT DISTURB"****.*

VERY IMPORTANT WORDS

Notice the application of Red sealant on certain adjustment screws or plugs. This sealant was applied at the factory and is the manufacturer's method of instructing anyone servicing the carburetor not to **DISTURB** the screw or plug.

The sealant is not affected by carburetor cleaner and should remain in place on the plug or screw and the carburetor for the entire useful life of the carburetor.



Another Carburetor ***"A"*** *design without the economizer (vent) jet.*

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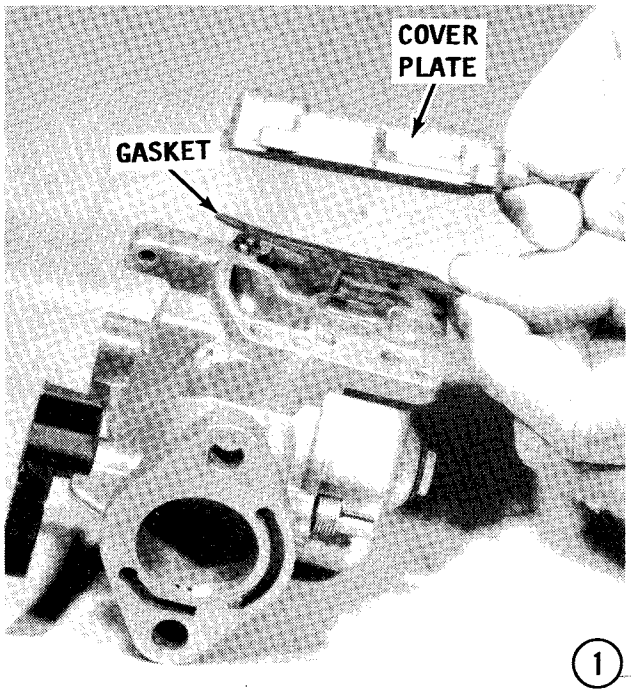

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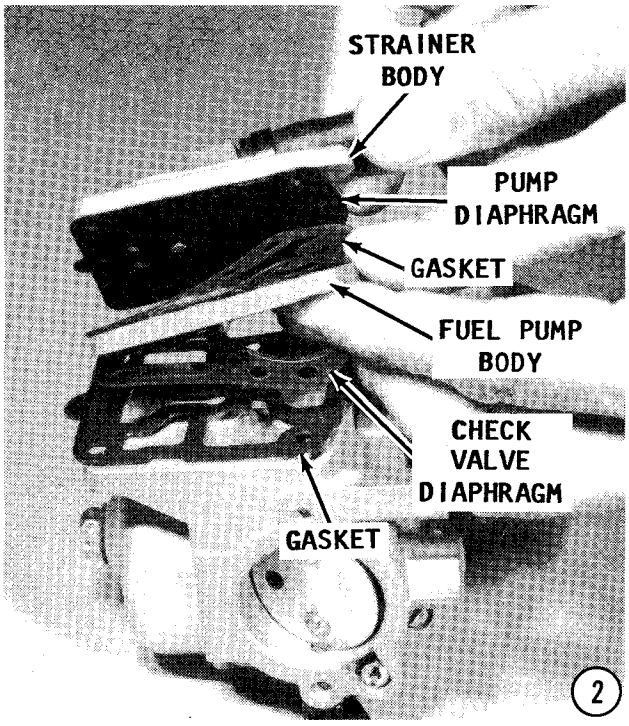
SPECIAL WORDS

On some type **"A"** carburetors, an economizer (or vent) jet is installed on the front carburetor face. This jet is not normally disturbed during a carburetor overhaul. However, this jet together with the main jet must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct main jet and vent sizes for various elevations.



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Units Without Integral Fuel Pump

1- Remove the four Phillips head screws with captive lockwashers. Lift off the cover plate. Remove and discard the gasket.

Units With Integral Fuel Pump

2- Remove the four Phillips head screws with captive lockwashers securing the fuel pump strainer body to the carburetor.

SPECIAL WORDS

If new fuel pump replacement parts were not purchased, then the following layers of diaphragms and gaskets must be removed with great care to prevent distorting or damaging these delicate parts.

Remove the following: the pump diaphragm, gasket, fuel pump body, check valve diaphragm and gasket.

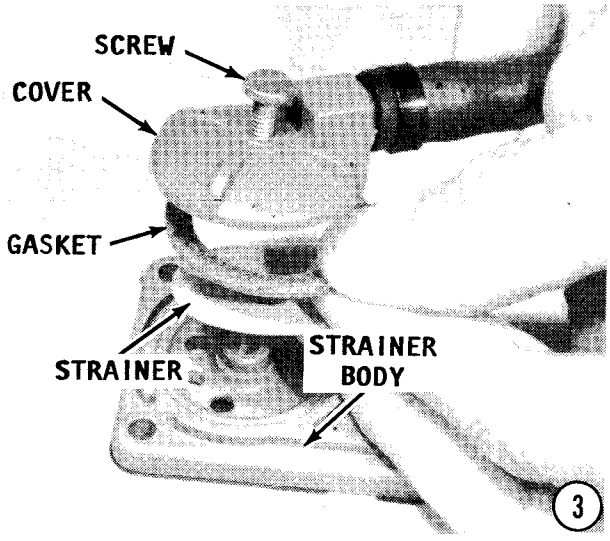
3- Loosen the slotted head screw on the top of the strainer cover and remove the cover, gasket, and strainer from the strainer body.

All Units

4- Back out the idle mixture screw and spring.

STOP THE WORK

Pick up the carburetor and shake it. If "something" is loose and rattling around inside the float bowl, the float has dropped sufficiently to allow the inlet needle to come out of the needle seat. If this part became loose during powerhead operation, the fuel would not be shut off and the float bowl would flood. If the part became loose due to the shaking, it could very well become a potential problem during powerhead



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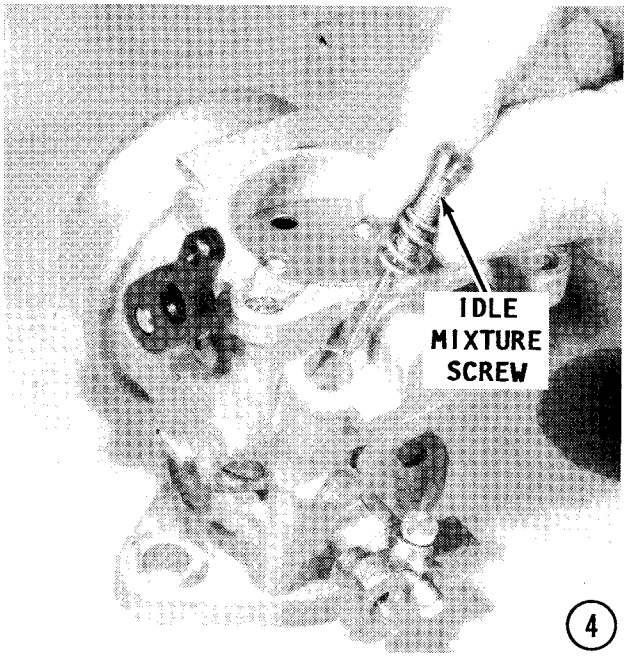


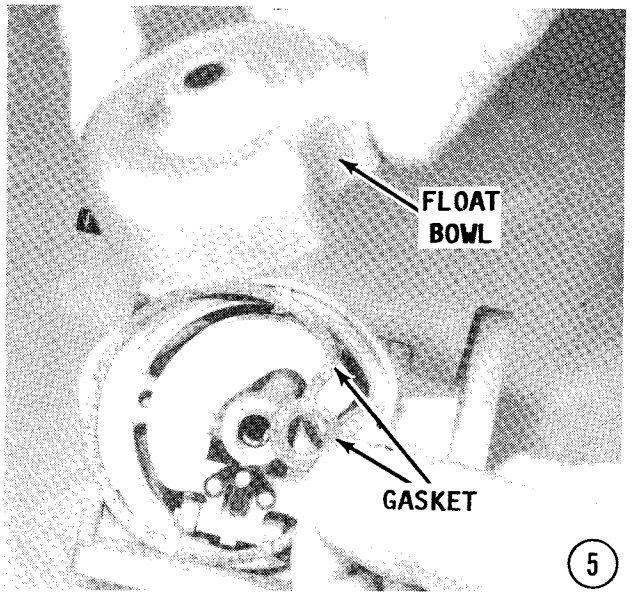
4

operation. The inlet needle has too much travel and could drop and become wedged between the float and seat.

On this type carburetor float, especially on later models, there is no adjustment for the float drop. A plastic tab limits the float drop, which cannot be bent. Older carburetors are equipped with a metal tab --no problem, these are adjustable.

Therefore, if the carburetor failed this simple test, a new float **MUST** be installed.

5- Remove the bolt securing the float bowl to the carburetor, remove and discard the gasket under the bolt. Lift off the float bowl and remove and discard the float bowl gasket, and center gasket.



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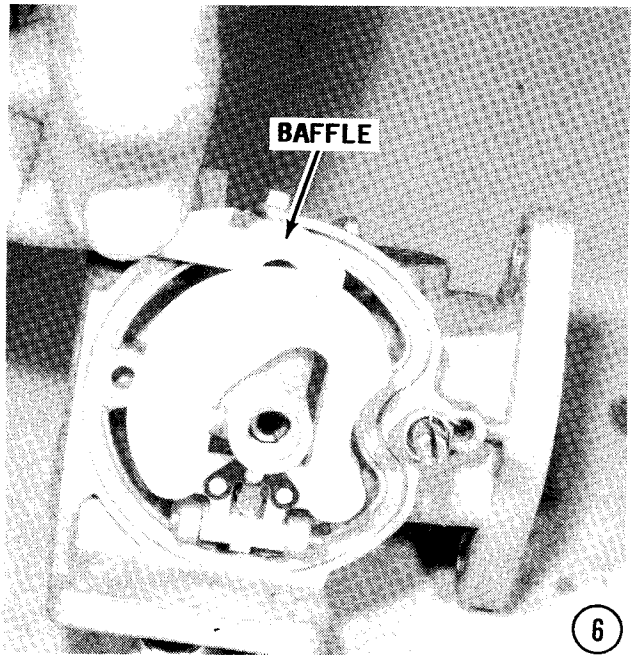

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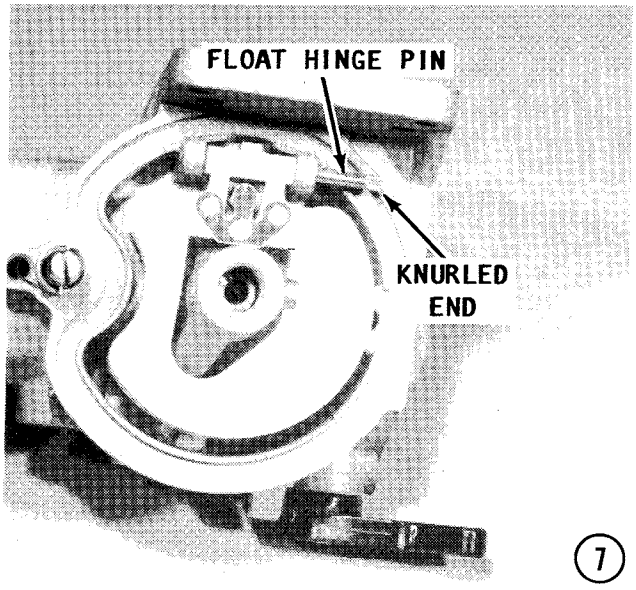
6- Slide the baffle out from under the float. This baffle is found only on newer carburetors. The purpose of the baffle is to prevent the fuel from "sloshing" against the main jet. During powerhead operation, the main jet must remain immersed in fuel and not be allowed to draw air.

7- Notice the float hinge pin has a knurled end and can only be removed in one direction. Use a long pointed punch and push the float hinge pin free of the mounting posts by, applying pressure from the rear of the carburetor (where the throttle return spring is located on the carburetor top).

8- Lift off the float.

9- Remove the inlet needle, with spring attached, from the needle seat. Do **NOT**



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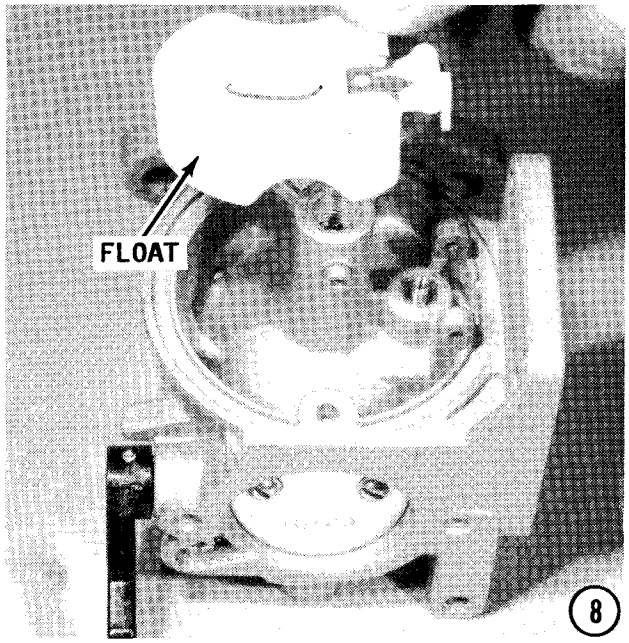


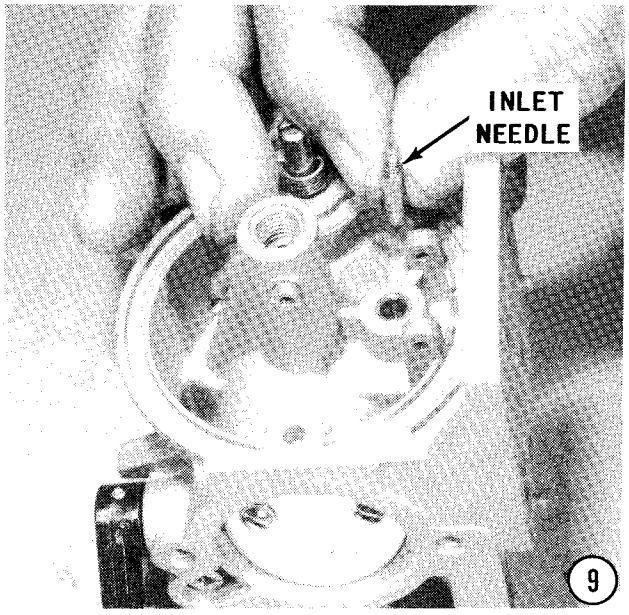
attempt to remove the needle seat. The seat is pressed into the carburetor body.

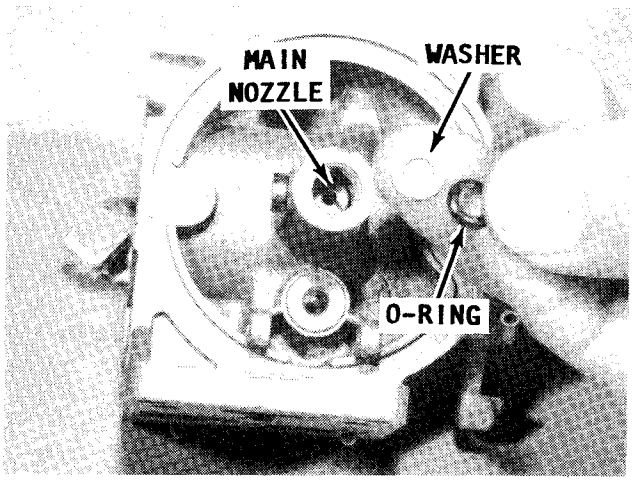
10- Use the appropriate size slotted screwdriver and remove the main jet and the main nozzle. Newer carburetors have a washer and tiny O-ring over the main nozzle which must be pried out before the main nozzle can be removed.

Main jet sizes must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct main jet sizes for various elevations.

GOOD WORDS

Further disassembly of the carburetor is not necessary in order to clean it properly.





Newer type Carburetor "A" has a washer O-ring over the main nozzle.

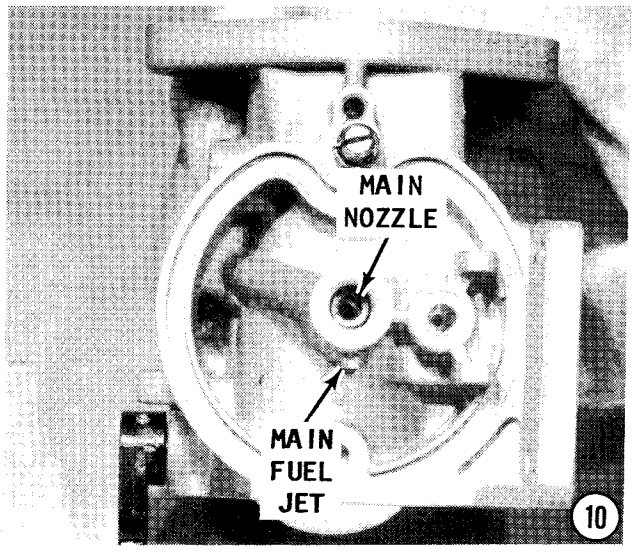
CLEANING AND INSPECTING

NEVER dip rubber parts or plastic parts in carburetor cleaner. These parts should be cleaned **ONLY** in solvent, and then blown dry with compressed air.

Place all metal parts in a screen-type tray and dip them in carburetor cleaner until they appear completely clean, then blow them dry with compressed air.

Blow out all passages in the castings with compressed air. Check all of the parts and passages to be sure they are not clogged or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Move the throttle shaft back-and-forth to check for wear. If the shaft appears to be too loose, replace the complete throttle body because individual replacement parts are **NOT** available.



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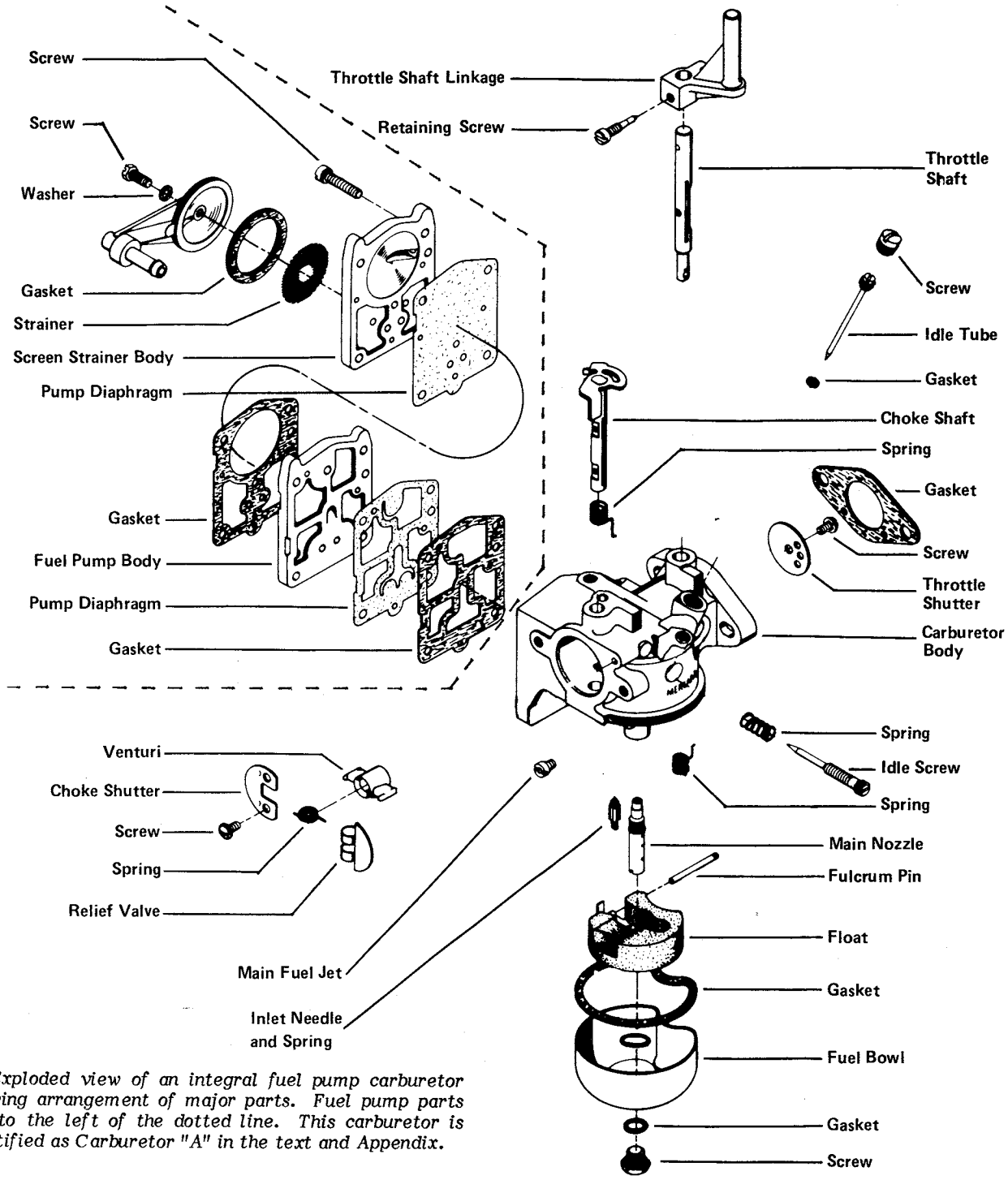

Exploded view of an integral fuel pump carburetor showing arrangement of major parts. Fuel pump parts are to the left of the dotted line. This carburetor is identified as Carburetor "A" in the text and Appendix.

Inspect the main body, airhorn, and venturi cluster gasket surfaces for cracks and burrs which might cause a leak. Check the float for deterioration. If hollow floats are used, check to be sure they do not contain any fluid. Check to be sure the float tab is in good condition. If any part of the float is damaged, the unit must be replaced. Check the float arm needle contacting surface and replace the float if this surface has a groove worn in it.

Inspect the tapered section of the idle adjusting needles and replace any that have developed a groove.

Most of the parts that should be replaced during a carburetor overhaul are included in an overhaul kit available from your local marine dealer.

Check the jet sizes with a drill of the proper size. **ALWAYS** hold the drill in a pin vise to avoid enlarging the jet orifice. Refer to the Carburetor Jet Size/Elevation

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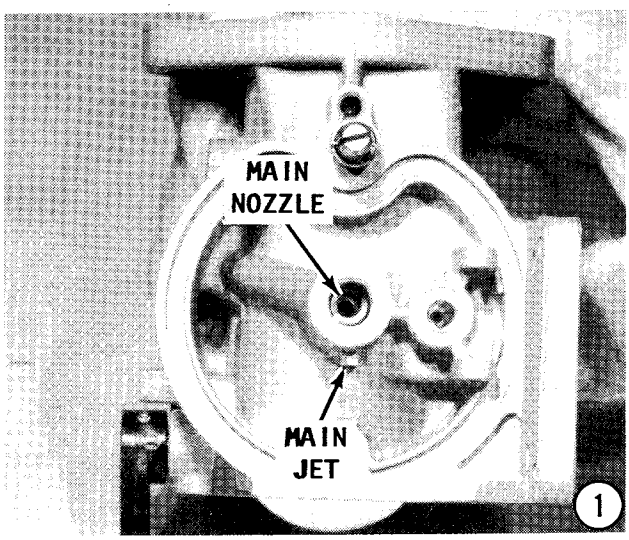


Chart in the Appendix for the proper size for your engine, carburetor, and anticipated elevation of operation.

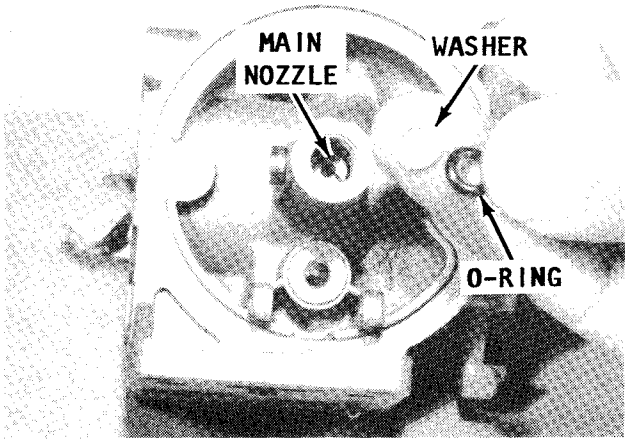
ASSEMBLING

1- No gaskets are installed under the main nozzle or main jet, but newer carburetors have a small washer and O-ring over the main nozzle. If these items were removed in Step 10 of disassembly they must be installed over the nozzle. Thread the main nozzle into the center turret and tighten the nozzle securely. Thread the main jet into the side of the center turret. Tighten the jet securely.

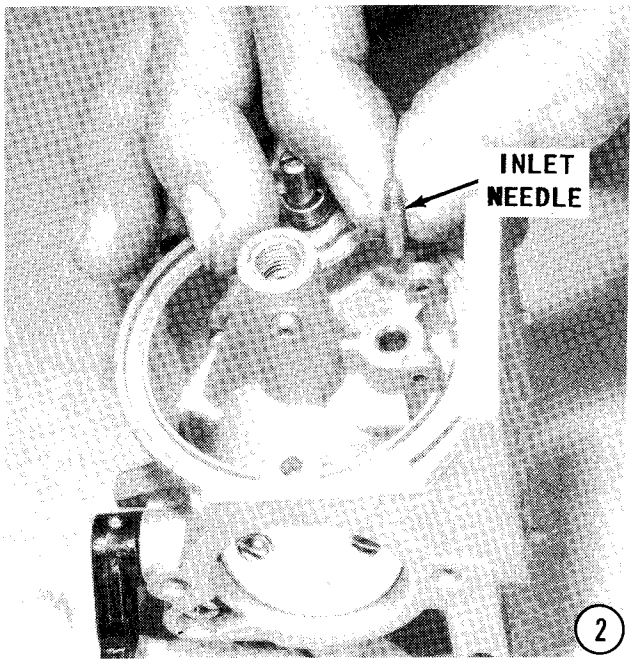
2- Slide the inlet needle into the needle seat.

3- Lower the float hinge down into position between the two mounting posts.

4- Insert the float hinge pin into the post nearest the choke shutter and push the pin into place until it is centered between the two mounting posts.

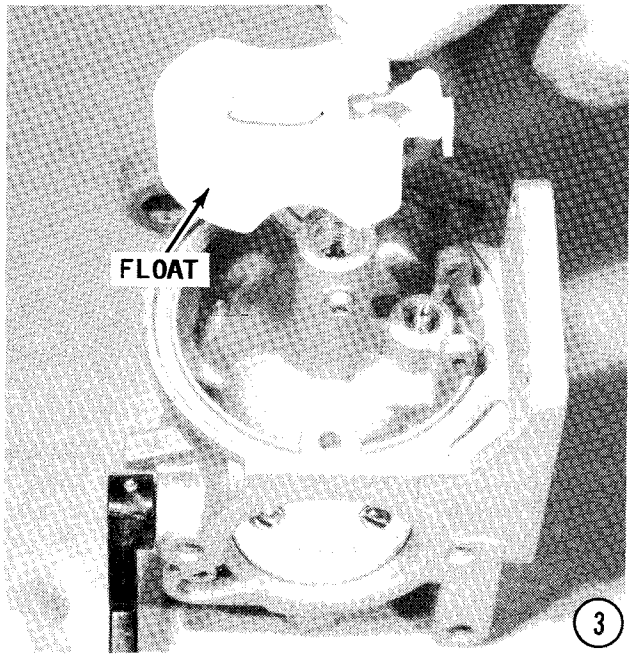


Newer type Carburetor "A" has a washer O-ring over the main nozzle.



5- Hold the carburetor body in the inverted position -- the same position it has been in since the start of the assembling procedures -- with the float resting on the inlet needle. Measure the distance between the float bowl gasket surface and a point on the float directly opposite the hinge, as indicated in the accompanying illustration. The distance should be 1/4" (6mm).

6- If the distance is not as specified, remove the float hinge pin to free the float. The float level adjustment may be made by bending the metal tab on which the inlet needle rests. Repeat Steps 5 and 6 until the specified distance between the float bowl



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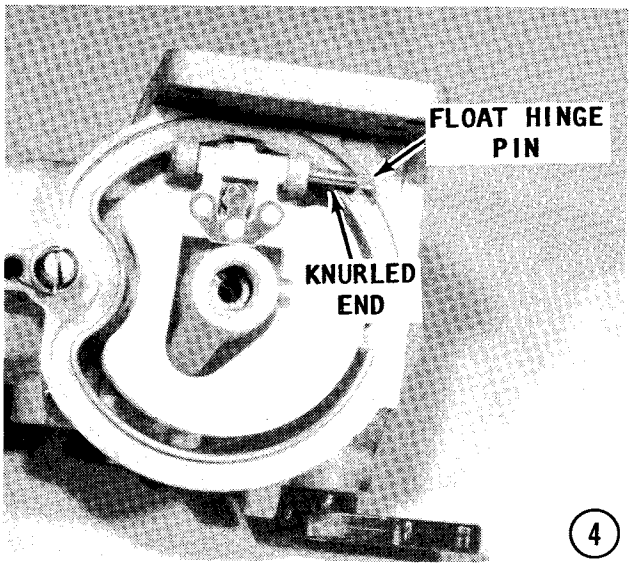


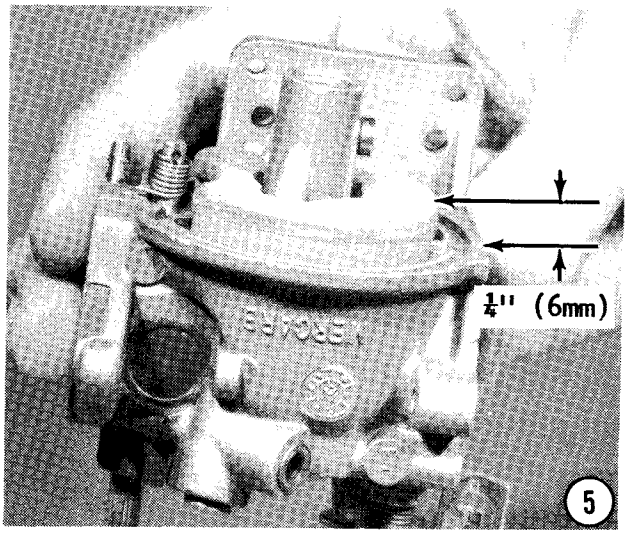
4

gasket surface and the surface of the float is obtained.

7- Turn the carburetor over and allow the float to hang freely. The float should be able to move freely, but not have so much travel to allow the inlet needle to slide completely out of the needle seat or become wedged between the seat and the float. If the float appears to have too much travel, adjustment is not possible, because a plastic tab limits the travel. The plastic tab **CANNOT** be bent. The float must be replaced.

8- Slide the baffle under the float on the opposite side to the float hinge and hook the stem of the baffle over the float bowl edge.

9- Position the float bowl gasket over the carburetor body and baffle stem. Place a new gasket over the threaded opening of the center turret. Seat the float bowl over the carburetor and secure the bowl in place with a new gasket and bolt. Tighten the bolt securely.



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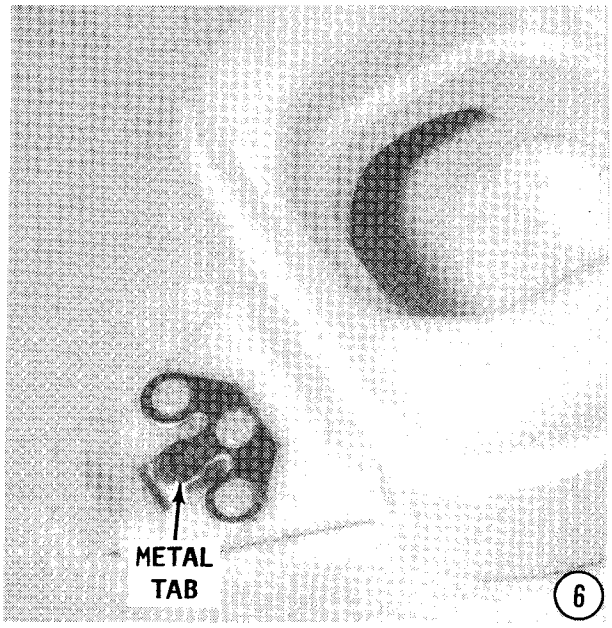

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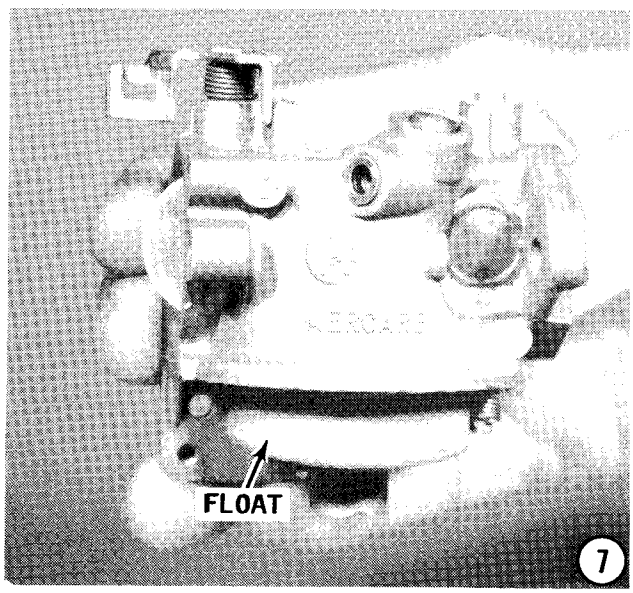

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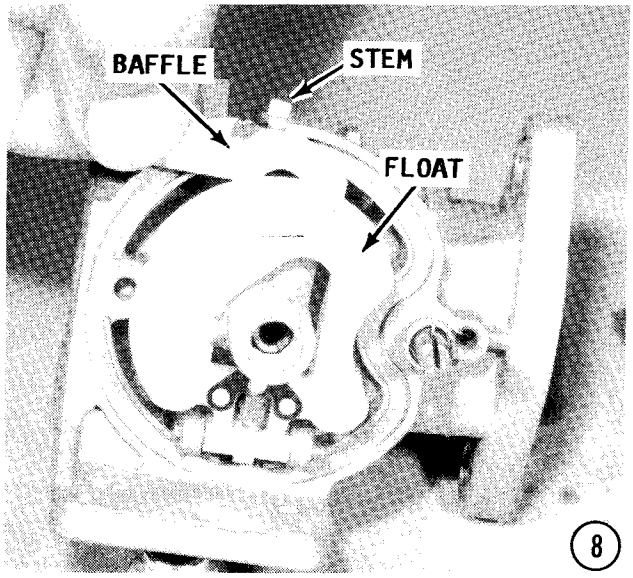

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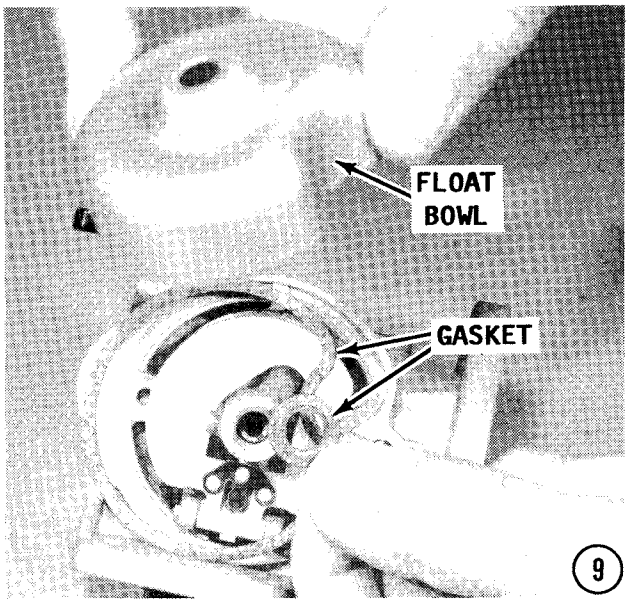


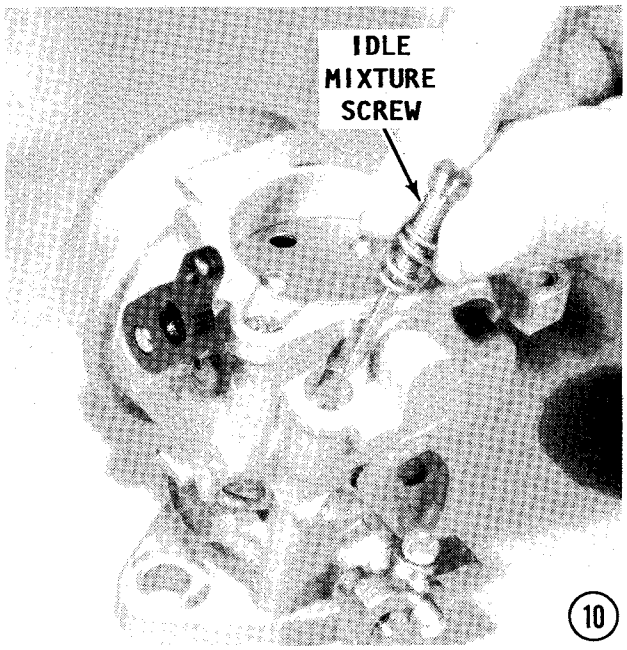
10- Thread the idle mixture screw into the carburetor until the screw is **LIGHTLY** seated. From this lightly seated position, back the screw out approximately 1-1/4 turns as a preliminary adjustment at this time.

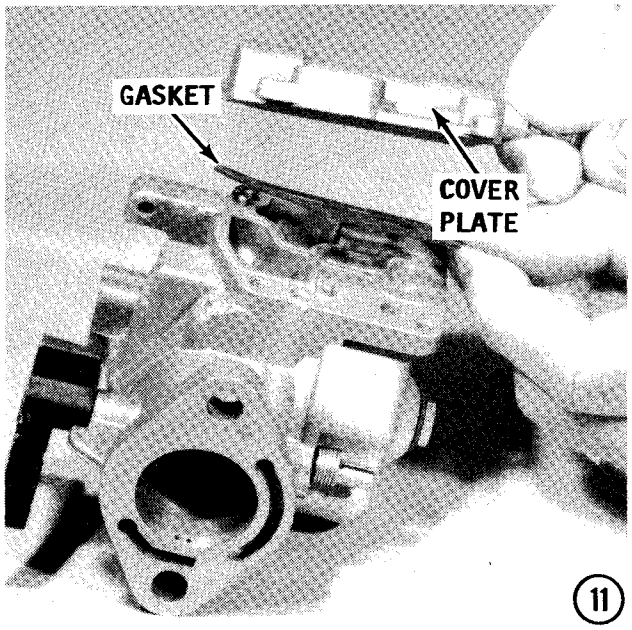
Units Without Integral Fuel Pump

11- Position a new gasket over the carburetor body. Place the cover plate over the gasket. Install and tighten the four Phillips head screws with captive lockwashers.

Units With Integral Fuel Pump

12- Position the strainer over the strainer body. Install a new gasket over the strainer, followed by the cover. Install and tighten the slotted head screw.



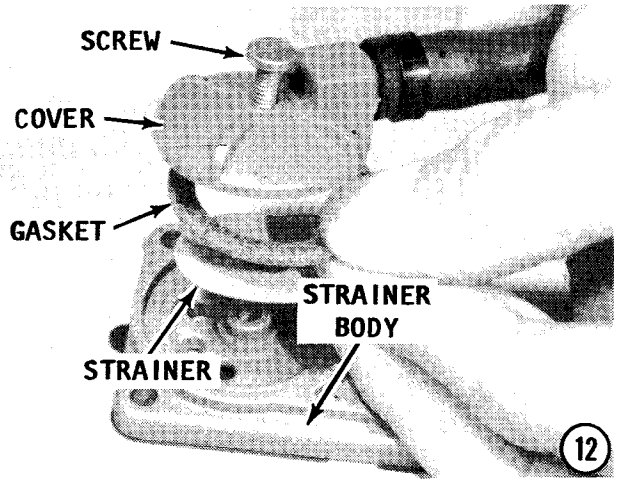


13- Position the following items in order over the carburetor body and check to be sure all items align with the mounting bolt holes: a gasket, check valve diaphragm, fuel pump body, another gasket, pump diaphragm and finally the assembled strainer pump body.

All Units

Installation and Closing Tasks

Position **NEW** gaskets in place on the intake manifold. Install each carburetor onto the manifold in the same position from which it was removed. Each carburetor should have been identified as instructed during the removal procedures. Secure the carburetors in place with the retaining nuts. Tighten the nuts alternately and evenly to a torque value of 100 in lb (11.3 Nm).



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Connect all fuel lines to the carburetors and tighten the clamps securely. Connect the fuel line from the fuel tank. Activate the fuel line squeeze bulb several times and check the carburetors and fuel lines for leaks. Connect the throttle and choke linkage to and between the carburetors. Connect the battery leads to the battery.

OPERATING ADJUSTMENTS

FIRST, THESE WORDS

Before fine carburetor adjustments can be properly made, the following conditions must exist:

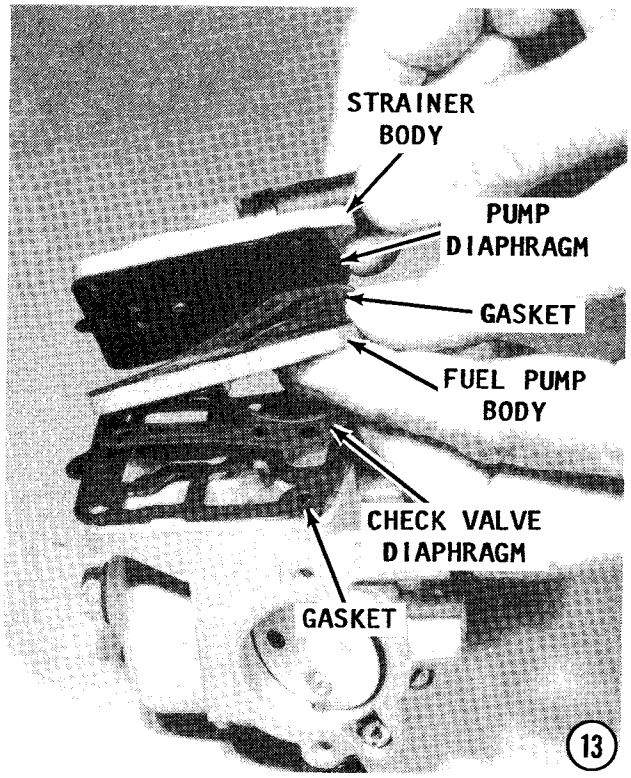
a. The correct engine-propeller combination must be used.

b. The power unit must be in forward gear.

c. The lower unit must be in the water.

d. The engine must be warmed to normal operating temperature.

e. The proper size fuel jet must be used for the elevation of operation. Main fuel jet size recommendations are intended as a guide only. If in doubt, try a size larger or smaller. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix. Spark advance change is **NOT** recommended for changes in elevation. In order to obtain proper powerhead rpm at higher elevation, a lower pitch propeller is suggested.



High-Speed Adjustment

The main fuel jet (high-speed) is changeable but not adjustable. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix.

Synchronizing

To synchronize the fuel and ignition systems, including the idle mixture adjustment, see Chapter 7. Consult the Table of Contents for the powerhead being serviced.

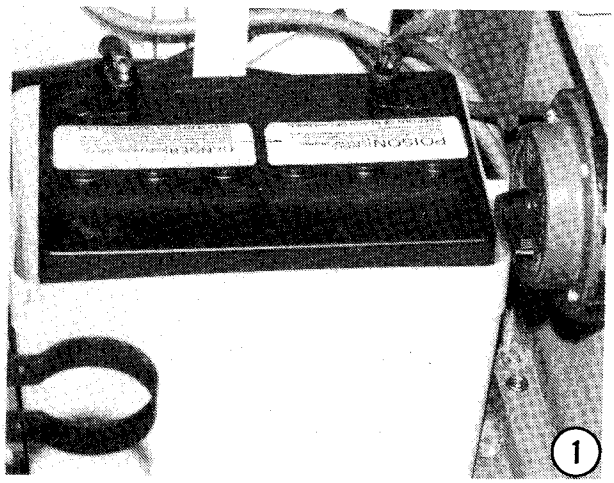
4-9 CENTER SQUARE BOWL CARBURETOR REFERENCED "B" IN APPENDIX

This section provides complete detailed procedures for removal, disassembly, cleaning and inspecting, assembling including bench adjustments, installation, and operating adjustments for the square bowl carburetor, identified as **"B"** in the Appendix.

This carburetor is equipped with a choke solenoid. However, it does not have a choke shutter valve in the carburetor throat. An enrichment valve performs the same function as the choke shutter and is linked to the choke solenoid. The enrichment valve is a mechanical valve and should not be confused with an enrichener valve which is an electrically operated valve installed on larger horsepower late model powerheads.
To synchronize the fuel and ignition systems, see Chapter 7.

REMOVAL AND DISASSEMBLING

1- Remove the battery leads from the battery terminals. Remove the front engine cover. Take off the wrap around cowl cover.



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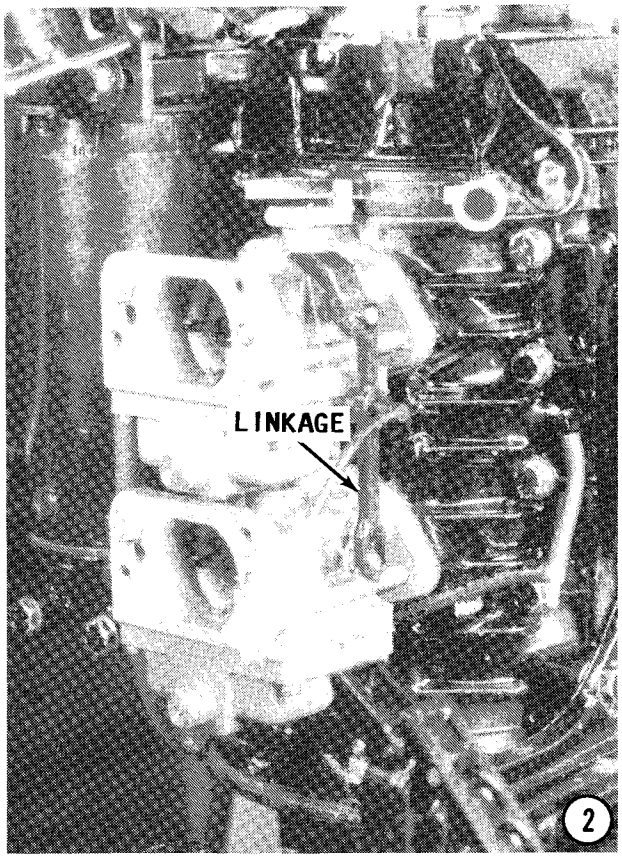
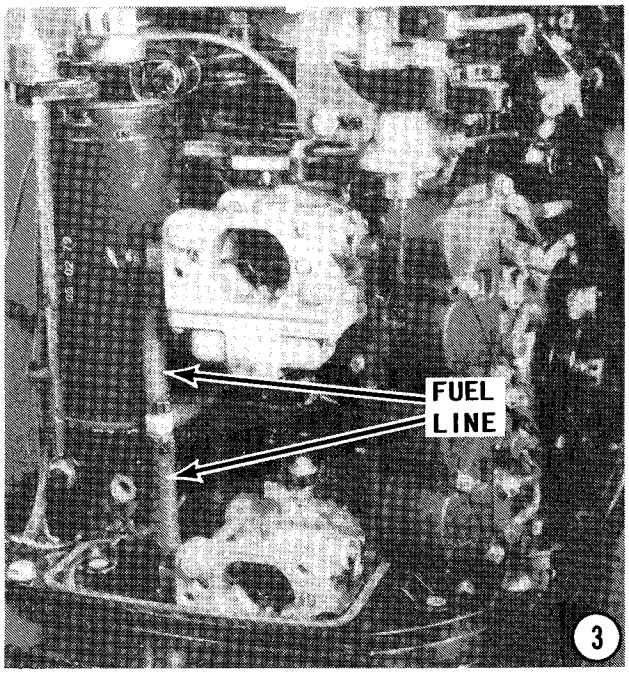
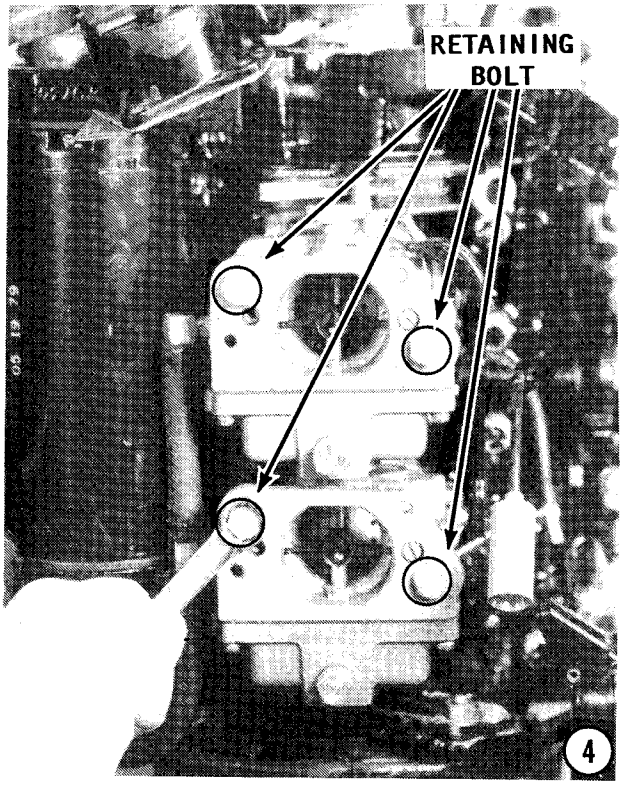


2- Take time to identify each carburetor to ensure each will be installed back in its original position. Disconnect the throttle and choke linkage from each carburetor.

3- Disconnect the fuel line from the engine. Remove the hose clamps on each fuel line to each carburetor. Remove the fuel line from each carburetor.

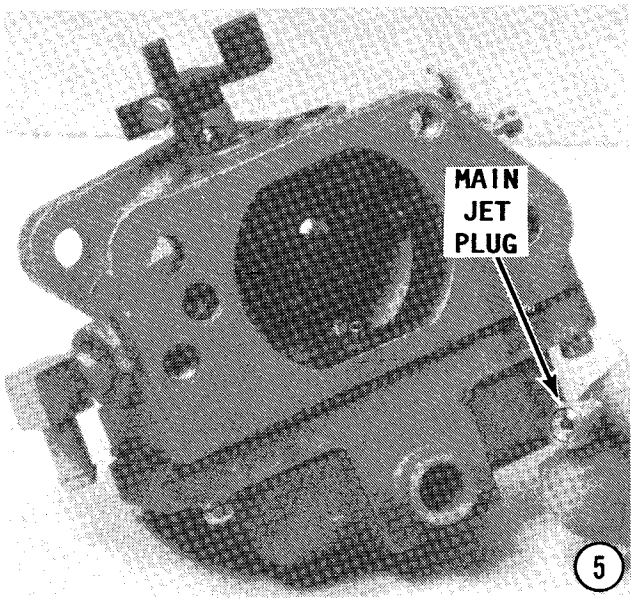




4- Remove the attaching nuts securing each carburetor to the intake manifold. Remove each carburetor from the engine. Since the carburetors are identical, the following procedures are to be repeated for each carburetor.

5- Remove the main jet plug located in the bottom of the carburetor bowl. **NOTE** that the main (high-speed) jet is located inside the plug. The jet may be removed, using the **PROPER** size screwdriver.

6- Turn the carburetor upside down and remove the four screws securing the bowl to



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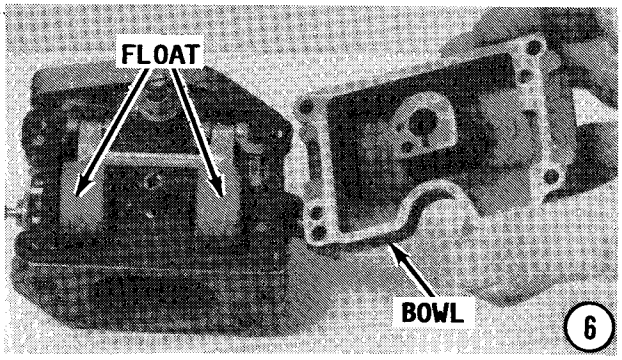
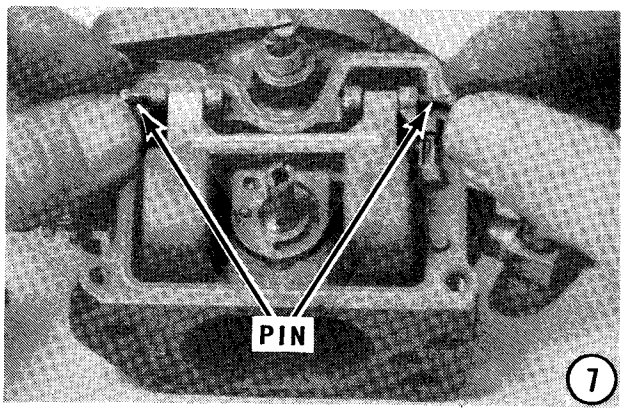


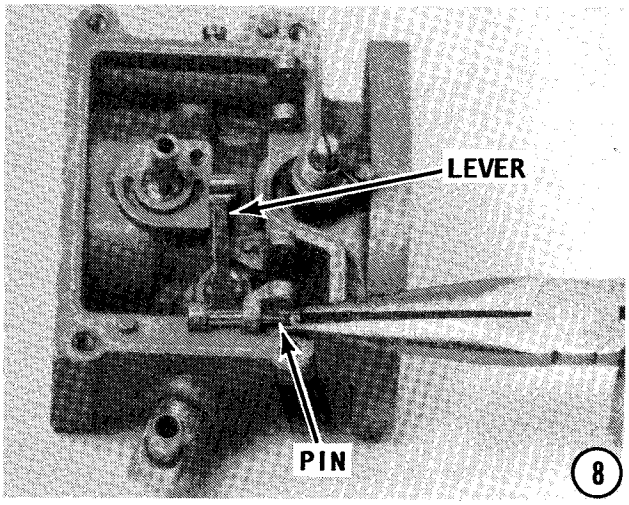


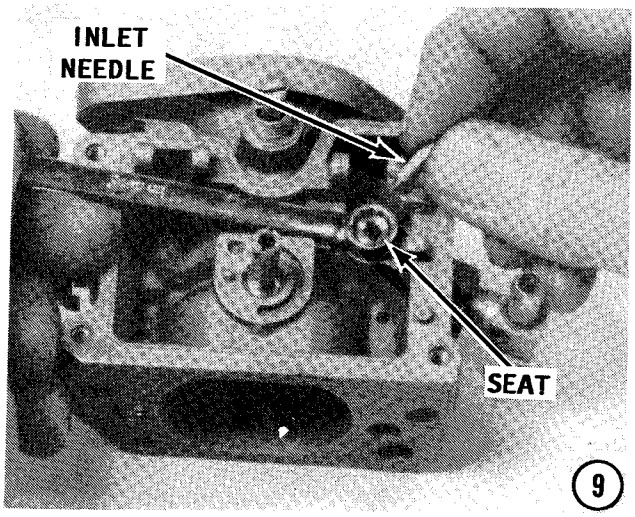
the body. Remove the bowl, and then remove and **DISCARD** the bowl-to-body gasket.

7- **OBSERVE** that the float is a double unit with two hinge pins. Withdraw both hinge pins by pushing each toward the **OUTER** edge of the carburetor. After the pins are free, lift the float from the carburetor body.

8- Remove the pin securing the float lever to the carburetor body by pushing the pin toward the backside of the carburetor. Remove the lever.

9- Withdraw the inlet needle from its seat. Remove the seat and the metal gasket installed below the seat.

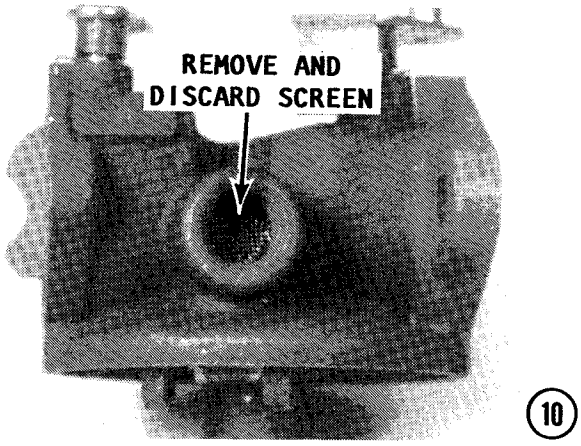


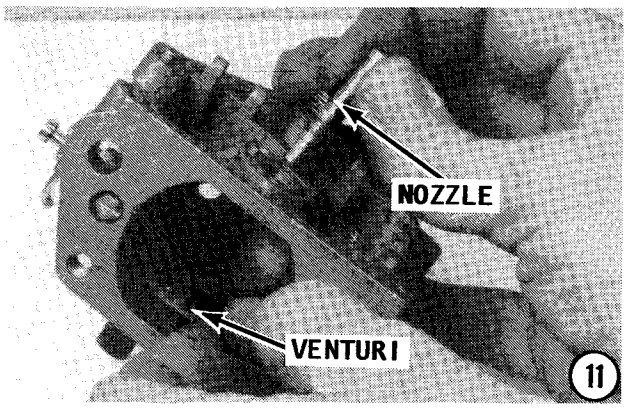


10- Remove the fuel inlet hose fitting. Check the filter screen inside the hole. Remove the screen. The factory does not recommend using a filter in the carburetor.

11- Remove the nozzle in the center of the carburetor body and at the same time observe that the venturi in the bore will now be loose. After the nozzle is out, remove the venturi from the carburetor bore.

12- Remove the screw and lockwasher securing the enrichment valve assembly in the carburetor. This screw is located on the





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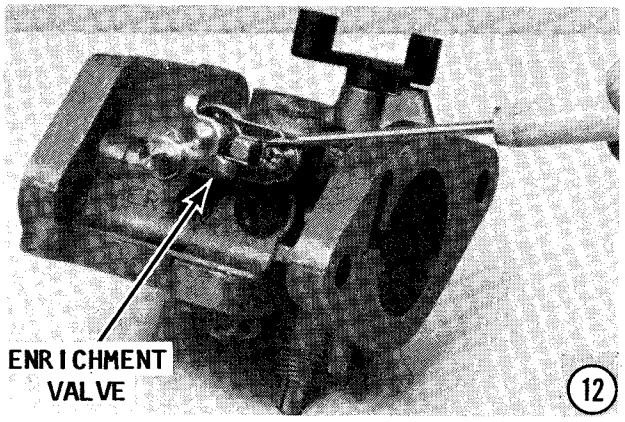
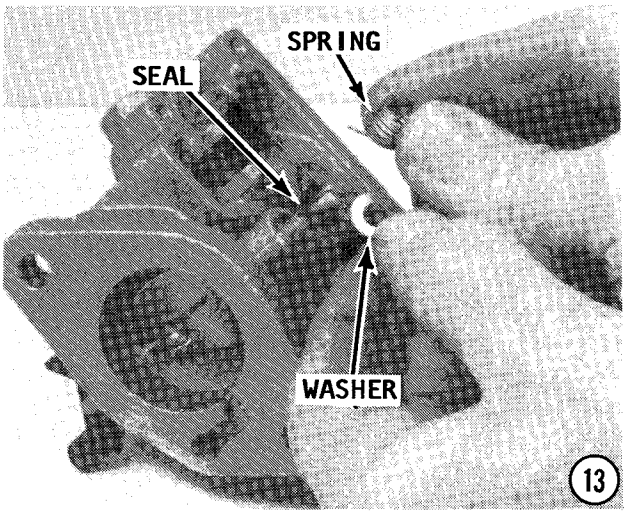


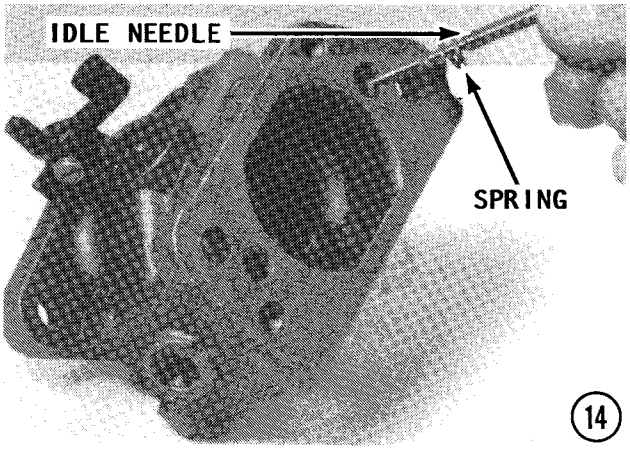


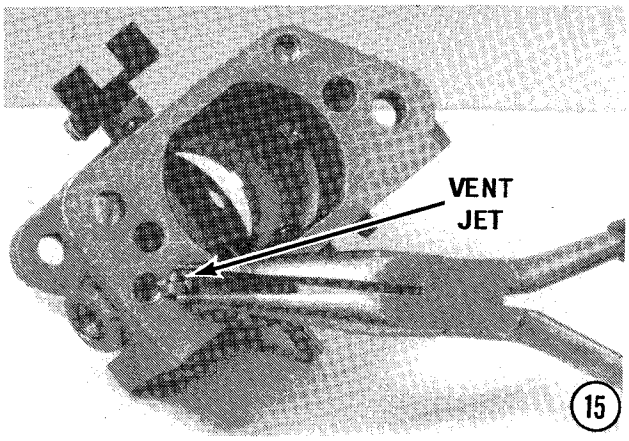
port side of the carburetor. Hold the enrichment valve and withdraw it straight out of the carburetor body.

13- Remove the throttle return spring, flat washer, and rubber seal from the bottom side of the carburetor.

14- Remove the idle needle from the starboard forward side of the carburetor. Notice how the needle comes out at an angle.

15- Remove the fuel bowl vent jet from the port side.





On this particular carburetor, the main fuel jet and the fuel bowl vent jet sizes must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct jet sizes for various elevations.

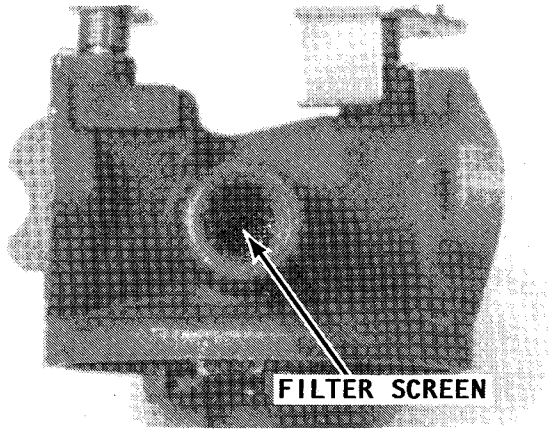
A GOOD WORD: Further disassembly of the carburetor is not neccessary in order to clean it properly.

CLEANING AND INSPECTING

NEVER dip rubber parts, plastic parts, diaphragms, or pump plungers in carburetor cleaner. These parts should be cleaned **ONLY** in solvent, and then blown dry with compressed air.

Place all of the metal parts in a screen-type tray and dip them in carburetor cleaner until they appear completely clean, then blow them dry with compressed air.

Blow out all passages in the castings with compressed air. Check all of the parts and passages to be sure they are not clogged



*Remove and **DO NOT** replace this filter screen. The manufacturer has determined the screen is too difficult to locate and actually it is not necessary.*

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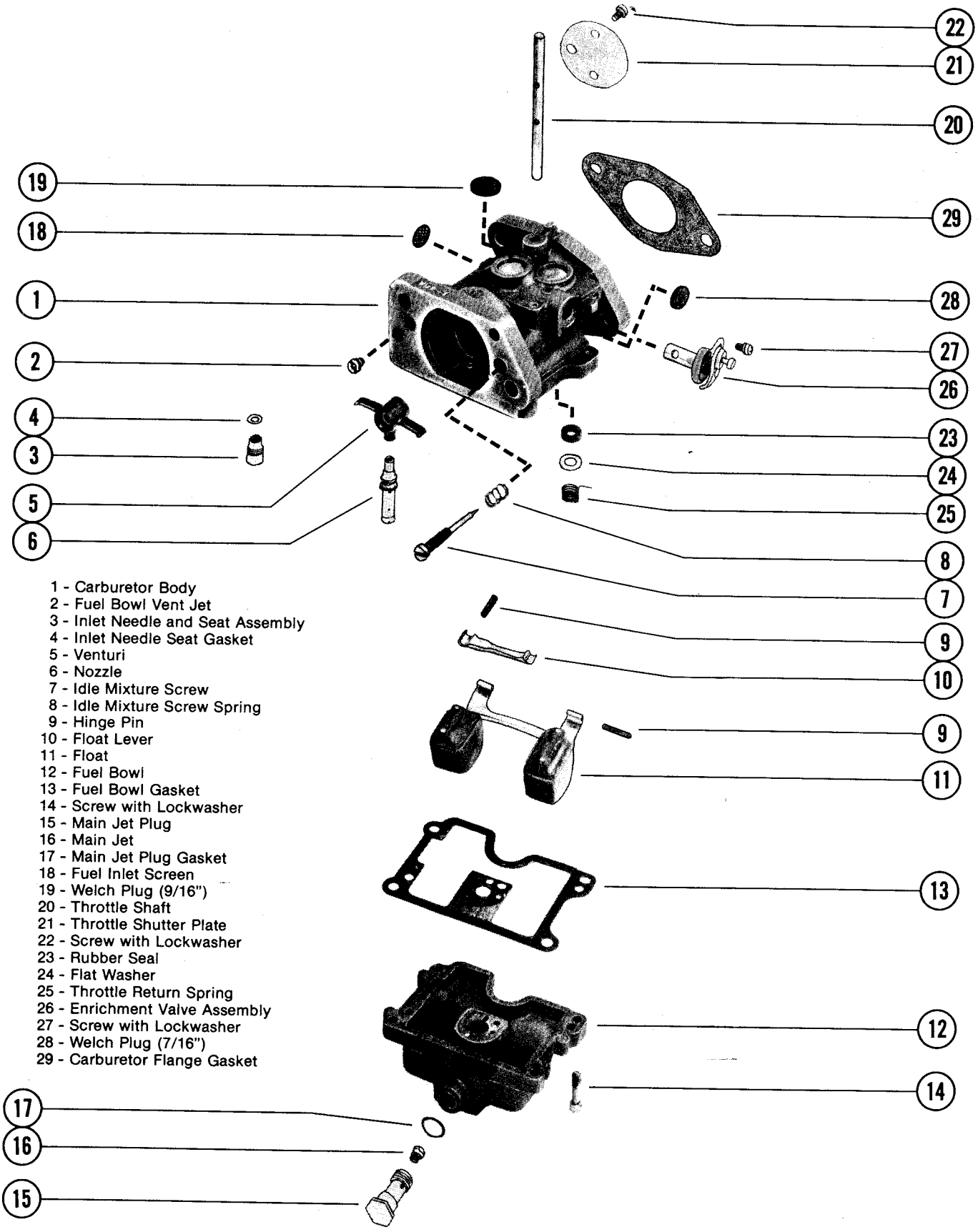

Exploded drawing of a center square bowl carburetor showing arrangement of major parts. This carburetor is identified as Carburetor ***"B"*** *in the text and Appendix.*

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or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Move the throttle shaft back-and-forth to check for wear. If the shaft appears to be too loose, replace the complete throttle body because individual replacement parts are **NOT** available.

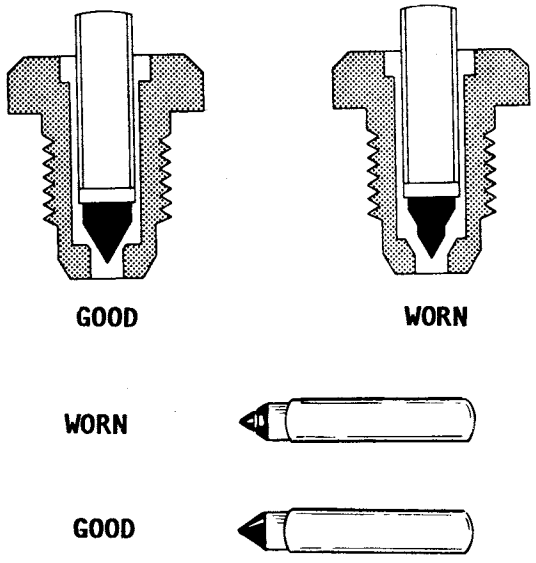
Inspect the main body, airhorn, and venturi cluster gasket surfaces for cracks and burrs which might cause a leak. Check the float for deterioration. If hollow floats are used, check to be sure they do not contain any fluid. Check to be sure the float spring has not been stretched. If any part of the float is damaged, the unit must be replaced. Check the float arm needle contacting surface and replace the float if this surface has a groove worn in it.

Inspect the tapered section of the idle adjusting needles and replace any that have developed a groove.

Most of the parts that should be replaced during a carburetor overhaul are included in an overhaul kit available from your local marine dealer. This kit will also contain a matched fuel inlet needle and seat. This combination should be replaced each time the carburetor is disassembled as a precaution against leakage.

Check the jet sizes with a drill of the proper size. **ALWAYS** hold the drill in a pin vise to avoid enlarging the jet orifice. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix for the proper size for your engine, carburetor, and anticipated elevation of operation.

Examine the throttle shaft for wear and the throttle shutter plates for damage.



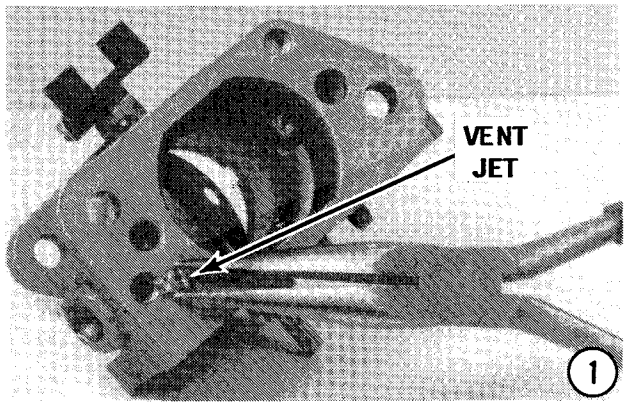
Needle and seat arrangement on the carburetor covered in this section, showing a worn and new needle for comparison.

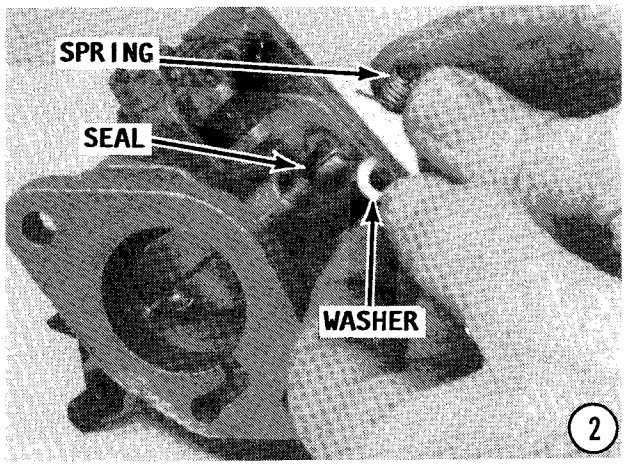
ASSEMBLING

1- Install the fuel bowl vent jet into the port side of the carburetor and tighten it securely.

2- Turn the carburetor upside down. Slide the rubber seal onto the throttle shaft with the lip **TOWARD** the carburetor. **OBSERVE** there are two sizes of springs to be installed onto the throttle shaft of the carburetors. **ALWAYS** install the strongest spring, the one with the largest diameter wire, onto the top mounted carburetor on **ALL** model engines. Slide the flat washer and throttle return spring onto the shaft. Hold the shutter plate in the closed position, and attach the throttle return spring.

3- Slide the spring onto the idle tube. **CAREFULLY** thread the idle tube into place on the starboard side of the carburetor until you feel it just barely seat. Now, as a preliminary adjusment, back the screw on the end of the tube out one complete turn.





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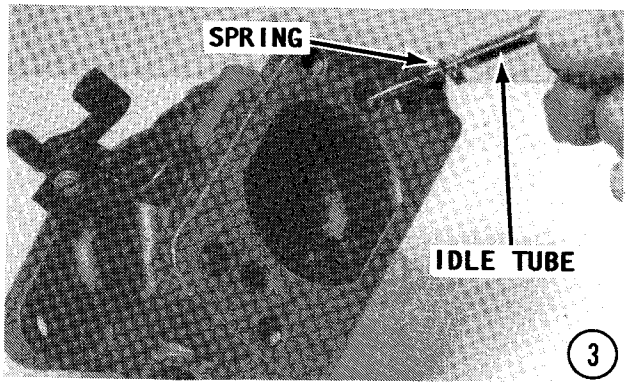
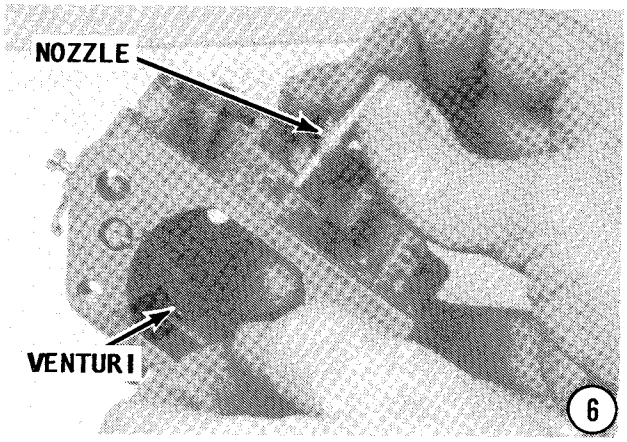


4- Install and position the enrichment valve assembly into the carburetor body. Secure the assembly in place with the screw and lockwasher. Make sure the spring arm is on the top of the square part of the carburetor.

5- Insert the venturi into the front of the carburetor and into the bore. The rounded edge must be installed into the carburetor towards the rear of the carburetor.

6- Install the nozzle through the top of the carburetor and into the venturi. The venturi is now held in place by the nozzle. Tighten the nozzle securely.

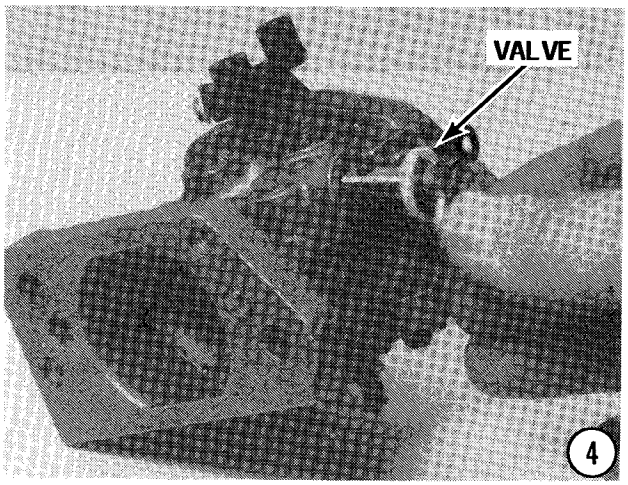
7- Position a **NEW** metal gasket onto the carburetor body at the inlet needle seat hole. Install the inlet needle seat, with rubber insert, into place and tighten the seat securely. Slide the needle into the seat.

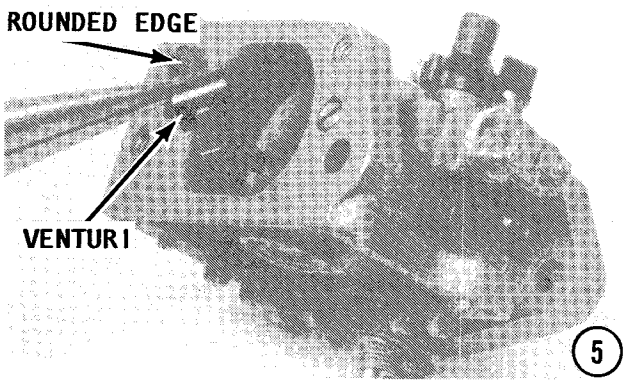


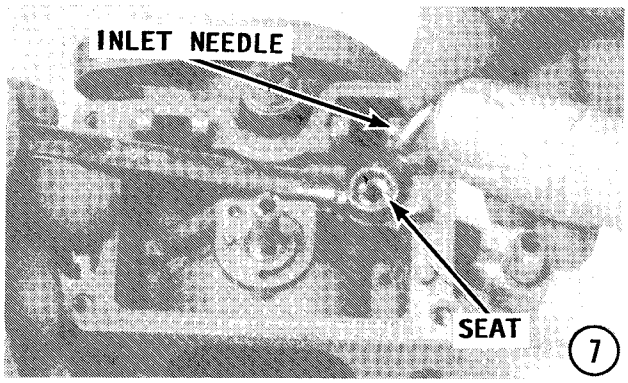
8- Position the float lever between the posts of the carburetor, and then slide the hinge pin into place from the rear of the carburetor. Use a flat end punch and seat the hinge pin until the knurled end of the pin is flush or within 1/32" (0.80mm) from the side of the post.

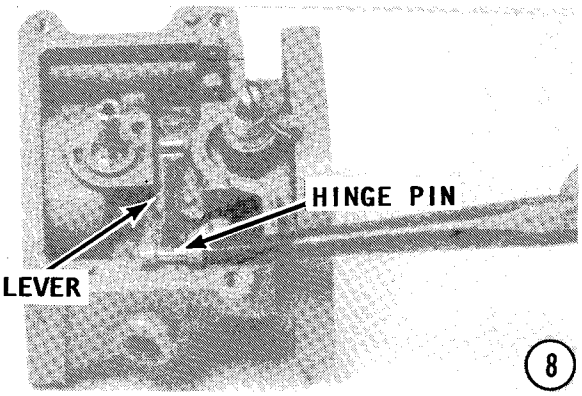
9- Slide the float into place between the posts of the carburetor. Insert both hinge pins through the posts from the outside edge.

10- Use a flat end punch to push the pins into the posts until the knurled end of each









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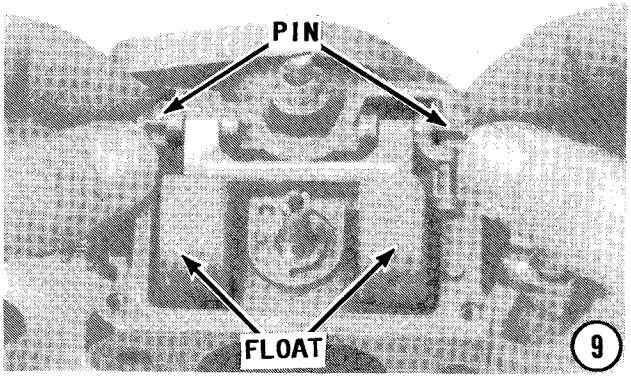
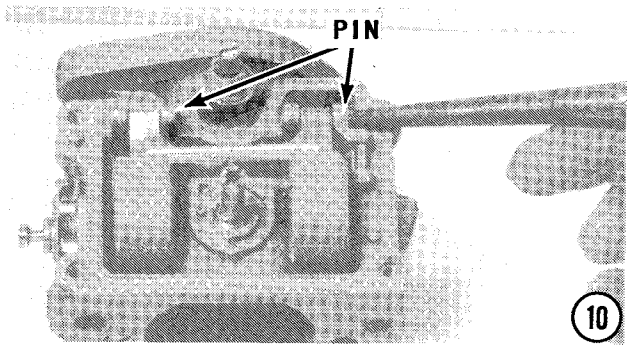
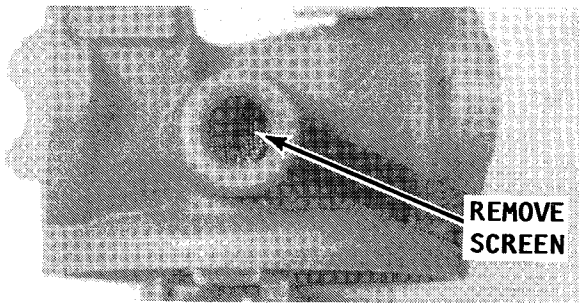
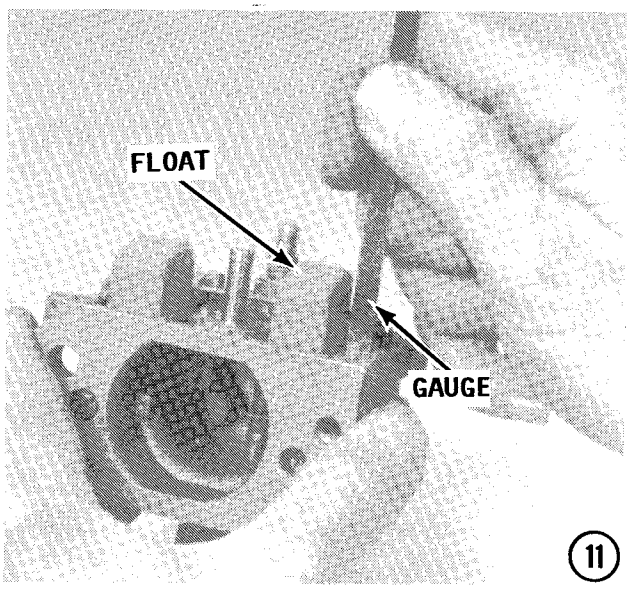
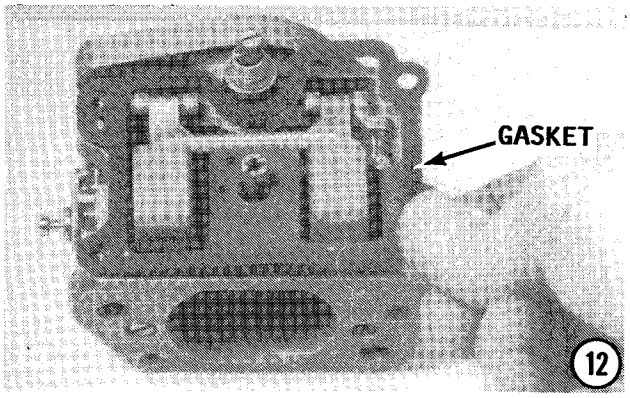






*Remove and **DO NOT** replace this filter screen. The manufacturer has determined the screen is too difficult to locate and actually it is not necessary.*



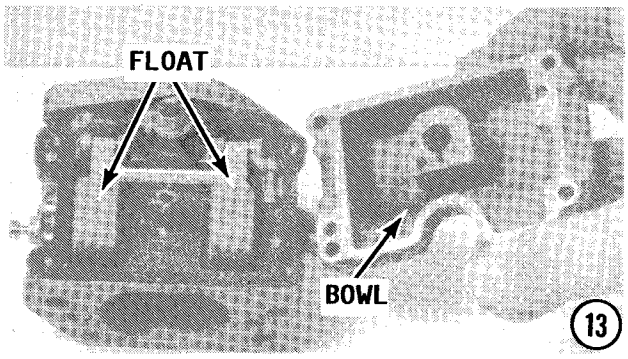


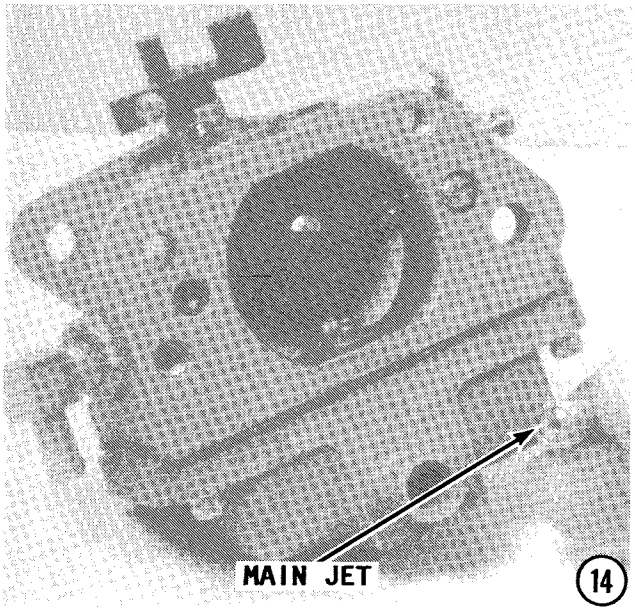
pin is flush or with 1/32" (0.80mm) from the side of the post.

Float Level Bench Adjustment

11- Turn the carburetor upside down with the floats resting on the inlet needle. Measure the distance from the base of the carburetor to the bottom edge of the float. This measured distance must be 11/16" (17.46mm). **CAREFULLY** bend the float lever to obtain the correct measurement.

12- With the carburetor still upside down, position a **NEW** gasket onto the body.





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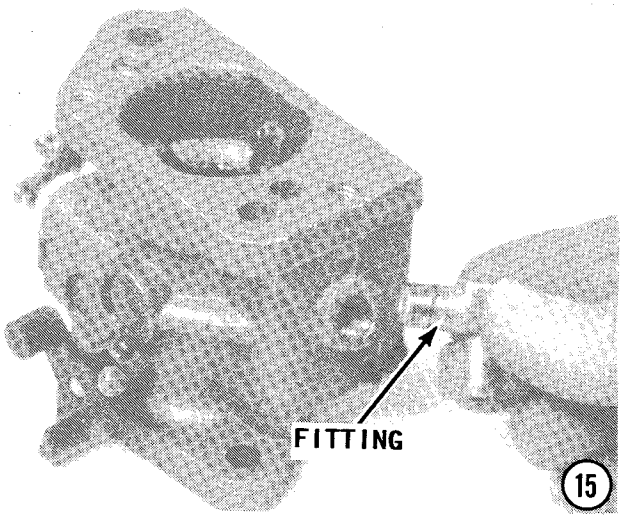


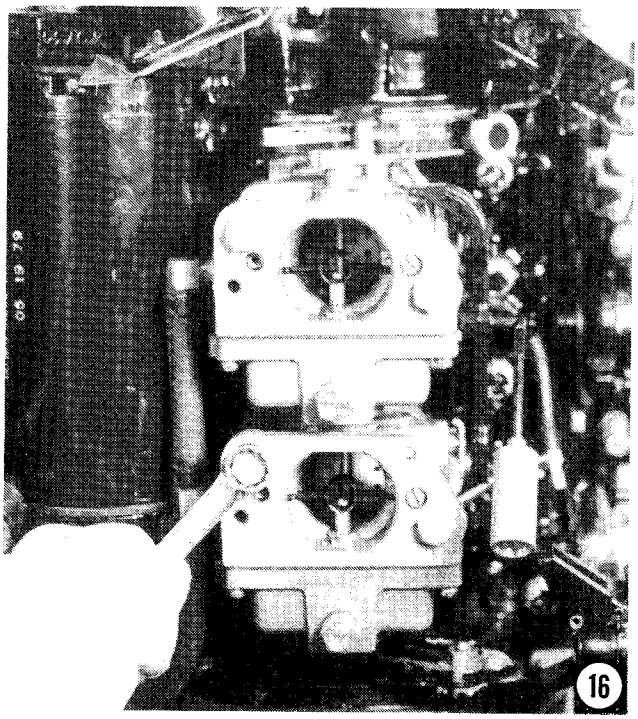
13- Place the fuel bowl in position and secure it with the four attaching screws.

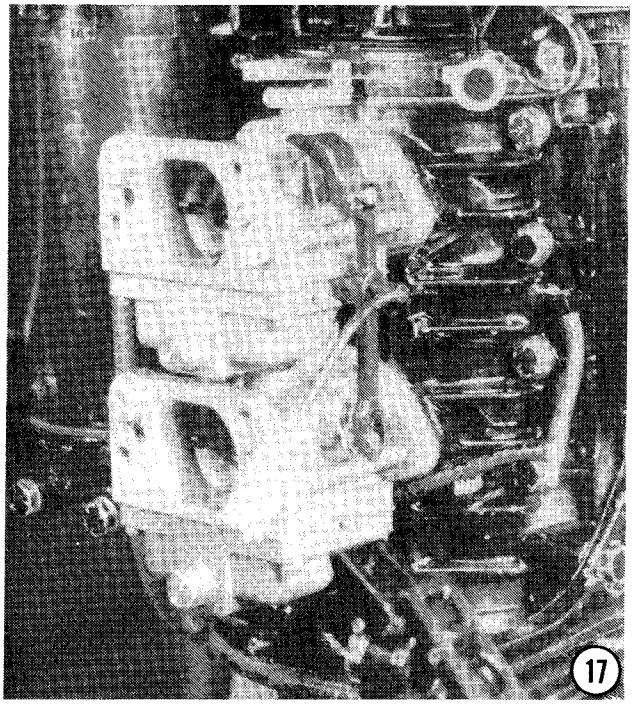
14- Install the main jet into the plug, if it was removed. Use a **NEW** gasket and install the plug into the carburetor bowl.

15- The factory does not recommend replacing the fuel filter. Install the fuel hose fitting.

INSTALLATION

16- Position a **NEW** gasket in place on the intake manifold. Install the carburetor onto the manifold in the same position from which it was removed. Each carburetor should have been identified as instructed during the removal procedures. Secure the carburetor in place with the retaining nuts. Tighten the nuts alternately to the torque value given in the Appendix.

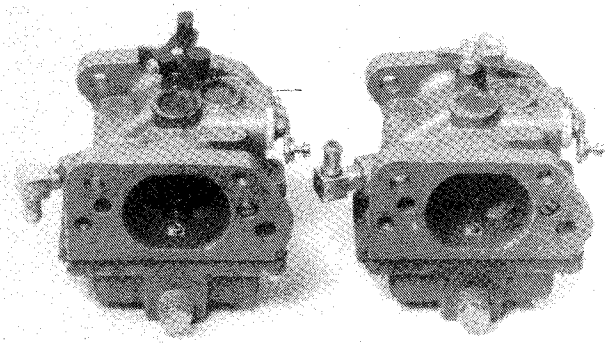




17- Assemble and install the other carburetors in a similar manner. Connect the manual choke to the choke rod. Connect all of the fuel lines to the carburetors and tighten the clamps securely. Connect the fuel line from the fuel tank. Activate the fuel line squeeze bulb several times and check the carburetors and fuel lines for leaks. Connect the throttle and choke linkage to and between the carburetors. Connect the battery leads to the battery.

Synchronizing

To synchronize the fuel and ignition systems, see Chapter 7.



*Carburetor "B" square bowl units. The left carburetor **MUST** be installed as the **TOP** carburetor because of unique linkage arrangement.*

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OPERATING ADJUSTMENTS

FIRST A FEW WORDS Before fine carburetor adjustments can be properly made, the following conditions must exist:

a. The correct engine-propeller combination must be used.

b. The power unit must be in forward gear.

c. The lower unit must be in the water.

d. The engine must be warmed to normal operating temperature.

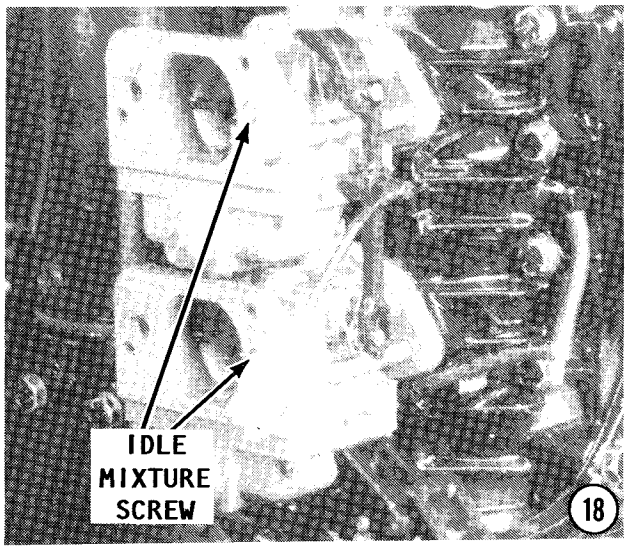
e. Main fuel jet size recommendations are intended as a guide only. If in doubt, try a size larger or smaller. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix. Spark advance change is **NOT** recommended for changes in elevation. In order to obtain proper engine rpm at higher elevation, a lower pitch propeller is suggested.

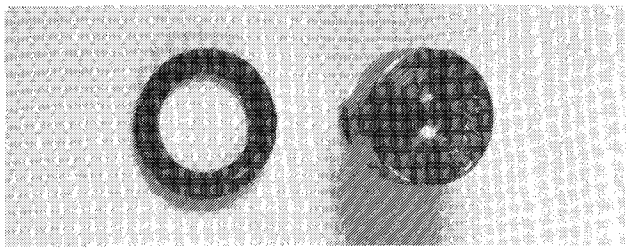
High-Speed Adjustment

The main fuel jet (high-speed) is changeable but not adjustable. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix.

Idle Mixture Adjustment

18- After the conditions have been met as listed in the first portion of this step, including the engine run until it has reached operating temperature, set the idle mixture screw one turn open from the lightly seated position. Now, with the engine operating at idle speed (750 to 800 rpm), **SLOWLY** turn the idle mixture screw counterclockwise until the affected cylinder starts to load up or fires unevenly due to the over-rich mixture. **SLOWLY** turn the idle mixture screw clockwise until the affected cylinder fires evenly and the engine rpm increases.





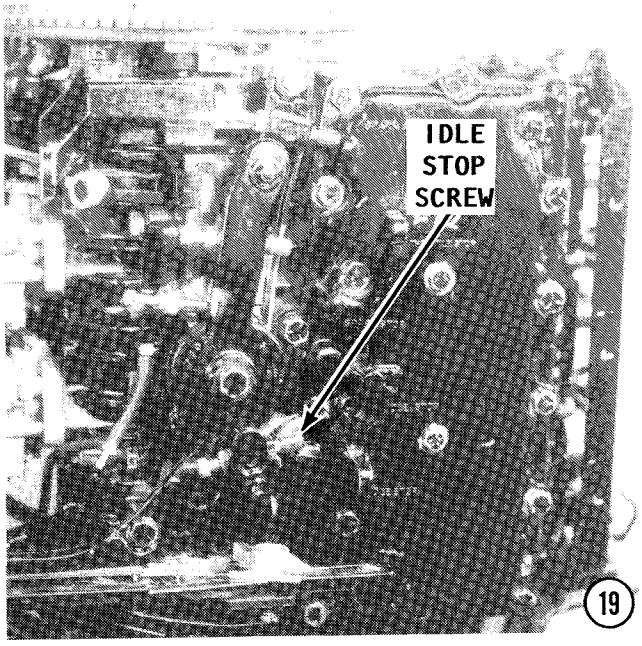
High-speed jet and gasket.

SOME ADVICE: Do not adjust to a leaner position than necessary. It is better to have the mixture set slightly on the rich side, rather than too lean. Too lean a mixture is often the cause of hard starting.

MORE ADVICE: If the engine hesitates during acceleration after adjusting the idle mixture, the mixture is set too lean and should be changed to the richer side until engine acceleration is smooth.

Idle Speed Adjustment

19- After the conditions listed at the beginning of this ADJUSTMENT section have been met, and the idle mixture adjustment has been properly made, as described in the previous step, then adjust the idle speed stop screw on the stop bracket until the engine idles at the recommended rpm given in the Tune-up Specifications in the Appendix. Continue running the engine in forward gear at the recommended wide open throttle (WOT) range to clear the engine, and then recheck the idle speed. Install the wrap around and front engine covers.



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4-10 SERIES WME CENTER SQUARE BOWL CARBURETOR REFERENCED "C" IN APPENDIX

This section provides complete detailed procedures for removal, disassembly, cleaning and inspecting, assembling including bench adjustments, installation, and operating adjustments for the Series WME square bowl carburetor, identified as Carburetor **"C"** in the Appendix. This carburetor is installed on 3-cylinder 75hp, 3-cylinder 90hp, and 4-cylinder 100hp and 115hp powerheads. To synchronize the fuel and ignition systems, see Chapter 7.

Replacement Carburetors

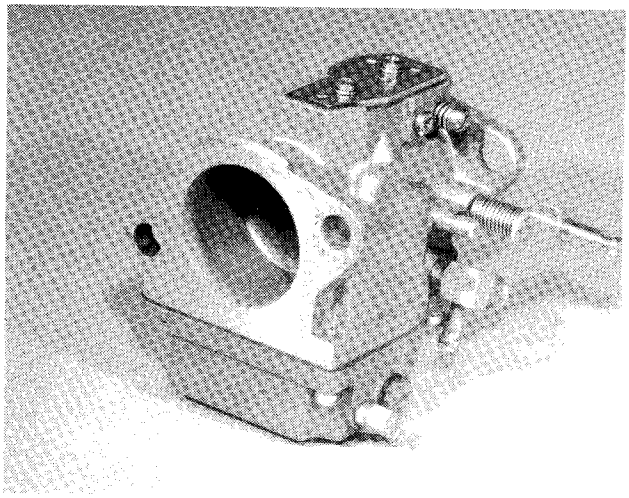
If a carburetor is no longer serviceable, the replacement carburetor must bear the same series number as the original. This number is stamped on the top of the carburetor mounting flange. On some very early models, this number will be found on the face of the air box mounting flange.

Series WME-8 carburetors are used on 75hp powerheads with a standard 0.068 main jet size and 0.094 bowl vent jet.

Series WME-10 carburetors are used on 90hp powerheads with a standard 0.072 main jet size and 0.094 bowl vent jet. These carburetors are interchangeable if the standard jets are changed to the correct value. If the top carburetor is being replaced, the old fuel bowl can be reused.

Series WME-11 carburetors are used on 100hp and 115hp powerheads with a standard 0.054 main jet size and no bowl vent jet. The manufacturer and Seloc do not recommend a Series WME-11 be used to replace either a Series WME-8 or Series WME-10 carburetor.

If replacing a Series WME-11 carburetor, be sure to specify the carburetor location to the parts person, because the lower two carburetors do not have an idle circuit and therefore they do not have an adjustable idle mixture screw. The opening has a non-removeable plug installed at the factory.



Carburetor "C" removed from the powerhead and ready for an overhaul.

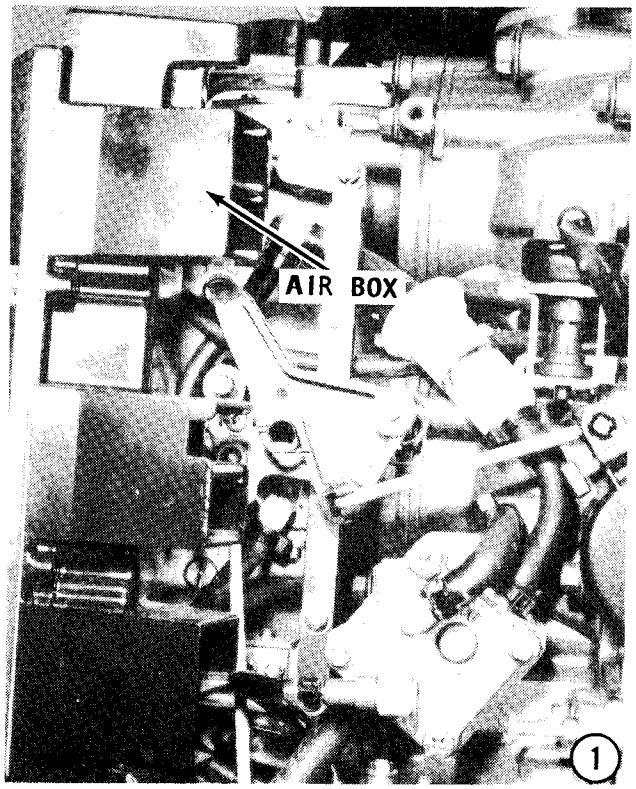
REMOVAL AND DISASSEMBLING CARBURETOR "C"

Check to be sure the carburetor/s being serviced are identified as Carburetor **"C"** from the Appendix and identifying illustrations at the beginning of this chapter. Only by proper carburetor identification can the reader be assured the correct procedures are being performed.

1- Remove the battery leads from the battery terminals. Remove the front engine cover. Take off the wrap around cowl cover. Remove the air box.

2- Take time to identify each carburetor to ensure each will be installed back in its original position, because each carburetor is **DIFFERENT.**

a- Each carburetor has slightly different linkage.



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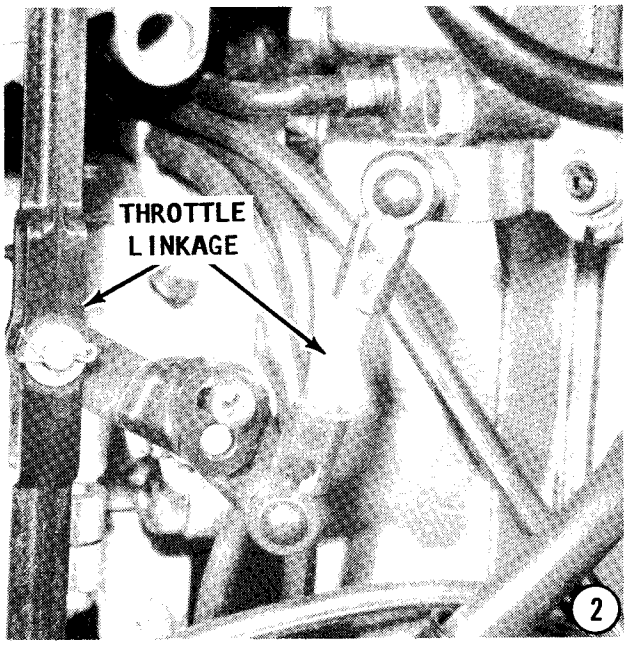
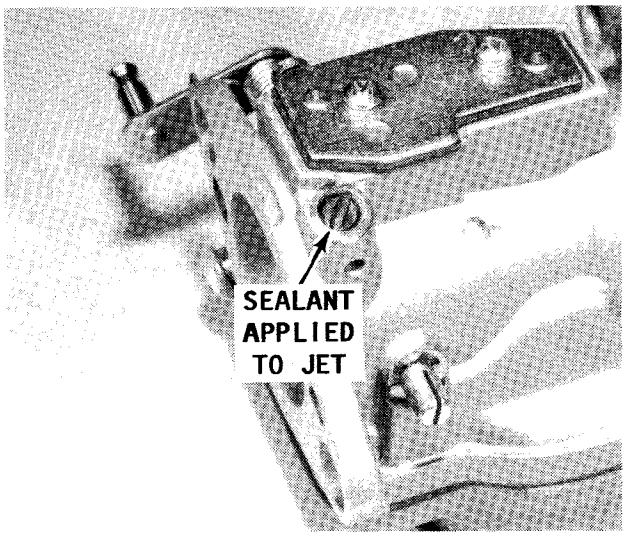


b- Only the top and second carburetors installed on 100hp or 115hp powerheads have an adjustable idle screw. The third and bottom carburetors have a non-removeable plug in place of the idle screw. This plug is clearly identified with a colored sealer, is preset at the factory, and **MUST** not be disturbed.

c- The fuel bowl of the top carburetor is unique from the others. The enrichener valve is fed by fuel from only the top carburetor float bowl.

Disconnect the throttle linkage from each carburetor. Disconnect the fuel line from the engine. Remove the hose clamps on each fuel line to each carburetor. Remove the fuel line from each carburetor.



Red sealant applied to screws or plugs are the manufacturer's method of giving the message: ***"DO NOT DISTURB".***

Remove the attaching nuts securing each carburetor to the intake manifold. Remove each carburetor from the powerhead. Apart from the specific differences mentioned above, which in most cases do not affect service procedures, the carburetors are identical, the following procedures are to be repeated for each carburetor. Where the differences affect service procedures, they will be clearly identified.

SPECIAL WORDS

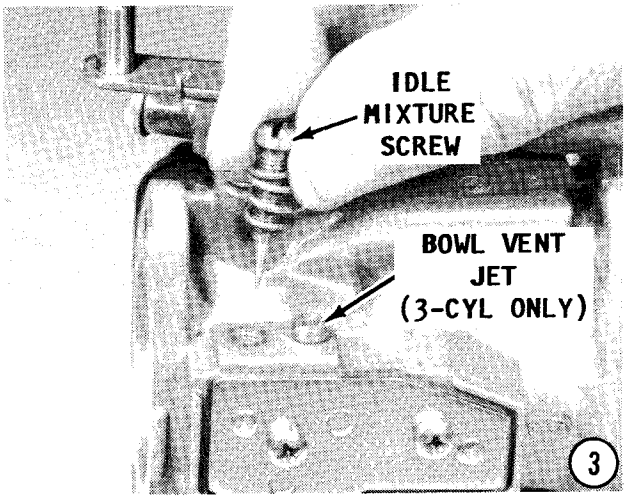
This carburetor does not have a traditional choke system. Instead, the choke function is performed by an enrichener system fed from the fuel bowl of the top carburetor. The extra fuel needed for cold powerhead startup is supplied to the intake manifold by an electrically operated device called the enrichener valve. Service procedures for this system are outlined in detail in Chapter 9, beginning on Page 9-20.

VERY IMPORTANT WORDS

Notice the application of Red sealant on certain adjustment screws or plugs. This sealant was applied at the factory and is the manufacturer's method of instructing anyone servicing the carburetor not to **DISTURB** the screw or plug.

The sealant is not affected by carburetor cleaner and should remain in place on the plug or screw and the carburetor for the entire useful life of the carburetor.

3- Back out the idle mixture screw. If servicing a 4-cylinder powerhead, the idle mixture screw on the two lower carburetors exist, but is **NOT** adjustable and must **NOT** be disturbed, as just described in the "Very Important Words".



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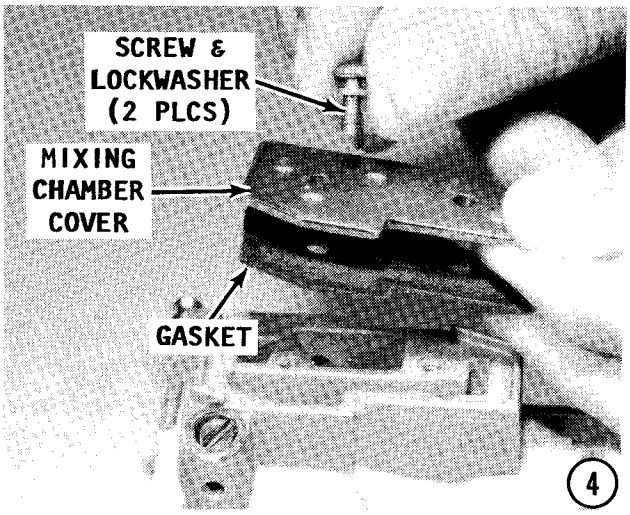


If servicing a 3-cylinder powerhead, remove the bowl vent jet located next to the idle mixture screw. This jet is identical on all three carburetors. The 4-Cylinder powerheads are not equipped with this jet.

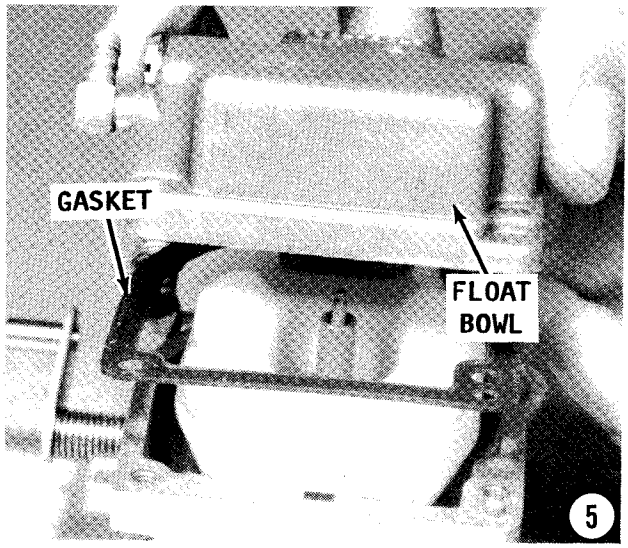
4- Remove the two Phillips head screws and captive lockwashers, and then remove the mixing chamber cover and gasket.

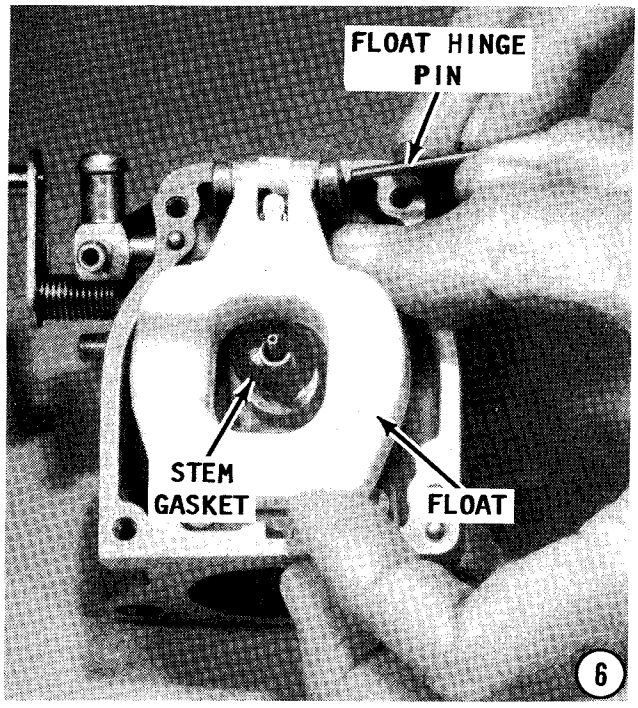
5- Remove the four Phillips head screws with captive lockwashers from the float bowl. Lift off the fuel bowl. Remove and discard the gasket.

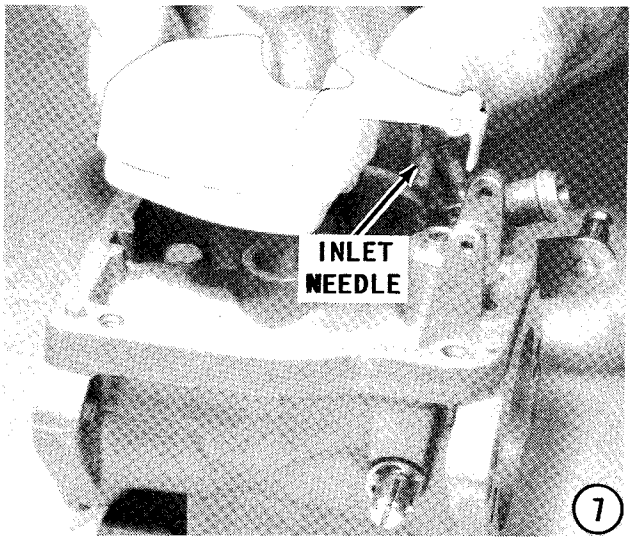
6- Remove the stem gasket from the center of the fuel bowl. Support the float and at the same time push the float hinge pin free of the mounting posts.

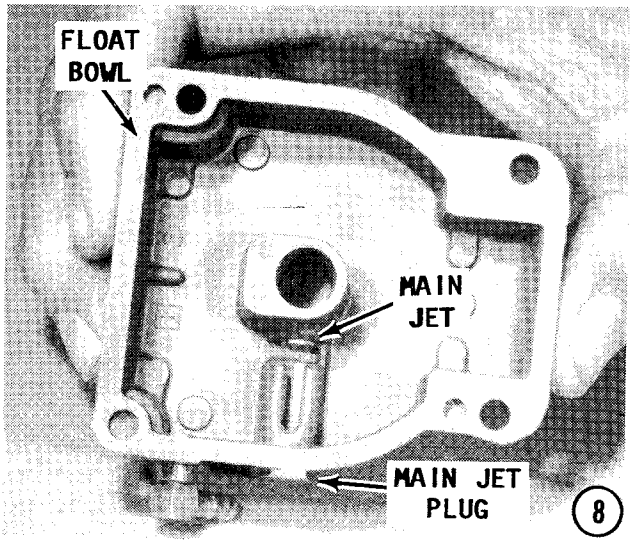
7- Carefully lift the float with the inlet needle attached from the needle seat. Detach the inlet needle from the float. The needle seat is not removable on this carburetor.

8- Remove the main jet plug and gasket from the exterior wall of the float bowl.









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This plug provides access for a screwdriver to be inserted into the opening and allows removal of the main jet from the side of the center turret. This design facilitates changing the size of the main jet, without removal of the carburetor from the powerhead. Main jet sizes must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct main jet sizes for various elevations.

GOOD WORDS

Further disassembly of the carburetor is not necessary in order to clean it properly.

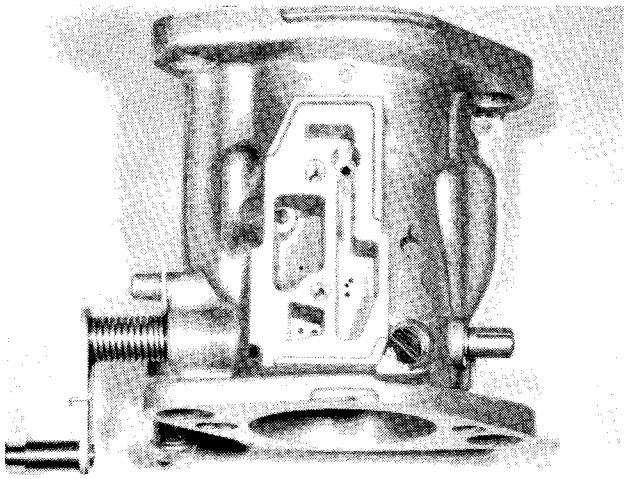
CLEANING AND INSPECTING

NEVER dip rubber parts or plastic parts in carburetor cleaner. These parts should be cleaned **ONLY** in solvent, and then blown dry with compressed air.

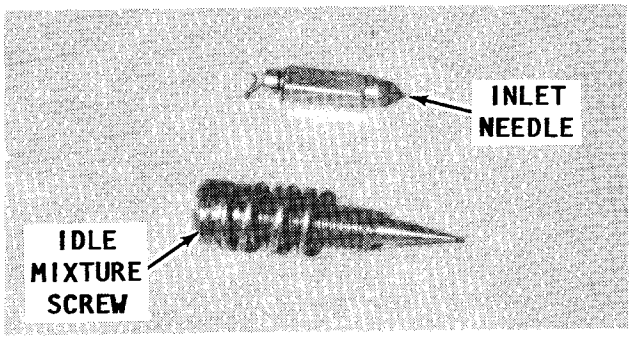
Place all metal parts in a screen-type tray and dip them in carburetor cleaner until they appear completely clean, then blow them dry with compressed air.

Blow out all passages in the castings with compressed air. Check all of the parts and passages to be sure they are not clogged or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Move the throttle shaft back-and-forth to check for wear. If the shaft appears to be too loose, replace the complete throttle body because individual replacement parts are **NOT** available.



***NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor, particularly those in the mixing chamber.*



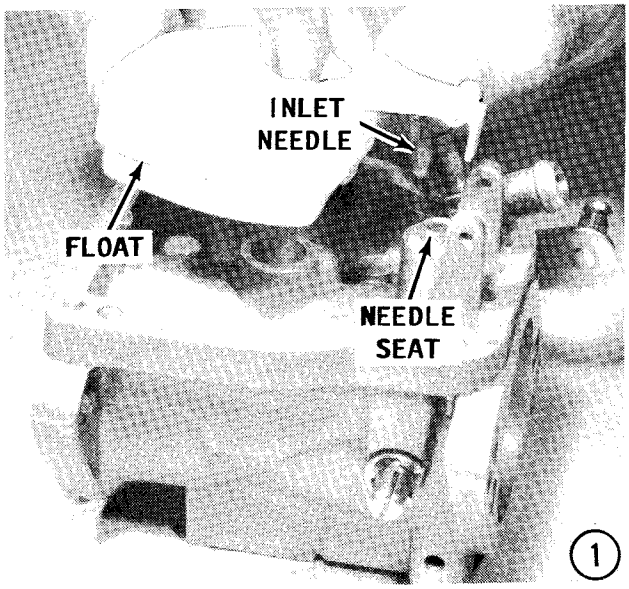
Inspect the taper of the inlet needle and the idle mixture screw for evidence of a worn groove.

Inspect the main body, airhorn, and venturi cluster gasket surfaces for cracks and burrs which might cause a leak. Check the float for deterioration. If hollow floats are used, check to be sure they do not contain any fluid. Check to be sure the float tab is in good condition. If any part of the float is damaged, the unit must be replaced. Check the float arm needle contacting surface and replace the float if this surface has a groove worn in it.

Inspect the tapered section of the idle adjusting needles and replace any that have developed a groove.

Most of the parts that should be replaced during a carburetor overhaul are included in an overhaul kit available from your local marine dealer.

Check the jet sizes with a drill of the proper size. **ALWAYS** hold the drill in a pin vise to avoid enlarging the jet orifice. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix for the proper size for your engine, carburetor, and anticipated elevation of operation.



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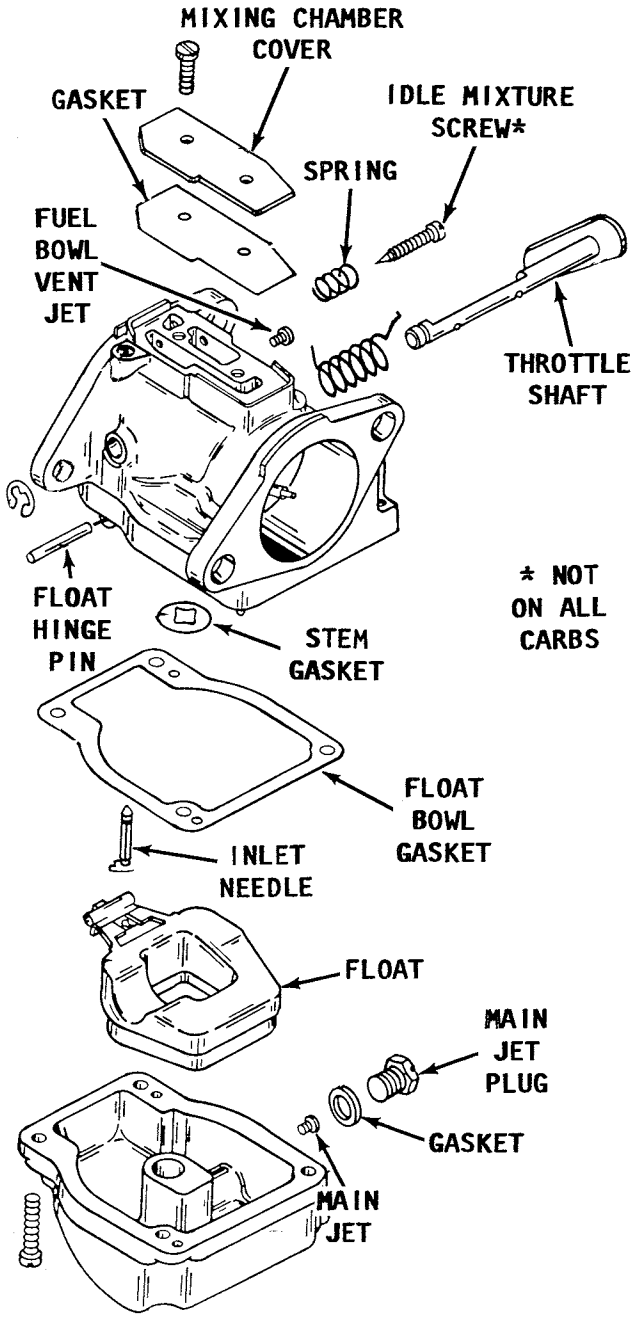
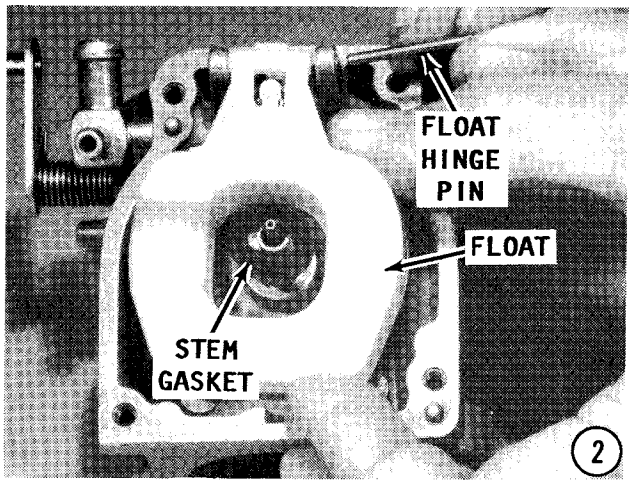


Exploded drawing of Carburetor "C", with major parts identified.

ASSEMBLING CARBURETOR "C"

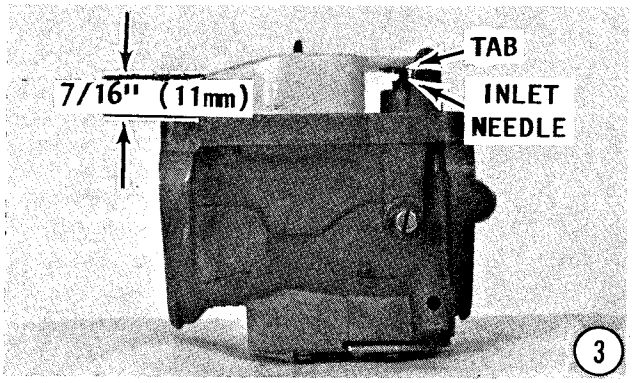
1- Hook the inlet needle spring over the float tab and lower the needle into its seat with the float hinge between the mounting posts.

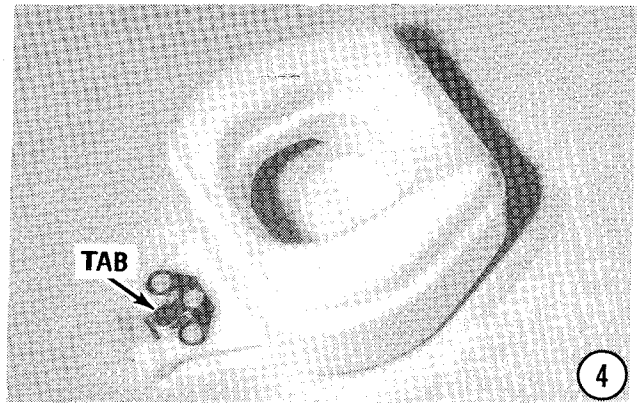
2- Slide the float hinge pin through the posts to secure the float. Center the pin between the posts. Place the stem gasket over the center turret.



3- Hold the carburetor body in the inverted position -- the same position it has been in since the start of the assembling procedures -- with the float resting on the inlet needle. Measure the distance between the float bowl gasket surface and a point on the float directly opposite the hinge. Notice the surface of the float curves downward. Therefore, the measurement point is the lowest on the horizontal surface. The distance should be 7/16" (11mm).

4- If the distance is not as specified, then remove the float hinge pin to free the float. The float height adjustment may be made by bending the tab on which the inlet needle hangs. Repeat Step 2 and 3 until the





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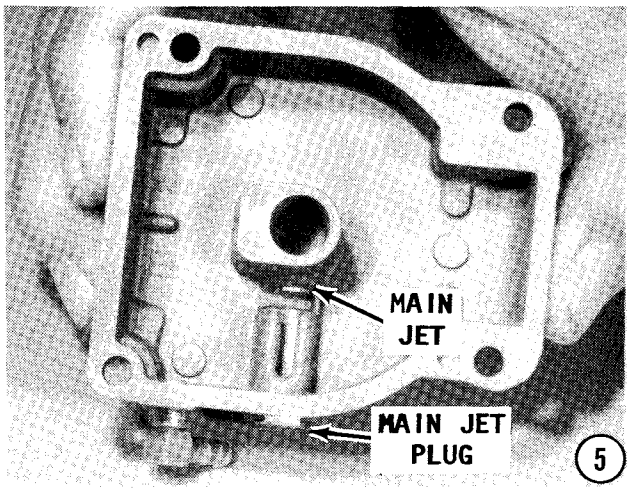
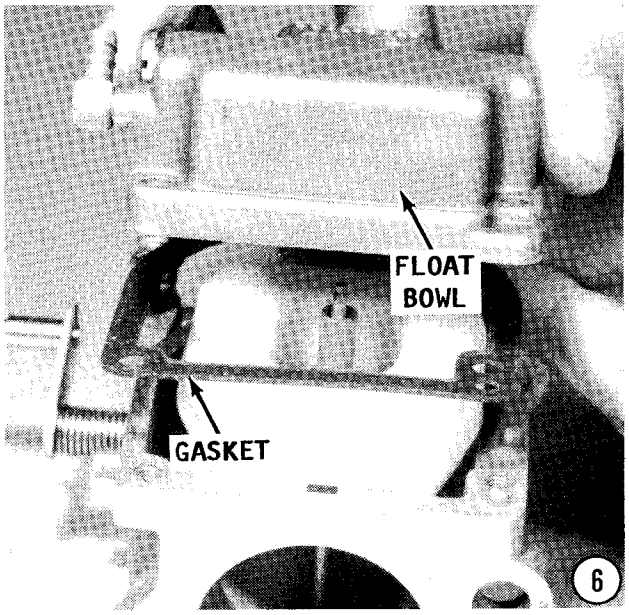
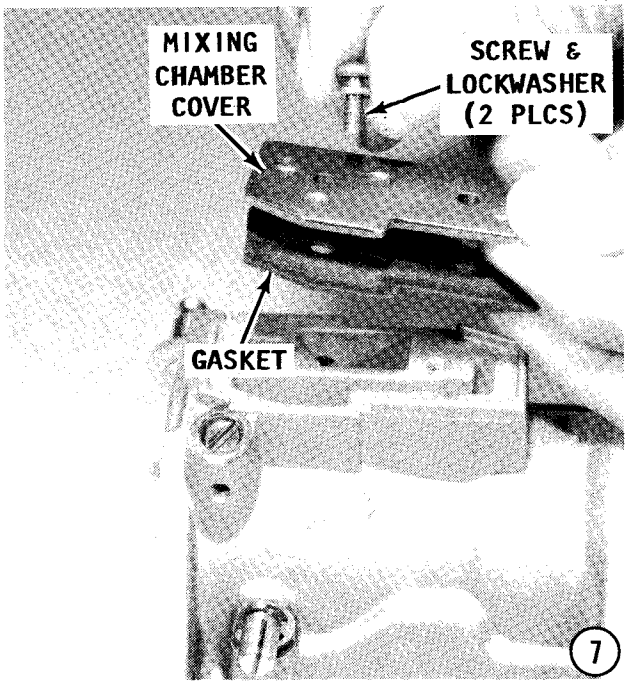






specified distance between the float bowl gasket surface and the lowest edge of the float is obtained.

5- Install the main jet into the center turret of the fuel bowl. Tighten the jet securely. Install the gasket and main jet plug in the exterior wall of the float bowl and tighten the plug securely.

6- With the carburetor still inverted, position a new gasket onto the body. Place the fuel bowl in position and secure it in place with the four Phillips head screws and captive lockwashers.

7- Position a new gasket over the mixing chamber. Install the cover and secure it in place with the attaching hardware.

8- Thread the idle mixture screw into the carburetor until the screw is **LIGHTLY** seated. From this lightly seated position, back the screw out approximately 1-1/4 turns as a preliminary adjustment at this time.

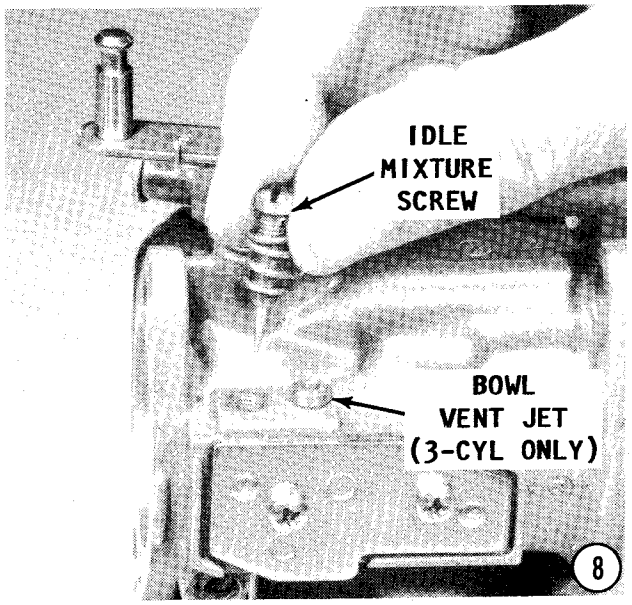
CRITICAL WORDS

The idle mixture screw on the two lower carburetors on a 4-cylinder powerhead are non-adjustable. The idle mixture screw is preset at the factory and then covered with a colored sealant. This is the manufacturer's method of communicating with everyone, **NOT** to disturb the adjustment.

If servicing a 3-cylinder powerhead, install and tighten the bowl vent jet.

INSTALLATION

9- Position **NEW** gaskets in place on the intake manifold. Install each carburetor



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onto the manifold in the same position from which it was removed. Each carburetor should have been identified as instructed during the removal procedures. Secure the carburetors in place with the retaining nuts. Tighten the nuts alternately and evenly to a torque value of 100 in lb (11.3 Nm).

10- Connect all of the fuel lines to the carburetors and tighten the clamps securely. Connect the fuel line from the fuel tank. Activate the fuel line squeeze bulb several times and check the carburetors and fuel lines for leaks. Connect the throttle linkage to and between the carburetors. Connect the battery leads to the battery.

OPERATING ADJUSTMENTS

FIRST, THESE WORDS

Before fine carburetor adjustments can be properly made, the following conditions must exist:

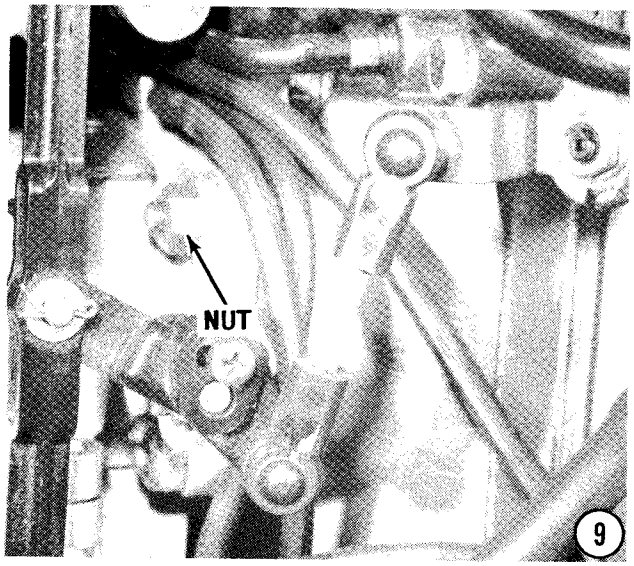
a. The correct engine-propeller combination must be used.

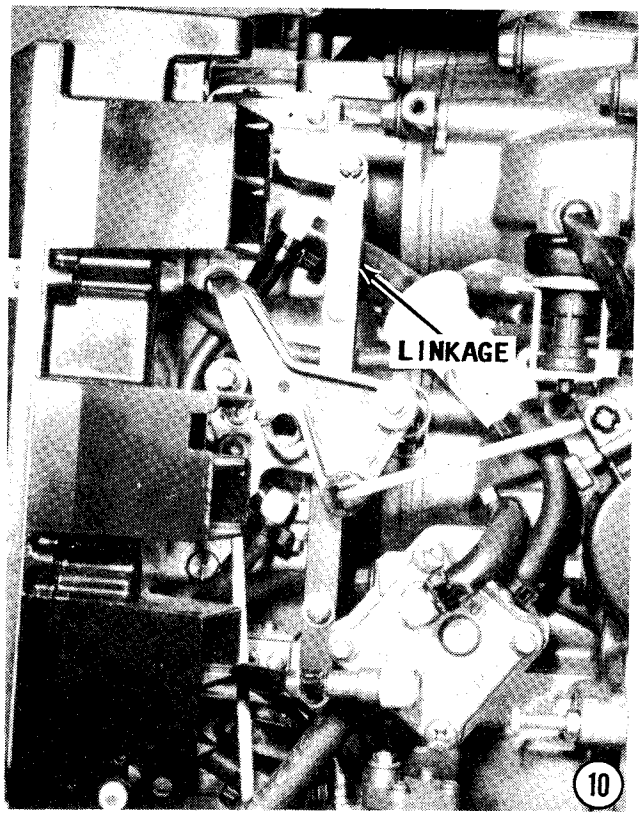
b. The power unit must be in forward gear.

c. The lower unit must be in the water.

d. The engine must be warmed to normal operating temperature.

e. The proper size fuel jet must be used for the elevation of operation. Main fuel jet size recommendations are intended as a guide only. If in doubt, try a size larger or smaller. Refer to the Carburetor Jet Size/ Elevation Chart in the Appendix. Spark advance change is **NOT** recommended for changes in elevation. In order to obtain proper engine rpm at higher elevation, a lower pitch propeller is suggested.





High-Speed Adjustment

The main fuel jet (high-speed) is changeable but not adjustable. Refer to the Carburetor Jet Size/Elevation Chart in the Appendix.

Synchronizing

To synchronize the fuel and ignition systems, including the idle mixture adjustment, see Chapter 7. Consult the Table of Contents for the powerhead being serviced.

4-11 SIDE BOWL AND BACK DRAG CARBURETOR REFERENCED "D" IN APPENDIX

This section provides complete detailed procedures for: removal, disassembly, cleaning and inspecting, assembling including bench adjustments, installation, and operating adjustments, for the side bowl and back drag carburetor, identified as Carburetor **"D"** in the Appendix. This carburetor is installed on 6- Cylinder in-line powerheads covered in this manual. To synchronize the fuel and ignition systems, see Chapter 7.

REMOVAL AND DISASSEMBLING

1- Remove the battery leads from the battery terminals. Using the quick-discon-

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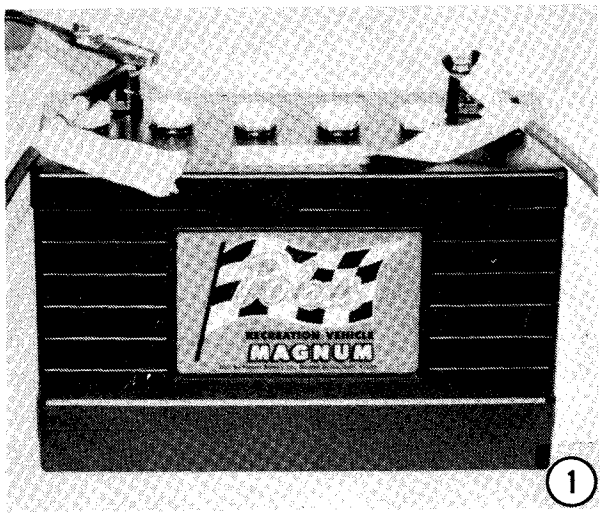
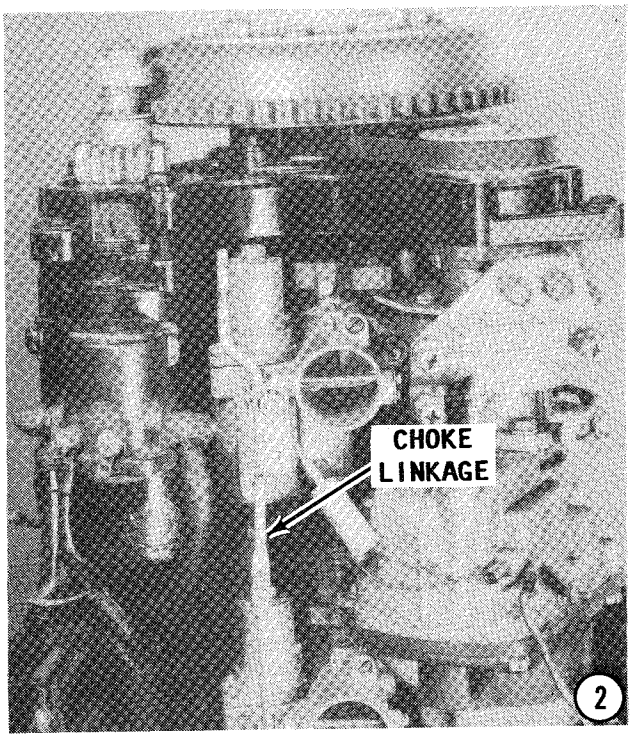
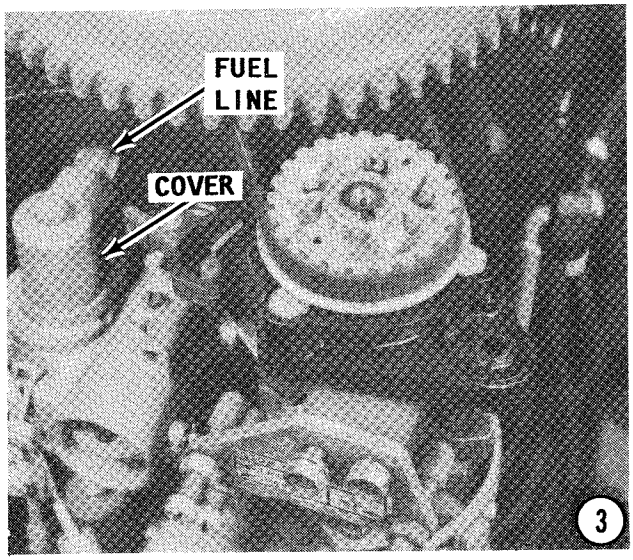
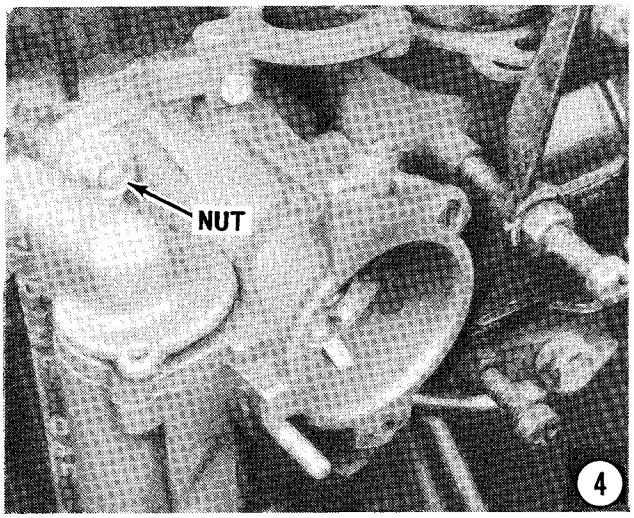








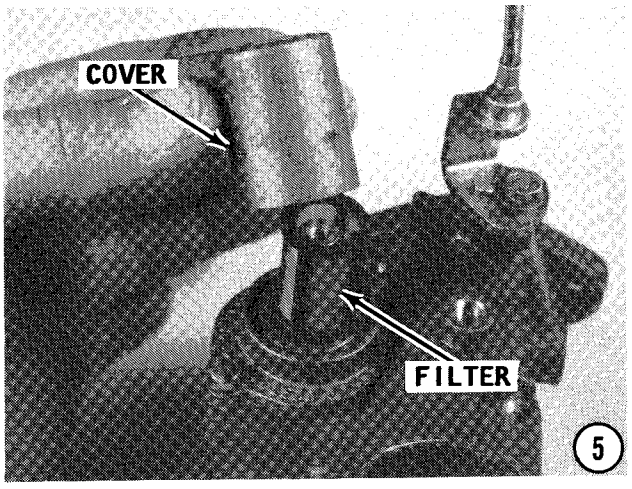
nect fitting, detach the fuel line from the engine or from the fuel tank.

2- Remove the cowl from the powerhead. Remove the choke and throttle linkage to the carburetor.

3- Remove the fuel line from the carburetors. This may be accomplished by either one of two methods. One is to remove the line from the strainer cover. The other is to remove the strainer cover bolt, and then lift the cover from the carburetor as shown in accompanying illustration.

4- Remove the nuts securing the carburetor to the crankcase. **TAKE TIME** to identify each carburetor to ensure it will be installed in its original position. Lift the carburetor from the engine and at the same time carefully disconnect the linkage.

5- Remove the 3/8" cap screw securing the strainer cover to the carburetor, if it was not removed during carburetor removal. **OBSERVE** the gasket under the screw as it is removed. Keep them together to ensure the gasket is installed during assembling. Remove the strainer cover, and then the gas-



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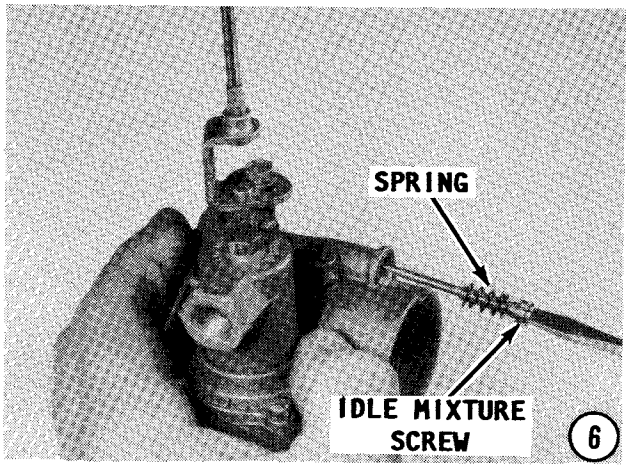


ket inside the strainer cover. Remove the gas fuel line fitting and the base gasket. Remove the fuel strainer.

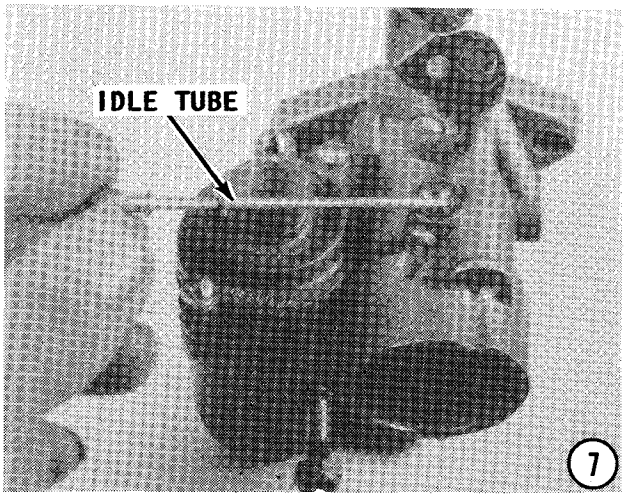
6- Remove the idle screw and spring from the carburetor.

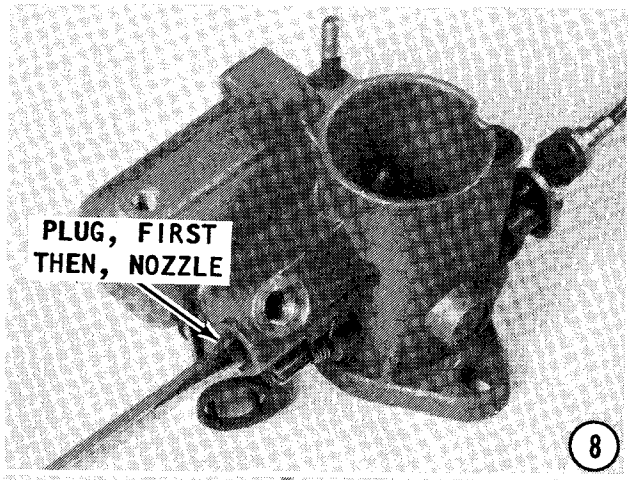
7- Carefully remove the idle tube from the top of the carburetor. This tube extends down inside the main discharge nozzle. A new tube gasket should **ALWAYS** be used. Therefore, **DISCARD** the old gasket.

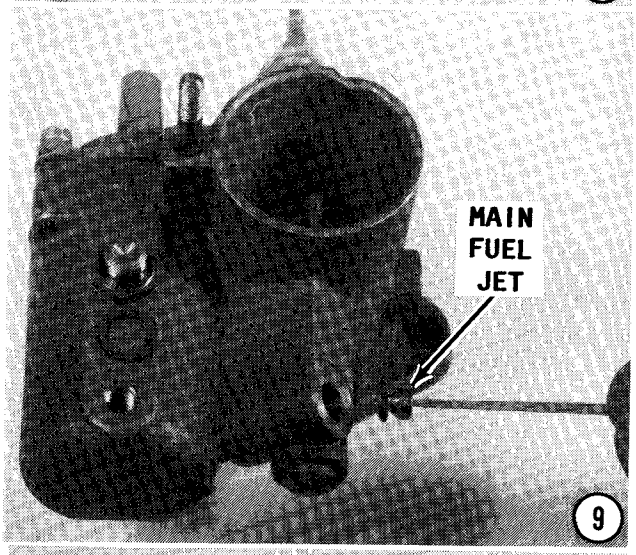
8- Remove the discharge screw plug from the bottom side of the carburetor. Use the **PROPER** size screwdriver and remove the main discharge nozzle.

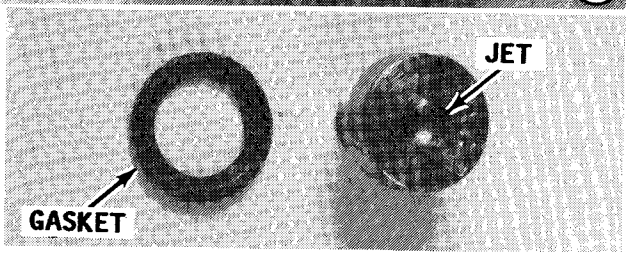
9- Remove the 7/16" brass hex head plug and gasket from the front of the carburetor and the other plug from the bottom. Do not remove the tube unless absolutely necessary. Only check to make sure it is tight. Use the **PROPER** size screwdriver and remove the main fuel jet and gasket.

10- Remove the float assembly by removing the two screws from the top of the carburetor. Lift the float assembly from the carburetor body, and then remove the gasket.

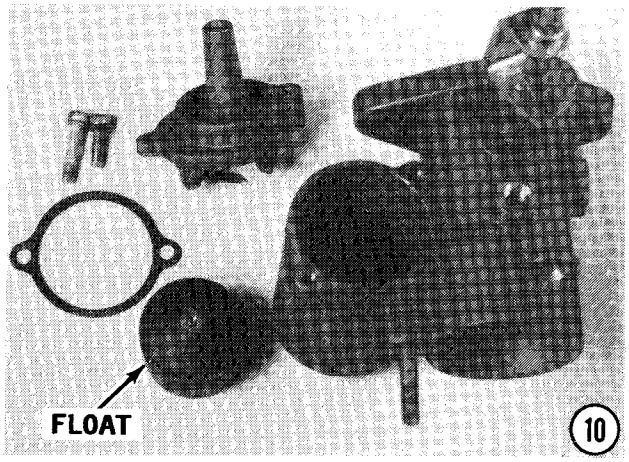








The main (high-speed) jet is not adjustable, but it is available in varying sizes. The jet may be replaced if the engine is to be operated at different elevations.



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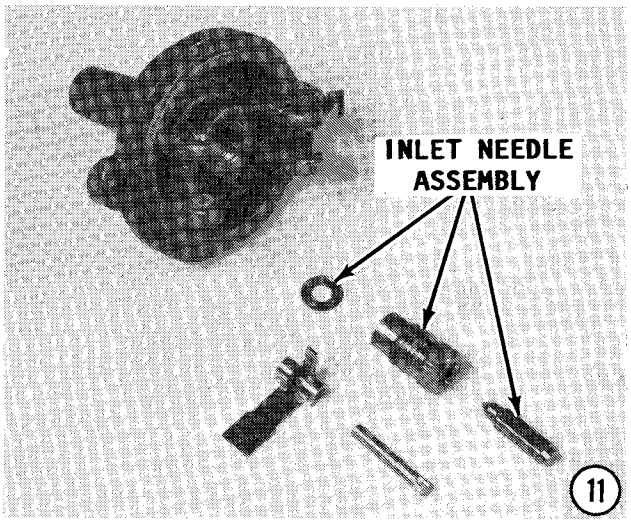
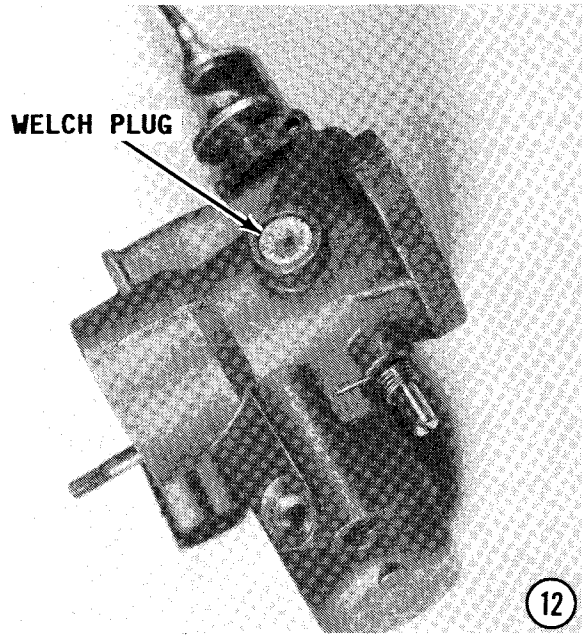
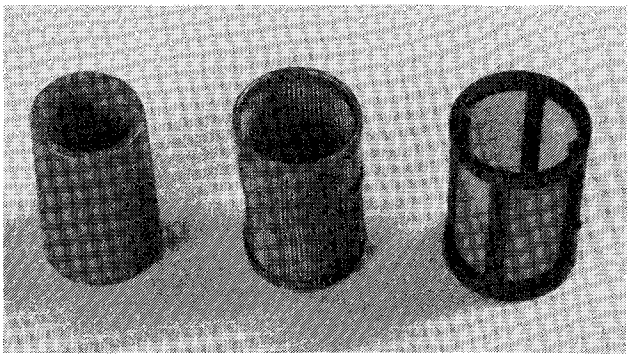


A fuel bowl vent jet is located on the exterior of the cover. This jet is not normally distrubed during carburetor overhaul. However, this jet together with the main jet must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct main jet and vent sizes for various elevations.

11- Turn the float cover upside down and notice the assembly has two levers. Remove the top lever pin and hinge back the other lever. Now, remove the inlet needle from the needle seat. Use the proper size socket and remove the needle seat. This seat has a standard right-hand thread. Reach into the body with a small punch and gently remove the gasket.

12- To remove the Welch plug on the side of the carburetor, use a sharp punch to puncture the center of the plug, and then pry out the plug A new Welch plug is **ONLY** available in a carburetor overhaul kit. The Welch plug covers the idle by-pass chamber.





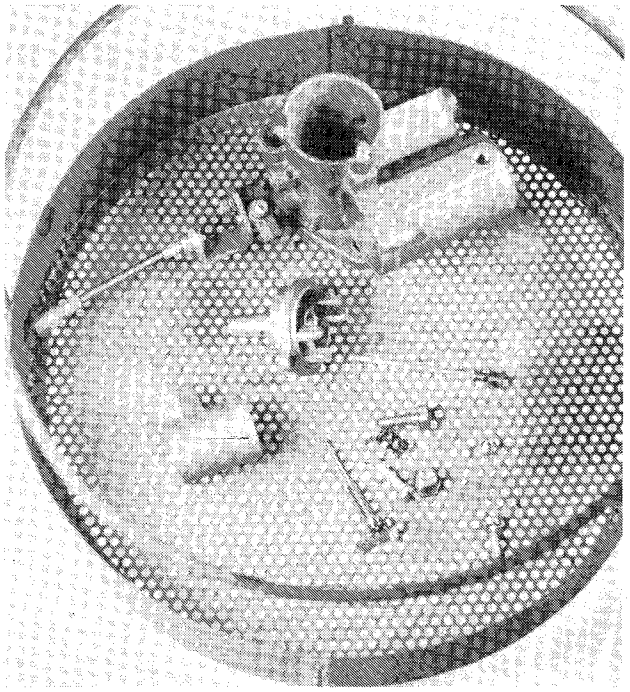
*Fuel strainers used with the side bowl Carburetor **"D"**. The two on the left are obsolete and should be replaced with the new type on the far right.*

A GOOD WORD: Further disassembly of the carburetor is not necessary.

CLEANING AND INSPECTING

NEVER dip rubber parts, plastic parts, diaphragms, or pump plungers in carburetor cleaner. These parts should be cleaned **ONLY** in solvent, and then blown dry with compressed air.

Place all metal parts in a screen-type tray and dip them in carburetor cleaner



*All rubber and plastic parts **MUST** be removed before carburetor parts are placed in a basket to be submerged in carburetor cleaner.*

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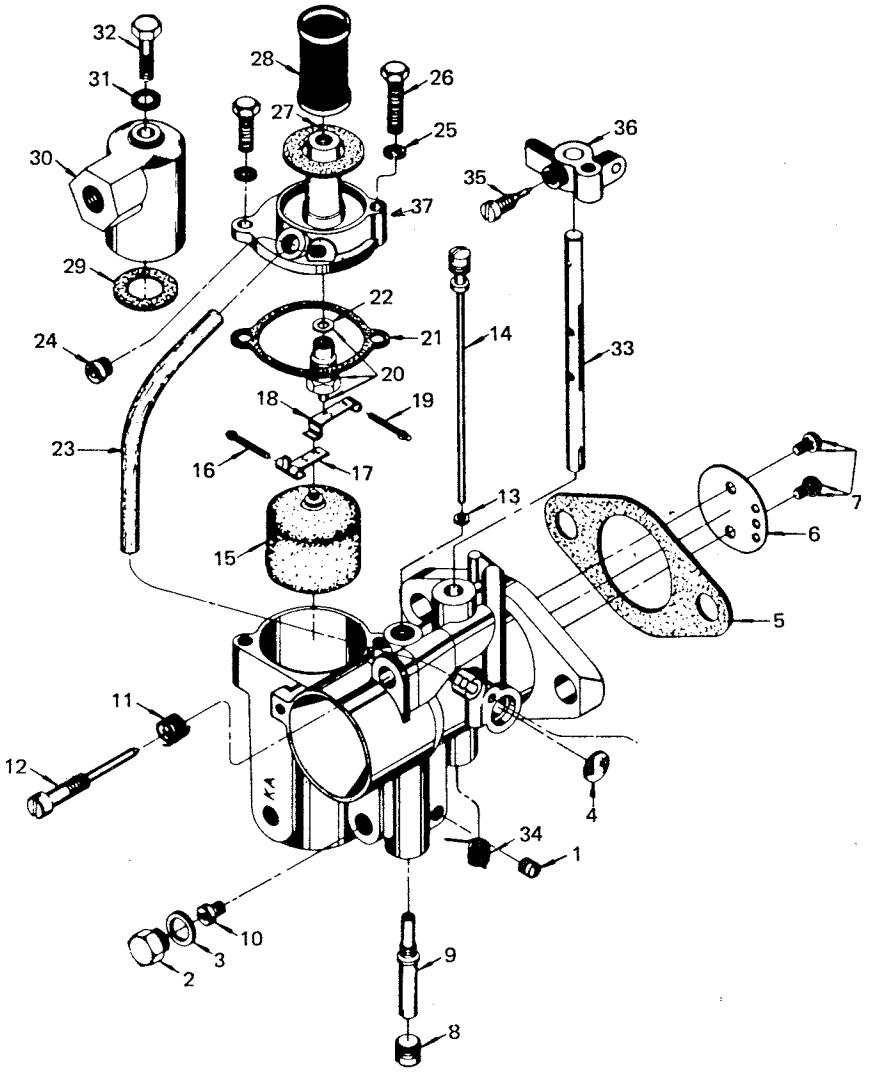

1-	PLUG				
2-	MAIN FUEL JET PLUG	14-	IDLE TUBE	26-	FLOAT COVER BOLT
3-	GASKET	15-	FLOAT	27-	GASKET
4-	WELCH PLUG	16-	LOWER FLOAT LEVER PIN	28-	FILTER SCREEN
5-	GASKET	17-	LOWER FLOAT LEVER	29-	GASKET
6-	THROTTLE SHUTTER	18-	UPPER FLOAT LEVER	30-	FUEL INLET COVER
7-	THROTTLE SHUTTER SCREW	19-	UPPER FLOAT LEVER PIN	31-	GASKET
8-	PLUG	20-	INLET NEEDLE & SEAT	32-	INLET COVER SCREW
9-	MAIN FUEL NOZZLE	21-	GASKET	33-	THROTTLE SHAFT
10-	MAIN FUEL JET	22-	GASKET	34-	SPRING
11-	SPRING	23-	BACK DRAG TUBE	35-	THROTTLE STOP LEVER
12-	IDLE MIXTURE SCREW	24-	BACK DRAG AIR JET	36-	THROTTLE STOP LEVER
13-	GASKET	25-	LOCKWASHER	37-	FLOAT BOWL COVER

Exploded view of the side bowl "back drag" carburetor, identified as Carburetor "D" in the text and appendix. This carburetor has an additional circuit which lowers the atmospheric pressure in the float bowl to increase fuel economy at certain midrange rpm. Major parts are identified.

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until they appear completely clean, then blow them dry with compressed air.

Blow out all passages in the castings with compressed air. Check all parts and passages to be sure they are not clogged or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Move the throttle shaft back-and-forth to check for wear. If the shaft appears to be too loose, replace the complete throttle body because individual replacement parts are **NOT** available.

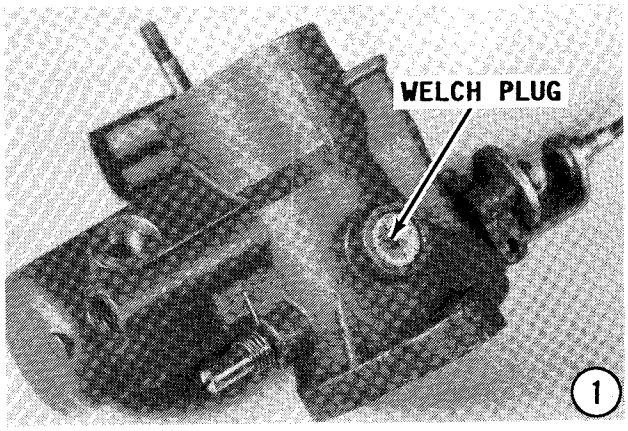
Inspect the main body, airhorn, and venturi cluster gasket surfaces for cracks and burrs which might cause a leak. If a hollow float is used, check to be sure it does not contain any fluid. Check the float for deterioration. Check to be sure the float spring has not been stretched. If any part of the float is damaged, the unit must be replaced. Check the float arm needle contacting surface and replace the float if this surface has a groove worn in it.

Inspect the tapered section of the idle adjusting needles and replace any that have developed a groove.

Most of the parts that should be replaced during a carburetor overhaul are included in overhaul kits available from your local marine dealer. One of these kits will contain a matched fuel inlet needle and seat. This combination should be replaced each time the carburetor is disassembled as a precaution against leakage.

ASSEMBLING AND INSTALLATION

1- If the Welch plug was removed, insert a new plug in position, and then tap it into place. Seal the outside edge of the plug with Gasketcinch, or equivalent.



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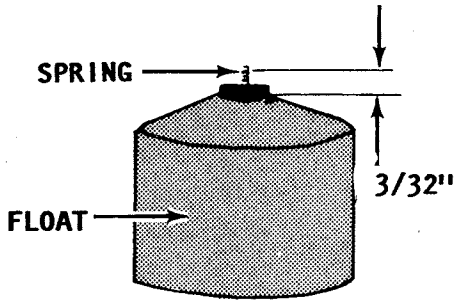

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2- Check the spring on the top of the float. If it does not extend out 3/32" (2.40 mm) the float **MUST** be replaced. Install the float onto the float pin, and then slide the float into the carburetor body.

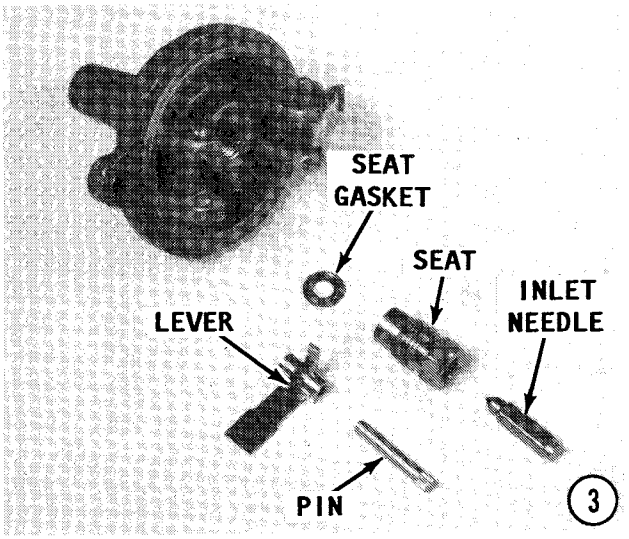
3- Insert a new needle seat gasket into place. Thread the inlet seat into the body and tighten the seat with the proper size socket to a torque value of 60 in.-lbs (6.78Nm). Discharge a drop of oil into the center of the seat, and then insert the inlet needle into the seat. Bend over the lever which was not removed on top of the inlet needle. Install the other lever on top of the lever in place, and then install the hinge pin.

Float Level Adjustment

4- Turn the float bowl cover upside down. Measure the distance from the face of the shoulder to the secondary lever. This measurement should be 13/32" $\pm$ 1/64" (10.32mm $\pm$ 0.40mm). **CAREFULLY** bend the primary lever as required to obtain the correct measurement.

Float Drop Adjustment

5- Turn the float bowl cover upright. Check to be sure the needle moves freely on



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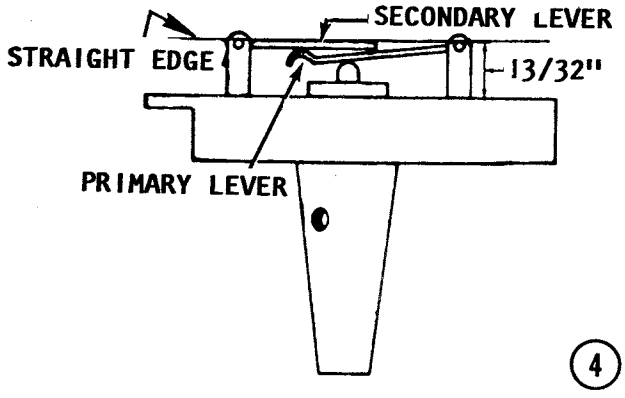

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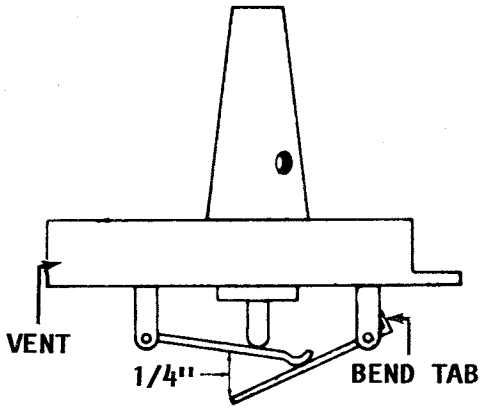

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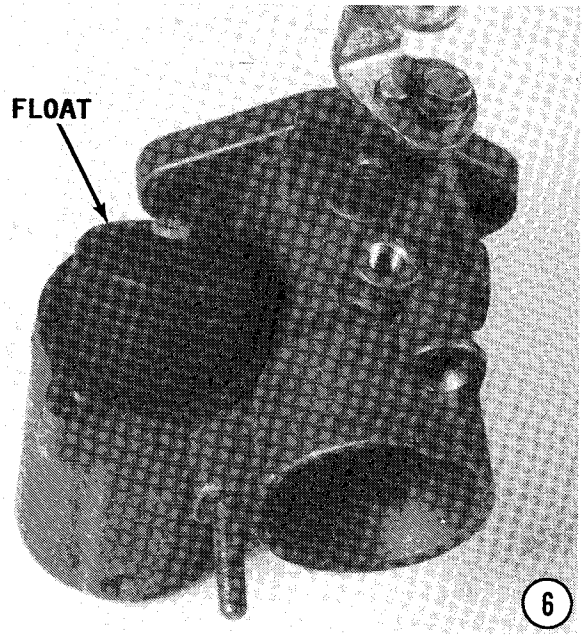
the actuating primary lever and that it is not sticking in the seat. Hold the bowl cover upright and measure the distance between the primary and secondary levers. This distance should be 1/4" (6.35mm). **CAREFULLY** bend the secondary lever stop tang to obtain the proper measurement.

6- Place a **NEW** gasket onto the float bowl. Then place the float into the float



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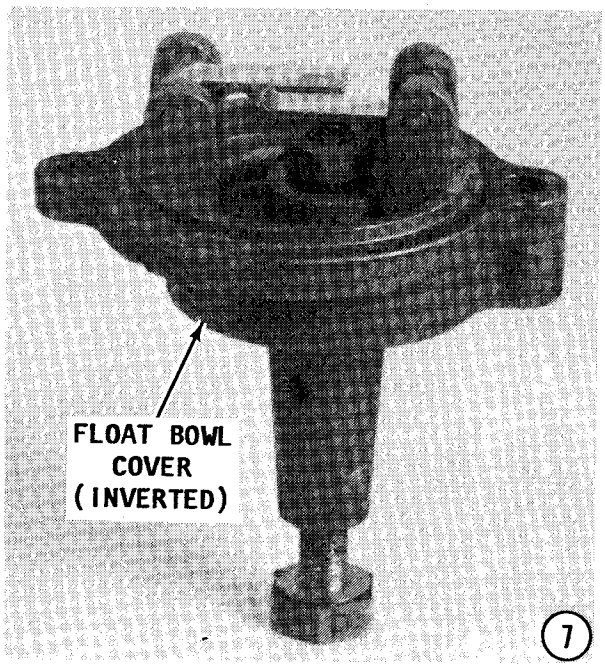
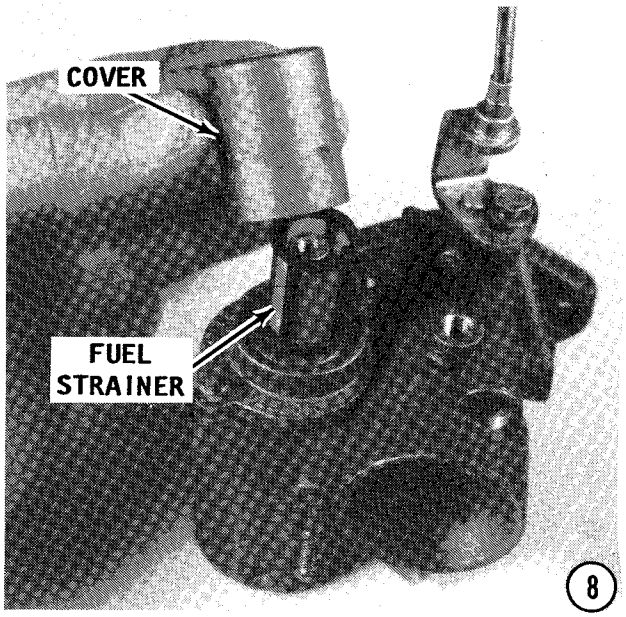


7

chamber. The vent hole in the cover **MUST** be installed toward the carburetor mounting flange. Invert the carburetor and check the float for free movement.

7- Place the float bowl cover over the float. Install the two screws and lockwashers, and tighten them alternately.

8- Position the large gasket over the tower of the float bowl cover. Install the fuel strainer. Insert a **NEW** gasket inside the strainer cover. Place the strainer cover over the float bowl cover. **ONE WORD:** If the strainer cover was left attached to the fuel line during disassembly, and is therefore, still on the engine, then bypass the next instruction. The cover will be installed



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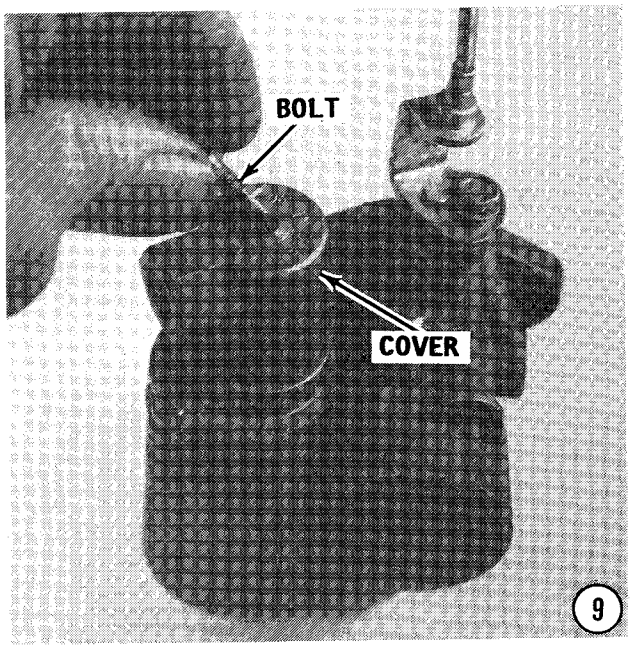
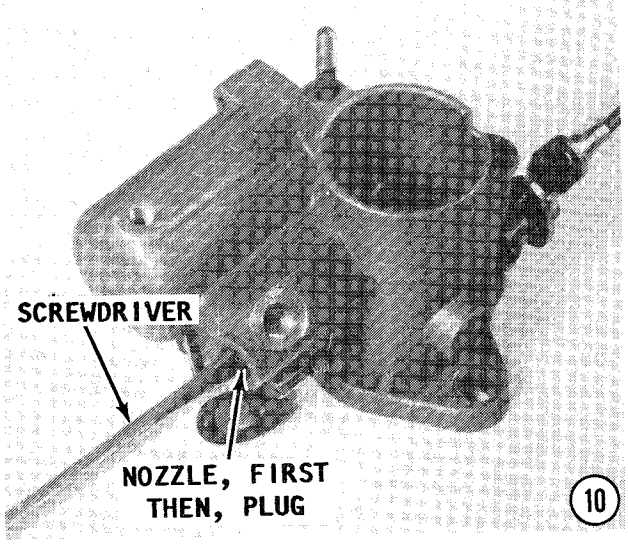
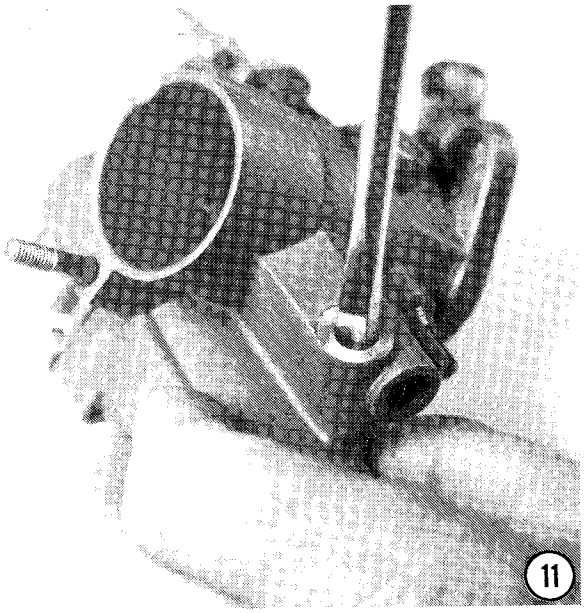
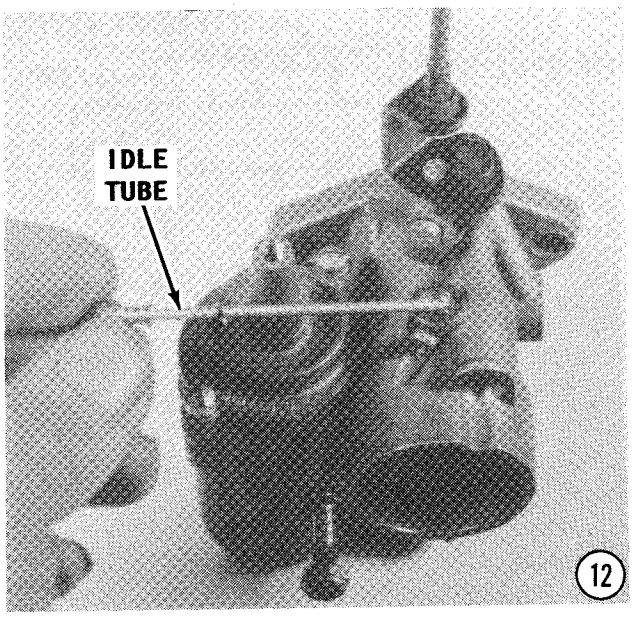








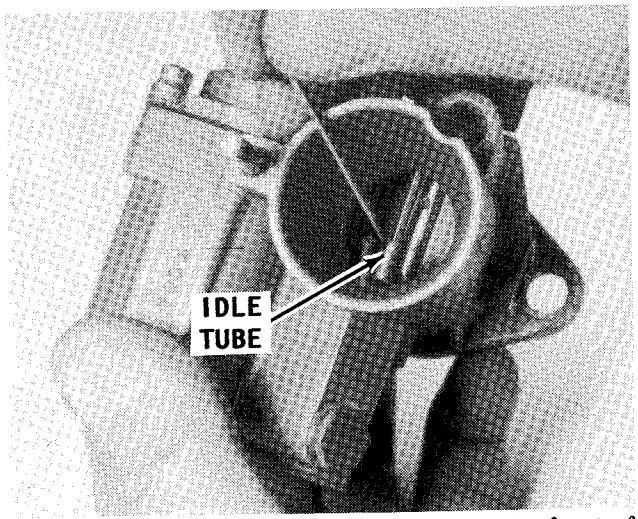
in Step 14. **BE SURE** the strainer cover is setting squarely on the float bowl cover, because if it is not positioned properly, the tower assembly on the float bowl cover will be broken when the strainer bolt is tightened.

9- Slide a **NEW** gasket onto the strainer bolt, and then install the bolt into the float bowl cover.

10- Thread the main nozzle into the bottom of the carburetor, and then tighten it securely using the **PROPER** size screwdriver. Install the nozzle plug.

GOOD WORD

Main fuel (high-speed) jet size recommendations are intended as a guide. If any change in size is to be made, check the Jet Size/Elevation Chart in the Appendix.



*The idle restriction tube **MUST** contact the front of the venturi tube.*

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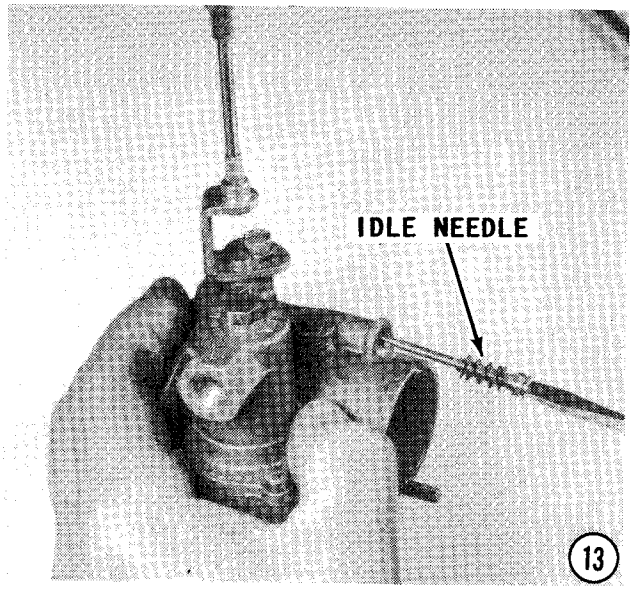
11- Slide a **NEW** gasket onto the main fuel jet. (On some models, this gasket is not used.) Use the **PROPER** size screwdriver and install the jet into the carburetor body. Position a **NEW** gasket onto the 7/16" brass plug, and then install the plug into the carburetor body.

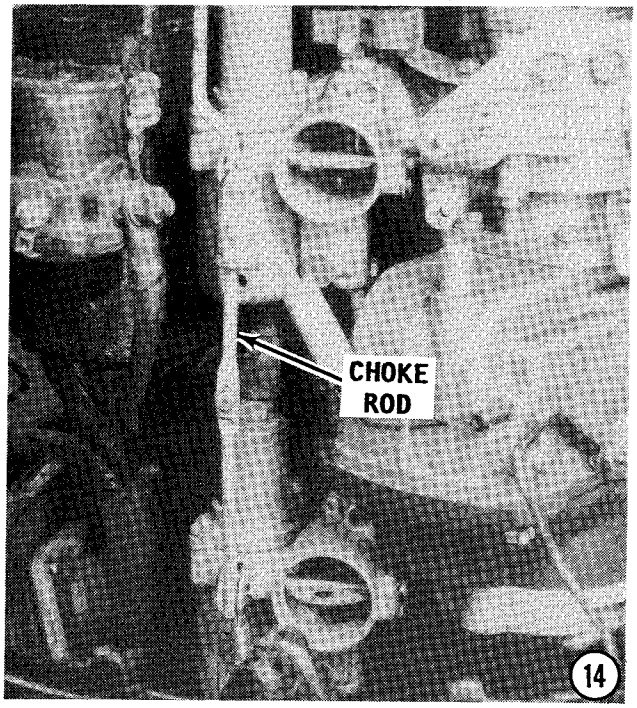
12- Slide a **NEW** gasket onto the idle tube. (On some models, this gasket is not used.) Thread the tube into the top of the carburetor and tighten it securely. When properly installed, the idle tube **MUST** touch the front of the venturi tube.

13- Position the spring over the idle adjusting screw, and then **SLOWLY** thread it into the carburetor body, until you can feel it seat. **DO NOT** tighten the screw or you will damage the tip. Now, as a preliminary adjustment, back the screw out 1 to 1½ full turns. Check the throttle shutters to be sure they do not bend in the carburetor venturi.

Installation

14- Install **NEW** carburetor flange gaskets. Attach the carburetor assembly to the crankcase. Tighten the attaching hardware alternately to the torque value given in the Appendix. Connect the fuel lines to the strainer cover of the carburetors. If the strainer cover was not installed in Step 8, then place the cover over the tower assembly of the carburetor. **BE SURE** the strainer cover is setting squarely on the float bowl cover, because if it is not positioned properly, the tower assembly on the float bowl cover will be broken when the strainer bolt is tightened.

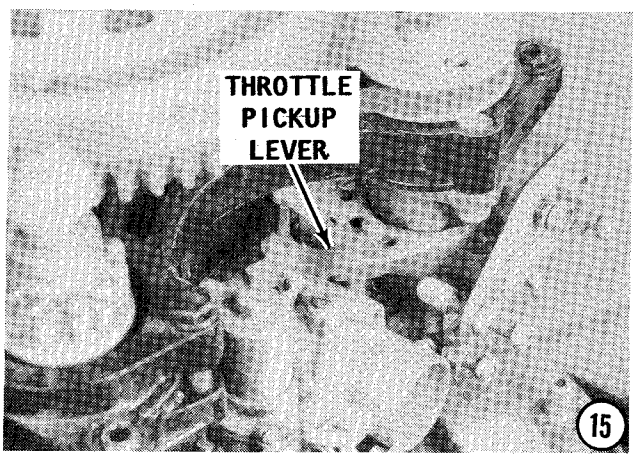




Replace the choke valves and springs by screwing in the choke lever pivot pins. Install the choke levers and the choke lever rod on the choke lever pivot pins. Insert the cotter pins to secure the rod to the lever pivot. **BE SURE** to insert the choke lever pins into the choke springs and the slot in the choke valve while installing it on the pivot pin. Connect the choke rod, positioning the spring on the choke rod pin. Secure the rod to the carburetor adjustment screw.

15- Install the throttle pickup bracket and the throttle pickup lever with the mounting screw on the lower carburetor, sliding the throttle pickup lever into the throttle valve shaft slot of the top carburetor. Check to be sure the cam on the carburetor is in front of the cam on the magneto plate.

Connect the throttle and choke linkage.



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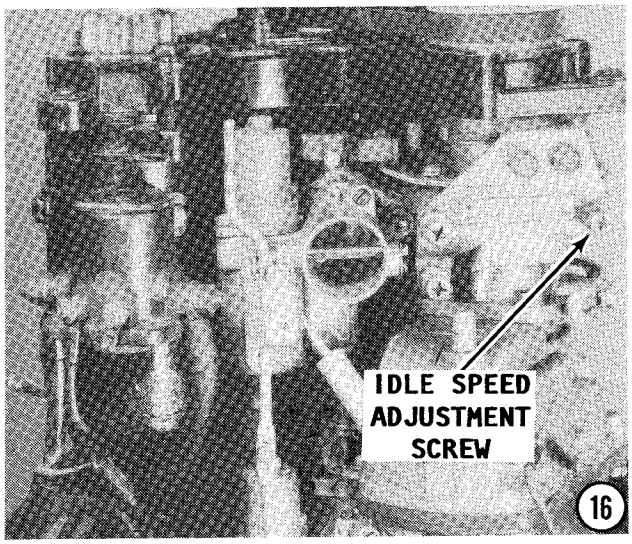


Synchronizing

To synchronize the fuel and ignition systems, see Chapter 7.

ADJUSTMENTS

FIRST A WORD: Before fine carburetor adjustments can be properly made, the following conditions must exist:

a. The correct engine-propeller combination must be used.

b. The power unit must be in forward gear.

c. The lower unit must be in the water.

d. The engine must be warmed to normal operating temperature.

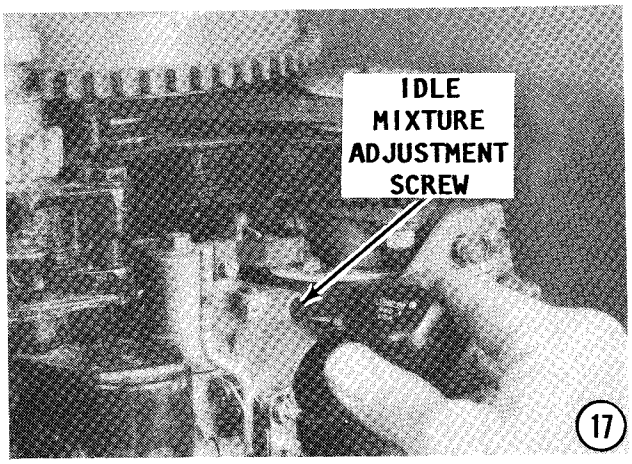
Idle-Speed Adjustment

16- After the engine has been warmed to operating temperature, turn the idle speed adjusting screw on the stop bracket until the engine idles at approximately 650 rpm in forward gear.

Idle Mixture Adjustment

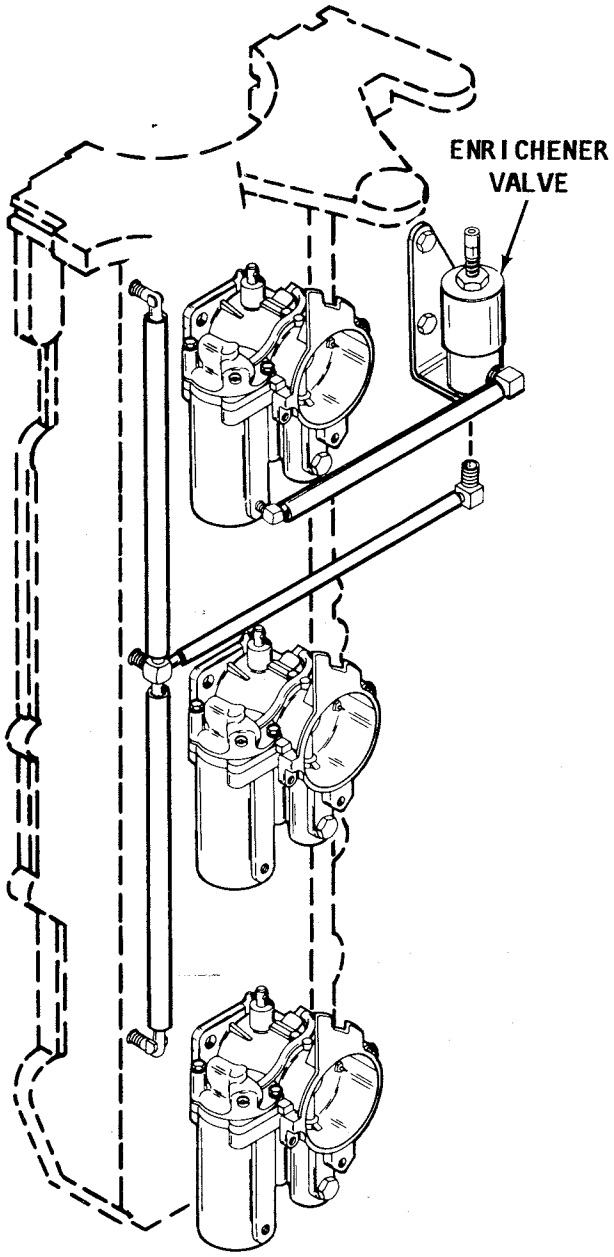
17- Turn the adjusting screw **CLOCKWISE** until the engine fires evenly and rpm begin to increase. Continue turning the adjusting screw until the mixture is so lean that the rpm begins to drop and the engine begins to misfire. Set the adjusting screw halfway between the rich and lean points.

ADVICE: It is better to have the mixture set slightly on the rich side, rather than too lean.



High-Speed Adjustment

The main (high-speed) fuel jet is not adjustable. If the engine is to be operated at elevations above 2500 ft., replace the main metering jet as indicated in the Jet Size/Elevation Chart in the Appendix.



Line drawing to illustrate the enrichener hose routing on all L6 powerheads covered in this manual.

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4-12 DUAL FLOAT CENTER BOWL CARBURETOR — V6 POWERHEADS REFERENCED "E" IN APPENDIX

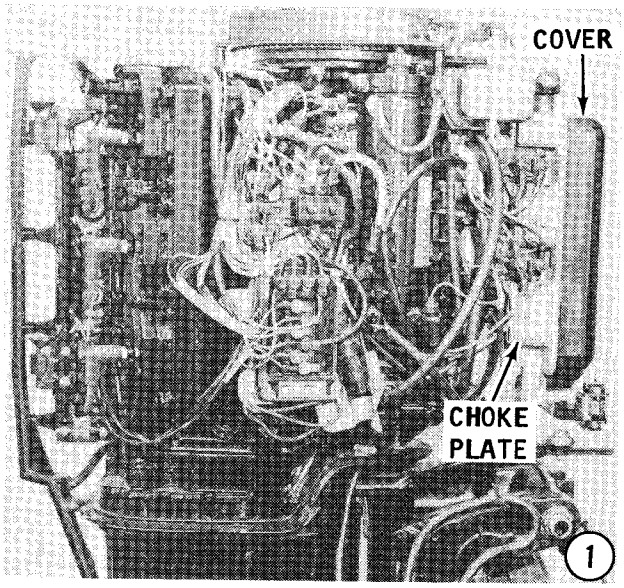
This section provides complete detailed procedures for: removal, disassembly, cleaning and inspecting, assembling including bench adjustments, installation, and operating adjustments, for the dual float center bowl carburetor used only on V6 powerheads, referenced **"E"** in the Appendix. To synchronize the fuel and ignition systems, see Chapter 7.

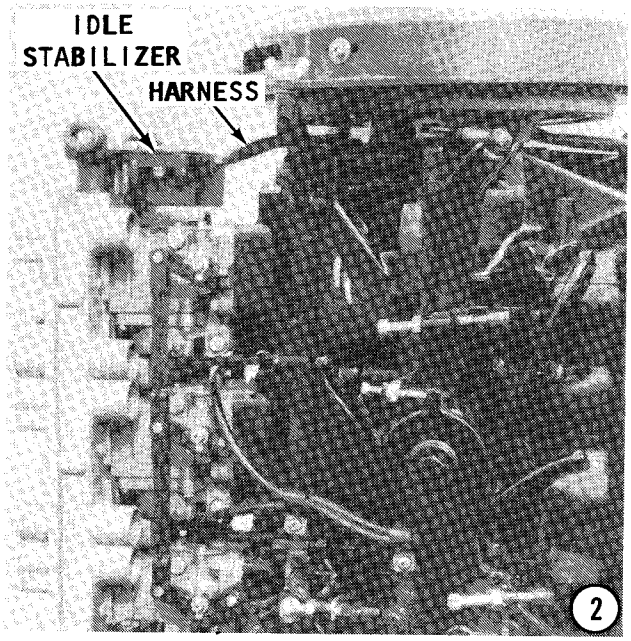
As the name implies, this carburetor has a double throat, double bowl, and double float system incorporated into a single body. By using three of these carburetors on a V6 powerhead, each cylinder is serviced by an individual carburetor throat, and associated mechanism. Each throat and mechanism functions independently from the other. **REMEMBER** this fact when troubleshooting the fuel system. The ignition system also has a separate unit for each cylinder.

Because the carburetors are identical, all of the procedures in this section may be repeated for each carburetor.

REMOVAL AND DISASSEMBLING

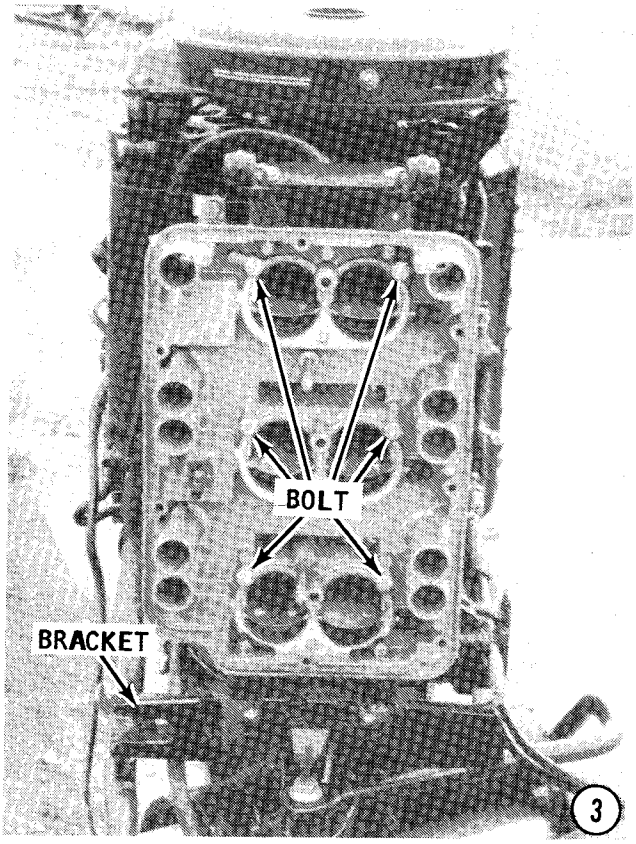
1- Remove the battery leads from the battery terminals. Disconnect the fuel line at the fuel tank or at the powerhead. Remove the choke knob and wing nuts with washers from the engine cover. Carefully lift off the engine cover from the choke plate and engine.





2- Trace the electrical harness from the idle stabilizer, mounted on top of the choke plate, to the powerhead switch box. This harness will contain three multicolored wires: a White/Black, a Red/White, and a Black wire. Make a note of the terminals these wires are connected to at the switch box, and then disconnect all three.

3- Remove the electrical cable, fuel line, and drain hose, from the bracket on the



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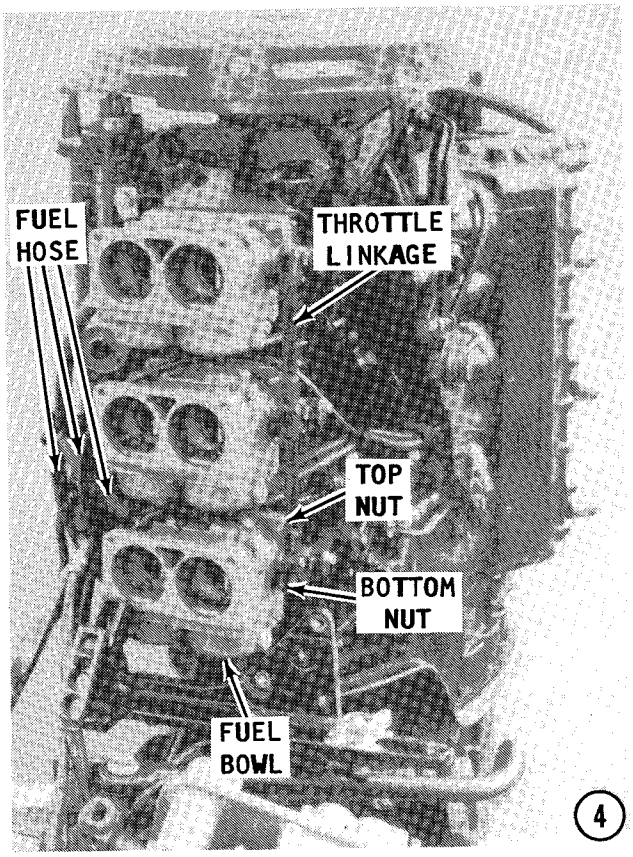
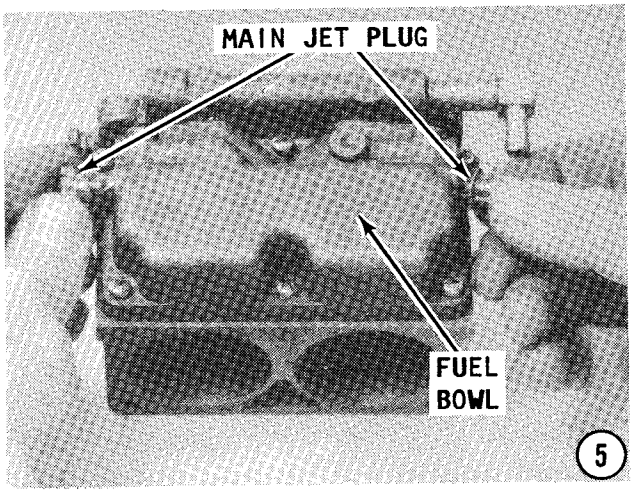


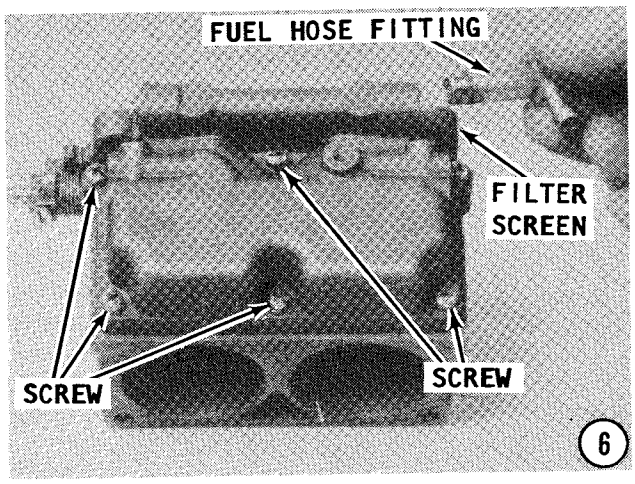
bottom of the choke plate. Remove the six bolts securing the choke plate to the carburetors, and then remove the choke plate. Observe how the choke solenoid plunger will pull out of the choke solenoid.

4- Disconnect the control linkage from all three carburetors by first pulling the cotter pins, and then removing the washers. Remove the hose clamps from all fuel and enricher hoses. Remove the hoses.

GOOD WORDS

Each carburetor **MUST** be installed back into the exact location from which it was





removed. The jets on the port and starboard side may differ on an idividual carburetor **AND** the jets differ from one carburetor to another, top, center, and bottom. Therefore, **TAKE TIME** to make an identification mark on each carburetor before removing it from the powerhead. **DO NOT** make a mark on the mating surface to the choke plate. A preferred location is on the float bowl.

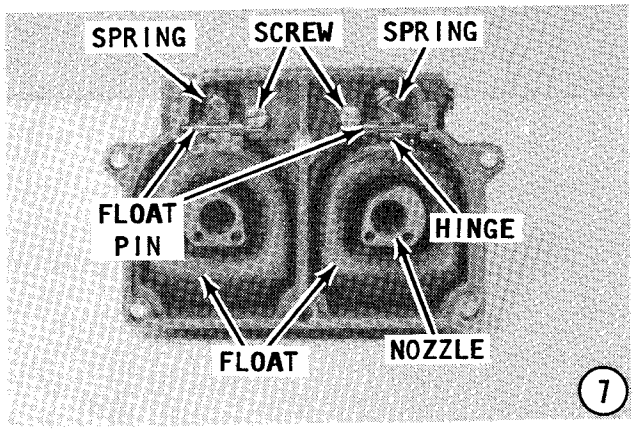
Remove the four attaching nuts securing each carburetor to the intake manifold, and then remove the carburetor.

Float Bowl

5- Remove the two main jet plugs and gaskets, one on each side in the bottom of the carburetor bowl. After the plugs have been removed, observe how the high speed jet inside each plug. The jets may be removed from the plugs using the **PROPER** size screwdriver.

Main jet sizes must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct main jet sizes for various elevations.

6- Remove the fuel inlet hose fitting.



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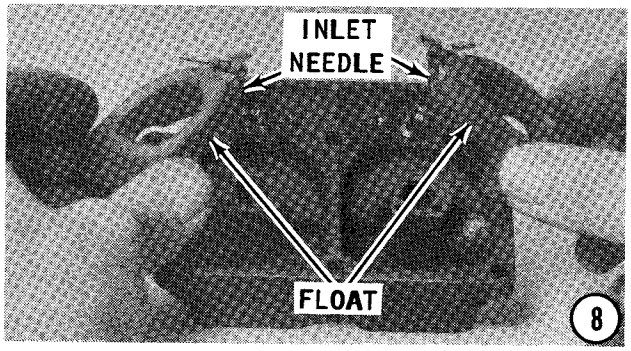


Check the filter screen inside the hole. Remove the screen. The factory does not recommend using a filter in the carburetor.

Turn the carburetor upside down and remove the six screws securing the bowl to the carburetor body. Lift the bowl from the body, and then remove and discard the bowl gasket and the two nozzle gaskets.

7- Remove the two screws holding the float pins to the fuel bowl.

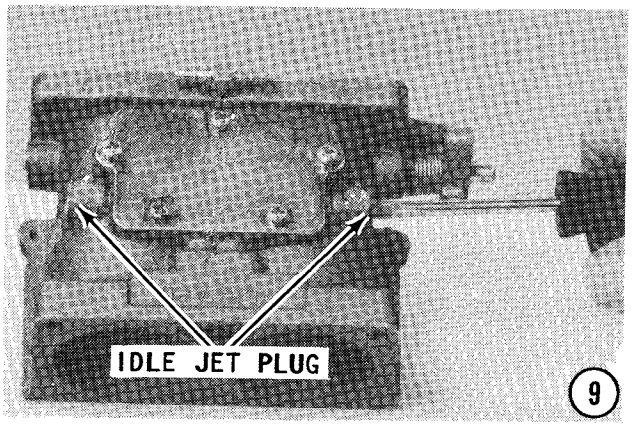
8- Lift out both floats, pins, and inlet needles. Remove both inlet needle seats and the gasket under each seat from the fuel bowl.

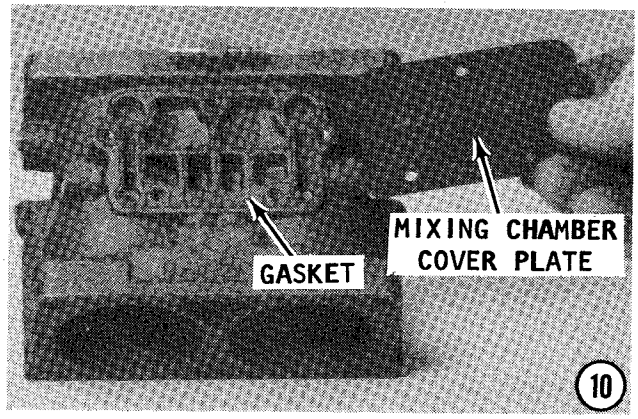
Body Disassembling

9- Remove the two idle jet plugs and gaskets. A plug is located on each side of the body near the top edge. Using the **PROPER** size screwdriver, remove the jets from the plugs. **TAKE TIME** to set the jets and other small parts aside, and in order, to ensure they will be installed back in the proper sequence and location.

SPECIAL WORDS

The two idle jets are not normally disturbed during a carburetor overhaul. However, the idle jets together with the main jets and the fuel bowl vent jets, must be changed when operating the powerhead at elevations higher than 2,500 feet above sea level. Consult the table in the Appendix for the correct main jet and vent sizes for various elevations.





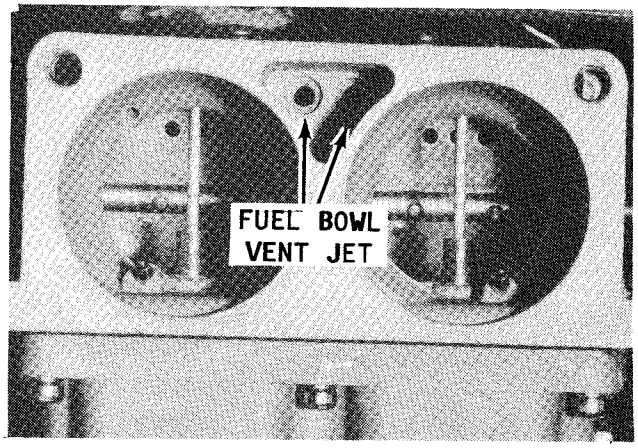
10- Remove the five screws securing the cover plate to the mixing chamber. Lift off the cover plate and the gasket.

VERY GOOD WORDS

Further disassembly of the carburetor is not necessary in order to clean it properly. Normally it is not necessary to service the fuel bowl vent jets. However, if the jets are removed, they **MUST** be kept in order and installed back into the correct carburetor. **REMEMBER,** the jets sizes differ between top, center, and bottom carburetors. See the table in the Appendix.

CLEANING AND INSPECTING

NEVER dip rubber parts, plastic parts, diaphragms, or pump plungers in carburetor cleaner. These parts should be cleaned **ONLY** in solvent, and then blown dry with compressed air.



Location of the fuel bowl vent jets. Changing to a jet with smaller orifice will result in a leaner air/fuel mixture at midrange. A larger orifice will result in a richer mixture at midrange.

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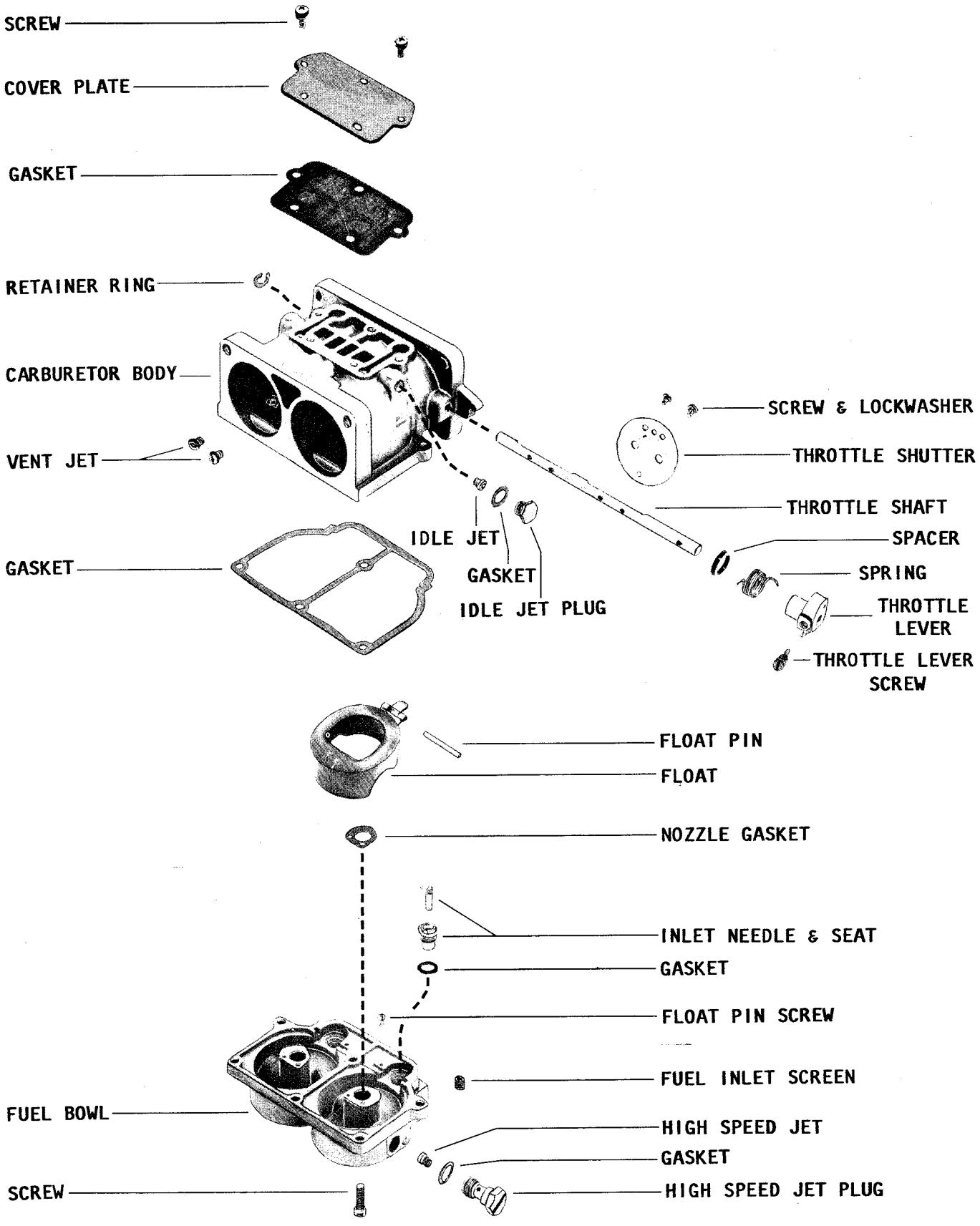

Exploded drawing of Carburetor "E", with major parts identified.

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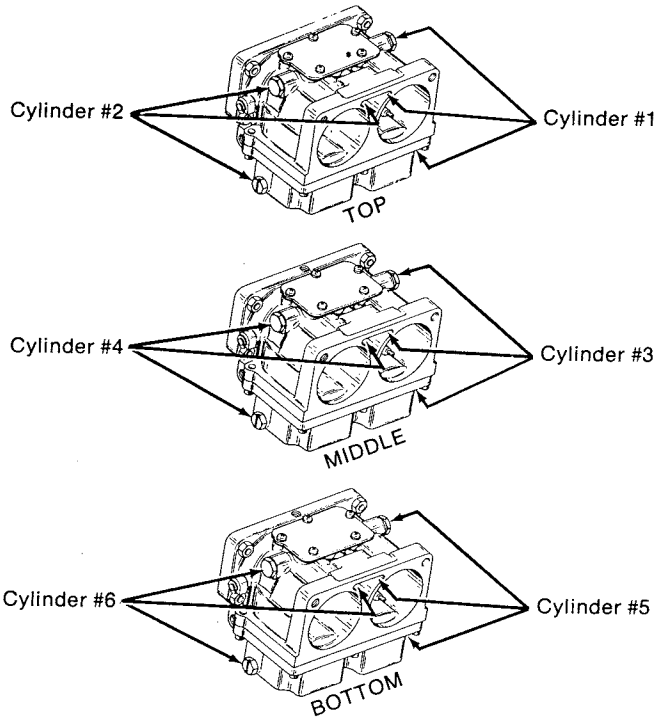
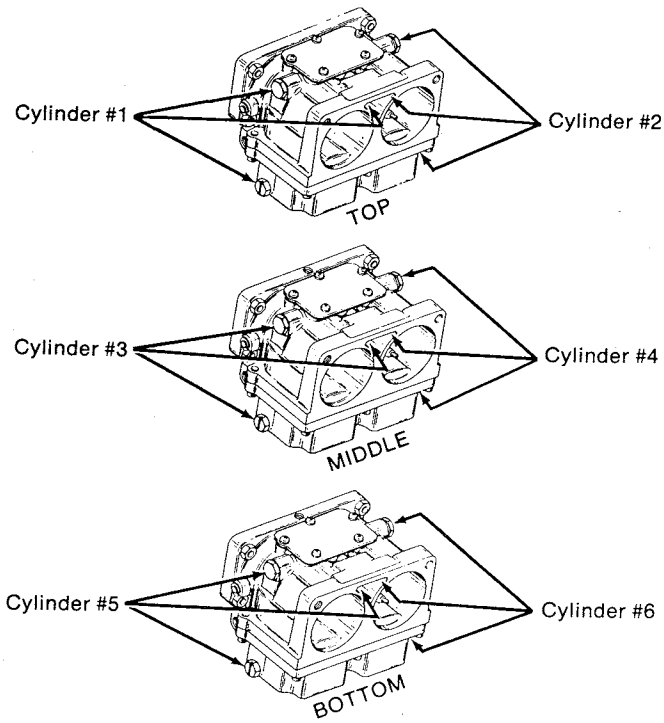


Jet locations for each cylinder for all Model 135hp, 150hp, and 175hp powerheads and Model 200hp S/N 6055032 and below.



Jet locations for each cylinder for all Model 200hp S/N 6055033 and above.

Place all metal parts in a screen-type tray and dip them in carburetor cleaner until they appear completely clean, then blow them dry with compressed air.

Blow out all of the passages in the castings with compressed air. Check all parts and passages to be sure they are not clogged or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Move the throttle shaft back and forth to check for wear. If the shaft appears to be too loose, replace the complete throttle body because individual replacement parts are **NOT** available.

Examine the throttle shutter plates for damage.

Inspect the main body, airhorn, and venturi cluster gasket surfaces for cracks and burrs which might cause a leak. Check the float for deterioration. Check to be sure the float springs have not been stretched. If any part of the float is damaged, the unit must be replaced. Check the float tab to inlet needle contacting surface and replace the float if a groove has been worn in this surface.

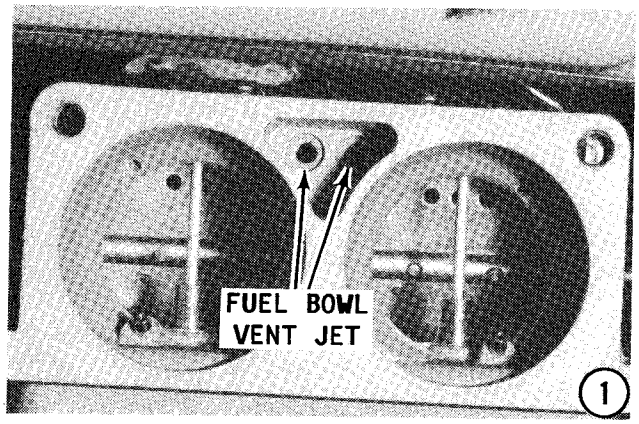
Most of the parts, requiring replacement during a carburetor overhaul, are included in an overhaul kit available from your local marine dealer. This kit will also contain a matched fuel inlet needle and seat. This combination should be replaced each time the carburetor is disassembled as a precaution against leakage.

Refer to the Carburetor Jet Size/Elevation Chart in the Appendix for the proper size for your engine, carburetor, and anticipated elevation of operation.

ASSEMBLING AND INSTALLATION

Body Assembling

1- Install the two fuel bowl vent jets between the carburetor throats, if they were removed. Refer to the chart in the Appendix for the correct sizing of these jets.



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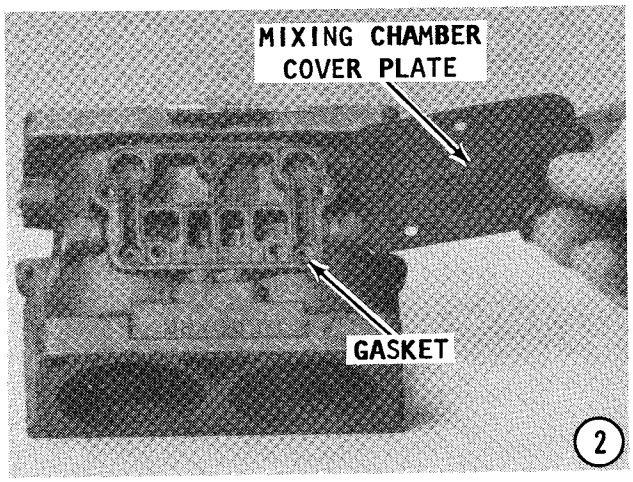
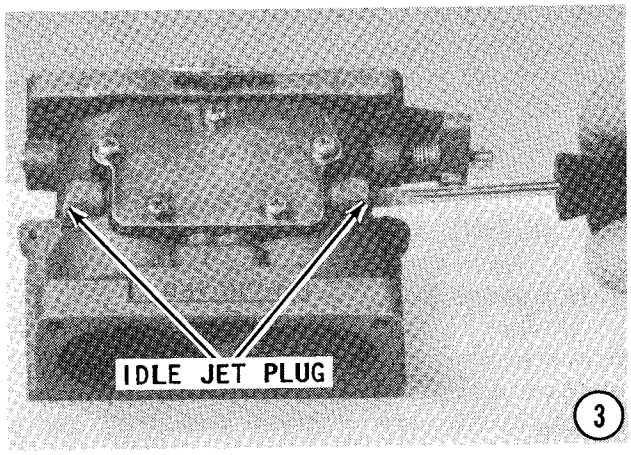


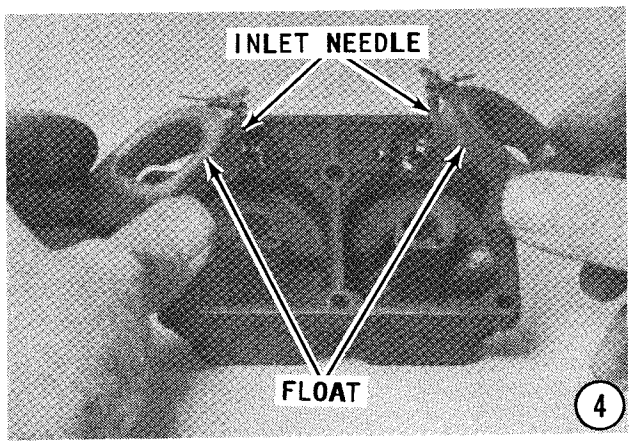
2- Place a **NEW** gasket over the mixing chamber. Install the mixing chamber cover and secure it with the attaching hardware.

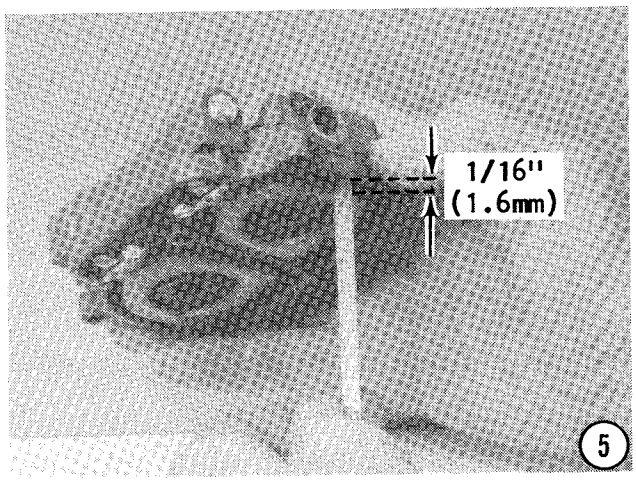
3- Install the two idle jets into their recesses on either side of the mixing chamber cover. Position a **NEW** gasket on each idle jet plug. Thread the plugs into the **SAME** location from which they were removed, as noted during disassembling.

Fuel Bowl

4- Install both inlet needle seats with **NEW** gaskets into the fuel bowl. Discharge a drop of oil into each seat. Hook the float pin and inlet needle with the spring onto each float. Lower each float into the fuel bowl and at the same time guide the inlet needle into its seat. Secure the float pin to the fuel bowl with the screw tightened securely.



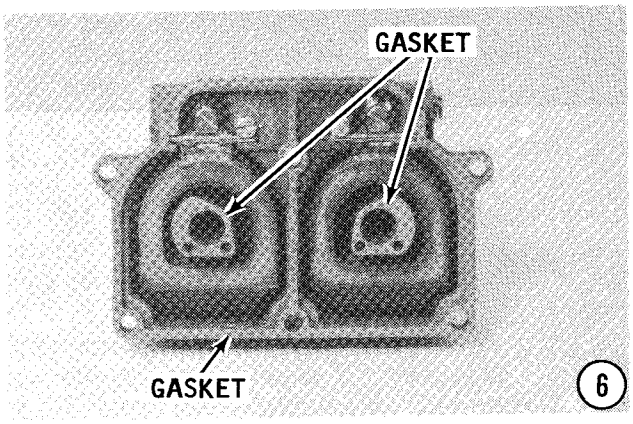




5- Turn the bowl upside down and allow the float to drop. Measure the distance from the base of the bowl to the bottom of the float. This measurement should be 1/16" (1.6mm). **CAREFULLY** bend the float tab to obtain the proper measurement.

6- Position a **NEW** fuel bowl gasket onto the carburetor body. Slide a **NEW** nozzle gasket down over each nozzle and into place on the carburetor body. With the carburetor body upside down, lower the bowl assembly onto the body.

7- Secure it in place with the six screws and lockwasher in the sequence shown in the accompanying illustration. Tighten the No. 1 screw **FIRST** and then tighten the others in a circular pattern working in either direction. Tighten the No. 1 screw a second time. The manufacturer does not recommend replacing the fuel filter. Install the fuel hose fitting.



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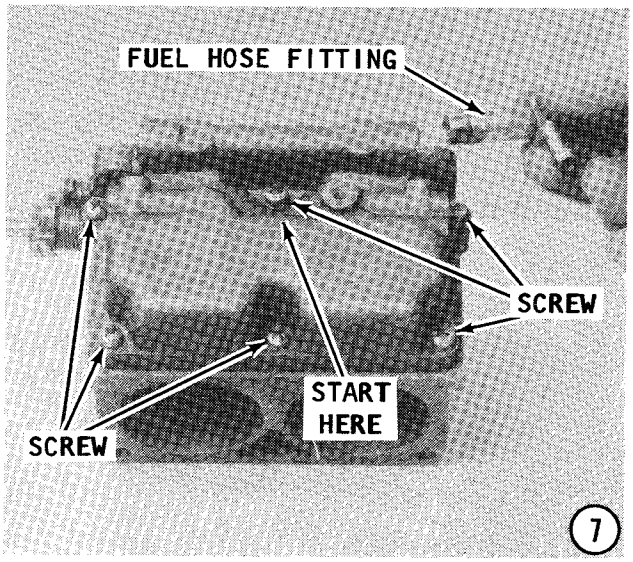


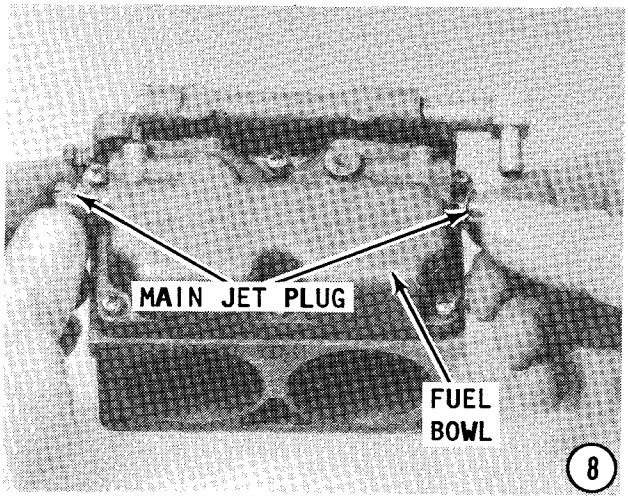
8- Check to be sure each main jet plug has its jet installed. Install the main jet plugs with **NEW** gaskets into both sides of the fuel bowl.

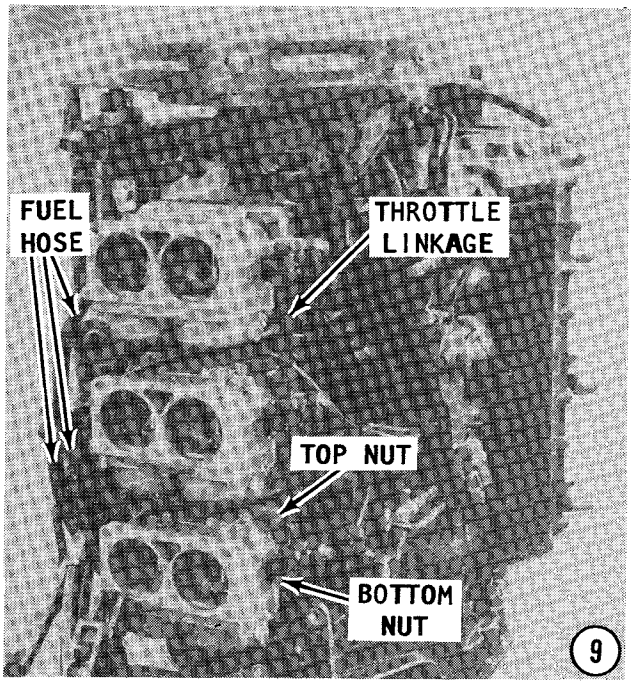
Installation to Powerhead

9- Place a new flange gasket for each carburetor in position on the intake manifold. Install and secure each carburetor in place with the four attaching nuts. Tighten the nuts alternately and evenly to the torque value listed in the Appendix.

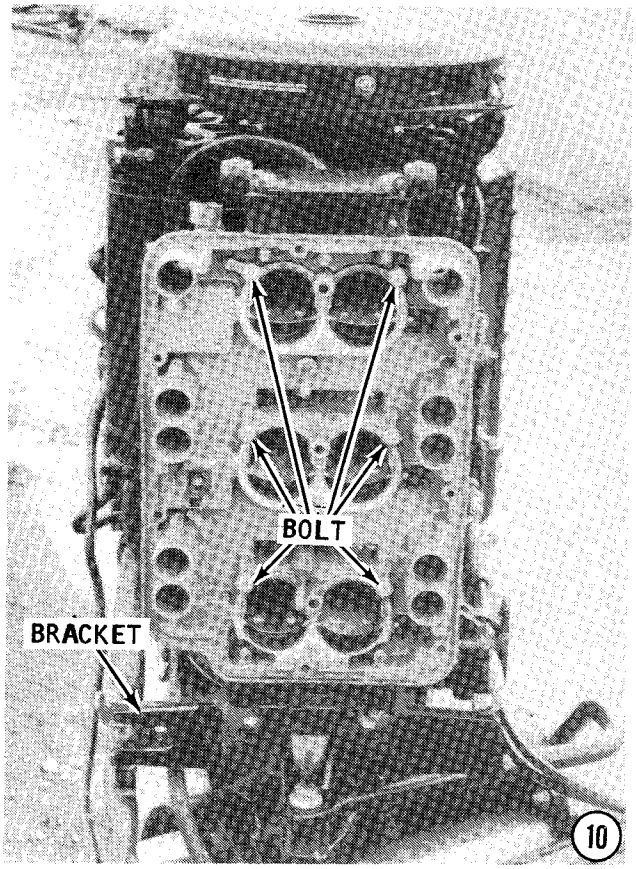
Connect all the fuel lines to the carburetors and tighten the clamps securely.

Connect the control linkage to and between the carburetors. Secure each connection with a washer and cotter pin. As the connections are made, look into each carburetor to be sure the throttle shutters are **CLOSED.** If the shutters are not closed, loosen the Phillips-head screw and force the shutter closed. Tighten the screw and proceed with connecting the linkage.





10- Connect the drain hose to the bottom of the choke plate. Insert the choke solenoid plunger into the choke solenoid and secure the choke plate to the carburetors with the six bolts. Slide the fuel line and electrical cable into the bracket on the bottom of the choke plate.



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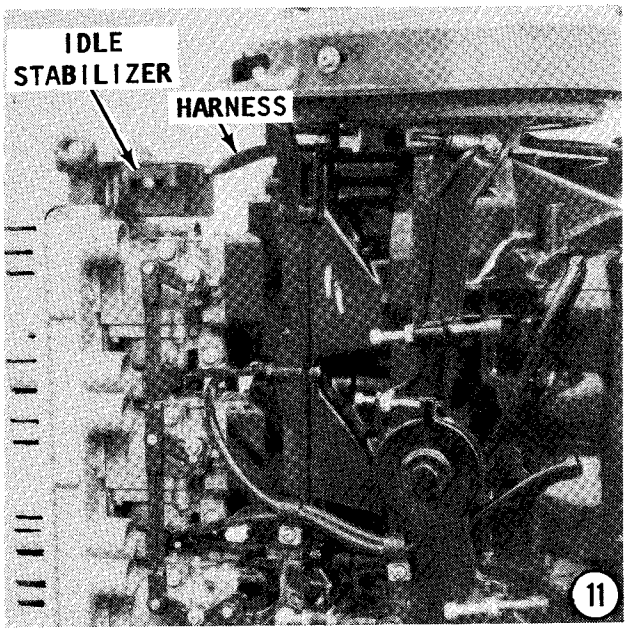
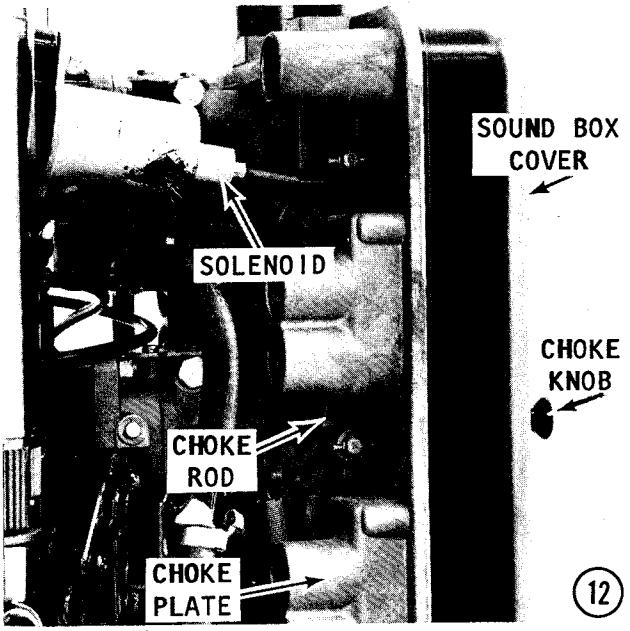
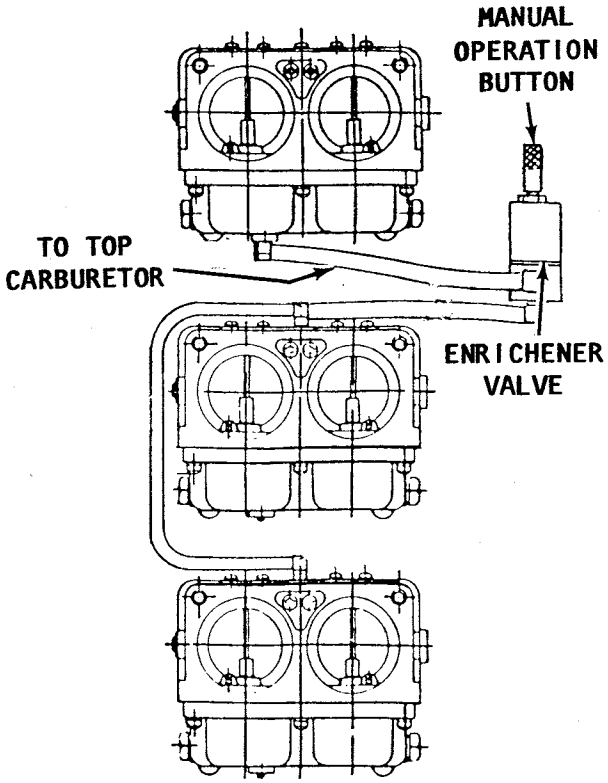




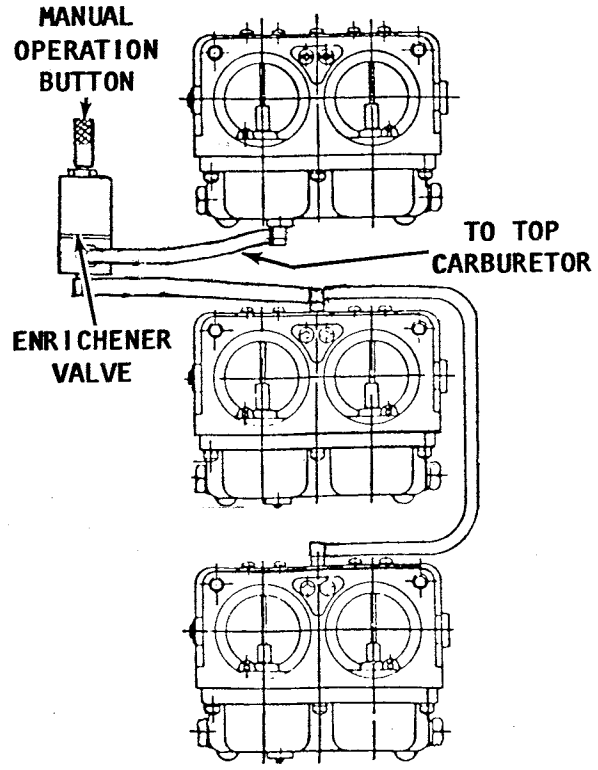
11- Connect the three or four wires from the idle stabilizer to their appropriate terminals in the switch box, as noted during removal.

12- Install the carburetor cover to the choke plate and secure it in place with the two flat washers, two locknuts, and the wing nuts. **CHECK TO BE SURE** the strainer cover is sitting squarely on the float bowl cover, because if it is not positioned properly, the tower assembly on the float bowl cover will be broken when the strainer bolt is tightened. Connect the manual choke to the choke rod. Connect the fuel line to the fuel tank. Activate the fuel line squeeze bulb several times and check the carburetors and fuel lines for leaks.

Connect the battery leads to the battery, if they were disconnected.



Enrichener valve and hose routing on the ***PORT*** *side of a V6 powerhead. The enrichener system performs a "choking" function.*



Enrichener valve and hose routing on the ***STARBOARD*** *side of a V6 powerhead.*

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Adjustments

The high-speed and idle jets are set at the factory and are **NOT** adjustable. To compensate for engine operation at various altitudes, refer to the Carburetor Jet Size Elevation Chart in the Appendix. Adjust idle speed rpm according to the recommendations given in the Specifications in the Appendix.

Synchronizing

To synchronize the fuel and ignition systems, see Chapter 7.

4-13 FUEL PUMP

THEORY OF OPERATION

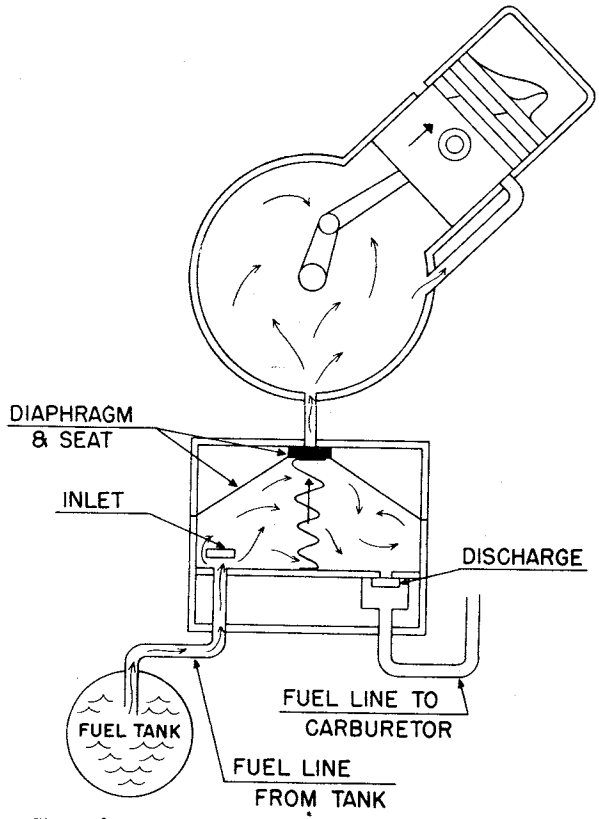
The next few paragraphs briefly describe operation of the fuel pump used on the outboard units covered in this manual. This description is followed by detailed procedures for testing the pressure, testing the volume, removing, and installing the fuel pump.

The fuel pump used is a diaphragm displacement type. The pump is attached to the cylinder bypass. Therefore, it is operated by crankcase impulses. A hand-operated squeeze bulb is installed in the fuel line to fill the fuel pump and carburetor with fuel before the engine starts. After engine start, the pump is able to supply an adequate supply of fuel to the carburetor to meet engine demands under all speeds and conditions.

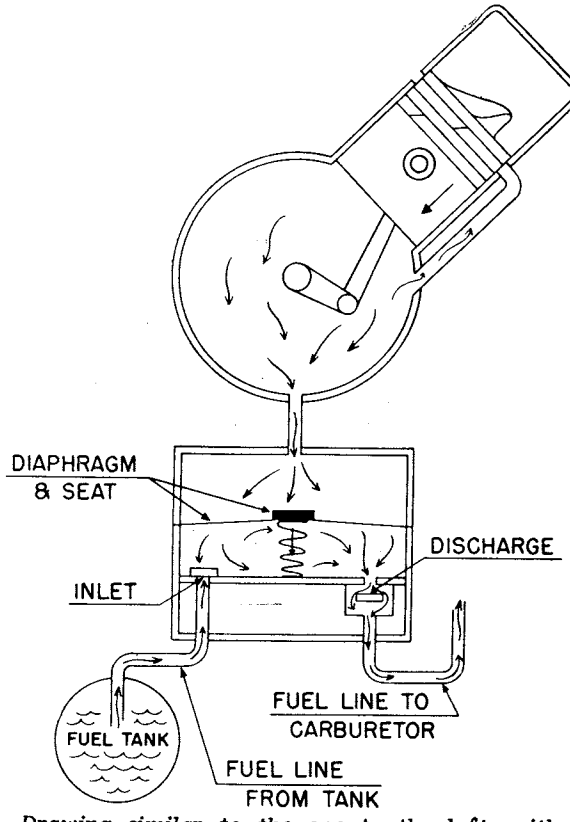
The pump consists of a diaphragm, two similar spring loaded disc valves, one for inlet (suction) and the other for outlet (discharge), and a small opening leading directly into the crankcase bypass. The suction and compression created, as the piston travels up and down in the cylinder, causes the diaphragm to flex.

As the piston moves upward, the diaphragm will flex inward displacing volume on its opposite side to create suction. This suction will draw liquid fuel in through the inlet disc valve.

When the piston moves downward, compression is created in the crankcase. This compression causes the diaphragm to flex in the opposite direction. This action causes the discharge valve disc to lift off its seat.



Simplified drawing of the fuel pump with the powerhead piston on the upward stroke. Notice the position of the diaphragm; the inlet disc is open; and the discharge disc is closed. The springs to preload the discs are not shown for clarity.



Drawing similar to the one to the left, with the powerhead piston on the downward stroke. Notice the position of the diaphragm; inlet disc is closed; and the discharge disc is open. Again, the springs to preload the discs are not shown for clarity.

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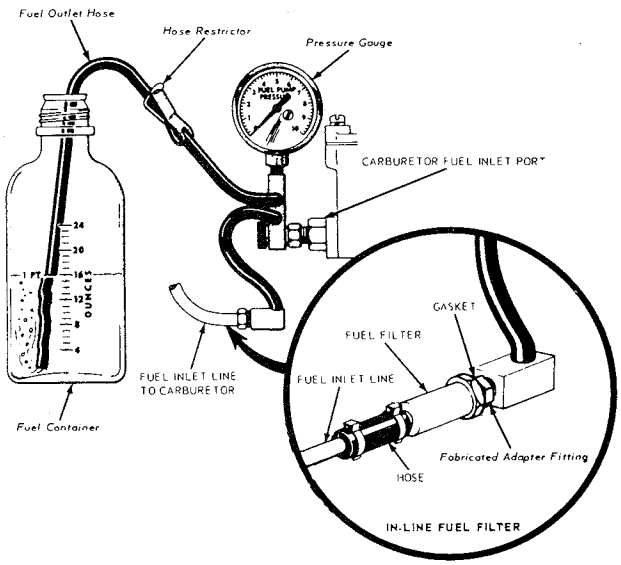


Test setup to check fuel pump pressure.

Fuel is then forced through the discharge valve into the carburetor.

The pump has the capacity to lift fuel two feet and deliver approximately five gallons per hour at 4 psi pressure.

Problems with the fuel pump are limited to possible leaks in the flexible neoprene suction lines; a punctured diaphragm; air leaks between sections of the pump assembly, or possibly from the disc valves not seating properly.

The pump is activated by one cylinder. If this cylinder indicates a wet fouled condition, as evidenced by a wet fouled spark plug, be sure to check the fuel pump diaphragm for possible puncture or leakage.

PUMP PRESSURE CHECK

GOOD WORDS

Lack of an adequate fuel supply will cause the engine to run lean, lose rpm, or cause piston scoring. If an integral fuel pump carburetor is installed, the fuel pressure **cannot** be checked.

With a multiple carburetor installation, fuel pressure at the top carburetor should be checked whenever insufficient fuel is suspected.

Fuel pressure should be checked if a fuel tank, other than the one supplied by the outboard unit's manufacturer, is being used. When the tank is checked, be sure the fuel cap has an adequate air vent. Verify that the fuel line from the tank is of sufficient size to accommodate the engine demands. An adequate size line would be one measuring from 5/16" to 3/8" (7.94 to 9.52mm) ID (inside diameter). Check the fuel filter on the end of the pickup in the fuel tank, to be sure it is not too small and that it is not clogged. Check the fuel pickup tube. The tube must be large enough to accommodate the fuel demands of the engine under all conditions. Be sure to check the filter at the carburetor. Sufficient quantities of fuel cannot pass through into the carburetor to meet engine demands if this screen becomes clogged.

Fuel Pump Test

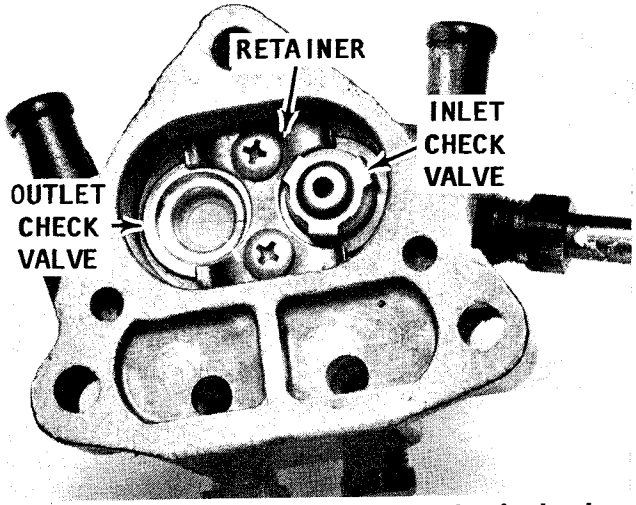
Install the fuel pressure gauge in the fuel line between the fuel pump and the carburetor. If multiple carburetors are installed, connect the gauge in the line to the top carburetor. Operate the engine at full throttle and check the pressure reading. The gauge should indicate at least 2 psi.

REMOVAL

Turn the fuel shut-off valve to the **OFF** position or disconnect the fuel line either at the fuel tank or at the engine.

TAKE CARE: In most cases the bolts attaching the pump to the engine also secure the pump together. Therefore, hold the pump together with one hand and remove the attaching bolts with the other.

Remove the pump and lay it on a suitable work surface. Now **CAREFULLY** separate the parts and keep them in **ORDER** as an assist in assembling. As you remove the check valves **TAKE TIME** to **OBSERVE** and **REMEMBER** how each valve faces, because it **MUST** be installed in exactly the same manner, or the pump will not function.



Typical early model fuel pump with the check valves removed. Notice the valves face in opposite directions.

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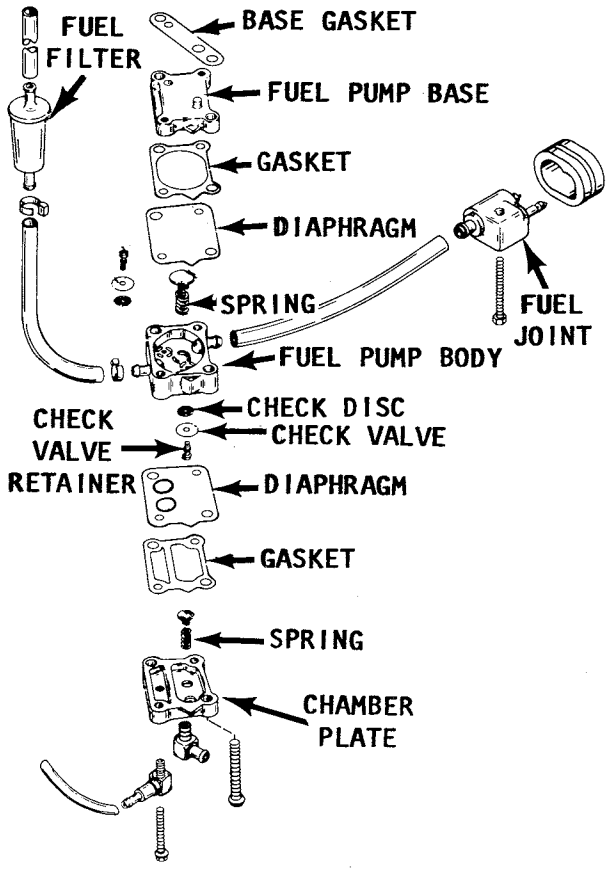


Exploded drawing of a late model fuel pump installed on smaller horsepower powerheads.

CLEANING AND INSPECTING

Wash all parts thoroughly in solvent, and then blow them dry with compressed air. **USE CARE** when using compressed air on the check valves. **DO NOT** hold the nozzle too close because the check valve can be damaged from an excessive blast of air.

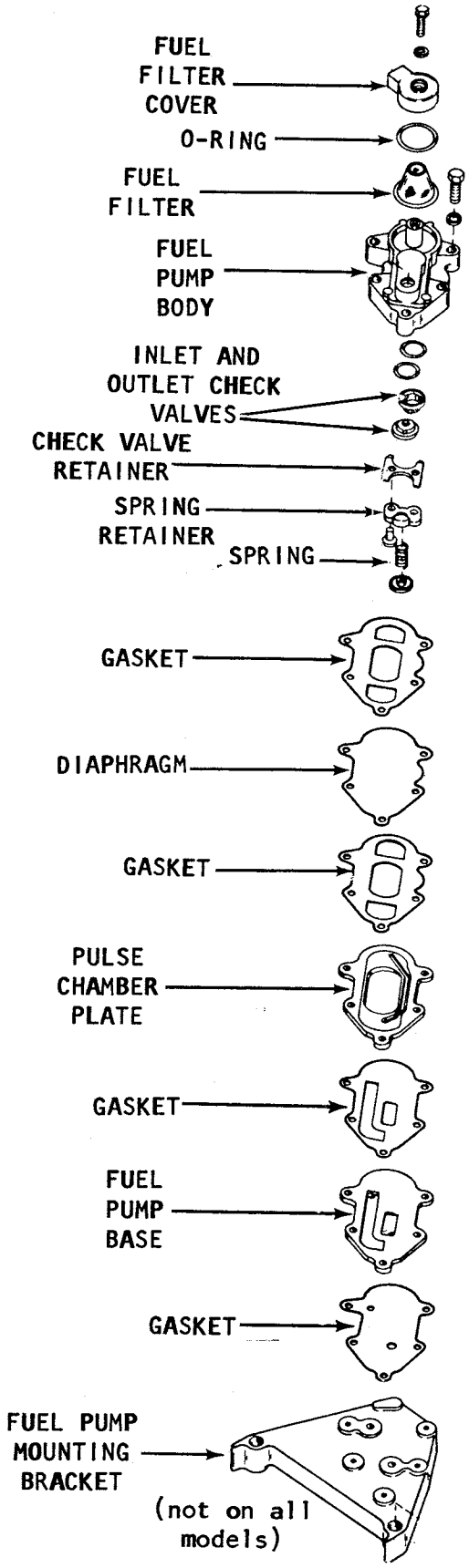
Inspect each part for wear and damage. Verify that the valve seats provide a flat contact area for the valve disc. Tighten all elbows and check valve connections firmly as they are replaced.

Test each check valve by blowing through it with your mouth. In one direction the valve should allow air to pass through. In the other direction, air should not pass through.

Check the diaphragm for pin holes by holding it up to the light. If pin holes are detected or if the diaphragm is not pliable, it **MUST** be replaced.

ASSEMBLING

Proper operation of the fuel pump is essential for maximum performance of the



Exploded drawing of the fuel pump installed on late model L6 and V6 powerheads.

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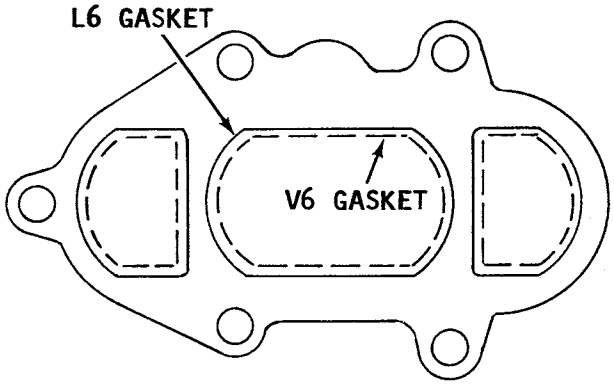
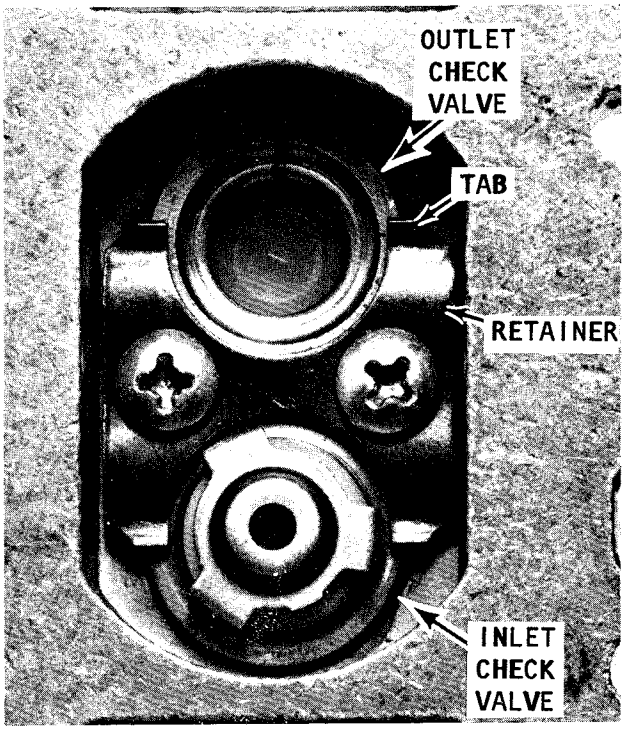


Check to be sure the proper diaphragm gasket is being used. The gaskets for L6 and V6 powerheads are similar in size and shape, but the L6 gasket is gray; the V6 gasket is tan.

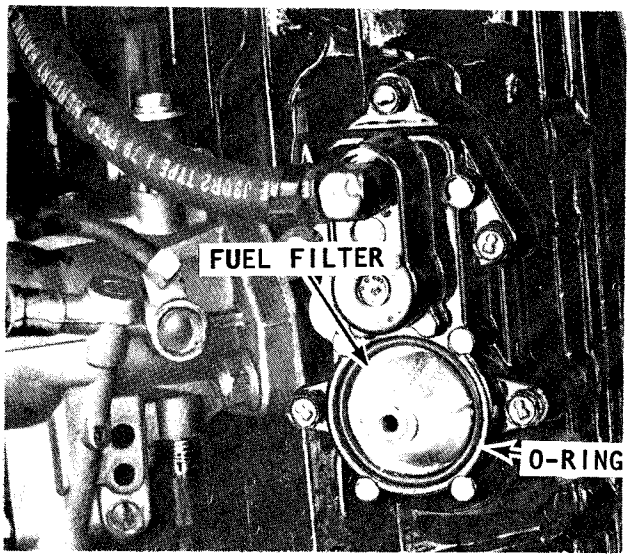
powerhead. Therefore, always use **NEW** gaskets.

NEVER use any type of sealer on fuel pump gaskets.

Place **NEW** check valve gaskets in position in their seats. Insert the check valve discs in their seats. The inlet check valve seat is identified by the protruding tip in the casting. The flat side of the check valve seats over this tip. The outlet check valve is set in opposite, with the flat end up. In this position the tension is against the valves.



*The retainer is installed with the tabs facing **UP**.*



*The fuel filter cover removed. A **NEW** O-ring should be installed each time the fuel filter is changed.*

Install the retainer on the check valves in the housing with the two tab ends facing **UP.**

CRITICAL WORDS

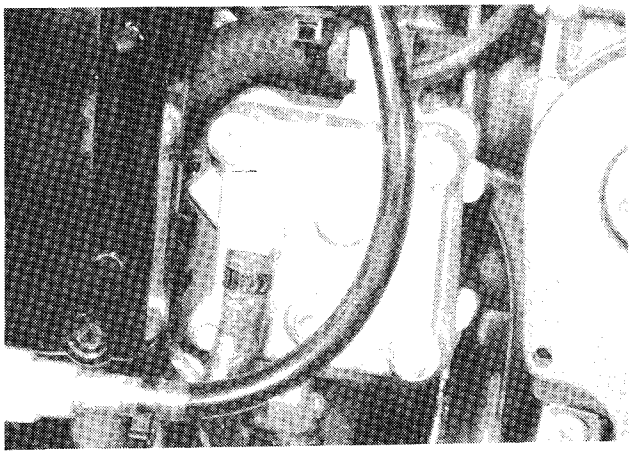
The tabs on the retainer must face **UP** or the retainer will be warped when the attaching screws are tightened.

Secure the retainer in place with the two attaching screws.

Place a **NEW** gasket on the pump body, then the neoprene diaphragm, and finally another **NEW** gasket. Mate the fuel pump cover to the body and hold it all together.

CAREFULLY place the fuel pump on the engine base. Install the retaining screws through the pump and into the engine block. Tighten the screws alternately to the torque value given in the Appendix.

Connect the fuel lines or turn the fuel valve to the **ON** position.



Typical location of the fuel pump installed on newer intermediate size powerheads.

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4-14 ELECTRONIC FUEL INJECTION (EFI)

Some late model V6 powerheads are equipped with an Electronic Fuel Injection (EFI) system. This fuel distribution system is computer controlled. Five different sensors provide the computer with information on rpm, throttle setting, manifold air temperature, powerhead temperature and manifold pressure -which automatically adjusts to barometric pressure. The EFI fuel system includes the fuel tank, an anti-syphon valve, a mechanical fuel pump, an electric "booster" fuel pump, a primary fuel filter, a secondary fuel filter, a vapor separator, a fuel pressure regulator, and an injector fuel rail supporting six fuel injectors. The electronic control system for the fuel system includes the six fuel injectors (each a mini solenoid), five sensors and an Electronic Control Unit (ECU) - a "black box".

GENERAL INFORMATION

The advantages of a fuel injection system over a carbureted fuel system are:

a- More efficient powerhead operation.
b- Thorough atomization of the injected mixture.
c- Increased fuel economy.
d- Fuel efficiency -- complete burning of the injected mixture.
e- Better "volumetric efficiency" (the ability of the powerhead to breathe air), due to the absence of a venturi.
f- Less harmful exhaust gases.

The first electronically controlled fuel injection system was introduced over 50 years ago -- in 1932 on diesel truck engines. Today, state-of-the-art microprocessors (commonly referred to as "computer chips") have lowered the cost of electronically controlled fuel injection systems. The price of EFI is now very close to the cost of modern carbureted systems. In the not too distant future, possibly all but the very smallest single cylinder powerheads may be operating on EFI!

EFI SYSTEM DESCRIPTION

The type of fuel injection used on some late model V6 powerheads, such as the 220hp Magnum, is called "Indirect Multi-Port Fuel Injection", because the fuel is injected into the intake manifold, before entering the combustion chamber. By design, the method of injection is also termed "Port Tuned Injection" -- each port has minimum and equal restriction to ensure all ports pass the same amount of air into the crankcase.

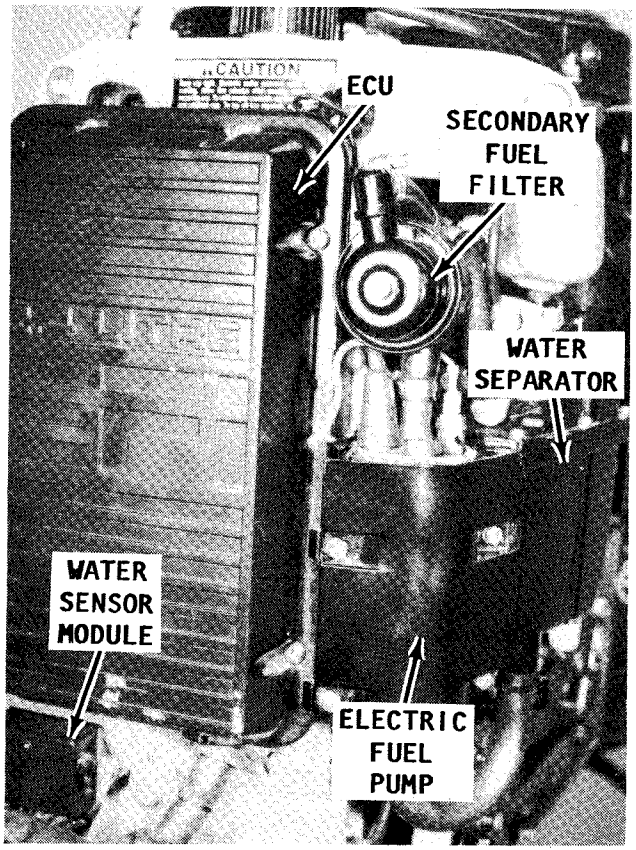
Pairs of injectors are pulsed sequentially and timed to the induction of air into the crankcase.

A computer housed in the Electronic Control Unit (ECU) accepts data from a number of sensors. Based on the information received, the ECU signals each fuel injector to inject a precise and correct amount of fuel.

A fuel injection system must provide the correct air/fuel ratio for all powerhead loads, rpm, and temperature conditions.

Manifold Pressure

Under normal operating conditions, an ideal air/fuel ratio is maintained. When the operator places a power demand on the powerhead by advancing the throttle, intake manifold pressure is reduced. Conversely, a reduction in intake manifold pressure, indicates an additional load has been placed on the powerhead. This added powerhead demand requires a richer air/fuel mixture.



Exterior view of a typical EFI system with some of the major parts identified.

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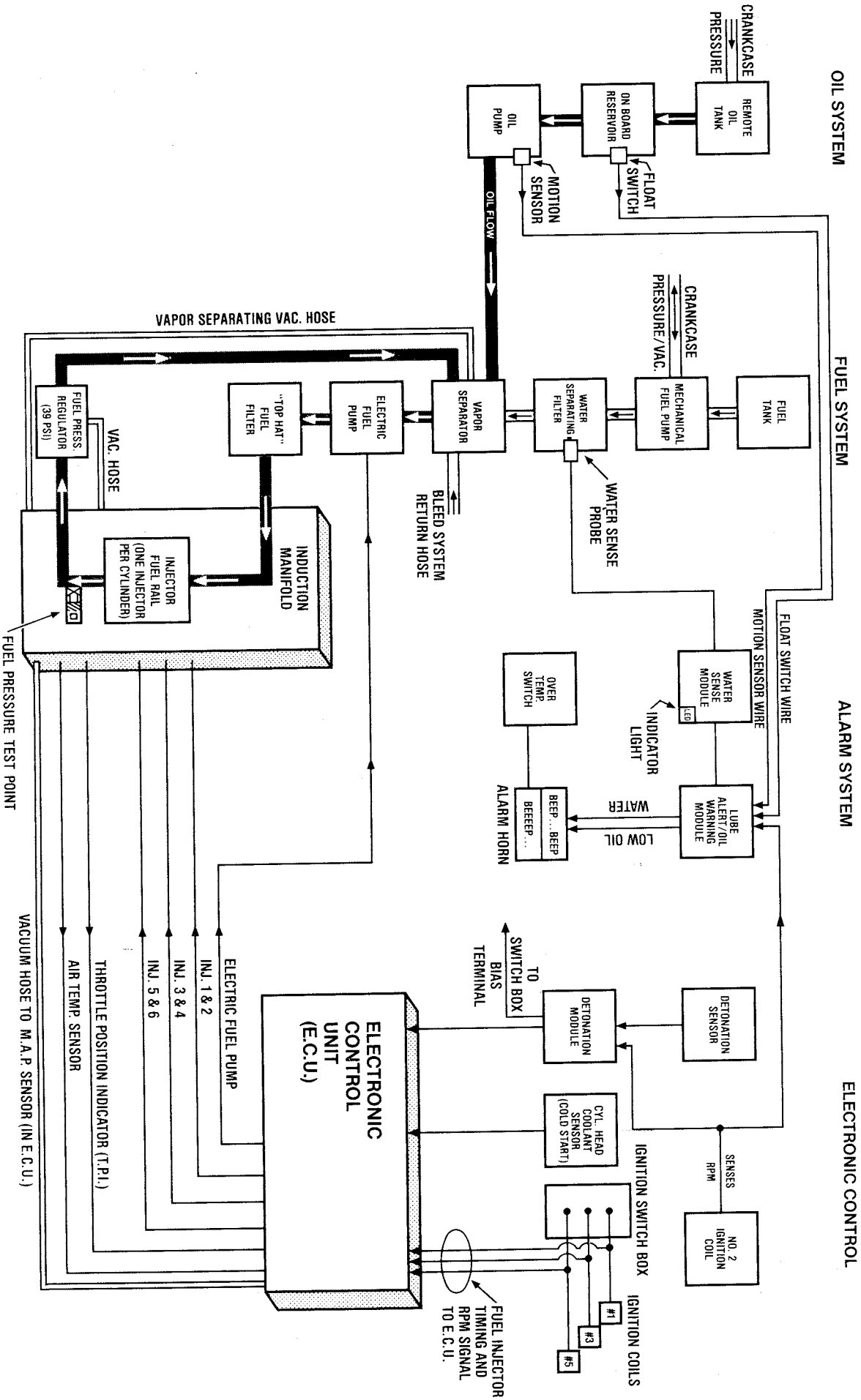

Classroom type system schematic to illustrate EFI fuel flow, sensor signal direction, and electrical current.

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ECU (Electronic Control Unit)

The ECU computes the new ideal air/-fuel ratio and the fuel injectors deliver the correct amount of fuel. When the powerhead and load demands stabilize, the ECU again receives data from the sensors and readjusts the ratio to the new stabilized condition.

Fuel Pumps & Routing

A mechanical fuel pump draws fuel from the fuel tank. Fuel from the tank passes through the primary fuel filter, a water separating filter, and then a vapor separator. An electric fuel pump boosts the flow of fuel from the vacuum operated mechanical fuel pump and passes the fuel on to a secondary fuel filter. A fuel pressure regulator restricts fuel pressure from 36 to 39psi, as set at the factory. Fuel is passed on to the fuel rail and is distributed to each injector. Excess fuel is routed back to the vapor separator.

Air Temperature Sensor

An air temperature sensor is located on the starboard side of the intake manifold, the sensor is mounted under the upper trim/tilt solenoid. Two Brown leads connect the sensor to the ECU. The sensor measures the ambient air temperature and conducts this information in the form of an electrical signal to the ECU. As the air temperature changes, the amount of oxygen per cubic foot also changes. The quantity of available oxygen has an affect on combustion and therefore must be taken into account when computing the ideal air/fuel ratio.

Manifold Absolute Pressure (MAP) Sensor

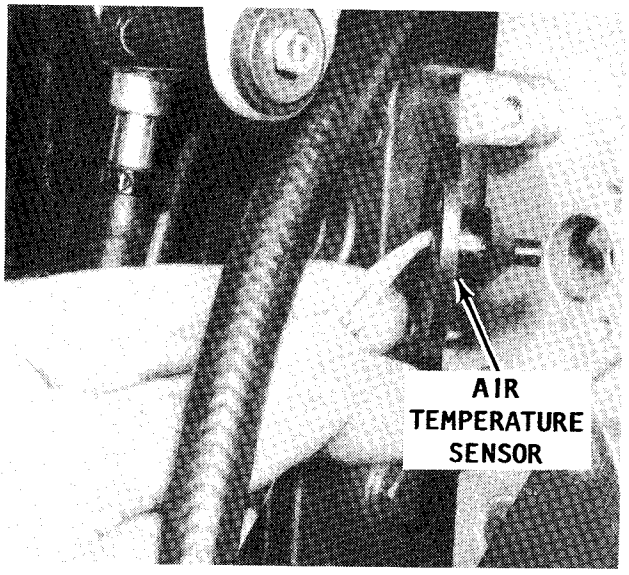
A MAP sensor is located inside the ECU. A vacuum hose connects the intake manifold to the sensor. The MAP sensor is a flexible type resistor. As the pressure changes, the resistor flexes and its resistance and the voltage applied across the sensor changes. This change is registered at the ECU.

Two conditions can affect the pressure in the manifold. The first, and most common condition, is a reduction in manifold pressure when load on the powerhead is increased. As mentioned earlier under "Manifold Pressure", when the operator places a power demand on the powerhead by advancing the throttle, intake manifold pressure is reduced. Conversely, a reduction in intake manifold pressure, indicates an additional load has been placed on the powerhead.

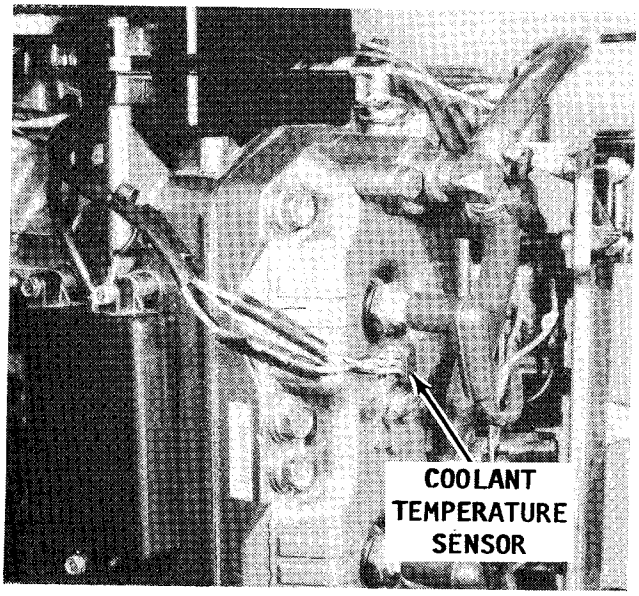
The second condition which may affect the manifold pressure is operation of the powerhead at high altitudes. Would you believe, high barometric pressures, powerhead operation on an extremely hot day, will also affect manifold pressure.

Coolant Temperature Sensor

The coolant temperature sensor is located in the port head. This sensor is a thermistor -- an electronic device which functions in the opposite manner of a resistor.



The EFI air temperature sensor is mounted under the upper trim/tilt solenoid on the starboard side of the powerhead.



The EFI coolant temperature sensor is located on the port cylinder head.

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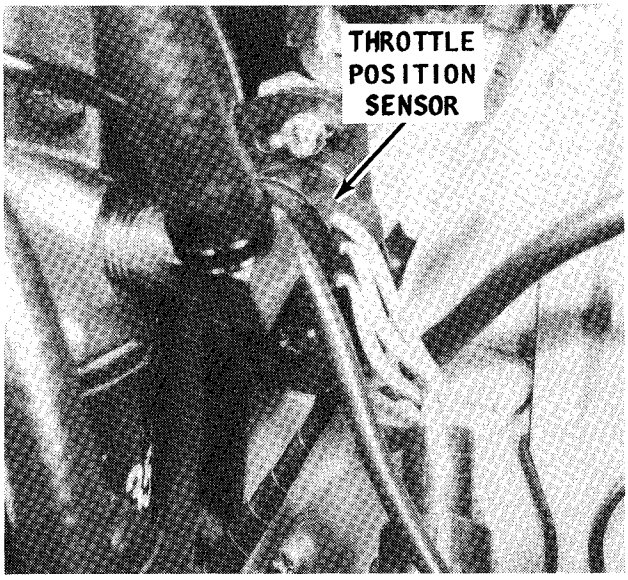
A resistor increases resistance with temperature (decreases voltage), with an increase in temperature. A thermistor varies resistance (increases or decreases voltage), with a change in temperature. When this voltage is received by the ECU, the information is used to determine injector pulse widths and spark advance. The temperature information is also used to determine if an extra charge of fuel is necessary for a cold powerhead. Powerhead temperature information is used by the ECU to assist in starting a cold powerhead by automatic fuel enrichment. In this manner, a choke is not required. Once the powerhead has reached operating temperature, enrichment is no longer required.

The powerhead temperature sensor has two Tan/Black leads. One lead is routed to the throttle position sensor via a junction and then on to the ECU. The other Tan/-Black lead is routed via a junction to the Orange lead from the throttle position sensor. The Orange lead is then connected to the ECU.

Throttle Position Sensor

The throttle position sensor is mounted on the bottom throttle shaft. The sensor is an encased potentiometer sending a signal to the ECU indicating powerhead load for a specific rpm. Powerhead load is influenced by the load in the boat, by the propeller type and size used with the outboard unit, performance demands imposed by the operator, and other operational factors.



The EFI throttle position sensor is mounted on the starboard side of the powerhead on the bottom throttle shaft.

The body of the sensor is stationary with a small shaft emerging from the center of the sensor. The shaft is connected to the throttle valve. As the throttle is advanced, movement is transferred to the sensor and the resistance changes. Therefore, the variable voltage signal sent to the ECU is directly proportional to the throttle position.

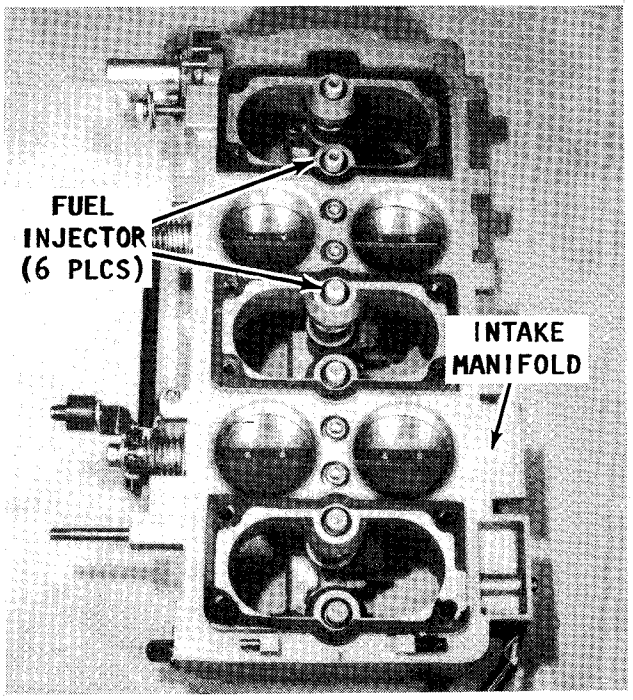
The throttle position sensor has three leads -- a Tan/Black, a Light Blue and an Orange lead. All three leads are connected to the ECU.

Fuel Injectors

The six fuel injectors force fuel under pressure into the intake manifold. Each injector is mounted on the fuel rail.

The injectors used in this type fuel injection system are solenoid operated. Each consists of a valve body, a needle valve, and valve seat. A small voltage is sent from the ECU to each injector. When this voltage is applied to the windings of the solenoid, a magnetic field is induced around the needle valve. The valve lifts off its seat and fuel is allowed to pass between the needle valve and the needle seat. Because the fuel is pressurized, a spray emerges from the injector nozzle.

The time interval for the injector to be open and emitting fuel is called the "pulse width". The actual "pulse width" for the



Intake manifold removed from the powerhead to show location of the six fuel injectors.

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injector is controlled by the ECU and must be measured in **MICROSECONDS.**

A small return spring seats the needle valve back onto the seat, the instant the voltage is removed.

The nozzle spray angle of each injector remains constant and is the same for all six injectors.

Two **O**-rings are used to secure each injector in the fuel rail. One **O**-ring provides a seal between the injector nozzle and the intake manifold. The other **O**-ring provides a seal between the injector and the fuel inlet connection. Both **O**-rings prevent excessive injector vibration. These **O**-rings are replaceable and are included in an injector overhaul kit.

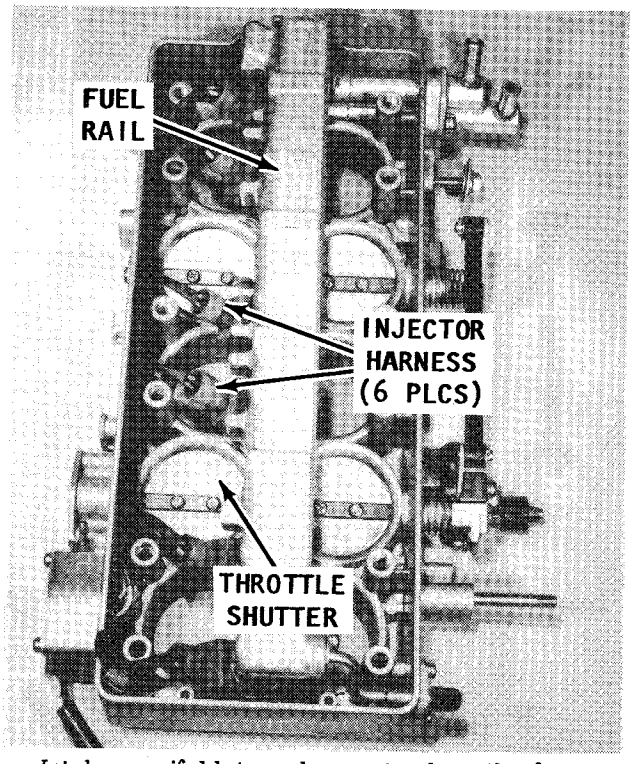
Fuel Rail

The fuel injectors are mounted on a rail extending the length of the intake manifold. Fuel enters the rail at one end and a fuel pressure test point is provided at the other end for troubleshooting purposes. Fuel is evenly distributed from the rail to each injector. The injectors are held in place with fragile wire clips.

Fuel Pressure Regulator

A fuel pressure regulator is connected to the fuel rail. The pressure regulator is a mechanical device used to maintain constant fuel pressure to ensure a uniform spray from the injectors. An electric fuel pump delivers fuel under pressure to the fuel rail. Usually an excessive amount of fuel is delivered to the injectors. All the fuel passes through the injector, but the excess is returned via the fuel regulator assembly in the following manner.

The fuel regulator is pre-set at the factory to operate between 36 and 39psi. When fuel pressure exceeds the regulator setting, excess fuel pushes a spring loaded diaphragm downward. This action uncovers a fuel return port and the excess fuel is routed back to the vapor separator. As the fuel pressure drops, the spring loaded diaphragm relaxes and the fuel return port is closed.



Intake manifold turned over to show the fuel rail injector harness leads and the throttle shutters.

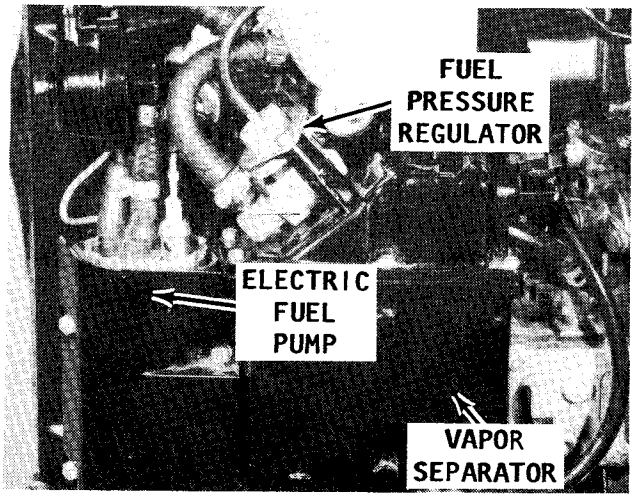
Throttle Shutter

The throttle shutter is a valve mounted at the air intake port of each cylinder. This valve controls the amount of air entering the intake manifold. The valve is controlled by the operator at the remote control box. There are six such valves, one per cylinder and each valve opens simultaneously and equally. The throttle position sensor is mounted on the bottom throttle shaft of the shutter valve.

The throttle position sensor reports the movement of the throttle shutter valve as an electronic signal to the ECU.

Electric High Pressure (Booster) Fuel Pump

The electric fuel pump is mounted on the port side of the powerhead next to the vapor separator. The purpose of the electric fuel



Location of the EFI fuel pressure regulator, electric fuel pump, and the vapor separator.

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pump is to boost the initial fuel pressure from the crankcase vacuum operated fuel pump, and deliver the fuel to the injectors under constant pressure of 36 to 39psi.

The electric (booster) fuel pump is a roller-cell type and is **NOT SERVICEABLE.**

The accompanying illustration shows the internal parts of an electric fuel pump. **DO NOT ATTEMPT TO OPEN THE PUMP ON THE POWERHEAD BEING SERVICED.**

Once opened, the airtight seal is lost and the integrity of the seal **CANNOT** be regained. The pump **MUST** be replaced.

This booster pump is unique because the pump and electric motor are housed together in one permanently sealed case, constantly surrounded with fuel. **Yes!,** the fuel actually flows past the electric motor brushes. If the case remains **ABSOLUTELY** airtight, there is **NO DANGER OF EXPLOSION.** However, if the case develops a crack, or is deformed in any way, there is the distinct possibility air may enter the case and together with the fuel form an **EXPLOSIVE MIXTURE!** Fuel, by itself will not ignite while exposed to a spark from the electric motor brushes, because there is no oxygen present for combustion. A mixture of 0.7 parts air to 1.3 parts fuel becomes explosive.

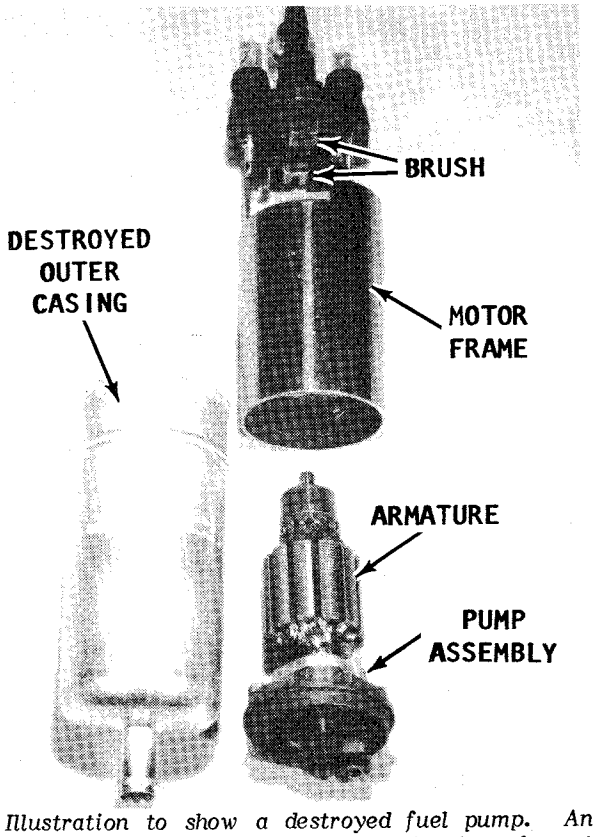


Illustration to show a destroyed fuel pump. An operational pump is an air tight sealed unit and must ***NEVER*** *be opened. Air inside the pump would create a highly volatile (explosive) atmosphere inside the pump, as explained in the text.*

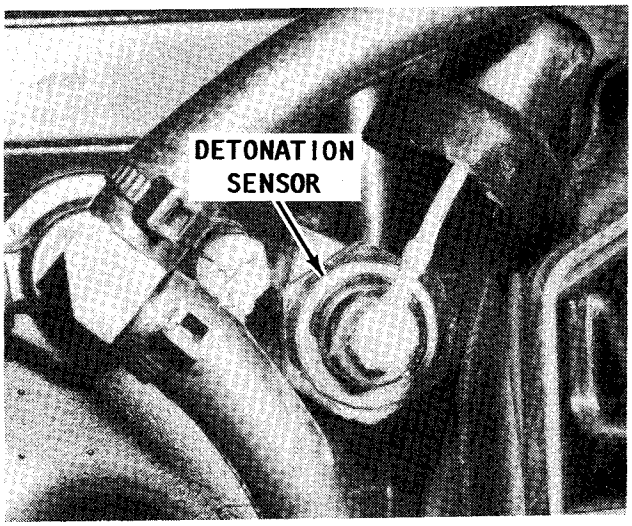
Pump action will commence the moment the ignition key switch is rotated to the **ON** position. If the key switch is held in the **ON** position for more than 30 continuous seconds, the ECU will cutoff electrical power to the pump and of course the pumping action will cease.

CRITICAL SAFETY WORDS

The powerhead must never be cranked without an adequate supply of fuel to the booster pump. If the electric pump draws air into the pump case, an explosive mixture may then form. On the other hand, a fuel injection system cannot be flooded. The fuel pressure regulator will activate the return circuit, and excess fuel will not flood the crankcase, as in a conventional carbureted powerhead. As explained earlier, the excess fuel will be returned to the vapor separator.

Detonation Sensor and Detonation Module

A detonation sensor is threaded into the portside cylinder head. The sensor has a single White/Blue lead connected to the center terminal. This lead connects the sensor to a detonation module which in turn is connected to the ECU. The sensor is able to detect the frequency of vibrations associated with pre-ignition and detonation, approximately 8,000 Hertz. If either of these conditions is due to fuel of an insufficient octane rating (less than 87), or a sudden change in loading of the powerhead, the sensor will be activated.



Location of the EFI detonation sensor threaded into the port cylinder head.

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An electronic signal is sent to the detonation module and the ECU. The result of these signals is ignition timing being retarded by as much as 8°.

Water Presence Sensor and Water Separating Filter

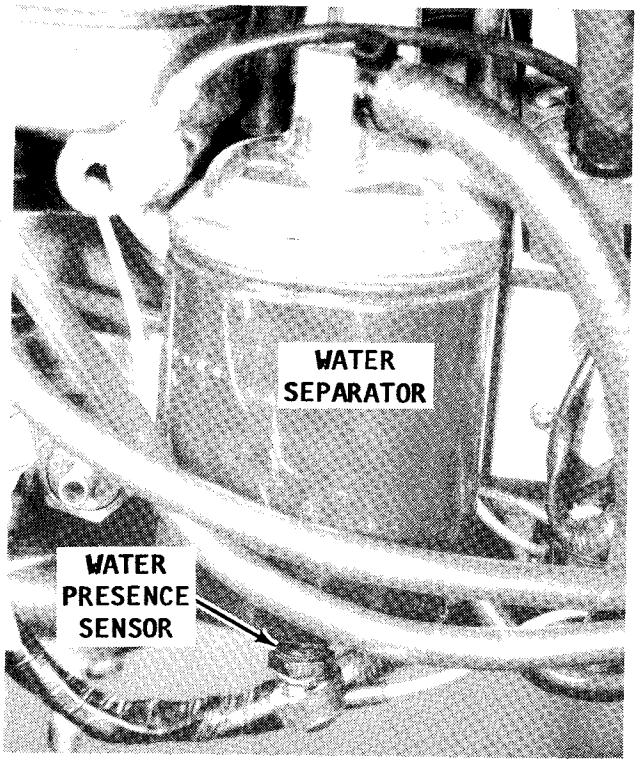
A canister type filter is installed between the mechanical fuel pump and the vapor separator. The purpose of this filter is as the name suggests, to separate water from the fuel. The presence of water in the fuel will alter the proportion of air/fuel mixture to the "lean" side, resulting in a higher powerhead operating temperature and possible damage to pistons if not corrected.

A water presence sensor is located at the base of the water separating filter. A Tan lead connects the sensor to a water sensor warning module, with an LED indicator warning light to inform the operator of an unacceptable quantity/level of water in the fuel. A signal is also transmitted to the Lube Alert Oil Warning Module which houses a horn, sounded at the signal of excess water in the filter.

RPM Sensor

The powerhead rpm sensor is housed within the ECU. Electronic pulses from the No. 2 ignition coil through the detonation module are received by the rpm sensor. These signals indicate powerhead rpm.

A Green lead connects the No. 2 ignition coil to the detonation module and then by a different colored lead to the ECU.



The EFI water separator is a disposable canister type filter with a sensor mounted on the filter base.

Vapor Separator

The vapor separator is located between the water separating filter and the electric fuel pump on the portside of the powerhead. This separator eliminates vapors from the fuel before the fuel reaches the electric fuel pump. The presence of vapors in the electric fuel pump could be **MOST HAZARDOUS!**

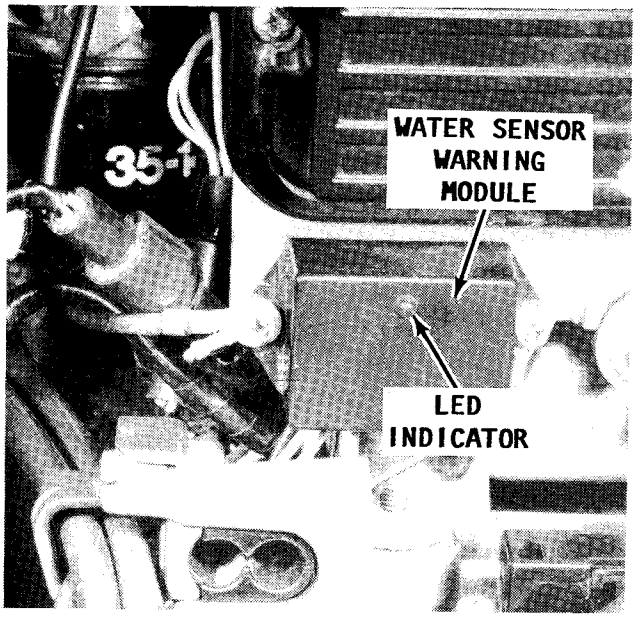
This type separator is called a float type, because it closely resembles a gigantic carburetor float bowl. Fuel and the associated vapors enter the separator from the water separating filter. Fuel in the separator causes the float to rise.

The vapor separator performs three essential functions:

1- Fuel vapors are channeled to the intake manifold and only liquid fuel is permitted to enter the electric fuel pump.

2- The vapor separator provides the means for mixing liquid fuel and oil from the oil pump.

3- The separator accepts excess fuel recycled into the system from the fuel pressure regulator and the powerhead bleed system.



The EFI water sensor warning module is mounted beneath the ECU. The module has an LED indicator light to warn the operator of an unacceptable amount of water in the fuel.

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Electronic Control Unit (ECU)

The fuel injection system is controlled by the ECU -- an onboard computer mounted as far from heat and vibration as possible. The computer is a sealed "black box" type unit and is in no way serviceable. The ECU receives signals from numerous sensors on the powerhead. From the signals received, the ECU determines the amount of fuel to be injected. This computer also determines the timing of the spark at the spark plugs.

The amount of fuel injected is determined by how long each injector nozzle remains open -- the "pulse width". The nozzle opens and closes in response to signals from the ECU.

The ECU receives three types of imput signals.

Analog signals change with changing conditions. For example: the coolant temperature sensor will have more electrical resistance when the powerhead is cold, than when the powerhead is hot.

Digital signals are a series of on and off pulses. These pulses are counted by the computer to determine a condition. For example: the signal sent from the No. 2 ignition coil will provide the computer with information on powerhead rpm.

Pressure Differential signals received through vacuum lines connecting the intake manifold to the ECU indicate powerhead loading to sensors within the computer.

Sensors located on the powerhead or inside the "Black Box" provide information to the computer on powerhead load, rpm, temperature and other conditions affecting operation.

The computer is **programmed** or provided with instructions, to produce correct air/-fuel mixtures and throttle openings for varying conditions.

Primary Fuel Filters

A fuel filter is installed at the base of the pickup tube in the fuel tank. Another fuel filter is installed at the inlet fitting of the crankcase vacuum operated fuel pump. In some cases, an in-line filter is installed between the fuel tank and the primary pump.

Secondary Fuel Filter

The secondary fuel filter, sometimes referred to as a "Top Hat" filter, is a very fine mesh screen filter mounted above the electric "booster" fuel pump. This filter performs the final filtering function before fuel enters the fuel rail.

Anti-Syphon Valve

An anti-syphon valve is considered an "After Market" item, not installed by the factory. Many people consider such a device to be a safety item, but more often than not, they cause more problems in the fuel delivery system than they solve.

If the valve becomes the least bit clogged with debris or a too small valve is installed in the fuel line, or the spring is too stout, a pressure drop may be develop from one side of the valve to the other. A pressure drop across the anti-syphon valve can cause poor powerhead performance and possible damage.

A defective or poor operating anti-syphon valve may cause one or more of the following problems:

Inadequate fuel pump pressure.

Loss of power at the powerhead.

Powerhead surging at high speed rpm.

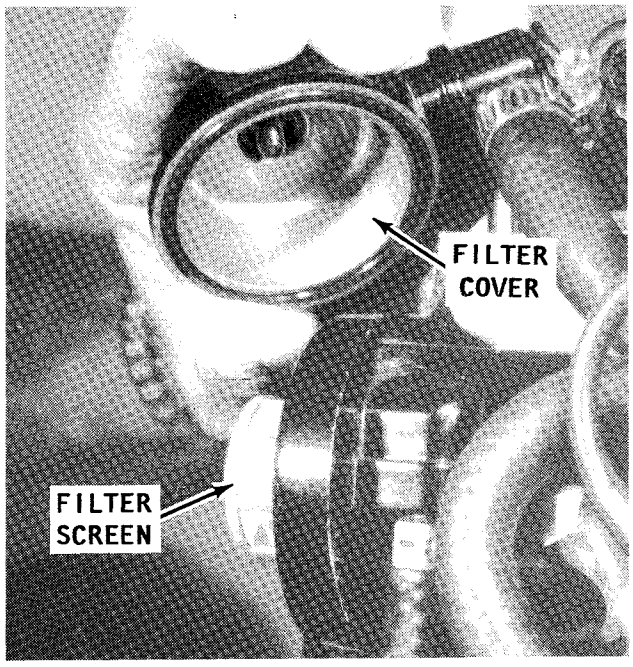
Piston dome erosion due to preignition or detonation.

Poor powerhead performance during acceleration -- unit falters or cuts out completely.

Powerhead fails to operate smoothly -- runs "rough".

Powerhead shuts down and fails to start.

Powerhead cannot be started.



*The EFI system **MUST** be depressurized before the filter cover is removed, as explained in the text.*

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TROUBLESHOOTING EFI

If a problem is encountered with powerhead startup or operation, the determination must be made: the problem is in the ignition system or the fuel system is at fault.

The first and easiest test to determine an ignition problem is to perform a spark test as outlined in Chapter 6. If the ignition system checks out and the preliminary troubleshooting narrows the area to the fuel system, proceed with the following fuel system tests.

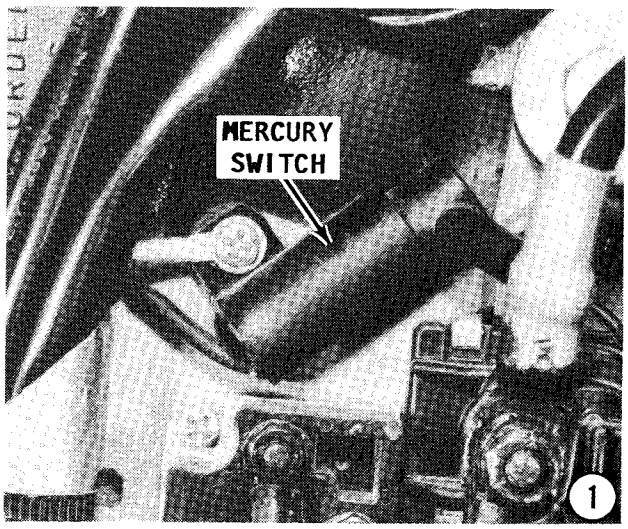
Checking Anti-Syphon Valve

If troubleshooting should indicate the anti-syphon valve is at fault, attempt to operate the powerhead with a separate source of fuel. In other words, the valve is physically bypassed.

If the valve proves to be the source of the problem, either remove the valve from the fuel line or replace the valve with a solenoid operated fuel shutoff valve.

VERY IMPORTANT WORDS

The following tests were designed for the person working with a Volt/Ohm/Ammeter only. All dealerships will have a Quicksilver Fuel Injection Tester. Seloc strongly suggests a certified marine mechanic be contacted to check a suspected EFI electrical component. The part may be removed and bench tested in the shop or left installed on the powerhead and tested in a shop having the professional test equipment. Proper testing and accurate diagnosis is **CRITICAL** before purchasing an expensive **NON-RETURNABLE** electronic component, especially a **NEW** ECU.



Installed Injector Test

1- Connect one end of a jumper cable to the terminal of the mercury switch and the other end to a suitable ground on the powerhead. The terminal will have a Black/-Yellow lead attached to it. Grounding the mercury switch is necessary to prevent the powerhead from accidentally starting while tests are being performed. Keep switch grounded with the jumper cable in place while performing Steps 2 thru 12, then remove the cable.

2- Rotate the ignition key to the **START** position and crank the powerhead through several revolutions. Rotate the key switch back to the **OFF** position. Remove the spark plugs one by one and inspect the electrode end. A damp electrode will indicate the injector is functioning for the cylinder being checked.

If all spark plugs are damp indicating the presence of fuel, all injectors are spraying fuel into the crankcase. If some spark plugs are damp with fuel, while others are dry, the electric fuel pump is probably functioning correctly. However, either the injectors of the "dry" cylinders have a restricted fuel flow **OR** the dry injectors have an electrical problem.

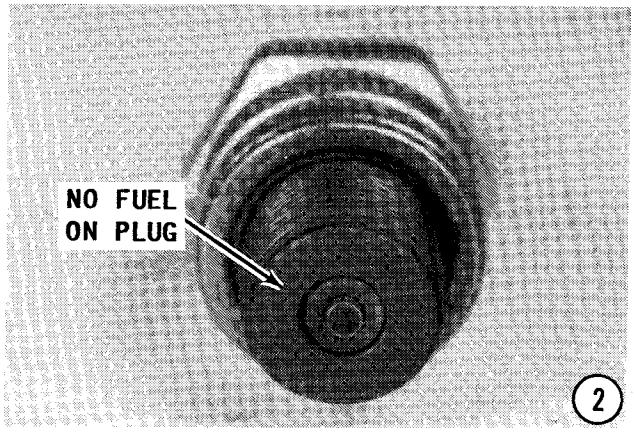
If all spark plugs are dry -- none are damp with fuel, a problem with fuel delivery exists. The problem may be:

A main fuel line blockage.

A faulty electrical component affecting operation of the entire system, such as a defective electric fuel pump, defective injector harness plug, or a component within the ECU.

Voltage to Electric Fuel Pump Test

3- Leave one end of the jumper cable connected to a good ground on the powerhead. Disconnect the other end of the cable



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from the mercury switch. This connection was made in Step 1. Now, connect free end of the jumper cable to the negative terminal on the electric fuel pump -- the terminal with a Red/Purple lead still attached.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Attempt to start the powerhead. If the electric fuel pump now operates and the powerhead starts, the problem is a bad ground connection to the pump. Unfortunately, the Red/Purple ground lead is connected directly to the ECU. To obtain a satisfactory ground, the temporary jumper cable must be replaced with a new permanent ground lead.

If the powerhead did not start, remove the temporary jumper cable from the electric fuel pump terminal and connect it back to the terminal on the mercury switch, as directed in Step 1.

Obtain a voltmeter. Select the 12V DC scale. Rotate the ignition key to the **ON** position, with the jumper cable connected to the mercury switch still in place.

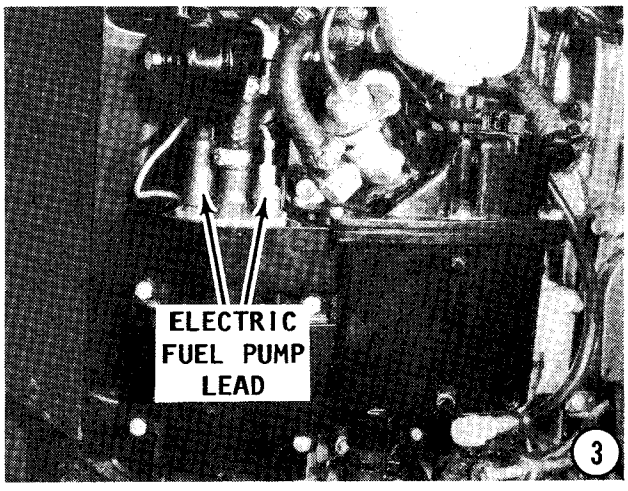
Disconnect the Red lead at the positive terminal on the electric fuel pump. Make contact with the Red meter lead to the positive terminal on the pump. Make contact with the Black meter lead to a suitable ground on the powerhead. The meter should register 12V.

If the meter fails to register 12V, keep the Black meter lead in place and move the Red meter lead to the positive terminal on the rectifier.

If the meter registers 12V at positive rectifier terminal, the ECU is defective, because the ECU is not transmitting voltage from its pickup point (here at the positive rectifier terminal) and delivering voltage to the pump.

If the meter fails to indicate 12V at the rectifier, the ECU is not being supplied with power and therefore cannot pass it on to the electric fuel pump. In this case the fault may lie in the battery, cables, connections, harness plug, or ignition switch.

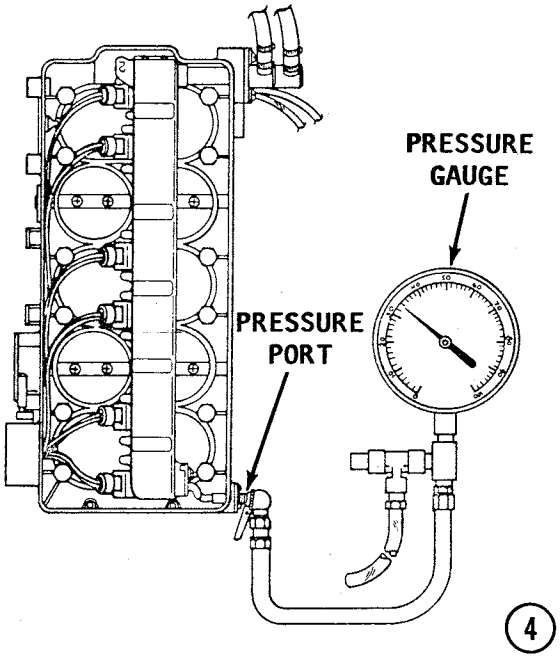
If the meter registered 12V at the electric fuel pump, the ECU is functioning correctly and the problem may lie in the portion of the fuel system past this connection: the electric fuel pump, the secondary filter or the injector harness plug.



3

Testing Electric Fuel Pump Operating Pressure

4- Obtain a pressure gauge capable of registering 50psi. Remove the plastic cap from the pressure port located portside at the bottom of the intake manifold. Connect the gauge to the pressure port. Rotate the ignition key to the **ON** position and crank the powerhead for about 15 seconds, with the jumper cable still in place grounding the mercury switch. Note the reading on the gauge. Normal powerhead operation requires pressure between 36 and 39psi (248.2 to 268.9kPa).



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If the reading is low, the cause may be a restriction in a fuel line. If there is no reading, the pump is defective and must be replaced. The pump is a sealed unit and **CANNOT** be serviced. See Page 4-91 for instructions on pump removal and replacement.

Secondary Fuel Filter

GOOD WORDS

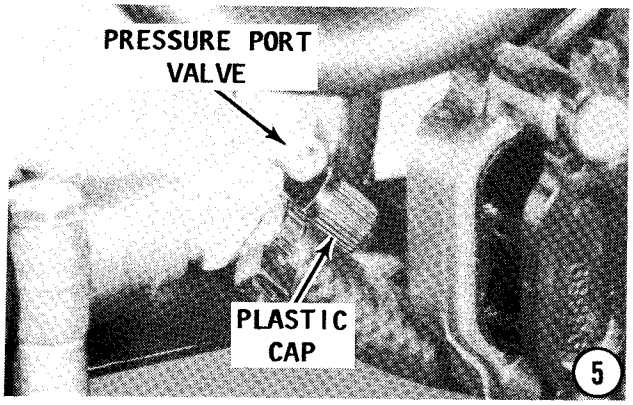
If the previous test proved fuel was being pumped from the electric fuel pump, then a clogged secondary fuel filter may be obstructing fuel flow to the fuel rail and injectors. Before the secondary fuel filter is removed, the system **MUST BE DEPRESSURIZED,** as described in the following step.

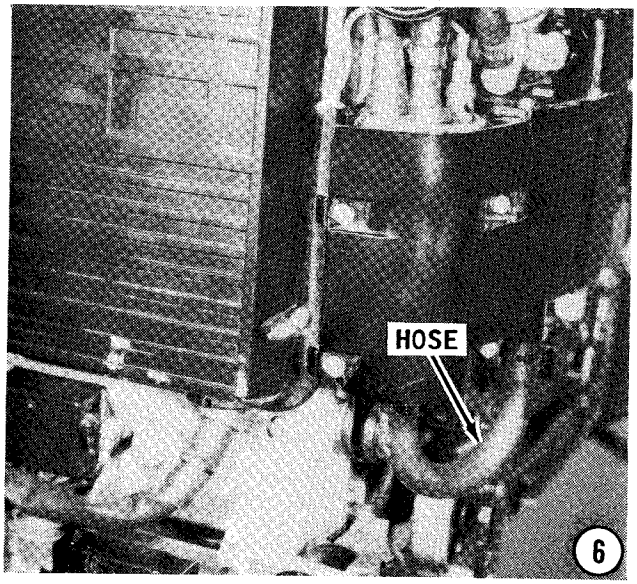
5- Remove the plastic cap over the pressure port located portside at the bottom of the intake manifold. A screwdriver will be used to depress the valve tip to release the pressure and allow fuel to drain from the valve. Place the screwdriver tip lightly over the valve tip and wrap a clean shop towel around the valve and screwdriver. This operation is similar to letting air out of tires! Once all the presssure has been released and the fuel flow ceases, refer to Page 4-89 to remove and service the secondary fuel filter.

Fuel Flow to Electric Fuel Pump

6- Obtain a suitable container and place it under the electric fuel pump and the vapor separator. Snip the Sta-strap around the hose connected to the bottom of the electric fuel pump. Gently pry the hose from the fitting on the pump and place the end in the container.

Rotate the ignition key to the "on" position and crank the powerhead, with the jumper cable still in place on the mercury switch, for about 15 seconds.



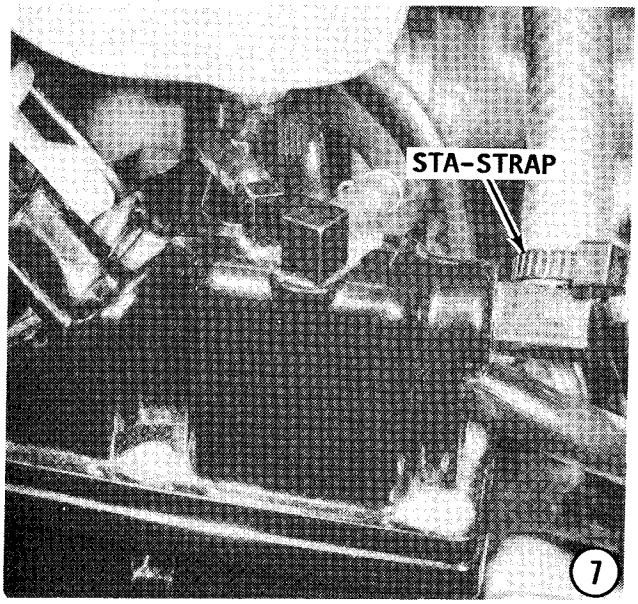


If fuel flowed from the disconnected hose, then all is well with the vapor separator, crankcase vacuum operated fuel pump, and water separating filter. Reconnect the hose using a new Sta-strap. If no fuel flowed, the problem could be with one of the components just mentioned.

If the vapor separator is suspected, see Page 4-91 for detailed procedures to remove, service and install the separator. After the work has been done repeat Step 4 to test the separator. If a course of further testing is decided upon, reconnect the hose using a new Sta-strap.

Fuel Flow Through Water Separating Filter

7- Obtain a suitable container. Snip the Sta-strap around the hose connected to the



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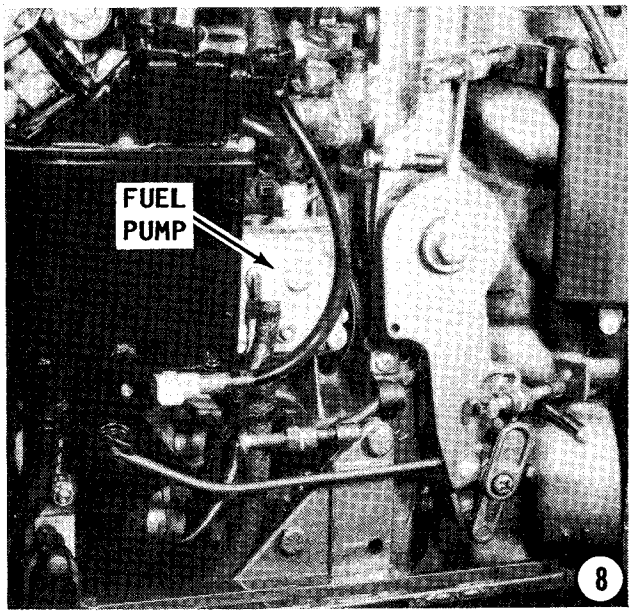
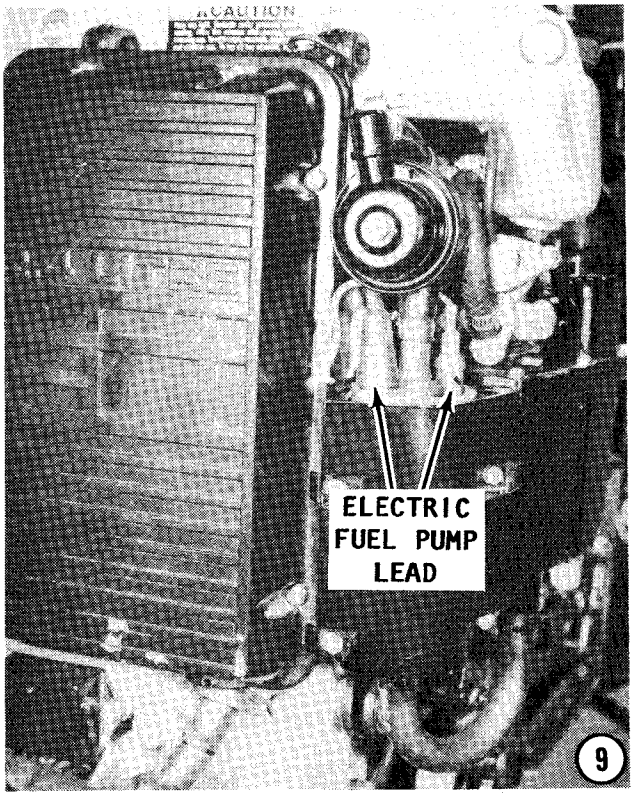


top of the vapor separator. Gently pry the hose from the fitting on the separator and place the end in the container.

Rotate the ignition key to the **ON** position and crank the powerhead, with the jumper cable still in place on the mercury switch, for about 15 seconds.

If fuel flowed from the disconnected hose, then all is well with the crankcase vacuum operated fuel pump and water separating filter. Reconnect the hose using a new Sta-strap.



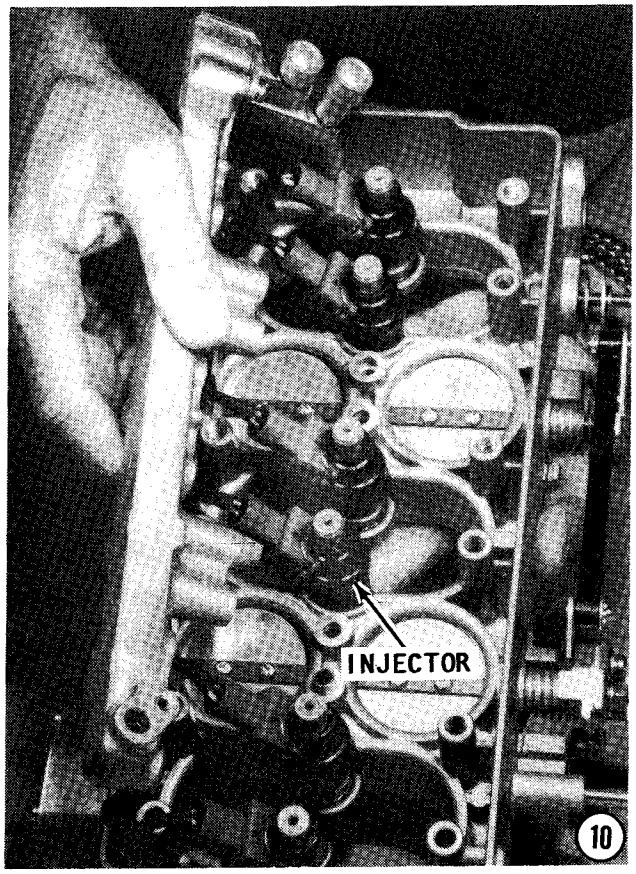
If no fuel flowed, the problem could be with one of the components just mentioned. Continue with the test procedures outlined in the following step to determine if the fuel is reaching the water separating filter. If fuel is found to flow up to the filter, but not through the filter, remove the Tan lead at the filter base. Remove the two fuel lines from the filter. Remove the attaching hardware and the filter. Install a new filter and secure it to the powerhead with the attaching hardware. Connect the two fuel lines and the Tan lead to the filter base.

Testing Crankcase Vacuum Operated Fuel Pump

8- To test the fuel pump, see the procedures beginning on Page 4-9. Service procedures for the fuel pump begin on Page 4-58. If the pump checks out okay, the fault may lie in the in-line fuel filter, or the filter at the base of the fuel tank pickup. Inspect, clean and replace as necessary.

Testing Injector Wiring Harness

9- Disconnect both the Red/Purple and Red leads at the fuel pump, to prevent the fuel being pumped during this test. Position the Red "hot" lead in such a manner to



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prevent it from making contact with any part of the powerhead.

10- To test for voltage to the injectors, the injector harness connector plug must be removed from each injector at the fuel rail. Perform Steps 1 thru 19 on Page 4-78 to remove the ECU and the induction cover from the manifold. These Steps can be performed with the unit removed from the powerhead, or with the unit still in place on the powerhead. The bolts securing the cover to the powerhead, pass through the manifold. Therefore, temporarily reattach the manifold to the powerhead while performing this test.

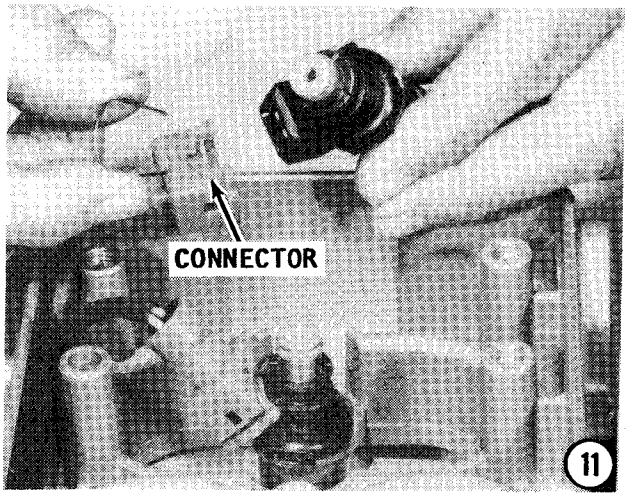
11- Once the connector has been removed from the injector, obtain a voltmeter and set the scale to 12V DC. Obtain a small jumper cable and use it to ground the manifold to the powerhead, because the three original grounding leads were removed in Step 9.

Rotate the ignition key to the **ON** position with the jumper cable still in place on the mercury switch.

Connect the Red meter lead to the Red injector lead and connect the Black meter lead to the other colored lead (two White, two Dark Blue and two Yellow leads) at each injector in turn.

The meter should register at least 9V at each injector. If voltage is present at each injector harness plug, skip the following test and proceed to Step 13. If voltage is not present at **ANY** injector connector plug, but Step 3 proved the ECU is supplied with battery voltage, then the ECU may not be supplying voltage to the main injector wire harness plug.

Reconnect the Red/Purple and Red leads at the electric fuel pump.



12- Disconnect the main injector harness at the connector plug. With the ignition key still in the **ON** position and with the jumper cable still in place on the mercury switch, check for voltage output from the ECU.

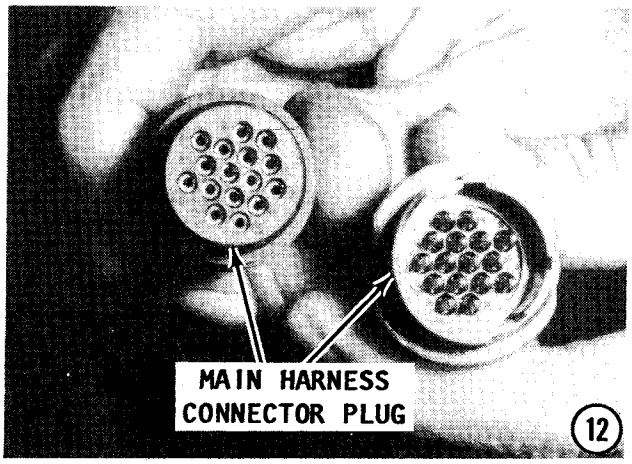
Obtain a voltmeter set to the 12V DC scale. Make contact with the Black meter lead to a good ground on the powerhead. Make contact with the Red meter lead to the Red #6 lead terminal at the connector plug from the ECU. If the meter registers no voltage, verify voltage is being supplied to the ECU by momentarily touching the Red meter lead to the "+" terminal on the rectifier. If voltage is indicated, then either the ECU is defective or there is a problem in the main ECU harness plug (which probably means a new ECU is required). If no voltage is indicated, remove the ECU and take the "Black Box" to the dealer for testing with a Quicksilver Fuel Injection Tester before purchasing a new unit.

If voltage is indicated at the Red #6 lead terminal at the connector plug from the ECU, but no voltage is indicated at any or only some of the plug connectors at the injectors, the injector harness is defective and must be replaced with a new harness.

The jumper cable, temporarily grounding the mercury switch, may now be removed and the Black/Yellow lead reconnected to the mercury switch terminal.

Testing Fuel Injectors

13- Follow the procedures outlined on Page 4-78 to remove the fuel injectors. Once the injectors are unplugged from their wiring harness and removed from the fuel rail, a simple test with a 9V battery can be performed to determine if the solenoid inside the injector is functioning properly.



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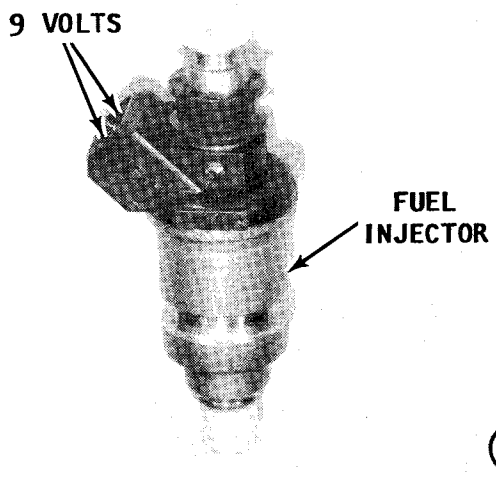
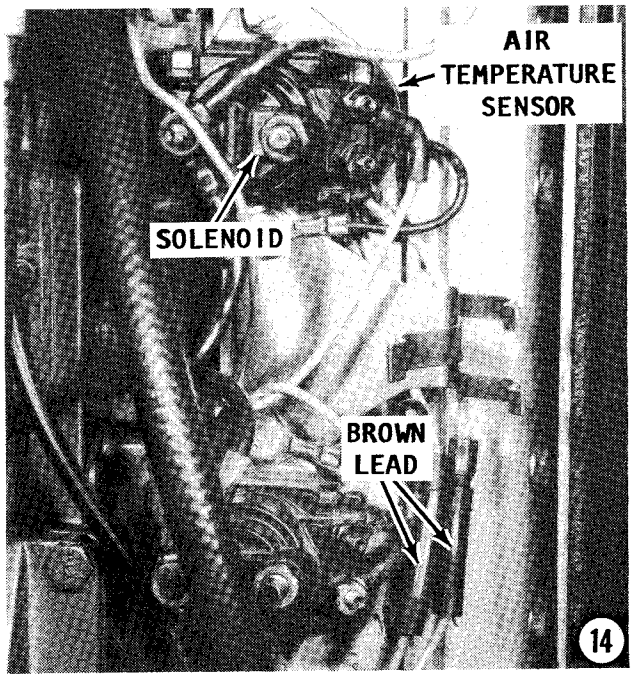


Obtain a 9V battery, such as those used in radios and calculators. Obtain two jumper leads with small alligator clips at each end.

Momentarily connect the battery across the two terminals inside the injector connector, making sure the two leads do not contact each other. For these tests the jumper cables may be connected in either way, because polarity does not affect the tests.

As soon as contact is made, the injector should emit a sound as the solenoid is energized and the needle is pulled off its seat. When contact is broken, the injector should again emit a sound as the needle returns under spring pressure back to its original position.



Perform this test on each injector in turn. If any injector fails this test, there is an internal defect in the injector. The needle is stuck or there is bad electrical connection. The injector must be replaced. A quick test to determine which of the two listed reasons prevent the injector from working properly is to perform a resistance test across the two injector terminals using a **DIGITAL** ohmmeter set to the Rx1 scale. Ohmmeter leads across the two injector terminals should register a reading of 1.1 ohm.

A clogged injector may possibly be cleaned by purchasing a fuel additive from the local automotive parts supply store and following the directions on the can.

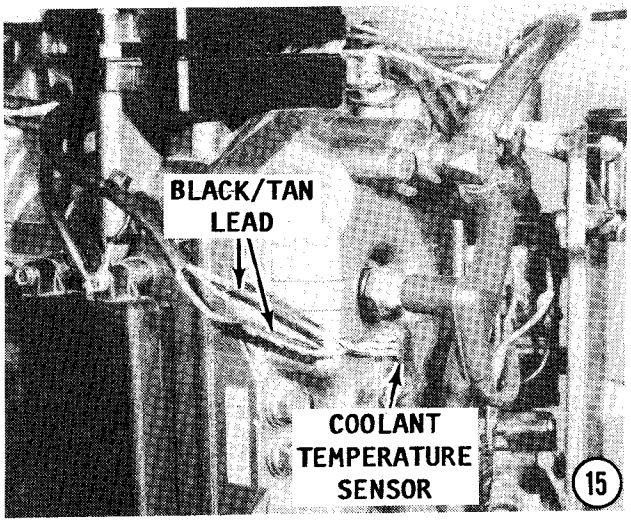
Air Temperature Sensor Resistance Check

The air temperature sensor need not be removed from the powerhead for testing purposes. This sensor is located on the starboard side of the intake manifold behind the upper trim/tilt solenoid.

14- Disconnect the two Brown leads from the air temperature sensor at their quick disconnect fittings. Obtain an ohmmeter and select the Rx1000 ohm scale. Make contact with the two meter leads across the two Brown leads. The meter should register approximately 8, (in reality 8,000 ohms). If the meter registers zero or infinity, the sensor should be replaced. If the meter registers in the kilo-ohm range, the sensor is probaby okay.

Coolant Temperature Sensor Resistance Test

15- Identify the two Black/Tan leads from the coolant temperature sensor loca-



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ted in the port head. Obtain an ohmmeter and select the Rx1000 ohm scale. Make contact with the two meter leads across the two sensor leads. The meter should register approximately 1, (in reality 1,000 ohms). If the meter registers zero or infinity, the sensor should be replaced. If the meter registers in the kilo-ohm range, the sensor is probably satisfactory.

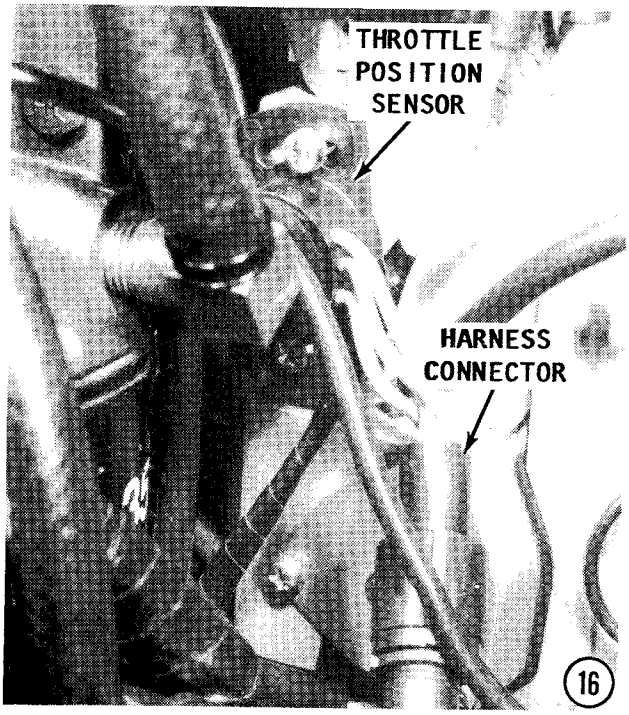
Throttle Position Sensor Resistance Test

Mark the original location of the throttle position sensor **BEFORE** performing any tests on the sensor which may lead to disturbing its original alignment. If this sensor is disturbed during testing or service procedures, a **DIGITAL** type voltmeter is needed to correctly reset the sensor on its mounting bracket, because voltages in the 1/10 range must be accurately read. A misaligned sensor could send misleading signals to the ECU and consequently affect the fuel delivery and ignition timing.

16- Mount the outboard in a test tank, or on a boat in a body of water.

RUNAWAY POWERHEAD

Never operate the powerhead above a fast idle with a flush attachment connected to the lower unit. Operating the powerhead at a high rpm with no load on the propeller shaft could cause the powerhead to **RUNAWAY** causing extensive damage to the unit.



Start the powerhead and allow it to run at 650 rpm until warmed to operating temperature.

CAUTION

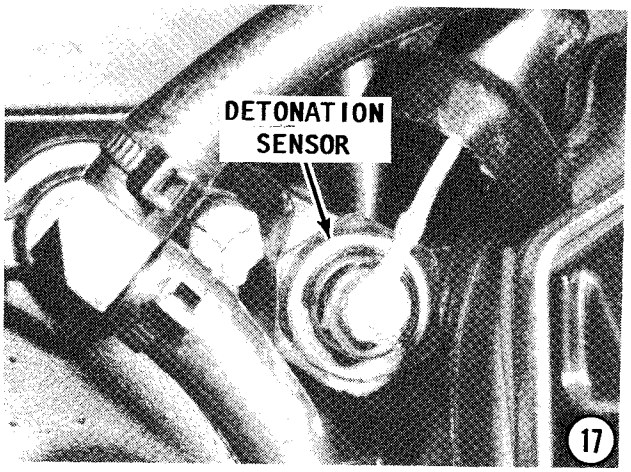
Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

DO NOT remove or change the throttle sensor position during the following test. Disconnect the wire harness from the sensor consisting of Orange, Light Blue and Tan/-Black leads at the harness connector. Obtain an ohmmeter and select the Rx1000 scale. Make contact with the Red meter lead to the Orange sensor terminal. Make contact with the Black meter lead to the Tan/Black sensor terminal. The meter should register between 800 and 1200 ohms at idle speed. Retain the Red meter lead in place, and move the Black meter lead to the Light Blue sensor terminal. The meter should register the same reading.

The lower the resistance reading, the leaner the air/fuel mixture. If the powerhead is overheating at idle speeds, perhaps due to an excessively lean mixture, the problem may lie in the throttle position sensor. Conversely, if the powerhead is smoking at idle speeds, due to an overrich mixture, again the problem may lie in a misaligned throttle position sensor.

Checking Detonation Sensor Resistance

17- Remove the single White/Blue lead from the detonation controller to the detonation sensor at the screw terminal of the sensor. Set this Black lead aside.



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Obtain an ohmmeter and set the scale to Rx1000 ohms. Make contact with the Red meter lead to the sensor terminal. Make contact with the Black meter lead to a suitable ground on the powerhead. A reading of no continuity (infinite resistance) should register on the meter. If the reading is less than infinity, there is a short in the sensor and the sensor **MUST** be replaced.

Checking Detonation Sensor Control Module

A **DIGITAL** voltmeter is required to perform this test.

18- Disconnect the Gray/White lead between the detonation module and the switchbox at the quick disconnect fitting. Make contact with the Red meter lead to the disconnected lead from the module and make contact with the Black meter lead to a suitable ground on the powerhead. Set the meter to the 10VDC scale.,

Mount the outboard unit in a test tank, or on a boat in a body of water.

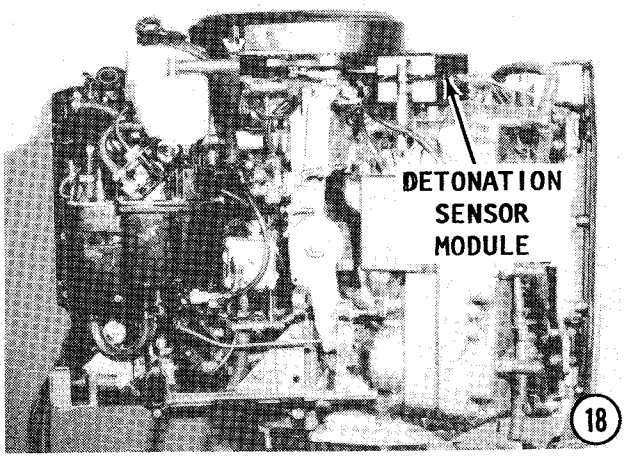
RUNAWAY POWERHEAD

NEVER, AGAIN, NEVER operate the engine at high speed with a flush device attached. The engine, operating at high speed with such a device attached, could **RUNAWAY** from lack of a load on the propeller, causing extensive damage.

Connect a tachometer to the powerhead.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.



Start the powerhead and allow it to reach operating temperature at idle speed.

The meter should register only one volt DC. Increase powerhead rpm to between 3500 and 4000. The meter should register zero volts. If the meter registers a fluctuating voltage higher than specified, the powerhead is experiencing detonation. If the meter registers a constant voltage higher than specified, the module is defective.

4-15 EFI FUEL SYSTEM MAINTENANCE

On fuel injected models, preventative maintenance includes checking, repairing or replacing:

loose, broken, cracked, kinked, or disconnected vacuum hoses

loose, corroded, or grounded electrical connections

loose, or improperly supported fuel rails, lines and injectors

dirty primary and/or secondary fuel filters

Even with the high price of fuel, removing gasoline that has been standing unused over a long period of time, is still the easiest and least expensive preventive maintenance possible. In most cases this old gas can be used without harmful effects in an automobile using regular gasoline.

LEADED GASOLINE AND GASOHOL

The manufacturer of the units covered in this manual recommends the powerheads be operated using either regular unleaded or regular leaded gasoline having a minimum octane rating of 86 or higher for all models with standard CDI ignition. However, the manufacturer recommends the use of premium unleaded or regular leaded gasoline with a minimum octane rating of 87 or higher for the V6 powerheads equipped with EFI.

In the United States, the Environmental Protection Agency (EPA) has slated a proposed national phase-out of leaded fuel, "Regular" gasoline, by 1988. Lead in gasoline boosts the octane rating (energy). Therefore, if the lead is removed, it must be replaced with another agent. Unknown to the general public, many refineries are adding alcohol in an effort to hold the octane rating.

Alcohol in gasoline can have a deteriorating effect on certain fuel system parts. Seals can swell, pump check valves can

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swell, diaphragms distort, and other rubber or neoprene composition parts in the fuel system can be affected.

Since about 1981, all manufacturers have made every effort to use materials that will resist the alcohol being added to fuels.

Fuels containing alcohol will slowly absorb moisture from the air. Once the moisture content in the fuel exceeds about 1%, it will separate from the fuel taking the alcohol with it. This water/alcohol mixture will settle to the bottom of the fuel tank. The engine will fail to operate. Therefore, storage of this type of gasoline for use in marine engines is not recommended for more than just a few days.

One temporary, but aggravating, solution to increase the octane of "unleaded" fuel is to purchase some aviation fuel from the local airport. Add about 10 to 15 percent of the tank's capacity to the unleaded fuel.

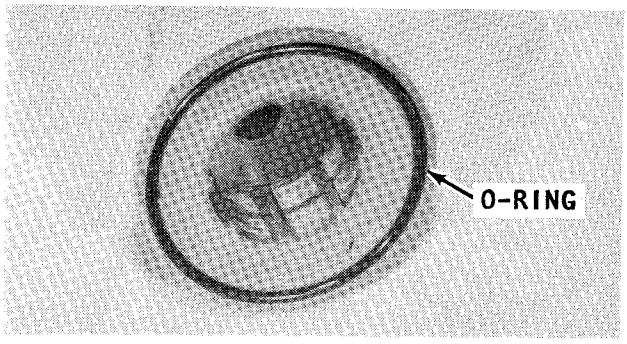
REMOVING FUEL FROM EFI SYSTEM

For many years there has been the widespread belief that simply shutting off the fuel at the tank and then running the powerhead until it stops is the proper procedure before storing the engine for any length of time. Right? **WRONG.**

It is **NOT** possible to remove all fuel in the system by operating the powerhead until it stops. Some fuel is trapped in the float chamber of the vapor separator, electric fuel pump, fuel filters, fuel pressure regulator and other passages and in the line leading to the fuel rail. The **ONLY** guaranteed method of removing **ALL** fuel is to take the time to drain the fuel completely from the system.

On fuel injected units, the manufacturer recommends the following procedures:

Prepare a mixture of 50:1 sufficient to keep the powerhead operating for ten minutes at idle speed. This mixture of 50:1 will provide an actual running mixture of 25:1 for operation.



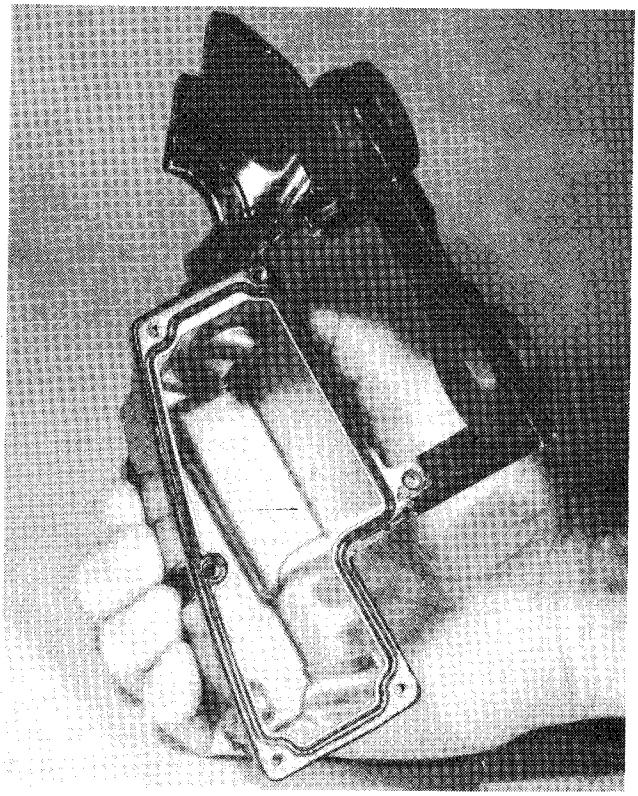
An EFI secondary filter screen with the sealing O-ring in place.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the powerhead and allow it to idle for about ten minutes. Disconnect the fuel supply from the tank at the fuel joint and allow the powerhead to die on its own from lack of fuel. Remove all the spark plugs and pour a couple of tablespoons of Quicksilver 2-Cycle Outboard Oil or a suitable substitute, into each spark plug opening. Place a socket over the flywheel nut and rotate the crankshaft **CLOCKWISE** through a few revolutions to evenly distribute and coat the internal powerhead parts with the oil. Install the spark plugs.

Remove the water separating filter and inspect the fluid draining from the filter. This filter should be changed each season or more frequently if purchased fuel is found to be contaminated. Remove the inlet hose



The vapor separator fuel bowl removed as part of the fuel draining procedure, as explained in the text.

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to the electric fuel pump and drain the contents of the vapor separator and as much as possible from the electric fuel pump. **DO NOT ATTEMPT TO OPEN THE ELECTRIC FUEL PUMP.** This pump is a sealed unit and **MUST** remain airtight.

Remove and drain fuel from the in-line fuel filter, if so equipped. **CAREFULLY** remove the cap from the secondary fuel filter. If any fuel remains in this filter after the powerhead has run dry, it will be under pressure from the electric fuel pump, therefore, release the cap slowly with a shop towel handy to soak up the fuel. Take the time to clean and inspect the fine wire mesh filter and wipe clean the inside of the cap and filter body.

4-16 SERVICING EFI

The following service procedures are divided into three parts.

First Part

The first portion covers servicing the intake manifold and the fuel injectors. Various sensors are attached to the intake manifold. These sensors may remain undisturbed because they do not affect the procedures. If the sensors themselves are to be removed and serviced, it is not necessary to remove the intake manifold, but merely to disconnect the wire harness or leads at quick disconnect fittings, remove the attaching hardware, and then remove the sensor from the powerhead.

Sometimes, as in the instance of the air temperature sensor, other components must be removed in order to gain access to the attaching hardware of the sensor. If servicing the throttle position sensor, mark the original location of the sensor **BEFORE** removal. If this sensor is misaligned during installation, a **DIGITAL** type voltmeter is needed to correctly reset the sensor on its mounting bracket, because voltages in the 1/10 range must be accurately read. A misaligned sensor could send misleading signals to the ECU and consequently affect the EFI and the ignition timing.

Second Part

The second portion of this section provides service procedures for the secondary fuel filter, the fuel pressure regulator, and the vapor separator. Procedures for these items begin on Page 4-89.

Third Part

The third portion of the section provides service procedures for the throttle position sensor. This sensor requires special adjustment following installation. Procedures for this sensor begin on Page 4-95.

SERVICING INTAKE MANIFOLD AND FUEL INJECTORS

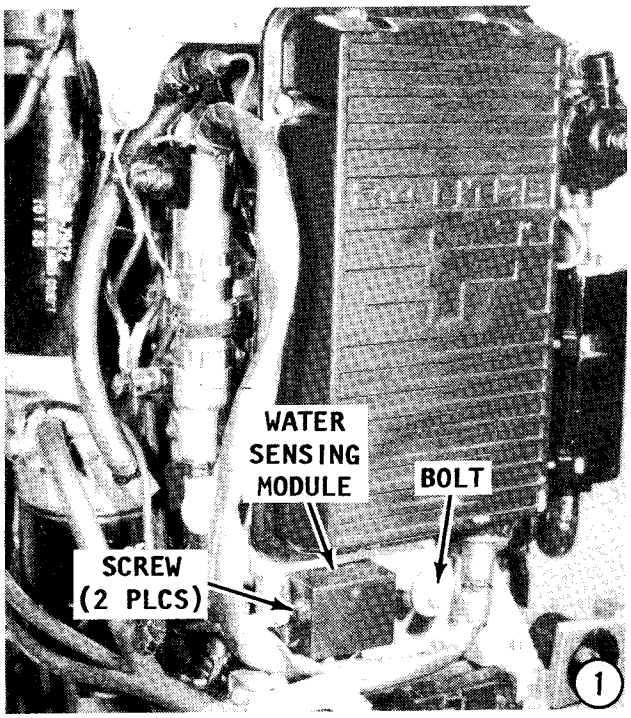
Removal

1- Remove the two screws securing the water sensing module to the powerhead. The left screw has two small Black grounding leads attached. The module will still be connected to the powerhead by other leads. Move the module aside. Remove the large bolt in the center at the base of the ECU.

SPECIAL WORDS

DO NOT disturb the small Phillips head screws around the perimeter of the ECU. The cover of the ECU will not come away once these bolts are removed. The bolts were installed during manufacture of the unit, and then the cover and the case were hermetically sealed using the Phillips head screws for alignment. Therefore, no purpose will be served, if these screws are removed.

2- Remove the two nuts on the studs at the top of the ECU. The right stud has a small Black ground wire over it.



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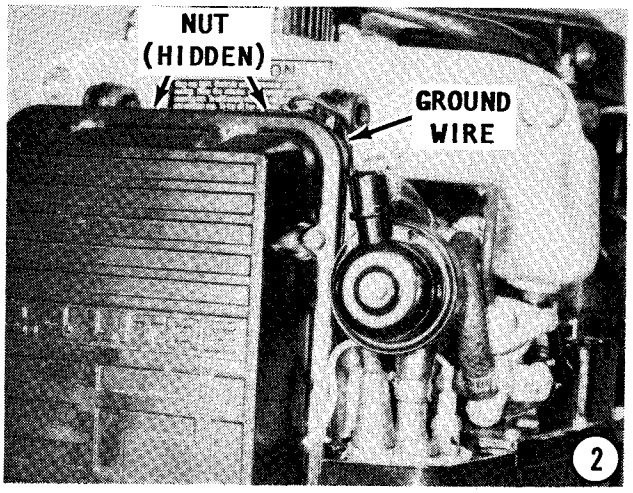
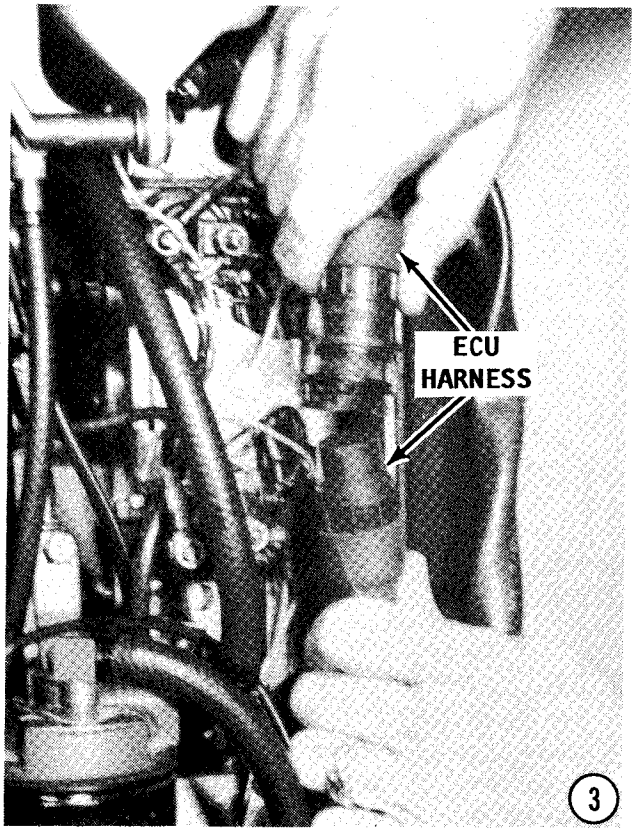
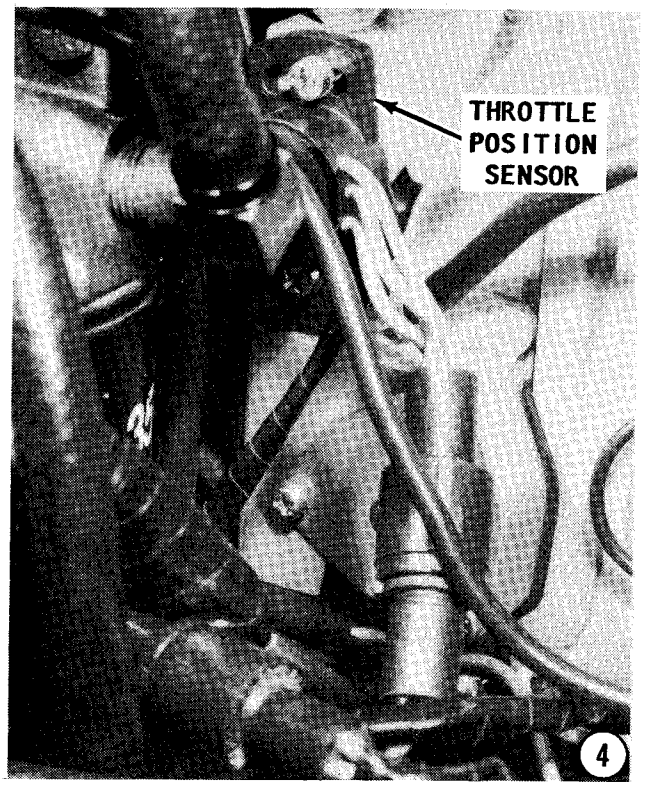


GOOD WORDS

It is far easier to disconnect leads and leave components still attached to the intake manifold, because some components are mounted behind others and should not be disturbed. For example: if the throttle position sensor is misaligned during installation, a **DIGITAL** type voltmeter is required to correctly reset the sensor on its mounting bracket. Voltages in the 1/10 range must be accurately read. A misaligned sensor could send misleading signals to the ECU and consequently affect the EFI and the ignition timing.

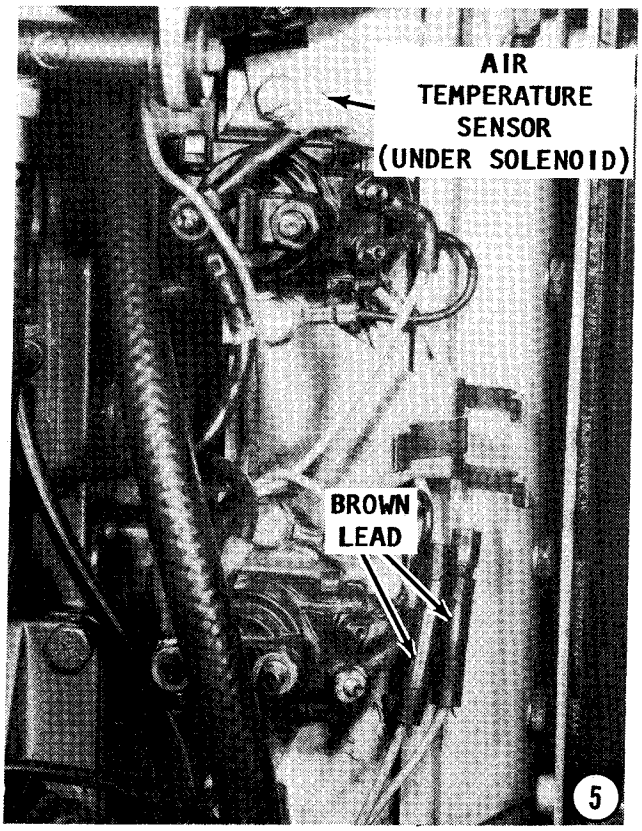




3- Disconnect the main harness plug.

4- Disconnect the throttle position sensor harness plug.

5- Disconnect the two leads from the air temperature sensor at their quick discon-



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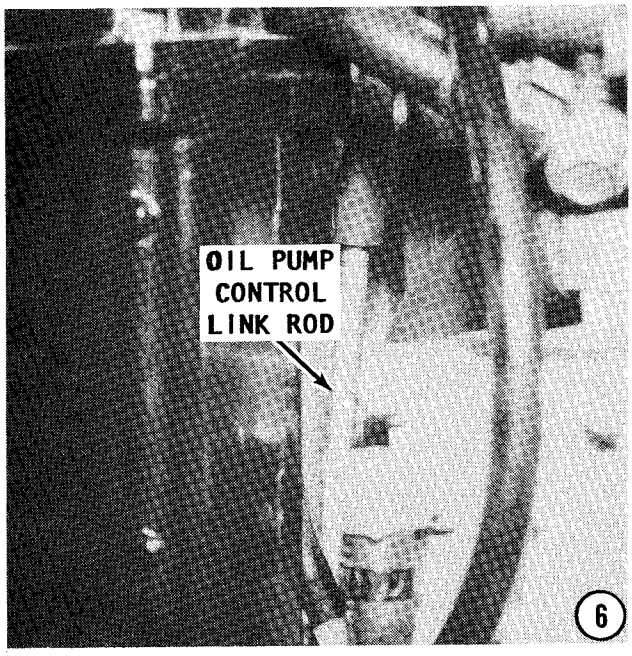
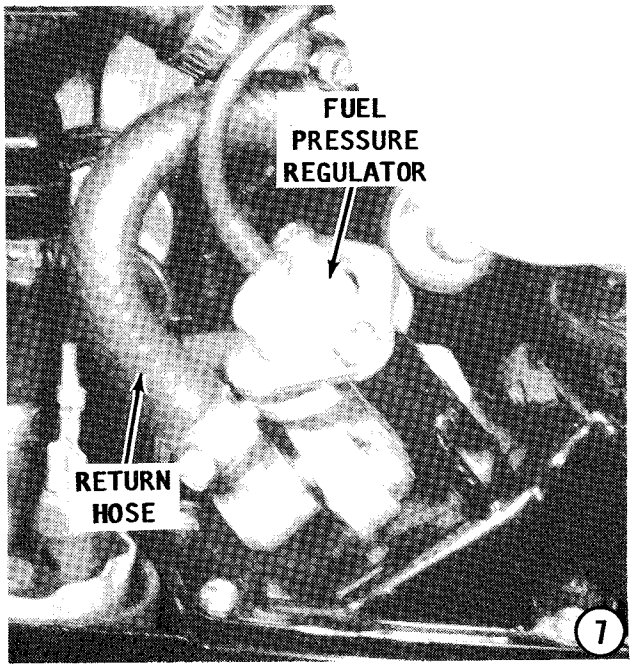


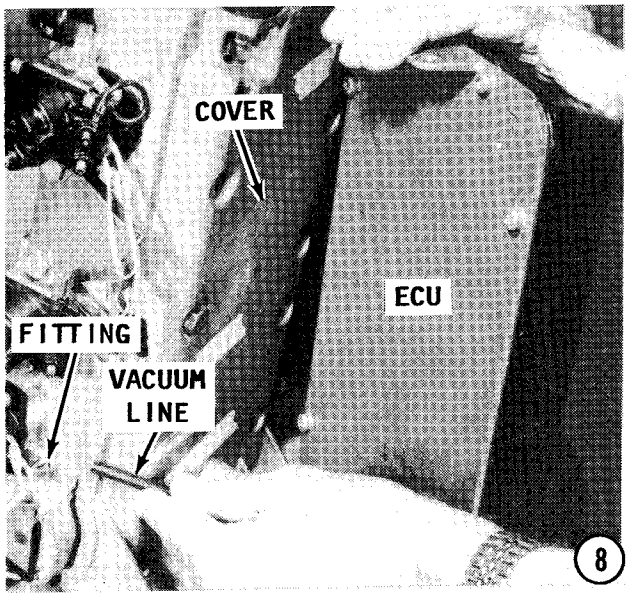
nect fittings. Disconnect the leads to the **UP** and **DOWN** trim/tilt solenoids. Disconnect the fuel injector plug harness.

6- Pry the oil pump control link rod from the ball joint on the intake manifold, leaving the rod on the oil pump. Disconnect the throttle control link rod from the throttle cam.

GOOD ADVICE

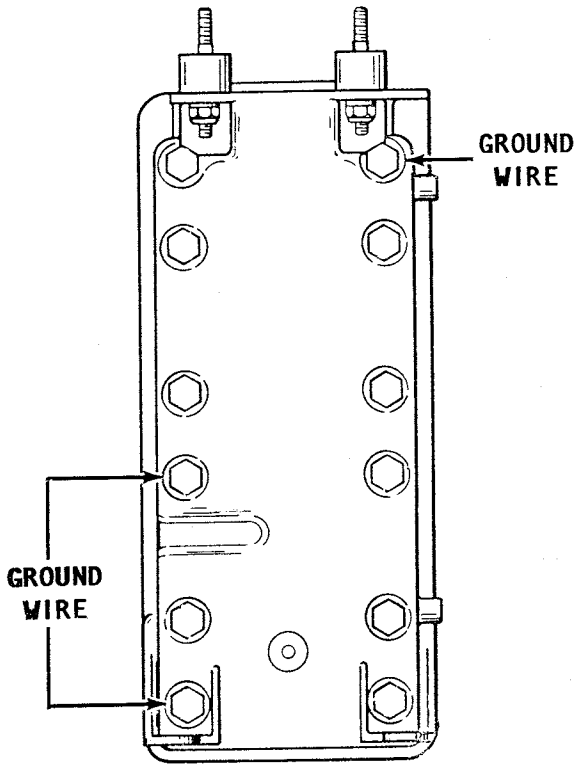
Three vacuum hoses connect the intake manifold to the vapor separator, the fuel pressure regulator and the ECU. Identify these hoses and tag each one as an assist in later installation.





Gently ease the two vacuum hoses free. One hose leads to the fuel pressure regulator and the other hose leads to the vapor separator. Loosen the clamp from the fuel supply hose at the secondary filter, and gently pull the hose free of the filter fitting.

7- Loosen the clamp and remove the return fuel hose from the fitting at the fuel



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pressure regulator. Lift off the cowl bracket which supported the ECU. Remove the two bolts from the lower support bracket.

8- Disconnect the vacuum line from the ECU at the fitting on the manifold next to the pressure port. Remove the ECU from the front cover.

9- Note the location of the three grounding leads on the front face of the intake manifold cover, as an aid during installation. Remove the twelve bolts securing the manifold to the powerhead. Notice all bolts are not the same length. Make a note as to length and location.

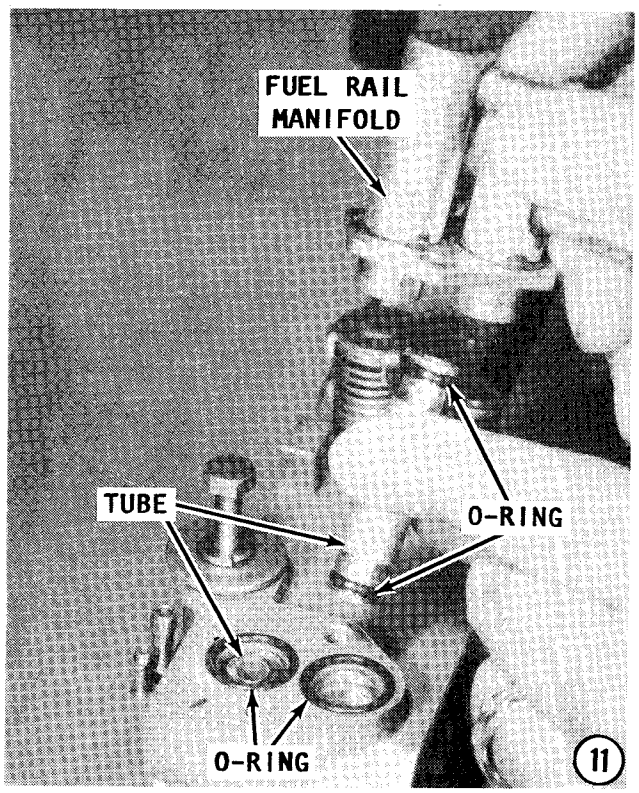
Lift the intake manifold from the powerhead. Remove and discard the gasket. Remove the front cover and gasket from the manifold.

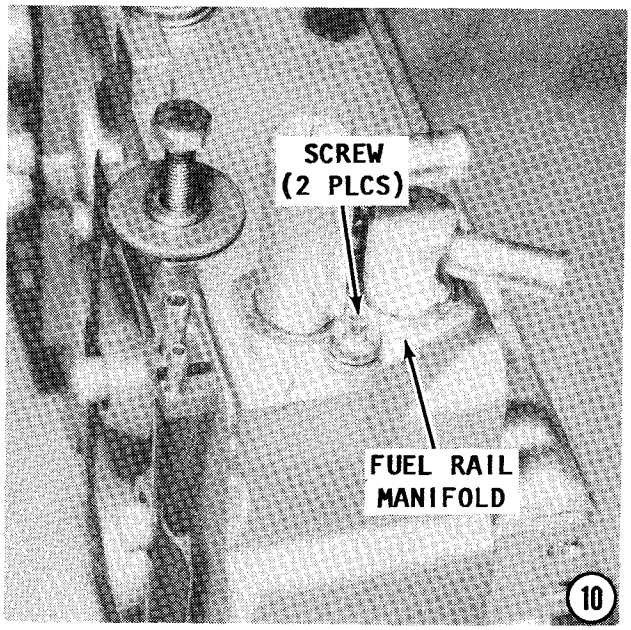
10- Remove the two Phillips head screws with captive lockwashers from the fuel rail manifold.

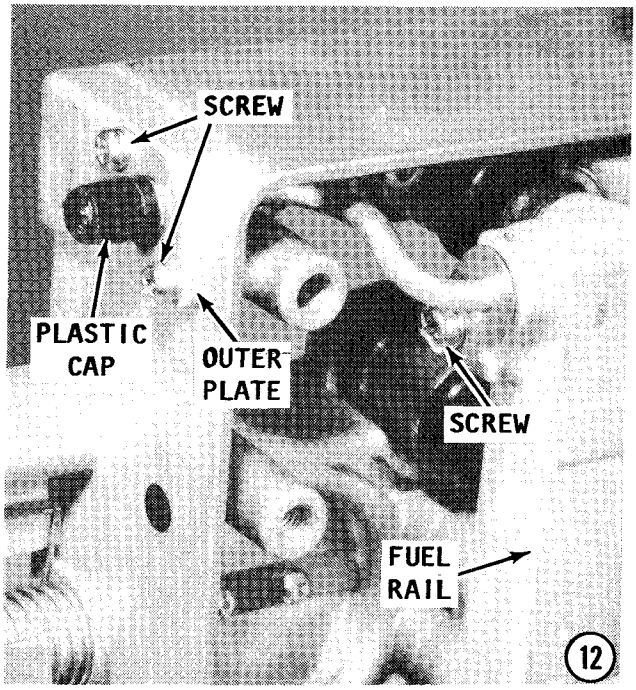
11- Gently pull the fuel rail manifold from the intake manifold. Two tubes are installed under the fuel rail manifold which will either come away with the fuel rail manifold or stay inside the intake manifold. Remove the two tubes. Both tubes are identical and have an **O**-ring at each end. The **O**-rings need not be removed unless they are no longer fit for service. Remove the two **O**-rings which seal the fuel rail-to-intake manifolds.

12- Remove the plastic cap from the pressure port on the side of the intake manifold. Remove the two Phillips head screws with captive lockwashers and the outer plate securing the port to the manifold. Remove the Phillips head screw with captive lockwasher from the fuel rail.

13- Ease out the pressure port fitting. As the port is pulled just slightly from the seated position, the attached tube will come out of the fuel rail. A number of small items along the length of this tube must be accounted for and not lost. First, a small **O**-ring around the pressure port. Next, another small **O**-ring around the tube, then a







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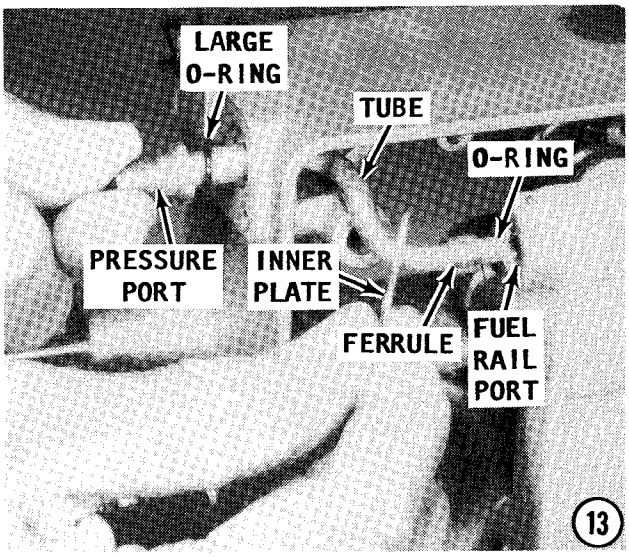
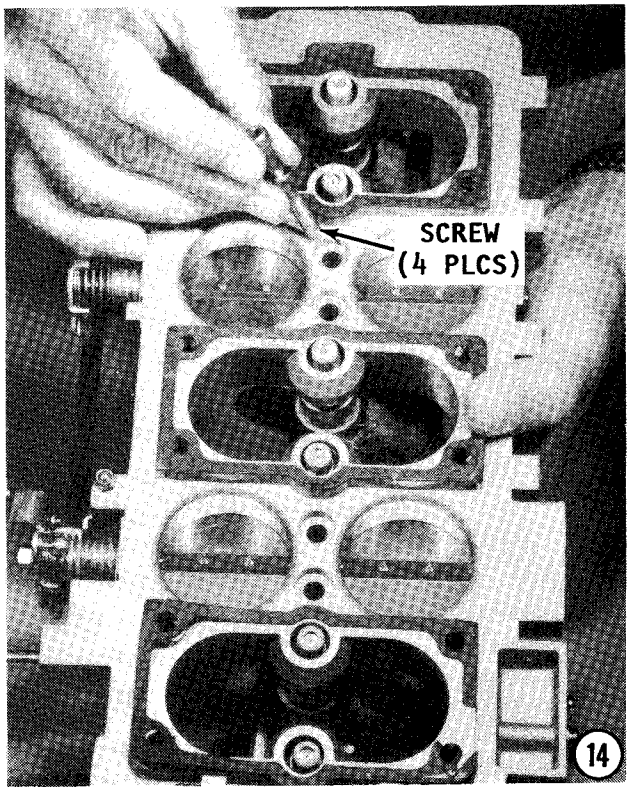


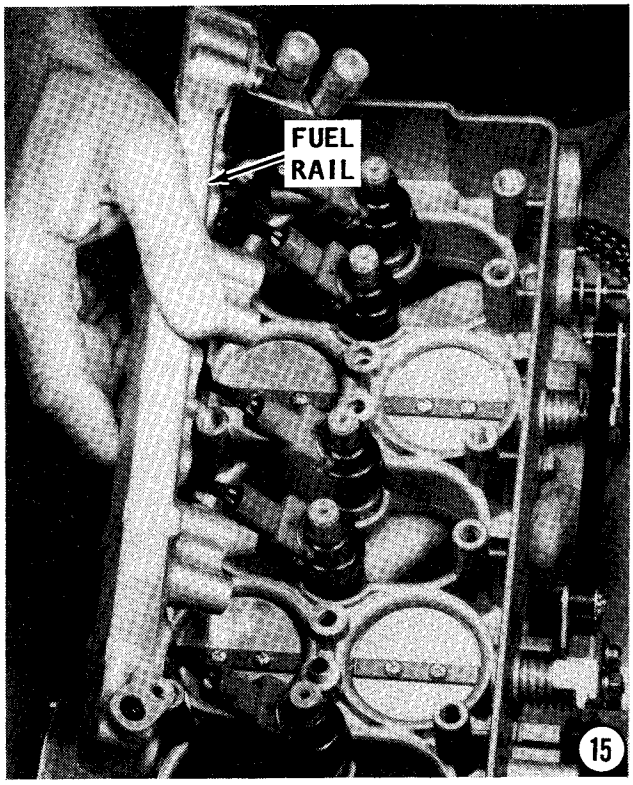
ferrule, and finally an inner plate. The items around the tube cannot be removed until the tube clears the port. The tube may then be guided clear of the manifold.

14- Remove the four long Allen head screws from the injector side of the manifold. Support the fuel rail and turn the manifold over.

15- Separate the fuel rail from the fuel injectors.

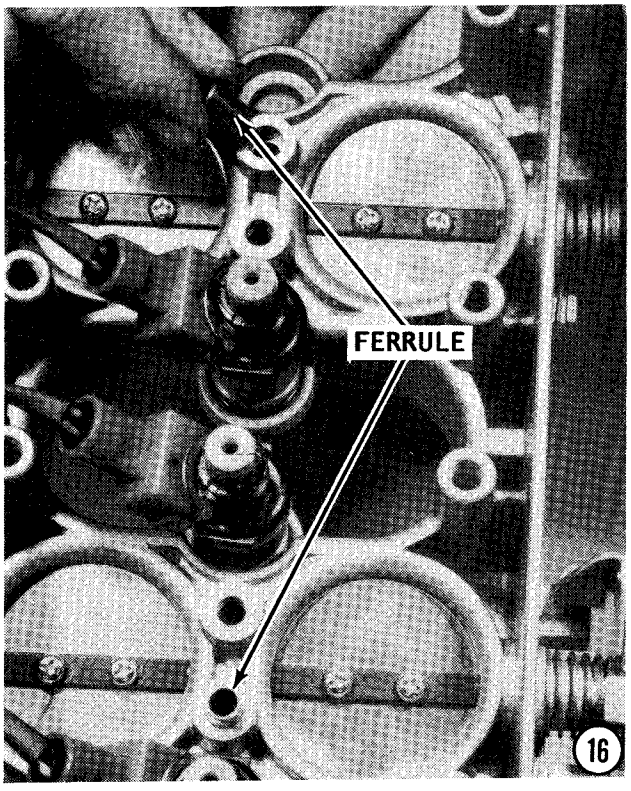
16- Remove the two ferrules from the manifold. These two ferrules may have remained either with the manifold or in the fuel rail.





17- Remove the two Phillips head screws with captive lockwashers from the fuel rail support tube. Lift the support tube from the rail. Lift out the two tiny plugs and a total of four O-rings from the rail.

18- Slowly pull each injector straight up and free of the manifold. The injectors are



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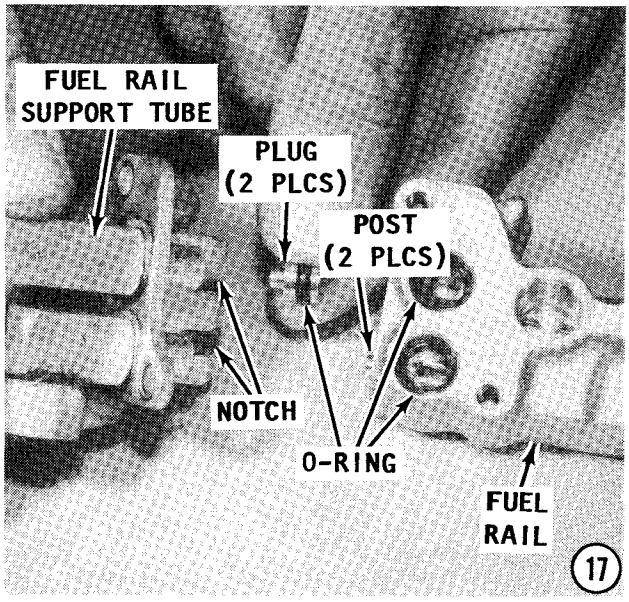
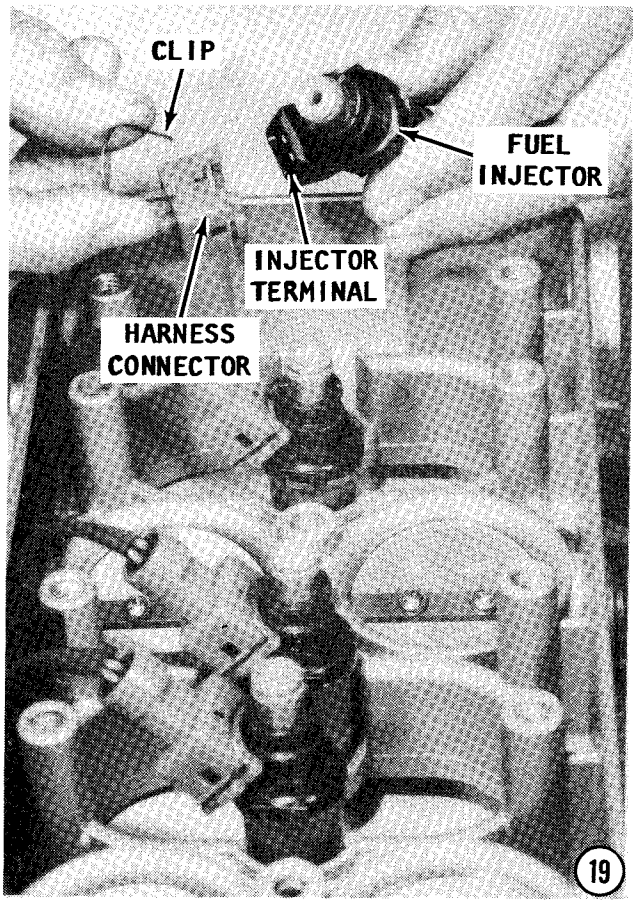
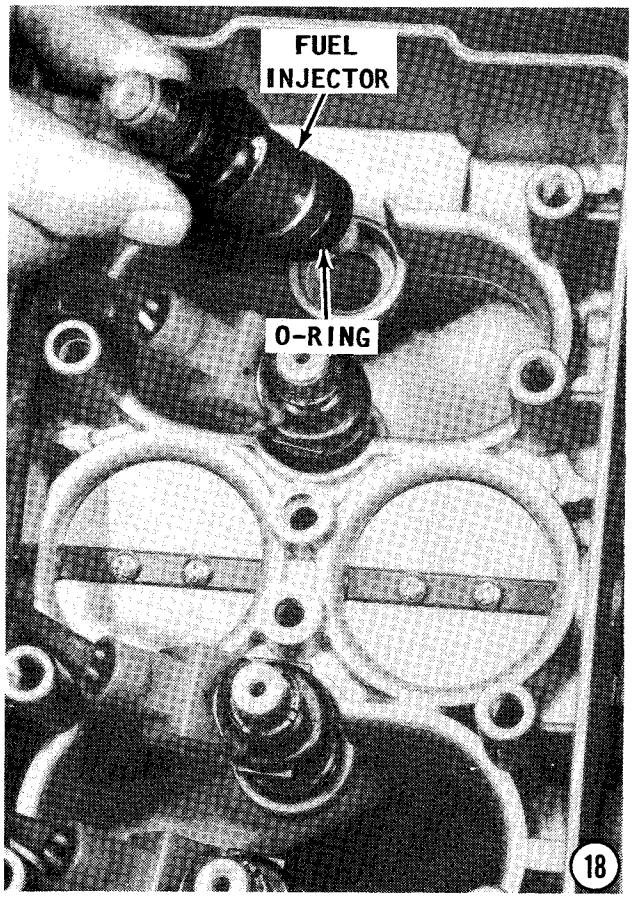
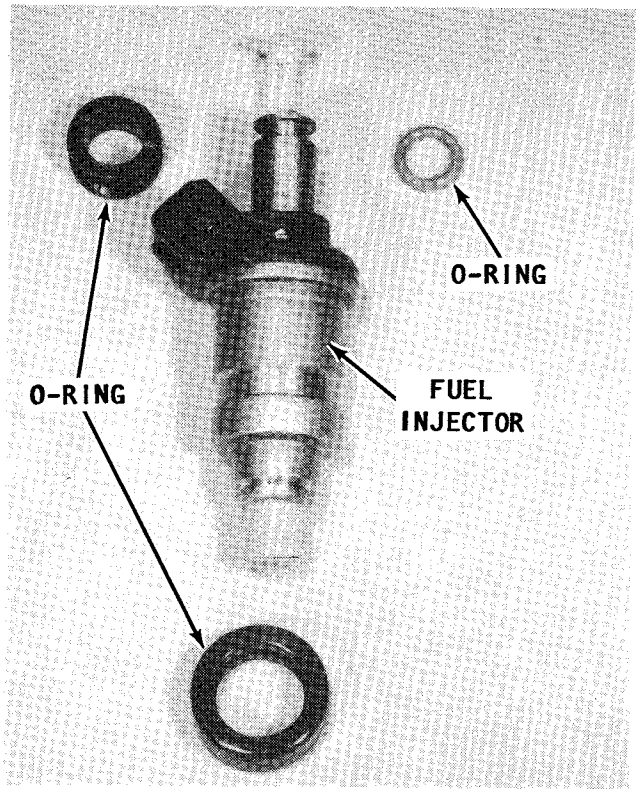


held in the manifold by rubber sealing rings only. These rings may harden or become gummy, depending on use, making removal of the injectors difficult.

19- Using a small slotted screwdriver, pry the retaining clip from the injector harness connector. Disconnect the harness from the injector. Disconnect the harnesses from the other injectors in a similar fashion.







An individual kit containing the necessary O-rings to seal just one injector during installation, may be purchased from the local marine dealer. A new kit for each injector removed should be purchased.

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CLEANING AND INSPECTING

The intake manifold, with sensors attached, may be carefully cleaned using a parts brush and solvent. Try not to get the solvent on the sensor or the wire harnesses.

NEVER dip rubber parts or plastic parts in carburetor cleaner. Blow the manifold dry with compressed air.

Move each throttle shaft back-and-forth to check for wear. If any shaft appears to be too loose, replace the manifold. Individual replacement parts are **NOT** available.

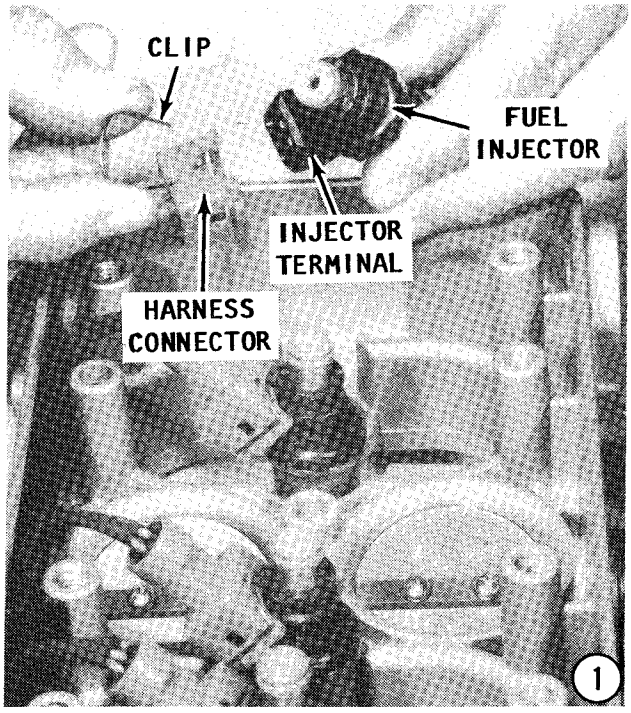
Check action of the throttle return springs. Remove and replace as necessary.

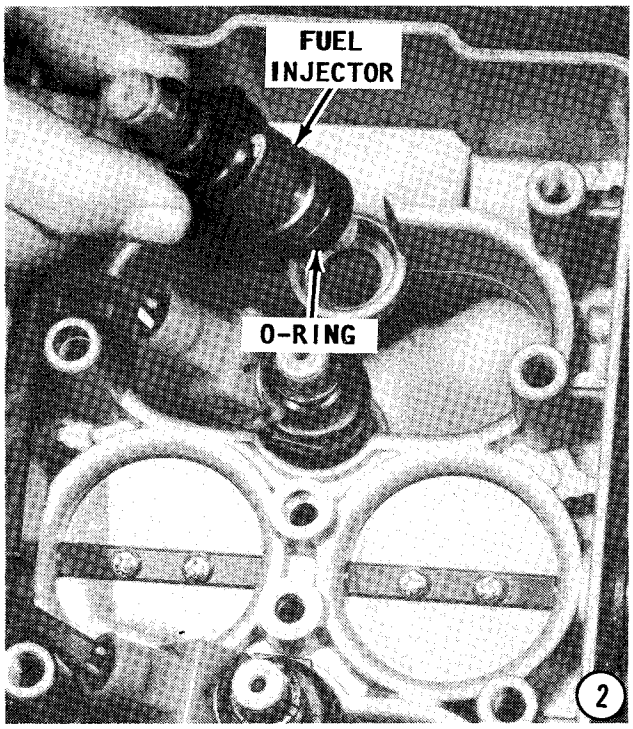
Inspect the main body of the intake manifold and cover gasket surfaces for cracks and burrs which might cause a leak.

A simple test on the internal fuel injector solenoids may be performed as described in Step 13 on Page 4-74.

Two **O**-rings are used to secure each injector in the fuel rail. One **O**-ring provides a seal between the injector nozzle and the intake manifold. The other **O**-ring provides a seal between the injector and the fuel inlet connection. Both **O**-rings prevent excessive injector vibration. These **O**-rings are replaceable and are included in an injector overhaul kit.

Inspect the sensors as far as possible without disturbing them. Check the wire harnesses for signs of chafing, cracks, or corroded connections.



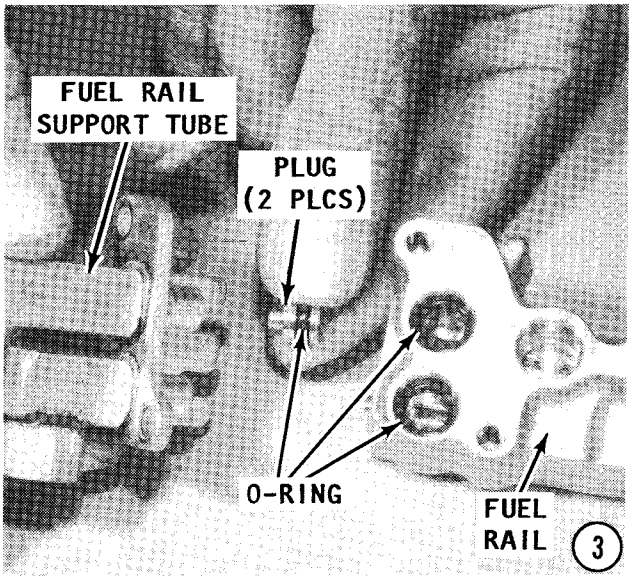


INSTALLATION

1- Position the retaining clip around the injector wire harness. Push the injector harness connector firmly over the injector terminal. The harness can only be connected one way. Slide the clip into place to secure the harness connector to the injector.

2- Using **NEW O**-rings, push the injector into place to seat firmly into the intake manifold. Repeat Step 1 and this step for all injectors.

3- Install the two tiny plugs into the fuel rail, with the larger end of the plug going into the fuel rail first. Install the two



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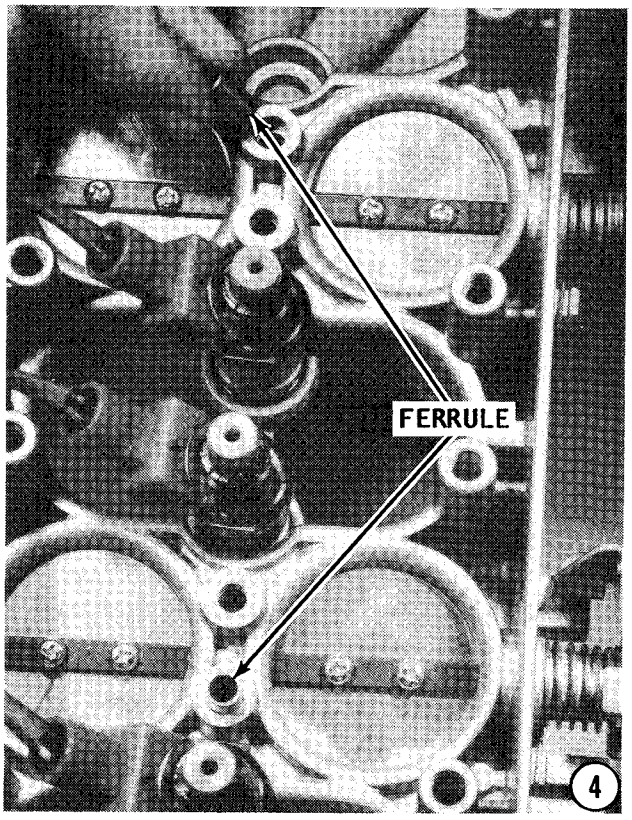
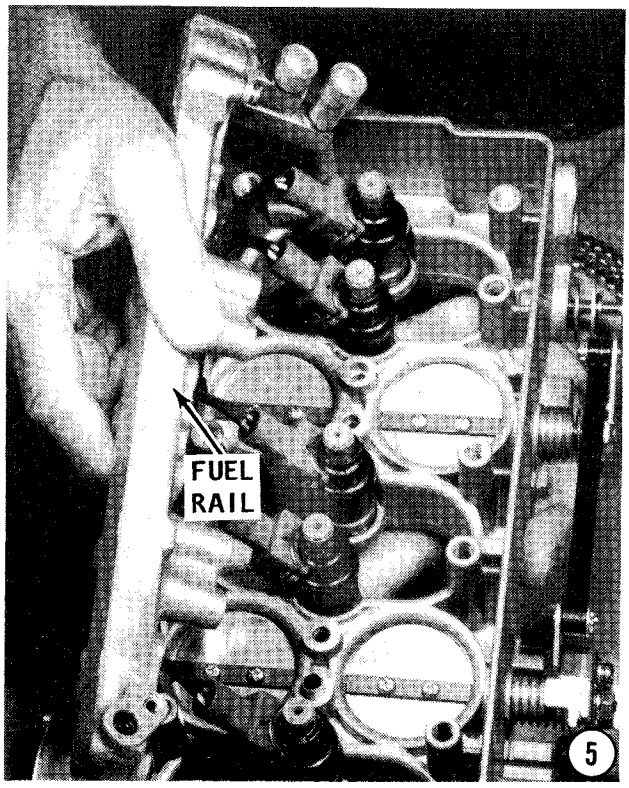
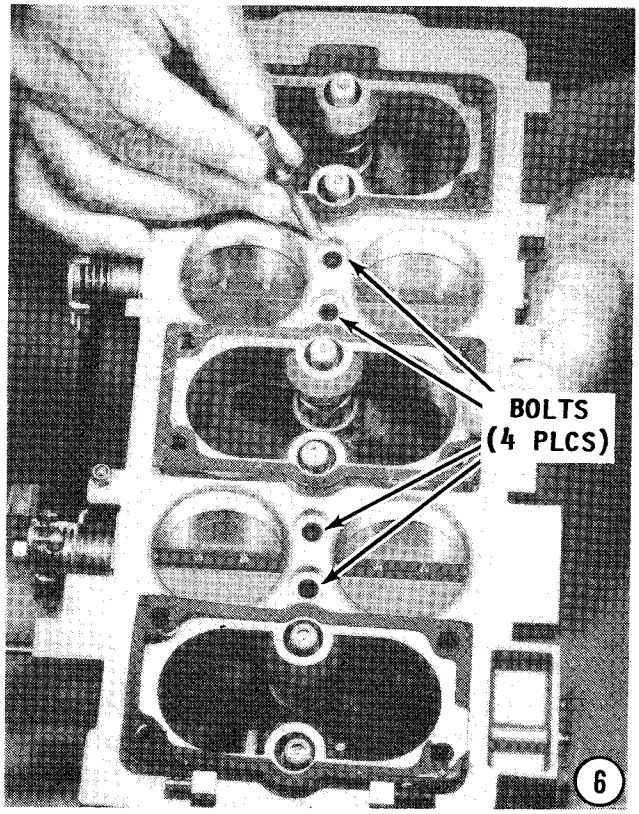


sealing O-rings over the two fuel ports in the rail. Install the fuel rail support tube over the rail with the two notches indexing over the two posts on the rail end. This ensures the support can only be installed one way over the rail. Install and tighten the two Phillips head screws with captive lockwashers.



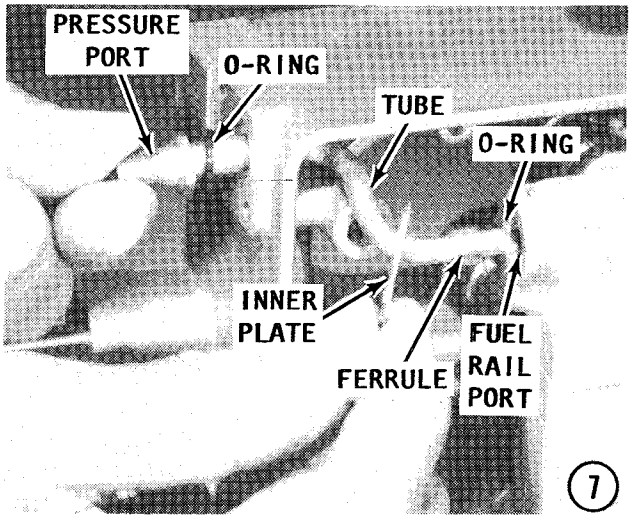


4- Position the two ferrules over the two outer holes in the intake manifold.

5- Lower the fuel rail over the ferrules and injectors. Make sure the rail is seated properly over each injector and none are askew. Support the rail with one hand and turn the manifold over.

6- Install the four long Allen head bolts. Tighten the bolts alternately and evenly to a torque value of 25 in lb (3.4Nm).

7- Slide the large O-ring over the tube. This O-ring remains on the outside of the



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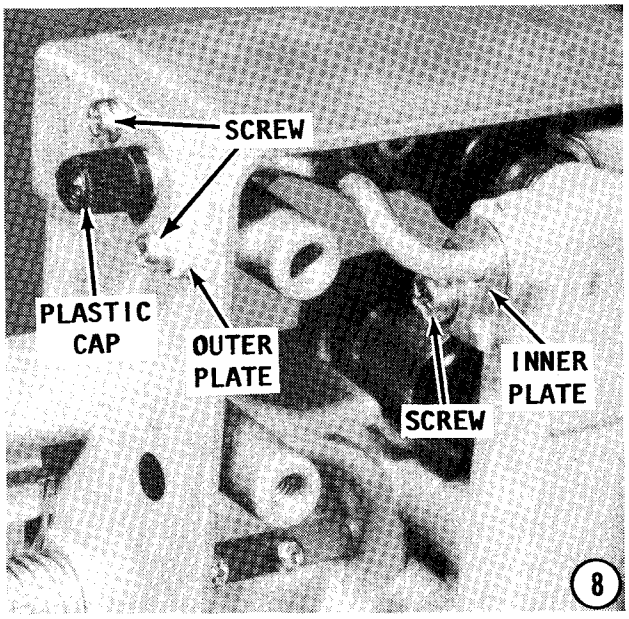
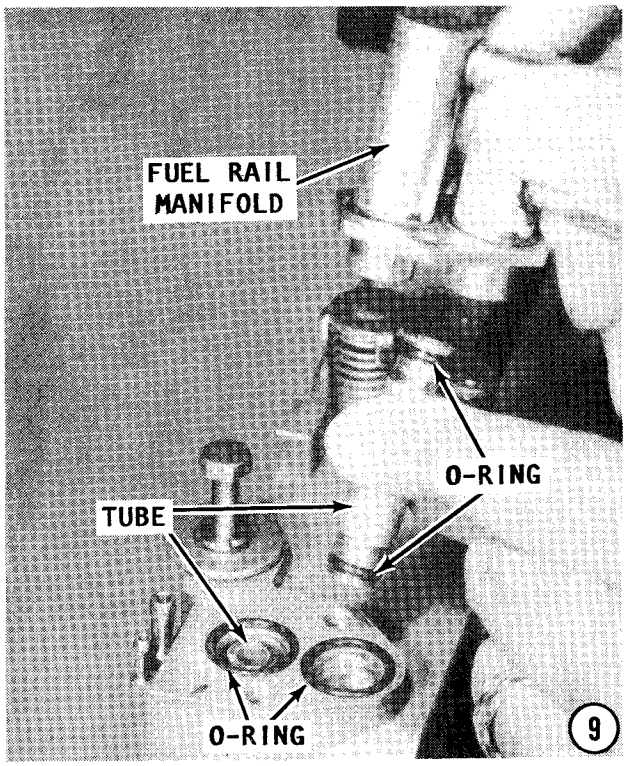
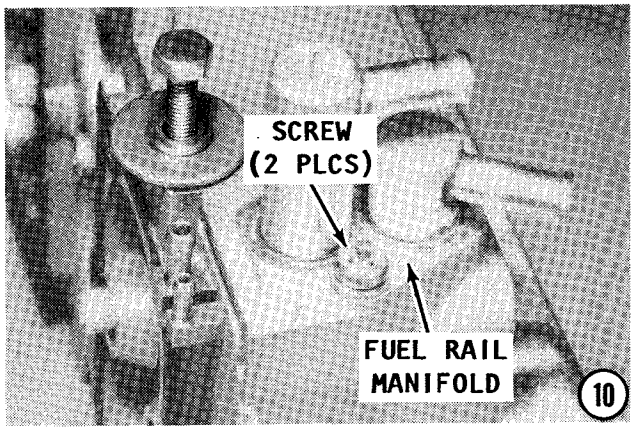


manifold. Insert the tube into the pressure port hole. Over the tube, first slide the inner plate, with the tang on the plate facing toward the rail upon installation, then the ferrule, and finally the small O-ring. Guide the tube into the fuel rail port, with the O-ring and ferrule entering the port first. Secure the inner plate to the rail with the Phillips head screw and captive lockwasher.

8- Seat the pressure port valve and O-ring into the manifold. Slide the outer plate over the valve, with the two screw holes



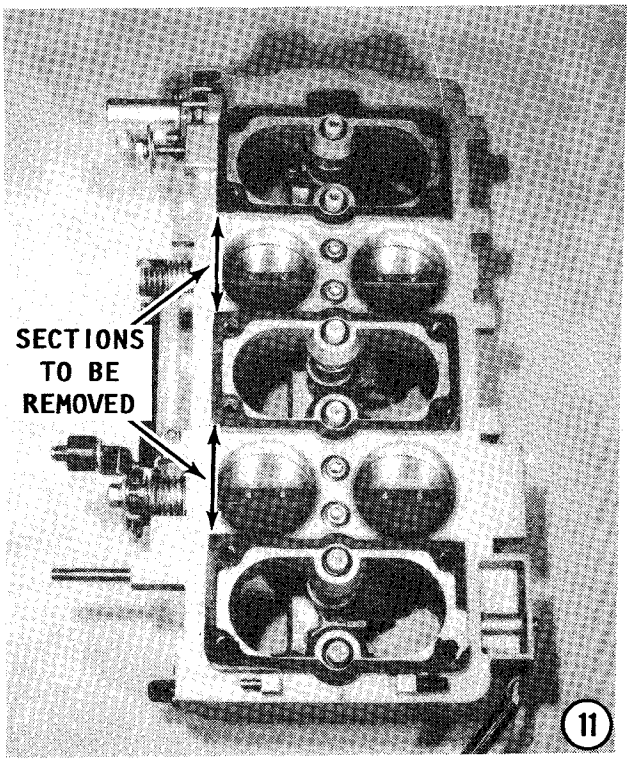


aligned. Install and tighten the two Phillips head screws with captive lockwashers.

9- Insert the two identical tubes, with an O-ring at each end, into the intake manifold. These tubes must seat in the fuel rail support tube. Position two O-rings over the ports. Install the fuel rail manifold over the tubes. The manifold can only be installed properly one way. The bolt holes will not align if the manifold is positioned incorrectly.

10- Install and tighten the two Phillips head screws securing the fuel rail manifold to the intake manifold.

11- Position a new gasket on the intake manifold. This gasket is purchased and installed in one piece. After installation, four sections of the gasket are removed, as indicated in the accompanying illustration.



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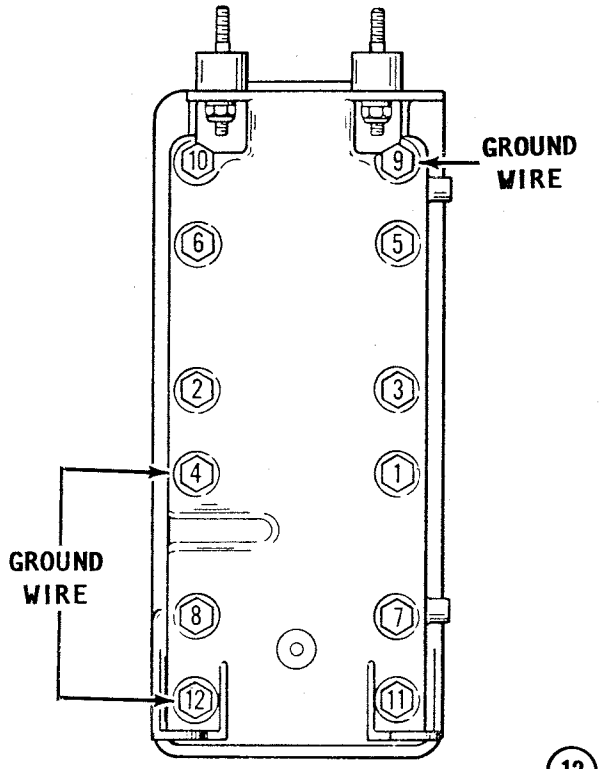
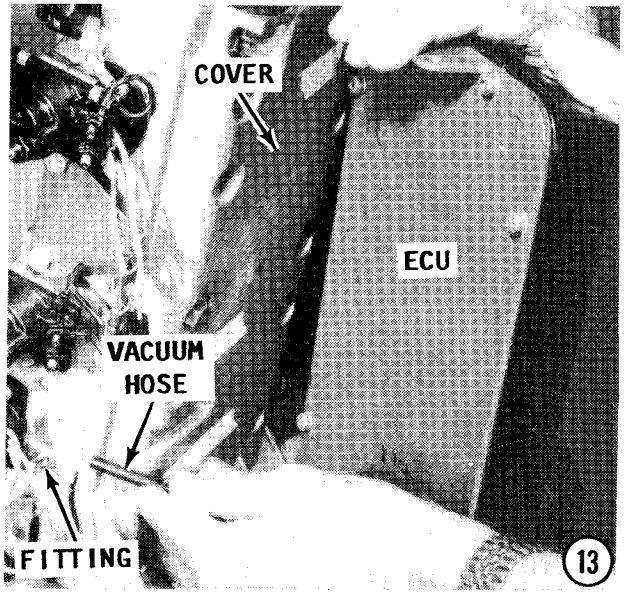


12

12- Install the intake manifold to the powerhead. The securing bolts have different lengths. Bolts identified as No. 4, 12, and 9 have grounding wires attached. Tighten all bolts to a torque value of 90 in lb (10.2Nm) in the sequence shown in the accompanying illustration. Position the top cowl bracket over the two studs on top of the intake manifold cover.

13- Connect the vacuum hose from the MAP sensor inside the ECU to the fitting on the intake manifold.



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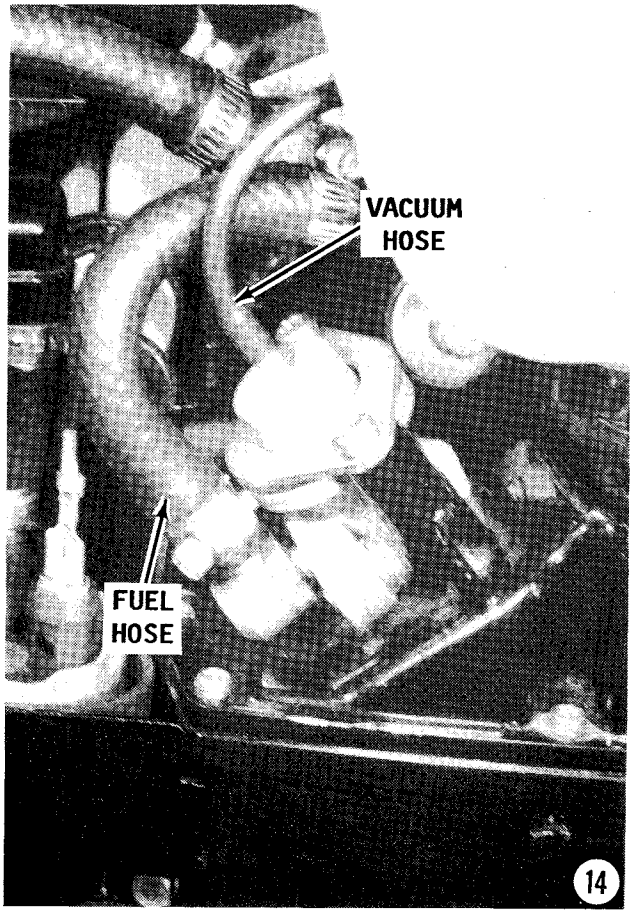
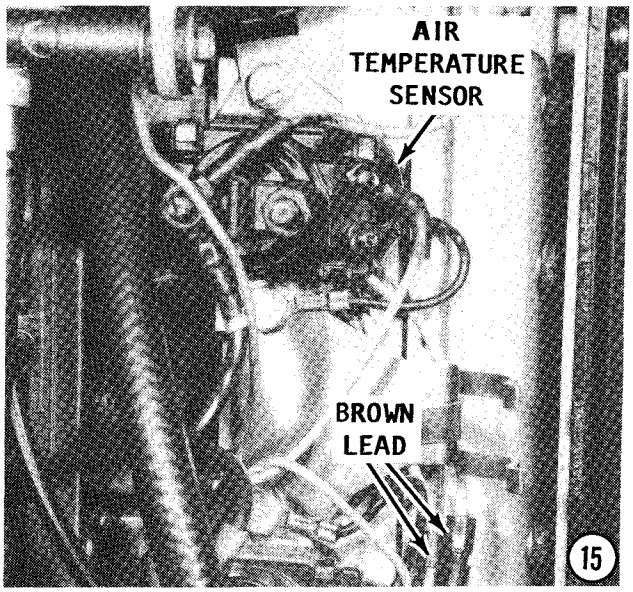


14

14- Connect the fuel return hose to the fuel pressure regulator and tighten the hose clamp. Connect the vacuum hose from the intake manifold to the fitting on the pressure regulator. Connect the vacuum hose from the intake manifold to the vapor separator.

15- Connect the two Brown leads from the air temperature sensor to the two Brown



15

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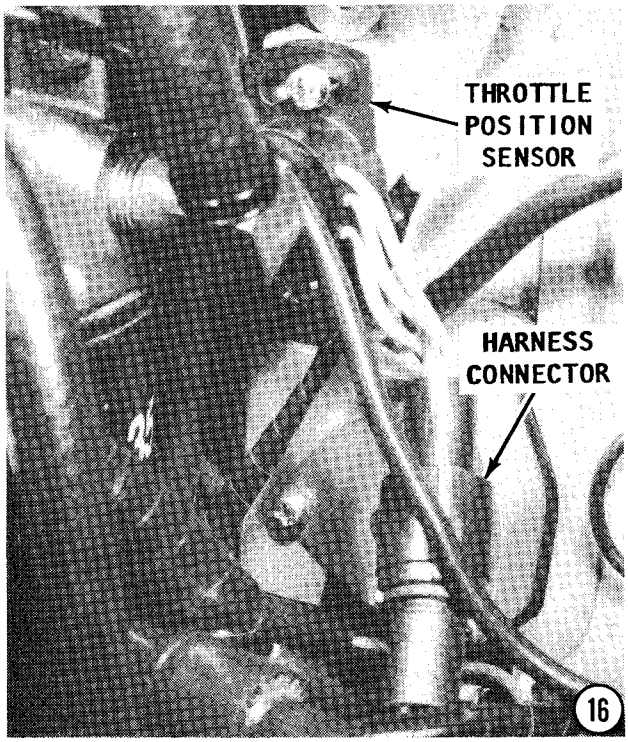
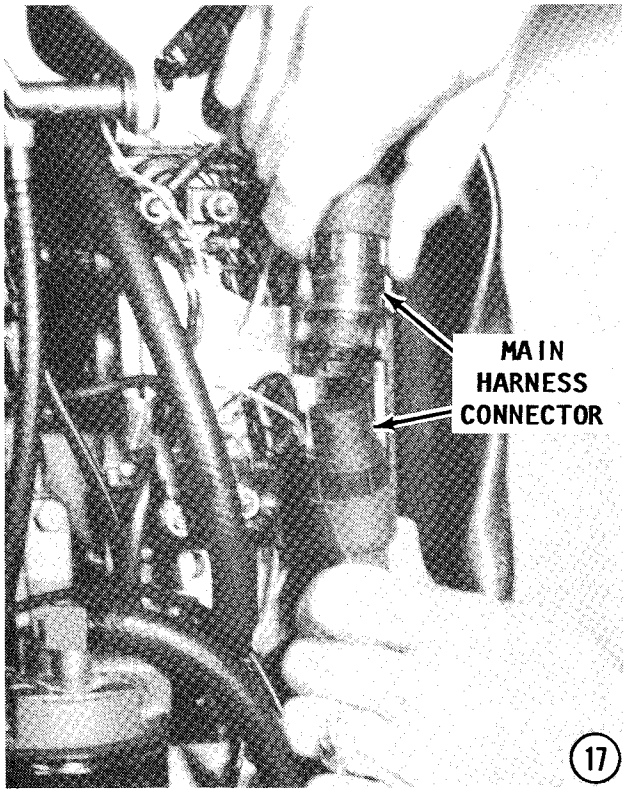


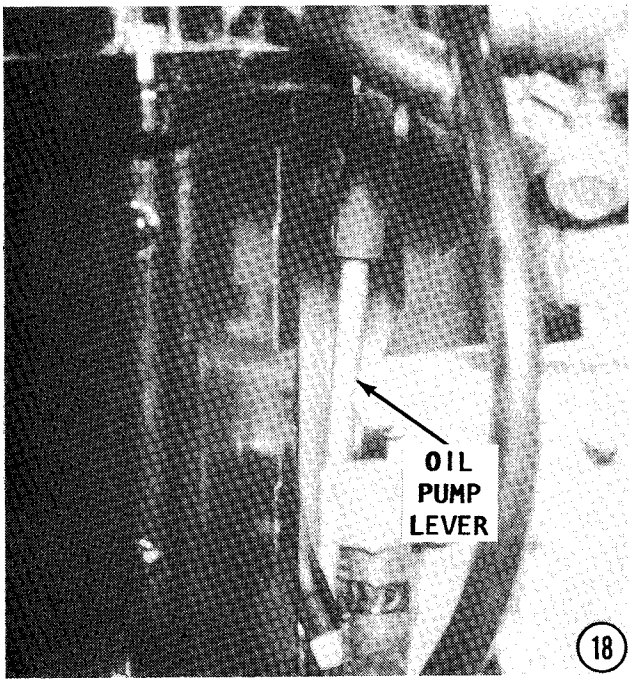
leads from the ECU at their quick connect fittings.

Connect the leads to both trim/tilt solenoids. Consult the wiring diagram in the Appendix as an aid in making these connections.

16- Connect the throttle position sensor harness consisting of Tan/Black, Light Blue and Orange leads to its harness connector from the ECU. Connect the fuel injector harness consisting of Yellow, Dark Blue, White, and Red leads to its harness connector from the ECU.

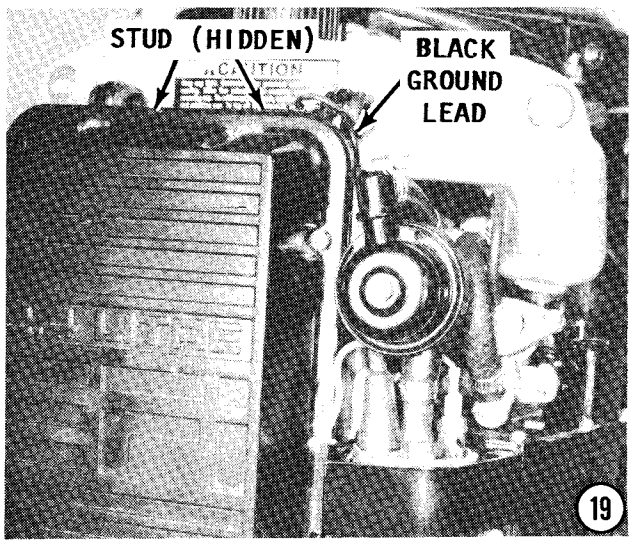


17- Connect the ECU wire harness connector to the main powerhead harness connector. The connection can only be made one way.



18- Rotate the oil pump lever **CLOCKWISE** and snap the oil pump control link rod on the ball joint onto the intake manifold throttle linkage. Attach the throttle control link rod to the throttle cam.

19-Slide the ECU down over the two top studs. Slide the small Black ground lead over the right stud. Install and hand tighten the two nuts.



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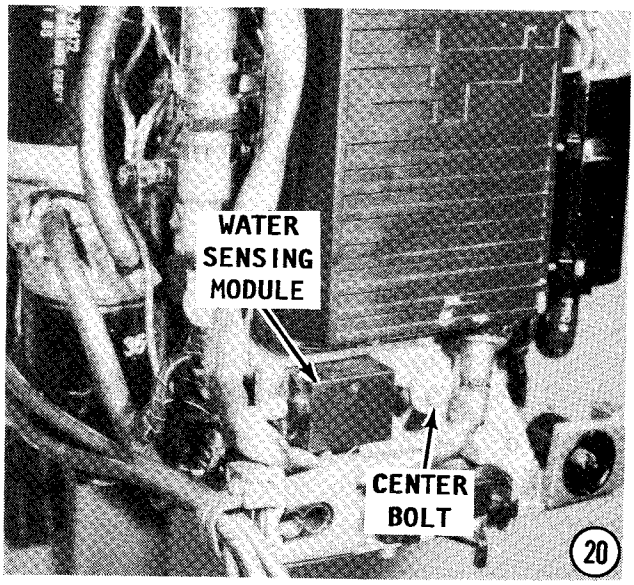


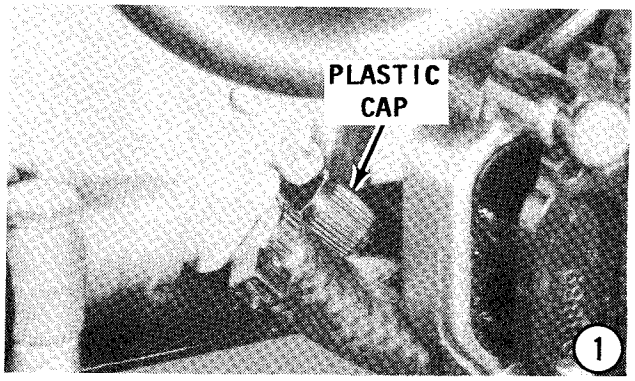
20- Install the single center bolt at the base of the ECU. Tighten this bolt and the two nuts installed in the previous step to a torque value of 45 in lb (5Nm). Install and tighten the two bolts on the lower support bracket. Install the water sensing module below the ECU. The left attaching Phillips head screw also acts as a grounding point for two small Black wires. Install and tighten both securing screws.

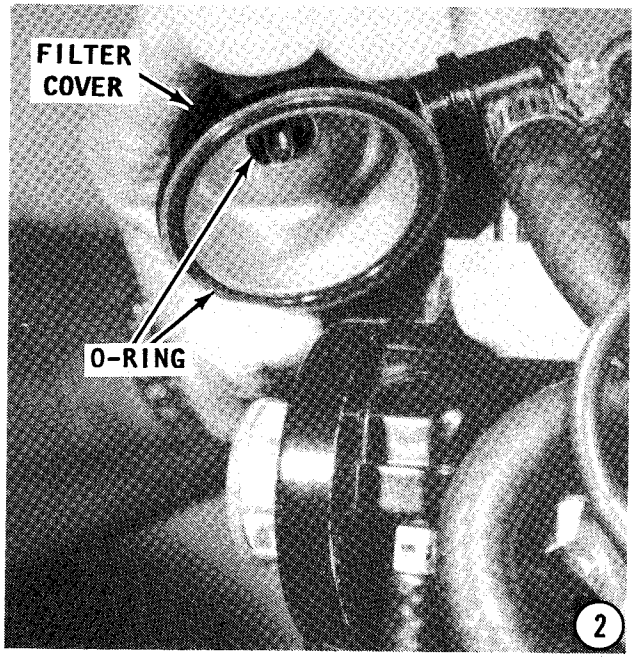
SECONDARY FUEL FILTER SEVICE

CRITICAL WORDS

Before the secondary fuel filter cover may be removed, the EFI system **MUST** be depressurized, as described in Step 1.

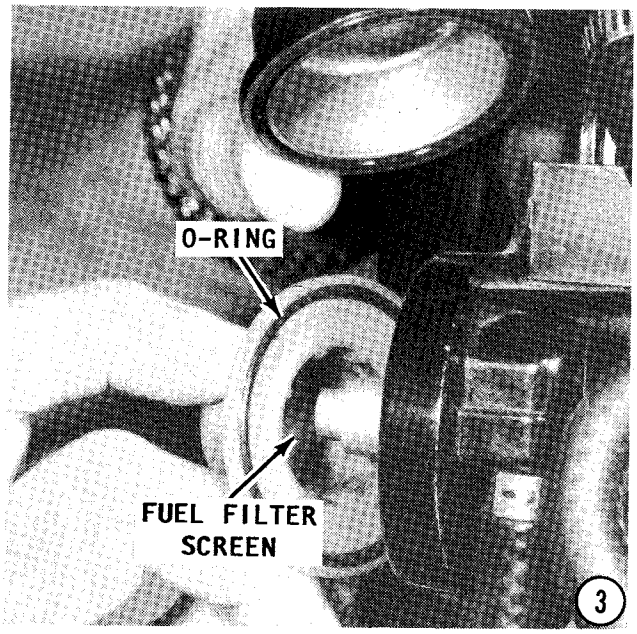
1- Remove the plastic cap over the pressure port located portside at the bottom of the intake manifold. A screwdriver will be used to depress the valve tip to release the pressure and allow fuel to drain from the valve. Place the screwdriver tip lightly over the valve tip and wrap a clean shop towel around the valve and screwdriver. This operation is similar to letting air out of tires! Once all the pressure has been released and the fuel flow ceases, **CAREFULLY** proceed with Step 2.





2- Loosen, but do **NOT** remove the center bolt on the filter cover. It is not necessary to remove the inlet fuel hose from the cover. Pry the cover from the filter. Remove the two O-rings. One large O-ring is located around the circumference of the cover and the other smaller O-ring will be found either inside the cover around the securing bolt, or on the filter screen.

3- Remove the filter screen and the large O-ring located around the inner circumference.



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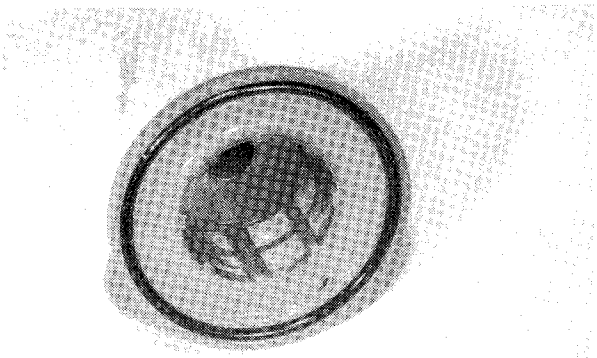


The secondary filter and O-ring holds fuel pressure in the system. Therefore, both must be in good condition.

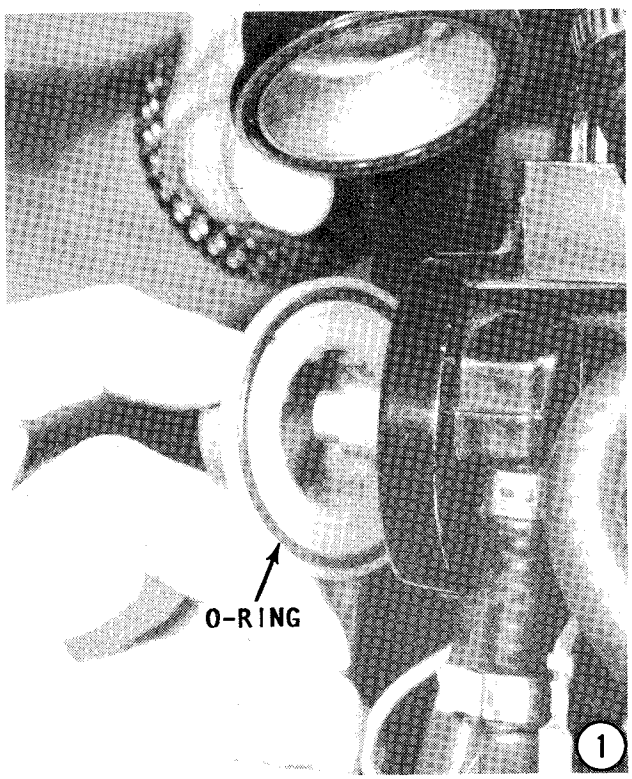
CLEANING AND INSPECTING

All three O-rings should be replaced. If they must be used again, they must be subjected to close inspection. If any O-ring appears to have the **SLIGHTEST** damage or distortion, the O-ring **MUST** be removed, discarded, and replaced. These O-rings provide a seal for fuel under pressure.

The screen can be rinsed in solvent and blown dry with compressed air. If the screen is damaged or distorted, the filter must be replaced.

INSTALLATION

1- Position a new O-ring around the inner circumference of the filter screen, and then place the screen in the filter housing.



2- Position a new O-ring around the circumference of the filter cover and another O-ring inside the cover around the center bolt. Install the filter cover over the filter screen. Tighten the center bolt to a torque valve of 25 in lbs (3Nm).

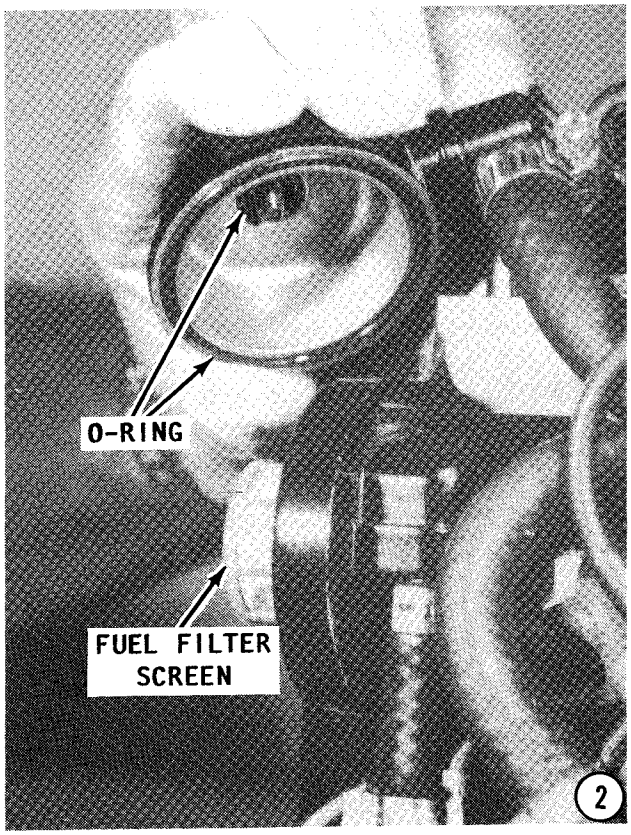
CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the powerhead and check for fuel leaks.

CRITICAL WORDS

The system will be pressurized almost instantly -- as soon as the powerhead is cranked. Watch for leaks around the cover and the center screw of the secondary fuel filter. Because the system is pressurized, a leak will not appear as drips. Instead, fuel will be **SPRAYED** all over the powerhead. Should this occur, shut down the powerhead immediately. **DO NOT** forget to **DEPRESSURIZE** the system at the pressure port on the intake manifold before making necessary repairs.



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FUEL PRESSURE REGULATOR AND VAPOR SEPARATOR SERVICE

SPECIAL WORDS

The accompanying illustrations were taken of a fuel pressure regulator and vapor separator removed from the powerhead. If only the fuel regulator is to be serviced, the work may be just as easily performed while the regulator is still in place on the powerhead. However, if the vapor separator is to be serviced, it must be removed from the powerhead. If only the vapor separator is to be serviced and not the fuel pressure regulator, simply skip the steps which pertain to the regulator.

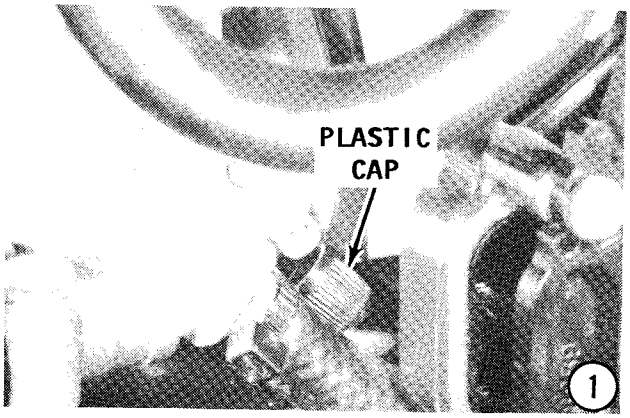
CAUTION

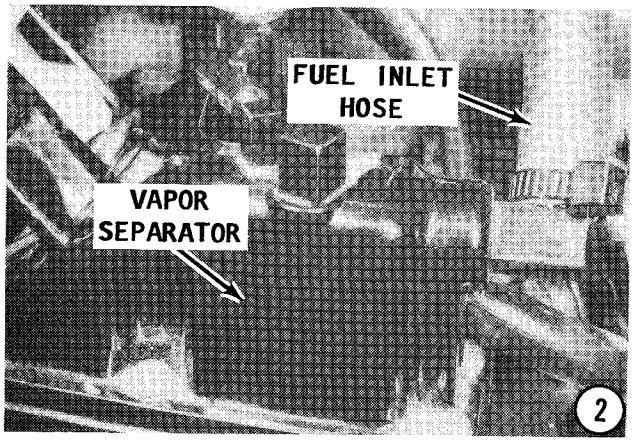
Before the vapor separator **OR** the fuel pressure regulator are removed, the EFI system **MUST** be depressurized, as described in Step 1.

1- Remove the plastic cap over the pressure port located portside at the bottom of the intake manifold. A screwdriver will be used to depress the valve tip to release the pressure and allow fuel to drain from the valve. Place the screwdriver tip lightly over the valve tip and wrap a clean shop towel around the valve and screwdriver. This operation is similar to letting air out of tires! Once all the presssure has been released and the fuel flow ceases, **CAREFULLY** proceed with the following step.

2- Remove and plug the fuel inlet hose from the water separating filter to the vapor separator cover fitting.

3- Remove and plug the oil inlet hose at the base of the vapor separator. Obtain a suitable container, then remove and drain the hose from the vapor separator to the electric fuel pump. Disconnect the Red and Red/Purple leads from the electric fuel

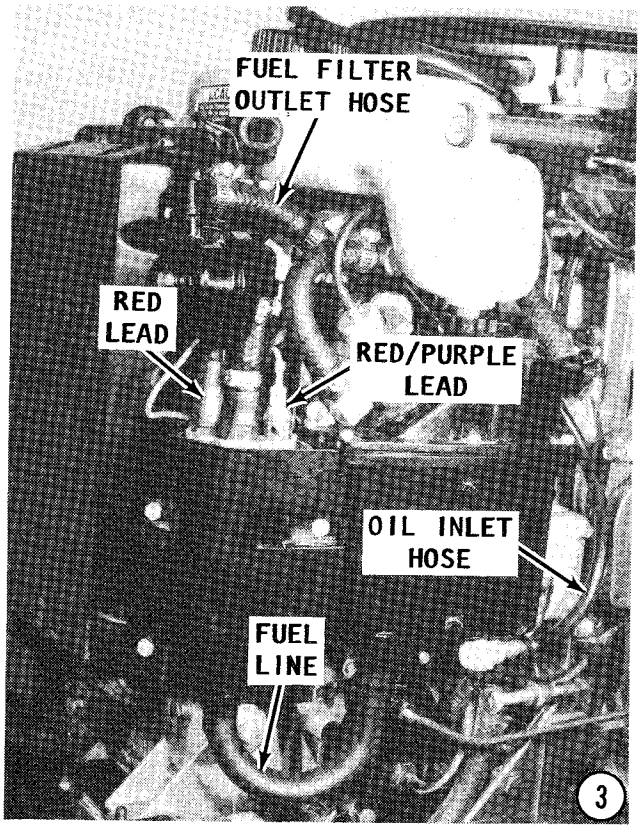




pump. Remove and drain the fuel return hose at the forward end of the fuel pressure regulator to the fitting on the separator cover. Remove the vacuum line from the intake manifold at the fitting on the fuel pressure regulator. Now, remove the two vacuum lines from the fittings on the vapor separator cover. One line is from the intake manifold and the other line from the crankcase regulator.

The vapor separator and fuel regulator assembly is now disconnected from the system ready for removal from the powerhead.

Remove the three attaching bolts, and then remove the assembly from the powerhead.



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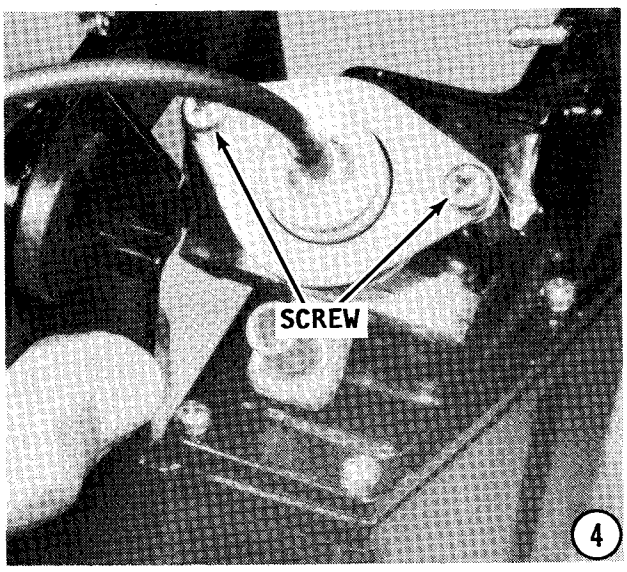


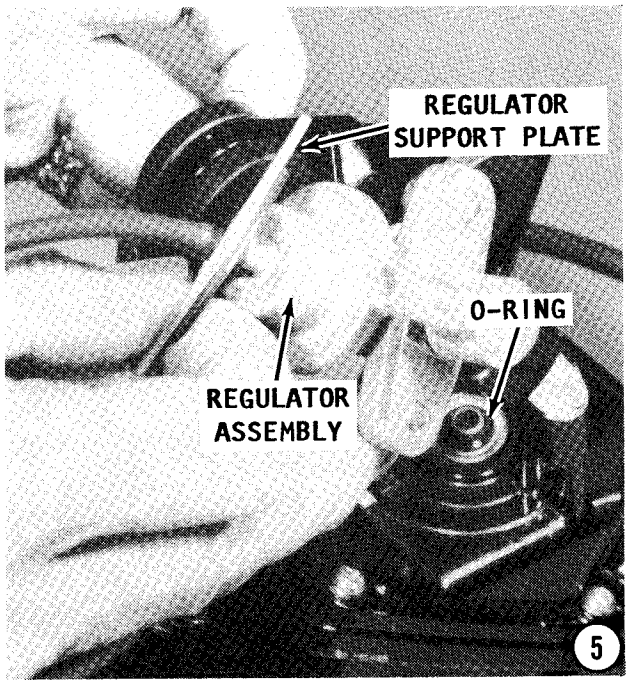
4- Remove the two Phillips head screws with captive lockwashers from the regulator support plate.

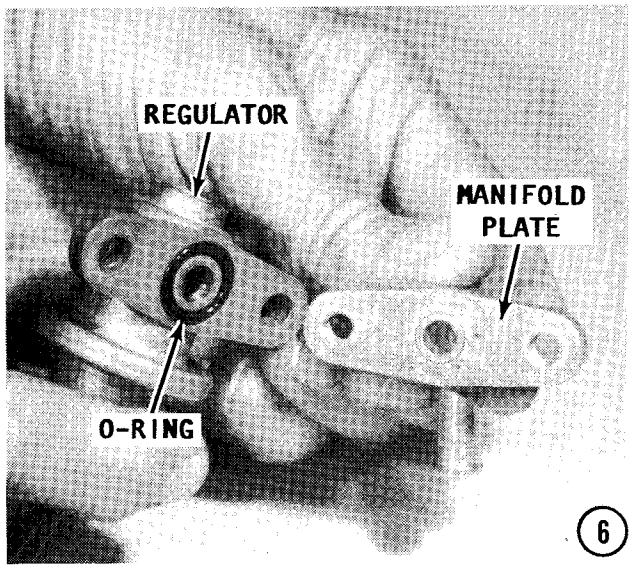
5- Remove the regulator from the water separator cover. Remove the O-ring from the separator cover.

6- Remove the two screws securing the regulator to the manifold plate, and then remove the O-ring.

7- Remove the six Phillips head screws with captive lockwashers from the vapor separator cover. Lift the cover slowly and squarely from the housing. The cover will come away with the float assembly attached.

8- Use a pair of needle nose pliers and pull the float hinge pin from the mounting





posts on the cover. Remove the float and inlet needle from the cover. The needle may be slid from the brass tab on the float. **TAKE CARE** not to alter the angle of the brass tab.

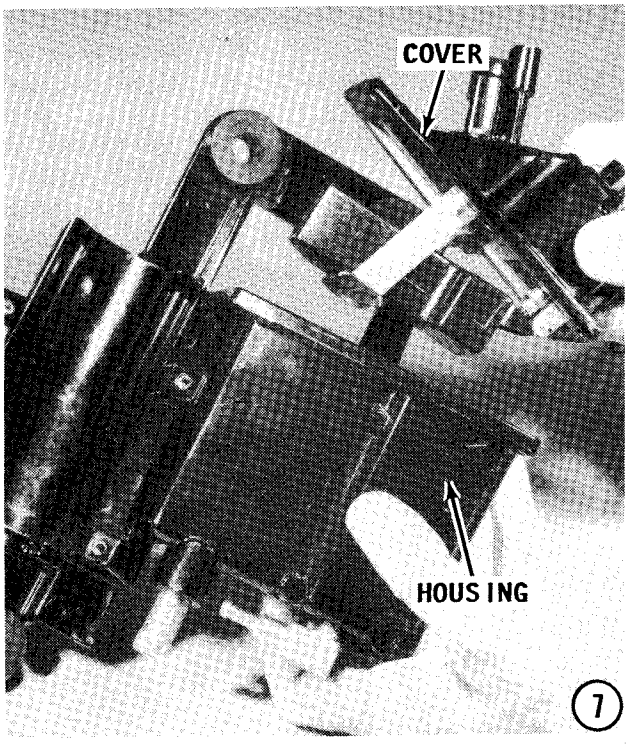
Remove the O-ring from the housing.

CLEANING AND INSPECTING

The inlet needle seat is pressed into the cover, therefore, it is not removeable or replaceable.

Rinse the housing in solvent, and then blow it dry with compressed air.

Check the float for deterioration. The float is hollow, therefore, check to be sure



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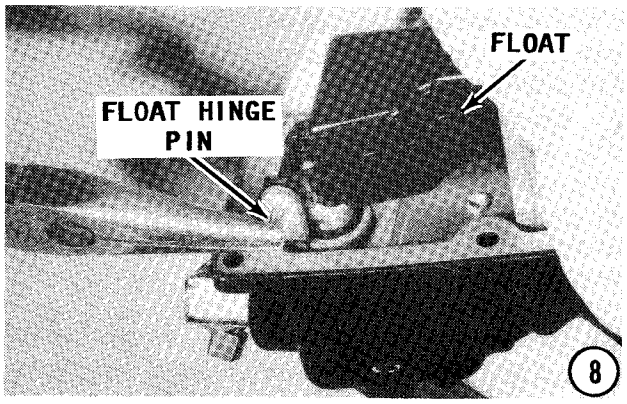
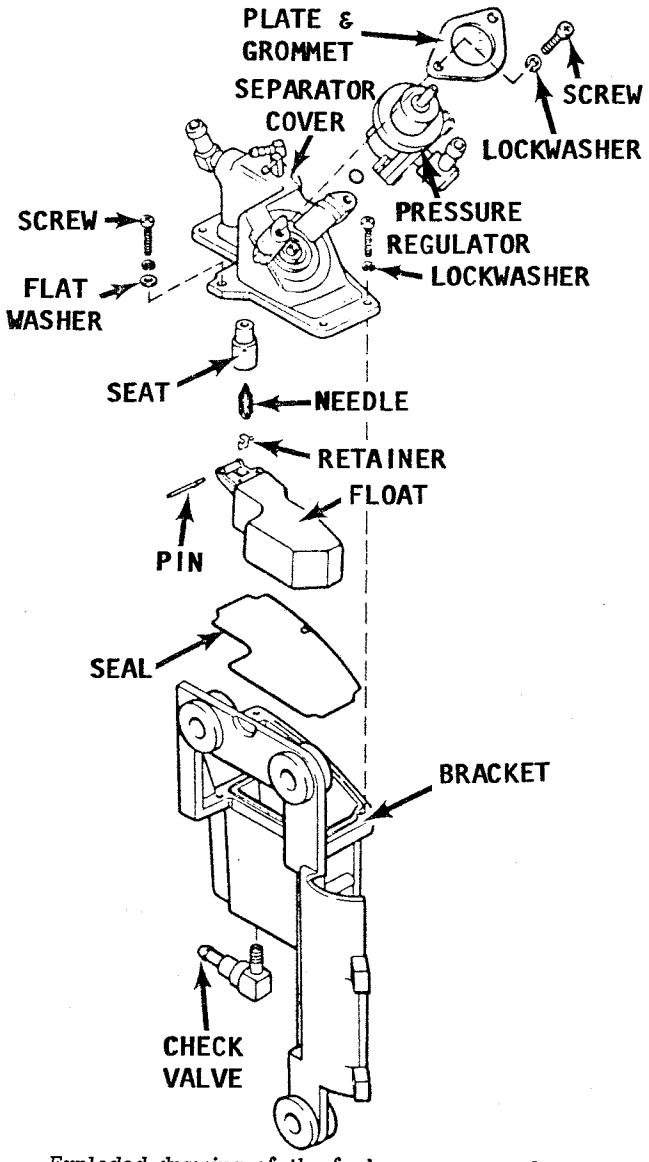
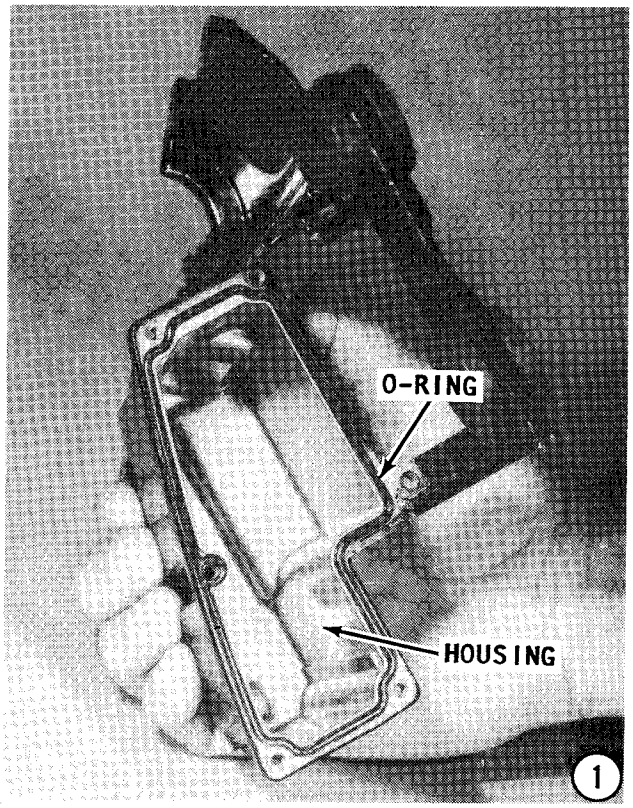


the float does not contain any fluid. Check to be sure the float tab is in good condition. If any part of the float is damaged, the unit must be replaced. Check the float tab-to-needle contacting surface and replace the float if this surface has a groove worn in it.



Exploded drawing of the fuel pressure regulator and vapor separator, with major parts identified.

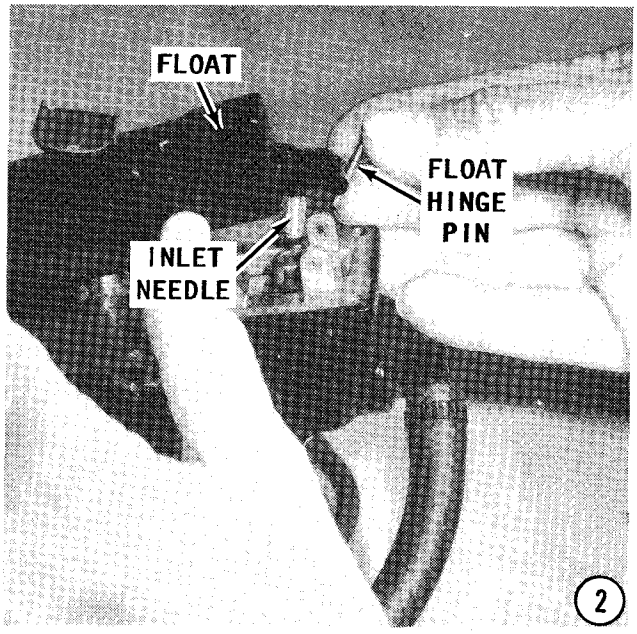


INSTALLATION

1- Install the O-ring around the housing.

2- Hang the inlet needle on the brass float tab. Lower the needle and float into place between the mounting posts, with the needle entering the seat. Insert the float hinge pin through the mounting posts.

3- Lower the cover assembly down into the housing. Install and tighten the six Phillips head screws with captive lockwashers.



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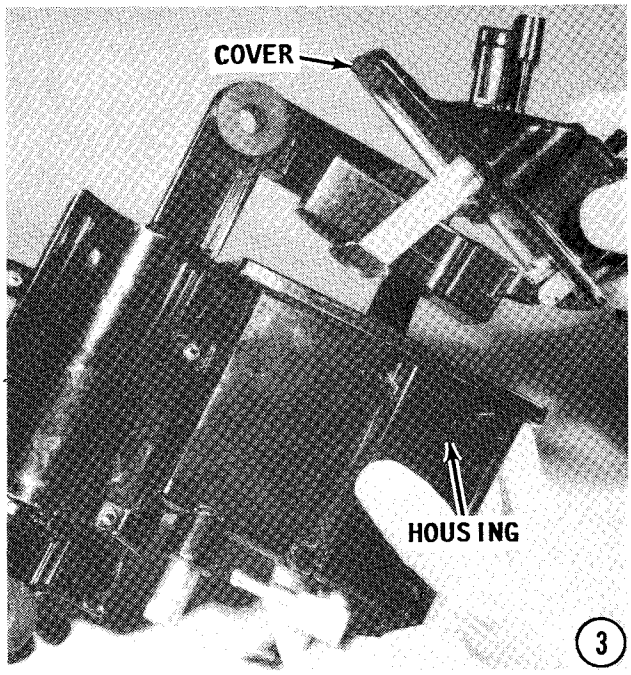
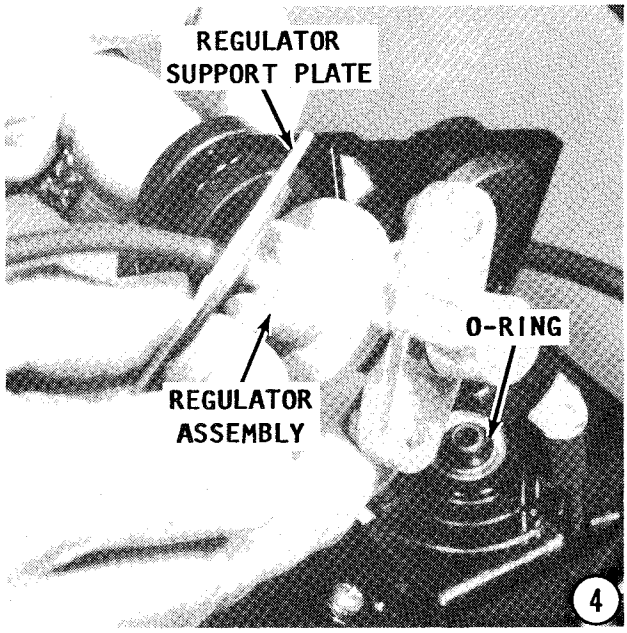


4- Position the **O**-ring around the regulator seat on the vapor separator cover. Install an **O**-ring in the regulator port, and then install the manifold plate to the regulator using the two Phillips head screws with captive lockwashers.

Position the regulator onto the vapor separator cover and slide the regulator support plate over the vacuum hose fitting.

5- Install and tighten the two Phillips head screws with captive lockwashers through the support plate and into the vapor separator cover.

6- Position the assembled vapor separator and fuel pressure regulator up against the powerhead. Install and tighten the three attaching bolts to a torque value of 90 in lbs (10.2Nm).



Connect the two vacuum hoses, one from the crankcase bleed system and the other from the intake manifold, to the two fittings on the vapor separator cover. Observe that these hoses have two different size inner diameters to fit over the two different size fittings.

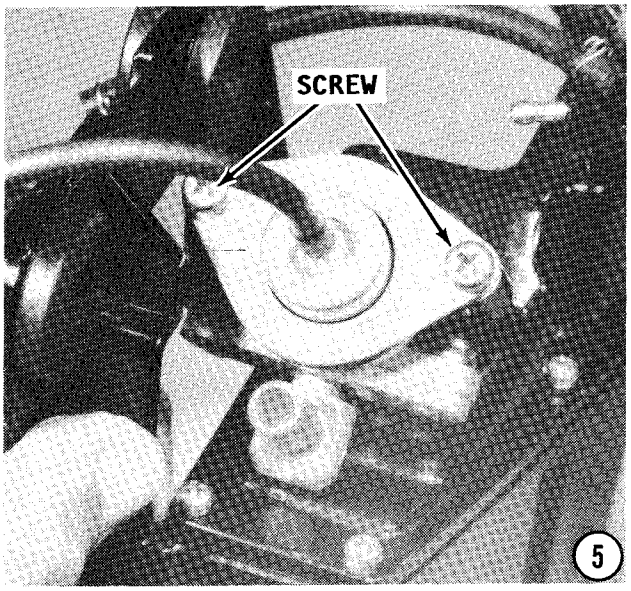
Connect the vacuum hose from the intake manifold to the fuel pressure regulator. Connect the fuel return hose between the vapor separator and the regulator. Connect the fuel filter outlet hose between the secondary fuel filter and the fitting on the intake manifold. Connect the Red and Red/Purple leads to the correct terminals on the electric fuel pump, as shown in the accompanying illustration. Connect the fuel line between the base of the vapor separator and the electric fuel pump. Remove the plug from the oil inlet hose and connect the hose to the fitting at the base of the vapor separator.

7- Remove the plug from the fuel inlet hose and connect the hose to the fitting at the top of the vapor separator cover.

Make a quick check of all connections made in the last two steps.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.



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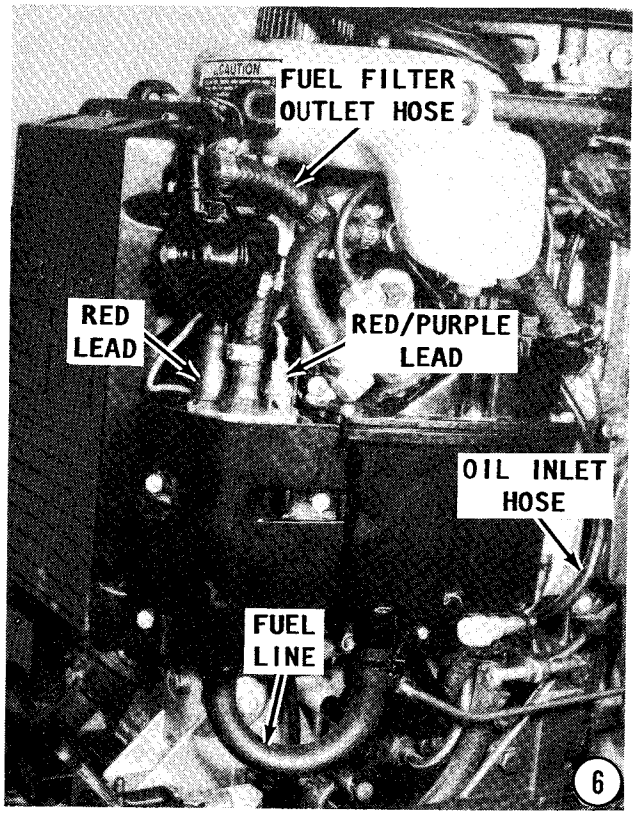
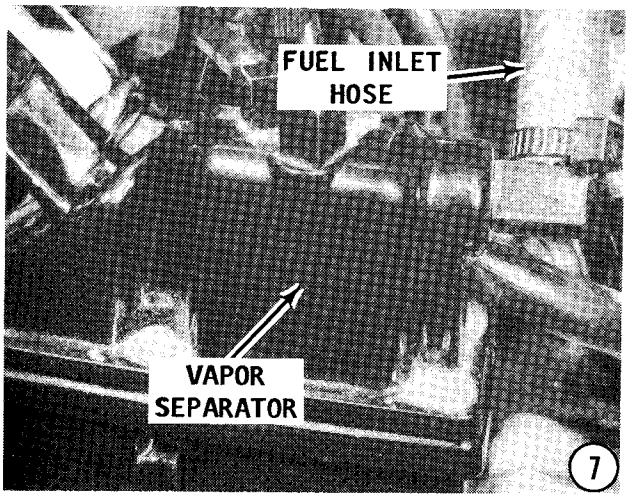


Start the powerhead and check for fuel leaks.

CRITICAL WORDS

The system will be pressurized as soon as the powerhead is cranked. Watch for leaks around all fuel hose connections which were disturbed. Because the system is pressurized, a leak will not appear as drips. Instead fuel will **SPRAY** all over the powerhead. Should this occur, shut down the powerhead immediately. **DO NOT** forget to **DEPRESSURIZE** the system at the pressure port on the intake manifold before making necessary repairs.



THROTTLE SENSOR SERVICE

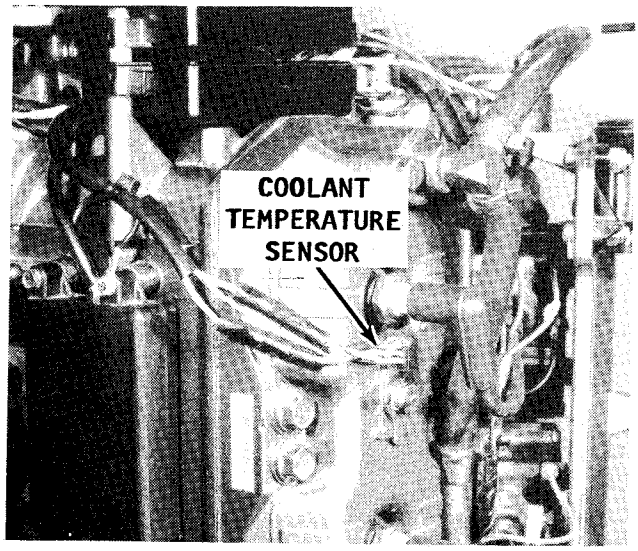
Mark the original location of the throttle position sensor **BEFORE** removal. If this sensor is misaligned during installation, a **DIGITAL** type voltmeter is needed to correctly reset the sensor on its mounting bracket. During alignment, voltages must be accurately measured to within 1/10 volt. A misaligned sensor could send misleading signals to the ECU and consequently affect the EFI and the ignition timing.

After marking the position of the throttle sensor, remove the two securing screws and lift the sensor free from the throttle shaft.

To install a new sensor, check to be sure the throttle position sensor shaft engages the slot on the throttle shaft. Secure the sensor with the attaching hardware, in **EXACTLY** the same location as before removal. The marks made during removal should be aligned. If no locating marks were made during removal, **CAREFULLY** examine the bracket for traces of an outline of the sensor and attempt to mount the sensor as near to the original location as possible. A difference of 0.04" (1mm) corresponds to 2° throttle angle.

Throttle position sensor adjustment is covered in the following paragraphs using a **DIGITAL** type voltmeter.

Do **NOT** attempt this adjustment unless an instrument is available capable of indicating voltage accurately to within 1/10 volt. If such an instrument is not available, it is strongly recommended qualified techni-



*The EFI coolant temperature sensor, located in the port cylinder head, **MUST** be grounded while the throttle position sensor is being adjusted.*

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cians at the local Mariner dealership install and calibrate this sensor using the necessary equipment.

Throttle Position Sensor Adjustment

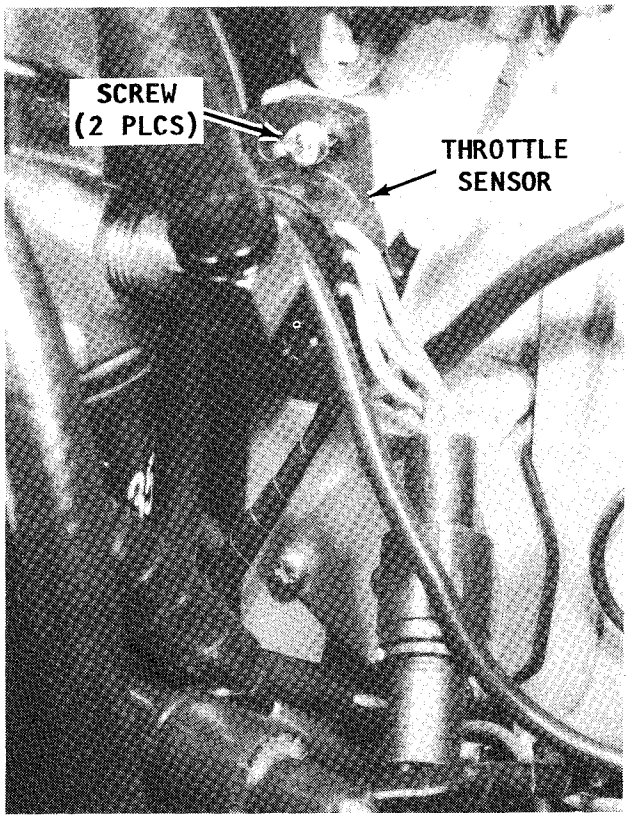
This adjustment is performed with the powerhead **NOT** running.

Loosen the screw next to the cam follower to allow the follower to ride freely along the throttle cam. On V6 powerheads with EFI and equipped with an idle speed screw, back off the idle speed screw, located just above the cam follower, from the stop on the intake manifold. The throttle position sensor **MUST** be adjusted with the throttle plates fully closed and with the arm of the throttle shaft against the throttle valve stop screw.

Disconnect the two Tan/Black leads from the powerhead coolant temperature sensor at their quick disconnect fittings. This sensor is located in the port cylinder head.

SPECIAL METER

The meter used in this test must have either a special harness for measuring the output voltage or have probes capable of piercing through the insulation of the wires to make contact without disconnecting the leads or damaging the insulation of the leads.



*The throttle position sensor **CANNOT** be accurately adjusted without the use of a digital type voltmeter.*

Select the Vx1 scale on the voltmeter. Ensure the two mounting screws of the sensor are snug enough to permit the sensor to be rotated a few degrees either way and still hold its position.

Make contact with the Red voltmeter lead to the Orange sensor lead. Make contact with the Black voltmeter lead to the Tan/Black sensor lead.

Turn the key to the **ON** position **WITHOUT** starting the powerhead. Begin by rotating the sensor **CLOCKWISE** as far as possible. Note the meter reading. Now, rotate the sensor **COUNTERCLOCKWISE** until the meter reading increases by 0.01 to 0.02 volts from the original reading. At this point, tighten both securing screws to a torque value of 23 in lb (2.5Nm) to hold the adjustment.

A misalignment of the sensor by 0.04" (1mm) on the mounting bracket corresponds to 2° of throttle angle.

With the voltmeter still connected, open and close the throttle valve a few times to be sure the output voltage fluctuates with different throttle angles. Also, check to see if the voltage reverts back to the specified level when the throttle valves are fully closed.

MARK the position of the new sensor in relation to the bracket as a preparation for possible future service.

Connect the two Tan/Black leads from the powerhead coolant temperature sensor at their quick connect fittings.

See Chapter 7, Section 7-36 for adjustment of the throttle cam and idle speed screw which were disturbed while making this adjustment.

FINAL WORDS

The operation of this sensor can be compared to the volume knob on a radio. If the listener has a favorite position for the knob, in time a "flat spot" will wear on the shaft and interference may result.

If the operator of the outboard has a favorite throttle position, in time a "flat spot" will wear on the sensor shaft and not provide the ECU with accurate information. This condition could lead to ignition timing which varies by as much as 20° with no change in throttle position and incorrect operation of the EFI.

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5
OIL INJECTION

5-1 INTRODUCTION

Oil injection systems replace the age old method of manually mixing oil with the fuel for lubrication of internal moving parts in the powerhead.

Since outboard units have grown in number of cylinders with accompanying increases in horsepower, and because the size of the fuel tanks also grew to handle the increased demand of these larger powerheads, the requirement for a more sophisticated method of mixing oil with the fuel for internal lubrication became a primary design objective.

Almost all outboard manufacturers have now developed their own method to provide adequate oil delivery to the cylinders under all demands of the powerhead. Each system has its own trade name.

"Auto Blend"

Mercury/Mariner engineers designed and developed their oil injection system to "blend" the correct amount of oil with the fuel prior to delivery to the carburetor/s. Therefore, the trade name used is "Auto Blend", because the blending is accomplished automatically for all powerhead demands and conditions.

Fuel from the tank moves to the "Auto Blend" unit where it mixes with the oil and is then pumped to the powerhead.

Advanced Oil Injection

Since 1984 a new oil injection system has been installed on the larger powerheads, with the exception of the 6-cylinder in-line units. The oil pump and an oil reservoir are mounted on the powerhead. The pump is driven by a worm gear directly off the crankshaft. Oil is pumped just a short distance to an oil/fuel mixing chamber and then routed to the carburetor/s or to the vapor separator on an electronic fuel injection system.



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5-2 "AUTO BLEND" OIL INJECTION

DESCRIPTION

"Auto Blend" was the first oil injection system installed on the outboard units covered in this manual. Originally it was used on only the larger horsepower outboards. Over the years, the system has been upgraded including the addition of an electronic control module, movement of the warning horn, and other improvements.

"Auto Blend" is not considered an optional accessory by the manufacturer and is not recommended to be installed on units not equipped with the system from the factory.

The system consists of an oil reservoir (tank), oil screen, diaphragm vacuum-operated fuel "pump", low oil warning horn, fuel filter, and the necessary fittings and hoses for efficient operation. The reservoir and associated parts are supported in a bracket mounted on a bulkhead or the boat transom. The unit is secured in the bracket with a nylon strap and Velcro fastener. This arrangement provides quick and easy removal from the boat for refilling, testing, or for security reasons.

Oil Reservoir (Tank)

The tank is constructed of slightly transparent material and the quantity of oil can be determined by a quick glance at the tank. The tank has sight level lines in half quart (0.47L) increments. Total capacity is 3.5 quarts (3.3L). **ONLY** 2-cycle outboard oil with a BIA rating of TC-W should be used.

A screen installed in the tank filters the oil mixing with the fuel. Normally, this screen does not require service.

Fuel "Pump"

A positive displacement diaphragm vacuum-operated fuel "pump" is mounted on the front of the oil tank. (In the strict sense of the word, it is not a pump because it is dependent on operation from another source.) The "pump" mixes oil with the fuel and is operated under vacuum supplied by the fuel pump mounted on the powerhead. The "pump" is provided with a drain plug.

Low Oil Warning Horn

A warning horn will sound to indicate one of two conditions:

a- The level of oil in the tank is dangerously low.

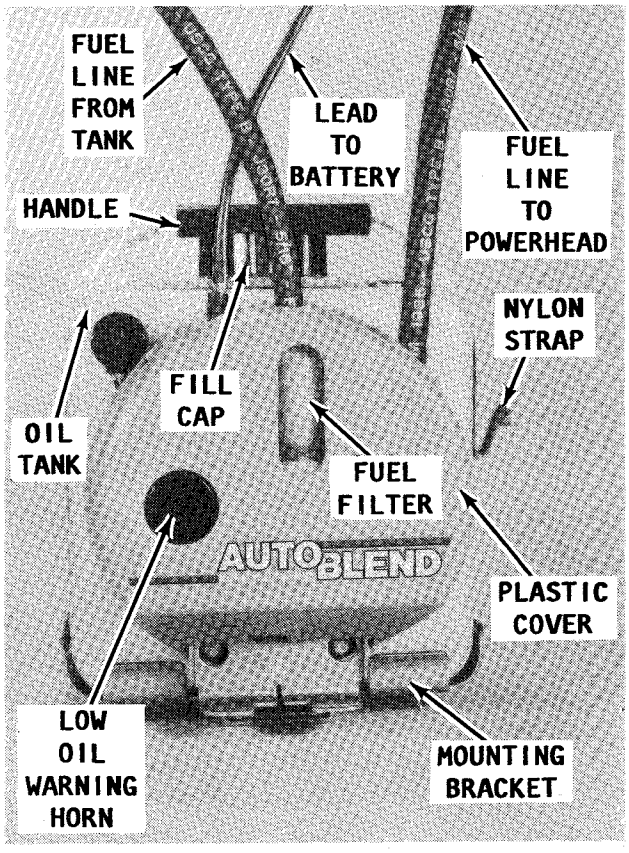
b- The oil screen in the tank has become clogged.

The horn circuit is connected to a 12-volt battery through leads and a harness plug. The **RED** lead is connected to the positive terminal of the battery. This lead has a 0.5 amp fuse installed as protection against damage to more expensive parts in the circuit. The black lead is connected to the negative battery terminal.

The harness plug should **NOT** be connected until the tank is filled with oil to prevent the horn from automatically sounding.

Fuel Lines

A 5/16" (7.87 mm) I.D. hose is used to connect the fuel tank to the oil injection unit and also from the unit to the powerhead. The hose between the oil injection tank and the powerhead pump should never exceed 5 feet (1.50 meters). Clear plastic support tubing (not shown in the accompanying illustration) is usually used over the fuel lines and secured with standard hose clamps.



The Auto Blend unit ready to be secured in the bracket for service. Usually, short pieces of clear plastic support tubing (not shown), are placed over the end of the fuel lines to prevent kinking at the fittings.

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These support tubes will prevent kinking at the fittings and subsequent restriction of fuel flow through the fuel lines.

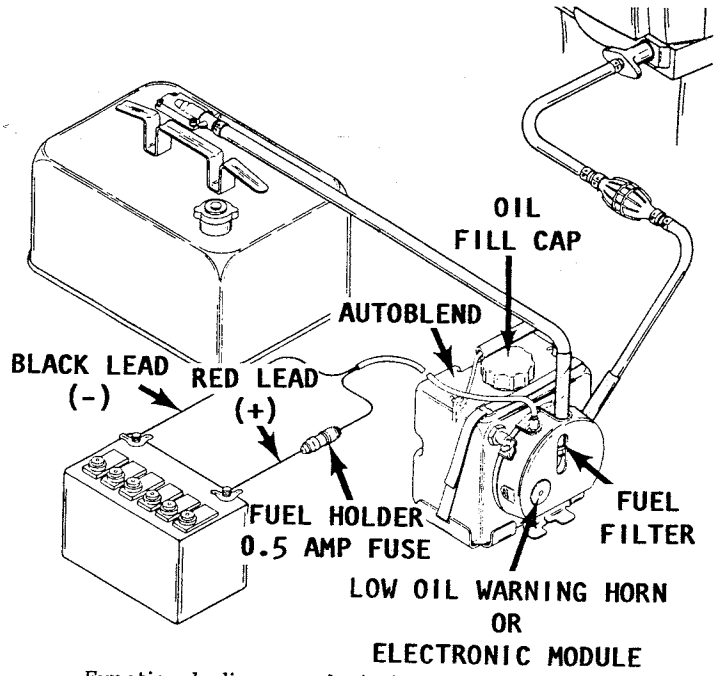
The inlet fitting of the oil tank also serves as a fuel filter. With this arrangement, the fuel must pass through the filter before mixing with the oil in the tank. The filter is transparent, therefore, sediment can quickly be identified when it is present. The filter can be easily removed, cleaned, and installed, without any special tools.

A primer bulb must be installed between the oil injection unit and the fuel pump on the powerhead. **NEVER** connect the primer bulb between the fuel tank and the oil tank. This error could cause serious damage to the oil injection unit by providing excessive pressure.

OPERATION

While the powerhead is operating, the oil injection unit provides a variable fuel/oil mixture to the fuel pump in a ratio of 50:1 at full throttle. This is standard mixture for normal operation.

During the break-in period for a new or overhauled powerhead, oil should be added to the fuel tank in a ratio of 50:1. This ratio of oil in the fuel tank, added with the ratio of 50:1 from the oil injection unit will provide a mixture of 25:1 to the powerhead. This ratio is recommended by the manufacturer during the break-in period.



Functional diagram depicting complete hookup of the Auto Blend oil injection system.

During normal operation, the level of oil in the tank will drop at a steady rate.

The unit must be positioned where the helmsperson may occasionally notice the decreasing amount in the tank. The decreasing oil level indicates the system is functioning properly and is supplying the correct proportions of fuel and oil to the powerhead.

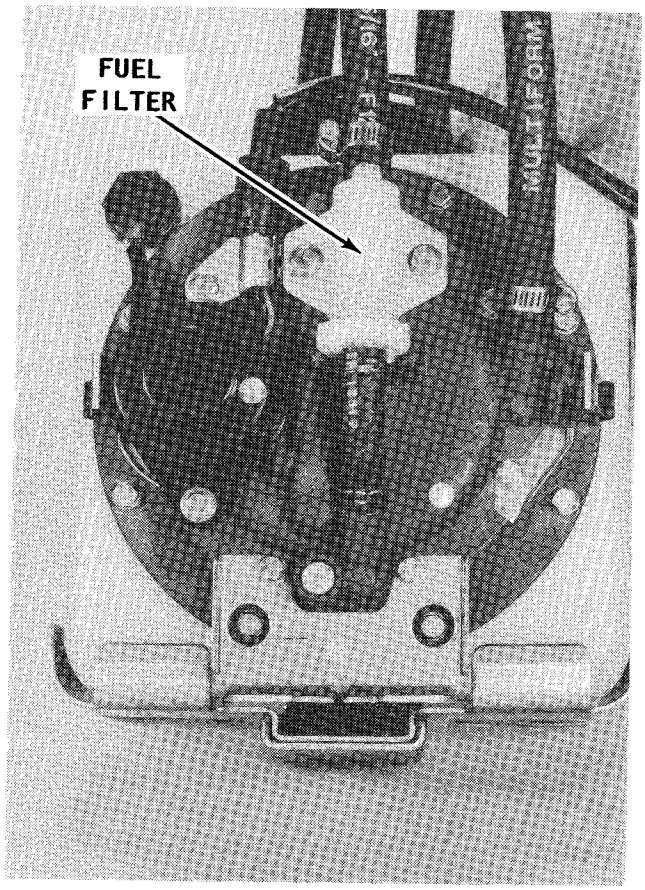
TROUBLESHOOTING

Lack of Fuel

If the powerhead fails to operate properly and troubleshooting indicates a lack of fuel to the fuel pump, the problem may be blockage of fuel in the fuel lines, in the fuel passageway in the oil injection unit, or a clogged fuel filter.

First, check the fuel lines to be sure they are free of stress, kinks, and nothing is laying on them, i.e.: tackle box, bait tank, etc.

Next, check the filter at the oil injection unit. Because the filter is transparent, any foreign material may be quickly discovered.



The fuel filter is transparent allowing visual inspection for foreign material. The filter may be removed and installed without the use of special tools.

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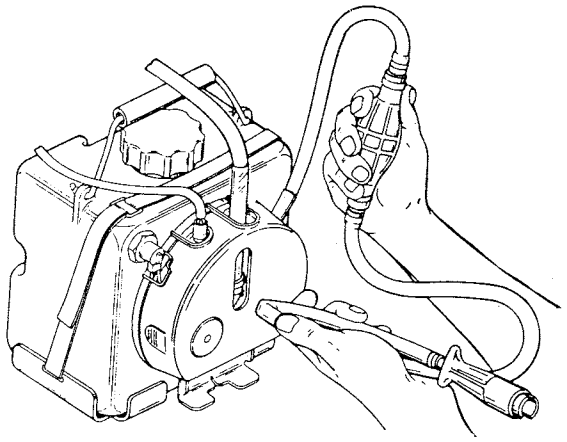

The outlet line and fitting may be back-flushed by kinking the hose and using the squeeze bulb, as explained in the text.

The filter may be removed, cleaned, and installed quickly, without the use of any special tools.

Finally, the fuel passageway in the "Auto Blend" unit may need to be back-flushed. This is accomplished by simply kinking the line and at the same time slowly squeezing the primer bulb, as shown in the accompanying illustration. The primer bulb should only be squeezed a few times to prevent building up excessive pressure in the unit.

Warning Horn Sounds

If the horn should sound during operation of the outboard unit, shut down the unit immediately and make a couple of quick checks.

First, check the oil level in the tank and replenish as required.

Next, check the oil screen in the tank. If it is clogged with sediment, remove the filter, clean it, and install it back in the tank.

If the warning horn sounds when it should, but is intermittent, or weak, the indication is an excessive resistance or a loose connection in the circuit.

Warning Horn Fails To Sound (When it should — low or no oil)

Models W/O Electronic Module

If the warning horn does not sound when the "Auto Blend" unit is inverted: First, check the 0.5 amp fuse in the in-line holder of the positive lead to the battery. Then, disconnect the two prong plug between the battery and the warning horn on the unit. Obtain and set a voltmeter to the 12V DC scale. Insert the two meter leads into the battery end of the disconnected plug. The meter should register at least 9V. If less than 9V is registered, the fault lies in the battery harness, the connector plug or the battery terminals. Correct or repair as necessary.

If the meter registers at least 9V, check for loose or dirty connections at the warning horn and repeat the test once more using two jumper leads in place of the battery harness.

Obtain and set an ohmmeter to the RX1000 scale. Insert one meter lead into the two prong connector leading from the warning horn. Make contact with the other meter lead to a suitable ground on the powerhead. The meter should register continuity. If continuity is not indicated, the horn is defective and must be replaced.

If continuity is indicated, check the battery connections and then the charge condition of the battery.

If the problem still persists, inspect the internal oil filter and finally replace the warning horn.

Models W/Electronic Module

If the warning horn does not sound a self test "beep" when the ignition switch is rotated to the **"ON"** position, proceed as follows: Identify the Purple lead between the main outboard harness connector and the three prong connector to the electronic module. Disconnect this lead at the quick disconnect fitting. Obtain and set a voltmeter to the 12V DC scale. With the ignition switch in the **"ON"** position, make contact with the Black meter lead to the negative battery terminal and the Red meter lead to the female part of the Purple lead connection.

If the meter fails to register at least 9V, the electronic module is not receiving battery voltage and therefore cannot signal the warning horn to sound. The problem lies elsewhere, probably in the battery connections. Perform corrections as required.

If the meter registers at least 9V, but still the warning horn does not sound a self test "beep", turn the ignition switch off. Connect a jumper cable between the Black and Tan or Tan/Blue leads at the female end of the three prong connector. This action bypasses the electronic module. If the horn now emits a "beep", the electric module is defective and must be replaced.

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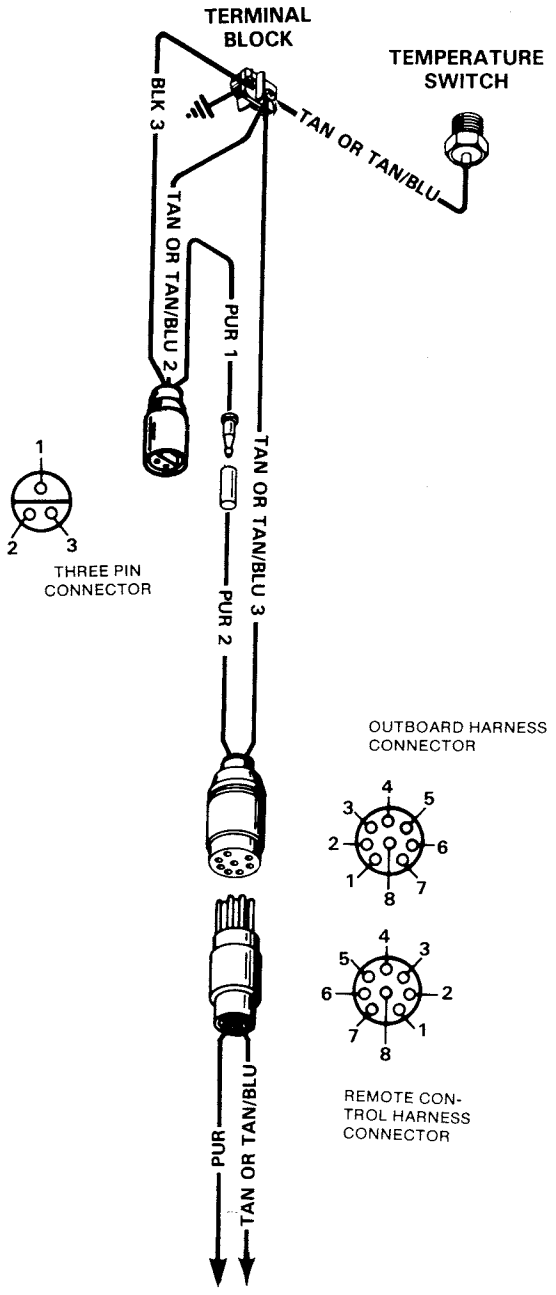
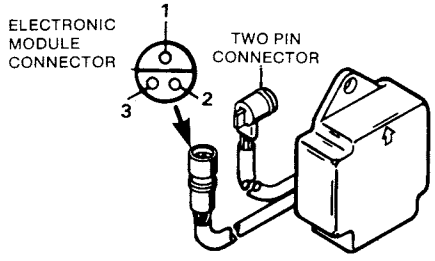


Auto Blend harness identification for resistance tests outlined in the text.



The electronic module and harnesses for the later version of Auto Blend.

If the horn still fails to sound, obtain and set an ohmmeter to the RX1000 scale. Check for electrical continuity between the Tan or Tan/Blue lead at the female end of the three prong connector and the Tan or Tan/Blue lead from the temperature switch at the terminal block on the powerhead.

If continuity is not indicated, check for an open in the circuit or loose, dirty or corroded connections, terminals, or connector pins along the length of the Tan or Tan/Blue lead. If continuity is indicated, but still the horn fails to sound a self test "beep", then the fault lies in the ground connection. A Black lead is used to ground the terminal block to the powerhead. This Black lead extends between the grounding screw on the powerhead and the three prong connector. Somewhere along the length of this Black lead there is an open in the circuit or a loose, dirty or corroded connection, terminal, or connector pin.

Warning Horn Sounds Continuously Powerhead Is Cold Or Not Operating Models W/Electronic Module

With the ignition key in the **"ON"** position, disconnect the three prong connector. If the horn is silent, the electonic module is defective and must be replaced. If the horn continues sounding, disconnect all three Tan or Tan/Blue leads at the terminal block on the powerhead.

If the horn continues to sound, the problem is not in the oil injection system but elsewhere, possibly in the remote control box.

The horn should now be silent. Connect the Tan or Tan/Blue leads one by one to determine which lead was grounded and activated the horn. Trace and replace the defective lead.

If the defective lead is the one to the temperature switch, the switch and lead are replaced as a unit.

Warning Horn Sounds Continuously During Powerhead Operation Oil Level Is Satisfactory Models W/Electronic Module

GOOD WORDS

Perform this test with the powerhead **NOT** operating, even though the symptoms appear when the powerhead is operating.

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Rotate the ignition key to the **"ON"** position. Disconnect the two prong connector at the "Auto Blend" unit. If the warning horn continues to sound, the electronic module is defective and **MUST** be replaced.

If the horn is now silent, the fault lies in the internal oil filter. Replace the filter.

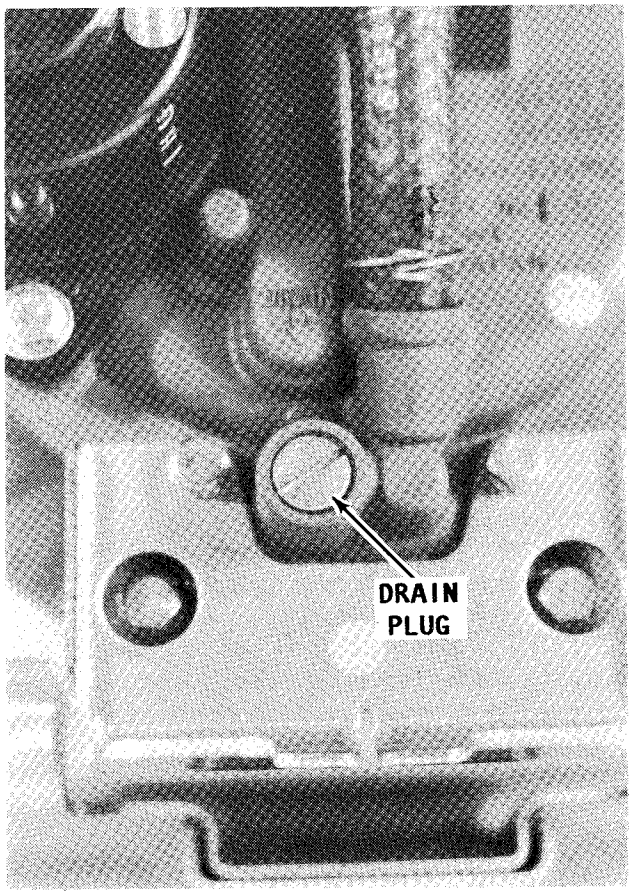
STORAGE
"AUTO BLEND" SYSTEM

Proper storage procedures are **CRITICAL** to ensure efficient operation when the unit is again placed in service.

First, disconnect the battery leads from the battery.

Next, disconnect and plug the fuel lines at the fuel tank and powerhead.

Now, drain all fuel from the unit. Remove the front cover of the unit by simultaneously pushing in on the cutaway tabs located on both sides of the cover, and at the same time pulling the cover away from the unit. Remove the drain plug and allow at least 5-minutes for all fuel to drain from the pump. Install the drain plug and tighten it securely.



*All fuel **MUST** be drained prior to placing the unit in storage, to prevent damage to the "pump" diaphragm.*

CRITICAL WORDS

All fuel **MUST** be drained from the oil injection fuel "pump". The percentage of alcohol in modern fuels seems to increase each year. This alcohol in the fuel is a definite enemy of the diaphragm in the "pump". Therefore, if any fuel is left in the "pump" during storage the diaphragm will most likely be damaged.

Install the front cover by aligning the cover openings on both sides of the unit, and then pushing in on the cover until it snaps into place.

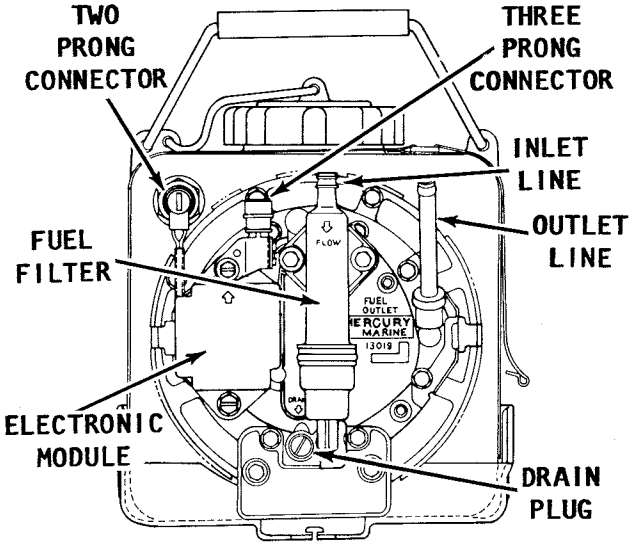
Oil may remain in the oil injection tank during storage without any harmful effects.

PREPARATION FOR USE
"AUTO BLEND" SYSTEM

First, remove the front cover of the unit by simultaneously pushing in on the cutaway tabs located on both sides of the cover, and at the same time pulling the cover away from the unit. Check to be sure the fuel drain plug is tight. Replace the front cover by aligning the cover openings on both sides of the unit, and then pushing in on the cover until it snaps into place.

Next, fill the oil tank with 2-cycle outboard oil with a BIA rating of TC-W. Tighten the fill cap securely.

Remove any plugs in the fuel lines, and then connect the hoses to the fuel tank and the powerhead. Remember, the squeeze bulb **MUST** be in the hose between the oil injection unit and the fuel pump on the powerhead.



Line drawing to clearly identify major parts of an Auto Blend unit.

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Connect the low oil warning wire harness to the battery. Connect the **RED** lead to the positive battery terminal and the **BLACK** lead to the negative battery terminal.

Check to be sure the low oil warning system is functioning correctly. First, verify the tank is full of oil, and then the fill cap is tightened securely. Now, turn the oil injection unit upside down. This position will allow the float to activate the horn.

If the horn sounds, immediately turn the unit rightside up and position it in the mounting bracket. Secure it in place with the strap and Velcro material.

If the horn does not sound, check the 0.5 amp fuse in the fuse holder of the positive battery lead. Check both the battery connections and the charge condition of the battery.

GOOD WORDS

The manufacturer recommends the fuel filter be replaced at the start of each season or at least once a year. The manufacturer also recommends oil be added to the fuel tank at the ratio of 50:1 for the first 6-gallons of fuel used after the unit is brought out of storage. The oil in the fuel tank plus the 50:1 oil mixture in the oil injection unit will deliver a mixture of 25:1 to the powerhead. This ratio will **ENSURE** adequate lubrication of moving parts which have been drained of oil during the storage period.

5-3 ADVANCED OIL INJECTION

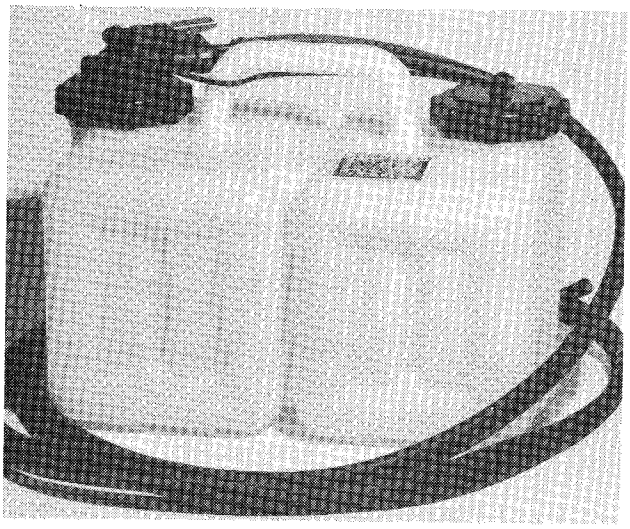
DESCRIPTION

Since introduction of the "Auto Blend" oil injection system covered in the previous section, engineers have strived to improve delivery of an oil/fuel mixture to the cylinders. The result of these efforts was introduction of a new system, we have labeled "Advanced Oil Injection".

As explained in the following paragraphs, an oil reservoir was mounted on the powerhead, the oil pump was moved from the boat to the powerhead, and an oil/fuel mixing chamber was added.

Components

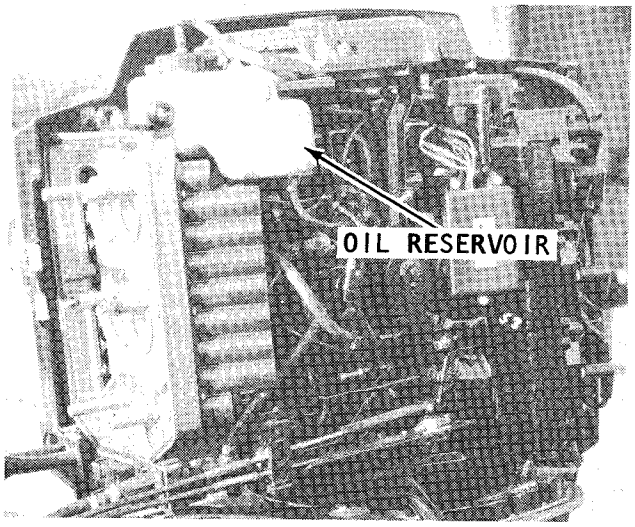
The system consists of a remote oil tank, an oil reservoir, an oil injection pump, three check valves, two sensors, a warning module, a warning horn, and the necessary electrical and hose connections for the system to operate properly. The accompanying functional diagram on the next page, will be most helpful in understanding how the system delivers the correct amount of oil/fuel mixture to the carburetors.



Remote oil tank for the V6 oil injection system ready for hookup and service.

Remote Oil Tank

The remote oil tank has a capacity of 3 gallons US (11.4L). This amount will provide enough oil to mix with 150 gallons (about 568L) with the powerhead operating at wide open throttle (WOT). The tank should be positioned in the boat as close to the outboard unit as possible and secured to keep it upright and prevent spillage. The tank is pressurized while the powerhead is operating. Therefore, the restraints used with



A reservoir tank is mounted on top the powerhead providing gravity flow to the oil pump.

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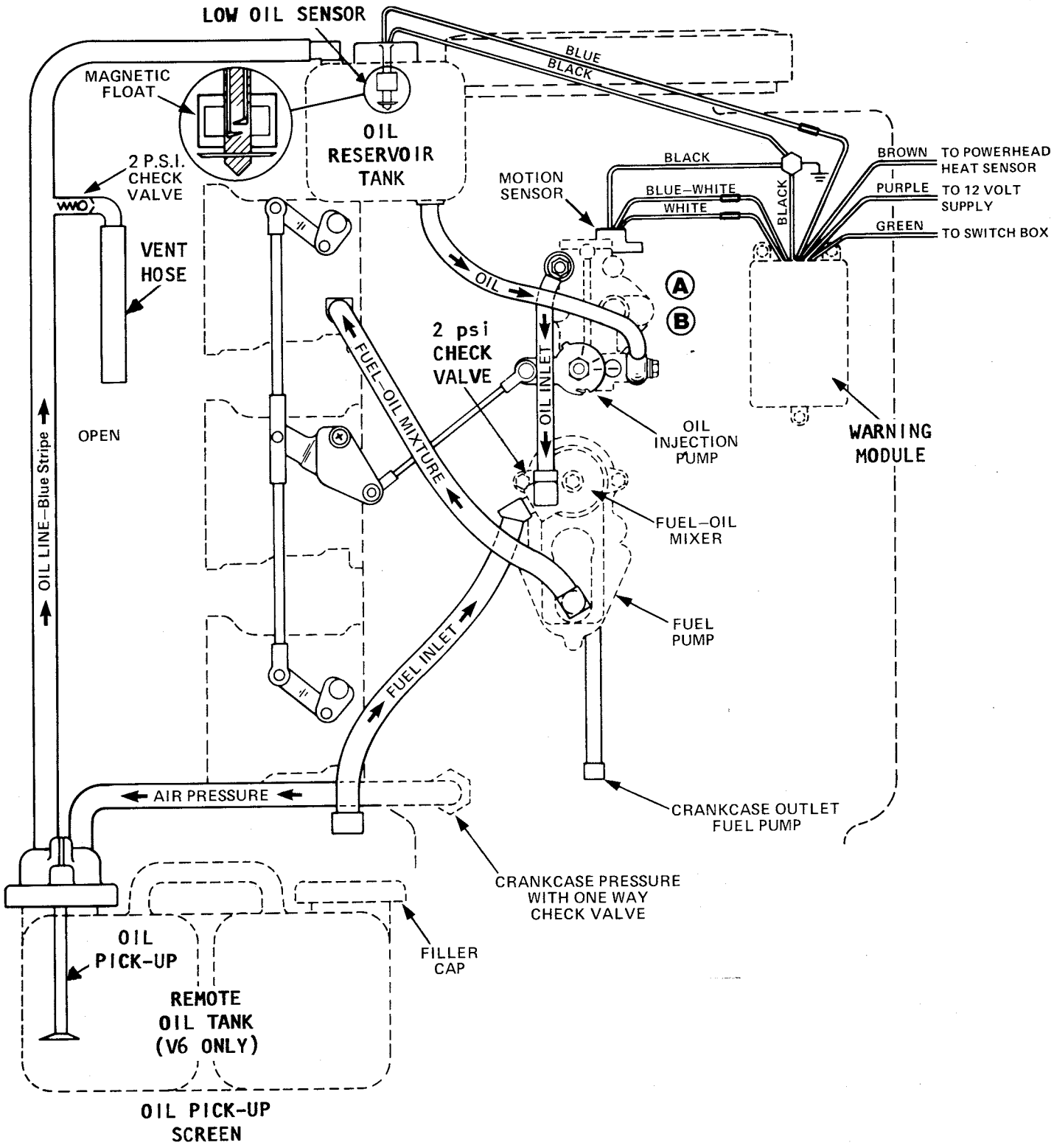

Functional diagram of the "advanced" oil injection system, used on V6 powerheads. This "advanced" oil injection system is also installed on newer (since 1987) 75hp & 90hp 3-cylinder and 100hp & 115hp 4-cylinder powerheads. The system on the 3- and 4-cylinder powerheads does not have the remote oil tank and associated parts. The oil reservoir tank is mounted on the powerhead, as indicated in the drawing.

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the tank should be left with a small amount of slack to enable the tank to expand slightly when it is under pressure.

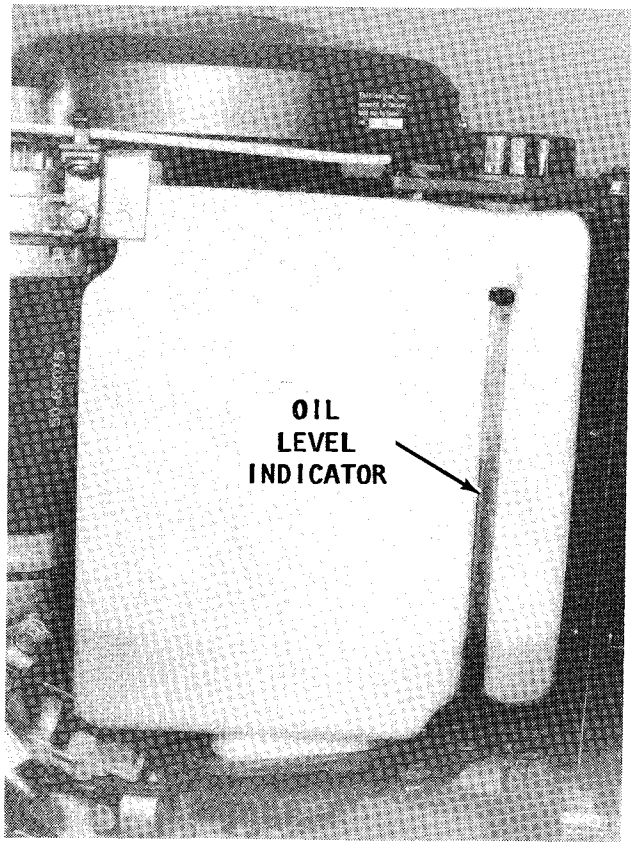
Another factor to be considered when placing the remote tank in the boat, is easy access for unlatching the quick disconnect fitting and removal of the tank for filling. However, it is not necessary to remove the tank for filling.

Oil Reservoir

The oil reservoir is much smaller than the remote tank and is attached to the powerhead under the cowling. The reservoir will only hold enough oil to mix with the fuel for about 30 minutes of powerhead operation at WOT, after the remote tank is drained. The prudent boat owner will consider the reservoir capacity as an emergency ration and will not rely on using it after the remote tank is empty.

Low Oil Sensor

The low oil sensor is installed in the top of the oil reservoir. This sensor operates on a magnetic float principle. As the oil level drops to the dangerous level, a circuit is closed and the warning horn will sound.



Since 1987, 75hp and 90hp 3-cylinder and 100hp and 115hp 4-cylinder powerheads are equipped with a single large oil tank mounted on the powerhead. The tank is provided with an oil level indicator which is visible through a window in the cowling.

Oil Pump

The oil pump is mounted on the powerhead and is driven by a gear and shaft arrangement off the crankshaft. Therefore, as soon as the crankshaft begins to rotate, even during the cranking process, the pump also rotates and begins to deliver oil to the fuel/oil mixer. The pump will meter oil for a mixture with the fuel of approximately 50:1 at wide open throttle and increases the ratio to 100:1 at idle speed.

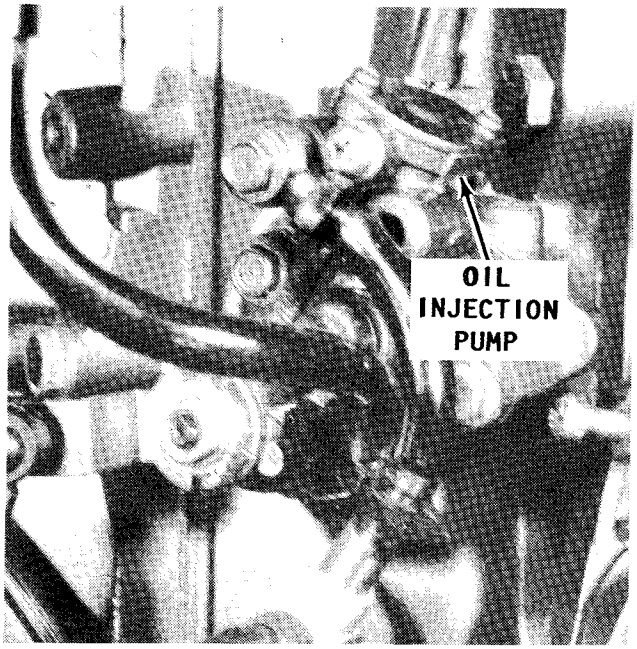
Motion Sensor

The motion sensor is considered a part of the oil pump. If the pump drive system fails to operate for any reason, the sensor will signal the warning module and the warning horn will sound.

Check Valves

Three check valves are used in the system. One 2 psi valve is connected to a Tee fitting in the oil line from the remote tank to the oil reservoir. The third side of the Tee fitting is vented to atmosphere. This check valve prevents pressure in the tanks and the lines from increasing above 2 psi.

The second check valve is also rated at 2 psi and is installed in the oil line just before it enters the fuel/oil mixer. This



The oil injection pump is driven off the crankshaft and supplies oil to the fuel pump. The oil pump is gravity fed from the oil tank mounted high on the powerhead.

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second valve prevents fuel from entering the oil system behind the fuel/oil mixer.

A third check valve is located in the pressure hose from the powerhead crankcase to the remote tank. This valve allows pressure to pass in only one direction.

Warning Module

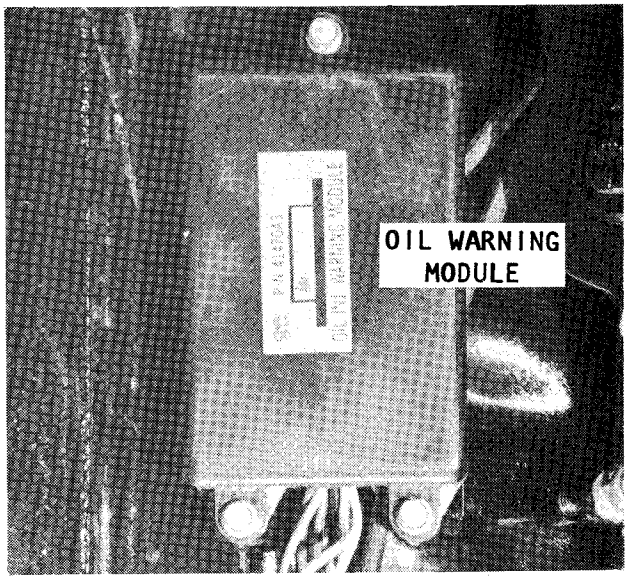
The warning module is connected electrically to the low oil sensor in the oil reservoir; to the motion sensor of the oil pump; to the powerhead heat sensor in the powerhead; to the switch in the remote control box; and to a 12-volt supply.

The module responds to signals from all three sensors and completes the circuit to the warning horn. By having the module connected to the ignition switch, each time the switch is turned on and before the powerhead starts, the warning horn will sound because the motion sensor sends a signal to the module indicating the pump is not operating. The horn sounding also assures the boat operator the system is functioning properly.

OPERATION
ADVANCED OIL INJECTION

When the key switch on the remote control box is turned to the **ON** position, the warning horn will sound intermittently, indicating the warning horn circuit is functioning.

Once the powerhead begins to operate, pressure from the crankcase passes through the one way check valve, through a connecting hose, through a fitting on top of the remote oil tank, and pressurizes the remote tank to 2 psi.



The oil warning module is clearly marked and is installed on the port side of the powerhead.

After the tank is pressurized, oil enters the pickup tube extending down into the tank from a cap on the tank top. A screen at the bottom of the pickup tube filters out foreign matter in the oil.

From the pickup tube, the oil passes upward through the oil hose with a blue stripe into the oil reservoir mounted on the powerhead.

From the reservoir, the oil is gravity fed downward to the oil injection pump.

Because the oil injection pump is mechanically operated through a gear and shaft from the crankshaft, as soon as the crankshaft begins to rotate, even during cranking, the pump begins to rotate also.

The injection pump will meter oil at an oil/fuel ratio of approximately 100:1 at idle speed and at 50:1 ratio at WOT.

This metering is controlled through direct linkage to the carburetor linkage.

From the oil injection pump, the oil is mixed with fuel from the fuel pump and transferred to the top carburetor.



At the first sign of trouble -- the oil warning horn sounding intermittently -- shut down the powerhead at once and check the supply of oil in the reservoir.

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FILLING OIL INJECTION SYSTEM

There is nothing mysterious or difficult about working with the oil injection system. A few points need to be mentioned to ensure proper performance of the system.

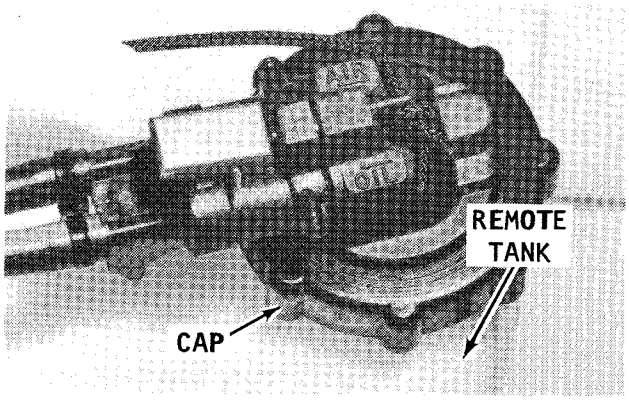
To fill the remote tank, first remove the filler cap from the top of the tank. If the tank is pressurized, a small amount of air will emit an audible sound as the air escapes when the cap is "cracked" open.

Next, fill the tank to the 3-gallon mark with oil. Do not fill the tank past the mark because space must be left to pressurize the tank from the powerhead crankcase. The manufacturer recommends Quicksilver Formula 2-cycle Outboard Motor Oil. If this oil is not available in your area, a high quality 2-cycle outboard oil with a BIA rating of TCW may be substituted.

After the tank is filled to the proper level, install the gasket and then tighten the fill cap securely. An air leak at the remote oil tank cap will allow crankcase pressure to escape and prevent the tank from being pressurized to the required 2 psi. Adequate pressure in the tank will prevent sufficient oil from reaching the oil reservoir on the powerhead.

Check the oil level in the reservoir. If the powerhead has been operated and the remote tank filled, before it was empty, the reservoir should still contain an adequate quantity of oil.

If necessary, remove the fill cap and add oil as required. Be sure to install the gasket and tighten the cap securely. Now, open the cap 1/2 turn. Operate the powerhead and observe trapped air being bled off from the reservoir fill cap. Once air has been purged from the hose between the remote tank and the reservoir, and from the reservoir, only oil will be discharged from around the cap. At this point, tighten the cap securely and observe -- no oil leak from the cap.



The "air in" and "oil out" fittings of the remote tank cap are embossed for identification. The powerhead supplies the air.

An air leak at the reservoir fill cap will cause oil to escape and a reduction in efficiency of the system.

Take time to check the routing of the pressure and oil hoses to and from the remote tank to ensure they do not contain any sharp bends, kinks, or have an object on them to restrict the flow of oil.

PURGING AIR (BLEEDING) ADVANCED OIL INJECTION SYSTEM

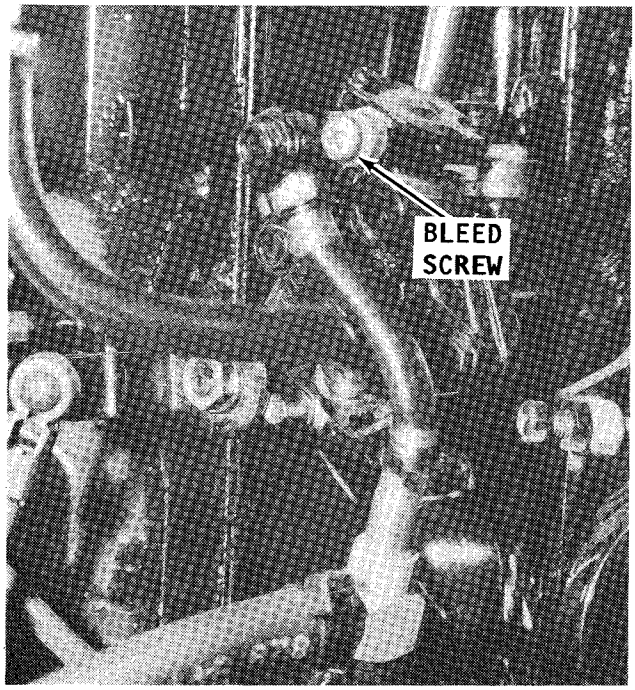
Air must be purged ("bled") from two areas of the system to ensure the proper amount of oil being delivered to the cylinders, either through the carburetors or the EFI system.

Bleed Air From Reservoir and Inlet Hose

With the powerhead operating at idle speed, "crack" the reservoir fill cap open about 1/2 turn. Air will escape from the cap. When the hose between the remote tank and the reservoir has been purged, and the reservoir purged, only oil will escape. Tighten the cap securely.

Bleed Air From Pump and Outlet Hose

With the powerhead not operating, hold an absorbent cloth below the oil injection



The oil pump bleed screw is located on the port side and is easily accessible.

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pump and be prepared to catch oil as it oozes from the bleed screw. Loosen the bleed screw three, maybe four full turns, and allow oil and any air to escape from the screw. When a steady stream of oil is observed with no sign of air, tighten the screw securely.

OIL PUMP ADJUSTMENT

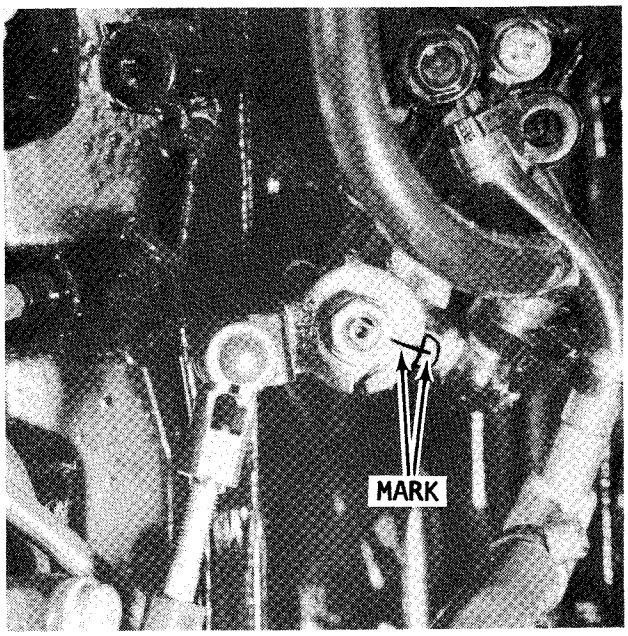
Because the oil injection pump meters oil to mix with fuel for delivery to the carburetors or the EFI system, the pump is physically connected through linkage to the throttle shaft linkage. This arrangement ensures a change in oil metering as the throttle is opened and closed.

To adjust the oil injection pump, begin with the throttle linkage in the idle position and the powerhead **NOT** operating. Observe the mark on the oil injection arm and the mark on the pump casting. The two marks should be aligned.

If the marks are not aligned, adjust the oil injection link rod as shown in the accompanying illustration.

TROUBLESHOOTING OIL ADVANCED INJECTION SYSTEM

The first indication of a problem in the oil injection system will be indicated by the warning horn sounding intermittently. If the horn sounds while the powerhead is operating, shut the unit down **IMMEDIATELY.**



To adjust the oil pump, align the two marks according to the procedures outlined in the text.

Open the cowling and make a visual inspection of the oil injection components. If the oil level in the reservoir is low, the horn was correct in sounding. Filling the reservoir with oil will **NOT** correct the problem. A determination must be made as to why the oil level is low.

Check the oil level in the remote tank. Add oil as required to bring the level up to the 3-gallon level mark. Inspect the oil hose with the blue stripe to be sure a piece of gear has not accidently been placed on the hose restricting oil flow to the reservoir.

WARNING

NEVER OPERATE THE POWERHEAD ON FUEL ONLY. IN AN EMERGENCY, ADD OIL FROM THE REMOTE TANK TO THE FUEL TANK. SERVICE THE OIL SYSTEM AT THE FIRST OPPORTUNITY.

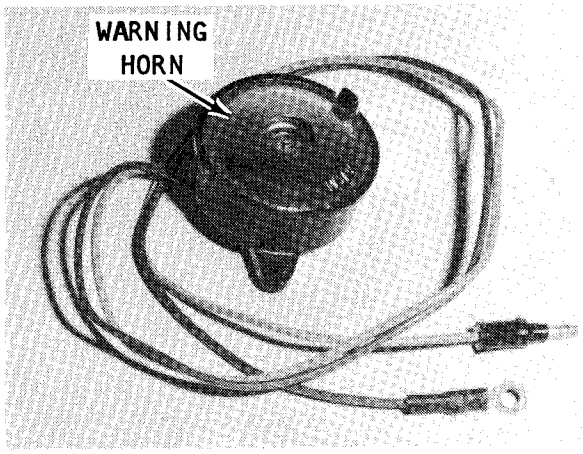
Consult the **TROUBLESHOOTING** chart in this section for possible causes and corrective action to be taken to return the oil injection system to satisfactory operation.

SERVICING ADVANCED OIL INJECTION

The following procedures provide detailed illustrated steps to service components of the "Advanced Oil Injection System".

Perform only the steps required to return the system to satisfactory operation.

Keep the work area as clean as possible and strive to prevent contaminants from entering the system. One of the filter screens in the fuel filter has extremely small openings and can become quickly clogged with dust particles or other foreign material.



The warning horn is usually located under the instrument control panel.

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TROUBLESHOOTING

Oil Level In Reservoir Low But Adequate In Remote Tank

Possible Cause	Corrective Action
Remote tank fill cap is leaking air.	Ensure gasket is in place & cap is tight.
Remote tank quick disconnect not connected.	Ensure fitting is fully connected.
Pickup screen clogged in remote tank.	Remove, clean, and replace screen.
Restriction in blue striped oil hose.	Check hose for kinks or obstruction.
Hose from reservoir to pump damaged.	Check for damage & replace, if required.
Hose between oil pump & fuel pump damaged.	Check for damage & replace, if required.
Check valve at fuel pump faulty.	Test & replace valve, if required.

Warning Horn Fails To Sound When Ignition Key Is Turned To ON

Possible Cause	Corrective Action
Faulty horn or open tan wire between horn and powerhead.	Disconnect tan lead from powerhead wiring harness at terminal block on powerhead. Ground tan lead to powerhead ground. Warning horn should sound. If not, check tan wire between horn and powerhead for open circuit. Check horn.
Warning module.	Ensure all warning module leads are connected to harness leads. If so, warning module is defective.

Horn Sounds Continuously When Ignition Key Is Turned To ON

Possible Cause	Corrective Action
Faulty powerhead overheat sensor.	Disconnect overheat sensor and turn ignition key to **ON** position. If horn still sounds continuously, warning module is at fault. Replace module and retest. If horn does not sound, overheat sensor is faulty. Replace.
	If horn sounds intermittently, warning module is faulty. Replace.

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TROUBLESHOOTING

Warning Horn Sounds When Powerhead Is Operating
Oil Level In Reservoir Adequate

Possible Cause	Corrective Action
Faulty powerhead ignition system.	Check ignition coil lead connections on ignition switch box. Determine the coil lead having the green wire from the warning module connected to it. Check the coil for correct voltage using the DVA. If voltage to coil is correct, voltage to warning module is correct.
Defective low oil sensor in reservoir.	Disconnect both low oil sensor leads from terminal connectors. Do not remove cap from reservoir. Connect ohmmeter between leads. Meter should indicate **NO** continuity. If continuity is present, sensor is faulty.
Defective motion sensor at oil pump.	**WARNING: TAKE STEPS TO PREVENT POWERHEAD START DURING FOLLOWING TESTS.** First, disconnect white lead from module. Check voltage from white lead. Voltage should be 12 volts plus or minus one volt. Next, connect white lead from module. Sensor leads must be connected to module for remaining tests. Insert probe into wire connection for voltage checks. Now, check output voltage to sensor by connecting voltmeter to Blue/White sensor lead. Remove spark plugs and ground spark plug leads. Turn ignition to **ON.** Use emergency start rope and rotate flywheel and at same time observe voltmeter. Output voltage should peak at 5 volts plus or minus one volt and then drop to less than 1 volt during every 2 revolutions of crankshaft. If **NO** voltage is present, then one of two conditions exists: Defective motion sensor -- replace sensor. Defective drive system -- test as described in next section.
Defective oil pump drive system.	**ENSURE** unit will have adequate cooling water. Use 50:1 fuel/oil mixture and start engine. Disconnect link rod between pump and carburetor linkage. Disconnect outlet hose of pump and observe if pump is discharging oil. If no oil, pump drive system is at fault.

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GOOD WORDS

The only purpose for disassembling oil injection pump is to locate a problem in oil delivery. For example, if the pump is frozen due to debris or rust, the pump can be disassembled and cleaned.

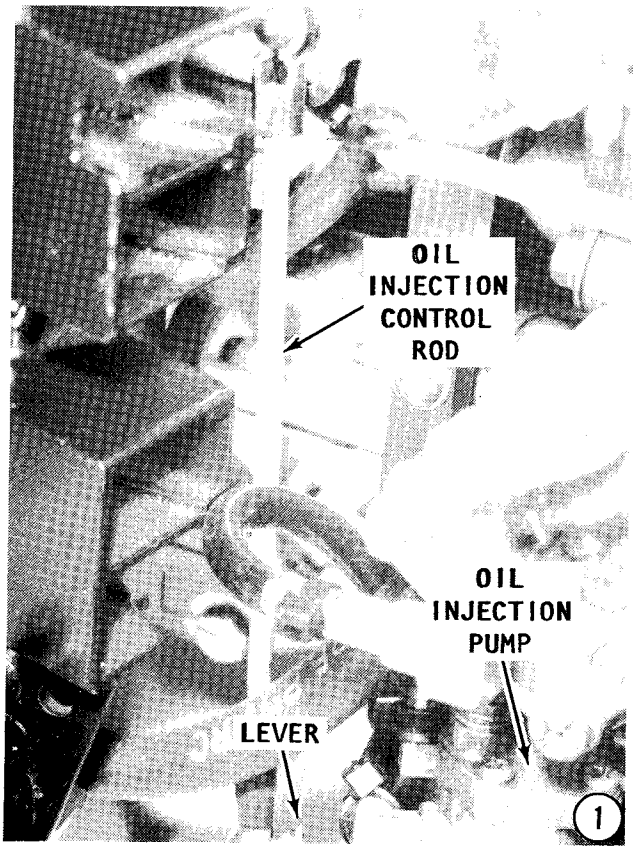
The manufacturer has made no provisions for rebuilding this pump. Spare parts are **NOT** available. If any part is found to be defective and no longer fit for service, other than O-rings, washers or possibly the spring, the pump must be replaced.

O-rings and washers can be matched and replaced, but the spring inside the pump is a component of the oil metering system. Therefore, the elasticity of the replacement spring must be evenly matched. Not an easy task.

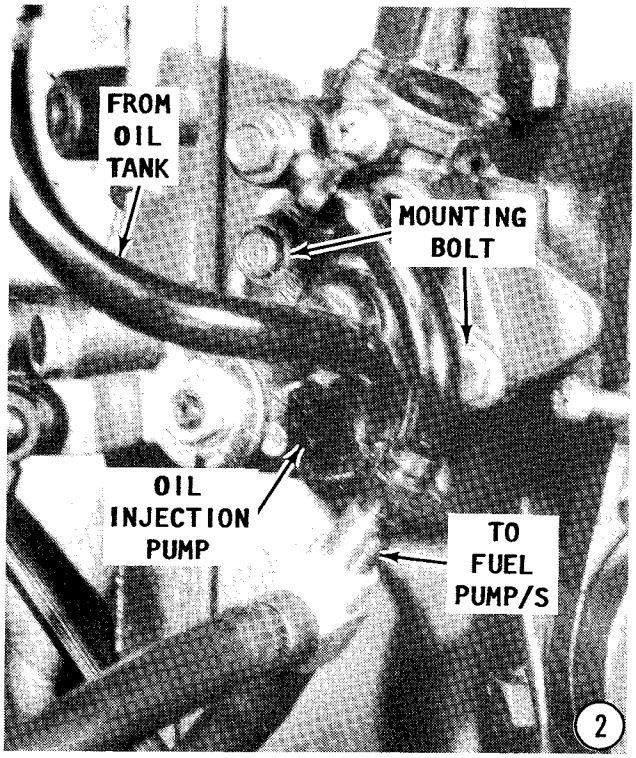
SAVE the O-rings, even if they are defective. The old ring will be essential when purchasing a new ring to ensure the proper type and size is obtained.

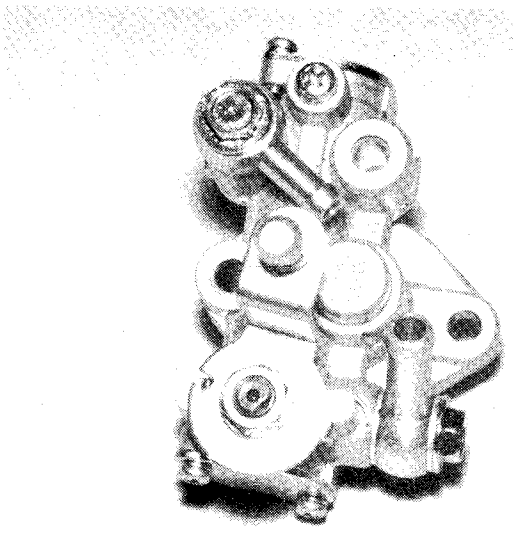
REMOVAL

1- Pry the oil injection link rod free of the ball joint on the injection pump lever. Take care not to alter the length of this rod. If the rod length is accidentally altered, procedures to adjust the length will be found on Page 5-12.



2- Position a suitable container as far as possible under the oil pump to receive oil drained from the tank. Snip the Sta-strap at the inlet fitting. Squeeze the oil supply line from the tank to the pump, to restrict the flow of oil while pulling it free of the fitting. Allow the contents of the tank to drain into the container. Pull the oil line free of the other oil pump fitting. Remove the two bolts securing the pump to the powerhead and lift the pump clear.





An oil injection pump removed from the powerhead ready for servicing.

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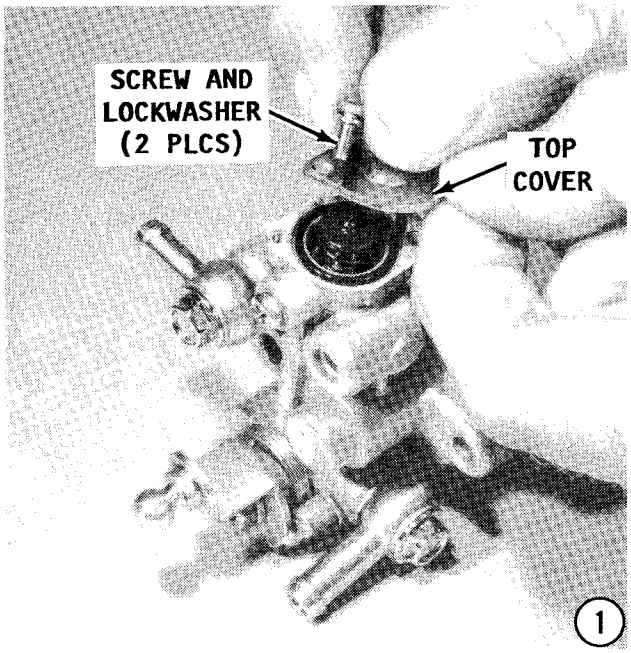

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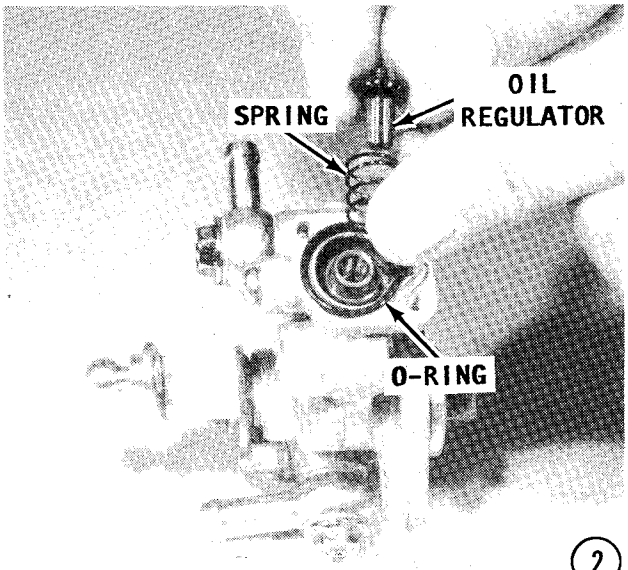

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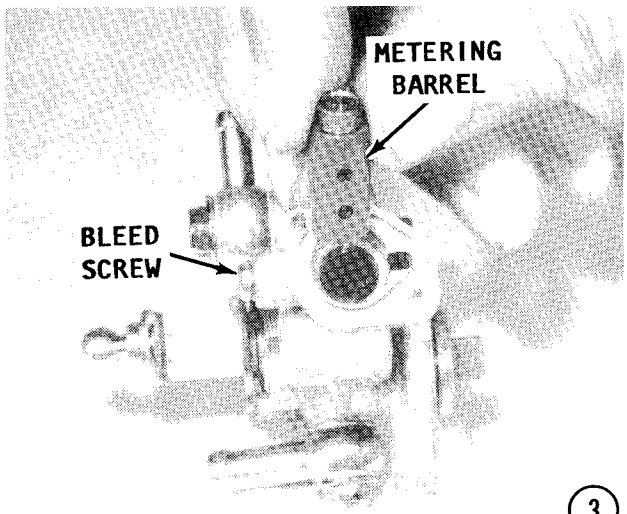

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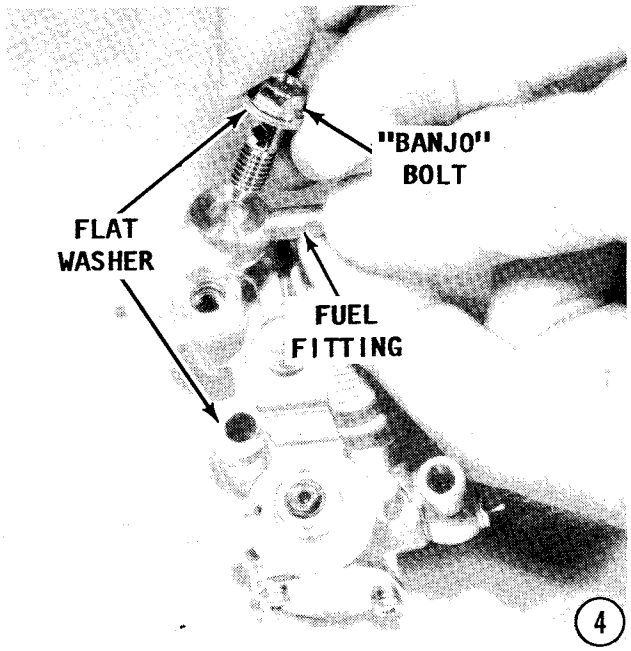

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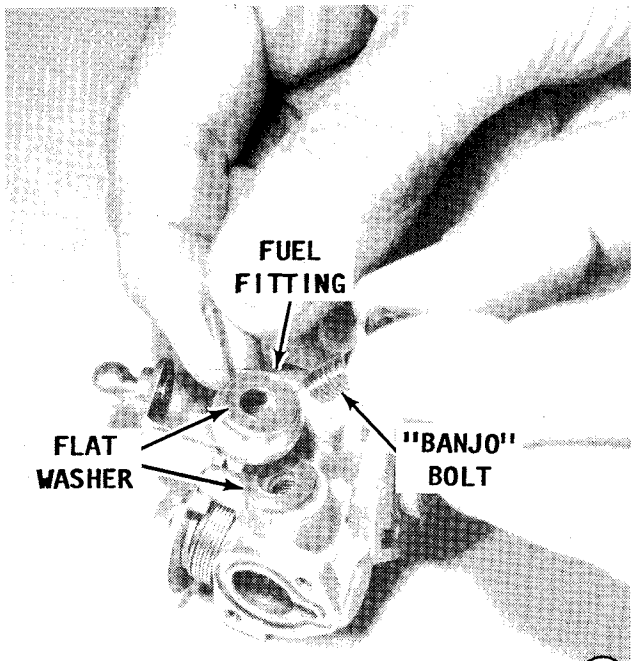
DISASSEMBLING

1- Remove the two Phillips head screws with captive lockwashers, and then remove the top cover.

2- Lift out the oil regulator and spring. Remove and save the O-ring.

3- Use a small pair of needle nose pliers and carefully pull out the metering barrel. Remove the bleed screw and gasket/washer.

4- Loosen and remove the "Banjo" bolt from the oil outlet fitting. The "Banjo" bolt is a very special bolt with a hole



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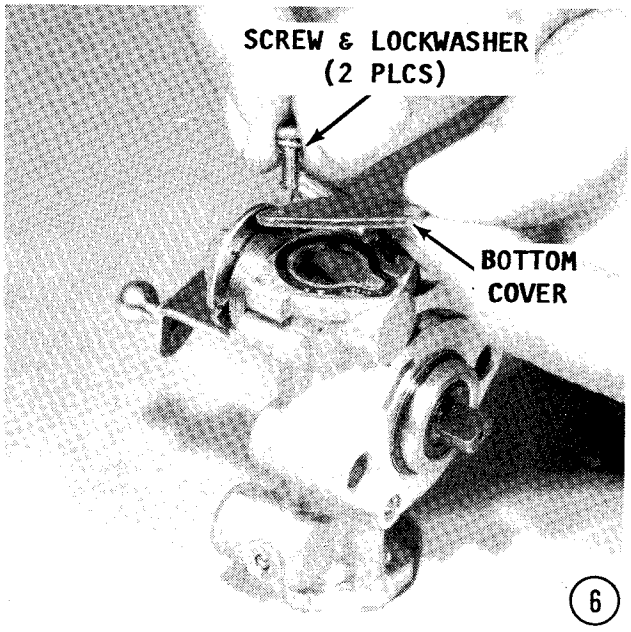

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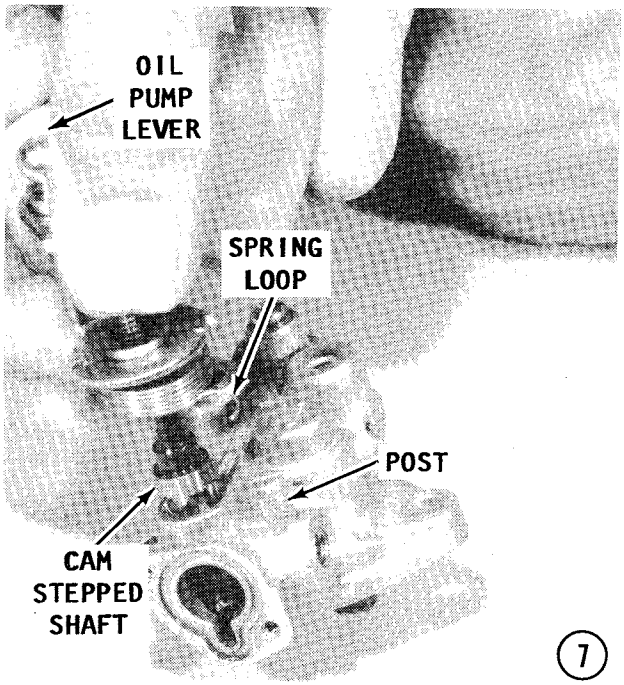
through the shank. The design allows the bolt to be used to secure the fitting and at the same time permit oil to pass through.

Remove the fuel fitting and the two flat washers, one on both sides of the fitting.

5- Remove the fuel inlet fitting in the same manner, as described in the previous step.

6- Remove the two Phillips head screws with captive lockwashers, and then remove the bottom cover. Save the **O**-ring.

7- Note the spring tension on the lever provided by the spring, as an aid during installation. Unhook the small spring loop from the post on the pump body and pull out



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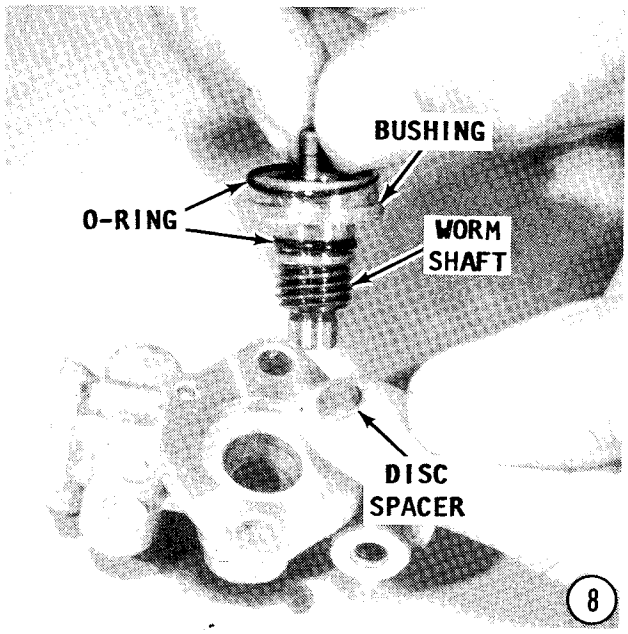

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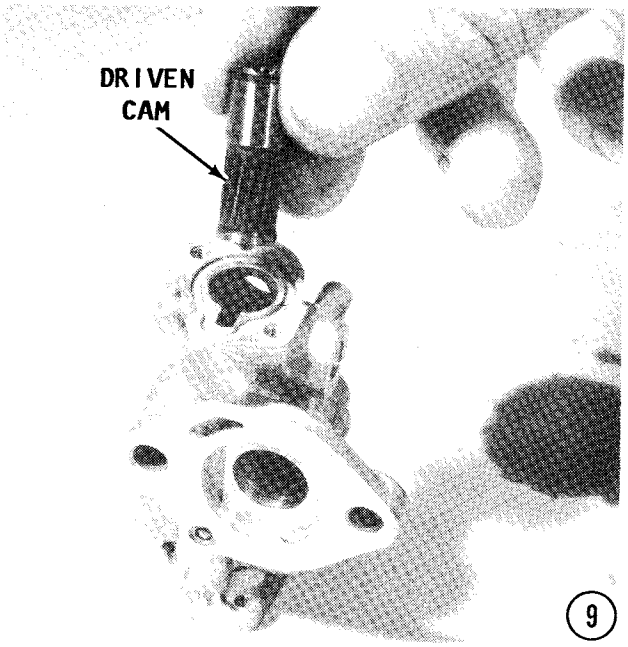
the oil pump lever and stepped cam shaft assembly. Save the **O**-ring.

8- Pull out the worm gear shaft and bushing from the side of the pump. Take care not to loose the small disc spacer at the end of the shaft. Save the two **O**-rings.

9- Push out the driven cam from the pump.

CLEANING AND INSPECTING

Make certain all **O**-rings are removed from the body before emersing the pump in solvent as the solvent will cause the rubber to swell and ruin the sealing properties of the **O**-rings.



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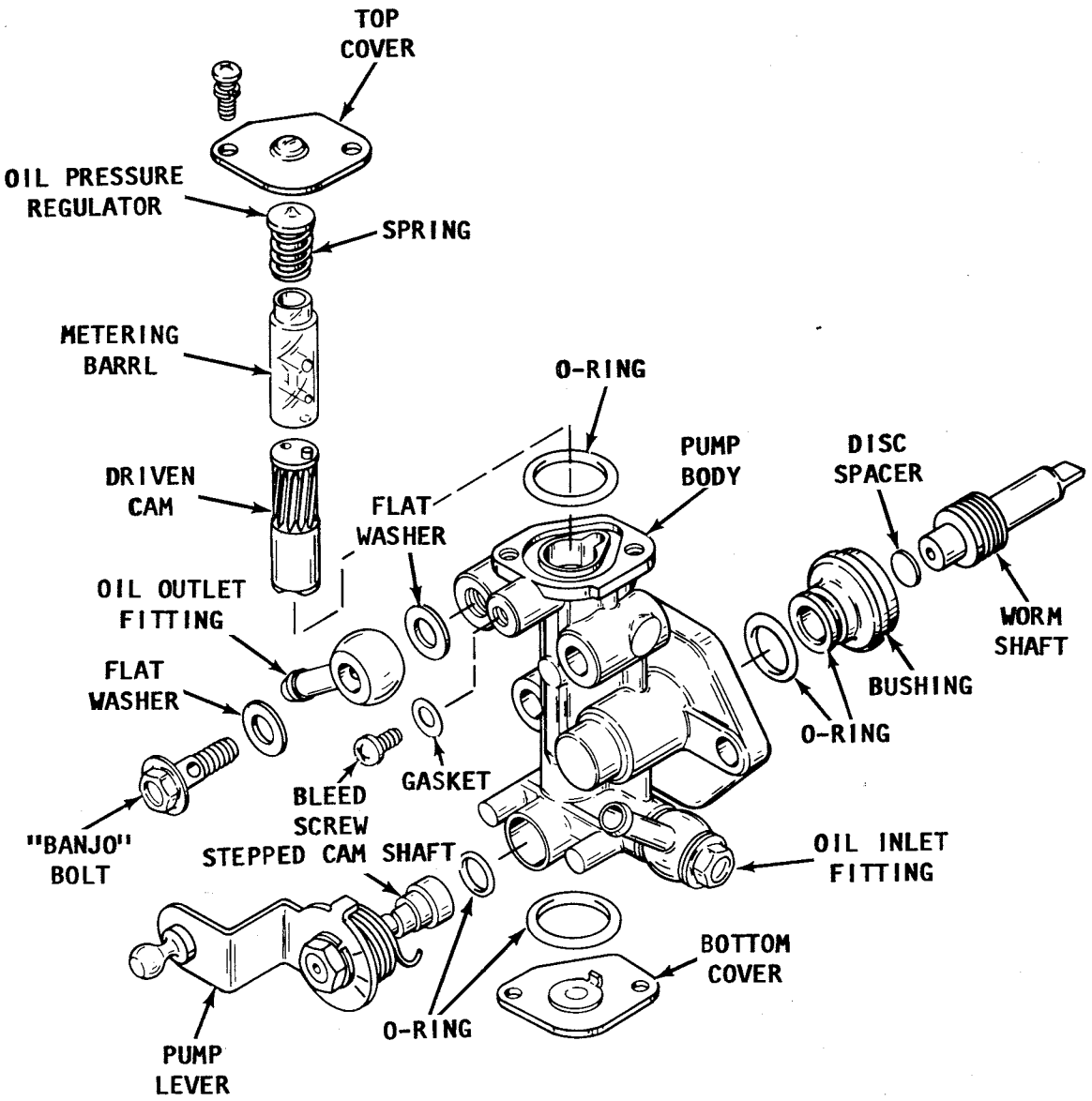

Exploded drawing of an oil injection pump with major parts identified.

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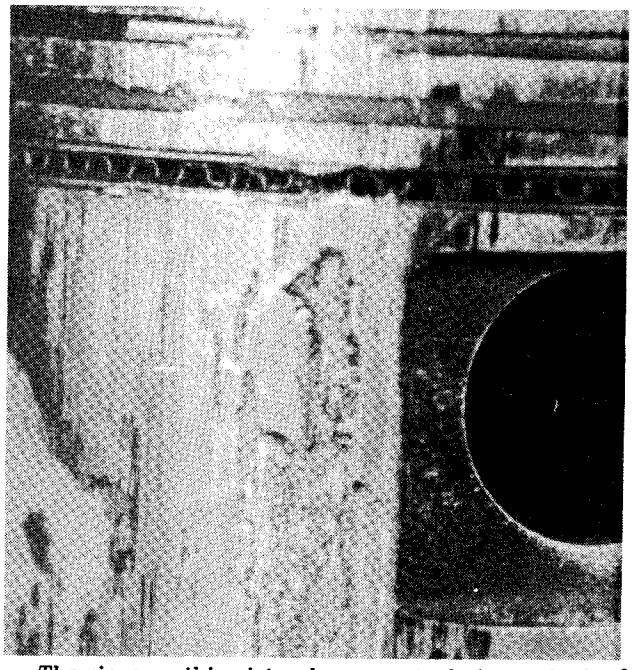
Rinse the pump body and pump covers in solvent and then blow them dry with compressed air. Check all parts and passages to be sure they are not clogged or contain any deposits.

Inspect the condition of the worm shaft threads/teeth and also those on the driven cam for excessive wear or cross threading. Inspect the two coupling posts on the driven gear which engage the holes in the metering barrel. If these posts are sheared off, or the holes elongated, the amount of oil delivered to the powerhead will be greatly restricted. Such a condition will cause a serious lack of lubrication in the powerhead. Therefore, the pump **MUST** be replaced.

The metering barrel and the driven cam ride on the stepped cam at the base of the pump. The regulator rides inside the top of the metering barrel. The top of the regulator rests against the top cover. As the stepped cam is rotated, by action of the oil pump injection lever, the metering barrel and driven cam are raised up against the spring pressure of the regulator spring.

As the metering barrel rises, relative to the regulator, small oil passages are blocked off. Thus, the action of the oil injection pump lever, regulates the oil flow at the outlet fitting. At low rpm, the metering barrel and driven cam ride on the high point of the stepped cam, restricting the flow of oil. At high rpm, the metering barrel, coupled with the driven cam, ride on the low side of the stepped cam shaft. In this position, the regulator is completely clear of the passages in the metering barrel and maximum oil flow is obtained. Any obstruction in these passages will restrict oil flow and subsequently powerhead lubrication.



The rings on this piston became stuck due to lack of adequate lubrication, incorrect timing, or overheating.

If the oil pump had a tendency to leak oil, a number of areas may be at fault. The first place, and most common, is the **O**-ring around the worm shaft. If this O-ring was distorted during installation, the pump would leak at this point.

The second place for leakage is the top and bottom pump covers. Missing or distorted **O**-rings will cause the pump to leak at the covers.

The third place for leakage is the inlet and outlet fittings on the pump. These fittings **MUST** have a flat washer on both sides of the fitting. If either washer is missing, an oil leak could develop at this point.

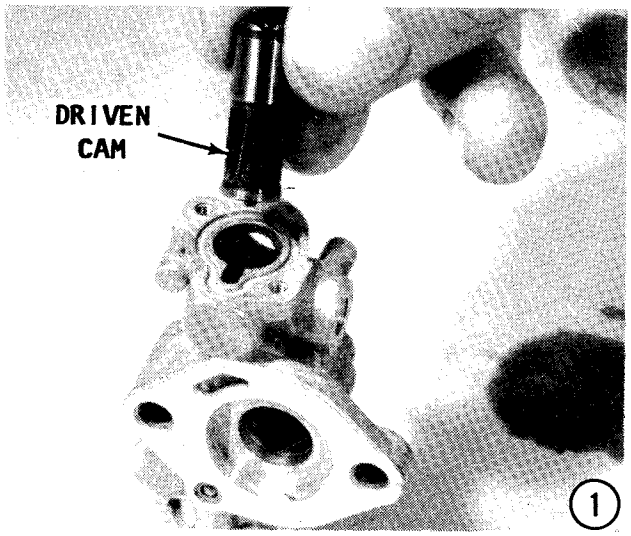
The fourth and last place for a leak is the gasket/washer under the bleed screw. Both of these items **MUST** be in place and in good condition.

Inspect the holes in the two "Banjo" bolts. These special type bolts **MUST** be used to secure the fittings. Obviously, a regular solid type bolt will fit, but will totally shut off the flow of oil through the fitting, with **DISASTEROUS** results to the powerhead.

Lightly oil all internal pump components before assembling.

ASSEMBLING

1- Slide the driven cam down into the bottom of the pump body, with the gear end



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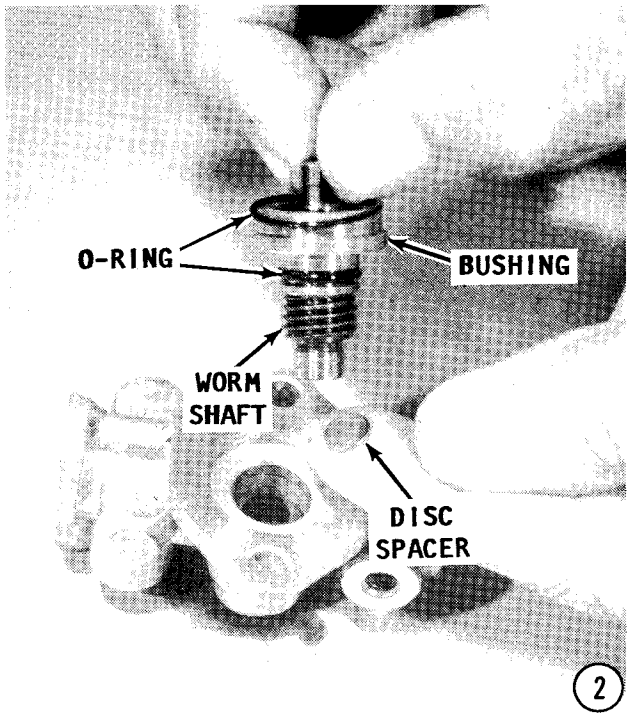
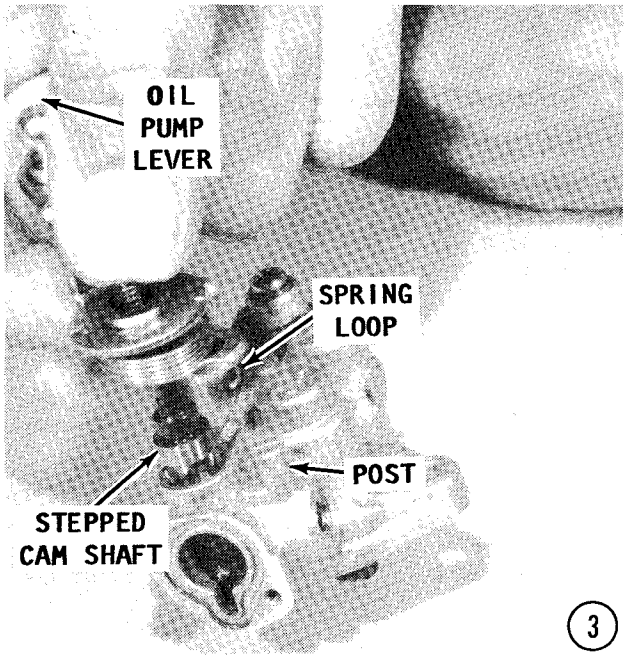
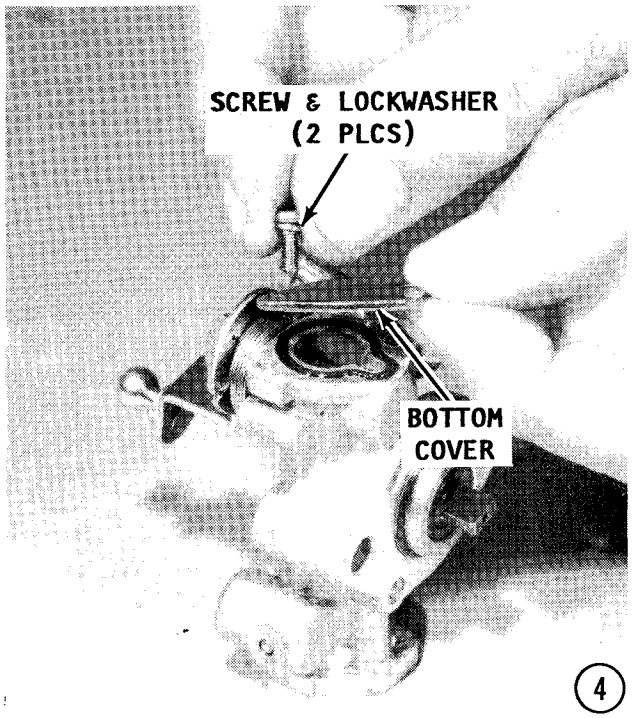


going in first. Line up the gear portion of the cam with the opening for the worm gear.

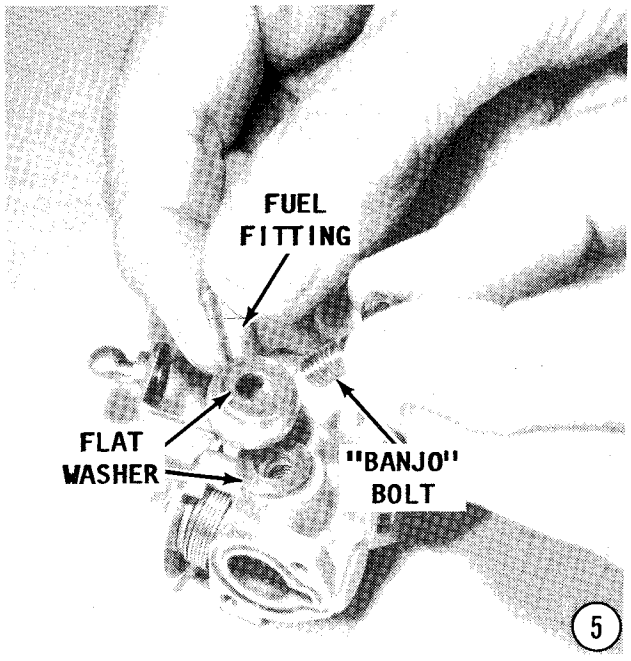
2- If the worm shaft was removed from the large bushing, slide the shaft back into place inside the bushing. Install the two O-rings around the bushing. Place the small disc spacer at the end of the worm shaft. Slide the assembled worm shaft into the pump with the teeth on the shaft indexing with the teeth on the driven cam. Push the shaft in until the shoulder of the bushing seats against the pump body.





3- Install the O-ring around the stepped cam shaft. Slide the oil pump lever and stepped cam assembly into place. Wind the spring **COUNTERCLOCKWISE** a couple turns, and then hook the loop around the post on the body. The spring tension will be adjusted later when the oil control link rod is installed. Push the driven cam down the oil pump bore until the cam rests against the stepped cam.

4- Install the O-ring into the groove on the base of the pump. Place the bottom cover over the O-ring with the tang on the



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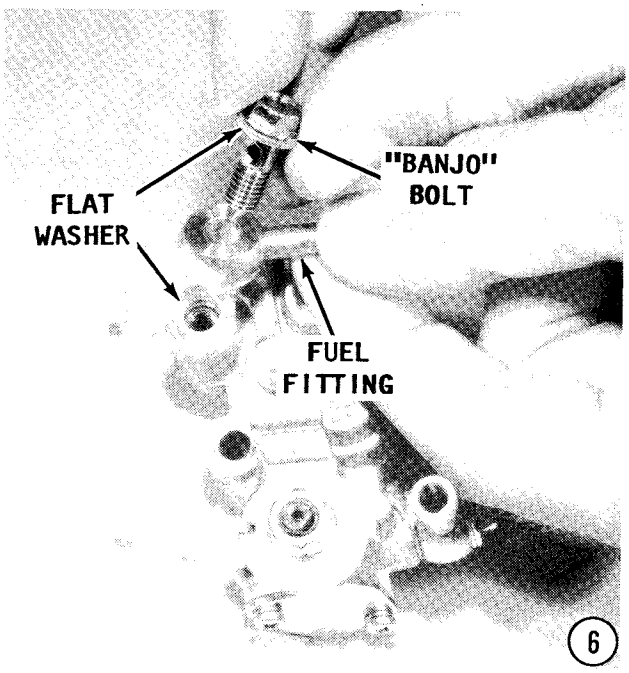

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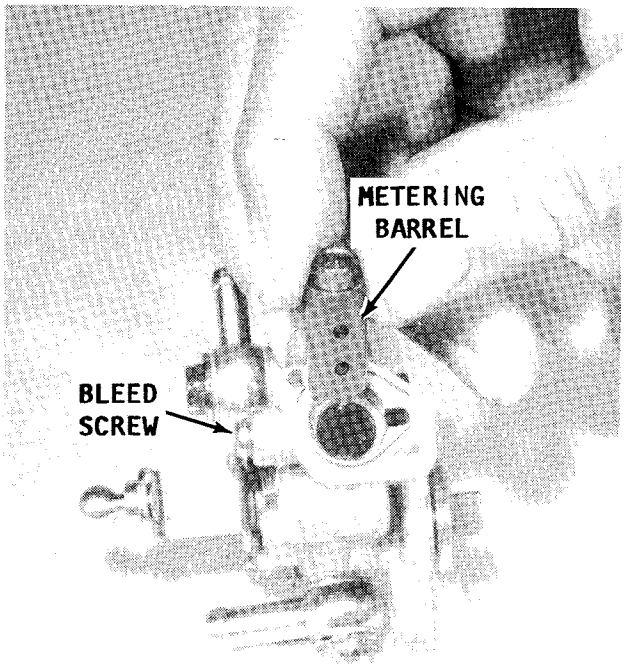
cover facing downward. Install and tighten the two Phillips head screws with their captive lockwashers.

5- Install a flat washer, the oil inlet fitting, another flat washer, and the "Banjo" bolt into the lower opening of the pump.

6- Install the flat washer, oil outlet fitting, another flat washer, and the "Banjo" bolt into the upper opening on the pump.

7- Slide the metering barrel into the pump bore with the posts on the driven cam indexing with the holes in the barrel. Install



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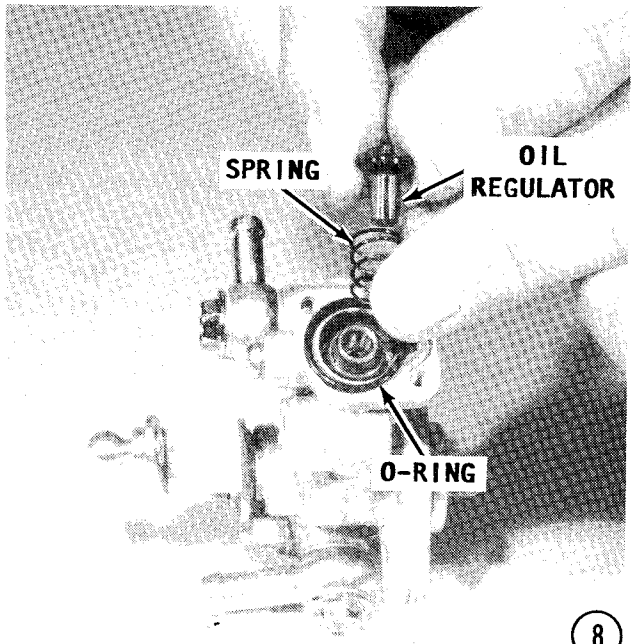

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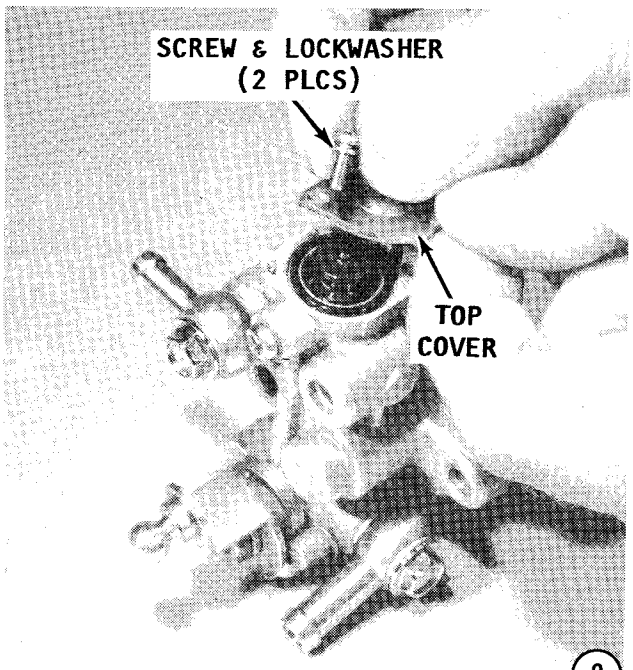
and tighten the bleed screw and the gasket-/washer.

8- Install the O-ring into the groove on the top of the pump. Slide the spring down over the metering barrel and insert the oil regulator into the center of the barrel.

9- Place the top cover over the pump with the dimple in the cover facing upward. Install and tighten the two Phillips head screws with captive lockwashers. Tighten the screws securely.

The pump is now ready for installation to the powerhead.



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INSTALLATION

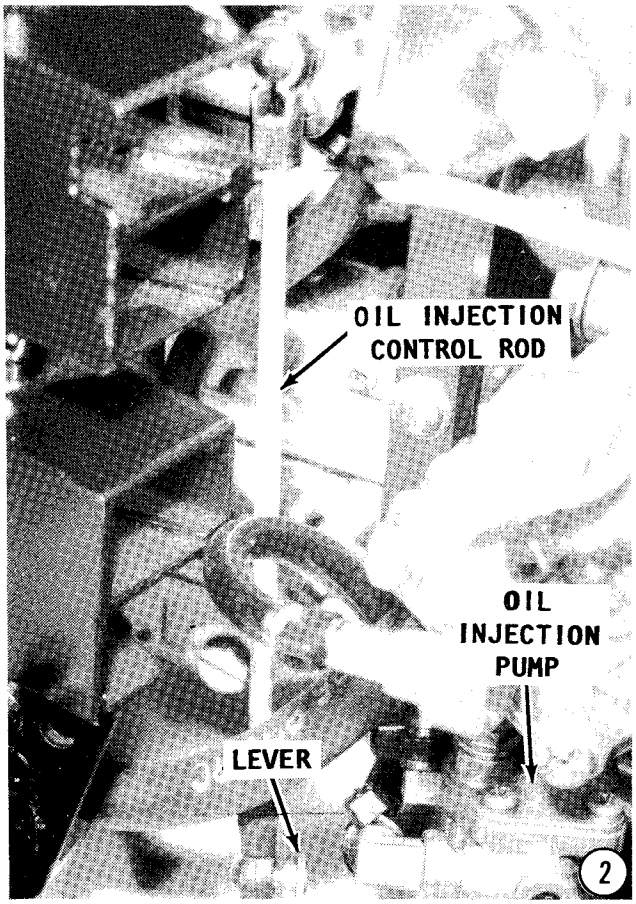
1- Check to be sure the shaft of the oil pump will index into the slot at the center of the crankshaft driven shaft. If the two are no longer aligned, rotate the pump shaft to match the slot in the driven shaft. Install the oil pump with the pump shaft indexed into the slot on the driven shaft. Secure the pump to the powerhead with the two attaching bolts. Tighten the bolts securely.

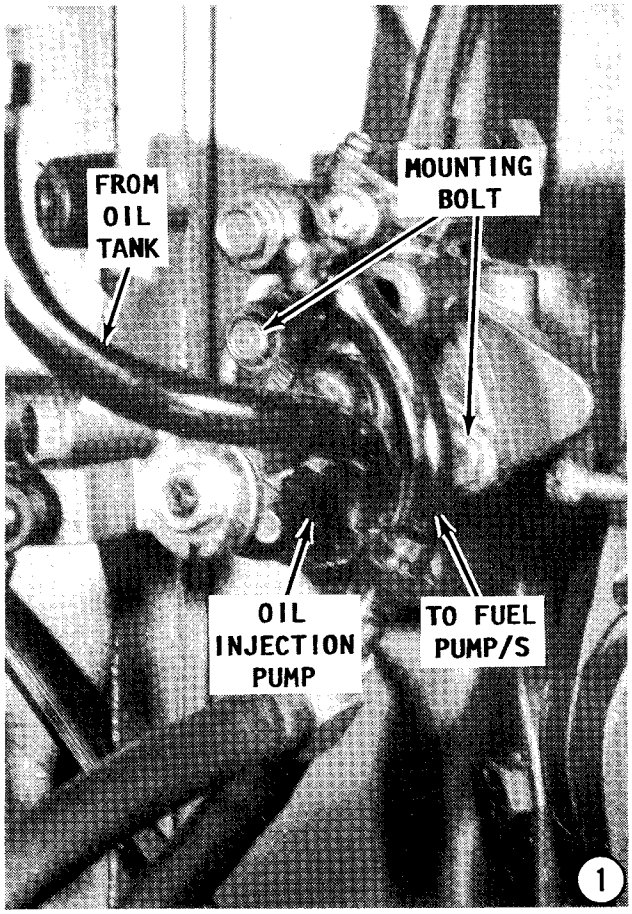
Connect the line from the tank to the lower pump fitting. Connect the line from the fuel pump to the upper pump fitting.

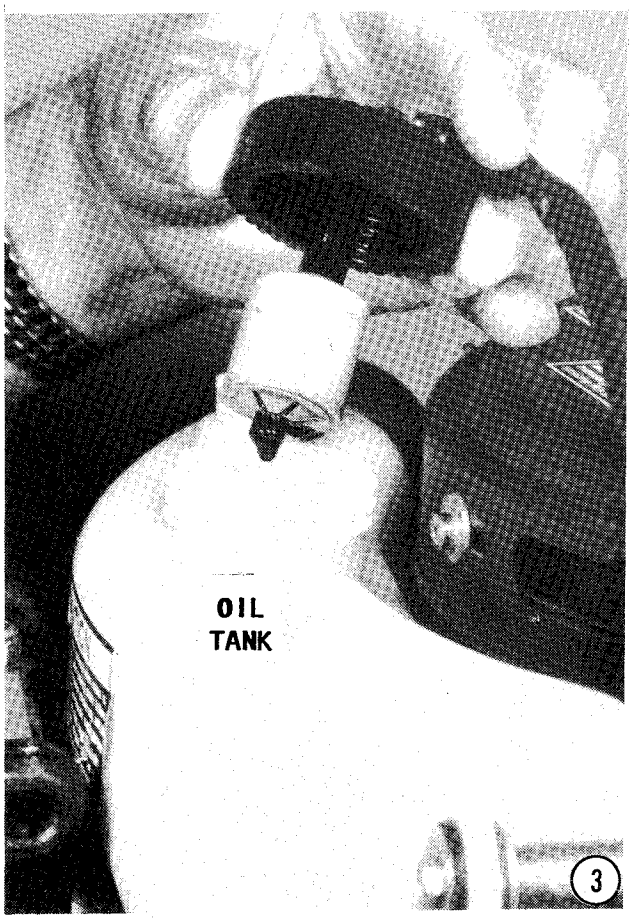
2- Snap the oil injection link rod back onto the ball joint on the pump lever. If the length of this link rod was accidentally altered, see Page 5-12 to adjust the rod to the correct length. Consult the table of Contents for the model being serviced.

Adjust the return spring tension on the lever shaft to permit the correct amount of friction for the lever to stay in place when the rod is moved.

3- Fill and bleed the oil injection system according to the procedures beginning on Pages 5-11.







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6
IGNITION

6-1 INTRODUCTION

The less an outboard engine is operated, the more care it needs. Allowing an outboard engine to remain idle will do more harm than if it is used regularly. To maintain the powerhead in top shape and always ready for efficient operation at any time, the unit should be operated every 3 to 4 weeks throughout the year.

The carburetion and ignition principles of two-cycle engine operation **MUST** be understood in order to perform a proper tune-up on an outboard motor.

If you have any doubts concerning your understanding of two-cycle engine operation, it would be best to study the operation theory section in the first portion of Chapter 8, before tackling any work on the ignition system.

Two different type ignition systems are used on the powerheads covered in this manual. Each system is easily recognized. One system has a distributor. Only a few early 90, 115, and 140hp 6-cylinder in-line powerheads have the distributor ignition.

Instead of a distributor, the new ignition system is labeled, Thunderbolt Flywheel CD Ignition. Almost all the powerheads covered in this manual have the new distributorless ignition system. The majority of ignition components for this new ignition system are housed under the flywheel.

The Thunderbolt Flywheel C.D. system has an ignition coil for each cylinder. The Thunderbolt Pointless Distributor C.D. system has only one coil which serves all cylinders.

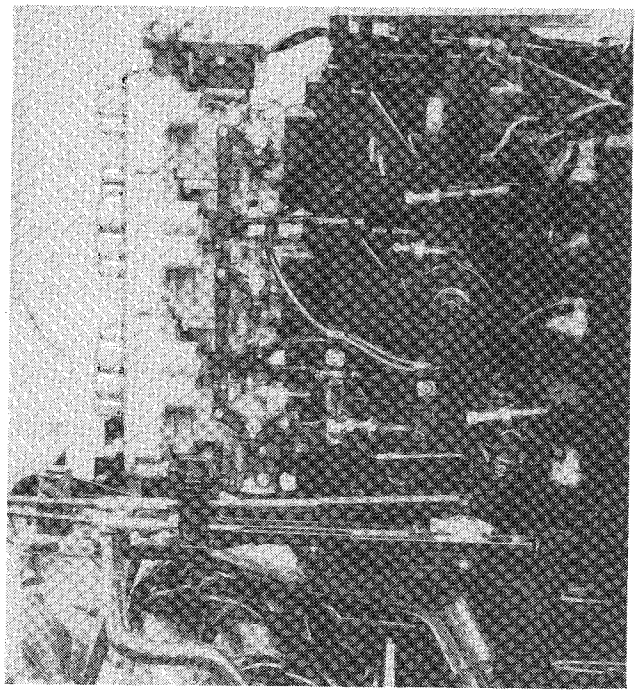
The first sections of this chapter will be devoted to an explanation of each ignition system and its theory of operation. The latter sections will provide troubleshooting and repair instructions for the systems. The last section covers the "black box" modules installed since about 1979. For timing and synchronizing procedures, see Chapter 7.

6-2 SPARK PLUG EVALUATION

Removal

Remove the spark plug wires by pulling and twisting on only the molded cap. **NEVER** pull on the wire or the connection inside the cap may become separated or the boot damaged. Remove the spark plugs and keep them in order. **TAKE CARE** not to tilt the socket as you remove the plug or the insulator may be cracked.

All spark plugs installed on powerheads covered in this manual are of the non-adjustable surface gap type, as shown in the accampanying illustration.



*The carburetion and ignition systems **MUST** be accurately synchronized for optimum performance.*

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The spark plugs should be replaced if the center electrode has burned back more than 1/32" (0.8mm) below the spark plug surface.

Inspect each spark plug for badly worn electrodes, glazed, broken, blistered, or lead fouled insulators. Replace all plugs, if one shows signs of excessive wear.

Check each spark plug to be sure they are all of the same manufacturer and have the same heat range rating.

Inspect the threads in the spark plug opening of the block, and clean the threads before installing the plug.

When purchasing new spark plugs, **ALWAYS** ask the marine dealer if there has been a spark plug change for the engine being serviced.

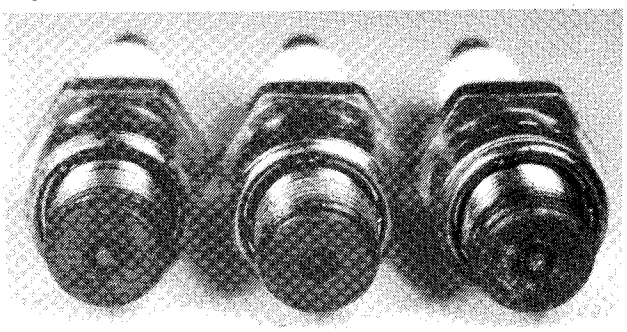
Correct Color

A proper firing plug should be dry and powdery. Hard deposits inside the shell indicate too much oil is being mixed with the fuel. The most important evidence is the light gray to tan color of the porcelain, which is an indication this plug has been running at the correct temperature. This means the plug is one with the correct heat range and also that the air-fuel mixture is correct.

Rich Mixture

A black, sooty condition on both the spark plug shell and the porcelain is caused by an excessively rich air-fuel mixture, both at low and high speeds. The rich mixture lowers the combustion temperature so the spark plug does not run hot enough to burn off the deposits.

Deposits formed only on the shell is an indication the low-speed air-fuel mixture is too rich. At high speeds with the correct mixture, the temperature in the combustion chamber is high enough to burn off the deposits on the insulator.



The spark plugs should be kept in order as they are removed from the powerhead to enable a proper diagnosis to be made of each cylinder operating condition .

Too Cool

A dark insulator, with very few deposits, indicates the plug is running too cool. This condition can be caused by low compression or by using a spark plug of an incorrect heat range. If this condition shows on only one plug it is most usually caused by low compression in that cylinder. If all of the plugs have this appearance, then it is probably due to the plugs having a too-low heat range.

Fouled

A fouled spark plug may be caused by the wet oily deposits on the insulator shorting the high-tension current to ground inside the shell. The condition may also be caused by ignition problems which prevent a high-tension pulse from being delivered to the spark plug.

Carbon Deposits

Heavy carbon-like deposits are an indication of excessive oil in the fuel. This condition may be the result of worn piston rings.

Electrode Wear

Electrode wear results in a wide circular gap and if the electrode becomes carbonized it will form a high-resistance path for the spark to jump across. Such a condition will cause the powerhead to misfire during acceleration. If all of the plugs are in this condition, it can cause an increase in fuel consumption and very poor performance at high-speed operation. The solution is to replace the spark plugs with a rating in the proper heat range.

Red rust-colored deposits on the entire firing end of a spark plug can be caused by water in the cylinder combustion chamber. This can be the first evidence of water entering the cylinders through the exhaust manifold. This condition **MUST** be corrected at the first opportunity. Refer to Chapter 8, Powerhead Service.

Installation

Crank the powerhead through several revolutions to blow out any material which might have become dislodged during cleaning.

Install the spark plugs and tighten them to a torque value of 20ft lbs (26Nm). **ALWAYS** use a new gasket and wipe the seats in the block clean. The gasket must be fully compressed on clean seats to complete the

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heat transfer process and to provide a gas tight seal in the cylinder. If the torque value is too high, the heat will dissipate too rapidly. Conversely, if the torque value is too low, heat will not dissipate fast enough.

6-3 THUNDERBOLT — DISTRIBUTOR CD IGNITION — POINTLESS

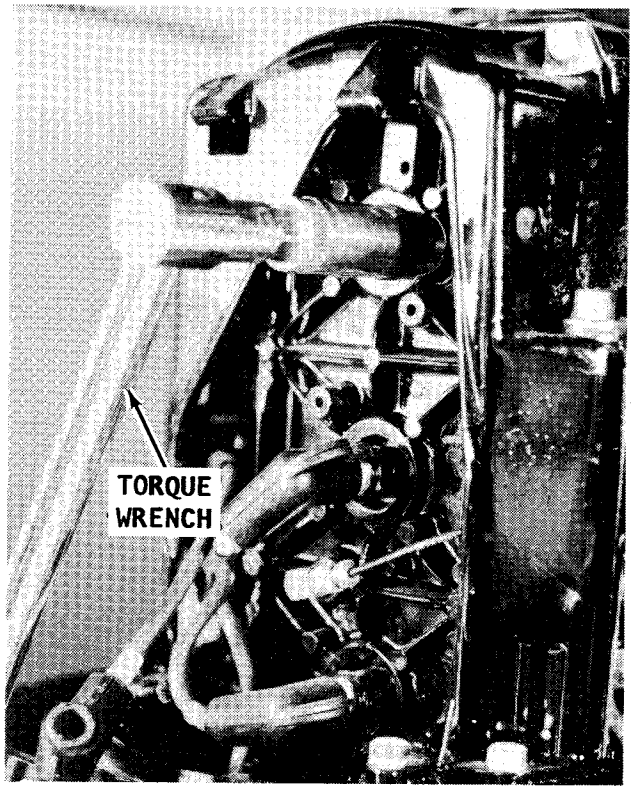
Description

This ignition system is easily identified because of the distributor and drive belt off the flywheel. Only a few early 90, 115, and 140hp 6-cylinder in-line powerheads have this type ignition.

CRITICAL WORDS

These next two paragraphs may well be the most important words in this chapter. Misuse of the wiring harness is the most single cause of electrical problems with outboard power plants.

A wiring harness is used between the key switch and the powerhead. This harness seldom contains wire of sufficient size to allow connecting accessories. Therefore, anytime a new accessory is installed, **NEW** wiring should be used between the battery and the accessory. A separate fuse panel **MUST** be installed on the control panel. To connect the fuse panel, use two Red and Black No. 10 gauge wires from the battery. CD ignition systems require a full 12-volts for proper operation. Therefore, again let it be said, **NEVER** connect accessories through the key switch.



The spark plugs should always be tightened to the torque value recommended by the manufacturer.

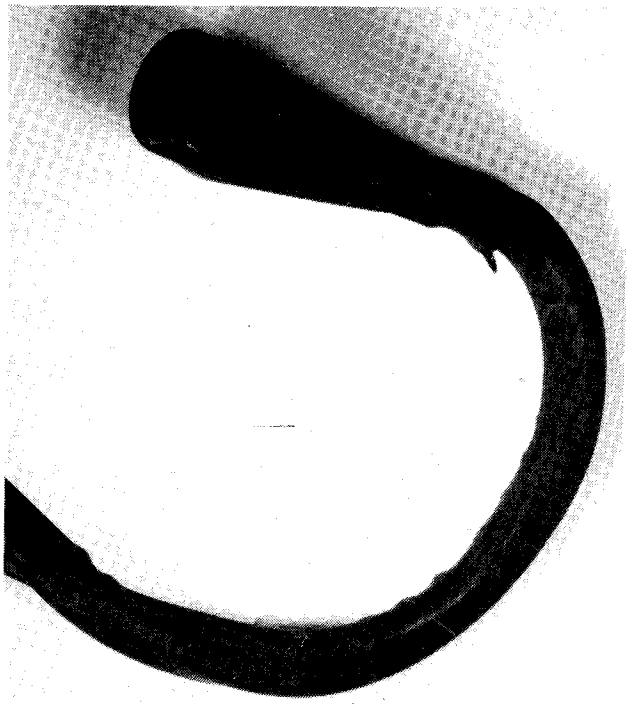
Key Switch

A marine type key switch **MUST** be installed as a replacement item. An automotive type switch installation may cause damage to the system.

Current Flow

The flow of current from the battery to the spark plug is as follows: When the ignition key switch is turned to the **ON** position, battery voltage is supplied to the switch box. At the switch box, the battery voltage is inverted to create AC voltage. This AC voltage is stepped up to a higher AC voltage and is rectified and stored in a capacitor in the switch box. Here the current awaits a trigger signal.

Now, at the same time the key switch is turned to the **ON** position, a reduced voltage is conducted to the trigger. This trigger is located in the distributor housing and consists of two opposite faced coils. One coil produces a magnetic field and is considered the **SENDER.** The opposite coil produces a trigger signal when a slot (window) in the



*A damaged wiring lead or harness cannot be repaired, it **MUST** be replaced.*

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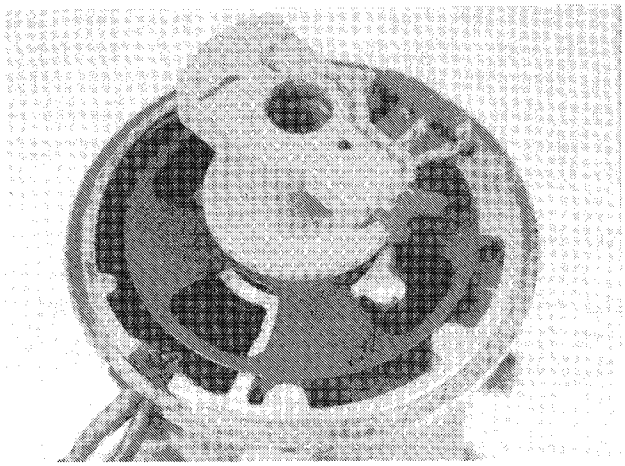


Distributor and rotor used with the Capacitor Discharge (CD) ignition system. The rotor is a part of the shaft and ***CANNOT*** *be removed.*

rotor disc passes between these coils. Therefore, this second coil is considered the **RECEIVER.**

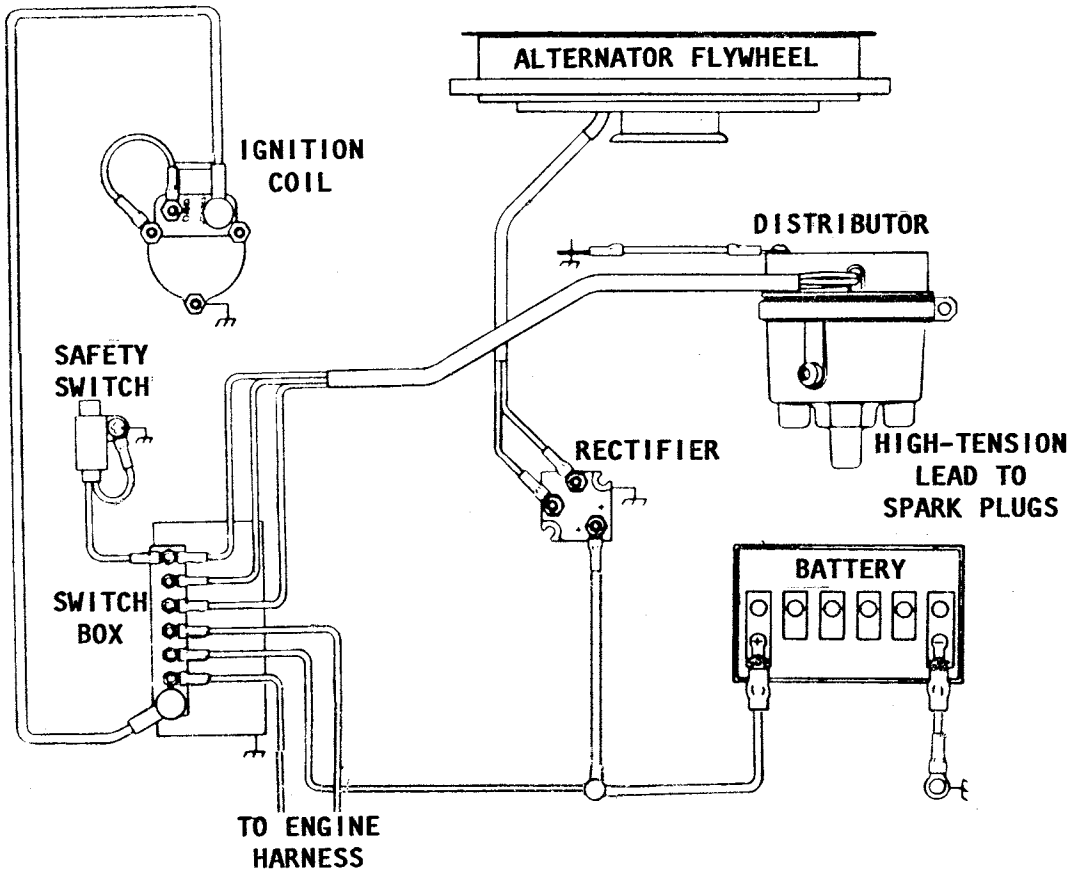
The rotor disc has one slot (window) for each cylinder in the powerhead. The disc is driven at crankshaft speed by the flywheel pulley, timing belt and distributor pulley. This trigger signal operates a SCR (switch control rectifier) which discharges the switch box capacitor into the primary winding of the ignition coil. A high strength magnetic field is built around the coil core. As the SCR turns off, there is no voltage to sustain this magnetic field, thus it collapses very rapidly, inducing a higher voltage in the secondary winding of the coil. This voltage is applied to the spark plugs by the distributor rotor, cap, and high-tension lead wires.

Advance or retard is accomplished by rotating the trigger coils in relation to the rotor disc openings.

The engine is shut down by turning the key switch to the **OFF** position. This action interrupts the battery voltage to the white terminal of the switch box.

TROUBLESHOOTING THUNDERBOLT — DISTRIBUTOR CD IGNITION — POINTLESS

Always attempt to proceed with the troubleshooting in an orderly manner. The "shot-in-the-dark" approach will only result in wasted time, incorrect diagnosis, replacement of unnecessary parts, and frustration.



Functional diagram of the Distributor Type ignition system covered in this section.

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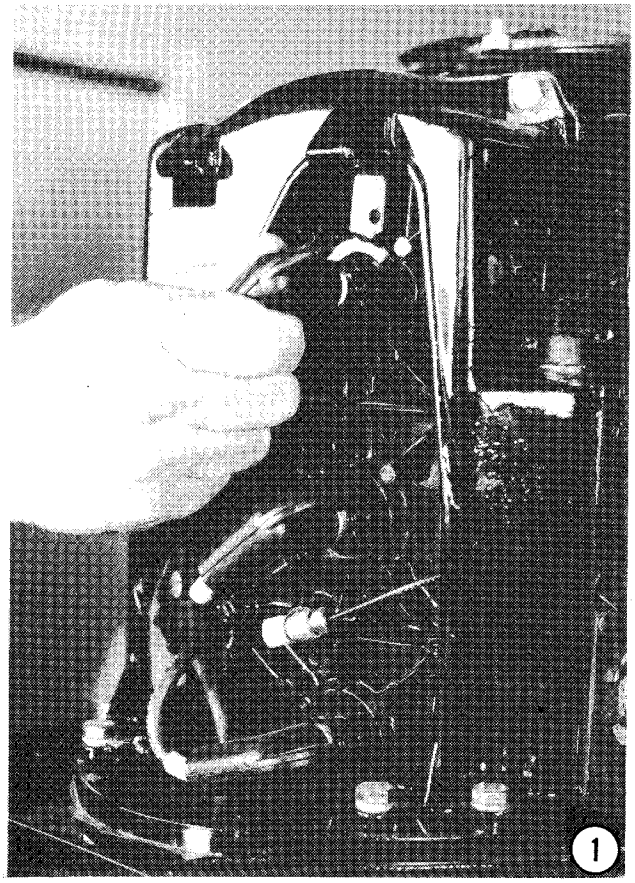
Begin the ignition system troubleshooting with the spark plugs and continue through the system until the source of trouble is located.

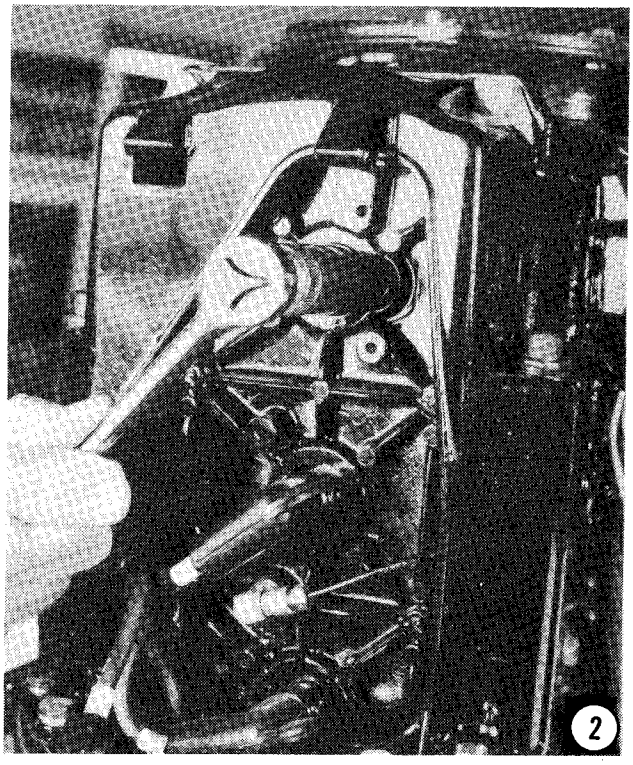
Spark Plugs

1- Check the plug wires to be sure they are properly connected. Check the entire length of the wires from the plugs to the distributor. If the wire is to be removed from the spark plug, **ALWAYS** use a pulling and twisting motion as a precaution against damaging the connection.

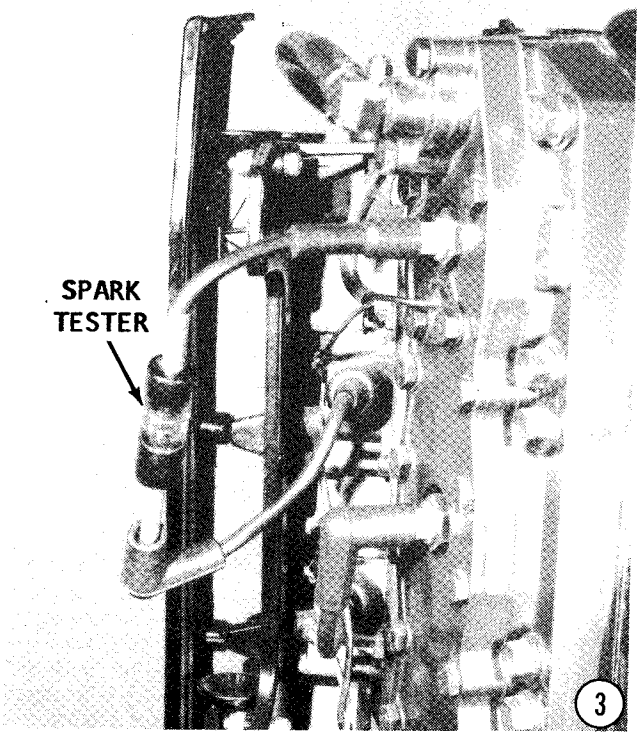
2- Attempt to remove the spark plugs by hand. This is a rough test to determine if the plug is tightened properly. You should not be able to remove the plug without using the proper socket size tool. Remove the spark plugs and keep them in order. Examine each plug and evaluate its condition as described in Section 6-2.

3- Use a spark tester and check for spark at each cylinder. If a spark tester is not available, hold the plug wire about 3/8" to 1/2" (9.53 to 12.7mm) from the powerhead. Rotate the flywheel with a rope wrapped around the flywheel or with a cranking motor and check for spark. A strong spark over a wide gap must be observed





when testing in this manner, because under compression a strong spark is necessary in order to ignite the air/fuel mixture in the cylinder. This means it is possible to think you have a strong spark, when in reality the spark will be too weak when the plug is installed. If there is no spark, or if the spark is weak, the trouble is most likely in the distributor or in the switch box.



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Compression

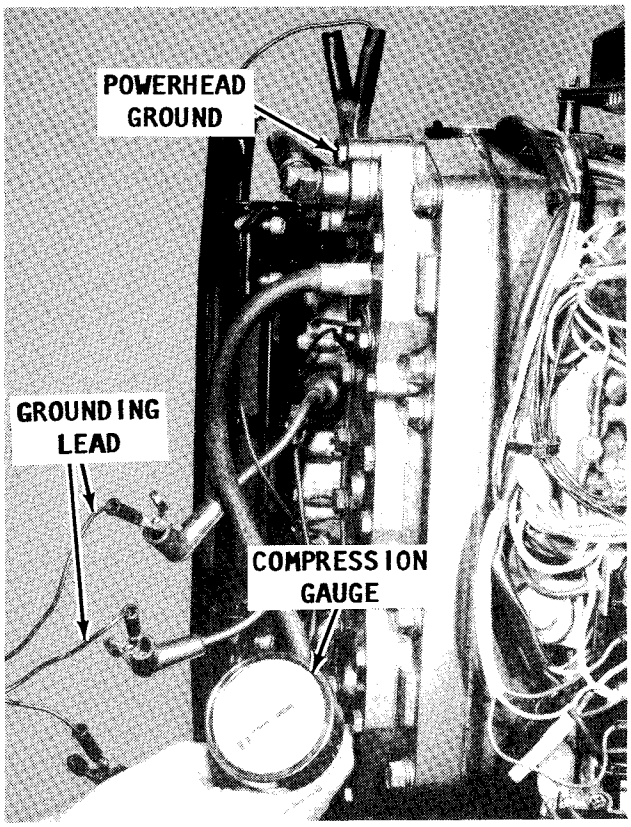
Before spending too much time and money attempting to trace a problem to the ignition system, a compression check of each cylinder should be made. If the cylinder does not have adequate compression, troubleshooting and attempted service of the ignition or fuel system will fail to give the desired results of satisfactory powerhead performance.

Remove the spark plug wires by pulling and twisting **ONLY** on the molded cap. **NEVER** pull on the wire because the connection inside the cap may be separated or the boot be damaged.

Ground the spark plug leads to the powerhead to render the ignition system inoperative while performing the compression check. This is also a precautionary measure to prevent damage to the ignition coil. If a lead is not grounded, the coil will attempt to match the demand created by the spark trying to jump from the center electrode to the nearest ground.

Remove the spark plugs. Insert a compression gauge into the cylinder spark plug hole. Crank the powerhead for several revolutions and note the compression reading. Repeat the procedure for each cylinder.

A variation in reading between the cylinders is far more important than the actual individual readings. If a particular cylinder varies more than 20 psi from the others, the cylinder may be scored, the rings frozen, or the piston burned.

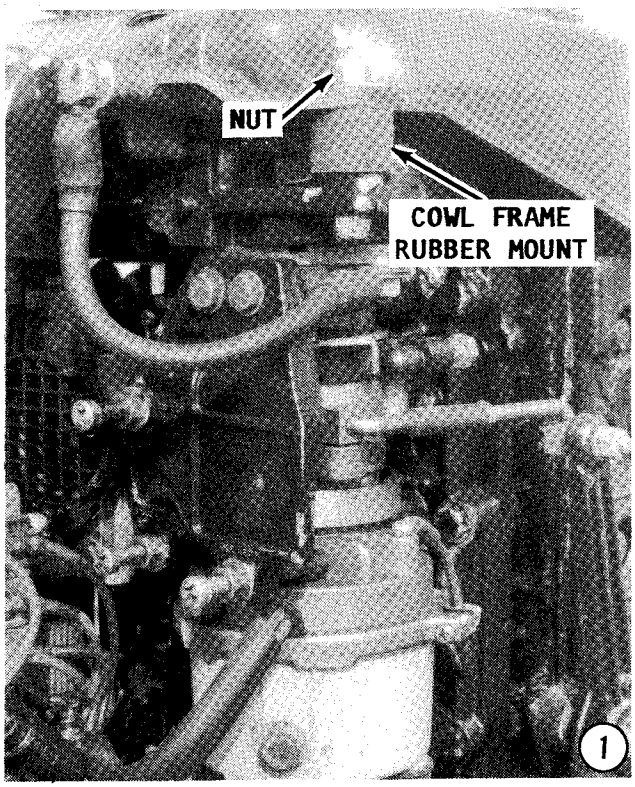


*When a compression check is performed, the spark plug leads **MUST** be grounded to the powerhead to prevent excessive strain on the coil. If the leads are not grounded, and simply left hanging, the coil will attempt to match the demand created by the spark trying to jump from the plug shell to nearest ground.*

DISTRIBUTOR OR SWITCH BOX TESTING

A Quicksilver Thunderbolt ignition analyzer **MUST** be used to properly test the distributor or switch box. Actually, the best advice that can be given is to remove the distributor and switch box, and then take them to your Mariner dealer for testing and check.

By taking them to the dealer two things will be accomplished. First, the dealer is equipped with trained personnel and adequate equipment to do the job properly. Secondly, electrical parts, in almost all cases, cannot be returned once the item leaves the store. Therefore, the cost of purchasing unnecessary electrical components is avoided. In short, you save time, money, and frustration by having the testing done right the **FIRST** time.



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IGNITION COIL CHECKS

MODEL	TESTER LEADS TO:	OHM SCALE	SCALE READING
90, 115 and 140hp Powerheads with Distributor Type Ignition	Between Positive and Negative coil terminals	Rx1	.01-.02
	Between coil tower and either positive or negative coil terminals	Rx1000	No Cont.
	Between coil tower and powerhead ground (if mounted) or to small pigtail (if not)	Rx100	57-73

SERVICING THUNDERBOLT — DISTRIBUTOR CD IGNITION — POINTLESS

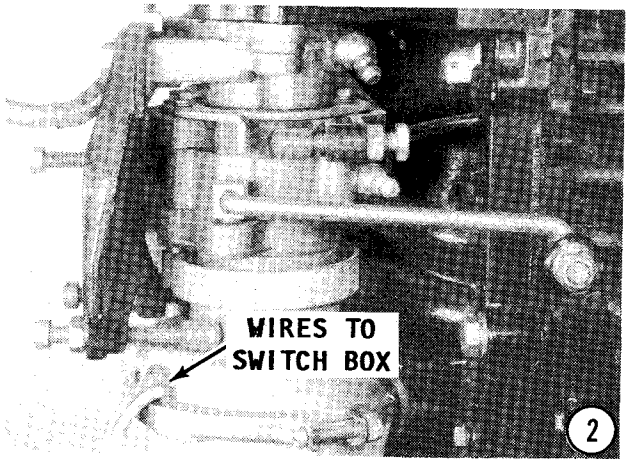
Ignition overhaul procedures may differ slightly on various outboard models, but the following general basic instructions will apply to all Mariner outboard engines equipped with the Thunderbolt -- CD Ignition --pointless --with a distributor.

Distributor Removal

1- Remove the electrical harness and the battery leads from the powerhead. Remove the wrap around cowling. Remove the support frame and rear support by removing the three nuts from the top of the cowl frame rubber mount.

2- Remove the two bolts and lockwashers at the front top of the support frame. Remove the four bolts and lockwashers at the bottom of the rear support bracket. Disconnect the choke solenoid wire at the solenoid, and then lift the top cowling support frame from the engine. At the switch box, disconnect the wires from the distributor.

3- Remove the attaching bolt, and then remove the distributor pulley cover. Slip the timing belt off the pulley. Now, work the pulley, key, and spacer from the distributor shaft.



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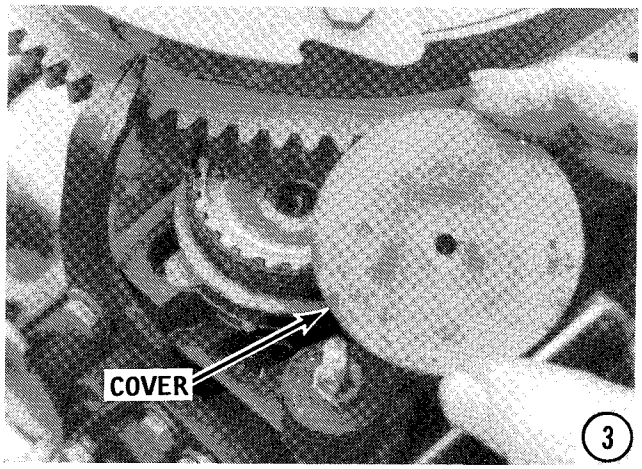
4- Remove the distributor drag link rod from the vertical throttle lever. Remove the ground wire screw from the distributor. Remove the three nuts, washer, and bolts securing the distributor to the powerhead and then remove the distributor.



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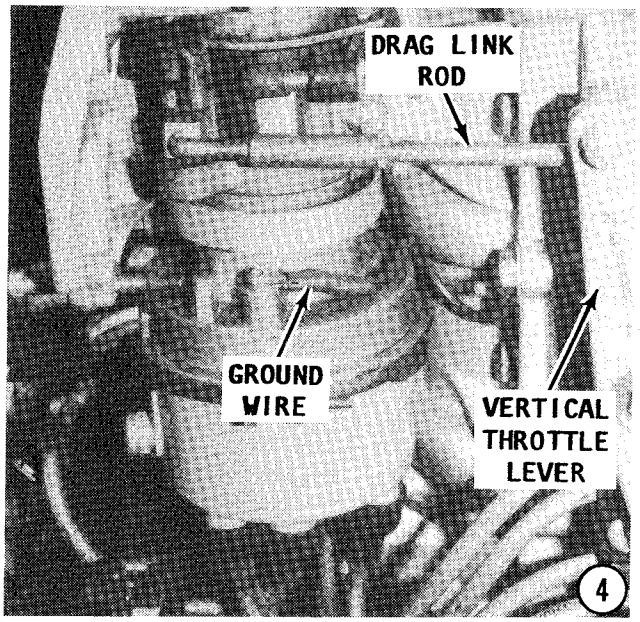

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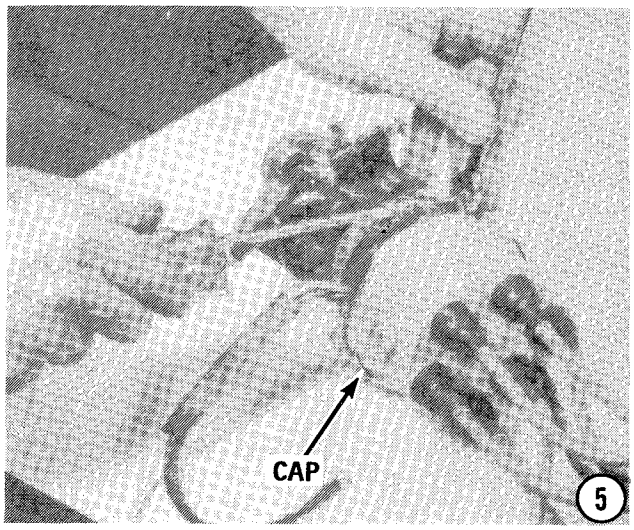
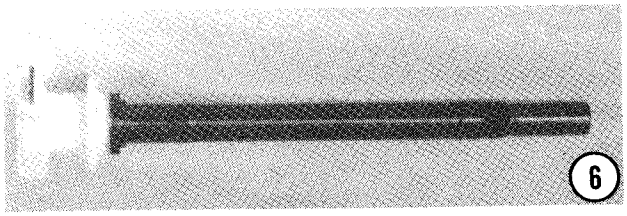


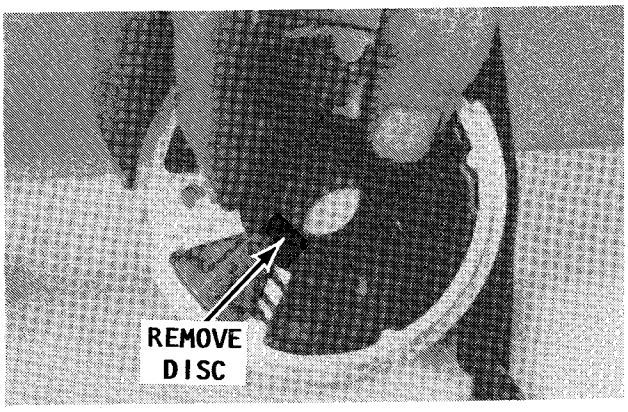
Distributor Cap

5- Remove the distributor cap retainer clamp screw and nut.

6- Lift the cap and clamp from the distributor. Further disassembly of the distributor is not necessary. If the rotor requires replacement, the distributor shaft must be removed and replaced with a new rotor and shaft assembly. The rotor **CANNOT** be removed from the shaft and replaced separately. Bend the tabs of the adaptor cap washer open. Unscrew the distributor housing cap from the adaptor.

Lift out the larger washer and **CAREFULLY** press the bearing out of the housing by working through the two holes provided for this purpose. Remove the nut and **GENTLY** tap the distributor shaft free.





*A disc is used to protect the trigger assembly from damage during shipment. This disc **MUST** be removed before the unit is installed for service.*

CLEANING AND INSPECTING

Inspect the ball bearings and the distributor housing for wear, dirt, or corrosion. Replace any defective parts. Carefully check the condition of the high-tension leads. Test the distributor cap for leakage paths. Such paths may be caused by broken leads, poor connections, moisture, dirt, carbon, or corrosion inside the distributor.

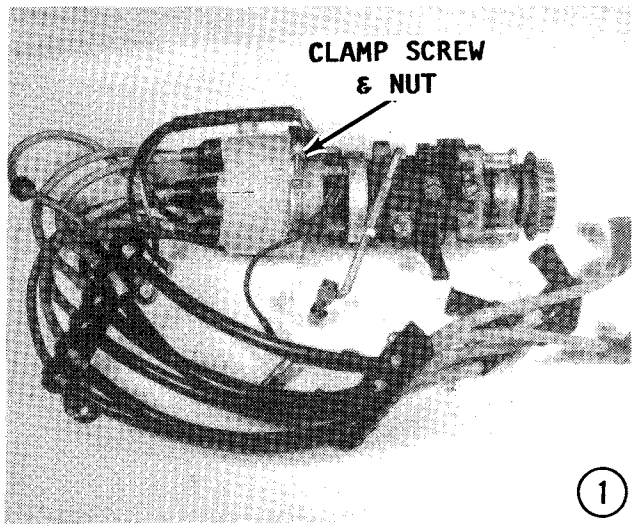
ASSEMBLING THUNDERBOLT — DISTRIBUTOR CD IGNITION — POINTLESS

GOOD WORDS

If the distributor shaft and rotor were disassembled perform the tasks in the next three paragraphs. If the shaft and rotor were not disassembled, proceed directly to Step 1.

Insert the distributor shaft through the rotor disc. Support the distributor housing between two blocks of wood in a vise. **CAREFULLY,** yes, very **CAREFULLY** tap the end of the distributor shaft. The shaft will pass through the bearing and associated parts as shown in the exploded drawing. Continue working the shaft in until the collar on the shaft seats into the recess of the distributor.

Thread the nut onto the distributor shaft. Slide the bearing onto the shaft. Continue to slide the bearing further onto the shaft by working through the two holes provided for this purpose, until the bearing makes contact with the backside of the nut.



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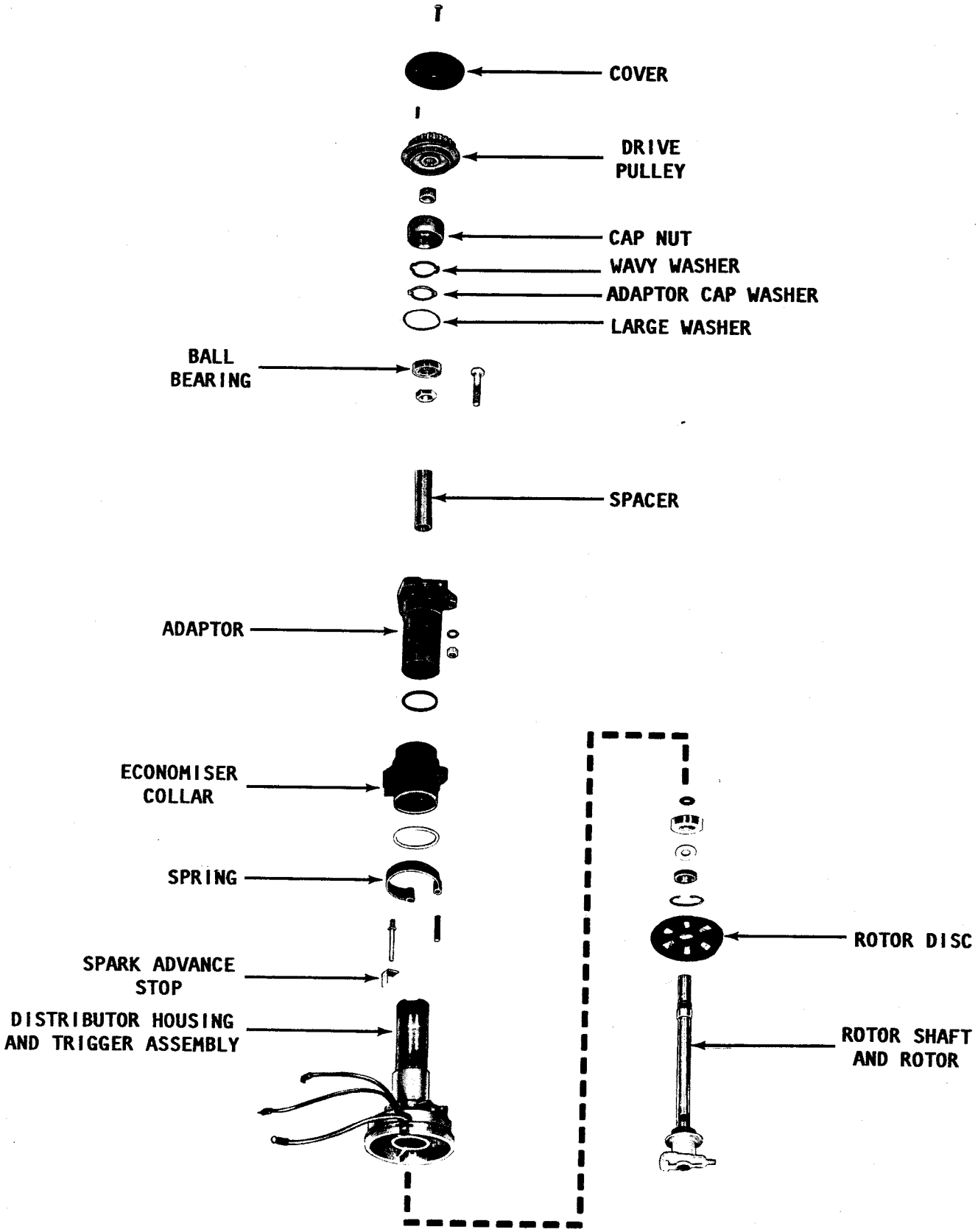

Exploded view of the belt-driven distributor for the CD (capacitor discharge) ignition system used on L6 powerheads.

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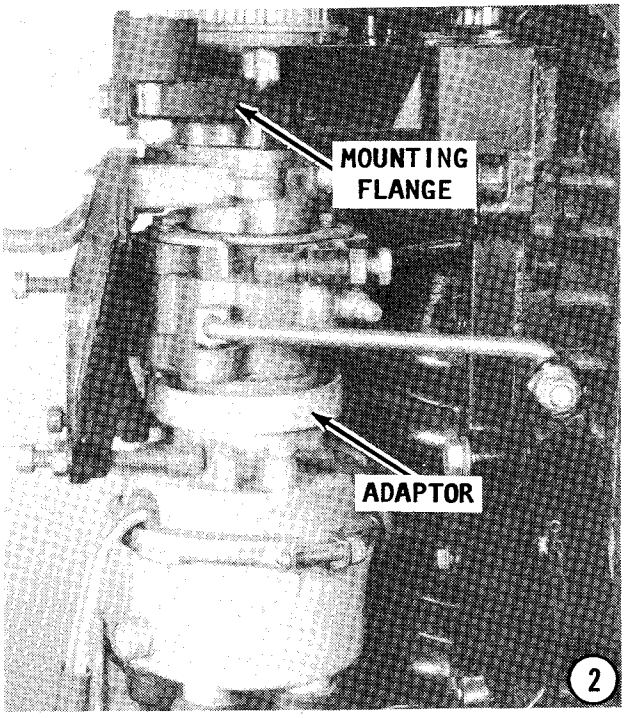
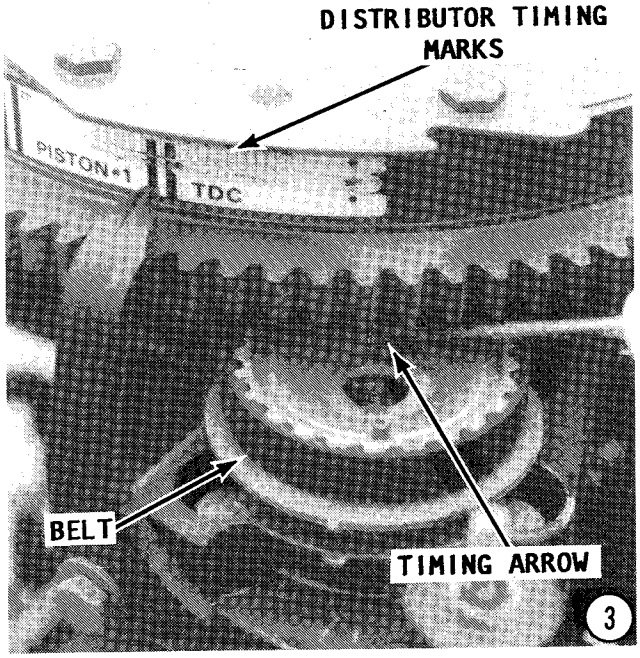
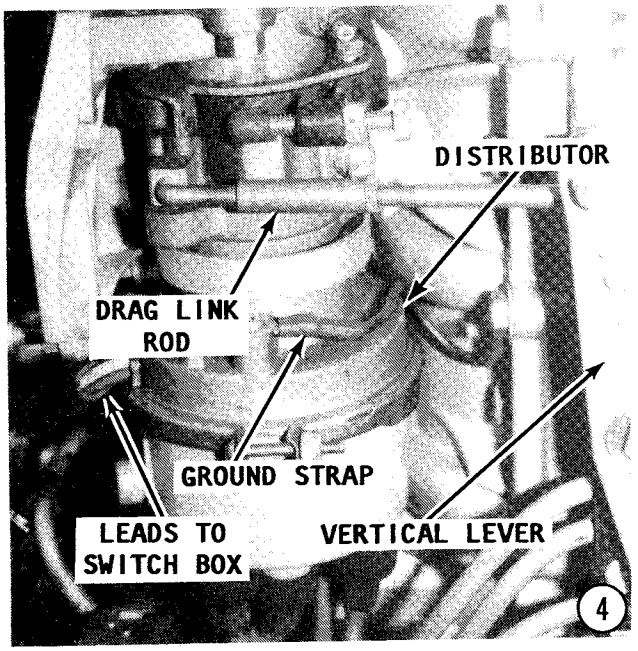


Replace the large washer. Slide the adaptor cap washer onto the shaft, then bend the tabs downward to secure it in place.

1- Place the distributor cap assembly onto the distributor housing. TAKE CARE not to damage the brush or spring. Install the distributor cap clamp and retainer with the screw and nut. Position the clamp screw and nut as shown.

2- Position the distributor and distributor adaptor assembly onto the powerhead



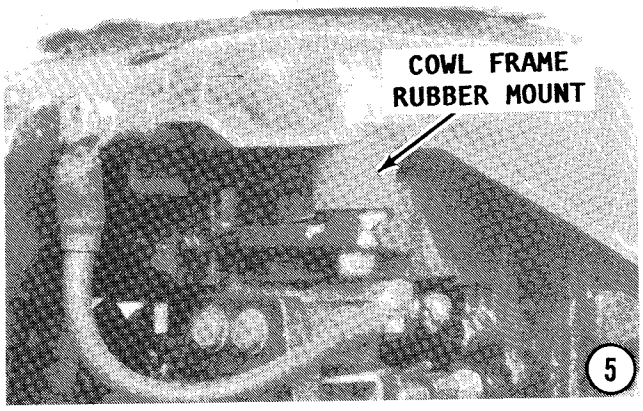


mounting flange. Check to be sure the driven pulley spacer and the distributor drive key are in position. Install the three screws securing the distributor to the powerhead block.

3- Align the arrow on the pulley with the timing mark on the flywheel, and then install the timing belt. Install the distributor pulley cover and secure it in place with the screw. Tighten the screw to a torque value of 60 in lb (0.68Nm).

4- Install the ground strap and connect the link rod to the vertical lever. Connect the high-tension lead to the coil. Install the vent tube. Connect the three trigger lead wires to the switch box matching the color code on the wires. Cover the terminals with a coating of Neoprene.

5- Install the cowl mounting brackets. Connect the electrical leads to the battery. For timing and synchronization instructions, see Chapter 7. Install the wrap around cowling.



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6-4 THUNDERBOLT — FLYWHEEL — CD COIL PER CYLINDER

DESCRIPTION

This system is alternator-driven with distributorless capacitor discharge.

The system consists of a stator assembly, trigger assembly, switchbox, one ignition coil per cylinder, and one spark plug per cylinder.

The stator assembly is mounted below the flywheel and consists of a series of capacitor charging coils. Permanent magnets are installed on the inside outer rim of the flywheel. The ignition coils produce AC voltage as the permanent magnets in the flywheel pass the stationary stator capacitor charging coils. The AC voltage is conducted to the switchbox where it is rectified and stored in a capacitor.

Theory of Operation

To begin a complete cycle: when the permanent magnets in the flywheel rim pass the stator coils, AC voltage is produced. This voltage is conducted to the switch box where it is rectified and stored in the capacitor. When the second set of magnets pass the trigger coils, another AC voltage is produced and conducted to an electronic switch (SCR) in the switch box.

The switch discharges the capacitor voltage into the ignition coil at a precise time and in the proper firing order sequence.

The capacitor voltage is conducted to the primary windings of the ignition coil. When the field generated by the coil (actually an electrical pulse) collapses, a high AC voltage charge is generated in the secondary windings and then conducted through the high-tension leads to the spark plugs. This high-voltage jumps the gap between the electrodes of the spark plug and ignites the air/fuel mixture in the cylinder.

This sequence occurs once for each cylinder per crankshaft revolution.

Advance or retard is accomplished by rotating the trigger coil position in relation to the permanent magnets on the flywheel hub.

CRITICAL WORDS

These next two paragraphs may well be the most important words in this chapter. Misuse of the wiring harness is the most single cause of electrical problems with outboard power plants.

A wiring harness is used between the key switch and the powerhead. This harness seldom contains wire of sufficient size to allow connecting accessories. Therefore, anytime a new accessory is installed, **NEW** wiring should be used between the battery and the accessory. A separate fuse panel **MUST** be installed on the control panel. To connect the fuse panel, use two Red and Black No. 10 gauge wires from the battery. CD ignition systems require a full 12 volts for proper operation. Therefore, again let it be said, **NEVER** connect accessories through the key switch.

Key Switch

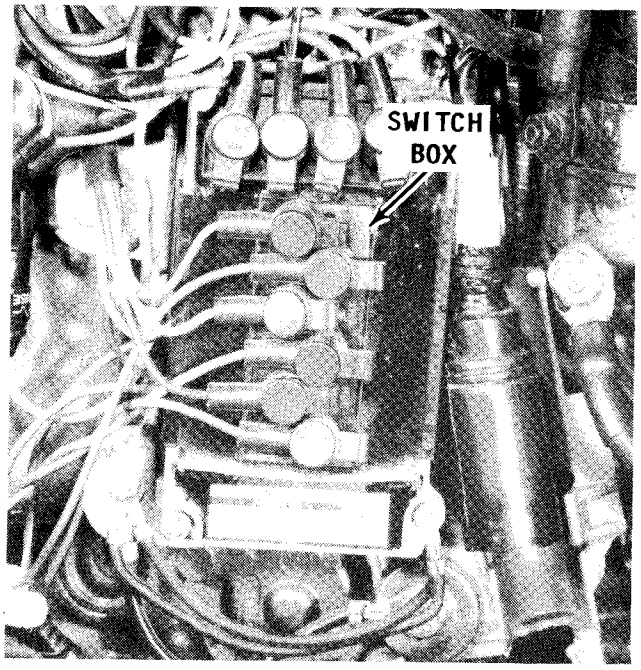
A marine type key switch **MUST** be installed as a replacement item. An automotive type switch installation may cause damage to the system.

TROUBLESHOOTING

READ, BELIEVE, & OBEY

Never touch or disconnect any ignition part on an engine equipped with this type ignition system while the powerhead is running, while the key switch is **ON**, or while the battery cables are connected, because high voltage is present.

The following safety precautions are listed for your personal safety and to prevent damage to expensive parts.



Typical switch box installation on a late model V6 powerhead.

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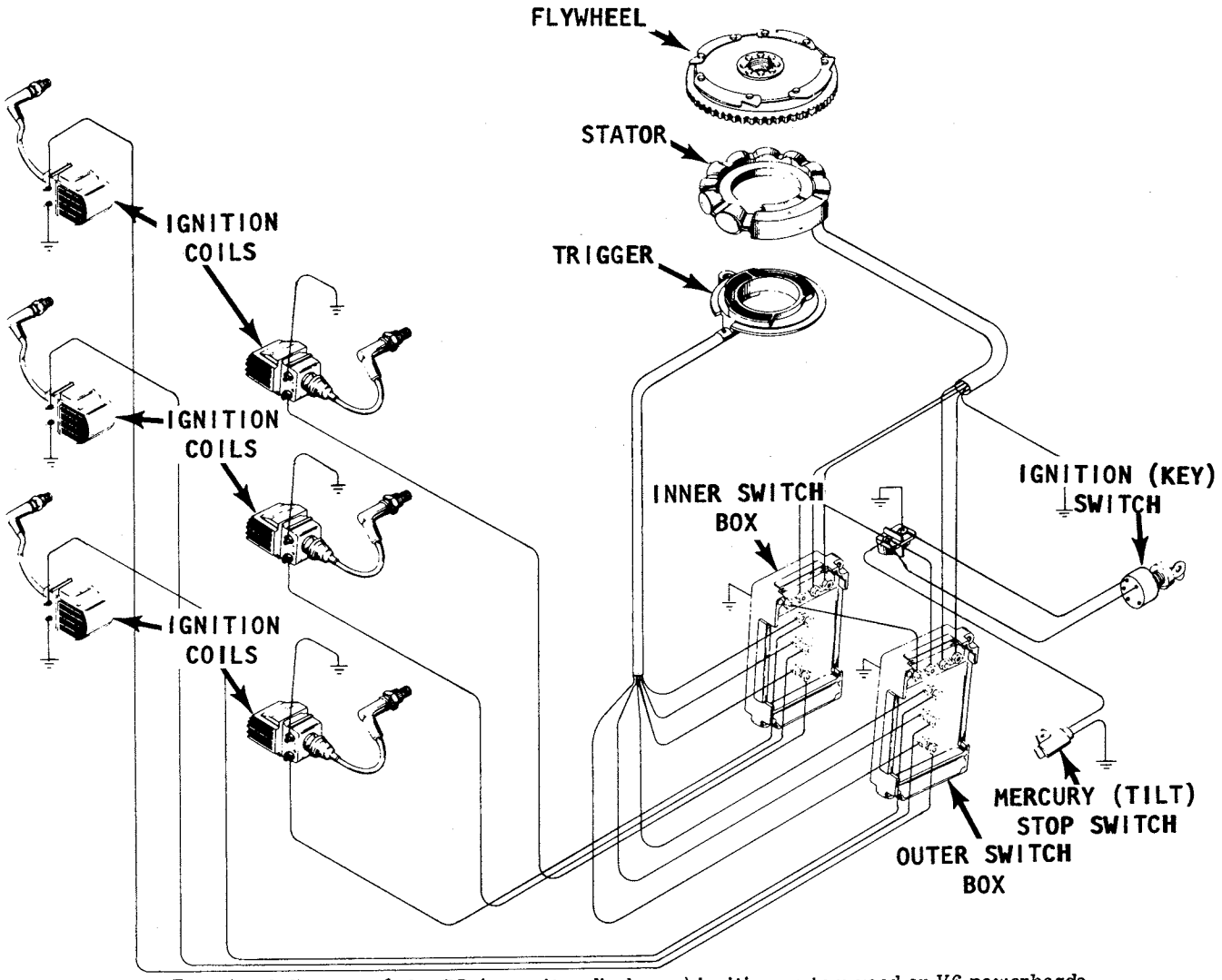

Functional diagram of the CD (capacitor discharge) ignition system used on V6 powerheads.

NEVER reverse battery cable connections. The battery negative (-) is ground. The Black cable must always be connected to this terminal. The Red cable must always be connected to the positive (+) terminal.

NEVER check polarity by "sparking" the battery terminals with the battery cable connections.

NEVER disconnect the battery cables while the powerhead is running.

NEVER crank the engine if the switch box is not properly grounded to the powerhead.

The switchboxes and ignition coils cannot be thoroughly checked with conventional test equipment. A Quicksilver Thunderbolt Ignition Analyzer is required to properly check these items.

All other components can be tested with a VOA (Volt/Ohm/Ampere) meter.

ALWAYS check the following areas for sources of trouble **BEFORE** opening up the ignition system.

Check to be sure the electrical harness, ignition switch, and mercury switch, are not the source of the problem.

Verify that the plug-in connectors are fully engaged and the terminals are free of corrosion.

Check to be sure all electrical components and/or ground wires are properly grounded to the powerhead. Inspect visible wire connections to be sure they are tight and free of corrosion.

Observe the entire electrical system for disconnected wires, and for short or open circuits.

Ready For Troubleshooting

Always attempt to proceed with the troubleshooting in an orderly manner. The "shot in the dark" approach will only result

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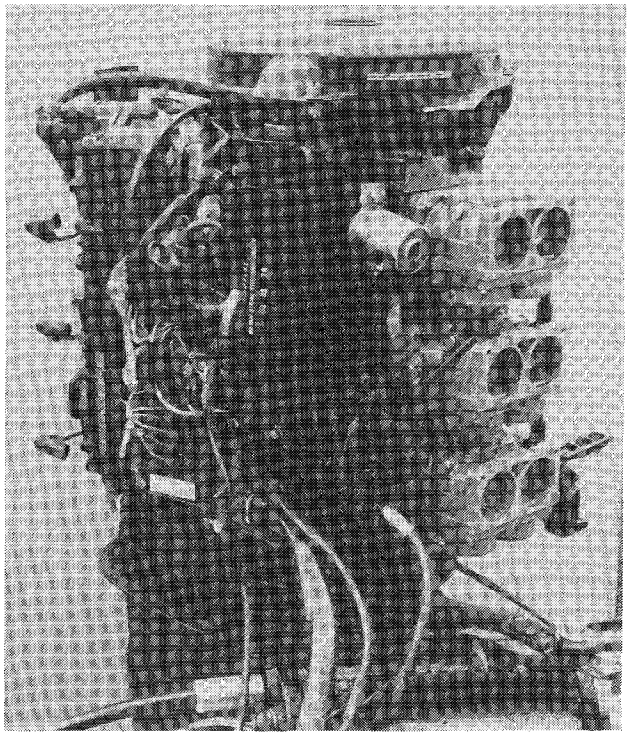


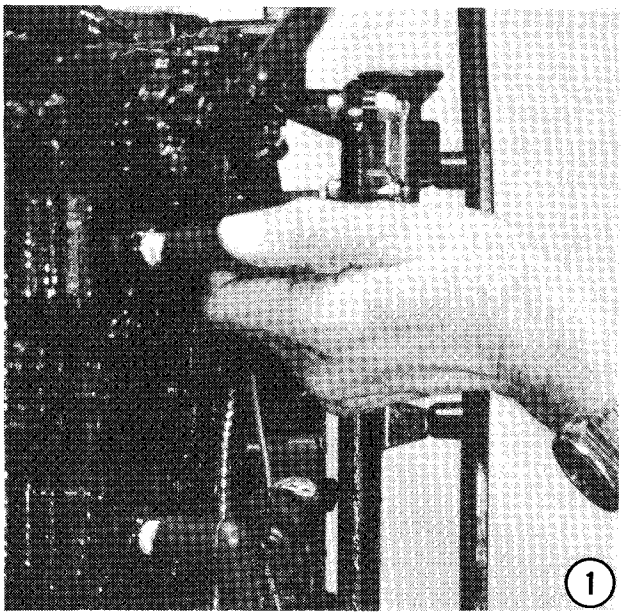
Do not overlook the obvious electrical connections when troubleshooting the ignition system.

in wasted time, incorrect diagnosis, replacement of unnecessary parts, and frustration.

Begin the ignition system troubleshooting with the spark plugs and continue through the system until the source of trouble is located.

Spark Plugs

1- Check the plug wires to be sure they are properly connected. Check the entire length of the wires from the plugs to the coil. If the wire is to be removed from the spark plug, **ALWAYS** use a pulling and twisting motion as a precaution against damaging the connection.



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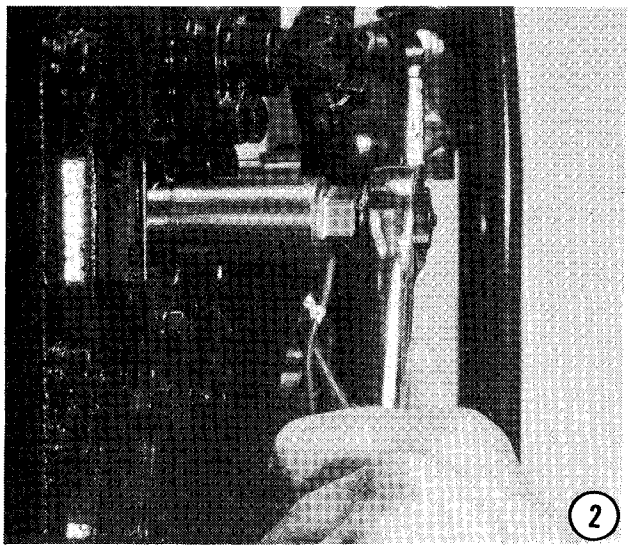

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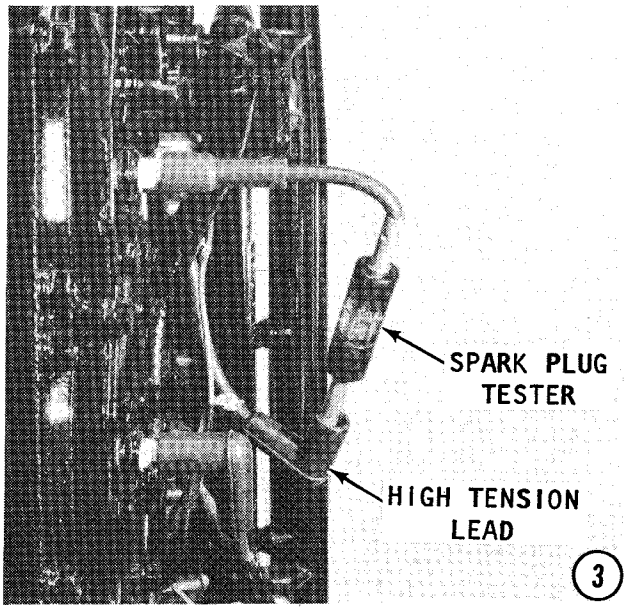
2- Attempt to remove the spark plugs by hand. This is a rough test to determine if the plug is tightened properly. You should not be able to remove the plug without using the proper socket size tool. Remove the spark plugs and keep them in order. Examine each plug and evaluate its condition as described in Section 6-2.

3- Use a spark tester and check for spark at each cylinder. If a spark tester is not available, hold the plug wire about 1/4-inch from the powerhead. Rotate the flywheel with a rope wrapped around the flywheel or with a cranking motor and check for spark. A strong spark over a wide gap must be observed when testing in this manner, because under compression a strong



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spark is necessary in order to ignite the air/fuel mixture in the cylinder. This means it is possible to think you have a strong spark, when in reality the spark will be too weak when the plug is installed. If there is no spark, or if the spark is weak, the trouble is most likely in the CD system.

ONE MORE WORD

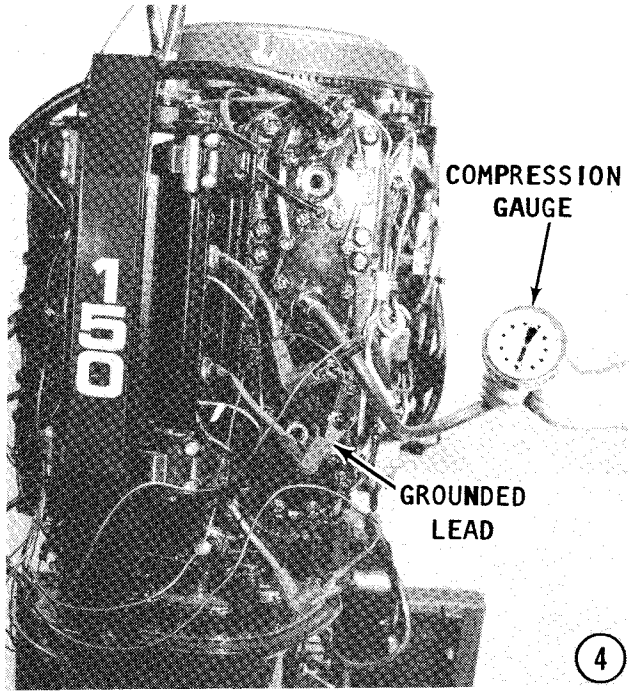
Each cylinder in this type ignition system has its own ignition circuit. This means if a strong spark is observed on any one cylinder and not at another, only the weak circuit is at fault. However, it is always a good idea to check and service all circuits while the flywheel is removed.

Compression

4- Before spending too much time and money attempting to trace a problem to the ignition system, a compression check of each cylinder should be made. If the cylinder does not have adequate compression, troubleshooting and attempted service of the ignition or fuel system will fail to give satisfactory powerhead performance.

Remove the spark plug wires by pulling and twisting **ONLY** on the molded cap. **NEVER** pull on the wire because the connection inside the cap may be separated or the boot be damaged.

Ground the spark plug leads to the powerhead to render the ignition system inoperative while performing the compression check. This is also a precautionary measure to prevent damage to the ignition coil. If a lead is not grounded, the coil will attempt to match the demand created by the spark trying to jump from the center electrode to the nearest ground.



Remove the spark plugs. Insert a compression gauge into the cylinder spark plug hole. Crank the powerhead through several flywheel revolutions and note the compression reading. Repeat the procedure for each cylinder.

A variation in reading between the cylinders is far more important than the actual individual readings. If a particular cylinder varies more than 20 psi from the others, the cylinder may be scored, the rings frozen, or the piston burned.

Stator Types

Two different type stator assemblies are installed on powerheads with the Type III ignition system. One type has a black ground wire. The stator is grounded to the powerhead through this black ground wire.

The other type does not have the black ground wire. The stator is grounded directly to the powerhead through the stator mounting plate.

Switch Box Testing

Two switch boxes are installed on L6 and V6 powerheads. Each switch box services three cylinders. On the L6 powerheads, the switch boxes are installed side-by-side. One box may be tested without removing the other box. On V6 powerheads, the boxes are stacked, one on top of the other. The top box must be removed in order to service the bottom box.

FIRST, THESE WORDS

Refer to the wiring diagrams in the Appendix for correct color coded wire location.

ONE MORE WORD

On the 6-cylinder in-line powerhead, the left switch box is installed upright and the terminals will appear as in the diagram on Page 6-15. The right switch box is inverted (upside down) and, therefore, the terminals will be opposite to the diagram.

CAUTION

The switch boxes **MUST** be properly grounded to the powerhead before cranking or the switch boxes will be damaged.

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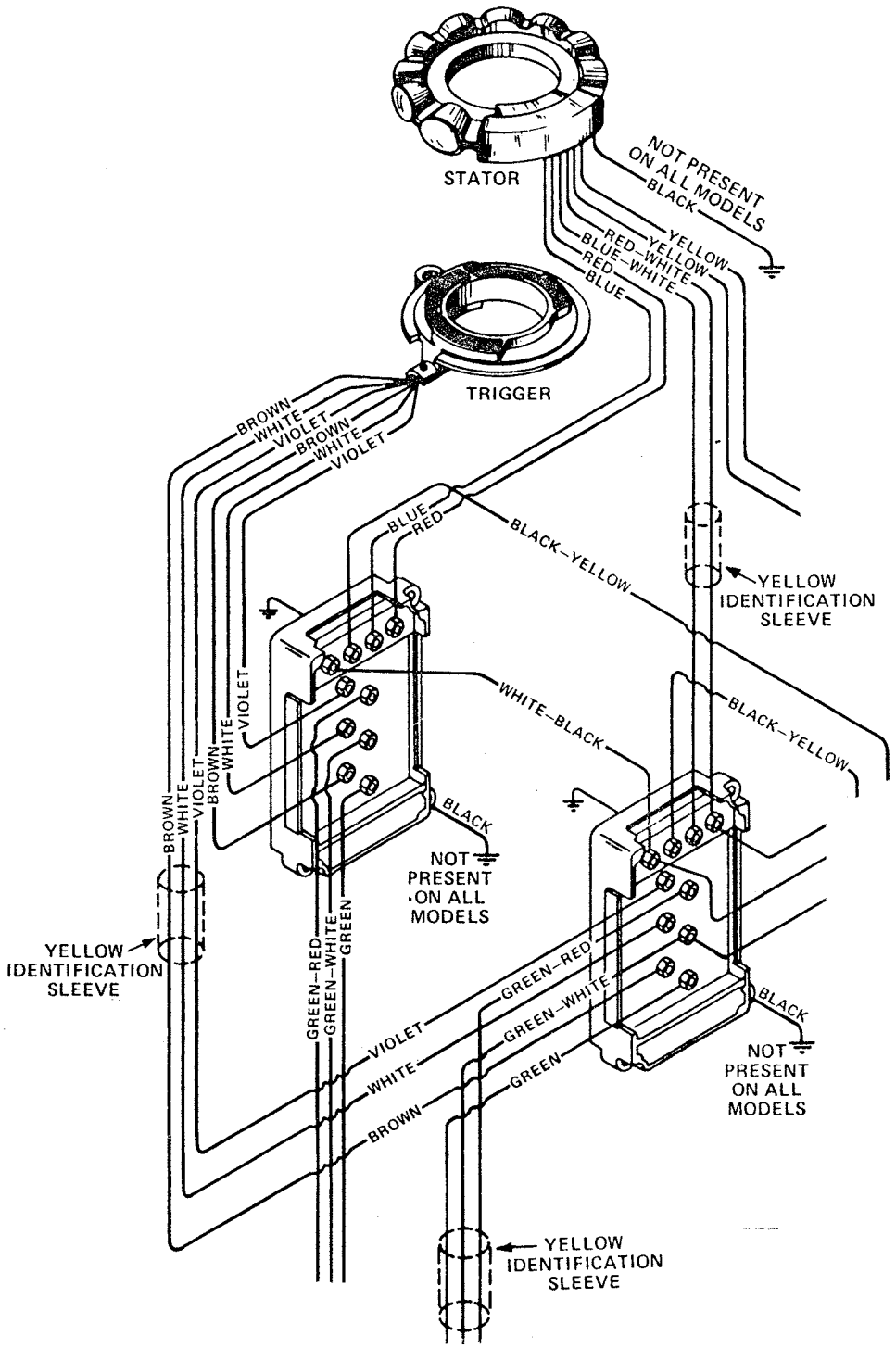

Typical functional diagram for late model V6 powerheads. The switch boxes are stacked one on top of the other. Therefore, the top box must be removed in order to service the bottom box. Refer to the wiring diagrams in the Appendix for the correct wiring color code for the powerhead being serviced.

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THUNDERBOLT IGNITION CHECKS

STATOR CHECKS

MODEL	TESTER LEADS TO:	OHM SCALE	SCALE READING
45, 50, 80, and 85hp (4-Cylinder) Powerheads	Between Blue and Blue/White stator leads	Rx1000	5.7-8.0
	Between Red and Red/White stator leads	Rx1	56-75
	Between Blue stator lead and powerhead ground	Rx1000	No Cont.
	Between Red stator lead and powerhead ground	Rx1000	No Cont.
50, 60, and 70hp (3-Cylinder) Powerheads	Between Red and Blue stator leads	Rx1000	5.4-6.2
	Between Red stator lead and powerhead ground	Rx1	125-175
75 and 90hp (3-Cylinder) Powerheads	Between Red and Blue stator leads	Rx1000	3.6-4.2
	Between Red stator lead and powerhead ground	Rx1	90-140
100 and 115hp (4-Cylinder) Powerheads	Between Blue and Blue/White stator leads	Rx1000	6.0-7.0
	Between Red and Red/White stator lead	Rx1	90-140
All L6 and V6 Powerheads	Between Blue and Red stator leads	Rx1000	5.4-6.2
	Between Blue/White and Red/White stator leads	Rx1000	5.4-6.2
	Between Red/White stator lead and powerhead ground	Rx1	125-175
	Between Red stator lead and powerhead ground	Rx1	125-175

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TRIGGER CHECKS

MODEL	TESTER LEADS TO:	OHM SCALE	SCALE READING
45, 50, 80, and 85hp (4-Cylinder) Powerheads	Between Brown and White/Black trigger lead	Rx100	7-10
	Between White and Violet trigger lead	Rx100	7-10
All 3-Cylinder Powerheads	Between Brown and White/Black trigger lead	Rx100	11-14
	Between White and White/Black trigger lead	Rx100	11-14
	Between Violet and White/Black trigger lead	Rx100	11-14
100 and 115hp (4-Cylinder) Powerheads	Between Brown and White/Black trigger lead	Rx100	7-10
	Between White and White/Black trigger lead	Rx100	7-10
All L6 and V6 Powerheads	Between Brown trigger lead (without Yellow sleeve) and White trigger lead (with Yellow sleeve)	Rx100	11-14
	Between White trigger lead (without Yellow sleeve) and Violet trigger lead (with Yellow sleeve)	Rx100	11-14
	Between Violet trigger lead (without Yellow sleeve) and Brown trigger lead (with Yellow sleeve)	Rx100	11-14

The stator must be grounded to the powerhead. Disconnect the Blue/White and the Red/White stator leads from the outer switch box. Disconnect the Blue and Red stator leads from the inner switch box.

If the specified readings are not obtained, the stator assembly **MUST** be replaced, see Servicing in this section.

If the stator assembly passed this test, connect the Red/White lead and the Blue/-White lead to the outer switch box. Connect the Blue and Red leads to the inner box.

Trigger Assembly Test

FIRST, these words: The switch boxes **MUST** be properly grounded to the powerhead before making this series of tests.

Perform the test indicated in the accompanying table.

If the specified readings are not obtained, the trigger assembly **MUST** be replaced, see Servicing in this section.

Ignition Coil Test

FIRST, these words: A VOA meter is only capable of detecting certain faults in

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IGNITION COIL CHECKS

MODEL	TESTER LEADS TO:	OHM SCALE	SCALE READING
75 and 90hp (3-Cylinder) and 100 and 115hp (4-Cylinder) Powerheads	Between Positive and Negative coil terminals	Rx1	.02-.04
	Between coil tower and negative coil terminal	Rx100	8-11
All other Powerheads covered in this manual	Orange and Blue coils: Between Positive and Negative coil terminals	Rx1	.02-.04
	Orange coils: Between coil tower and either Positive or Negative coil terminal	Rx1000	No Cont.
	Orange coils again: Between coil tower and powerhead ground (if mounted) or to small pigtail on backside (if not)	Rx100	8-11
	Blue or Black coils: Between coil tower and either Positive or Negative coil terminal (mounted or not)	Rx100	8-11

an ignition coil. Replace the coil, if the meter readings are not as specified in the accompanying chart. If the coil tests are satisfactory, but the coil is still suspected, an Ignition Analyzer must be used to check the coil further. If an analyzer is not available the coil should be replaced or checked at your Mariner dealer.

CAUTION

The switch boxes **MUST** be properly grounded to the powerhead before cranking the engine, or the switch boxes will be damaged.

Continuity Test
Shift Box Side
Remote Control Harness Connector

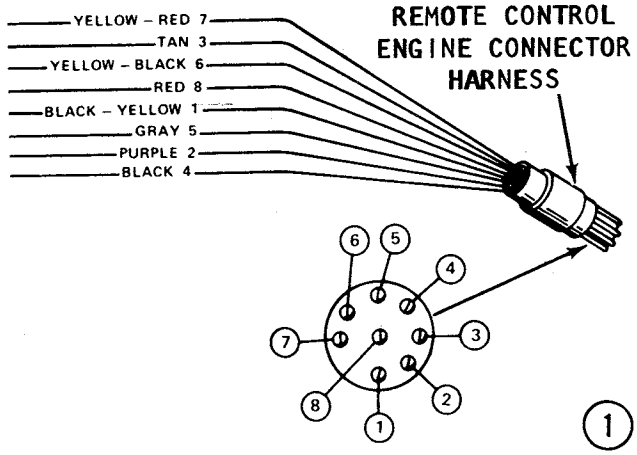
1- Remove the remote control wiring harness and the instrument panel connectors at the powerhead. The wiring diagrams in the Appendix will be helpful when making the connections after testing. Connect one lead of the ohmmeter to the No. 7 terminal and the other lead to the No. 4 terminal of the remote control harness connector. Use the RX1 scale. Check to be sure the key switch is in the **OFF** position. The ohmmeter **MUST** indicate continuity.

Connect one meter lead to terminal No. 1 of the remote control harness connector and the other test lead to terminal "A" of the instrument panel connector. Move the key switch to the **RUN** position. The ohmmeter **MUST** indicate continuity.

Check to be sure the shift lever is in the neutral position. Connect one lead of the ohmmeter to terminal No. 1 and the other lead to terminal No. 3 of the remote control harness connector. Move the key switch to the **RUN/START** position. The ohmmeter **MUST** indicate continuity.

Ignition Switch Test
Commander Shift Box Installation

2- Remove the remote control wiring harness and the instrument panel connectors



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at the powerhead. The wiring diagrams in the Appendix will be helpful when making connections after testing. Connect one ohmmeter lead to the Black (M) terminal and the other lead to the Black/Yellow (M) terminal of the remote control harness connector. Use the RX1 scale. Check to be sure the key switch is in the **OFF** position. The ohmmeter **MUST** indicate continuity.

Connect one ohmmeter lead to the Red (B) terminal and the other lead to the Purple (A) terminal of the remote control harness connector. Use the RX1 scale. Rotate the key switch to the **RUN** position. The ohmmeter **MUST** indicate continuity.

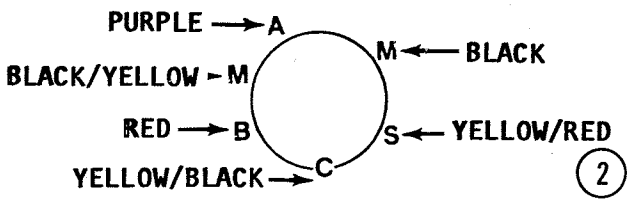
Check to be sure the shift lever is in the **NEUTRAL** position. Connect one ohmmeter lead to the Red (B) terminal and the other lead to the Yellow/Red (S) terminal of the remote control harness connector. Move the key switch to the **RUN/START** position. The ohmmeter **MUST** indicate continuity.

Keep the key switch in the **RUN/START** position and check for continuity between the Purple (A) terminal and the Yellow/Red (S) terminal. Repeat the continuity check between the Red (B) terminal and the Purple (A) terminal on the remote harness connector. In each test, the ohmmeter **MUST** indicate continuity.

Position the key switch in the **CHOKE** position. Connect one ohmmeter lead to the Red (B) terminal and the other lead to the Yellow/Black (C) terminal of the remote control harness connector.

Keep the key switch in the **CHOKE** position and check for continuity between the Purple (A) terminal and the Red (B) terminal. Repeat the continuity check between the Yellow/Black (C) terminal and the Purple (A) terminal on the remote harness connector. In each test the ohmmeter **MUST** indicate continuity.

If the meter readings are other than as specified during any of the above tests, recheck the ignition switch soldered connections to verify the switch and not the wiring is at fault. Replace the switch **ONLY** with a Mariner switch because an automobile type switch will damage the CD unit.



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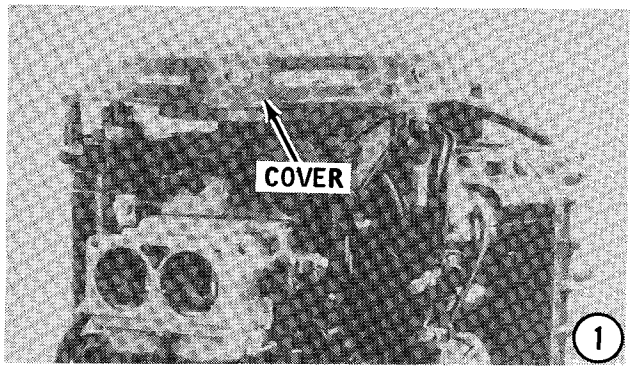

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IGNITION SYSTEM SERVICE

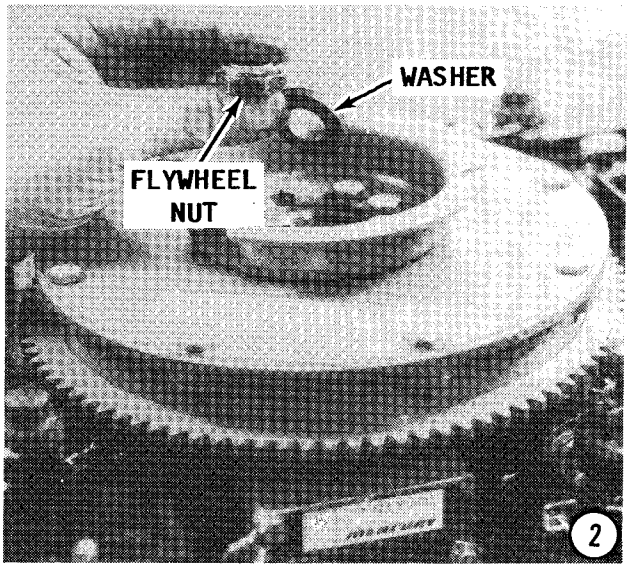
Any CD ignition system installed on a powerhead covered in this manual will usually operate over extremely long periods of time without requiring adjustment or repair. However, if ignition system problems are encountered, and the usual corrective actions such as replacement of spark plugs and timing does not correct the problem, the CD output should be checked to determine if the unit is functioning properly.

Overhaul procedures may differ slightly on various outboard models, but the following general basic instructions will apply to all Mariner high-speed flywheel CD ignition systems.

Flywheel Removal

1- Remove the three wing-nuts and then enough of the cover to expose the flywheel. Disconnect the leads from the battery terminals.

2- Remove the crankshaft nut in the center of the flywheel. A flywheel strap may be required to hold the flywheel securely while the nut is loosened.



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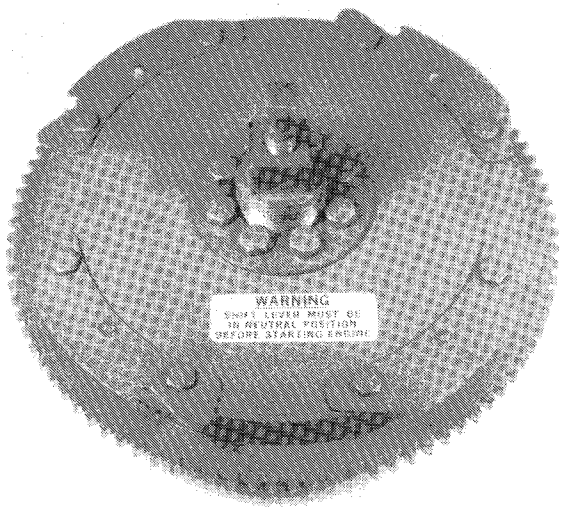
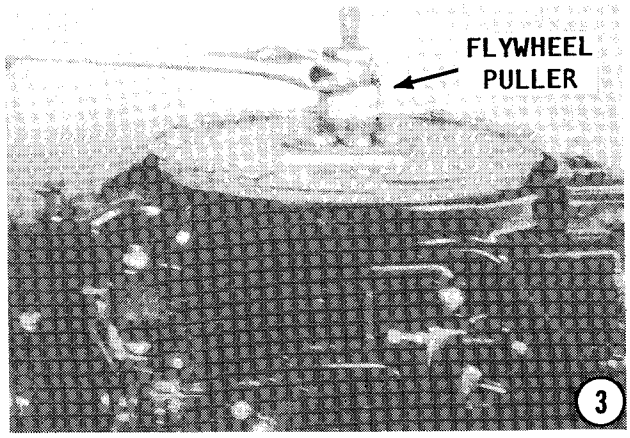


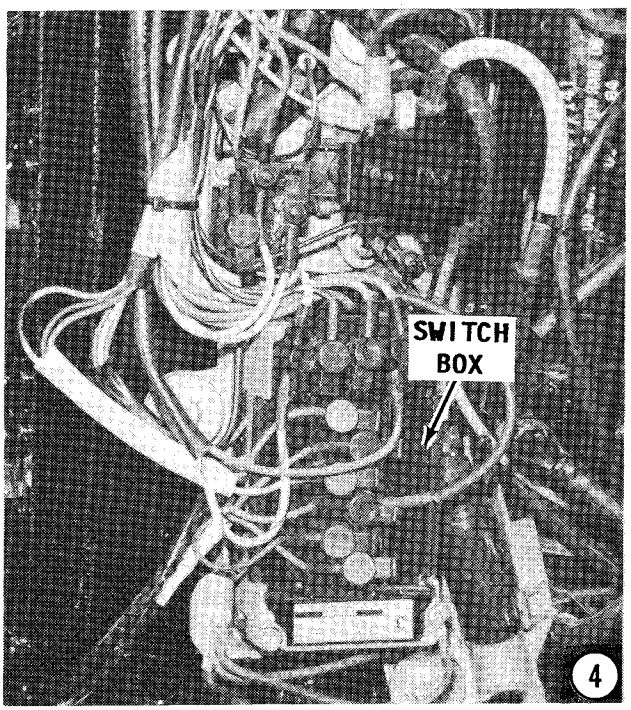
The small investment involved to purchase the proper tool for removal of the flywheel will save much frustration, time, and possibly replacement of expensive parts.

3- Obtain the proper type flywheel puller. **NEVER** attempt to use a puller which pulls on the outside edge of the flywheel or the flywheel may be damaged. After the puller is installed, tighten the center screw onto the end of the crankshaft. Continue tightening the screw until the flywheel is released from the crankshaft. Remove the flywheel. **NEVER** hammer on or heat the end of the puller center bolt in an effort to remove the flywheel. Such action will damage the crankshaft or the bearings.

4- STOP, and carefully observe the layout of the electrical system and associated wiring. Study how the CD system is assembled. Because there are so many different CD installation arrangements, it is not possible to illustrate all of them, and even if they were shown, you would not be able to identify the circuitry for the engine being serviced.

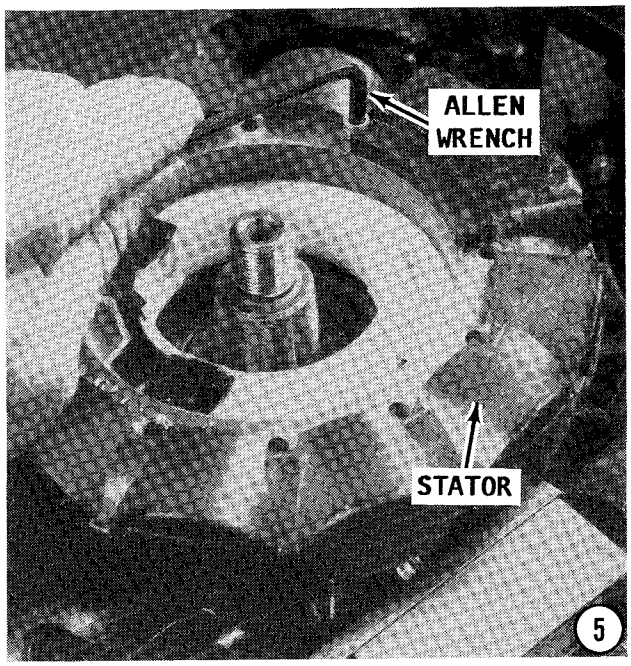
TAKE TIME to make notes of the wire routing. You may elect to follow the practice of many professional mechanics by taking a series of photographs of the powerhead with the flywheel removed, one from the top, and a couple from the sides showing the wiring and arrangement of parts.





5- Remove the four stator attaching screws using an Allen wrench. Lift the stator and set it aside. It is not necessary to disconnect the wiring to the stator. See the chart on Page 6-16, to test the stator.

6- Remove the locknut securing the link rod swivel into the spark advance lever. Pull the link rod out of the lever.



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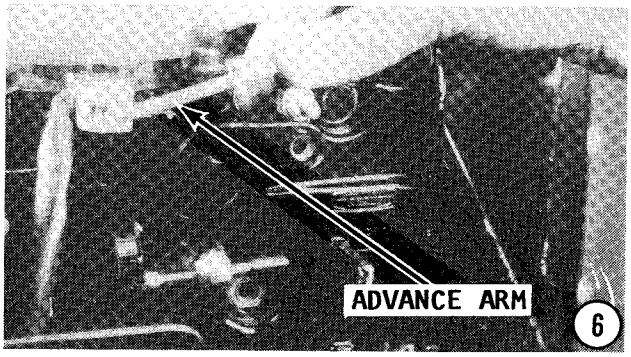


7- Disconnect all trigger assembly leads from the switch box. Lift the trigger assembly from the powerhead. See chart on Page 6-17, to test the trigger assembly.

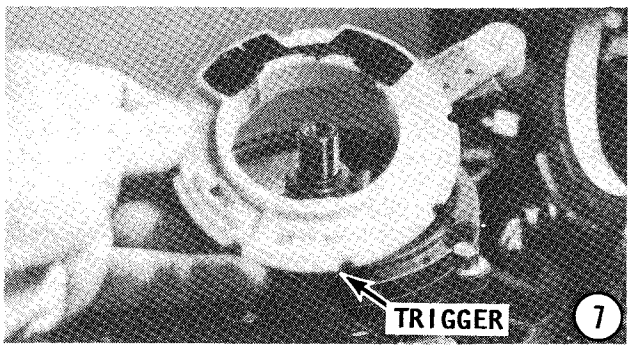
CLEANING AND INSPECTING

Inspect the flywheel for cracks or other damage, especially around the inside of the center hub. A damaged flywheel can be **EXTREMELY** dangerous. The forces exerted on the flywheel while it is spinning at high rpm are sufficient to shatter an unbalanced damaged flywheel. Inspect the magnets to see if they are held tightly around the outer circumference of the flywheel rim. Check the surface of the magnets for fractures and grooves.

Grooves around the inner perimeter would indicate a component mounted on the stator plate is not aligned properly or the component is loose. Fractured or damaged magnets cannot be replaced. Both the magnets and flywheel share the same part number, therefore attempting to remove the magnets would be a pointless task. If magnets or the flywheel is defective, the entire flywheel must be replaced.

Check to be sure small metal particles have not become attached to the magnets. Verify each magnet has good magnetism by using a screwdriver or other suitable tool.

Thoroughly clean the inside taper of the flywheel and the taper on the crankshaft to prevent the flywheel from "walking" on the crankshaft during operation.



Check the top seal around the crankshaft to be sure oil has not been leaking onto the stator plate. If there is **ANY** evidence the seal has been leaking, it **MUST** be replaced.

Test the stator assembly to verify it is not loose. Attempt to lift each side of the plate. There should be little or no evidence of movement.

SPECIAL WORDS ON FLYWHEEL MAGNETS

The outer ends of any magnet are called poles. One end is the north pole and the other end is the south pole. The magnetic field surrounding a magnet is concentrated around these two poles.

Some flywheel magnets are fairly long and curved around the outer perimeter of the underside of the flywheel. Others are short and are mounted around the center hub, depending on the location of the coils mounted on the stator. Magnets are usually installed in pairs with the north pole of one adjacent to the south pole of its neighbor and so on. In this manner continuous magnetic field surrounds the inside of the flywheel.

If a flywheel is accidently dropped, not only could the teeth be damaged, but the impact will weaken the magnetic strength of all the magnets housed in the flywheel.

If one or more of the magnets should break or fracture, two new magnetic poles will be created. A long magnet with two poles will become two short magnets with four poles. The new poles will possess only half the magnetic strength of an original pole. The overall magnetic field will be altered. The new field of the shorter magnets will not extend to cover the area of the flywheel.

Serious consequences apply to a CD type ignition system in the event of a flywheel magnet fracture. Trigger coils evenly spaced around the perimeter of the stator plate are energized by the concentrated magnetic field at the magnet poles. If new poles are suddenly created, the trigger will receive conflicting signals from the magnets and may even attempt to fire the cylinder twice in one revolution.

All these reasons require the flywheel to be handled with **CARE.**

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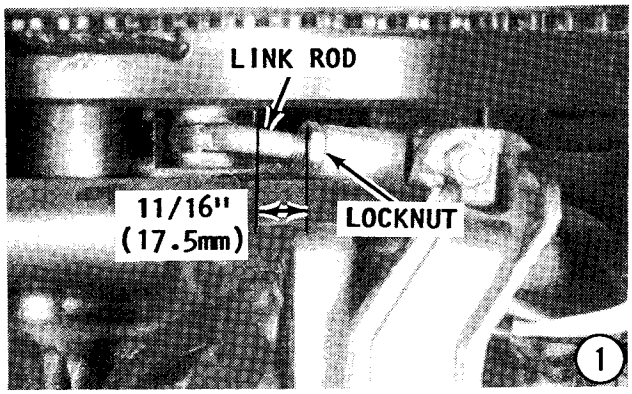


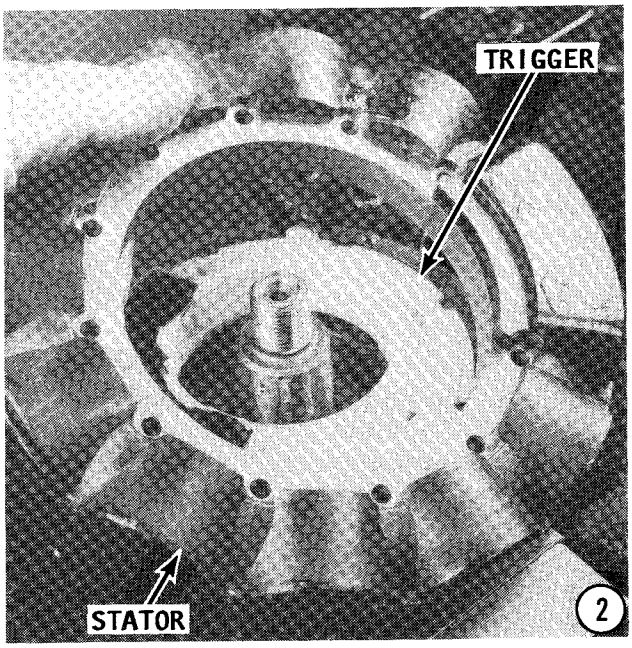
ASSEMBLING FLYWHEEL PARTS

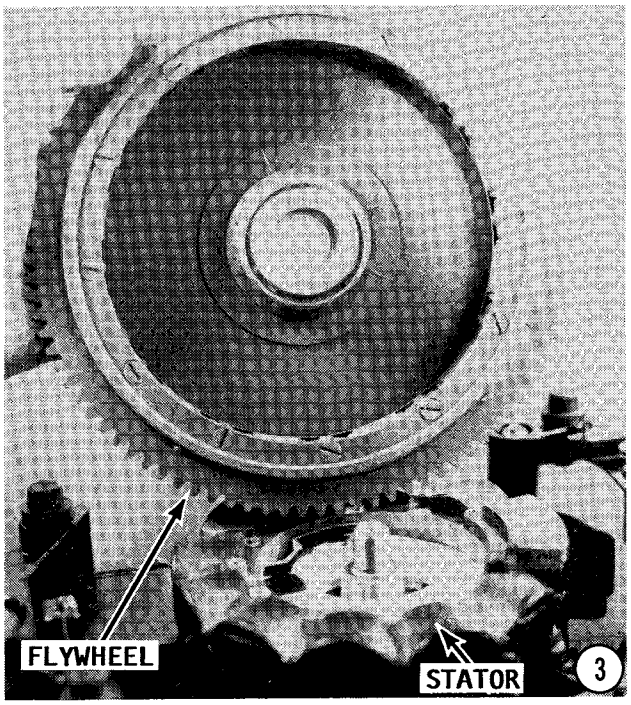
1- Place the trigger onto the powerhead in the upper end cap. Fasten the link rod swivel to the spark advance lever and secure it in place with the locknut.

Adjust the locknut to obtain a distance of 11/16" (17.5mm) between the axis of the trigger extension and the outer edge of the locknut. No adjustment is required for in-line powerheads.

Route the trigger wiring harness along the side of the powerhead and then connect the wires to the proper terminals in the switch box. Refer to the diagram or photographs made before removal. If this was not done, check the wiring diagrams in the Appendix. Wires with yellow sleeves **MUST** be connected to the terminals of the switch box.

2- Place the stator in position over the trigger assembly. Apply a drop of Loctite A, or equivalent, to the threads of the

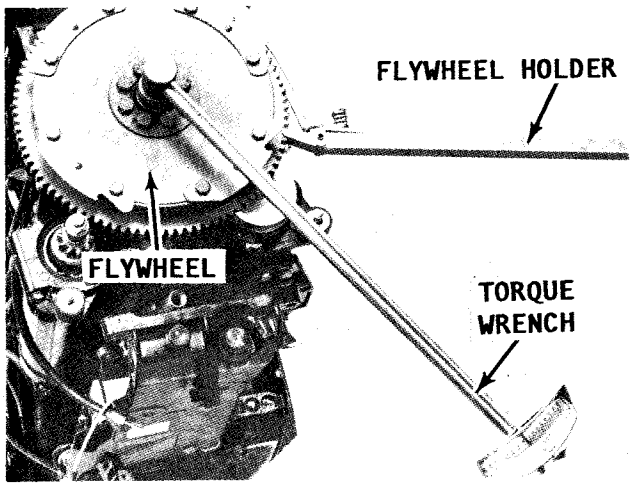




stator attaching screws. Install and tighten the attaching screws to a torque value of 30 in lb (3.4Nm). Connect the stator leads to the proper terminals of the rectifier and switch box. Refer to the wiring diagrams in the Appendix. Wires with the yellow sleeves **MUST** be connected to the terminals of the outer switch box.

Flywheel Installation

3- Place the key in the crankshaft keyway. Check the flywheel magnets to be



*A flywheel holder should **ALWAYS** be used when tightening the flywheel nut. The holder will prevent movement of the flywheel while tightening the nut to the proper torque value. **NEVER** attempt to wedge tools between the flywheel and the starter pinion gear. Such a practice only invites disaster. The pinion gear is manufactured from softer metal than the flywheel to ensure failure of an inexpensive part before damage is caused to the more costly flywheel.*

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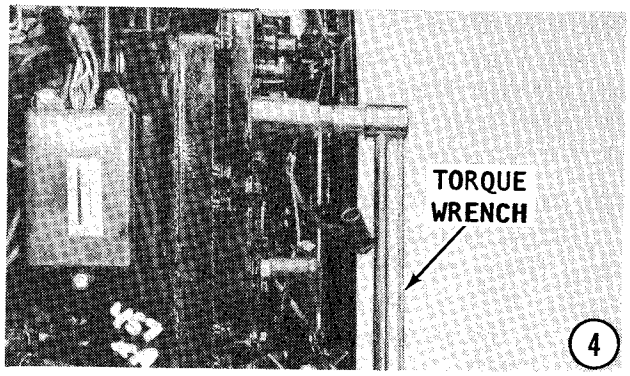


sure they are free of any metal parts. Double check the taper in the flywheel hub and the taper on the crankshaft to verify they are clean and contain no oil, as a precaution against the flywheel "walking" on the crankshaft during operation. Slide the flywheel down over the crankshaft with the keyway in the flywheel aligned with the key on the crankshaft. Rotate the flywheel clockwise and check to be sure the flywheel does not contact any part of the magneto or the wiring. Thread the flywheel nut onto the crankshaft and tighten it to the following torque values for the powerheads indicated:

75hp & 90hp -- 3-cyl.	120 ft lbs (163Nm)
100 & 115hp -- 4-cyl.	120 ft lbs (163Nm)
All other 3- & 4-cyl.	85 ft lbs (115Nm)
All L6 & V6	100 ft lbs (136Nm)

4- Install the spark plugs and tighten them to a torque value of 20.5 ft lb (27Nm). Install the electrical leads to the battery terminals.

For detailed timing and synchronizing procedures, see Chapter 7.

6-5 ELECTRONIC IDLE STABILIZER AND SPARK ADVANCE MODULES

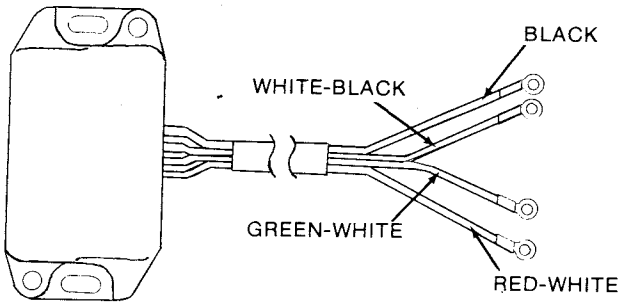
Since about 1979, all L6 and V6 powerheads have been equipped with one or more of the following units or combination of units:

an idle stabilizer
and/or
a high speed advance module
and/or
a low speed/high speed spark advance module.

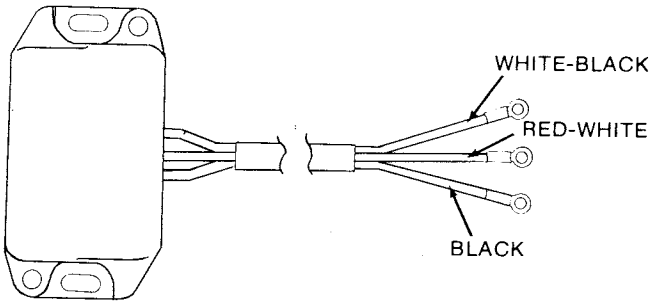
All of these units are "black boxes". By "black box" the term means the item is a sealed unit and cannot be opened or serviced. Therefore, if troubleshooting should indicate the module is defective, it **MUST** be replaced. In short, it either functions properly or it is replaced.

These "black box" units are usually installed on the upper front cowling support bracket, but may be found in other locations on various powerheads.

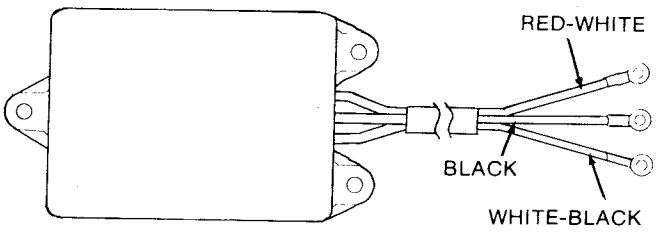
The **ONLY** method to determine which "black box" is installed on the powerhead being serviced is to make an identification of the wires from the "black box" to the switch boxes as follows:



Color coding for the idle stabilizer "black box" module.



Color coding for the high speed spark advance "black box" module.



Color coding for the low speed/high speed spark advance "black box" module.

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Idle Stabilizer (2 mounting screws)	White/Black Red/White Black
High Speed Spark Advance Module (2 mounting screws)	Black White/Black Green/White Red/White
Low Speed/High Speed Spark Advance Module (3 mounting screws)	Red/White Black White/Black

"BLACK BOX" OPERATION

Idle Stabilizer will electronically advance the timing by as much as 9° if the idle speed falls below 550 rpm.

High Speed Spark Module will advance the timing by 6° when the powerhead rpm reaches 5600. The timing will remain advanced until powerhead rpm drops to 5400. At this speed, the module will retard the timing by 6°.

Low Speed/High Speed Spark Advance will affect both idle and high speed powerhead operation by advancing the spark at idle and high speed.

CRITICAL WORDS

When timing the powerhead using the cranking motor, the White/Black wire from the idle stabilizer or the low speed/high speed spark advance module **MUST BE DISCONNECTED** from the switch box and the end taped off with insulating tape. If this wire is not disconnected, there is no way on this green earth to properly time the powerhead.

If servicing a V6 Model 200 powerhead, Serial No. 6073192 or higher, the White/-Black wire to the combination low speed/-high speed advance module must also be disconnected.

TROUBLESHOOTING "BLACK BOX" MODULES

To determine if a module is functioning properly, a timing light must be connected to the No. 1 (top starboard bank) spark plug lead. A tachometer **MUST** also be connected either directly to the powerhead or through the remote control unit

Start and operate the powerhead until it reaches normal running temperature.

SPECIAL WORDS

Because the individual modules and the tachometer have a sensitivity variance, the affected rpm may vary slightly from the stated rpm speeds.

Idle Stabilizer Module

Allow the powerhead to idle above 600 rpm, then retard the ignition timing by slowly pulling forward on the spark lever arm. If the system is functioning properly a rapid spark advance, perhaps 9° from the idle setting, should be noted, as the powerhead slows to below about 550 rpm.

As mentioned at the beginning of this section, the module is a sealed "black box" and cannot be opened or repaired. If the unit is defective, it **MUST** be replaced.

High Speed Spark Advance Module

Slowly advance the throttle to above 5600 rpm and at the same time observe the timing. The timing should advance about 6° at approximately 5600 rpm. Now, decrease powerhead speed to about 5400 rpm and at the same time observe the timing. The timing should retard about 6°.

As mentioned at the beginning of this section, the module is a sealed "black box" and cannot be opened or repaired. If the unit is defective, it **MUST** be replaced.

Low Speed/High Speed Spark Advance Module

Low Speed Function

Allow the powerhead to idle above 600 rpm, then retard the ignition timing by slowly pulling forward on the spark lever arm. If the system is functioning properly a rapid spark advance, perhaps 9° from the idle setting, should be noted, as the powerhead slows to below about 550 rpm.

High Speed Function

Slowly advance the throttle to above 5600 rpm and at the same time observe the timing, with the timing light. The timing should advance about 6° at approximately 5600 rpm. Now, decrease powerhead speed to about 5400 rpm and at the same time observe the timing. The timing should retard about 6°.

As mentioned at the beginning of this section, the module is a sealed "black box" and cannot be opened or repaired. If either function of the unit is defective, it **MUST** be replaced.

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7
TIMING AND SYNCHRONIZING

7-1 INTRODUCTION AND PREPARATION

Timing and the synchronization on a multicylinder outboard powerhead is extremely important to obtain maximum efficiency. The powerhead cannot perform properly and produce its designed horsepower output if the fuel carburetion and ignition systems have not been precisely adjusted.

Synchronization

In simple terms, synchronization is timing the carburetion to the ignition. This means, as the throttle is advanced to increase powerhead rpm, the carburetor and the ignition systems are both advanced equally and at the same rate.

Therefore, anytime the fuel system or the ignition system on a powerhead is serviced to replace a faulty part, or any adjustments are made for any reason, powerhead timing and synchronization **MUST** be carefully checked and verified.

For this reason the timing and synchronizing procedures have been separated from all others and presented alone in this chapter.

Before making adjustments with the timing or synchronizing, the ignition system should be thoroughly checked according to the procedures outlined in Chapter 6, and the fuel system must be in good working order per Chapter 4.

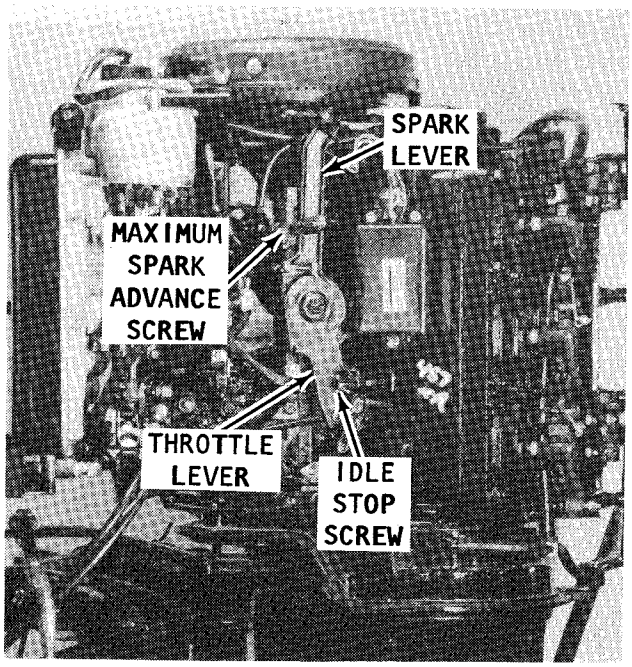
Timing

All outboard engines have some type of synchronization between the carburetion and ignition systems.

Many models do not have timing marks on the flywheel and a dial indicator must be used to properly time the powerhead. On later models the flywheel does have a timing mark and the powerhead may be properly timed using a timing light. This method has its disadvantages, because the powerhead must be run at full throttle in forward gear in a test tank, or at full throttle on the boat in a waterway. The problems of roaring across a lake or down the river at full throttle and attempting to check the timing with a light can easily be imagined.

Therefore, the timing light is not too practical a method of timing and synchronizing a large horsepower powerhead if a test tank is not available.

On some late model and larger horsepower units, the timing is checked using a timing light while cranking the powerhead. Using this procedure it is not necessary to mount the powerhead in a test tank or to move the boat into a body of water. **HOWEVER,** a flush device **MUST** be used and the



Typical location of some principle adjustment points for synchronizing and timing a late model powerhead.

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powerhead **NEVER** operated above 1000 rpm.

PREPARATION

Timing and synchronizing the ignition and fuel systems on an outboard unit are critical adjustments. Therefore, the following equipment is essential and is called out repeatedly in this section. This equipment must be used as described unless otherwise instructed. Naturally, they are removed following completion of the adjustments.

Dial Indicator

Top dead center (TDC) of the No. 1 (top) piston must be precisely known before the timing adjustment can be made. TDC can only be determined through installation of a dial indicator into the No. 1 spark plug opening.

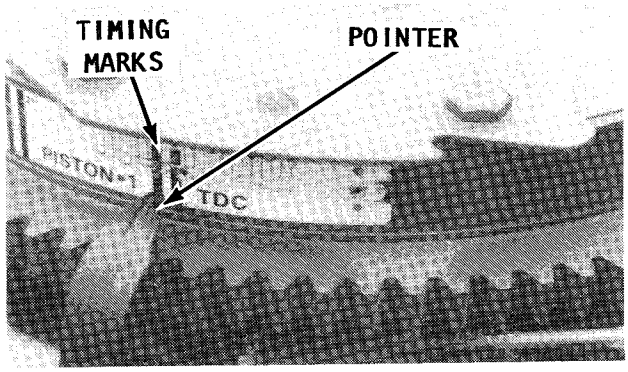
Timing Light

During many procedures in this section, the timing mark on the flywheel must be aligned with a stationary timing mark on the powerhead while the powerhead is being cranked, or is running. Only through use of a timing light connected to the No. 1 spark plug, can the timing mark on the flywheel be observed while the powerhead is operating.

Tachometer

A tachometer connected to the powerhead must be used to accurately determine powerhead speed during idle and high speed adjustments.

The meter readings range from 0 to 6,000 rpm in increments of 100 rpm. Tachometers have solid state electronic circuits which eliminate the need for relays or batteries and contribute to their accuracy.



Typical flywheel timing marks and stationary pointer used on the powerheads covered in this manual.

Most marine outboard units have a female plug at the forward end of the shift box as a convenience for installation of a tachometer. Therefore, when purchasing a tachometer, check to be sure the adaptor plug will mate with the fitting on the shift box.

If the boat is not equipped with a tachometer, connect one lead to the primary (negative (-)) terminal of any one coil. Connect the other lead of the tachometer to a good ground on the powerhead.

Test Tank

The powerhead must be operated at various times during the procedures. Therefore, a test tank, flush device, or moving the boat into a body of water, is necessary.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

NEVER, AGAIN, NEVER operate the engine at high speed with a flush device attached. The powerhead, operating at high speed with such a device attached, would **RUNAWAY** from lack of a load on the propeller, causing extensive damage.

Flywheel Rotation

During the procedures listed in this chapter, the instructions may call for rotating the flywheel until certain marks are aligned with the timing pointer. When the flywheel must be rotated, **ALWAYS** move the flywheel in a **CLOCKWISE** direction, unless instructed to do otherwise. Only in very rare instances will the order be given to rotate the flywheel counterclockwise. When the flywheel is rotated in the opposite direction, the water pump impeller tangs will be twisted backwards. Should the powerhead be started with the pump tangs bent back in the wrong direction, the tangs may not have time to bend in the correct direction before they are damaged. The least amount of damage to the water pump will affect cooling of the powerhead.

Therefore, if the flywheel is ever rotated counterclockwise for any reason, **ALWAYS** rotate the flywheel **CLOCKWISE** manually, to place the water pump vanes in

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the proper direction **BEFORE** starting the powerhead.

7-2 IGNITION TIMING

The spark ignites the air/fuel mixture in the combustion chamber at approximately TDC at idle speeds and at a specific number of degrees of advance before TDC at high speeds. These settings will assure maximum efficiency for horsepower and fuel consumption.

At high speeds, the burning process must start as the piston moves upward in the bore. The burning process will be completed by the time the piston reaches TDC. Maximum combustion chamber pressure will be exerted on the piston dome at TDC to provide the maximum torque and subsequent energy transfer from the cylinder through the drive system to the propeller.

7-3 CARBURETOR SYNCHRONIZATION

Synchronizing the carburetor with the ignition system ensures the carburetor will provide an increased amount of air/fuel mixture for combustion at increased rpm.

These adjustments are:

Idle mixture
Idle speed
Primary throttle pickup
Maximum spark advance
Full throttle stop adjustment
Secondary pickup adjustment

Not all carburetors installed on the powerheads covered in this manual have all the adjustments listed.

Primary Throttle Pickup Adjustment

The throttle control may be a remote control lever or a throttle twist grip. The control is always connected by linkage to the trigger assembly. When the throttle is advanced to increase powerhead rpm, the trigger coils are also advanced.

This arrangement provides advanced powerhead timing automatically as powerhead rpm increases.

The carburetor **MUST** provide additional fuel as powerhead rpm increases. The throttle plate shutter position in the carburetor bore determines the volume of air/fuel mixture supplied to the combustion chamber.

The throttle pickup adjustment is the preset point of spark advance when the throttle plate shutter **BEGINS** to open.

Idle Mixture Adjustment

Operating Principle

As the piston moves upward in the cylinder bore, a suction (negative pressure) draws air through the carburetor throat. The area where the carburetor throat narrows is called the venturi. This reduction in the throat size has the effect of reducing air pressure. Reduction of air pressure increases air speed through the venturi.

A simple example in the outside world, is to consider the increased wind through a mountain pass.

Because of carburetor design, at idle speed fuel is made available at the top of the idle tube. The incoming air stream mixes with the fuel to form a combustible air/fuel mixture in the correct proportions.

The needle end of the idle adjustment screw may be opened to allow more air to enter or closed to restrict the flow of air past the top of the idle tube. In this manner the proportion of air/fuel mixture may be altered.

The correct setting of the idle mixture screw will provide an optimum mixture for powerhead operation at idle speed.

The idle mixture screw is **ALWAYS** equipped with a spring to prevent the screw setting from changing if the powerhead is subjected to vibration.

The tapered end of the screw must be in good condition to allow fine tuning of the mixture proportions.

A screw which has been excessively tightened will have a "deformed" end and should be replaced.

Making Idle Mixture Adjustment

The idle mixture and idle speed are set at the factory. Due to local conditions, it may be necessary to adjust the carburetor while the engine is running in a test tank or with the boat in a body of water. For maximum performance, the idle mixture and the idle rpm should be adjusted under actual operating conditions.

Set the idle mixture screw at the specified number of turns open from a lightly seated position.

Start the powerhead and allow it to warm to operating temperature.

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CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

NEVER, AGAIN NEVER, operate the powerhead at high speed with a flush device attached. The powerhead operating at high speed with such a device attached, would **RUNAWAY** from lack of a load on the propeller shaft, causing extensive damage.

With the engine running in forward gear, slowly turn the idle mixture screw **COUNTERCLOCKWISE** until the affected cylinders start to load up or fire unevenly, due to an over-rich mixture. Slowly turn the idle mixture screw **CLOCKWISE** until the cylinders fire evenly and engine rpm increases. Continue to slowly turn the screw **CLOCKWISE** until too lean a mixture is obtained and the rpms fall off and the engine begins to misfire. Now, set the idle mixture screw one-quarter (1/4) turn out (counterclockwise) from the lean-out position. This adjustment will result in an approximate true setting. A too-lean setting is a major cause of hard starting a cold engine. It is better to have the adjustment on the rich side rather than on the lean side. Stating it another way, do not make the adjustment any leaner than necessary to obtain a smooth idle.



Location of the idle mixture screw on a 75hp and 90hp 3-cylinder powerhead.

If the engine hesitates during acceleration after adjusting the idle mixture, the mixture is too lean. Enrich the mixture slightly, by turning the adjustment screw inward until the engine accelerates correctly.

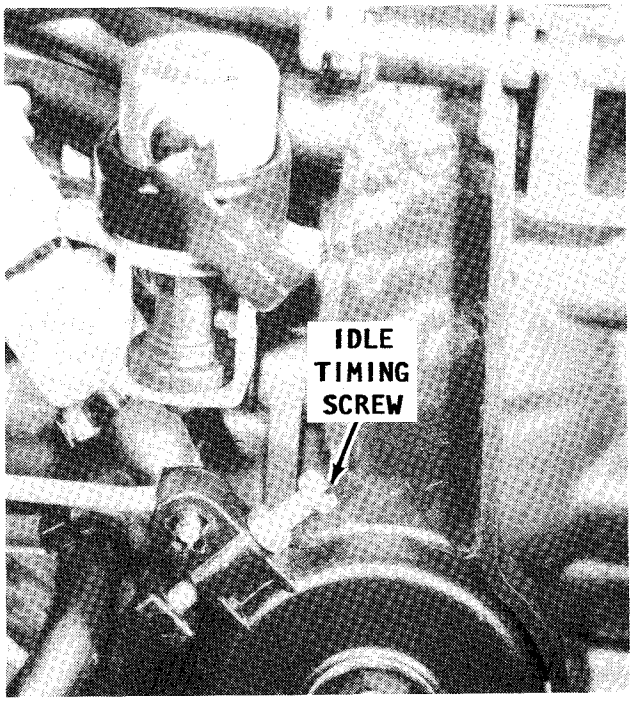
Idle Speed

The idle speed is always adjusted **AFTER** the idle mixture is set. Idle speed is considered the minimum rpm at which the powerhead will operate smoothly. The idle speed is set with an adjustable screw. This screw may be on the carburetor linkage, in the throttle linkage, or part of the magneto linkage depending on the model being serviced.

Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged. Connect the fuel line to a fuel source. Plug the electrical harness into the engine receptacle. Remove the engine cowling. Connect a tachometer to the engine.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the



Location on a 75hp and 90hp 3-cylinder powerhead of the idle timing screw (commonly called idle speed screw on other powerheads).

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water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

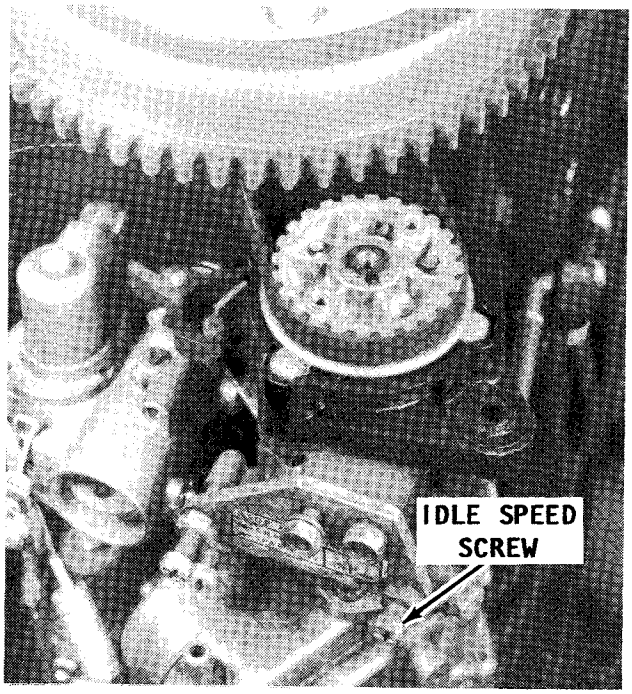
Start the powerhead and allow it to warm to operating temperature.

Remove the cable barrel from the barrel retainer, and loosen the locknut on the idle adjustment screw. Shift the engine into **FORWARD** gear. Adjust the idle rpm to the proper rpm as listed in the Specifications in the Appendix. Tighten the locknut to hold the adjustment. With the end of the throttle cable connected to the throttle lever, hold the throttle lever against the idle stop. Adjust the throttle cable barrel to slip into the barrel retainer on the cable anchor bracket with a very light preload of throttle lever against the idle stop. Lock the barrel in place.

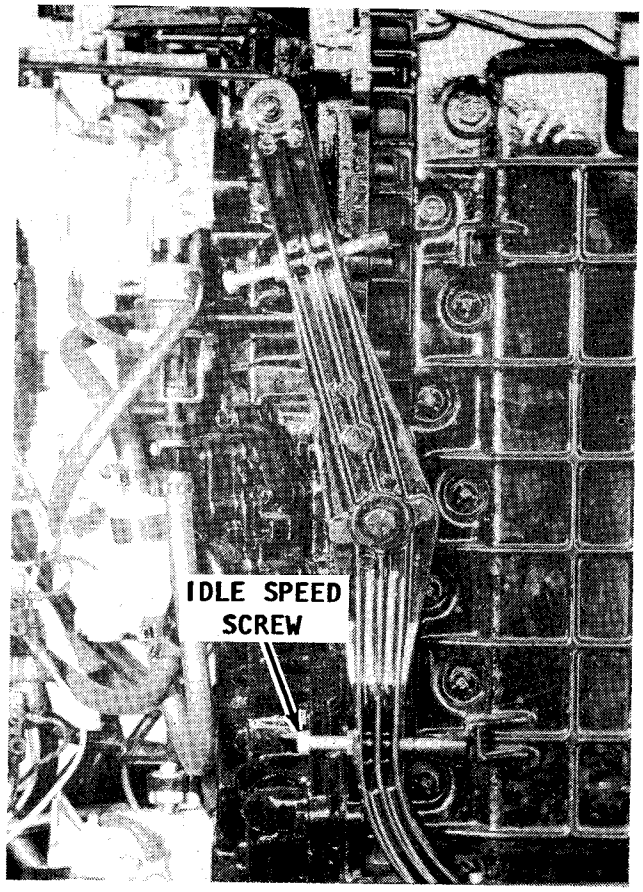
BAD NEWS

An excessive preload on the throttle cable will cause difficulty when shifting from **FORWARD** gear to **NEUTRAL.**

The preload may be easily checked by placing a piece of paper between the idle stop screw and the idle stop, and then withdrawing it. If the paper does not tear, but drag can still be felt, the preload is correct. Adjust the cable barrel, if necessary, to obtain the proper preload just described. Install the powerhead cowling.



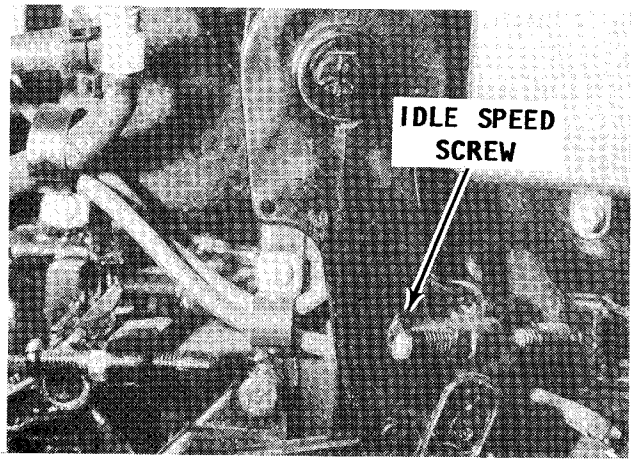
Location of the idle speed screw on 90hp, 115hp, and 140hp powerheads with distributor ignition.



Location of the idle speed screw on 90hp, 115hp, and 140hp powerheads with distributorless ignition.

FINAL WORDS:

If sufficient throttle cable barrel adjustment is not available, a check **MUST** be made for correct installation of the link rod (located between the throttle lever and the throttle cam). Each end of this link rod must be threaded into its plastic barrel until it bottoms against the throttle lever or the throttle cam casting, and then backed out



Location of the idle speed screw on most V6 powerheads.

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from this position **ONLY** far enough to obtain correct orientation of the link rod. The link rod must be backed out **LESS** than one turn. All timing adjustments must be reset after this procedure has been completed. Disconnect the tachometer and the flush device.

7-4 ELECTRONIC IDLE STABILIZER AND SPARK ADVANCE MODULES

Since about 1979, all L6 and V6 powerheads have been equipped with one or more of the following units or combination of units:

an idle stabilizer
and/or
a high speed advance module
and/or
a low speed/high speed spark advance module.

All of these units are "black boxes". By "black box" the term means the item is a sealed unit and cannot be opened or serviced. Therefore, if troubleshooting should indicate the module is defective, it **MUST** be replaced. In short, it either functions properly or it is replaced.

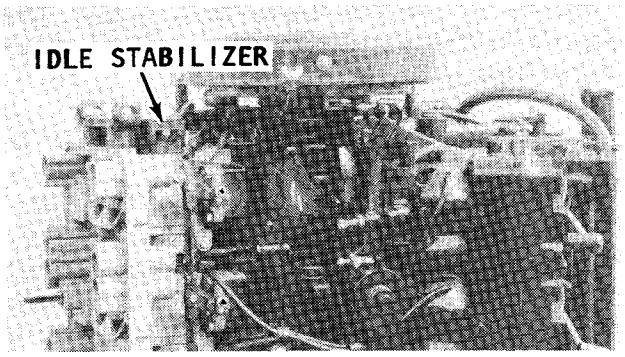
These "black box" units are usually installed on the upper front cowling support bracket, but may be found in other locations on various powerheads.

The **ONLY** method to determine which "black box" is installed on the powerhead being serviced is to make an identification of the wires from the "black box" to the switch boxes as follows:

Idle Stabilizer	White/Black
(2 mounting screws)	Red/White
	Black
High Speed Spark	Black
Advance Module	White/Black
(2 mounting screws)	Green/White
	Red/White
Low Speed/High Speed	Red/White
Spark Advance Module	Black
(3 mounting screws)	White/Black

"BLACK BOX" OPERATION

Idle Stabilizer will electronically advance the timing by as much as 9° if the idle speed falls below 550 rpm.



Typical location of a "Black Box" idle stabilizer module on an early model V6 powerhead.

High Speed Spark Advance Module will advance the timing by 6° when the powerhead rpm reaches 5600. The timing will remain advanced until powerhead rpm drops to 5400. At this speed, the module will retard the timing by 6°.

Low Speed/High Speed Spark Advance will affect both idle and high speed powerhead operation by advancing the spark at idle and high speed.

CRITICAL WORDS

When timing the powerhead using the cranking motor, the White/Black wire from the idle stabilizer or the low speed/high speed spark advance module **MUST BE DISCONNECTED** from the switch box and the end taped off with insulating tape. If this wire is not disconnected, there is no way on this green earth to properly time the powerhead.

7-5 4-CYLINDER POWERHEADS
50HP — 1982-85
45HP -- SINCE 1986

1- Mount the outboard in a test tank, or move the boat into a body of water. **NEVER** use a flush device when making the primary pickup, maximum advance timing, or the secondary pickup adjustments. Remove the powerhead cowl. Connect the fuel line to a fuel source. Connect a tachometer to the engine. Connect a timing light to the No. 1 (top) spark plug. On all carburetors: back the idle mixture screw out 1-1/4 to 1-1/2 turns from a lightly seated position.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the power-

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head is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the powerhead and allow it to warm to operating temperature.

Shift the outboard into **FORWARD** gear.

Primary Pickup Synchronizing Timing

2- With the engine running in **FORWARD** gear, aim the timing light at the timing decal, and advance powerhead rpm until the timing pointer is aligned with the following marks on the timing decal:

Serial numbers 4576236 to 5531629 -- pointer aligned with 7° to 9° BTDC.

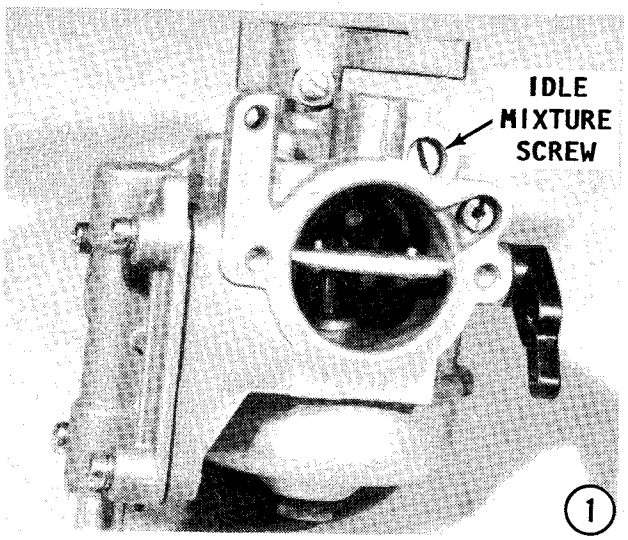
Serial numbers 5531630 & above --pointer aligned with 2° BTDC to 2° ATDC.

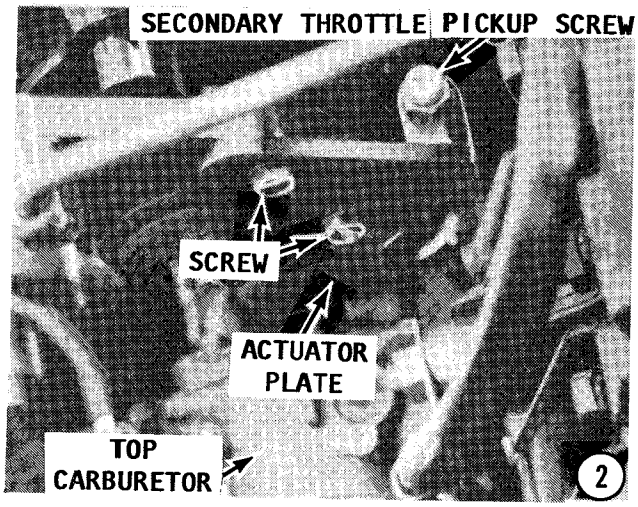
From this position, loosen the two throttle actuator plate retaining screws.

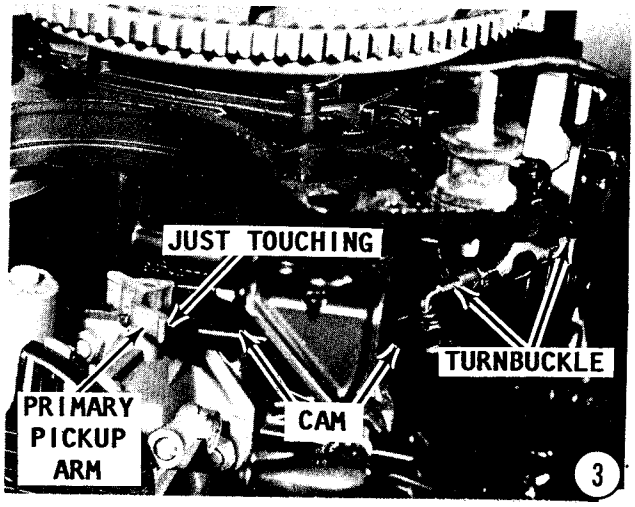
3- Rotate the actuator plate until the primary cam just makes contact with the primary pickup arm on the carburetor cluster. Tighten the retaining screws to hold the adjustment. Back-off the throttle to idle speed.

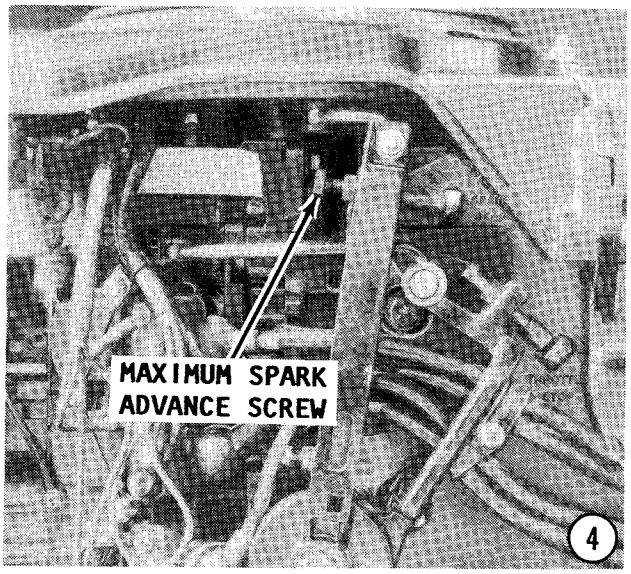
Maximum Advance Timing

4- With the engine running in **FORWARD** gear, and the timing light aimed at the timing decal, advance engine speed until the timing pointer aligns with the 32° BTDC mark on the timing decal. Loosen the locknut and adjust the maximum spark stop screw until the end of the screw just makes contact with the stop. **AN EXPLANATION:** This adjustment will result in a spark advance of 30° at maximum rpm, due to the spark advance characteristics of this ignition system. Tighten the locknut to hold the adjustment. Back-off engine speed to idle and shut down the engine. Remove the timing light.









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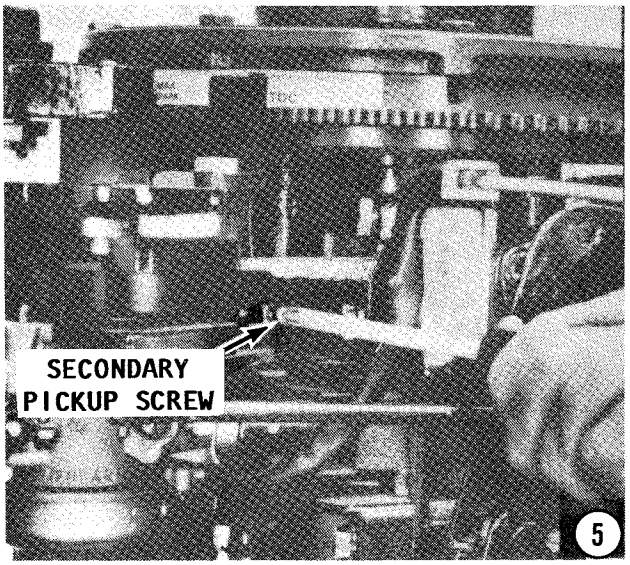
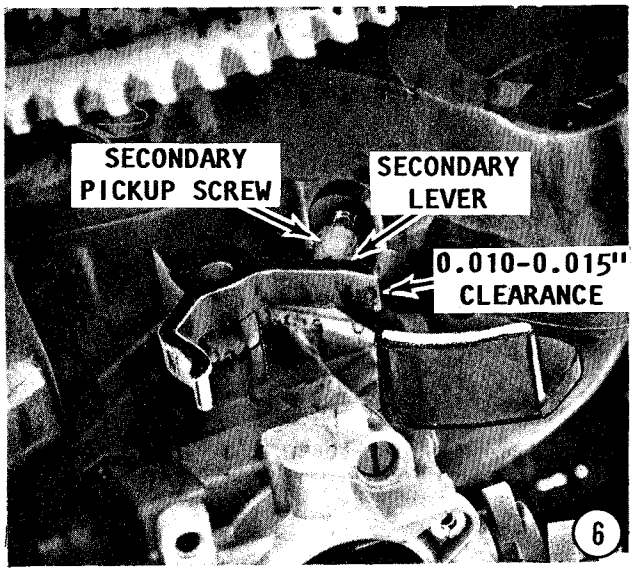


Secondary Pickup Adjustment

5- With the engine **NOT** running, move the throttle lever until the maximum spark advance screw is against the stop, and then loosen the locknut and adjust the secondary pickup screw until the end of the screw just makes contact with the secondary lever.

6- With the engine **NOT** running, move the throttle lever to the wide open throttle (WOT) position. Loosen the locknut and adjust the full throttle stop screw to permit the carburetor shutters to fully open at WOT. Check to be sure the carburetor shutters do not act as a throttle stop. Use a feeler gauge and check the clearance between the secondary pickup screw and the carburetor cluster secondary lever. This clearance should be 0.010" - 0.015" (0.25 - 0.38mm). Tighten the locknut to hold the adjustment. Disconnect the fuel line, tachometer, and timing light. Remove the engine from the test tank.

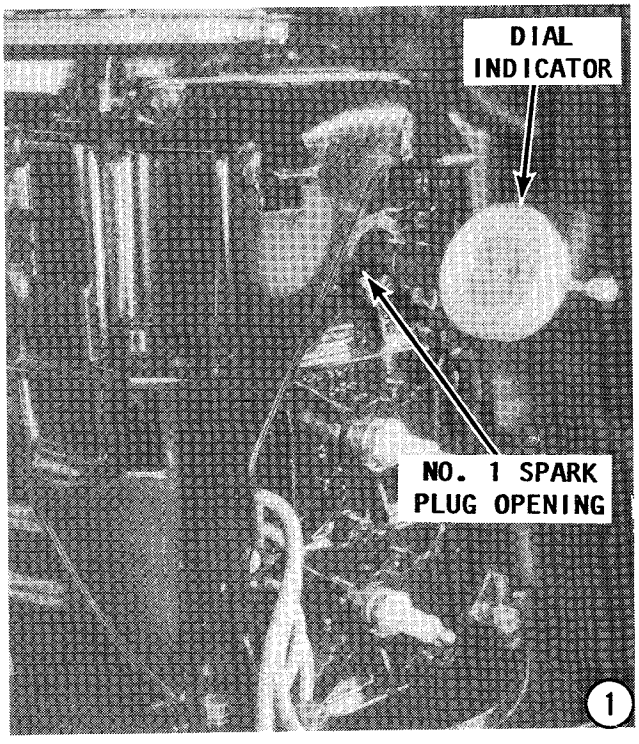


7-6 3-CYLINDER POWERHEADS
50HP SINCE 1986
60HP SINCE 1984
70 HP — 1980-83

Timing Pointer Adjustment

A SAFETY WORD: To prevent the engine from starting and possibly causing personal injury during the timing procedure, **ALWAYS** remove all spark plugs before starting the adjustment procedures.

1- Remove all spark plugs. Install a dial indicator in the No. 1 (top) spark plug opening. Rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). At this point, set the dial indicator at 0°. Rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle is approximately 1/4-turn beyond 0.464 (11.80mm), then rotate the flywheel **CLOCKWISE** until the dial indicator reads exactly 0.464" (11.80mm). If necessary, loosen the attaching screw and shift the timing pointer, until the .464" mark on the timing decal is aligned with the groove in the timing pointer, as shown. Tighten the pointer attaching screw to hold the adjustment. Remove the dial indicator. Install the spark plugs.



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Primary Pickup Synchronizing

A primary pickup adjustment is not possible for the powerheads listed above for this section.

Maximum Spark Advance Timing

Connect a flush device to the lower unit. **NEVER** operate the engine over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no-load condition on the propeller. A "runaway" engine could be severely damaged.

2- On all carburetors, back the idle mixture screw out 1-1/4 to 1-1/2 turns from a lightly seated position.

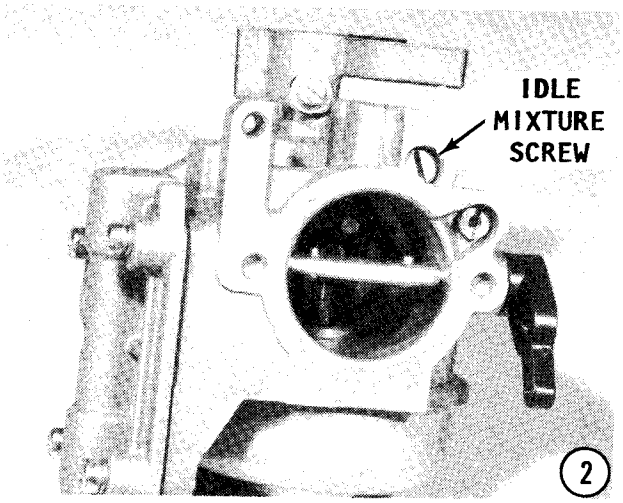
Connect a timing light to the No. 1 (top) spark plug lead.

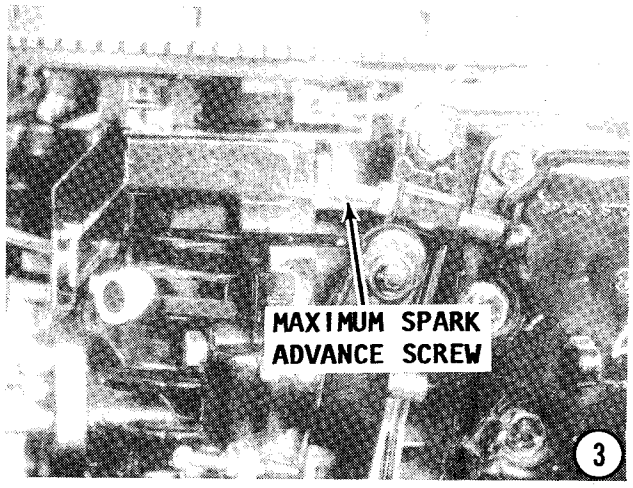
Start the powerhead and allow it to warm to operating temperature.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

3- Loosen the locknut on the maximum spark advance screw. Shift the outboard into **FORWARD** gear. Aim the timing light at the timing decal. Advance the throttle until powerhead speed is 5300 to 5800 rpm. Now, rotate the maximum spark advance screw until the timing pointer is aligned with the 23° BTDC mark on the timing decal. Tighten the locknut to hold the adjustment. Reduce powerhead rpm to idle speed, and then shut down the powerhead. Remove the timing light.

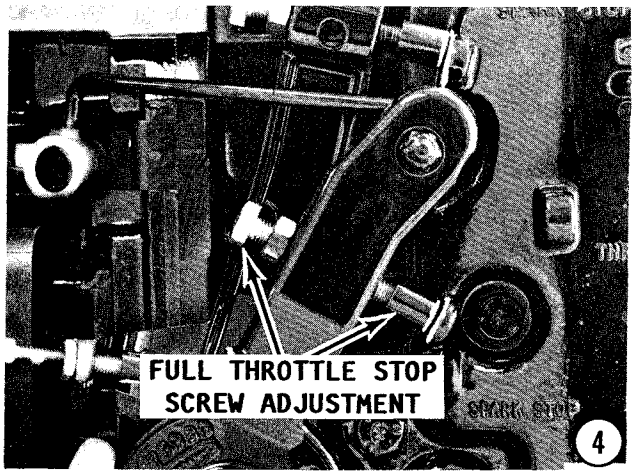


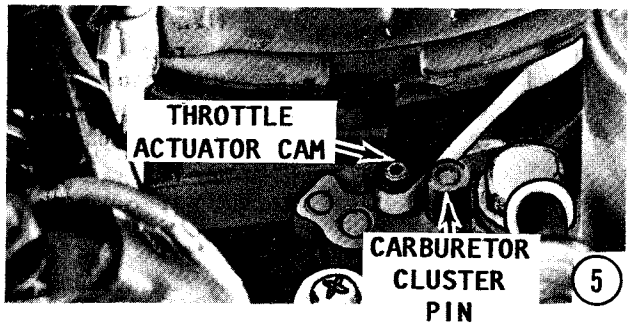


Full Throttle Stop Adjustment

4- With the powerhead shut down, move the throttle arm to the wide open throttle (WOT) position and adjust the throttle stop screw until the carburetor shutter is at the full open position. Check to be sure the shutter does not act as a stop.

5- Use a feeler gauge and check the clearance between the throttle actuator cam and the carburetor cluster pin, with the throttle lever against the throttle stop screw. This clearance should be 0.010" - 0.015" (0.25 - 0.38mm). Loosen the locknut on the throttle stop screw and make an adjustment, if necessary. Tighten the locknut to hold the adjustment.





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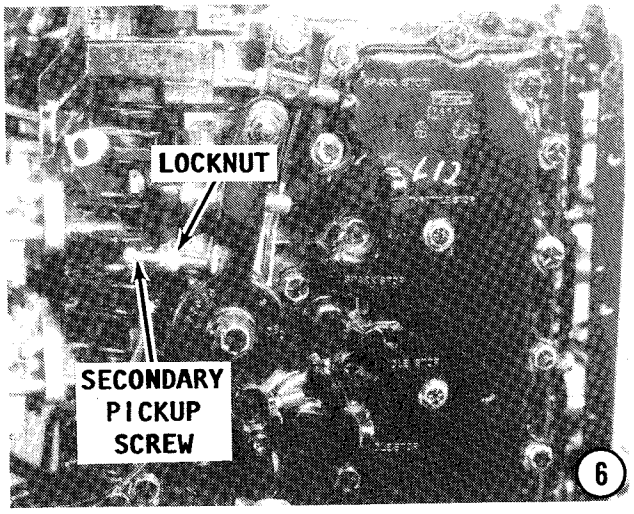


Secondary Pickup Adjustment

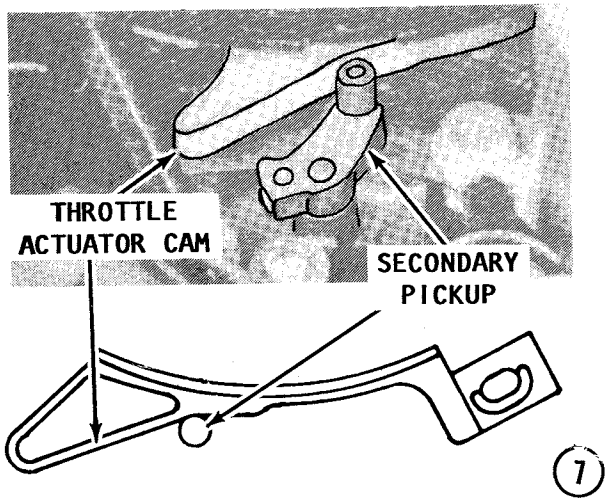
6- With the engine **NOT** running, loosen the locknut on the secondary pickup adjustment screw. Now, move the spark arm to maximum spark.

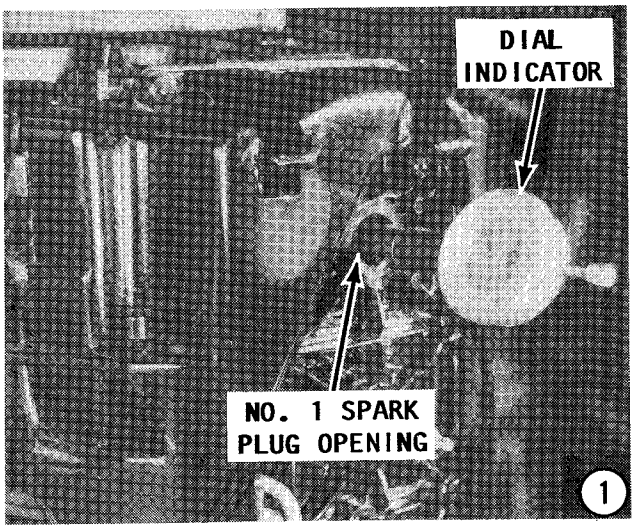
7- Adjust the secondary pickup adjustment screw until the carburetor cluster pin just makes contact with the secondary pickup point on the throttle cluster cam. Tighten the locknut to hold the adjustment. Move the throttle lever back to the idle position. Install the powerhead cowl.

7-7 4-CYLINDER POWERHEADS
75HP — 1984-86
80HP — 1978-83
85HP — 1977 ONLY

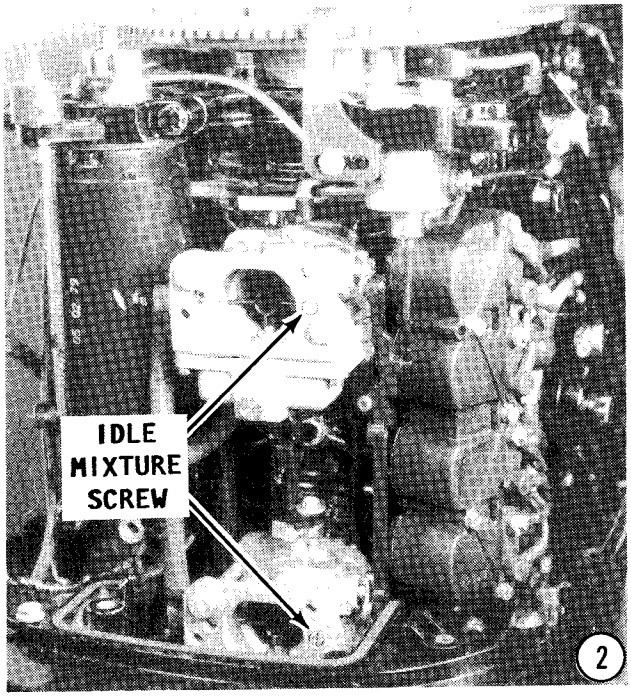
Timing Pointer Adjustment

A SAFETY WORD: To prevent the engine from starting and possibly causing personal injury during the timing procedure, **ALWAYS** remove all spark plugs before starting the adjustment procedures.





1- Remove all spark plugs. Install a dial indicator in the No. 1 (top) spark plug opening. Rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). At this point, set the dial indicator at 0°. Rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle is approximately 1/4-turn beyond 0.464 (11.80mm), then rotate the flywheel **CLOCKWISE** until the dial indicator reads exactly 0.464" (11.80mm). If necessary, loosen the attaching screw and shift the timing pointer, until the .464" mark on the timing decal is aligned with the groove in the timing pointer, as shown. Tighten the pointer attaching screw to hold the adjustment. Remove the dial indicator. Install the spark plugs.



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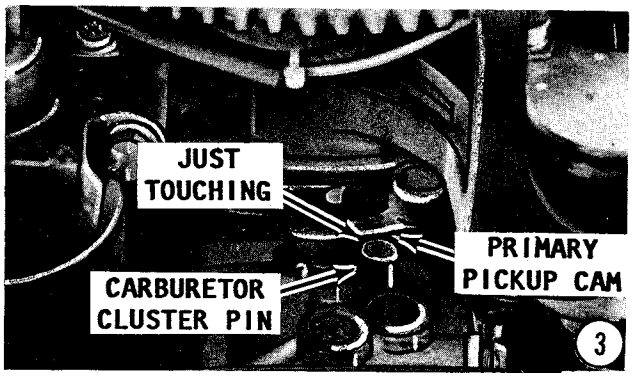


Primary Pickup Synchronizing Timing

2- Mount the engine in a test tank, or move the boat into a body of water. **NEVER** use a flush device while making the primary pickup or maximum advance adjustments. Connect a timing light to the No. 1 (top) spark plug lead. On all carburetors: back out the idle mixture adjustment screw 1-1/2 turns from the lightly seated position.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the powerhead and allow it to warm to operating temperature.

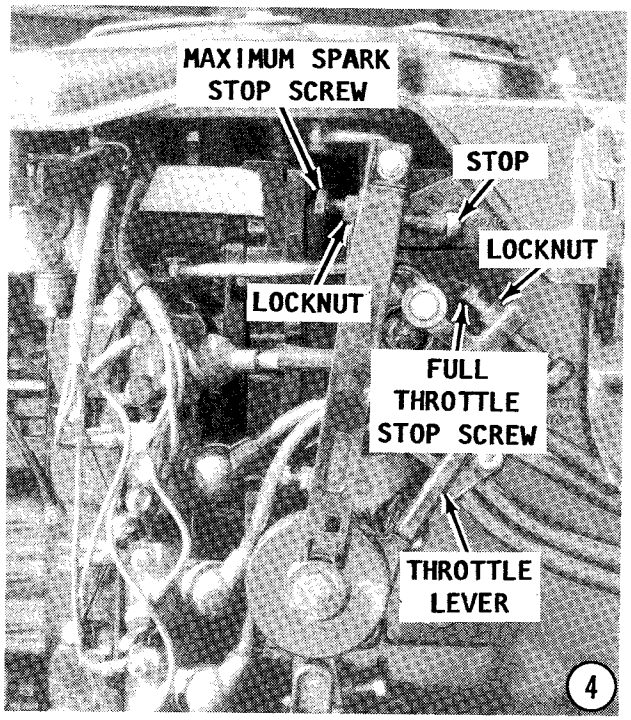
3- With the outboard in **FORWARD** gear and running at idle speed, move the throttle lever until the throttle primary pickup cam just makes contact with the primary pickup on the carburetor cluster.

Loosen the locknut on the primary pickup screw. Without moving the throttle lever, adjust the primary pickup screw until the timing pointer is aligned with the following marks on the timing decal:

Serial numbers 4423112 and below -- pointer aligned with 2° to 5° BTDC.

Serial numbers 4423113 and above -- pointer aligned with 2° BTDC to 2° ATDC.

Tighten the locknut to hold the adjustment.



Maximum Advance Adjustment

4- With the engine in **FORWARD** gear and running at idle speed, aim the timing light at the timing decal and at the same time, advance engine speed until the timing pointer is aligned with the 27° BTDC mark on the timing decal. Loosen the locknut on the maximum spark advance stop screw. Adjust the maximum spark advance stop screw until the end of the screw just makes contact with the screw stop. Tighten the locknut to hold the adjustment. Back-off the throttle to idle speed, and then shut down the engine. Remove the timing light.

Maximum Throttle Stop Adjustment

With the engine **NOT** running, advance the throttle lever to the wide open throttle (WOT) position. Loosen the locknut on the full throttle stop screw. Adjust the full throttle stop screw until the carburetor shutter is in the full open position. Tighten the locknut to hold the adjustment. Check to be sure the carburetor shutters do not act as a throttle stop. Use a feeler gauge and check the clearance between the throttle cam and the pin on the carburetor cluster, when the throttle is at the WOT position. This clearance should be 0.010" - 0.015" (0.25 -0.38mm). Remove the engine from the test tank.

7-8 3-CYLINDER POWERHEADS 75HP AND 90HP — 1987 AND ON

Timing Pointer Adjustment

A SAFETY WORD: To prevent the engine from starting and possibly causing personal injury during the timing procedure, **ALWAYS** remove all spark plugs before starting the adjustment procedures.

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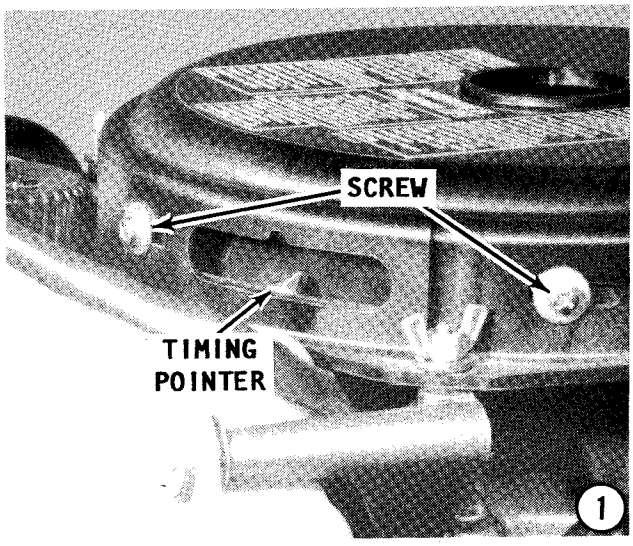
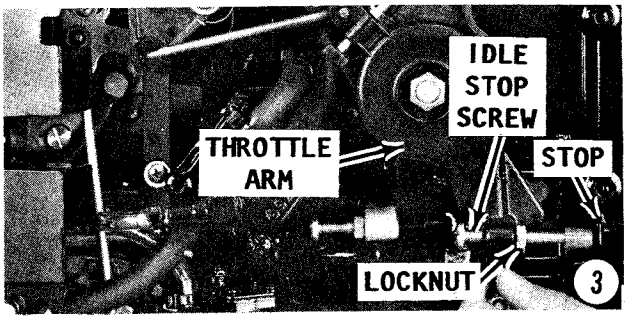


1- Remove all spark plugs. Install a dial indicator in the No. 1 (top) spark plug opening. Rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). At this point, set the dial indicator at 0°. Rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle reads .550" BTDC, then rotate the flywheel **CLOCKWISE** until the dial indicator reads exactly .491" BTDC.

If necessary, loosen the attaching screws and shift the timing pointer, until the .491" mark on the timing decal is aligned with the groove in the timing pointer, as shown. Tighten the pointer attaching screws to a torque value of 20 in lbs (2.3Nm) to hold the adjustment. Remove the dial indicator. Install the spark plugs.

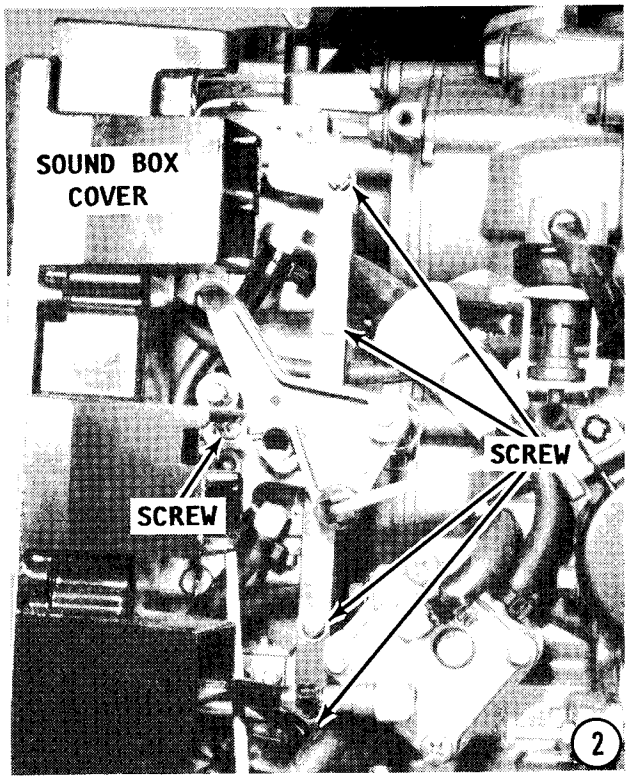


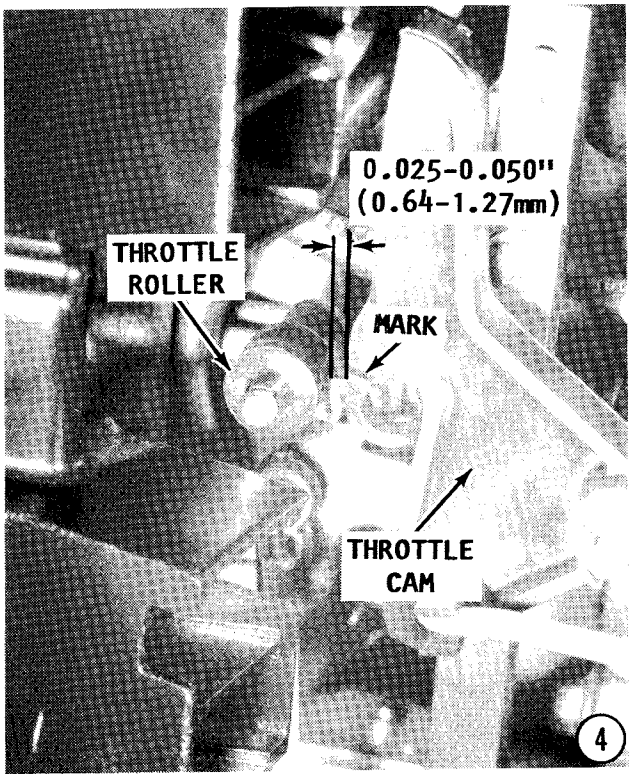
2- Remove the eight attaching screws securing the sound box cover to the powerhead, and then remove the cover.

Loosen, but do **NOT** remove the Phillips head screw under the cam follower. Again, loosen but do **NOT** remove the four Phillips head screws on the carburetor tie bar. Hold all three throttle shutter valves closed and tighten the four screws on the carburetor tie bar.

3- Loosen the locknut on the idle stop screw. Hold the throttle lever aft until the idle stop screw rests against the stop on the outer exhaust cover.

4- Position the throttle roller against the throttle cam as far as possible. Adjust the idle stop screw until the throttle roller rests against the throttle cam at the raised mark on the cam.





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Back off the idle stop screw until a clearance of 0.025 to 0.050" (0.64-1.27mm) exists between the throttle roller and the throttle cam. Tighten the locknut on the idle stop screw to hold the adjustment.

5- Move the throttle lever aft until the maximum spark advance screw contacts the stop on the outer exhaust cover.

6- Loosen the locknut on the full throttle stop screw. Adjust the full throttle stop screw and at the same time observe all three throttle shutter valves. The shutter valves **MUST** be in the fully open position. Check to be sure the throttle valves do not act as a throttle stop and approximately 0.015" (0.40mm) free play exists in the throttle linkage at WOT. Tighten the locknut on the full throttle stop screw to hold the adjustment.

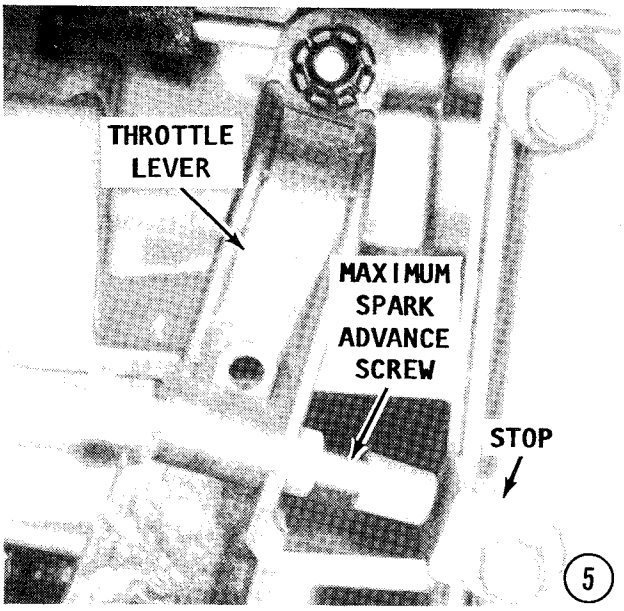
Idle Timing Adjustment

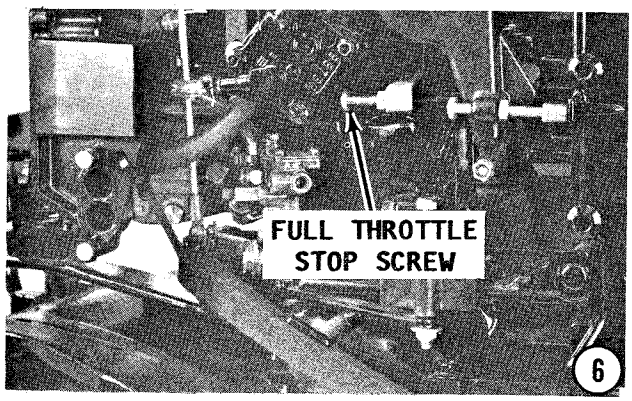
The following adjustment performed in Step 7 and Step 8 are made while the powerhead is being cranked. Therefore, stay **CLEAR** of the propeller because it will be rotating.

SPECIAL WORDS

A fully charged battery must be used while making this adjustment or an inaccurate reading may be obtained.

7- Connect a timing light to the No. 1 (top) spark plug lead. With the lower unit in **NEUTRAL,** hold the throttle lever in the forward position, and at the same time, loosen the locknut on the idle timing screw.





WARNING: KEEP FINGERS CLEAR OF THE ROTATING FLYWHEEL.

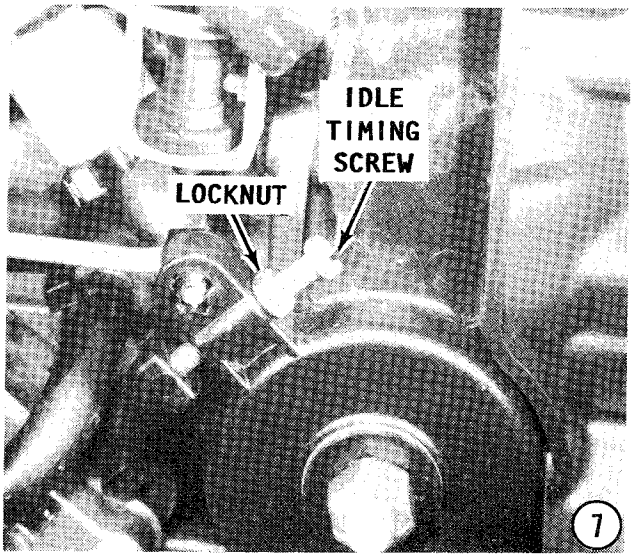
Crank the powerhead with the cranking motor and at the same time, aim the timing light at the timing decal. Adjust the idle timing screw until the timing pointer aligns with the 2° BTDC mark on the decal. Tighten the locknut to hold this position.

Maximum Timing Adjustment

8- Loosen the locknut on the maximum spark advance screw. Hold the throttle lever in the aft position until the maximum spark advance screw contacts the stop on the outer exhaust cover. Crank the powerhead with the cranking motor and at the same time adjust the maximum spark advance screw until the timing pointer aligns as follows:

75hp powerhead -- 18° BTDC mark.
90hp powerhead -- 28° BTDC mark.

Due to the unique characteristics of this particular ignition system, this adjustment



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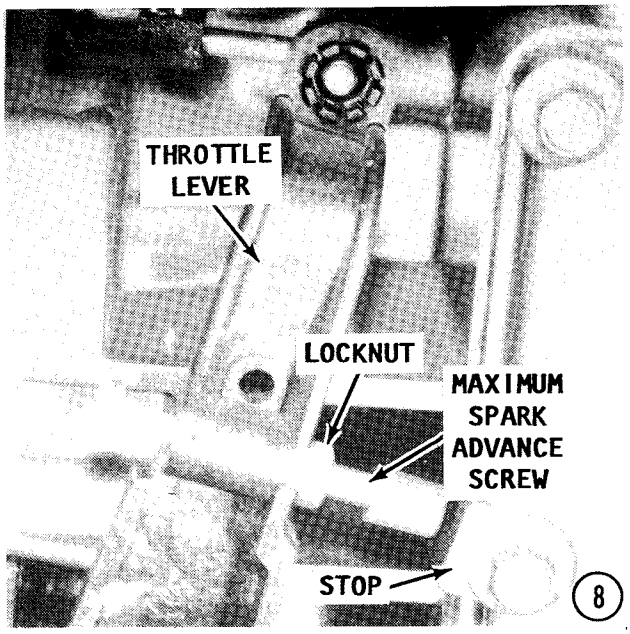


at powerhead cranking speed will result in a spark advance of 16° BTDC for the 75hp powerhead and 26° BTDC for the 90hp powerhead at 5,000 rpm.

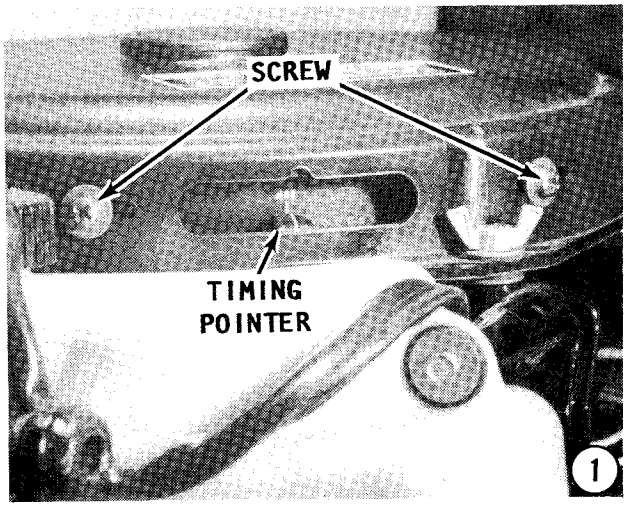
Tighten the locknut on the maximum spark advance screw to hold the adjustment. Remove the timing light.

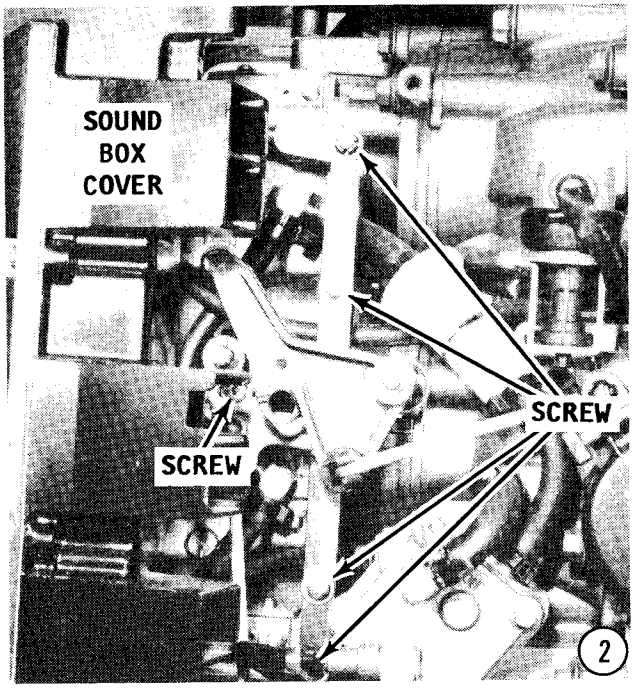
7-9 4-CYLINDER POWERHEADS
100HP — 1988 AND ON
115HP — 1989 AND ON

Timing Pointer Adjustment

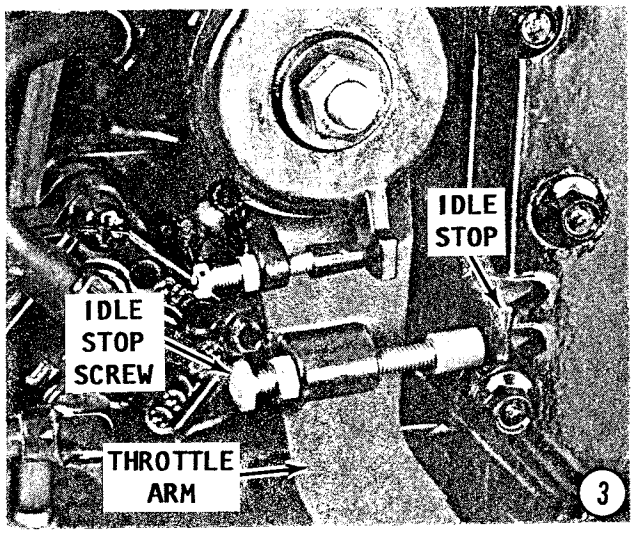
A SAFETY WORD: To prevent the engine from starting and possibly causing personal injury during the timing procedure, **ALWAYS** remove all spark plugs before starting the adjustment procedures.

1- Remove all spark plugs. Install a dial indicator in the No. 1 (top) spark plug opening. Rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). At this point, set the dial indicator at 0°. Rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle reads .600" BTDC, then rotate the flywheel **CLOCKWISE** until the dial indicator reads exactly .554" BTDC. If necessary, loosen the attaching screws and shift the timing pointer, until the .554" mark on the timing decal is aligned with the groove in the timing pointer, as shown. Tighten the pointer attaching screws to a torque value of 20 in lbs (2.3Nm) to hold the adjustment. Remove the dial indicator. Install the spark plugs.





2- Remove the eight attaching screws securing the sound box cover to the powerhead, and then remove the cover.



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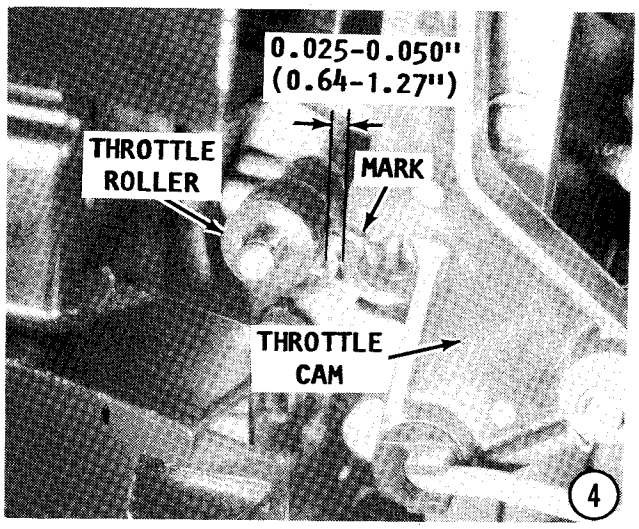


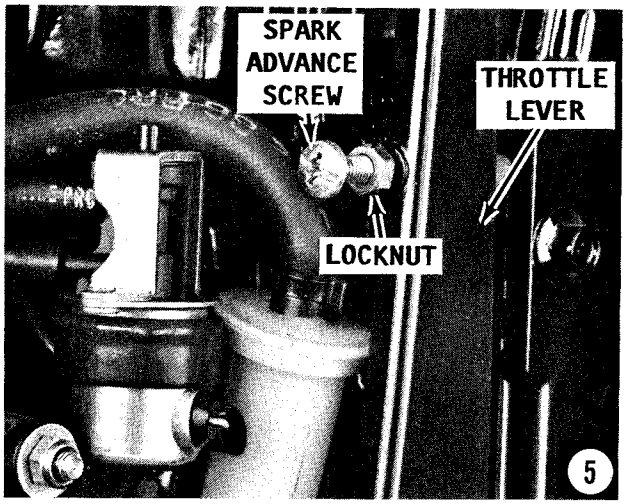
Loosen, but do **NOT** remove the Phillips head screw under the cam follower. Again, loosen but do **NOT** remove the six Phillips head screws on the carburetor tie bar. Hold all three throttle shutter valves closed and tighten the six screws on the carburetor tie bar.

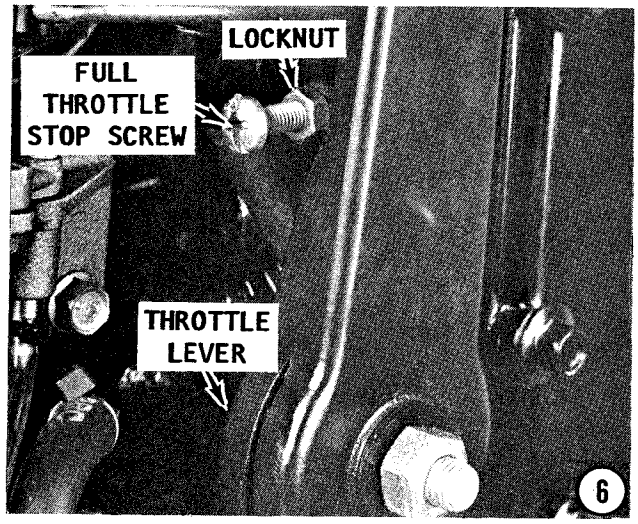
3- Loosen the locknut on the idle stop screw. Hold the throttle lever aft until the idle stop screw rests against the stop on the outer exhaust cover.

4- Position the throttle roller against the throttle cam as far as possible. Adjust the idle stop screw until the throttle roller rests against the throttle cam at the raised mark on the cam.

Back off the idle stop screw until a clearance of 0.005-0.020" (0.13-0.50mm) exists between the throttle roller and the throttle cam. Tighten the locknut on the idle stop screw to hold the adjustment.

5- Move the throttle lever aft until the maximum spark advance screw contacts the stop on the outer exhaust cover.





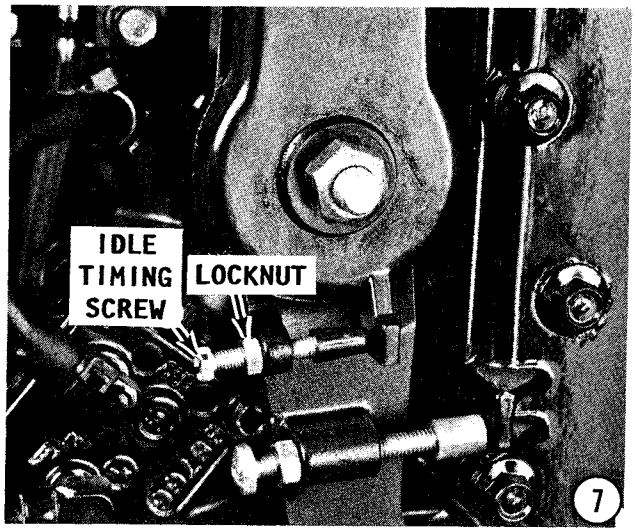
6- Loosen the locknut on the full throttle stop screw. Adjust the full throttle stop screw and at the same time observe all four throttle shutter valves. The shutter valves **MUST** be in the fully open position. Check to be sure the throttle valves do not act as a throttle stop and approximately 0.015" (0.40mm) free play exists in the throttle linkage at WOT. Tighten the locknut on the full throttle stop screw to hold the adjustment.

Idle Timing Adjustment

The following adjustment performed in Step 7 and Step 8 are made while the powerhead is being cranked. Therefore, stay **CLEAR** of the propeller because it will be rotating.

SPECIAL WORDS

A fully charged battery must be used while making this adjustment or an inaccurate reading may be obtained.



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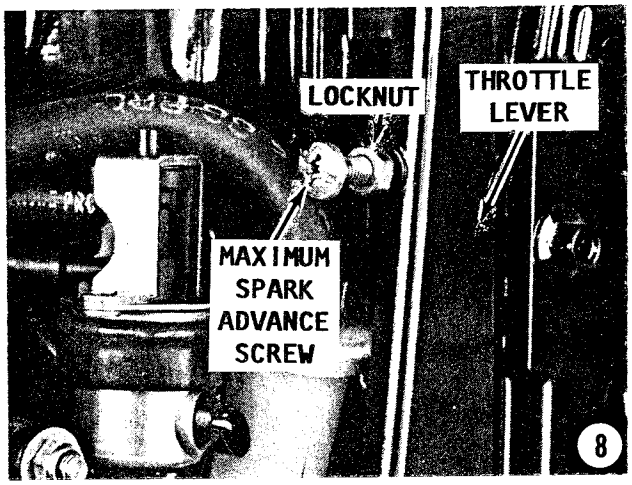


7- Connect a timing light to the No. 1 (top) spark plug lead. With the lower unit in **NEUTRAL,** hold the throttle lever in the forward position, and at the same time, loosen the locknut on the idle timing screw.

WARNING: KEEP FINGERS CLEAR OF THE ROTATING FLYWHEEL.

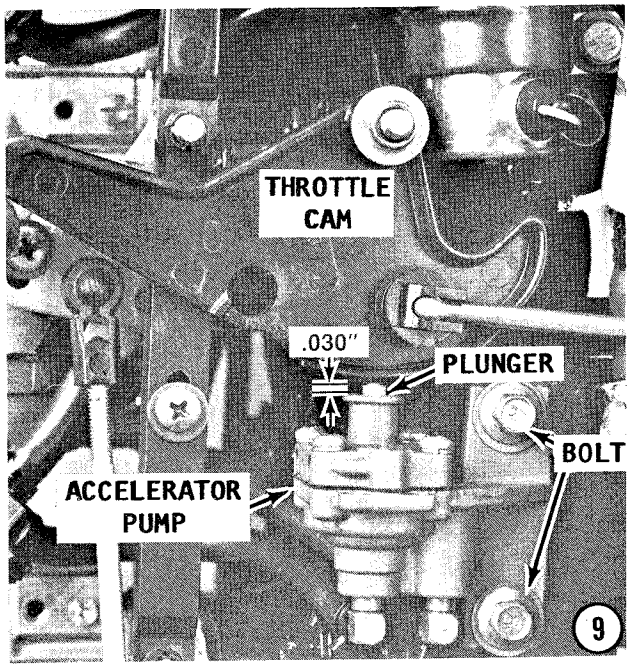
Crank the powerhead with the cranking motor and at the same time, aim the timing light at the timing decal. Adjust the idle timing screw until the timing pointer aligns with the 3° BTDC mark on the decal. Tighten the locknut to hold this position.

Maximum Timing Adjustment

8- Loosen the locknut on the maximum spark advance screw. Hold the throttle lever in the aft position until the maximum spark advance screw contacts the stop on the outer exhaust cover. Crank the powerhead with the cranking motor and at the same time adjust the maximum spark advance screw until the timing pointer aligns with the 27° BTDC mark on the timing decal.

Due to the unique characteristics of this particular ignition system, this adjustment at powerhead cranking speed will result in a spark advance of 23° BTDC at 3,000-5,000 rpm.

Tighten the locknut on the maximum spark advance screw to hold the adjustment. Remove the timing light.



Accelerator Pump Adjustment

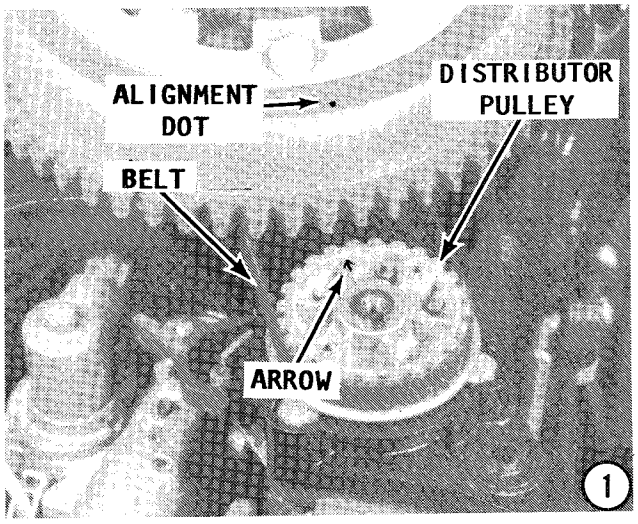
9- Move the throttle lever aft to the full WOT position. This action will cause the throttle cam to fully depress the plunger on top of the accelerator pump. With the plunger depressed, measure the distance between the contact point of the cam and the plunger to the upper surface of the accelerator pump. The manufacturer calls for this measurement to be 0.030" (0.76mm). A tolerance is not given.

If an adjustment is necessary, loosen the two accelerator pump mounting bolts and reposition the pump body until the required measurement is obtained. Tighten the two bolts securely to hold the new adjustment.

7-10 6-CYLINDER IN-LINE 90HP, 115HP, AND 140HP POWERHEADS WITH DISTRIBUTOR

Belt Timing

1- Remove the powerhead cowling. Remove all of the spark plugs as a **SAFETY**



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measure to ensure the engine does not fire while making adjustments. Observe the single dot (three dots on Models 115 and 150 prior to 1978) alignment mark on the flywheel and the arrow cast into the distributor pulley. Remove the bolt, washers, pulley cover, and the belt. Now, rotate the flywheel **CLOCKWISE** until the alignment mark on the flywheel is aligned with the center of the distributor shaft.

Rotate the distributor pulley until the arrow is pointing at the flywheel alignment mark. Hold the pulley in this position and install the belt. Install the pulley cover, washers, and bolt. Tighten the bolt to a torque value of 60 in lb (6.9Nm).

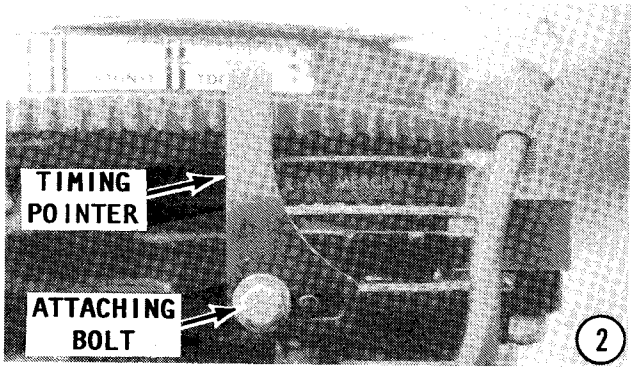
SOME GOOD WORDS:

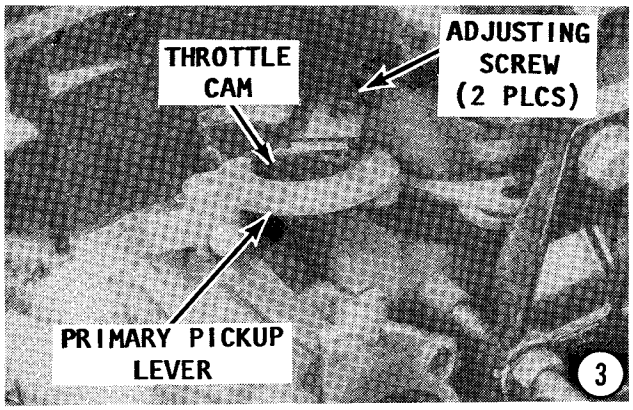
On 6-cylinder powerheads with Thunderbolt Ignition, the arrow on the pulley may not align exactly with the mark on the flywheel. In such a case, align the arrow slightly **CLOCKWISE** (when viewed from the front of the powerhead). Such alignment will appear to be approximately 1/2 tooth off. This is acceptable. **IF** the belt is installed with the pulley 1/2 tooth to the left (counterclockwise) powerhead synchronization will be very difficult. Actually, such an incorrect adjustment will result in rough engine operation.

Timing Pointer Adjustment

2- Install a dial indicator into the No. 1 (top) spark plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle is approximately 1/4-turn beyond the .464 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at .464.

Adjust the timing pointer until the pointer is aligned with the .464 mark on the timing decal. Remove the dial indicator. Install the spark plugs.





Primary Pickup Synchronizing Timing

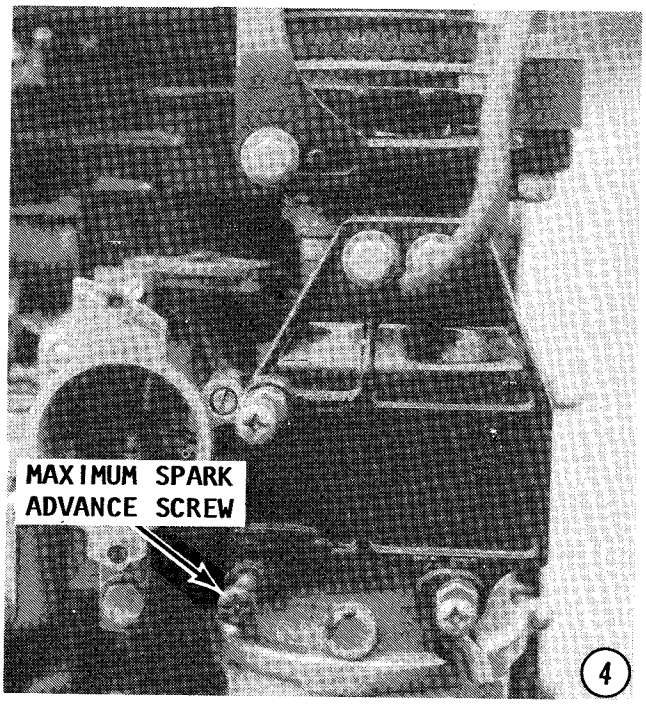
3- Mount the engine in a test tank, or move the boat into a body of water. **NEVER** use a flush device while making the primary pickup, maximum advance, or secondary pickup adjustments. Connect the fuel line to a fuel source. Plug the electrical harness into the powerhead receptacle. Connect a timing light to the No. 1 (top) spark plug.

On all carburetors: back the idle mixture screw out 1-1/4 turn from the lightly seated position.

Start the powerhead and allow it to warm to operating temperature.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the power-



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head is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Shift the lower unit into **FORWARD** gear. Advance the throttle until the timing pointer is aligned with the 4°-6° BTDC mark on the timing decal.

Without moving the throttle lever, loosen the actuator plate attaching bolts and rotate the actuator plate until the throttle cam just makes contact with the primary pickup lever on the carburetor cluster. Tighten the attaching bolts to hold the adjustment.

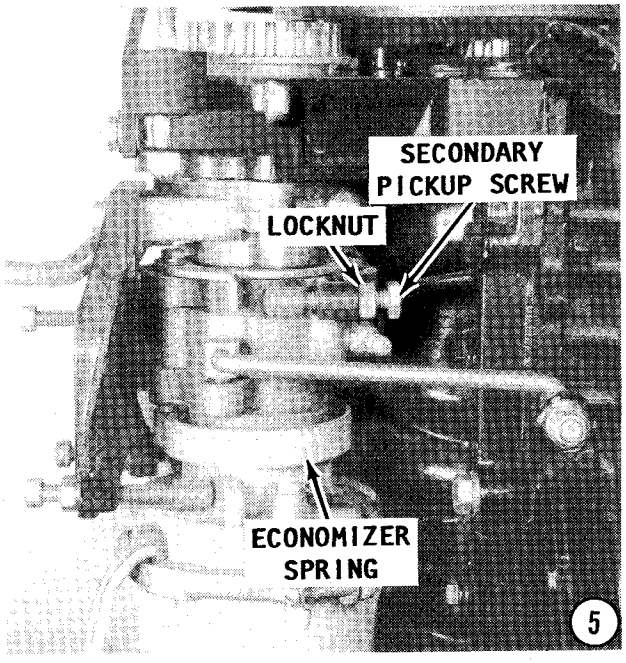
Maximum Advance Timing

4- With the powerhead running and the lower unit in **FORWARD** gear, advance the powerhead speed until the timing pointer is aligned with the 21° BTDC mark on the timing decal. Loosen the locknut, and adjust the maximum spark advance stop screw until the end of the screw just makes contact with the distributor adaptor. Tighten the locknut to hold the adjustment. Back-off the throttle to the normal idle position. Shut down the powerhead. Disconnect the timing light and fuel line. Remove the engine from the test tank.

Secondary Pickup Adjustment

5- With the powerhead **NOT** running, advance the throttle lever until the distributor just makes contact against the maximum spark advance screw, but not actuating the economizer spring. Loosen the locknut and adjust the throttle secondary pickup screw until the secondary pickup just makes contact with the secondary lever on the carburetor. Tighten the locknut to hold the adjustment.

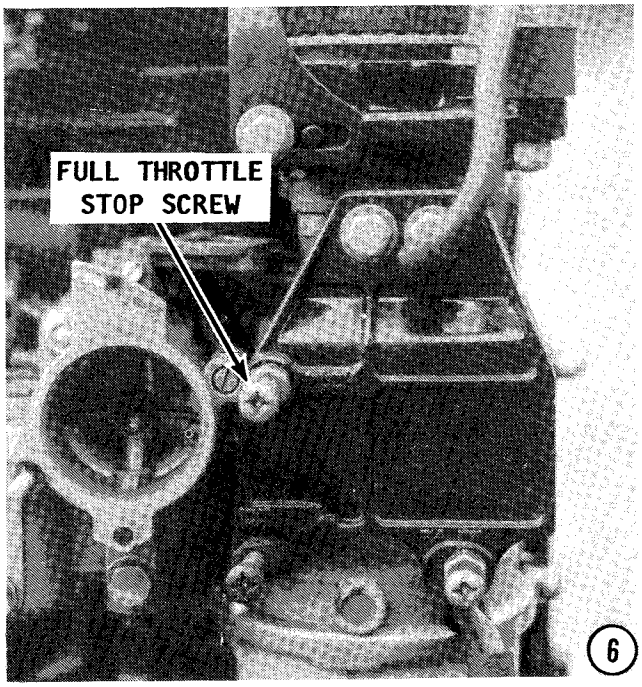
6- With the powerhead **NOT** running, advance the throttle lever to the wide open throttle (WOT) position. Loosen the locknut and adjust the full throttle stop screw to permit full throttle opening. Check to be sure the carburetor shutters do not act as a throttle stop. Use a feeler gauge and check the clearance between the throttle secondary pickup and the secondary lever on the carburetor, when the throttle is at WOT. This clearance should be 0.010 - 0.015" (.25-.38mm). Tighten the locknut to hold the adjustment.



7-11 6-CYLINDER IN-LINE 90HP, 115HP, AND 140HP POWERHEADS WITHOUT DISTRIBUTOR

Timing Pointer Adjustment

1- Remove the No. 2 thru No. 6 spark plugs. Disconnect the fuel line at the fuel source. Install a dial indicator into the No. 1 (top) spark plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle is approximately 1/4-



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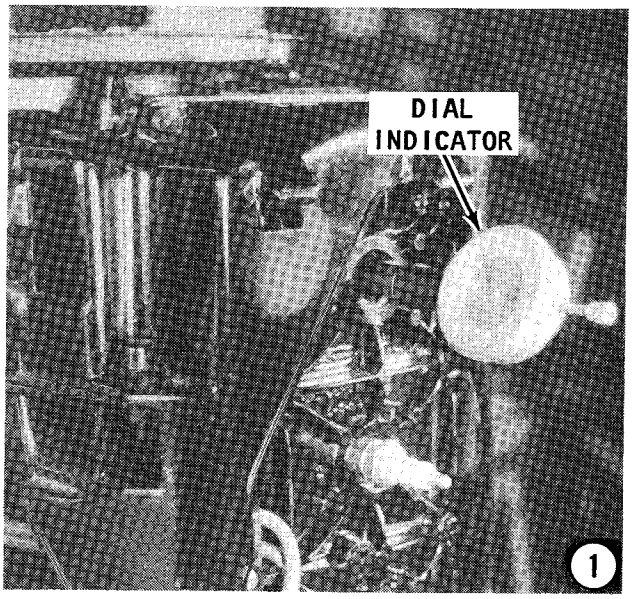


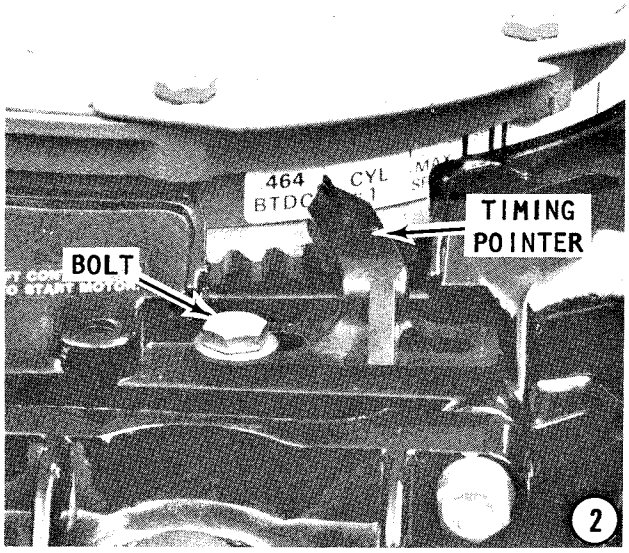
turn beyond the .464 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at the .464 mark.

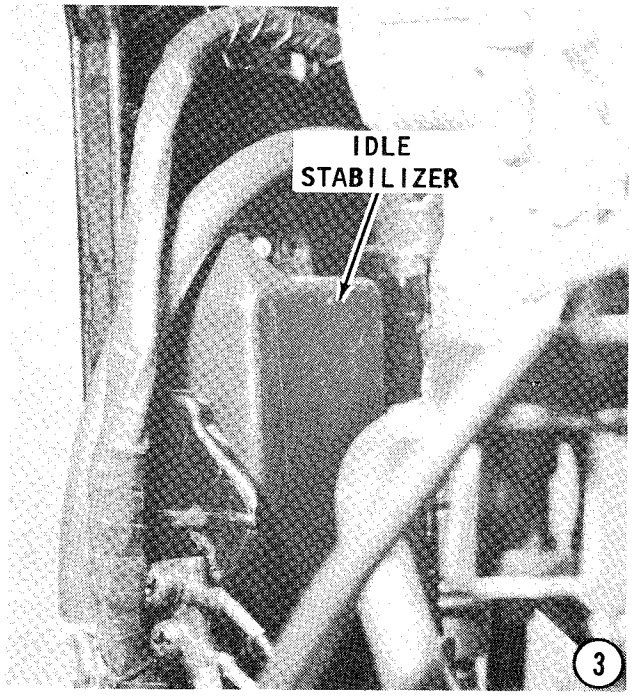
2- Adjust the timing pointer until the pointer is aligned with the .464 mark on the timing decal. Remove the dial indicator. Install the No. 1 spark plug.

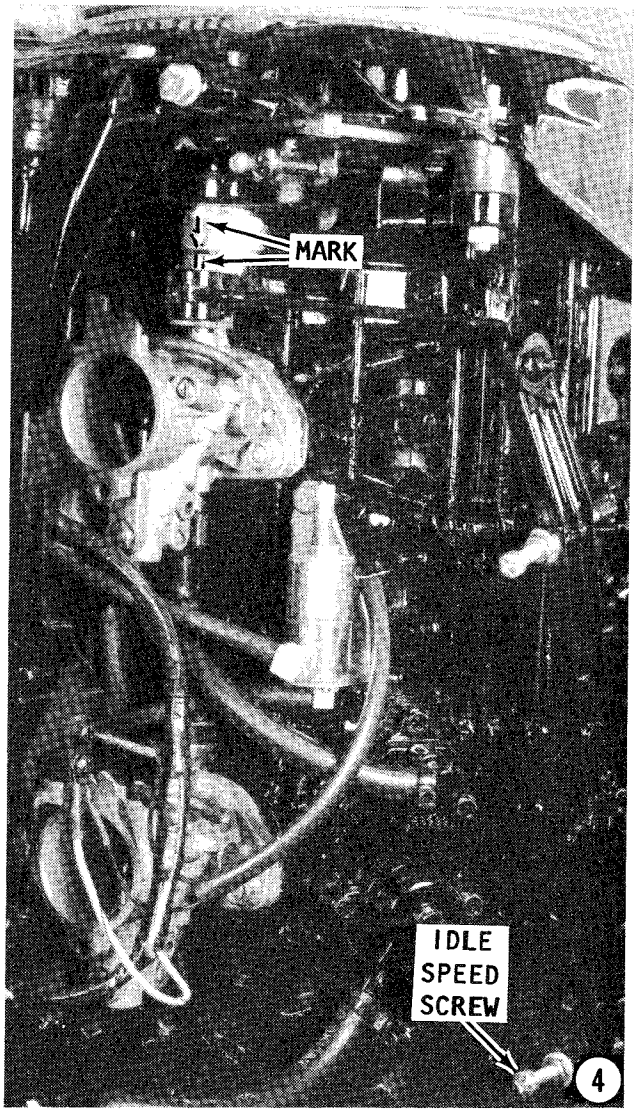
3- If the unit being serviced has an idle stabilizer (small "black box" mounted behind the forward plate), disconnect the White/Black wire at the top switch box during the timing procedures. Wrap tape around the end of the wire to prevent it from shorting out.

Primary Pickup Synchronizing Timing

4- Plug the electrical harness into the powerhead receptacle. Connect a timing light to the No. 1 (top) spark plug.







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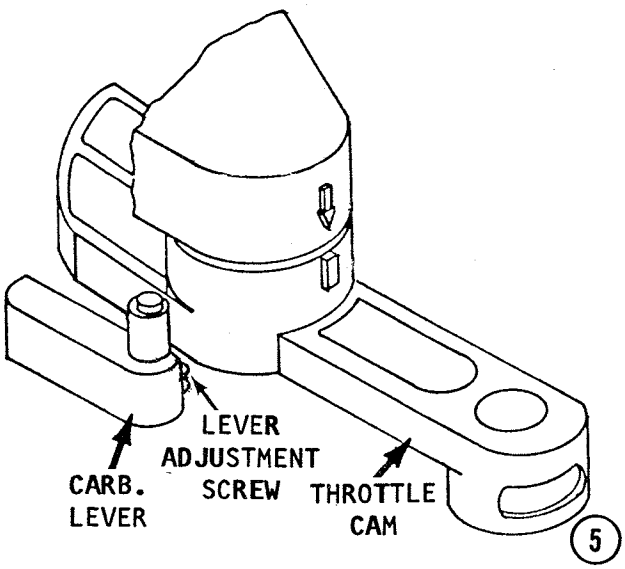
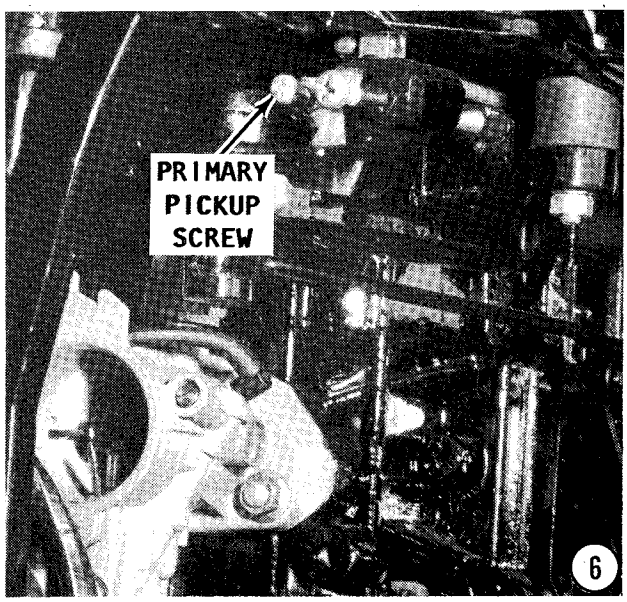
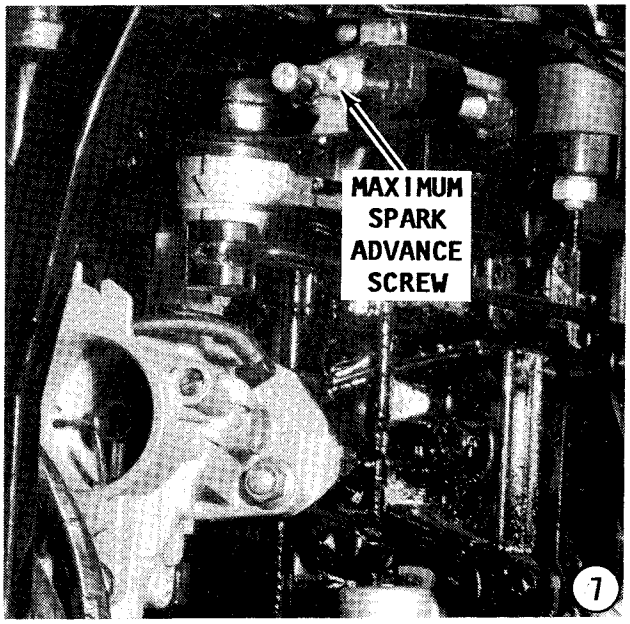


Remove the throttle cable barrel from the barrel retainer on the cable anchor bracket. Loosen the locknut on the idle speed screw. Adjust the idle speed adjusting screw until the mark on the throttle cam aligns with the arrow on the powerhead bracket. Tighten the locknut on the idle speed screw to hold the adjustment.

5- Loosen the carburetor lever adjusting screw. Hold the idle speed screw against its stop on the powerhead and **CHECK** to be sure the shutter in each carburetor is closed.

6- Crank the engine and at the same time adjust the primary pickup adjusting screw until the timing mark on the flywheel aligns with the timing pointer. The timing pointer should already be adjusted according to the procedures in Step 1, as follows:





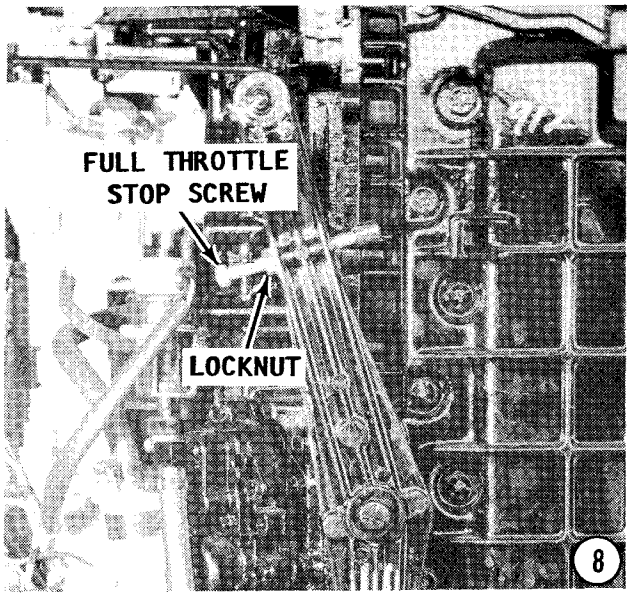
90hp powerhead -- 1° - 3° BTDC
115hp powerhead -- 5° - 7° BTDC
140hp powerhead -- 4° - 6° BTDC

Maximum Spark Advance Adjustment

7- With the throttle lever against the stop, crank the powerhead with the cranking motor and at the same time, adjust the spark advance adjusting screw until the 20° BTDC mark on the timing decal on the flywheel aligns with the timing pointer.

SPECIAL WORDS

The timing mark alignment will change from cranking speed to operating speed due to the electronic characteristics of this particular ignition system. At WOT, the alignment will be 18° BTDC.



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8- Loosen the locknut on the full throttle stop screw. Hold the throttle lever at the wide open throttle position and at the same time observe in each carburetor to be sure each butterfly is wide open. Adjust the throttle stop screw to ensure a wide open throttle position. Tighten the locknut to hold the adjustment.

Idle Speed Adjustment

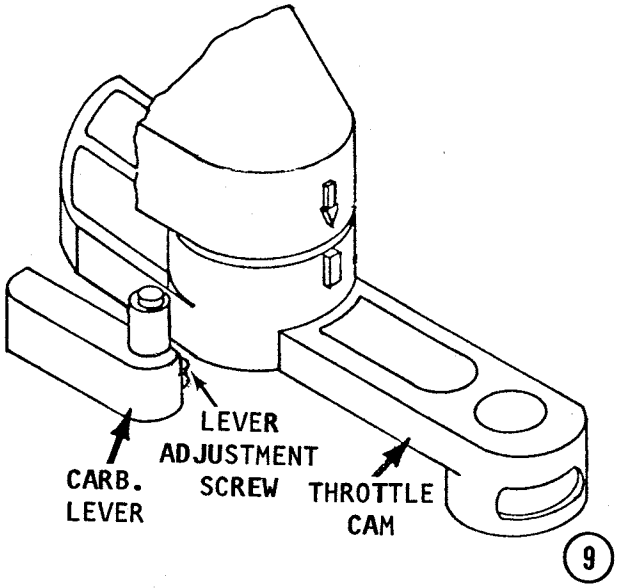
Install the other five spark plugs. Connect the idle stablizer White/Black lead to the switch box. Install a tachometer to the powerhead. Operate the outboard in an adequate size test tank or body of water.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

9- Check to be sure the throttle shutters do **NOT** act as a throttle stop. Adjust the lever adjustment screw on the carburetor lever to obtain 0.010 to 0.015" (0.25 to 0.038mm) clearance between the throttle cam and the roller on the carburetor lever.

10- Shift the unit into **FORWARD** gear. Rotate the idle speed adjusting screw to obtain approximately 650 rpm. The cables from the control box **MUST** match the engine after the adjustments have been made or the adjustment will be lost. After the adjustment is satisfactory, stop the engine and disconnect the tachometer.



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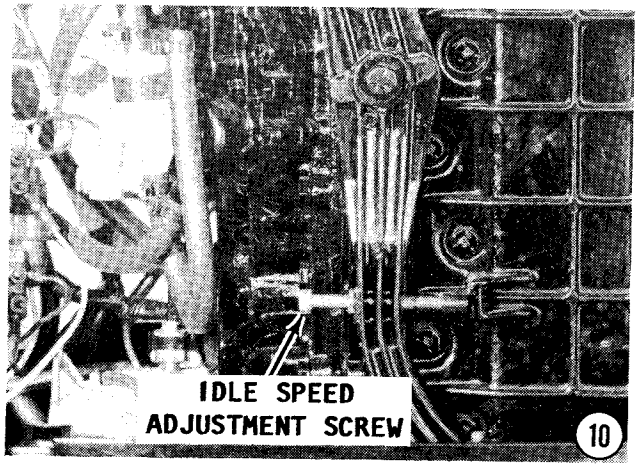

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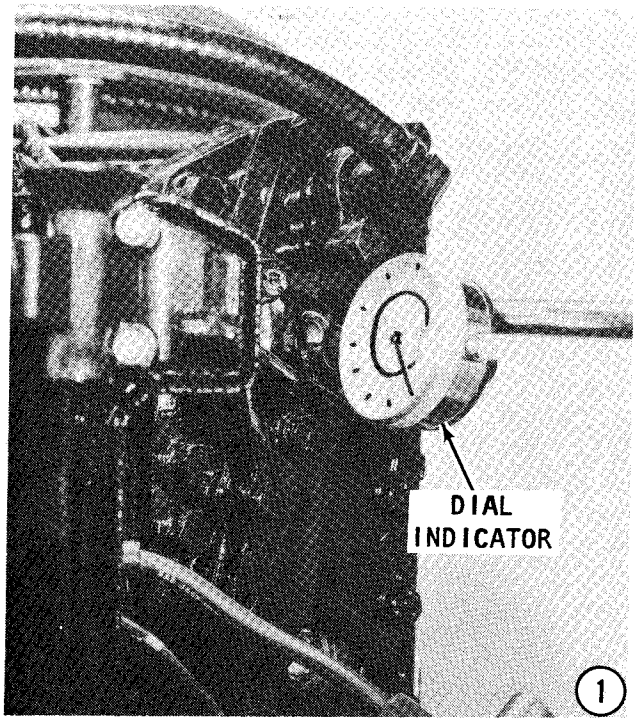
7-12 V6 CYLINDER POWERHEADS 175HP —SERIAL NUMBERS 4838074 TO 6618750

Timer Pointer Adjustment

1- Remove all of the spark plugs. Install a dial indicator into the No. 1 (top) spark plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle is approximately 1/4 turn beyond the .462 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at .462. Adjust the timing pointer until the pointer is aligned with the .462 mark on the timing decal. Remove the dial indicator. Install the spark plugs.



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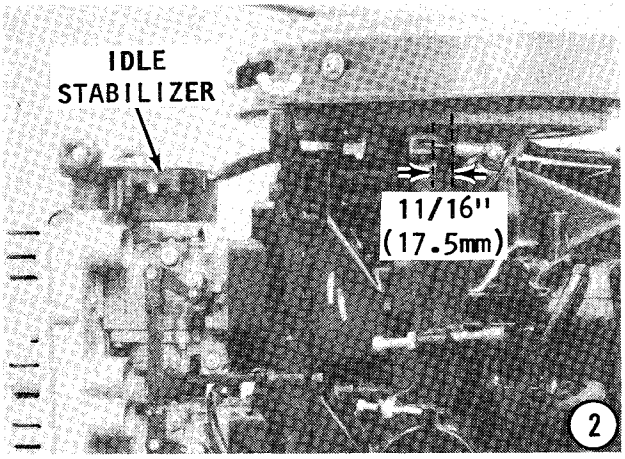


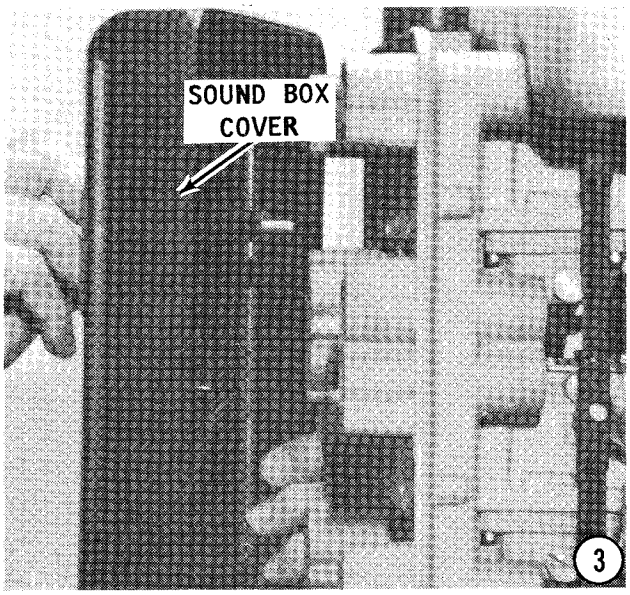
Primary Pickup Synchronizing

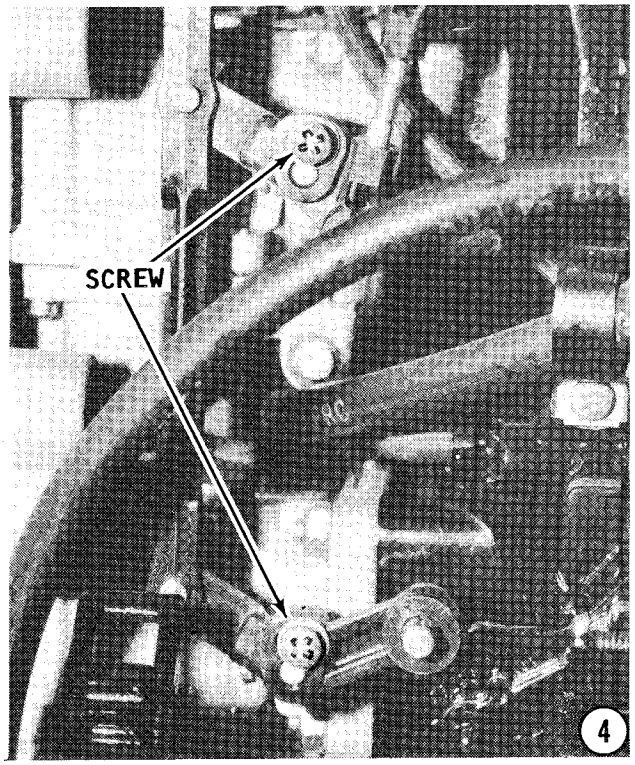
2- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged. Remove the powerhead cowling.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Start the engine. **DISCONNECT** the fuel line to the powerhead. Allow the powerhead to run until it shuts down from lack of fuel.

If the unit being serviced has an idle stabilizer **OR** a low speed/high speed spark advance module (small "black box" mounted on top of the air box cover, or on top of the starboard cylinder head), the White/Black wire **MUST** be disconnected from the switch box. Wrap tape around the end of the wire





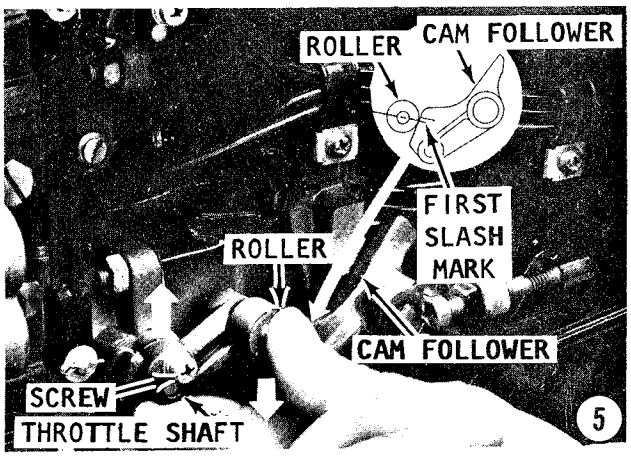
to prevent it from shorting out. If the link rod was disassembled, check to be sure 11/16" (17.5mm) dimension is held, as shown in the accompanying illustration.

SAFETY WORDS

To prevent the engine from firing during the timing procedure, remove all the spark plugs **EXCEPT** the No. 1 plug (top, starboard bank).

Connect a timing light to the No. 1 spark plug. Plug the electrical harness into the powerhead receptacle. Remove the throttle cable barrel from the barrel retainer on the anchor bracket.

3- Remove the choke knob and wing nuts, and then remove the sound box cover



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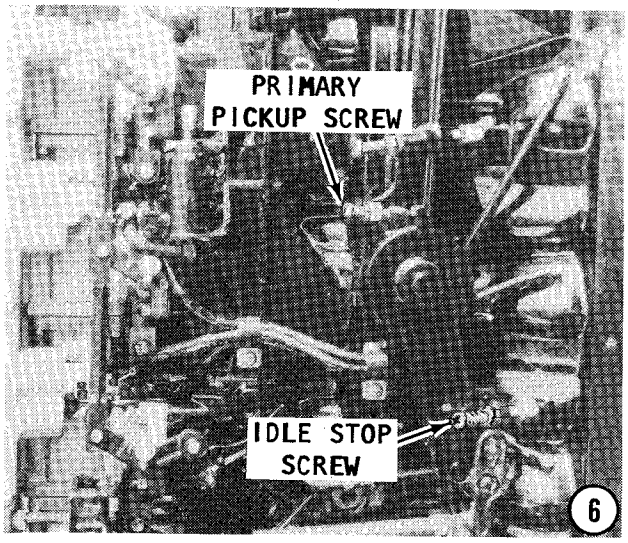
from the powerhead. This cover must be removed in order to be sure all carburetor throttle shutters are closed and that they will open together.

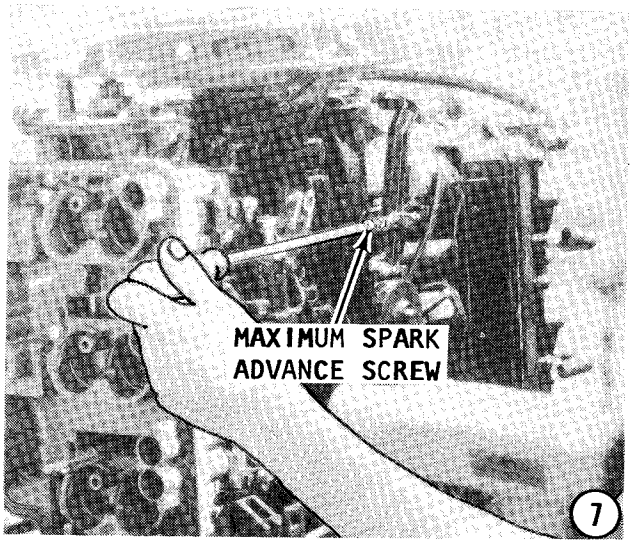
4- Loosen the carburetor synchronizing screws and allow the shutters to close freely. Lightly press the cam follower roller against the throttle cam, and at the same time, lift up on the bottom carburetor throttle shaft to remove looseness in the linkage parts.

5- Loosen the locknut and adjust the idle stop screw until the first (short) embossed mark on the throttle cam just makes contact with the roller. Tighten the locknut to hold the adjustment. Maintain a slight pressure against the roller, and at the same time lift up the bottom throttle shaft, then tighten all of the carburetor synchronizing screws. Check to be sure the carburetor throttle shutters are completely closed when the roller makes contact with the first (short) embossed mark on the throttle cam. Also verify that all looseness is removed from the linkage. The carburetor shutter plates **MUST** start to open exactly at the same time the throttle lever is actuated. Install the sound box cover onto the carburetors with the wing nuts. Install the choke knobs.

Primary Pickup Synchronizing Timing

6- Shift the engine into **NEUTRAL.** Hold the throttle with the idle stop screw against the idle stop. Loosen the locknut, and then crank the engine and adjust the throttle primary pickup screw until the 14° ATDC mark on the timing decal is aligned with the timing pointer. Tighten the locknut to hold the adjustment.





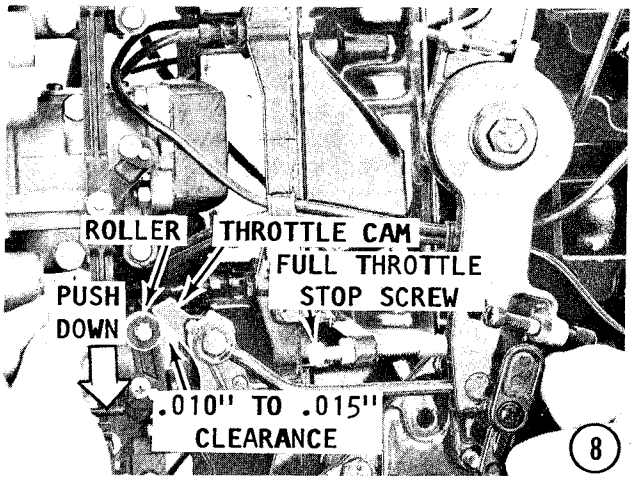
Maximum Advance Timing

7- With a timing light connected to the powerhead and the engine in **NEUTRAL,** move the throttle lever to position the maximum spark screw against the stop. Crank the engine. Loosen the locknut, and adjust the maximum spark screw until the 20° BTDC mark on the timing decal is aligned with the pointer.

AN EXPLANATION

This adjustment will result in a spark advance of 18° at maximum rpm, due to the spark advance characteristics of this ignition system. Tighten the locknut to hold the adjustment. Remove the timing light.

8- With all the spark plugs **REMOVED,** move the throttle lever to the wide open throttle (WOT) position. Loosen the locknut and adjust the full throttle stop screw to permit full throttle shutter opening at WOT. Check to be sure the throttle shutters do not act as a throttle stop. Use a feeler gauge and check the clearance between the



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roller and the throttle cam at WOT. This clearance should be 0.010 - 0.015" (0.25 - 0.38mm). Tighten the locknut to hold the adjustment. Install the spark plugs. Connect the White/Black wire between the idle stabilizer **OR** ignition module and the switch box.

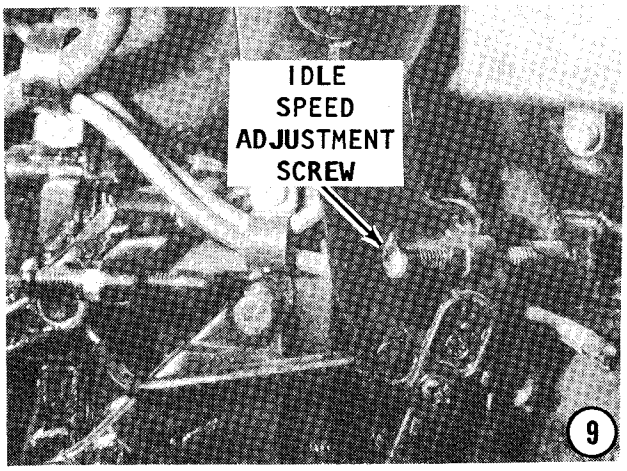
Idle Adjustment

9- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged. Connect the fuel line to a fuel source. Install a tachometer to the powerhead. Plug the electrical harness into the powerhead receptacle. Remove the powerhead cowling.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Start the engine and allow it to warm to operating temperature.

Remove the cable barrel from the barrel retainer, and loosen the locknut on the idle adjustment screw. Shift the engine into **FORWARD** gear. Adjust the idle rpm to 600 - 700 rpm. Tighten the locknut to hold the adjustment. With the end of the throttle cable connected to the throttle lever, hold the throttle lever against the idle stop. Adjust the throttle cable barrel to slip into the barrel retainer on the cable anchor bracket with a very light preload of throttle lever against the idle stop. Lock the barrel in place.



BAD NEWS:

An excessive preload on the throttle cable will cause difficulty when shifting from **FORWARD** gear to **NEUTRAL.** The preload may be easily checked by placing a piece of paper between the idle stop screw and the idle stop, and then withdrawing it. If the paper does not tear, but drag can still be felt, the preload is correct. Adjust the cable barrel, if necessary, to obtain the proper preload just described. Install the powerhead cowling.

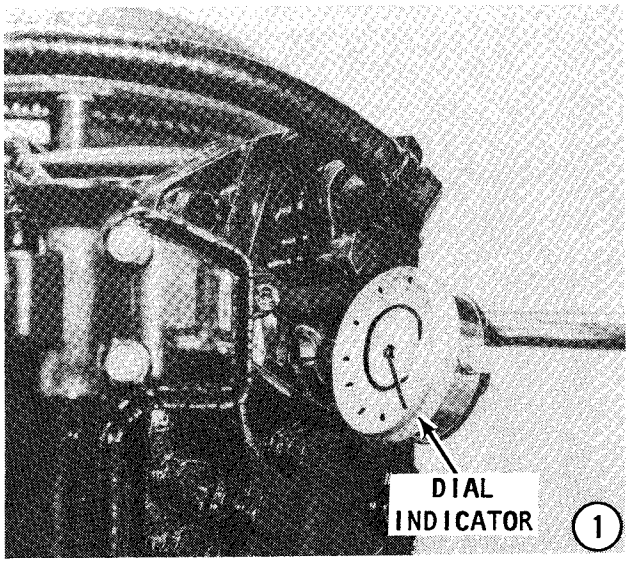
FINAL WORDS:

If sufficient throttle cable barrel adjustment is not available, a check **MUST** be made for correct installation of the link rod (located between the throttle lever and the throttle cam). Each end of this link rod must be threaded into its plastic barrel until it bottoms against the throttle lever or the throttle cam casting, and then backed out from this position **ONLY** far enough to obtain correct orientation of the link rod. The link rod must be backed out **LESS** than one turn. All timing adjustments must be reset after this procedure has been completed. Disconnect the tachometer and the flush device.

7-13 V6 CYLINDER POWERHEADS 150HP —SERIAL NUMBERS 5203428 AND BELOW 200HP SERIAL NUMBERS 5363917 AND BELOW

SPECIAL WORDS

If the Model 150 has Serial No. 5203428 or below, and is equipped with carburetors



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which have "WH9" embossed on the mounting flange, use the timing procedure for Model 150 serial No. 5203429 and above on Page 7-27.

Timer Pointer Adjustment

1- Remove all of the spark plugs. Install a dial indicator into the No. 1 (top) spark plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTER-CLOCKWISE** until the dial indicator needle is approximately 1/4 turn beyond the .462 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at .462. Adjust the timing pointer until the pointer is aligned with the .462 mark on the timing decal. Remove the dial indicator. Install the spark plugs.

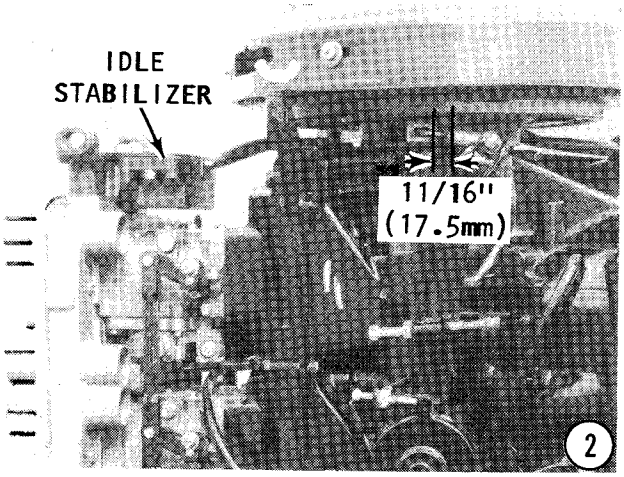
Primary Pickup Synchronizing Timing

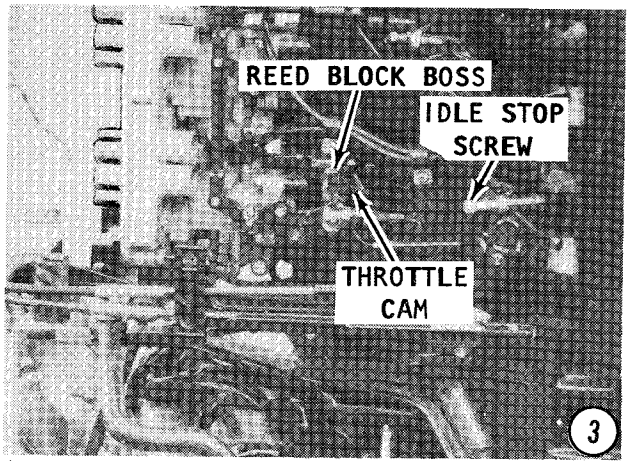
2- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Start the engine. **DISCONNECT** the fuel line to the powerhead. Allow the powerhead to run until it shuts down from lack of fuel.

If the unit being serviced has an idle stabilizer OR a low speed/high speed spark advance module (small "black box" mounted on top of the air box cover, or on top of the starboard cylinder head), the White/Black wire **MUST** be disconnected from the switch box. Wrap tape around the end of the wire to prevent it from shorting out. If the link rod was disassembled, check to be sure 11/16" (17.5mm) dimension is held, as shown in the accompanying illustration.





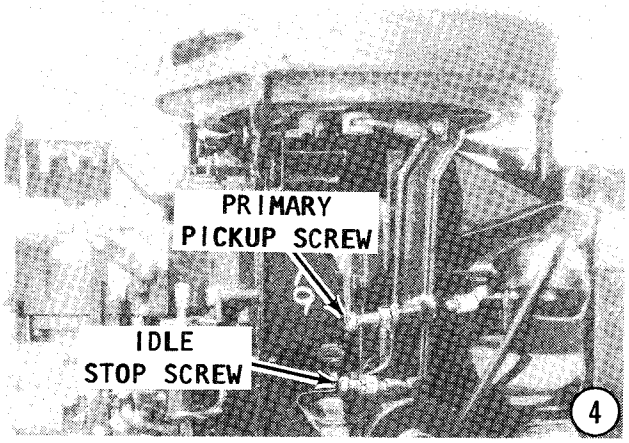
SAFETY WORDS

To prevent the engine from firing during the timing procedure, remove all spark plugs **EXCEPT** the No. 1 plug (top, starboard bank).

3- Connect a timing light to the No. 1 spark plug. Remove the throttle cable barrel from the barrel retainer on the cable anchor bracket. Loosen the locknut on the idle stop screw. Adjust the idle stop screw until the top surface of the throttle cam is aligned with the edge of the reed block housing boss, as shown. Do **NOT** install the throttle cable at this time.

Primary Pickup Synchronizing Timing

4- With the engine in **NEUTRAL,** hold the throttle arm so the idle stop screw is against the idle stop, and then crank the engine with the cranking motor. While the



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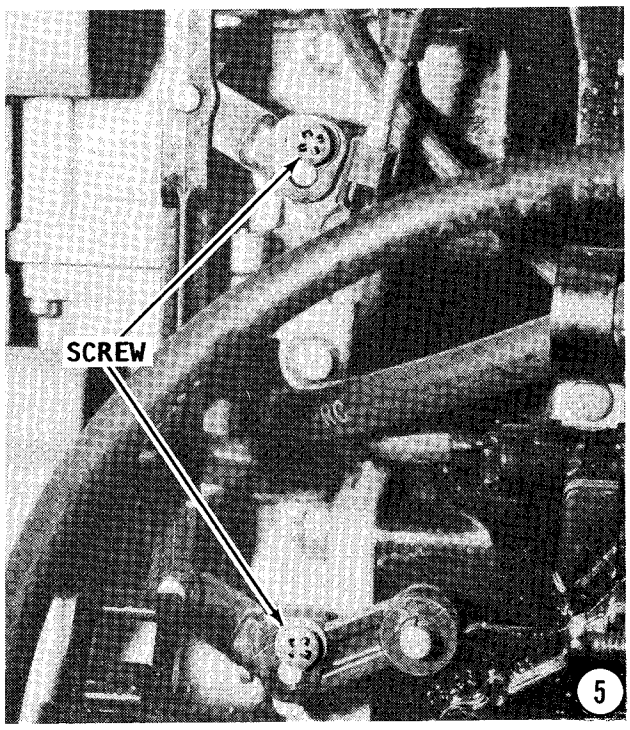
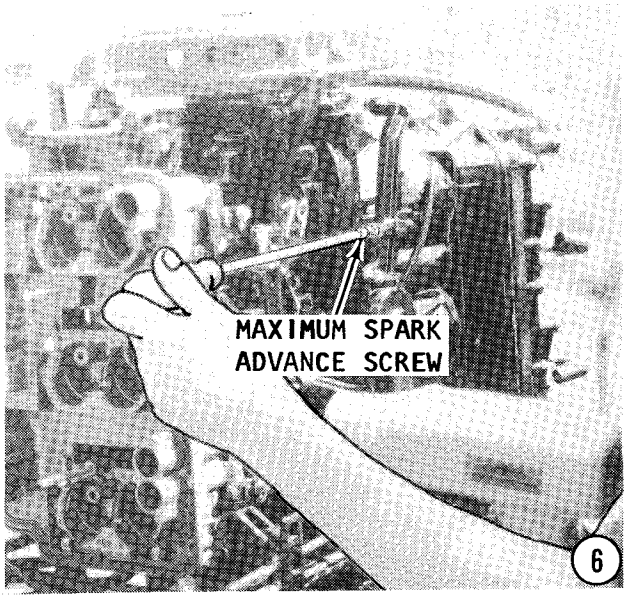


engine is being cranked, adjust the throttle primary pickup screw until the 11°ATDC primary pickup mark on the timing decal is aligned with the timing pointer. Tighten the locknut to hold the adjustment.

5- Loosen the three carburetor synchronizing screws. Position the throttle lever against the idle stop. With the lever in this position, move the roller arm until the roller just makes contact with the throttle cam. Without moving the roller arm, tighten the three carburetor synchronizing screws to hold the adjustment.



Maximum Advance Timing

6- With the engine in **NEUTRAL,** move the throttle lever until the maximum spark screw makes contact with the stop. Crank the engine with the cranking motor. Loosen the locknut and adjust the maximum spark screw until the 20° mark for the Model 200, or the 18° mark for the Model 150, is aligned with the timing pointer.

AN EXPLANATION

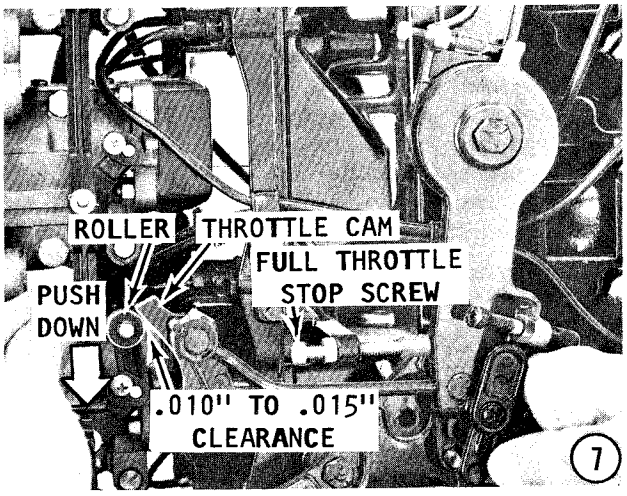
This adjustment will result in a spark advance of 18° on the Model 200, and 16° on the Model 150, at maximum rpm, due to the spark advance characteristics of this ignition system. Tighten the locknut to hold the adjustment. Remove the timing light.

Throttle Stop Adjustment

7- Move the throttle lever to the wide open throttle (WOT) position. Loosen the locknut and adjust the full throttle stop screw to permit full throttle shutter opening at WOT. Check to be sure the throttle shutters do not act as a throttle stop. Use a feeler gauge and check the clearance between the roller and the throttle cam at WOT. This clearance should be 0.010 - 0.015" (.25-.38mm). Tighten the locknut to hold the adjustment. Install the spark plugs. Connect the White/Black wire between the idle stabilizer or ignition module and the switch box.

Idle Adjustment

8- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damag-



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ed. Connect the fuel line to a fuel source. Plug the electrical harness into the engine receptacle. Remove the engine cowling. Connect a tachometer to the engine.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

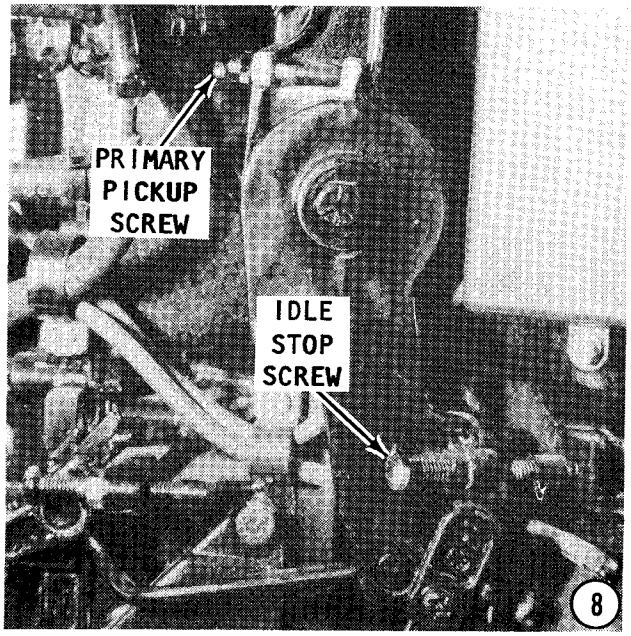
Start the engine and allow it to warm to operating temperature.

Remove the cable barrel from the barrel retainer, and loosen the locknut on the idle adjustment screw. Shift the engine into **FORWARD** gear. Adjust the idle rpm to the proper rpm as listed in the Specifications in the Appendix. Tighten the locknut to hold the adjustment. With the end of the throttle cable connected to the throttle lever, hold the throttle lever against the idle stop. Adjust the throttle cable barrel to slip into the barrel retainer on the cable anchor bracket with a very light preload of throttle lever against the idle stop. Lock the barrel in place.

BAD NEWS:

An excessive preload on the throttle cable will cause difficulty when shifting from **FORWARD** gear to **NEUTRAL.**

The preload may be easily checked by placing a piece of paper between the idle stop screw and the idle stop, and then withdrawing it. If the paper does not tear, but drag can still be felt, the preload is correct. Adjust the cable barrel, if necessary, to obtain the proper preload just described. Install the powerhead cowling.



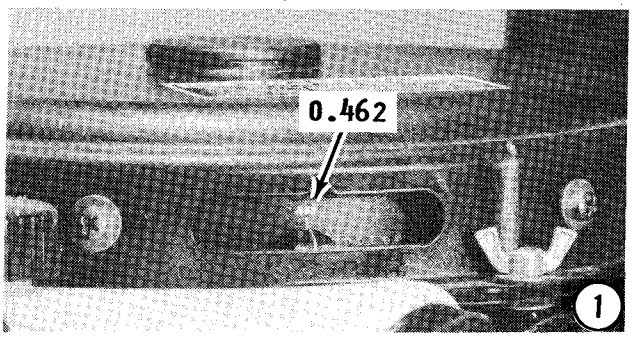
FINAL WORDS:

If sufficient throttle cable barrel adjustment is not available, a check **MUST** be made for correct installation of the link rod (located between the throttle lever and the throttle cam). Each end of this link rod must be threaded into its plastic barrel until it bottoms against the throttle lever or the throttle cam casting, and then backed out from this position **ONLY** far enough to obtain correct orientation of the link rod. The link rod must be backed out **LESS** than one turn. All timing adjustments must be reset after this procedure has been completed. Disconnect the tachometer and the flush device.

7-14 V6 CYLINDER POWERHEADS
135HP ALL
150HP SERIAL NUMBERS
5203429 AND ABOVE
175HP W/O EFI SERIAL NUMBERS
6618751 AND ABOVE
200HP SERIAL NUMBERS
5363918 TO 6073191

Timer Pointer Adjustment

1- Remove all of the spark plugs. Install a dial indicator into the No. 1 (top) spark plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTER-CLOCKWISE** until the dial indicator needle is approximately 1/4 turn beyond the .462 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at .462. Adjust the timing pointer until the pointer is aligned with the .462 mark on the timing decal. Remove the dial indicator. Install the spark plugs.



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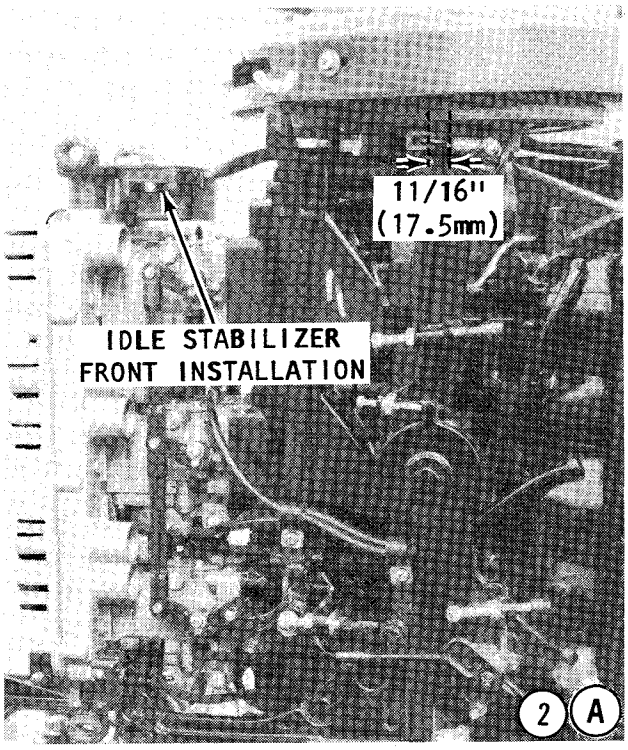
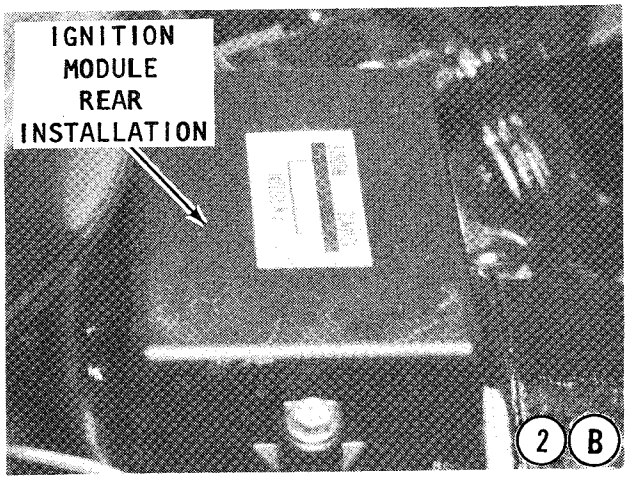


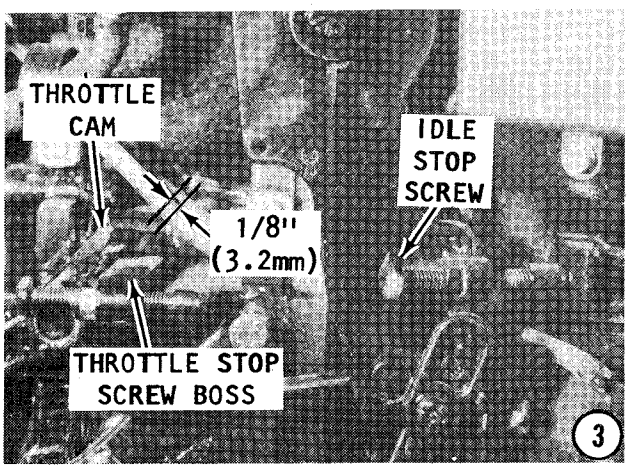
Primary Pickup Synchronizing Timing

2- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Start the engine. **DISCONNECT** the fuel line to the powerhead. Allow the powerhead to run until it shuts down from lack of fuel.



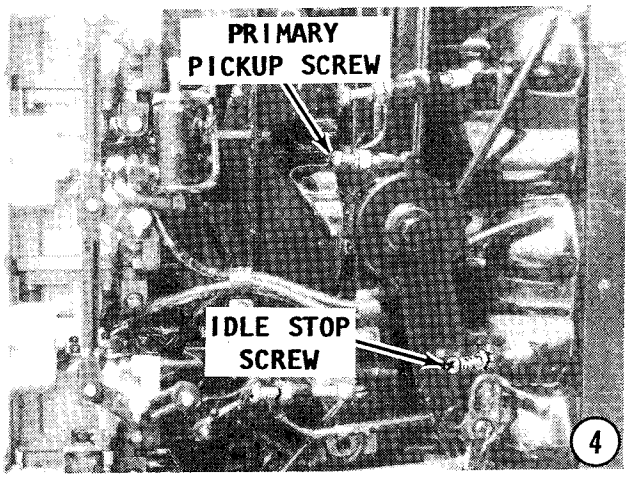


If the unit being serviced has an idle stabilizer **OR** a low speed/high speed spark advance module (small "black box" mounted on top of the air box cover, or on top of the starboard cylinder head), the White/Black wire **MUST** be disconnected from the switch box. Wrap tape around the end of the wire to prevent it from shorting out. For units without oil injection, the idle stabilizer is mounted on top of the air box cover. For units with oil injection, the idle stabilizer or ignition module is mounted above the starboard cylinder head. If the link rod was disassembled, check to be sure 11/16" (17.5mm) dimension is held, as shown in the accompanying illustration.

SAFETY WORDS

To prevent the engine from firing during the timing procedure, remove all spark plugs **EXCEPT** the No. 1 plug (top, starboard bank).

3- Connect a timing light to the No. 1 spark plug. Remove the throttle cable barrel from the barrel retainer on the cable anchor bracket. Loosen the locknut on the idle stop screw. Adjust the idle stop screw



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until the bottom edge of the throttle cam is aligned with the edge of the front corner of the throttle stop screw boss, as shown. Do **NOT** install the throttle cable at this time.

Primary Pickup Synchronizing Timing

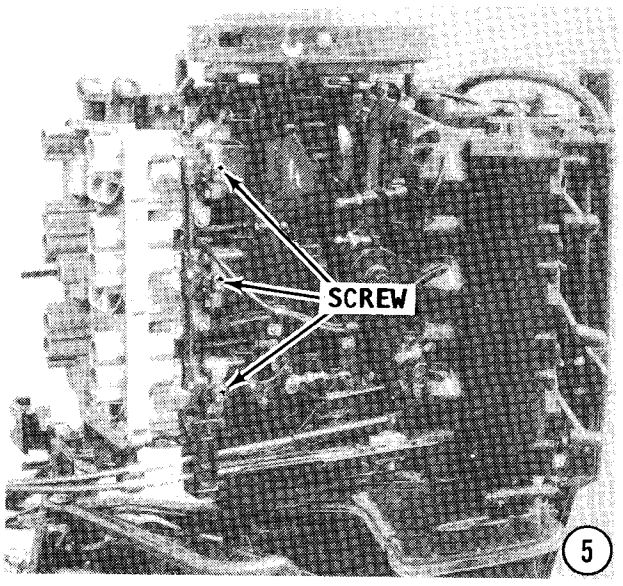
4- With the engine in **NEUTRAL,** hold the throttle arm so the idle stop screw is against the idle stop, and then crank the engine with the cranking motor. While the engine is being cranked, adjust the throttle primary pickup screw until the timing pointer is aligned with throttle primary pickup mark on the timing decal, as follows:

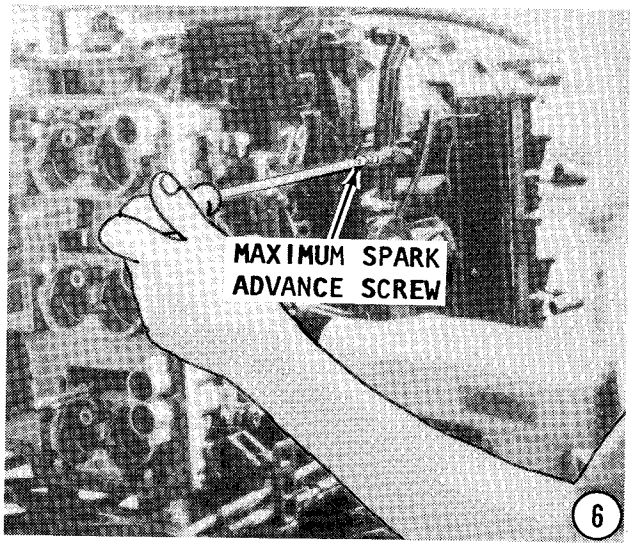
135hp powerhead -- 11° ATDC
150hp powerhead -- 11° ATDC
175hp powerhead -- 7° ATDC
200hp powerhead -- 10° ATDC

5- Loosen the three carburetor synchronizing screws. Position the throttle lever against the idle stop. With the lever in this position, move the roller arm until the roller just makes contact with the throttle cam. Without moving the roller arm, tighten the three carburetor synchronizing screws to hold the adjustment.

Maximum Advance Timing

6- With the engine in **NEUTRAL,** move the throttle lever until the maximum spark screw makes contact with the stop. Crank the engine with the cranking motor. Loosen the locknut and adjust the maximum spark screw until the maximum spark advance timing mark is aligned with the timing pointer, as follows:





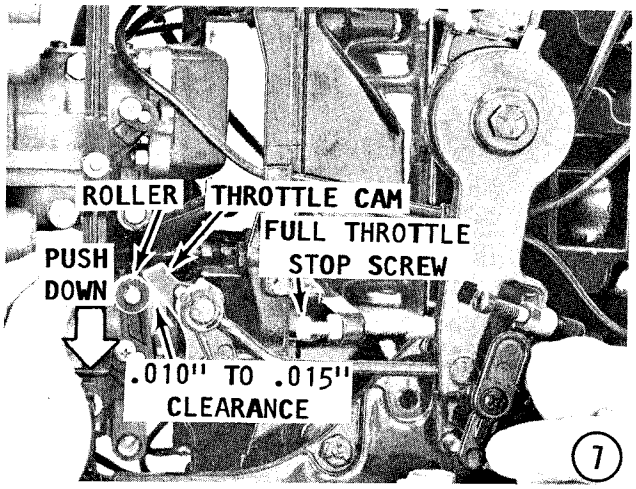
135hp powerhead -- 18° BTDC
150hp powerhead -- 18° BTDC (except Magnum 150Hp)
Magnum 150Hp -- 22° BTDC
175hp powerhead -- 20° BTDC
200hp powerhead -- 20° BTDC

AN EXPLANATION

The table above represents the maximum spark advance at cranking speed. This adjustment will result in a spark advance reduction of 2° at maximum rpm, due to the spark advance characteristics of this ignition system. Tighten the locknut to hold the adjustment. Remove the timing light.

Throttle Stop Adjustment

7- Move the throttle lever to the wide open throttle (WOT) position. Loosen the locknut and adjust the full throttle stop screw to permit full throttle shutter opening at WOT. Check to be sure the throttle shutters do not act as a throttle stop. Use a



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feeler gauge and check the clearance between the roller and the throttle cam at WOT. This clearance should be 0.010 - 0.015" (.25-.38mm). Tighten the locknut to hold the adjustment. Install the spark plugs. Connect the White/Black wire between the idle stabilizer or ignition module and the switch box.

Idle Adjustment

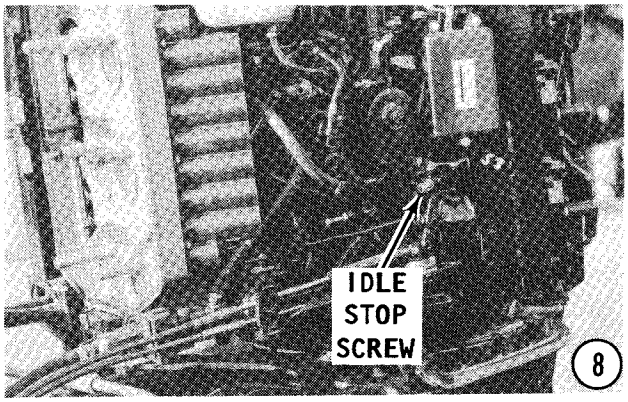
8- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged. Connect the fuel line to a fuel source. Plug the electrical harness into the engine receptacle. Remove the engine cowling. Connect a tachometer to the engine.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the engine and allow it to warm to operating temperature.

Remove the cable barrel from the barrel retainer, and loosen the locknut on the idle adjustment screw. Shift the engine into **FORWARD** gear. Adjust the idle rpm to the proper rpm as listed in the Specifications in the Appendix. Tighten the locknut to hold the adjustment. With the end of the throttle cable connected to the throttle lever, hold the throttle lever against the idle stop. Adjust the throttle cable barrel to slip into the barrel retainer on the cable anchor bracket with a very light preload of throttle lever against the idle stop. Lock the barrel in place.



BAD NEWS

An excessive preload on the throttle cable will cause difficulty when shifting from **FORWARD** gear to **NEUTRAL.**

The preload may be easily checked by placing a piece of paper between the idle stop screw and the idle stop, and then withdrawing it. If the paper does not tear, but drag can still be felt, the preload is correct. Adjust the cable barrel, if necessary, to obtain the proper preload just described. Install the powerhead cowling.

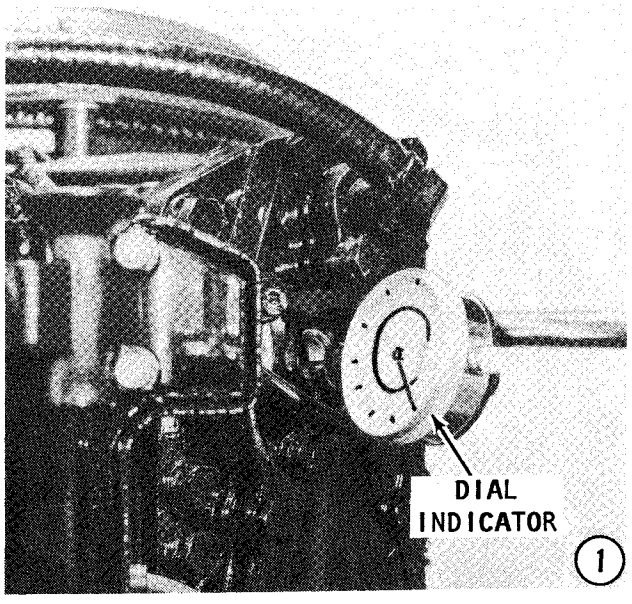
FINAL WORDS

If sufficient throttle cable barrel adjustment is not available, a check **MUST** be made for correct installation of the link rod (located between the throttle lever and the throttle cam). Each end of this link rod must be threaded into its plastic barrel until it bottoms against the throttle lever or the throttle cam casting, and then backed out from this position **ONLY** far enough to obtain correct orientation of the link rod. The link rod must be backed out **LESS** than one turn. All timing adjustments must be reset after this procedure has been completed. Disconnect the tachometer and the flush device.

7-15 V6 CYLINDER POWERHEADS 200HP SERIAL NUMBERS 6073192 AND ABOVE

Timer Pointer Adjustment

1- Remove all of the spark plugs. Install a dial indicator into the No. 1 (top) spark



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plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTER-CLOCKWISE** until the dial indicator needle is approximately 1/4 turn beyond the .462 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at .462. Adjust the timing pointer until the pointer is aligned with the .462 mark on the timing decal. Remove the dial indicator. Install the spark plugs.

Primary Pickup Synchronizing Timing

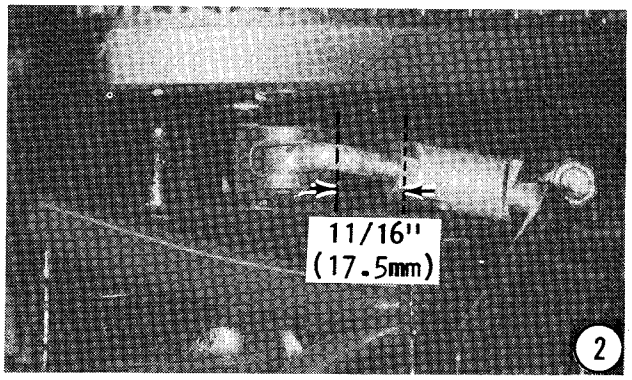
2- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged.

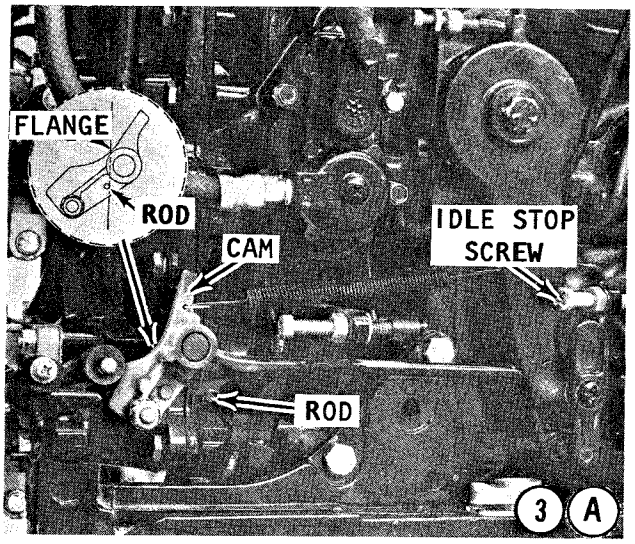
CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the engine. **DISCONNECT** the fuel line to the powerhead. Allow the powerhead to run until it shuts down from lack of fuel.

If the unit being serviced has an idle stabilizer **OR** a low speed/high speed spark advance module (small "black box" mounted on top of the air box cover, or on top of the starboard cylinder head), the White/Black wire **MUST** be disconnected from the switch box. Wrap tape around the end of the wire to prevent it from shorting out. If the link rod was disassembled, check to be sure 11/16" (17.5mm) dimension is held, as shown in the accompanying illustration. If servicing the Model 200 V6 powerhead, Serial No. 6073192 and above, the White/Black wire to the combination low speed/high speed advance module must also be disconnected and the end taped.





SAFETY WORDS

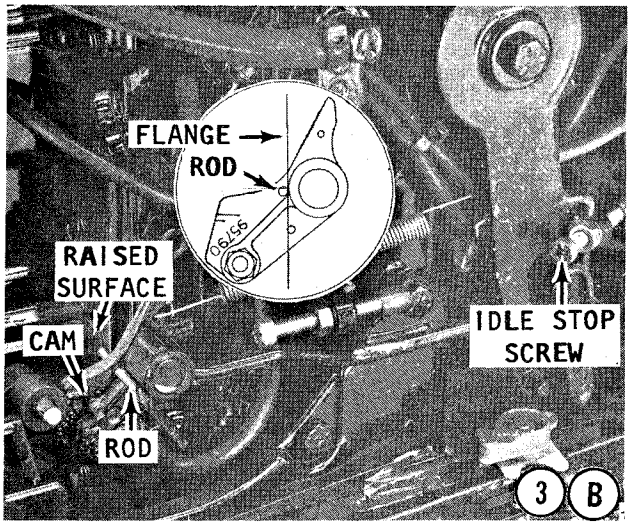
To prevent the engine from firing during the timing procedure, remove all spark plugs **EXCEPT** the No. 1 plug (top, starboard bank).

Connect a timing light to the No. 1 spark plug. Remove the throttle cable barrel from the barrel retainer on the cable anchor bracket.

SPECIAL WORDS

Two different type throttle cams are used on the models covered in this section. A 1/8" (3.2mm) diameter rod or drill is required to set the timing. Rod or drill placement is different for the two cams.

Refer to illustration 3A if there is no casting number embossed on the throttle cam. Refer to illustration 3B if the number



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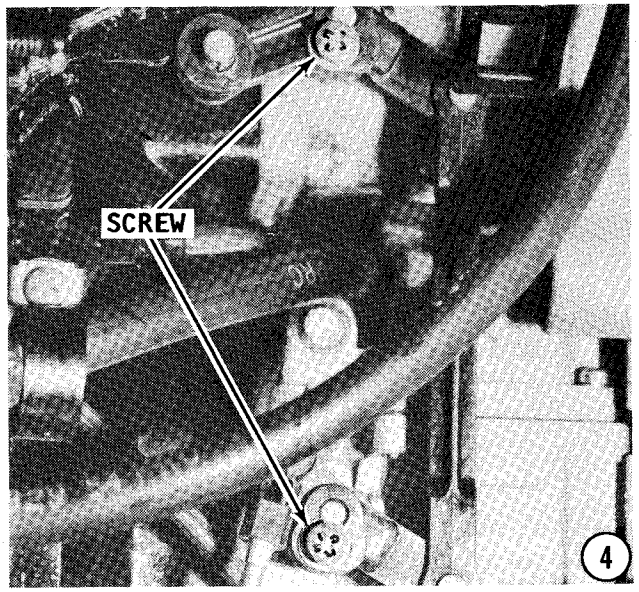


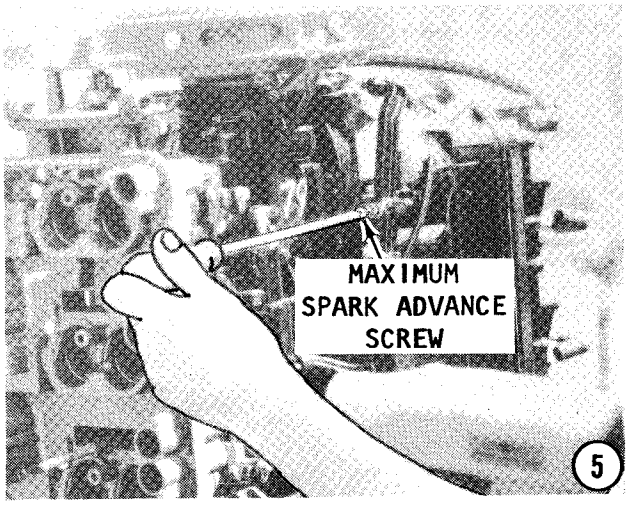
95790 is embossed on the cam. The timing procedure is identical for both type of cams.

3- Insert a 1/8" (3.2mm) rod or drill bit into the hole in the cam. Hold the rod or drill perpendicular to the throttle cam and adjust the idle stop screw to allow the rod or drill to rest against the leading edge of the carburetor adaptor flange (not on the raised surface just beyond the edge). Tighten the locknut on the idle stop screw to hold this adjustment.

With the engine in **NEUTRAL,** push the throttle arm and idle stop screw against the stop. Crank the powerhead with the cranking motor and adjust the throttle primary pickup screw to align with the specified throttle primary pickup mark on the flywheel.

DEGREE CHANGE

For models with Serial No. 6537932 or below, the setting is 12° ATDC. For models Serial No. 6537933 and above, and all Model 200 powerheads with WH28 embossed on the carburetor mounting flange, the setting is 7° ATDC.



Primary Pickup Synchronizing Timing

4- Loosen the three carburetor synchronizing screws. Position the throttle lever against the idle stop. With the lever in this position, move the roller arm until the roller just makes contact with the throttle cam. Without moving the roller arm, tighten the three carburetor synchronizing screws to hold the adjustment.

Maximum Advance Timing

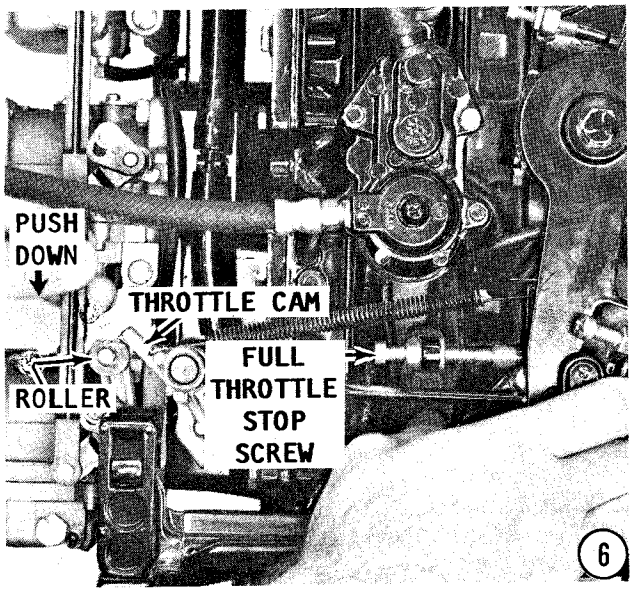
5- With the engine in **NEUTRAL,** move the throttle lever until the maximum spark screw makes contact with the stop. Crank the engine with the cranking motor. Loosen the locknut and adjust the maximum spark screw until the 22° mark is aligned with the timing pointer.

AN EXPLANATION

This adjustment will result in a spark advance of 26° at maximum rpm, due to the spark advance characteristics of this ignition system. Tighten the locknut to hold the adjustment. Remove the timing light.

Throttle Stop Adjustment

6- Move the throttle lever to the wide open throttle (WOT) position. Loosen the locknut and adjust the full throttle stop screw to permit full throttle shutter opening at WOT. Check to be sure the throttle shutters do not act as a throttle stop. Use a



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feeler gauge and check the clearance between the roller and the throttle cam at WOT. This clearance should be 0.010 - 0.015" (.25-.38mm). Tighten the locknut to hold the adjustment.

Install the spark plugs. Connect the White/Black wire between the ignition module and the switch box.

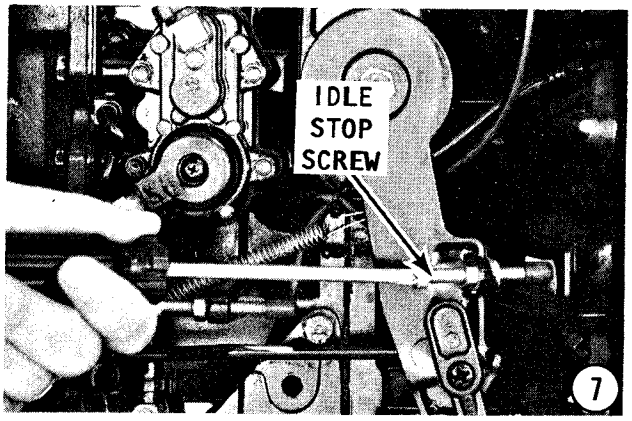
Idle Adjustment

7- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged. Connect the fuel line to a fuel source. Plug the electrical harness into the engine receptacle. Remove the engine cowling. Connect a tachometer to the engine.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Start the engine and allow it to warm to operating temperature.

Remove the cable barrel from the barrel retainer, and loosen the locknut on the idle adjustment screw. Shift the engine into **FORWARD** gear. Adjust the idle rpm to the proper rpm as listed in the Specifications in the Appendix. Tighten the locknut to hold the adjustment. With the end of the throttle cable connected to the throttle lever, hold the throttle lever against the idle stop. Adjust the throttle cable barrel to slip into the barrel retainer on the cable anchor bracket with a very light preload of throttle lever against the idle stop. Lock the barrel in place.



BAD NEWS

An excessive preload on the throttle cable will cause difficulty when shifting from **FORWARD** gear to **NEUTRAL.**

The preload may be easily checked by placing a piece of paper between the idle stop screw and the idle stop, and then withdrawing it. If the paper does not tear, but drag can still be felt, the preload is correct. Adjust the cable barrel, if necessary, to obtain the proper preload just described. Install the powerhead cowling.

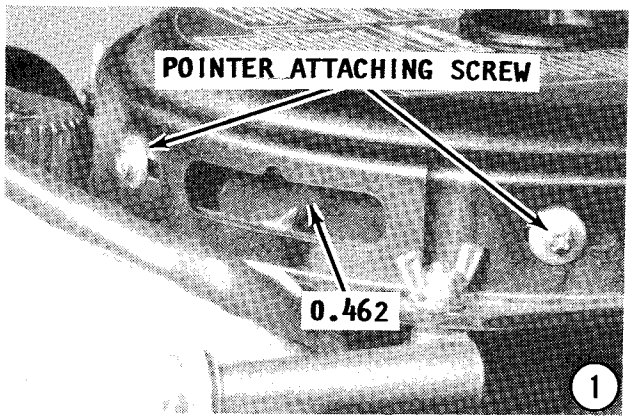
FINAL WORDS

If sufficient throttle cable barrel adjustment is not available, a check **MUST** be made for correct installation of the link rod (located between the throttle lever and the throttle cam). Each end of this link rod must be threaded into its plastic barrel until it bottoms against the throttle lever or the throttle cam casting, and then backed out from this position **ONLY** far enough to obtain correct orientation of the link rod. The link rod must be backed out **LESS** than one turn. All timing adjustments must be reset after this procedure has been completed. Disconnect the tachometer and the flush device.

7-16 V6 POWERHEAD WITH EFI

Timer Pointer Adjustment

1- Remove all of the spark plugs. Install a dial indicator into the No. 1 (top starboard) spark plug opening. Slowly rotate the flywheel **CLOCKWISE** until the No. 1 piston is at top dead center (TDC). Set the dial indicator at 0°. Slowly rotate the flywheel **COUNTERCLOCKWISE** until the dial indicator needle is approximately 1/4 turn bey-



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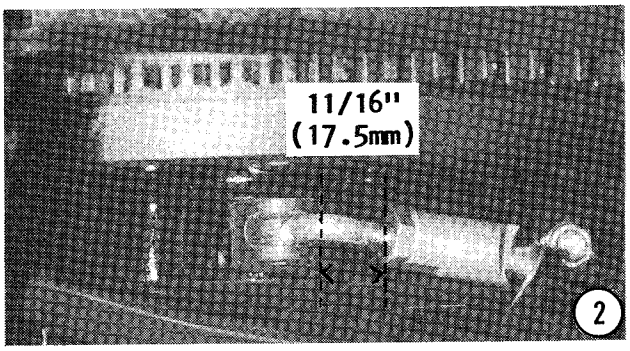


ond the .462 mark to approximately the .480 mark. Now, slowly rotate the flywheel back **CLOCKWISE** until the dial indicator is exactly at .462. Adjust the timing pointer until the pointer is aligned with the .462 mark on the timing decal. Remove the dial indicator. Install the spark plugs.

2- Check to be sure 11/16" (17.5mm) dimension of the control arm link rod, is held, as shown in the accompanying illustration. This distance is measured from the outer side of the link elbow to the surface of the locknut.

Throttle Cam Adjustment

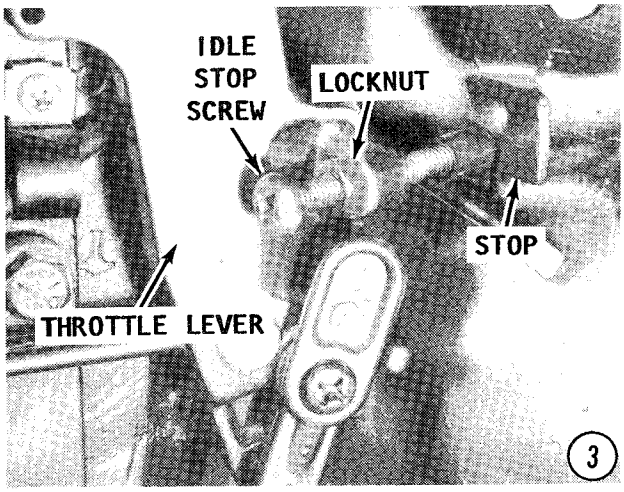
3- Loosen the locknut on the idle stop screw. Move the throttle lever until the idle stop screw makes contact with the idle stop and hold the lever there for the duration of the following step.

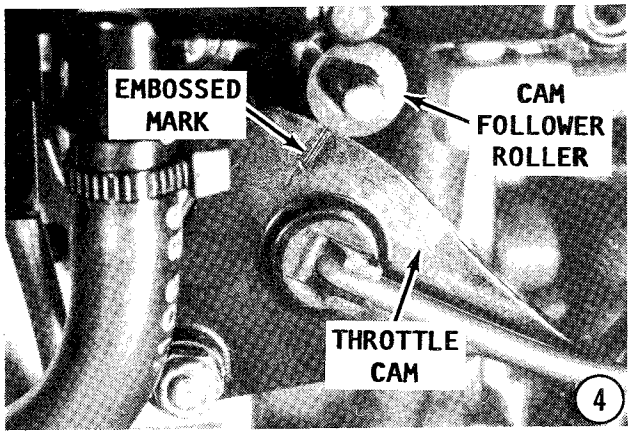
4- Rotate the idle stop screw until the cam follower roller contacts the throttle cam at the embossed line on the cam. Tighten the locknut to hold this position.

Idle Timing at Cranking Speed

SAFETY WORDS

To prevent the engine from firing during the timing procedure, remove all spark plugs





EXCEPT the No. 1 plug (top, starboard bank).

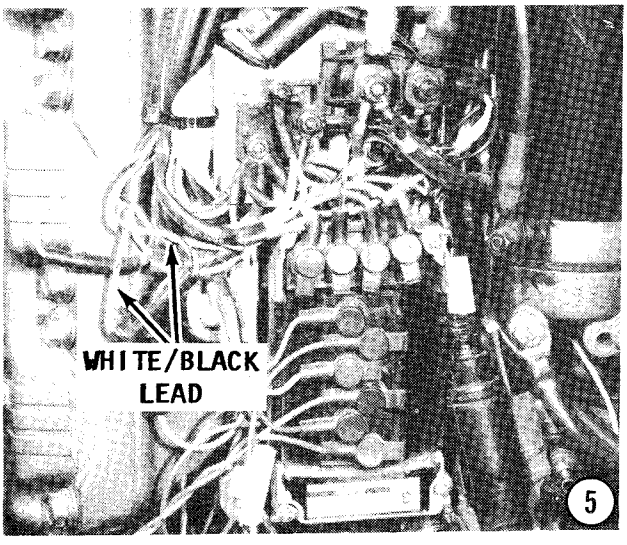
5- Identify the idle stabilizer mounted on top of the starboard cylinder head, and the small Black/White wire leading from the module. This wire **MUST** be disconnected at the switchbox. Wrap tape around the end of the wire to prevent it from shorting out.

6- Move the throttle lever until the idle stop screw contacts the idle stop, and hold the lever there for the duration of the following step.

7- Loosen the locknut on the idle timing screw. Crank the powerhead with the cranking motor and at the same time rotate the idle timing screw until the 8°BTDC mark on the timing decal aligns with the timing pointer. Tighten the locknut on the idle timing screw to hold this adjustment.

Maximum Advance Timing Adjustment at Cranking Speed

8- Loosen the locknut on the maximum spark advance screw. Move the throttle lever until the maximum spark advance screw contacts the stop. Hold the lever



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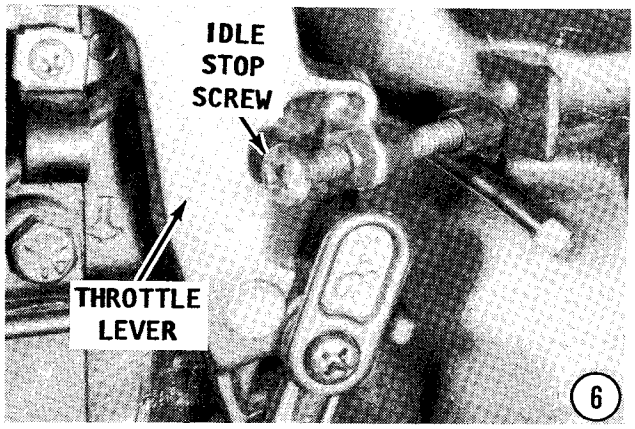


there for the duration of this step. Crank the powerhead with the cranking motor and at the same time rotate the maximum spark advance screw until the 20° BTDC timing mark on the flywheel decal aligns with the timing pointer. Tighten the locknut on the maximum spark advance screw to hold this adjustment.

Turn the ignition switch off and install the remaining five spark plugs.

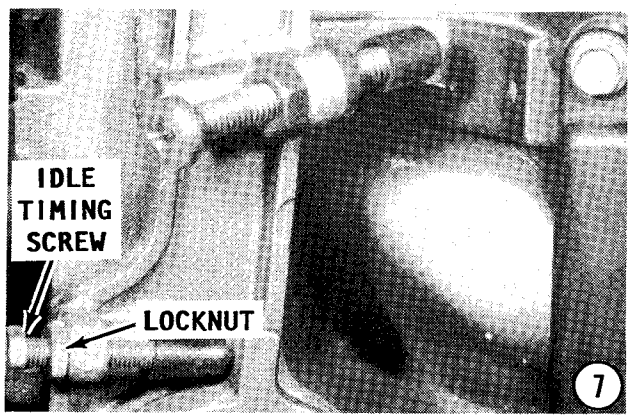
Idle RPM Adjustment at Idle Speed Units With or Without an Idle Mixture Screw

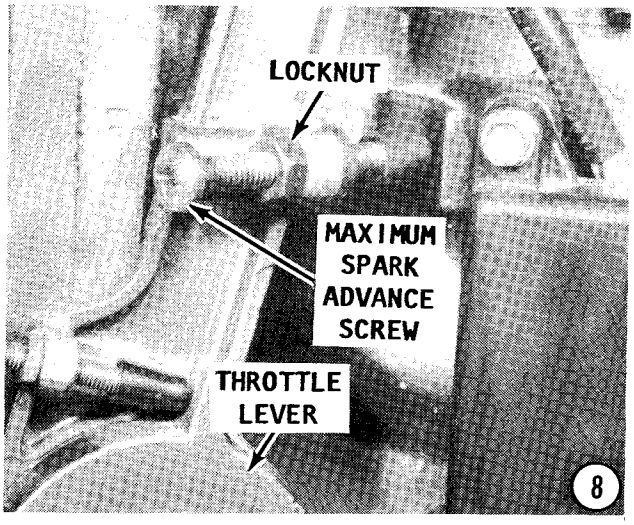
9- Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the engine and allow it to warm to operating temperature. Shift the unit into

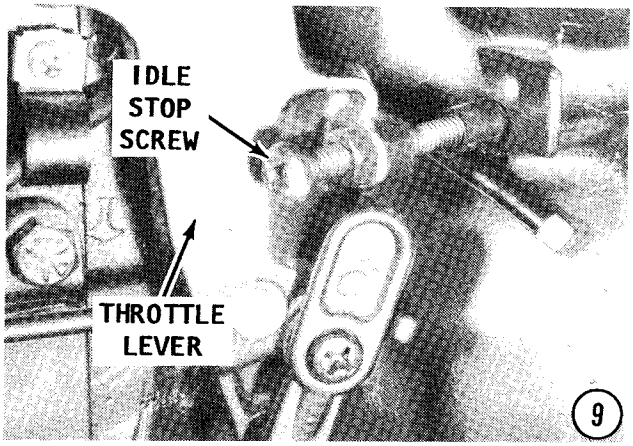


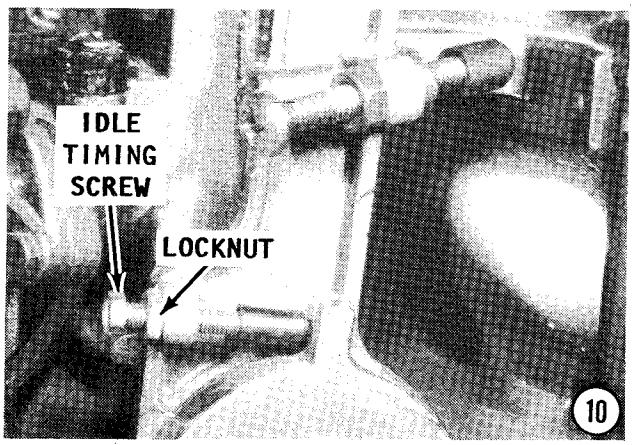


FORWARD gear, keeping the powerhead rpm down between 600 and 675.

With the throttle cable barrel removed from the barrel retainer, move the throttle lever until the idle stop screw contacts the idle stop and hold the lever there for the duration of the following step.

10- Loosen the locknut on the idle timing screw. Rotate the idle timing screw until the 9° ATDC mark on the timing decal aligns with the timing pointer. Tighten the locknut to hold this adjustment.





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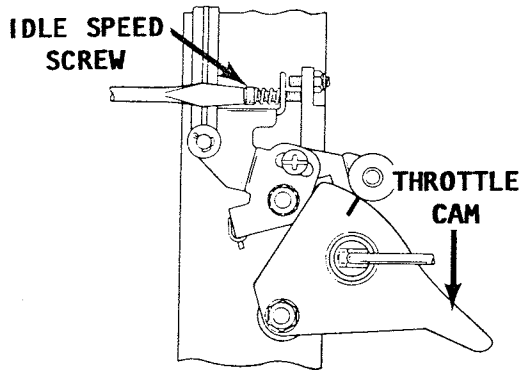


11

Units With an Idle Speed Screw

11- With the powerhead running in **FORWARD** gear at low rpm, move the throttle lever until the idle stop screw contacts the idle stop. Adjust the idle speed screw until the powerhead idles at between 600 and 675 rpm. Shut down the powerhead.

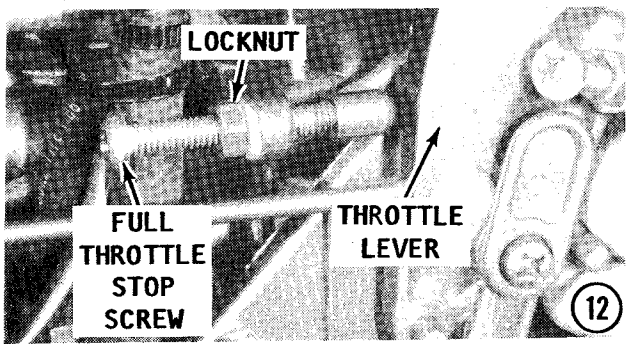
Loosen the cam follower roller securing screw. Once more move the throttle lever until the idle stop screw contacts the stop. Bring the roller down against the throttle cam to make contact at the line embossed on the cam. Tighten the roller securing screw to hold this adjustment.

All Units

Connect the White/Black lead from the idle stabilizer module, located on the starboard side of the powerhead, at its quick disconnect fitting.

Maximum Advance Adjustment with Powerhead NOT Running

12- Loosen the locknut on the full throttle stop screw. Move the throttle lever forward until the lever contacts the full throttle stop screw. Rotate the screw until all the throttle valves are fully open, while a **slight** clearance is maintained between the throttle shaft arm and the stop on the intake manifold. Tighten the locknut to hold this adjustment.



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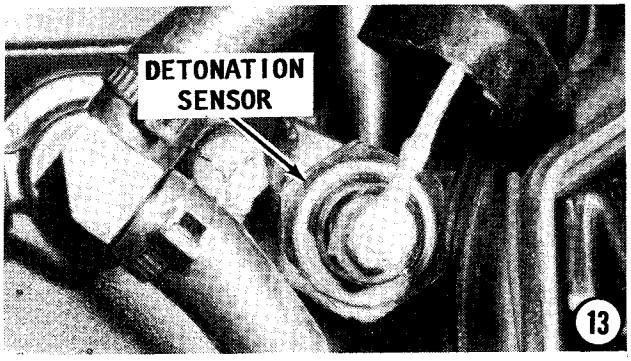


13

Maximum Advance Adjustment with Powerhead Operating at WOT

13- Disconnect the White/Blue lead from the detonation sensor on the cylinder head.

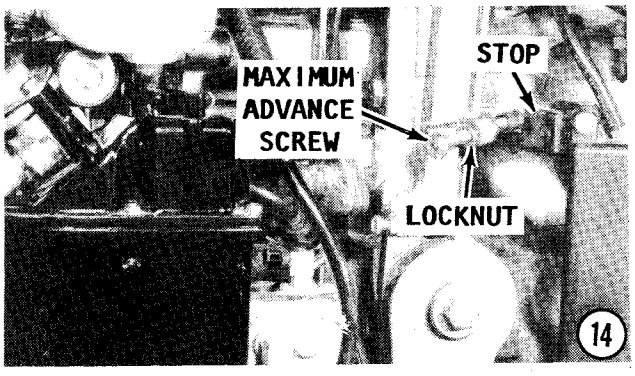
14- Connect a timing light to the powerhead.

Connect a flush device to the lower unit. **NEVER** operate the powerhead over 1000 rpm with a flush device attached, because the engine may **"RUNAWAY"** due to the no load condition on the propeller. A "runaway" engine could be severely damaged.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the engine and allow it to warm to operating temperature. Shift the unit into **FORWARD** gear. Aim the timing light at the timing decal and advance the throttle until the maximum spark advance screw contacts the stop. Adjust the screw to align the 19° BTDC mark on the timing decal with the timing pointer. Tighten the locknut to hold this adjustment. Back off the throttle to idle speed, and then shut down the powerhead. Disconnect the timing light and reconnect the White/Blue lead to the detonation sensor.



14

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8
POWERHEAD

8-1 CHAPTER ORGANIZATION AND GENERAL POWERHEAD INFORMATION

This Chapter is divided into five working sections as follows:

8-1 This section, chapter organization and general powerhead information.

8-2 Complete service of Mariner original design 3-, 4-cylinder, and L6 powerheads, as follows:

45hp	4-cyl.	1986 & On
50hp	4-cyl.	1982-85
50hp	3-cyl.	1986 & On
60hp	3-cyl.	1984 & On
70hp	3-cyl.	1980-83
75hp	4-cyl.	1984-86
80hp	4-cyl.	1978-83
85hp	4-cyl.	1977 only
90hp	L6	1978-86
115hp	L6	1978-88
140hp	L6	1978-80

8-3 Complete service of Mariner redesigned 3- and 4-cylinder powerheads, as follows:

75hp	3-cyl.	1987 & On
90hp	3-cyl.	1987 & On
100hp	4-cyl.	1988 & On
115hp	4-cyl.	1989 & On

8-4 Complete service of a V6 powerhead.

8-5 Cleaning and inspecting of powerhead components for all models.

The redesign of the original inline block became available in 1987 on a few selected models. The reeds were relocated to a reed block housing behind the carburetors, as in the existing V6 block. The original design powerhead has reeds arranged around the crankshaft. The shape of the reeds on these new powerheads are very different to the V6 reeds. The V6 reeds have horizontally or vertically mounted blocks of reeds. The new 3- and 4-cylinder reed blocks have reed petals arranged in a circle and are called the "rose petal design" by the manufacturer. This type design affords better fuel distribution and provides a smoother operating powerhead. The reeds on these models can



New boat and outboard unit in a dealer's lot ready to give a new owner many "fun days" on the water.

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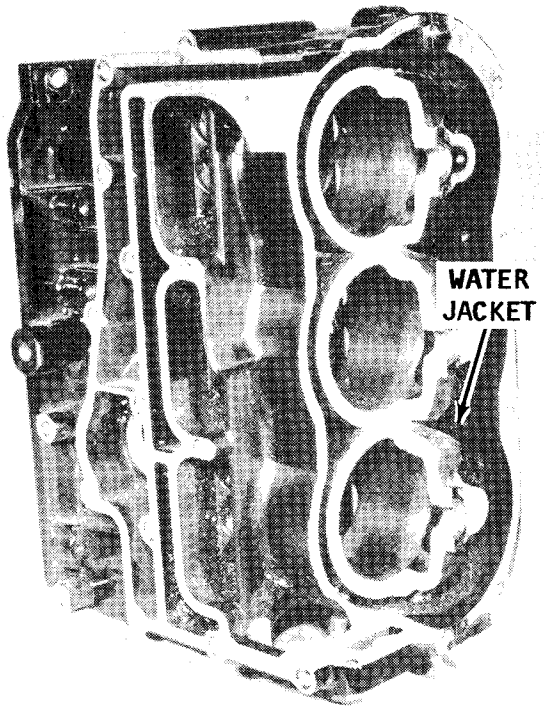
now be serviced without removal and disassembly of the powerhead.

Other differences between the original and redesigned block are in the cylinder head area. The redesigned block and cylinder head are a one-piece casting. Only the cylinder cover is removable to gain access to the water jacket surrounding the cylinder walls. A cutaway of the block and head casting is shown in the accompanying illustration.

The redesigned block has a much larger bore of 3.375" (85.7mm) for both 3- and 4-cylinder blocks, as compared to the original bore of 2.875" (73mm) for 3-cylinder blocks or 2.562" (65mm) for 4-cylinder blocks.

The 100hp and 115hp 4-cylinder block has two accelerator check valves on the starboard side of the block. These check valves are a part of the "2+2" concept described in detail on Page 4-13. Simply stated, this powerhead does not fire on all four cylinders below 1800 rpm. Every other cylinder fires, in the regular firing order, to provide smooth operation and fuel economy at idle speed.



Photograph of a "classroom" type cutaway redesigned cylinder block, used on large bore 3- and 4-cylinder powerheads since 1987. The block and head are cast in one piece. Only the cylinder cover is removable to gain access to the water jacket surrounding the cylinder walls.

GENERAL POWERHEAD INFORMATION

The carburetion and ignition principles of two-cycle engine operation **MUST** be understood in order to perform a proper tune-up on an outboard motor or industrial engine.

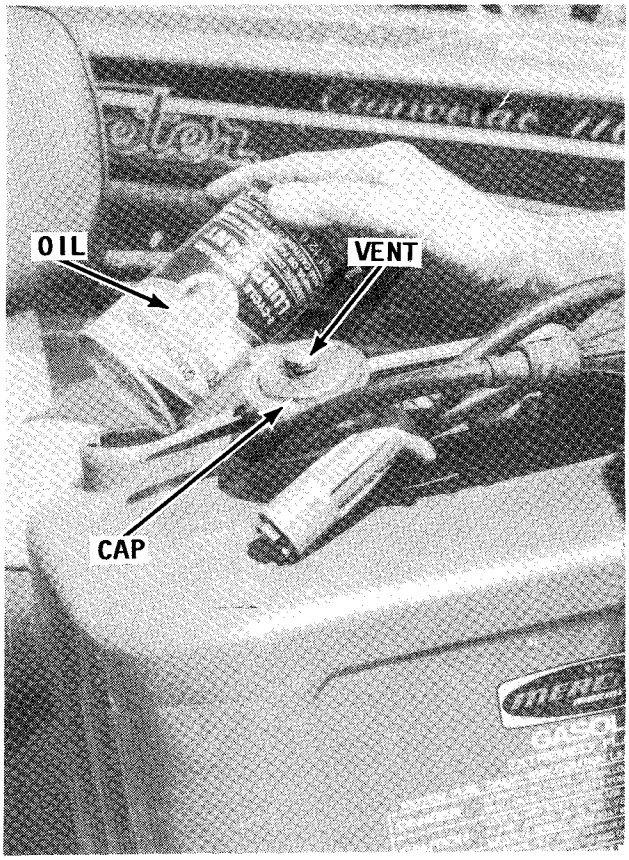
The two-cycle engine differs in several ways from a conventional four-cycle (automobile) engine.

1- The method by which the fuel-air mixture is delivered to the combustion chamber.
2- The complete lubrication system.
3- In most cases, the ignition system.
4- The frequency of the power stroke.

These differences will be discussed briefly and compared with four-cycle engine operation.

Intake/Exhaust

Two-cycle engines utilize an arrangement of port openings to admit fuel to the combustion chamber and to purge the exhaust gases after burning has been completed. The ports are located in a precise



Adding approved lubricant to the fuel tank at the time the tank is being filled. Some fuel must be in the tank to prevent the oil from sticking to a dry bottom.

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pattern in order for them to be opened and closed at an exact moment by the piston as it moves up and down in the cylinder. The exhaust port is located slightly higher than the fuel intake port. This arrangement opens the exhaust port first as the piston starts downward and therefore, the exhaust phase begins a fraction of a second before the intake phase.

Actually, the intake and exhaust ports are spaced so closely together that both open almost simultaneously. For this reason, the pistons of most two-cycle engines have a deflector-type top. This design of the piston top serves two purposes very effectively.

First, it creates turbulence when the incoming charge of fuel enters the combustion chamber. This turbulence results in more complete burning of the fuel than if the piston top were flat. The second effect of the deflector-type piston crown is to force the exhaust gases from the cylinder more rapidly.

This system of intake and exhaust is in marked contrast to individual valve arrangement employed on four-cycle engines.

Lubrication

A two-cycle engine is lubricated by mixing oil with the fuel. Therefore, various parts are lubricated as the fuel mixture passes through the crankcase and the cylinder. Four-cycle engines have a crankcase containing oil. This oil is pumped through a circulating system and returned to the crankcase to begin the routing again.

Physical Laws

The two-cycle engine is able to function because of two very simple physical laws.

One: Gases will flow from an area of high pressure to an area of lower pressure. A tire blowout is an example of this principle. The high-pressure air escapes rapidly if the tube is punctured.

Two: If a gas is compressed into a smaller area, the pressure increases, and if a gas expands into a larger area, the pressure is decreased.

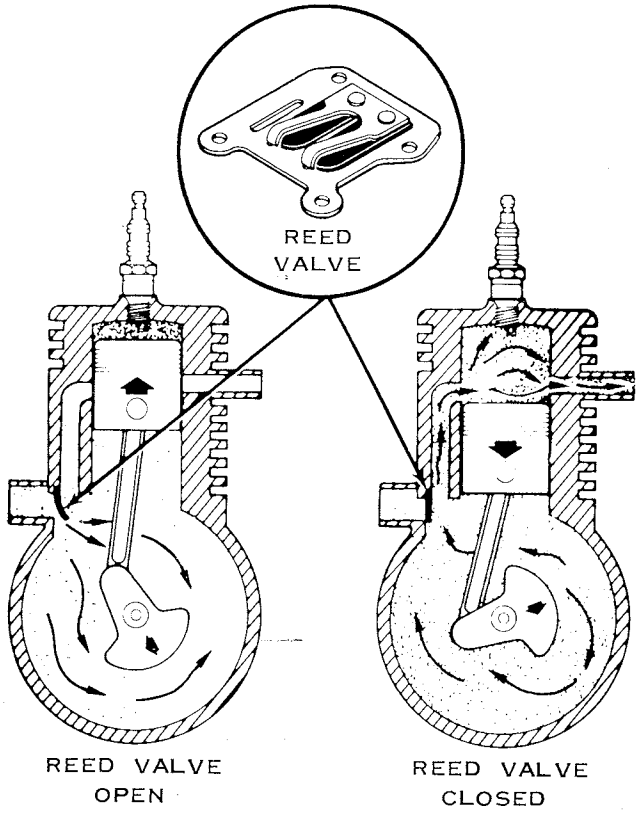
If these two laws are kept in mind, the operation of the two-cycle engine will be easier understood.

Actual Operation

Beginning with the piston approaching top dead center on the compression stroke: The intake and exhaust ports are closed by the piston; the reed valve is open; the spark plug fires; the compressed fuel-air mixture is ignited; and the power stroke begins. The reed valve was open because as the piston moved upward, the crankcase volume increased, which reduced the crankcase pressure to less than the outside atmosphere.

As the piston moves downward on the power stroke, the combustion chamber is filled with burning gases. As the exhaust port is uncovered, the gases, which are under great pressure, escape rapidly through the exhaust ports. The piston continues its downward movement. Pressure within the crankcase increases, closing the reed valves against their seats. The crankcase then becomes a sealed chamber. The air-fuel mixture is compressed ready for delivery to the combustion chamber.

As the piston continues to move downward, the intake port is uncovered. A fresh air/fuel mixture rushes through the intake port into the combustion chamber striking the top of the piston where it is deflected along the cylinder wall. The reed valve



Reed valves are used to control the flow of air/fuel into the crankcase and eventually into the cylinder. As the piston moves upward in the cylinder, the resulting suction in the crankcase overcomes the spring tension of the reed. The reed is pulled free from its seat and the air/fuel mixture is drawn into the crankcase.

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remains closed until the piston moves upward again.

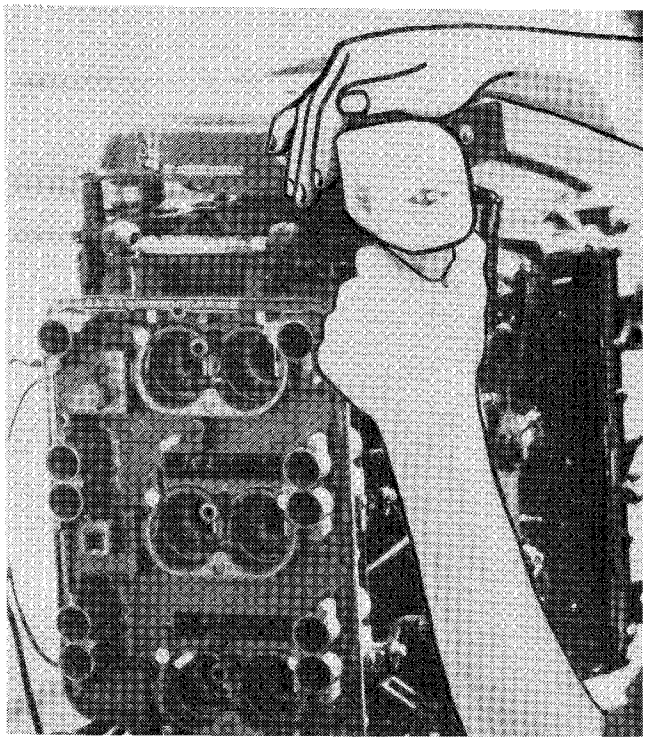
When the piston begins to move upward on the compression stroke, the reed valve opens because the crankcase volume has been increased, reducing crankcase pressure to less than the outside atmosphere. The intake and exhaust ports are closed and the fresh fuel charge is compressed inside the combustion chamber.

Pressure in the crankcase decreases as the piston moves upward and a fresh charge of air flows through the carburetor picking up fuel. As the piston approaches top dead center, the spark plug ignites the air-fuel mixture, the power stroke begins and one complete cycle has been completed.

Timing

The exact time of spark plug firing depends on engine speed. At low speed the spark is retarded, fires later than when the piston is at or beyond top dead center. Engine timing is built into the unit at the factory.

At high speed, the spark is advanced, fires earlier than when the piston is at top dead center. On some late models and larger engines, the timing can be changed in the field to meet advance and retard factory specifications.



Using a timing light while making adjustments. An assistant is usually required to provide some degree of shade in order to observe the light on the timing marks.

Summary

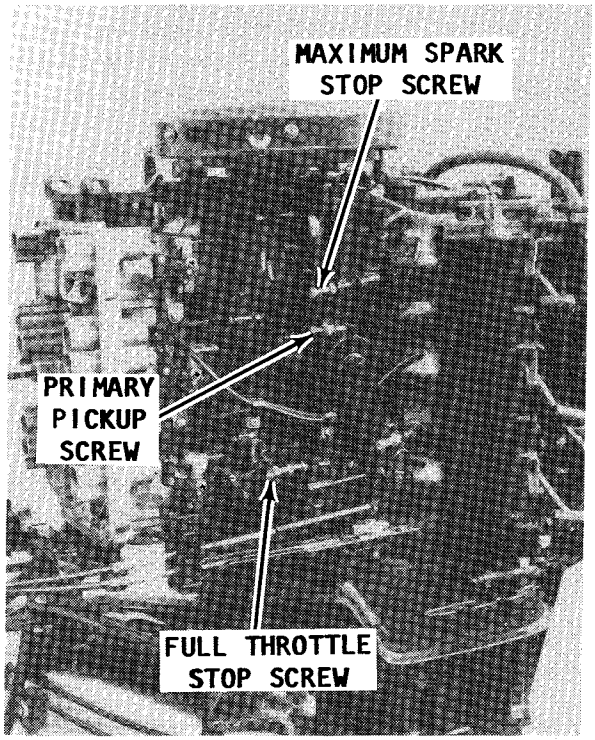
More than one phase of the cycle occurs simultaneously during operation of a two-cycle engine. On the downward stroke, power occurs above the piston while the ports are closed. When the ports open, exhaust begins and intake follows. Below the piston, fresh air-fuel mixture is compressed in the crankcase.

On the upward stroke, exhaust and intake continue as long as the ports are open. Compression begins when the ports are closed and continues until the spark plug ignites the air-fuel mixture. Below the piston, a fresh air-fuel mixture is drawn into the crankcase ready to be compressed during the next cycle.

COOLING LECTURE

The water circulating in the cooling jacket surrounding the powerhead is controlled by the powerhead operating temperature and subsequently by the water pressure. At powerhead startup and at low idle speeds, the thermostat is closed. There is no movement of water until the temperature in the cooling jacket reaches 145°F (60°C).

At approximately this temperature the thermostat begins to open allowing fresh cold water from the water pump to circu-



Location of the maximum spark stop screw, full throttle stop screw, and the primary pickup screw adjustments.

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late through the water jacket. If the cool water reduces the operating temperature of the powerhead below 145°F (60°C), the thermostat starts to close and restrict the flow of water. The water remains in the cooling jacket until it reaches the required temperature once more and the cycle repeats itself.

In this way, the thermostat acts as a restriction in the water passageway. If the previous owner decided to "do away" with the thermostat under the misapprehension the thermostat contributed to overheating problems, he/she may have created a new problem instead of solving the original malfunction. Actually, the thermostat may have been permanently stuck in the closed or partially closed position preventing adequate water to circulate. Other problems may have existed in the cooling jacket such as an excessive build up of scale.

Removing the thermostat from the system eliminates the restriction in the passageway. Water is free to flow through the head and block removing heat generated by combustion. Such a condition of "overcooling" may cause one or more of the following problems.

The time for the powerhead to reach operating temperature will be **MUCH** longer.
The efficiency of combustion in the cylinders is reduced because the spark plugs run "cold".
Fuel will not atomize properly in a cool combustion chamber.
The total air/fuel mixture in the cylinder may not be ignited.
The spark plugs may foul.

All these problems may cause the powerhead to fail -- not only performancewise, but failure to operate. Time, frustration, and expense can all be saved through installation of the correct thermostat.

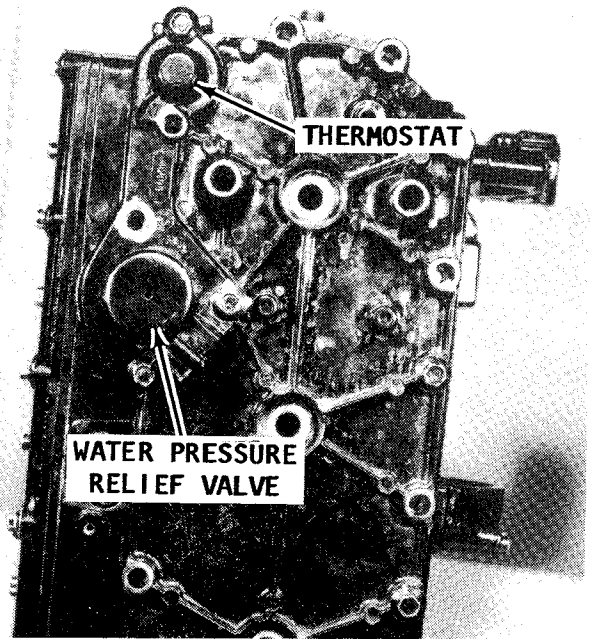
Driveshaft rpm is equal to crankshaft rpm. Because the water pump impeller is mounted on the driveshaft, an increase in powerhead rpm will increase water pump rotation. Faster water pump impeller rotation will produce higher water pressure in the cooling system. Excessive pressure will be relieved at the weakest point in the system -- any gasket sealing surface which interfaces the water jacket: the thermostat, exhaust cover, cylinder cover, or cylinder head gasket.

To prevent such an occurrence, a pressure relief valve, also known as a poppet valve is installed in the powerhead. Excessive pressure causes the poppet valve to lift off its seat and permit more cooling water to circulate through the water jacket, bypassing the thermostat.

The advantage of such a relief valve are two fold: first, the pressure is reduced at the thermostat, safeguarding all the gaskets previously mentioned. Secondly, the poppet valve allows the powerhead to operate at a reduced temperature at high rpm, taking away the excessive heat produced at the combustion chambers.

Because temperatures are highest in the region of the combustion chamber, the block expands and contracts more in this area than in any other. This constant expansion and contraction at the head gasket sealing surface, together with excessive water pressure, could cause water to be drawn into the combustion chamber on the downward stroke of the piston. If the cylinder head bolts are not tightened properly to the correct torque value, the possibility of water entering the combustion chamber through the head gasket is greatly increased.

If the pressure relief valve becomes stuck shut due to scale, salt etc., such a



The thermostat and water pressure relief valve are usually located next to cylinder No. 1. This cylinder, on an in-line or V6 powerhead, usually operates at the highest temperature because it is greatest distance from the water pump.

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condition will result in powerhead overheating at high rpm. This is a **VERY** common problem on older powerheads, especially those used in salt water.

Procedures to free a stuck relief valve are drastic, but worth the time and effort. Detailed instructions are included in this chapter to remove the valve cover if the bolt heads have become rounded, if the bolt heads should snap off during the removal effort, and if the relief valve has become stuck fast in the cooling passageway.

The operation of the thermostat can be checked using heat sensitive material which melts at a specific temperature. Such items are called "thermomelt sticks", and can usually be purchased at a welding supply store. Because the thermostat is rated at 145°F (60°C), a 125°F (50°C) thermomelt stick and a 163°F (70°C) thermomelt stick should be purchased to bracket above and below the thermostat temperature.

Move the outboard unit to a test tank or mount the unit on a boat in a body of water. Leave the cowling off to permit testing.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Start the powerhead and allow it to reach normal operating temperature. Hold both the lower and higher temperature thermomelt sticks against the top of the cylinder cover close to the thermostat. Keep the powerhead speed at approximately 1500 rpm. The lower temperature thermomelt stick should melt. The higher thermomelt stick should not melt.

If the lower temperature thermomelt stick does not melt, the thermostat may be stuck open preventing the powerhead from reaching normal operating temperature.

If the higher temperature thermomelt stick melts, the powerhead is overheating.

Overheating may be caused by:

Thermostat stuck shut.
Thermostat, exhaust cover gasket, cylinder cover gasket, or cylinder head gasket leaking.
Blocked water passages.
Damaged or leaking water pump.

Remove the lower temperature thermomelt stick, but keep the higher temperature thermomelt stick against the top of the cylinder cover close to the thermostat. Allow the powerhead speed to increase to approximately 4000 rpm. The higher temperature thermomelt stick should now melt.

Failure of the thermomelt stick to melt may be caused by:

Pressure relief valve is stuck shut.
Thermostat, exhaust cover gasket, cylinder cover gasket, or cylinder head gasket is leaking.
Water passages are blocked.
Water pump is damaged or leaking.

If the overheating warning horn sounds, the powerhead temperature has reached approximately 212°F (100°C) and the water is about to boil! Shut down the powerhead immediately.

If the powerhead appears to be overheating, but the warning horn is silent, a quick test of the sending unit circuit is as follows: Turn the ignition switch to the **ON** position, but do **NOT** start the powerhead. Use a long screwdriver and touch the terminal at the tip of the sending unit. Ground the shank of the screwdriver against the nearest spark plug. If the sending unit circuit is functioning correctly, the warning horn should sound, even on a cold powerhead.

If the horn does not sound, see Chapter 9.

End Cooling Lecture

Cylinder Drain System

The cylinder drain system is also known as the "bleed" system.

The arrangement of hoses and one-way check valves eliminates excess raw fuel which normally accumulates in the lower recesses of the crankcase. Droplets of raw fuel are formed as the unburnt air/fuel mixture de-atomizes due to condensation. At low rpm, the air/fuel mixture is held within the crankcase for a longer period of time than at high rpm.

This condition allows the mixture to condense on the inner surface of the crankcase. When the cylinder drain (fuel bleed) system is functioning properly with all hoses open and check valves in good condition, excess fuel will be channeled from the crankcase, via hoses, to the intake manifold where it

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mixes with fresh fuel and is recycled back into the crankcase.

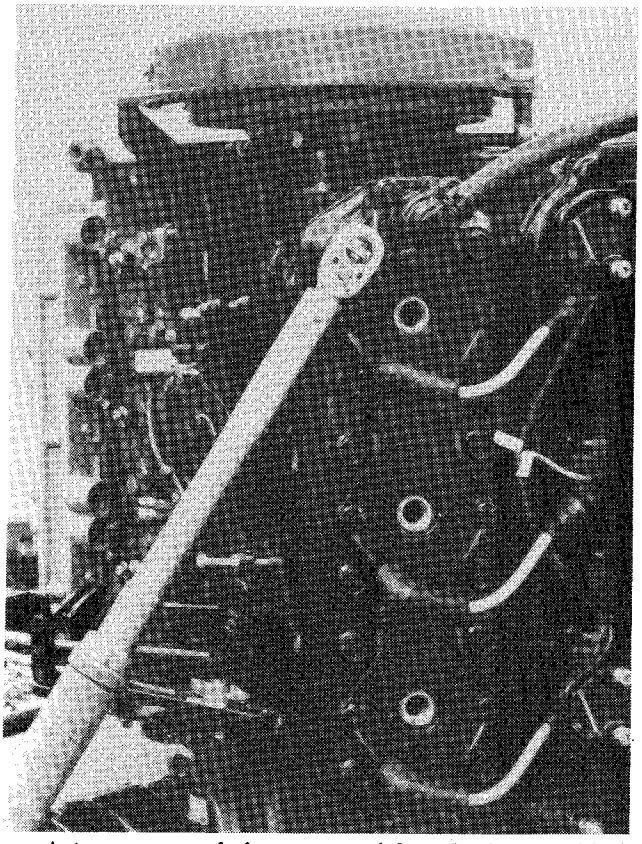
If the drain hoses become plugged or the check valves fail to function properly, excess fuel will remain in the crankcase as fuel droplets.

These droplets enrich the new charge of air/fuel mixture entering the crankcase. The ratio of fuel is increased almost to a fuel saturated condition -- very little air. The mixture entering the combustion chamber is therefore over rich and causes the powerhead to falter and the plugs to foul. Powerhead performance at low rpm will continue to worsen. If the condition is not corrected, the powerhead will fail to operate.

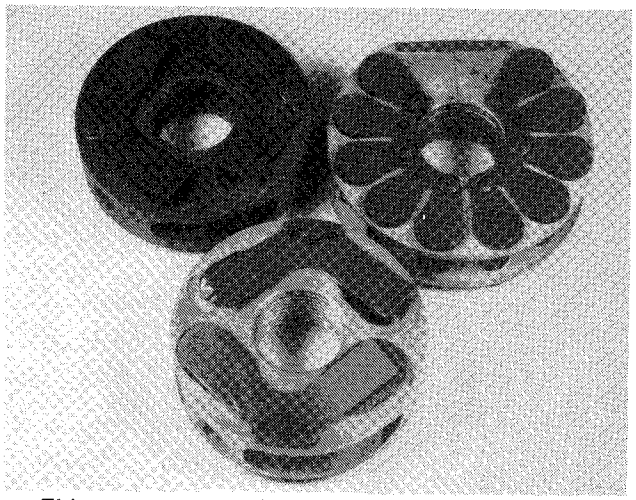
Repair Procedures

Service and repair procedures will vary slightly between individual models, but the basic instructions are quite similar. Special tools may be called out in certain instances. These tools may be purchased from the local marine dealer.

The powerheads covered in this Chapter have some differences in construction. Two of the most prominent differences are:



A torque wrench is an essential tool when working on any powerhead. Bolts, studs, and nuts must be tightened to the required torque value.



This type reed block is installed around the crankshaft on early 3- and 4-cylinder, and all L6 powerheads.

Direct charge or cross-flow fuel-air induction into the cylinder.

Caged or uncaged crankpin connecting rod bearings.

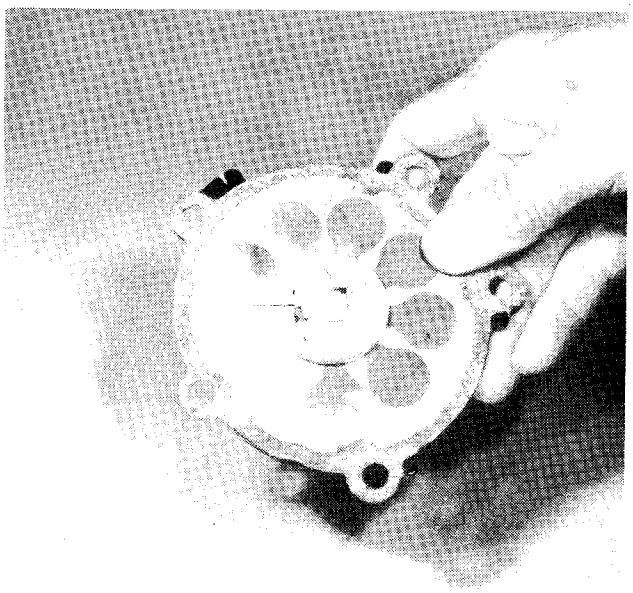
Service procedures for these differences are identified wherever they occur.

Torque Values

All torque values must be met when they are specified. Refer to the Specifications in the Appendix.

Powerhead Components

Service procedures for the carburetors, fuel pumps, cranking motor, and other powerhead components are given in their respective Chapters of this manual. See the Table of Contents.



The "rose petal" design reed block used on large bore 3- and 4-cylinder powerheads since 1987.

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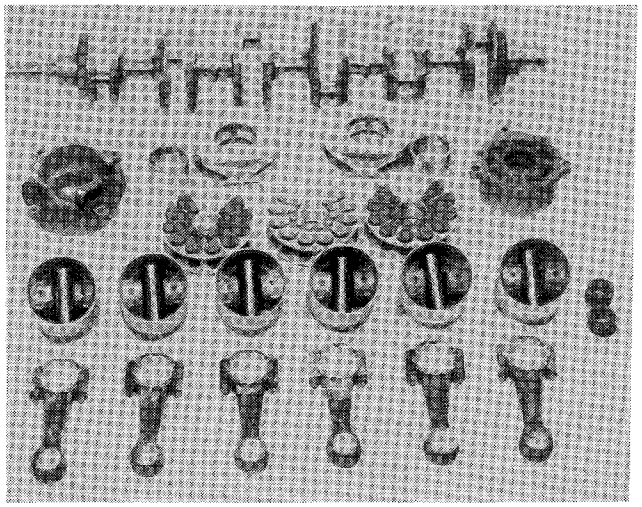
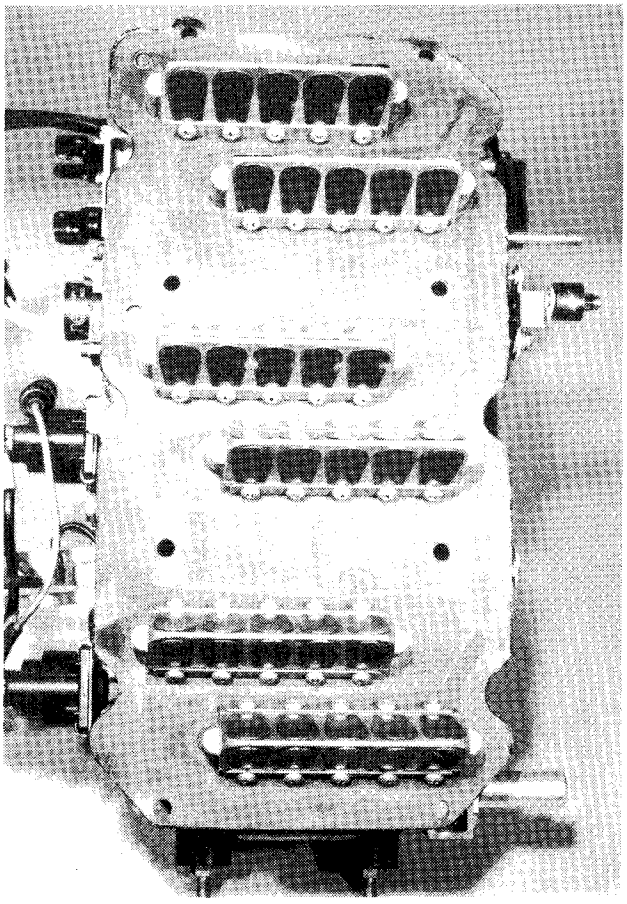


Internal parts of a 6-cylinder powerhead cleaned and arranged in order ready for assembling. Naturally, a smaller powerhead with less cylinders will have less parts.

Reed Block Installation

Some of the engines covered in this chapter have the reed block assembly installed around the crankshaft. This means, in order to replace a broken reed on one of these engines, the engine would have to be overhauled.



A horizontal design reed block used on all V6 powerheads covered in this manual.

Cleanliness

Make a determined effort to keep parts and the work area as clean as possible. Parts **MUST** be cleaned and thoroughly inspected before they are assembled, installed, or adjusted. Use proper lubricants, or their equivalent, whenever they are recommended.

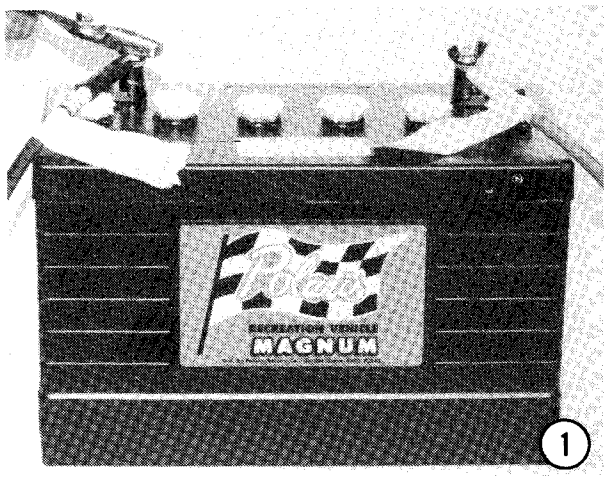
8-2 REMOVAL AND DISASSEMBLING

This section covers complete service of Mariner original design 3-, 4-cylinder, and L6 powerheads, as follows:

45hp	4-cyl.	1986 & On
50hp	4-cyl.	1982-85
50hp	3-cyl.	1986 & On
60hp	3-cyl.	1984 & On
70hp	3-cyl.	1980-83
75hp	4-cyl.	1984-86
80hp	4-cyl.	1978-83
85hp	4-cyl.	1977 only
90hp	L6	1978-86
115hp	L6	1978-88
140hp	L6	1978-80

ADVICE

Before commencing any work on the powerhead, an understanding of two-cycle engine operation will be most helpful. Therefore, it would be well worth the time to study the principles of two-cycle engines, as outlined briefly in Section 8-1. A Polaroid, or equivalent instant-type camera is an extremely useful item, providing the means of accurately recording the arrangement of parts and wire connections **BEFORE** the disassembly work begins. Such a record is invaluable during the assembly work.



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POWERHEAD REMOVAL

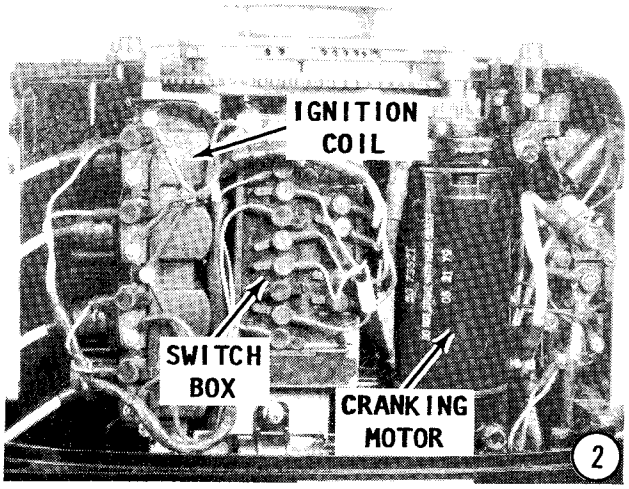
1- Disconnect the battery leads at the battery. Disconnect the fuel line at the tank or the engine. Remove the front cowl and the wrap-a-round cowls. Place the shift guide block in the neutral gear position. Remove the shift link attaching nut. Remove the two rear cowl support shock mounting nuts, and then the rear cowl supports.

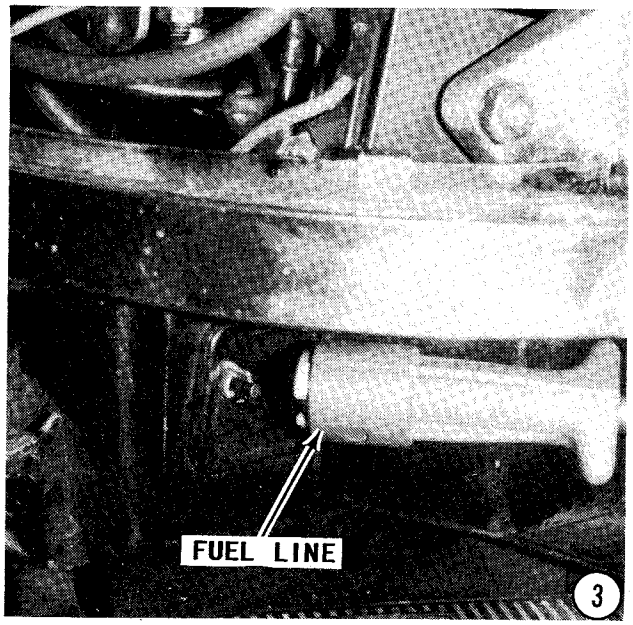
2- Remove the locknuts from the top and bottom front cowl support shock mounts, and then remove the front cowl support. Remove the four sta-straps from the front of the engine. Remove the center cowl support.

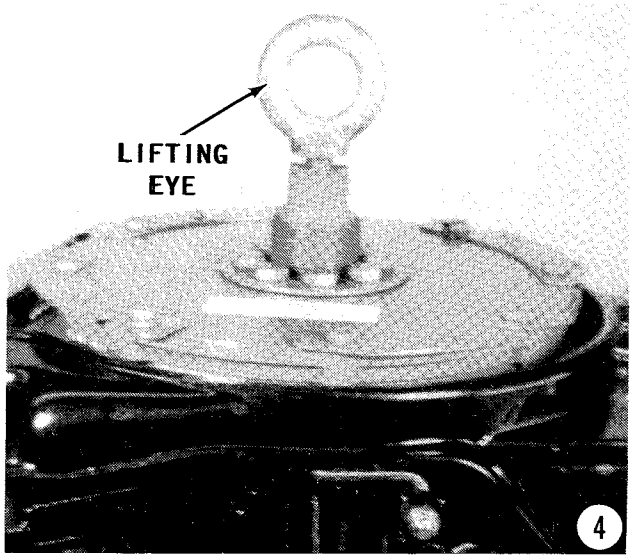
STOP, and carefully observe the wiring and hose connections before proceeding. Because there are so many different engines and the arrangement is slightly different on each, it is not possible to illustrate all of them. Even if they were shown, you would not be able to identify the engine being serviced. Therefore, **TAKE TIME** to make notes and tag the wiring and hoses. You may elect to follow the practice of many professional mechanics by taking a series of photographs of the engine, one from the top, and couple from the sides showing the wiring and arrangement of parts.

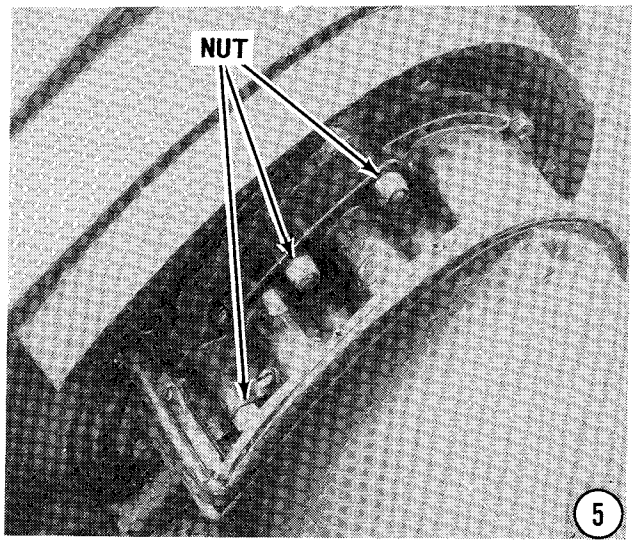
3- Disconnect the fuel line from the fuel pump. Disconnect the water hose from the exhaust plate elbow. Disconnect the hose from the tattle-tale fitting in the rear support. Remove the nuts on the bottom side of the powerhead from the intermediate housing.

4- Remove the plastic cap from the flywheel and thread a lifting eye onto the end of the crankshaft as far as it will go.









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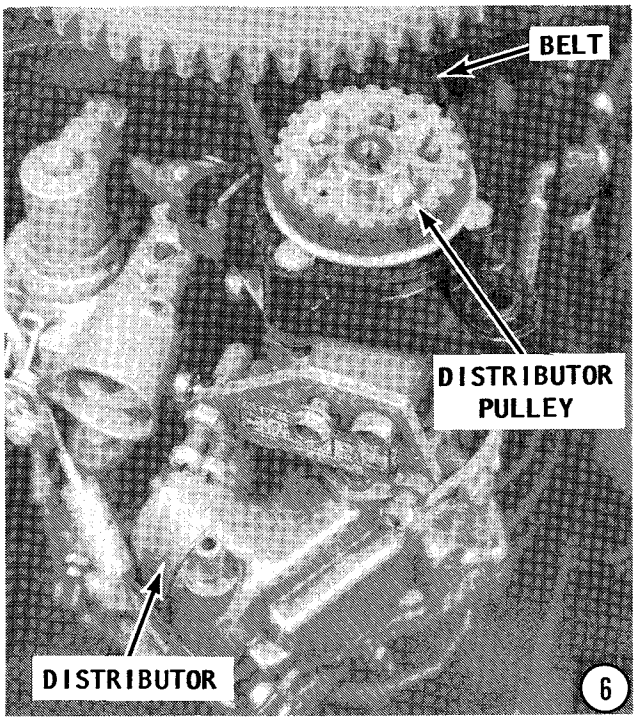


5- Remove the nuts from the studs securing the powerhead to the intermediate housing. Using a suitable hoist, lift the powerhead free of the intermediate housing.

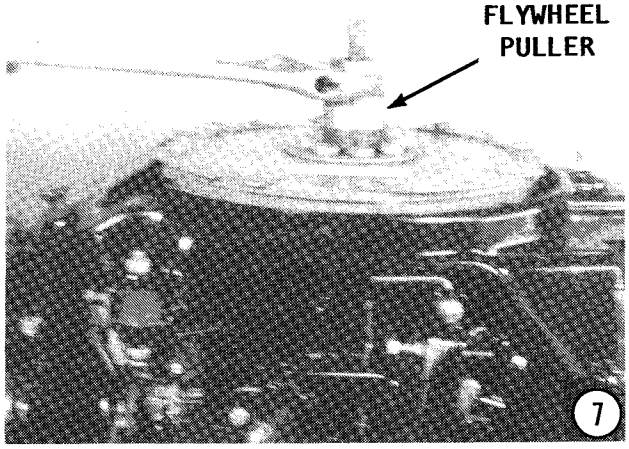
BAD NEWS

If the unit is several years old, or if it has been operated in salt water, or has not had proper maintenance, or shelter, or any number of other factors, then separating the powerhead from the intermediate housing may not be a simple task.

An air hammer may be required on the studs to shake the corrosion loose; heat may have to be applied to the casting to expand it slightly; or other devices employed in order to remove the powerhead.

One very serious condition would be the driveshaft "frozen" with the crankshaft. In this case, a circular plug-type hole must be drilled and a torch used to cut the driveshaft.

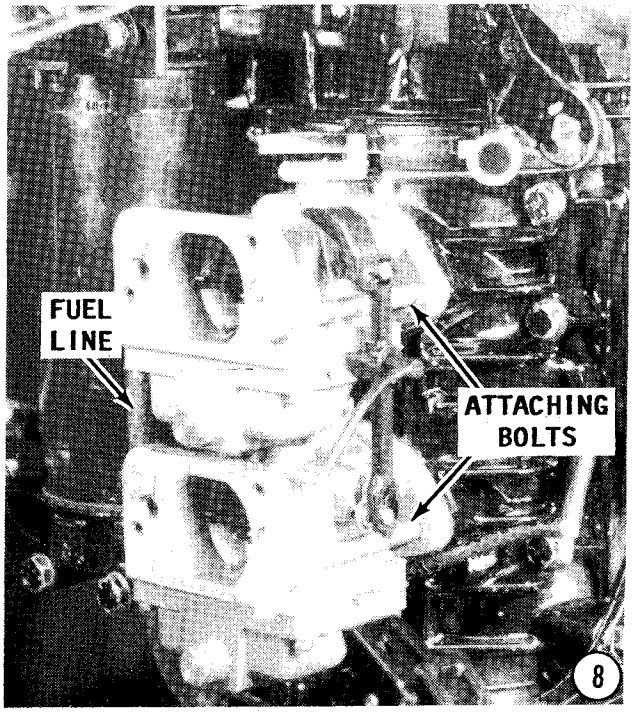
The following procedures pickup the work after the powerhead has been separated from the intermediate housing.



POWERHEAD DISASSEMBLYING

6- Because there are so many models with varying electrical and ignition systems, refer to Chapter 6 for disassembly procedures of the ignition system. If a distributor is used, remove the timing belt pulley cover and slip the belt free of the pulley on the distributor. Remove the ground wire from the engine to the distributor. Remove the high-tension leads from the spark plugs. **ALWAYS** use a pulling and twisting motion as a precaution against damaging the connection. Remove the two retaining bolts from the distributor, and at the same time hold the distributor to prevent it from falling and being damaged.

7- To remove the flywheel: Remove the flywheel nut. It may be necessary to use a flywheel strap to prevent the flywheel from turning in order to loosen the nut. Install a flywheel puller, C-91-48501A1, and a crankshaft protector cap, C-91-24161. These two items are necessary and may be obtained from the local marine dealer. Tighten the large square of the puller until the screw is tight against the end of the driveshaft.



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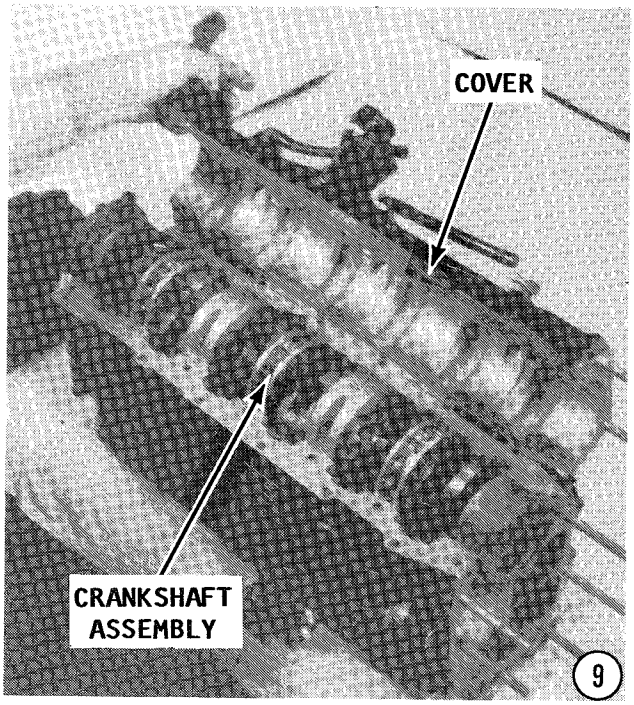
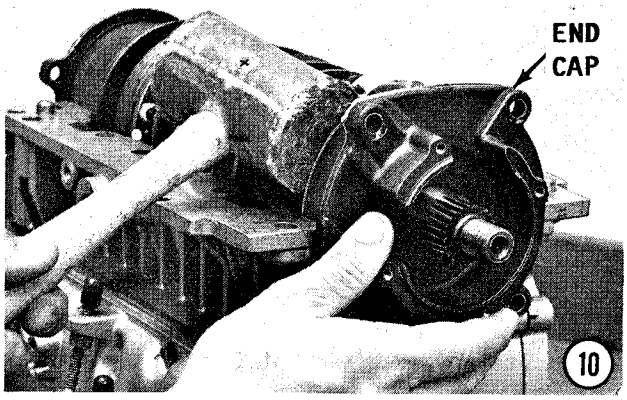
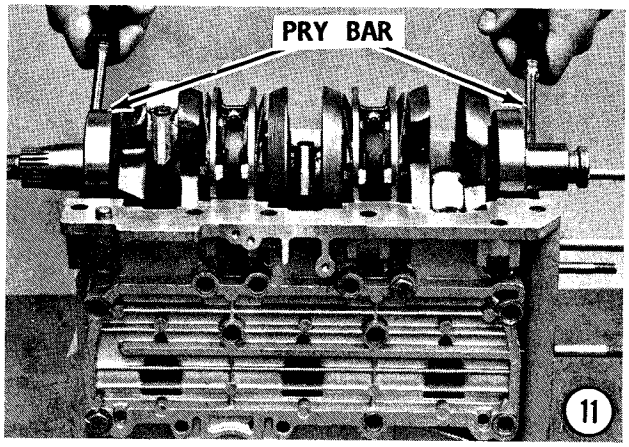


Now, tighten the center bolt on the puller. Continue to tighten on the center bolt until the flywheel breaks loose from the crankshaft. **NEVER** strike the flywheel with a mallet or other tool in an effort to break the flywheel loose. Such action will loosen the bottom seal, **DESTROY** the lower bearing, or possibly damage the crankshaft. Lift the flywheel from the crankshaft. Remove the puller and the protective cap. Remove the stator and trigger plate assembly.

8- Remove all carburetors together as an assembly. This is accomplished by first disconnecting the fuel lines to the carburetors, and then removing the four attaching nuts from the carburetors. Remove the fuel pump, the switch box, and the starter.

9- Remove the crankcase cover bolts and the end cap bolts. **NEVER** pry between the block and the crankcase with **ANY** type of tool. Use a soft-headed mallet and tap





on the side of the cover to jar it loose from the block.

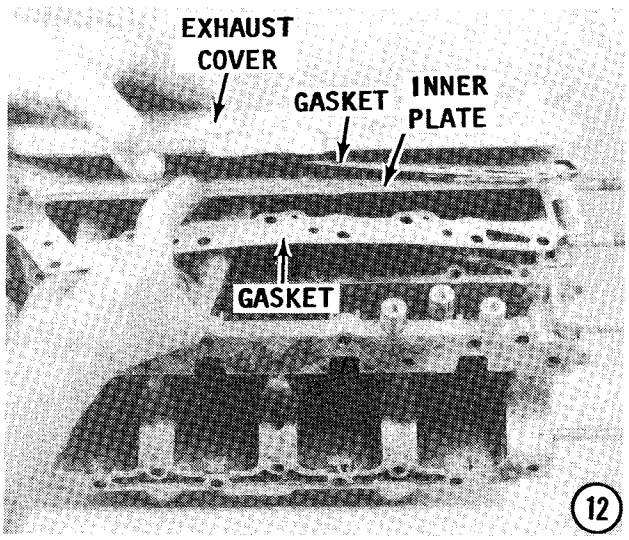
10- Remove the end caps by tapping on them with a soft-headed mallet. **DO NOT** tap on the shims.

11- Pad the crankcase mating surface near the ends of the crankshaft with small pieces of wood. Now, use two pry-bars, one at each end, and work the crankshaft assembly supports loose from the locating pins in the cylinder block. Lift the crankshaft assembly clear of the cylinder block and place it on a clean work surface.

ADVICE

The exhaust cover should always be removed during an engine overhaul. Many times water in the engine is caused by a leaking exhaust cover gasket or plate.

12- Remove the retaining bolts from the exhaust cover, and then remove the exhaust cover and baffle plate. **NEVER** pry between the block and the cover with **ANY** kind of tool. Tap the cover loose with a soft-



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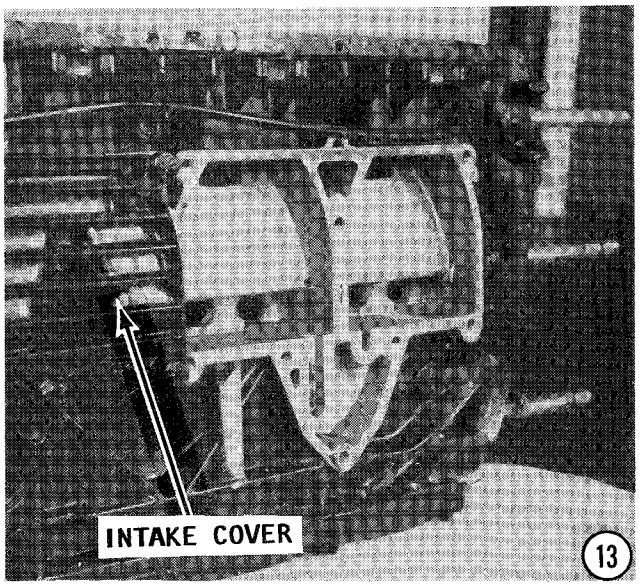
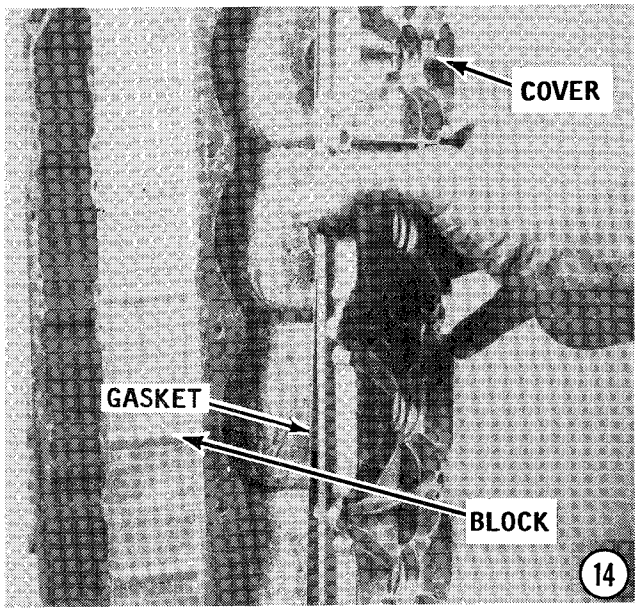


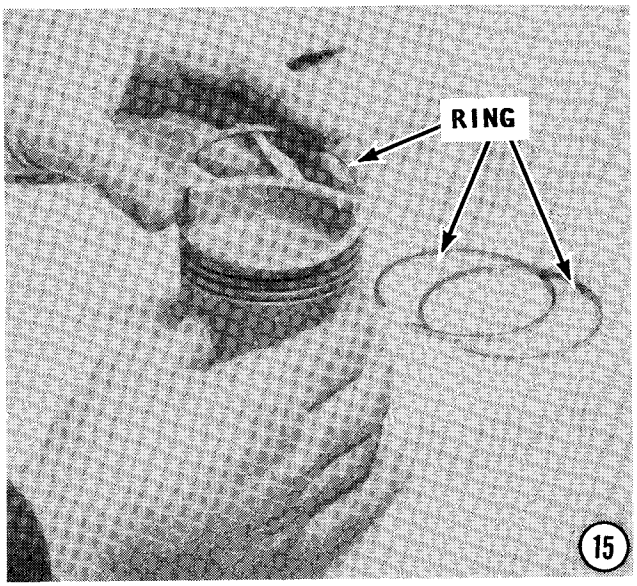
headed mallet, and then tap the plate loose with a punch.

13- Turn the cylinder block over and remove the bolts from the transfer port covers. Remove the cover. **NEVER** pry between the block and the cover with **ANY** kind of tool. Tap the cover loose with a soft-headed mallet.

14- Cover the work bench with a clean towel. Lay the block on the clean surface with the crankshaft side down. **TAKE CARE** not to damage the side of the block. Remove the bolts from the cylinder block cover, and then remove the cover. **NEVER** pry between the block and the cover with **ANY** kind of tool. Tap the cover loose with a soft-headed mallet.

15- Good shop practice dictates to replace the rings during a powerhead overhaul.

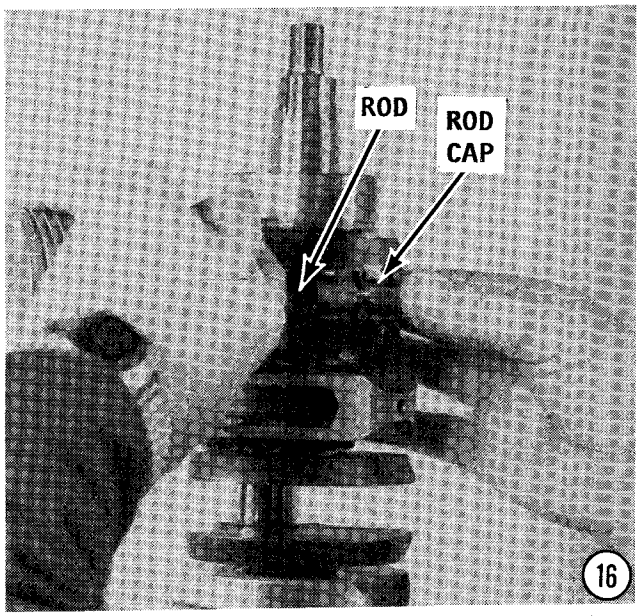




However, if the rings are to be used again, expand them **ONLY** enough to clean the piston and the grooves because used rings break easily. If new rings are to be installed, use a piston ring expander and remove the old rings from the piston.

ADVICE: New needle bearings should be installed in the connecting rods, even though they may appear to be in serviceable condition. New bearings will ensure lasting service after the overhaul work is completed. If it is necessary to install the used bearings, keep them separate and identified to ensure they will be installed onto the same crankpin throw and with the same connecting rod from which they were removed.

16- Remove the connecting rod nuts and bolts, and then remove the rod cap and



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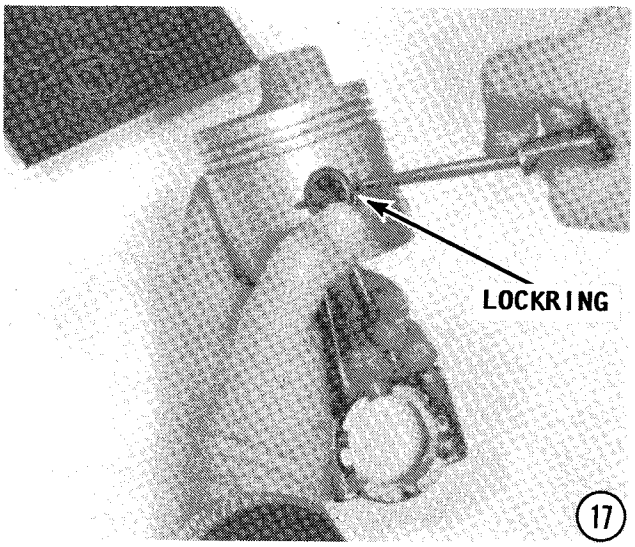
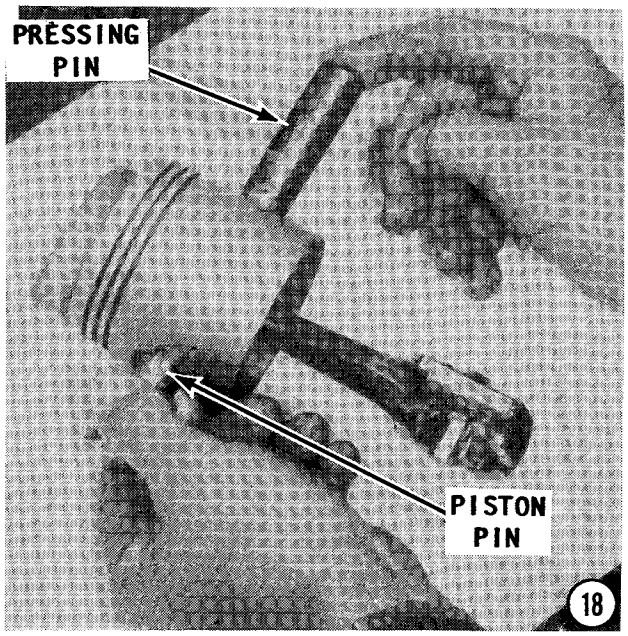
connecting rod, bearings and cages. Immediately after disassembling the rod from the cap and crankshaft, temporarily install the cap and rod together to ensure they will be installed properly. Check each mark alignment.

17- WEAR eye protection glasses while removing the piston pin lockrings, because the lockring is made of spring steel and may slip out of the pliers or pop out of the groove with considerable force. Remove the two G-type lockrings using a pair of needle-nose pliers. A lockring tool, C-91-5252A1, may be used to remove the lockring. A third alternative, is to use a punch to pop the lockring out. If a punch is used **TAKE CARE** not to damage the piston. **DISCARD** the lockrings, because they should not be used a second time.

18- Handle the piston with care because the skirt can be easily bent out-of-round. **TAKE TIME** to make an identification mark on the "I" beam of each rod and a matching mark on the inside of each piston skirt. This mark should be made with a marker, white-out, paint, or any substance which will adhere to a metal surface. **UNDER NO CIRCUMSTANCES** should the mark be a series of notches, or gouges, or even scribed. All these can cause "stress risers", and under heavy engine loads can cause parts to crack and fail.

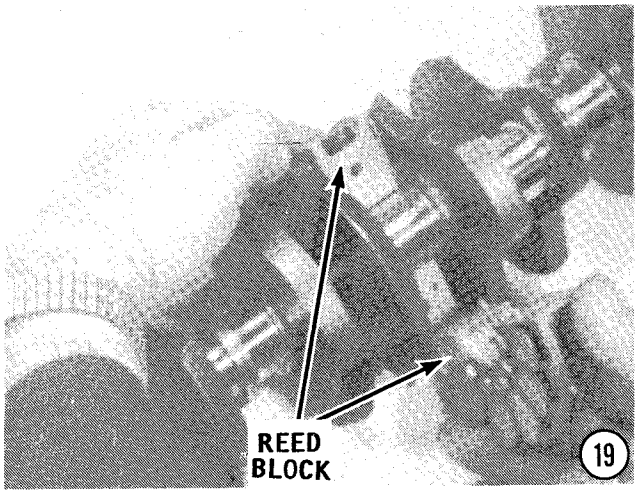
These identification marks will ensure the same rod will be matched with the same piston and installed into the same cylinder bore during assembly. Remove the piston from the rod by first inserting a pressing pin into the hollow end of the piston pin. Next, support the bottom of the piston with one hand and drive the pin through the piston with a mallet and the pressing pin.





BAD NEWS: On some models it may be necessary to heat the top of the piston to approximately 190°F with hot water or a heat lamp before the piston pin can be driven out. On some models, needle bearings are used with the piston pin. These bearings will fall out after the pin has been removed.

19- Remove the valve-type main bearing by removing the two Phillips head screws. **TAKE CARE** not to bend or distort the reed valve stops. Tap the side of the reed cage at the solid section with a soft-headed mallet to separate the halves. After the halves have been removed, assemble them together again, to ensure they remain as a matched set. Reed housing repair is covered in the



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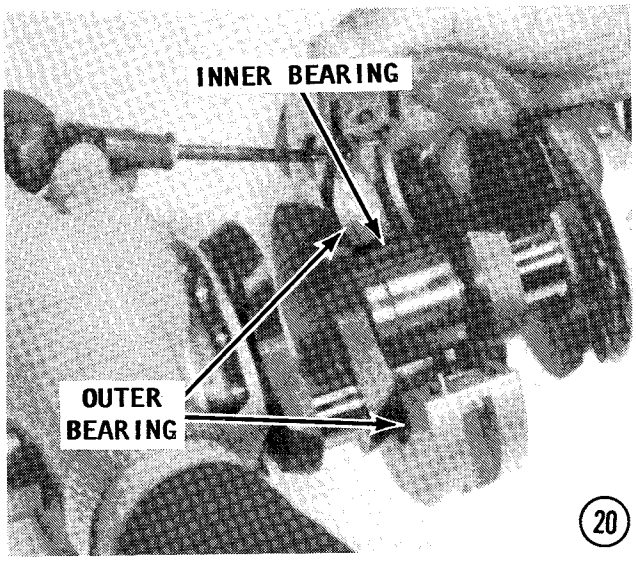


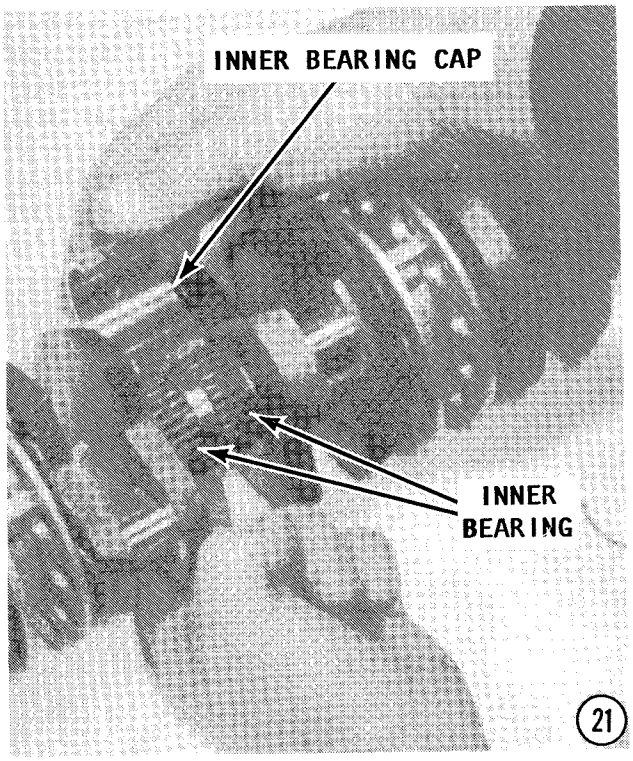
Cleaning and Inspecting portion of this chapter begining on Page 8-95.

20- Remove the snap ring from the main bearing and remove the main bearing outer races and bearings. **TAKE CARE** not to distort the snap ring during removal. Keep the bearing halves together in a clean area.

21- Continue removing the other bear ings. **TAKE CARE** not to damage the crankshaft bearing serfaces while they are exposed during service work.

CLEANING AND INSPECTING

See the last portion of this chapter, Section 8-5, for detailed comprehensive procedures to clean and inspect all components of the powerhead.



POWERHEAD ASSEMBLING AND INSTALLATION

FIRST THESE WORDS

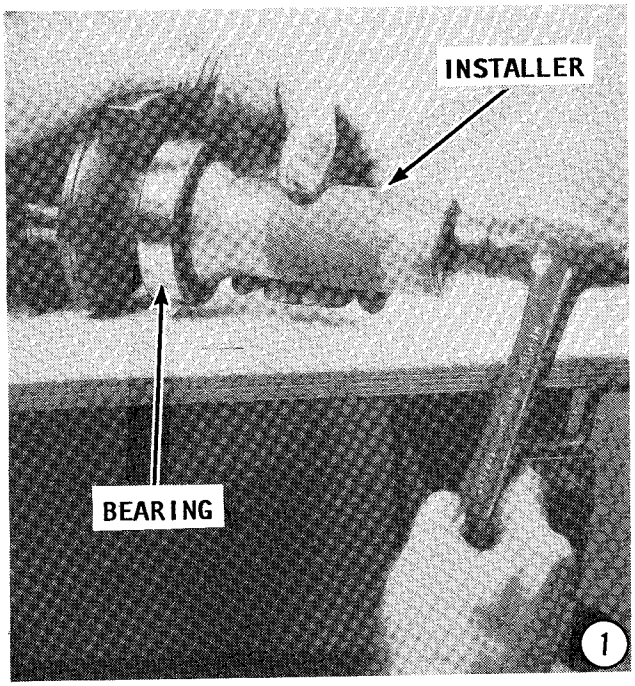
Be sure all parts to be re-used have been carefully cleaned and thoroughly inspected. Parts that have not been properly cleaned, or parts not suitable for service can damage a good powerhead within a few minutes after starting the engine.

NEW gaskets **MUST** always be used during an overhaul.

A torque wrench is essential to correctly assemble the powerhead. **NEVER** attempt to assemble a powerhead without a torque wrench. Attaching bolts **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. Tighten all bolts to 1/3 the torque value, then repeat the sequence tightening to 2/3 the torque value. Finally, on the third and last sequence, tighten to the full torque value.

ASSEMBLING

1- To replace the upper and lower bearings: Place one of the bearings onto the crankshaft, and then press the bearing into place on the shaft. Using a press is the preferred method as a precaution against



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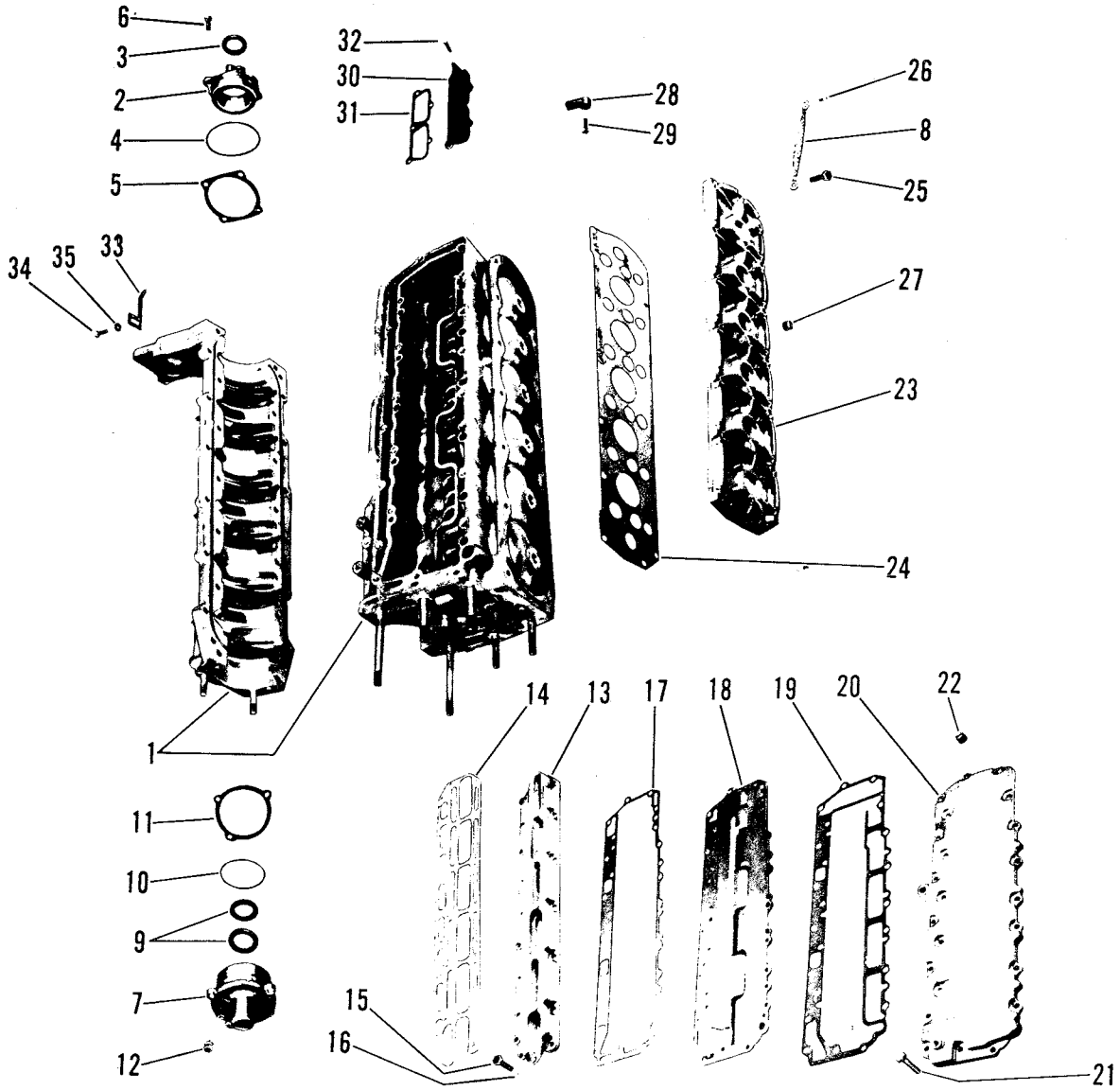

1 - Cylinder Block and Crankcase Assembly
2 - Upper End Cap Assembly
3 - End Cap Oil Seal
4 - "O" Ring
5 - End Cap to Crankcase Shim
6 - End Cap Mounting Screw
7 - Lower End Cap Assembly
8 - Exhaust Cover Ground Strap Assembly
9 - End Cap Oil Seal
10 - End Cap "O" Ring
11 - End Cap to Crankcase Shim
12 - End Cap Mounting Screw
13 - Cylinder Block Cover Water Jacket
14 - Water Jacket Cover Gasket
15 - Water Jacket Cover to Cylinder Block Screw
16 - Water Jacket Cover Fastening Screw Washer
17 - Cylinder Block to Baffle Plate Gasket
18 - Exhaust Manifold Plate Baffle
19 - Baffle Plate to Exhaust Manifold Cover Gasket
20 - Exhaust Manifold Cover
21 - Manifold Cover Mounting Screw
22 - Exhaust Manifold Cover Pipe Plug
23 - Cylinder Block Cover
24 - Cylinder Block Cover Gasket
25 - Cover Mounting Screw
26 - Ground Strap Attaching Screw
27 - Cylinder Block Cover Pipe Plug
28 - Cylinder Block Bracket Mount Support
29 - Bracket-to-Cylinder Block Screw
30 - Transfer Port Cover
31 - Transfer Port Cover Gasket
32 - Transfer Port Cover Mounting Screw
33 - Timing Pointer
34 - Timing Pointer Attaching Screw
35 - Timing Pointer Screw Washer

Exploded drawing of a 6-cylinder in-line (L6) cylinder block and crankcase assembly, with major parts identified. The 3- and 4- cylinder blocks are very similar in design and construction, but with fewer cylinders.

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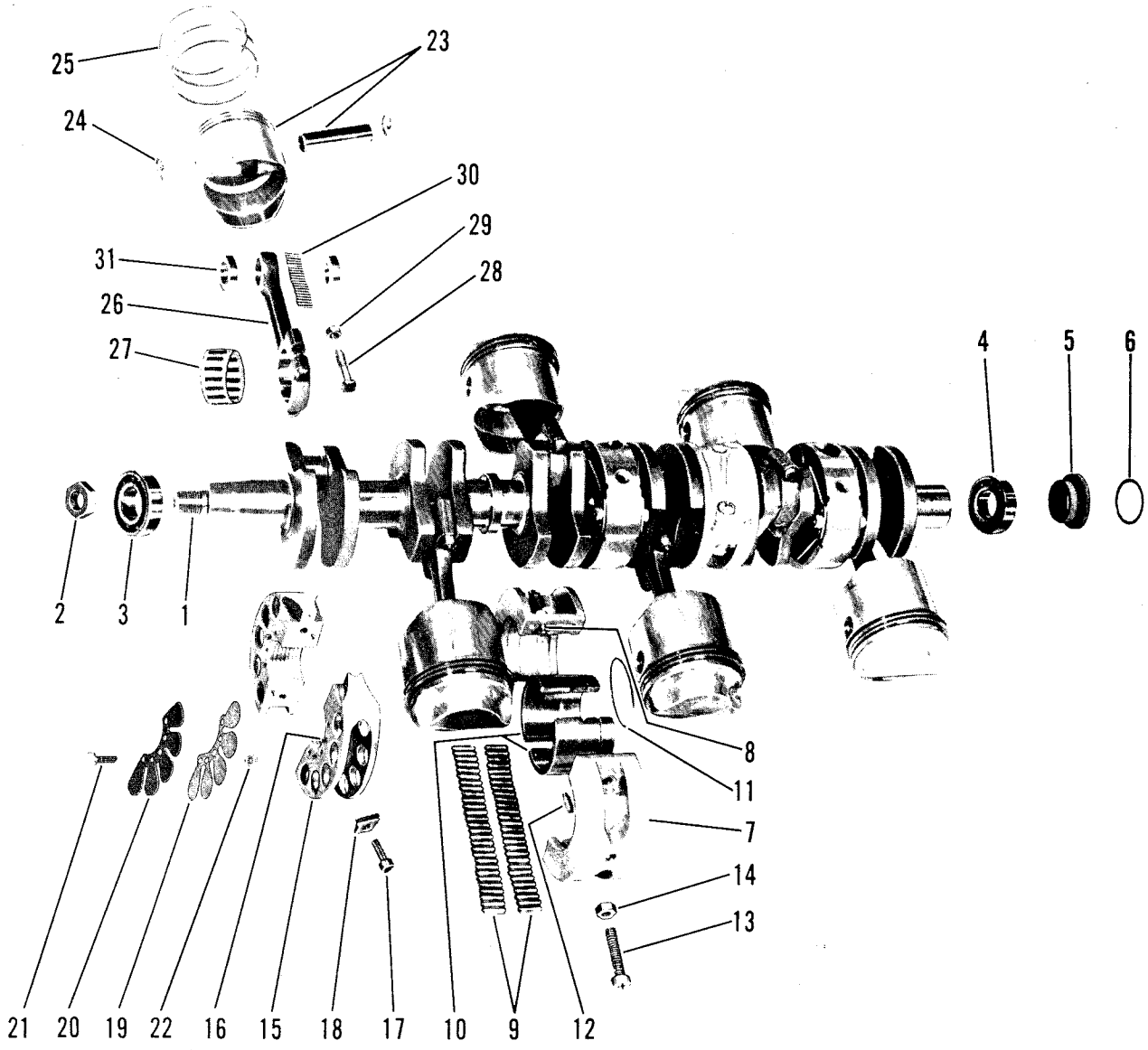

1 - Crankshaft Assembly
2 - Flywheel to Crankshaft Nut
3 - Upper Ball Bearing
4 - Lower Ball Bearing
5 - "O" Ring Carrier Assembly
6 - "O" Ring Carrier
7 - Centermain Bearing Assembly
8 - Centermain Bearing Dowel Pin
9 - Outer Race Needle Bearing
10 - Outer Race (Pair)
11 - Outer Race Snap Ring
12 - Stepped Dowel Pin
13 - Centermain Bearing Clamping Screw
14 - Bearing Clamping Screw Nut
15 - Valve Type Main Bearing Assembly
16 - Main Bearing Dowel Pin
17 - Main Bearing Clamping Screw
18 - Main Bearing Clamping Screw and Nut
19 - Main Bearing Reed Set (Matched)
20 - Main Bearing Reed Valves and Reed Stop
21 - Reed Stop Mounting Screw
22 - Reed Stop Screw and Nut
23 - Piston and Piston Pin Assembly
24 - Piston Pin Lock Ring
25 - Piston Ring
26 - Connecting Rod and Cap Assembly
27 - Crankpin Bearing Assembly
28 - Connecting Rod Screw
29 - Connecting Rod Screw Nut
30 - Piston Pin Bearing Needle
31 - Needle Locating Washer

Exploded drawing of a 6-cylinder in-line (L6) crankshaft assembly and associated parts. The 3- and 4-cylinder crankshaft assemblies are very similar in design and construction, but with fewer piston assemblies.

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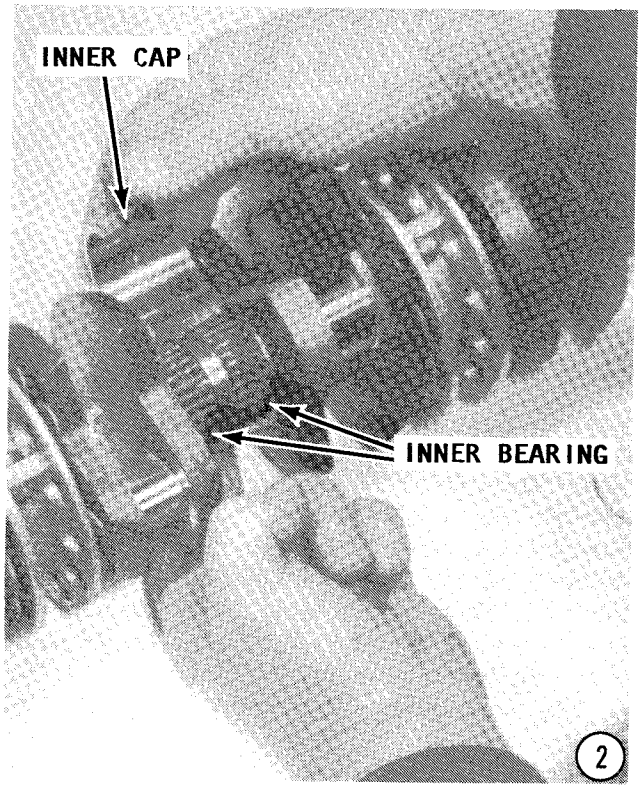
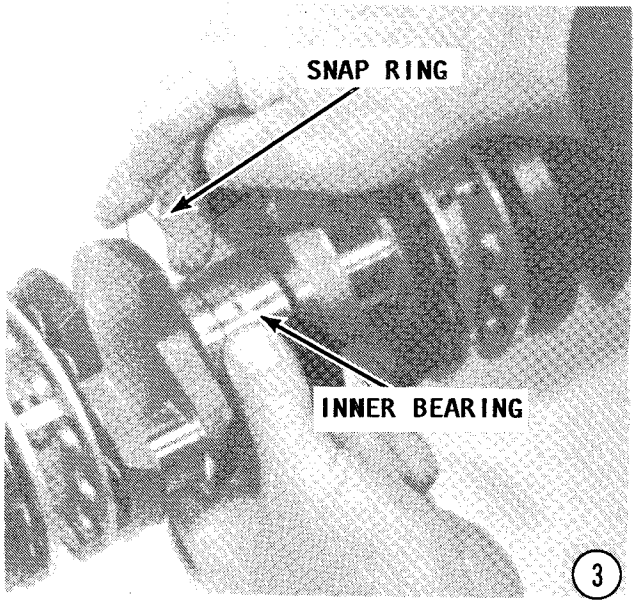
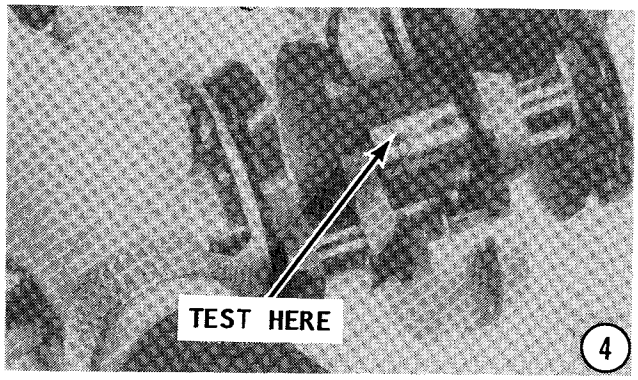


damaging the bearing. However, an installer and hammer may be used **WITH CARE**, as shown.

2- Lubricate the main bearing inner race with Multipurpose Lubricant, or equivalent, and then place the needle bearings around the crankshaft. **NEVER** mix new needle bearings with used bearings in the same race. If some of the bearings require replacement, **ALL** bearings must be replaced.

3- Install the bearing onto the crankshaft with the snap ring **TOWARD** the top of the crankshaft. Place the snap ring in the groove of the bearing. Observe that the mating surfaces of the bearing are rough breaks. Check to be sure the mated areas are together. Repeat Steps 2 and 3 for the other main bearing.

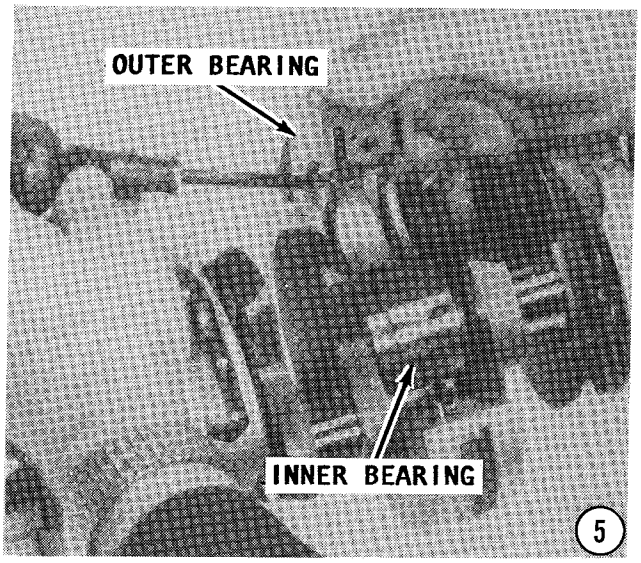




4- Check the number of needle bearings inside the main bearing race by first sliding the bearing race upward, and then inserting the pointed end of an awl between the needle bearings. If the bearing race halves separate, the race is full. Remove the awl and slide the race downward into place. Repeat the check with the awl on the upper row of needle bearings. Check the other main bearing in the same manner.

5- Install the main bearing outer caps around the inner main bearing. Check to be sure the pin in the outer cap indexes with the hole of the inner bearing. Coat the threads of the bolts with a thin film of light-weight oil. Install and tighten the bolts alternately and evenly until secure.

6- Install the reed block halves around the crankshaft. Check to be sure the pin on one of the reed block halves indexes into the matching hole of the other half. Coat the



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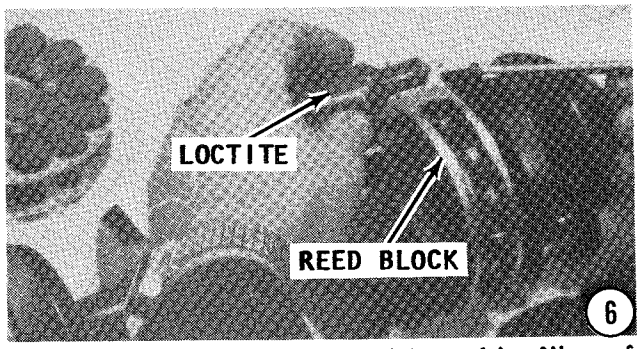
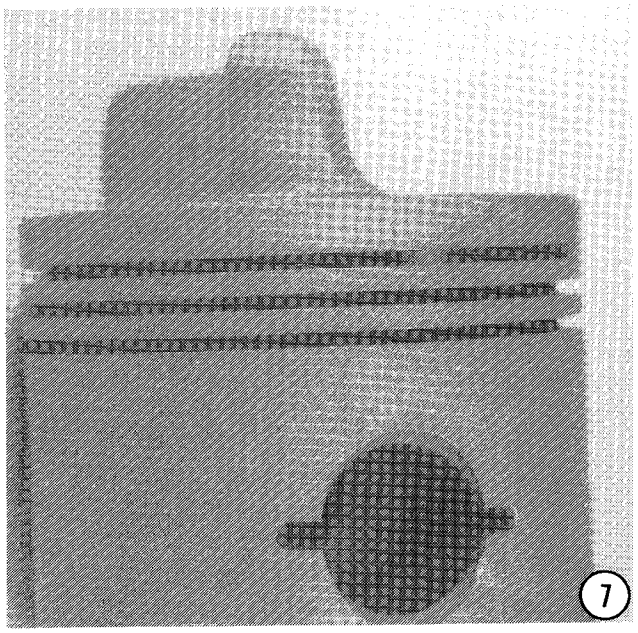


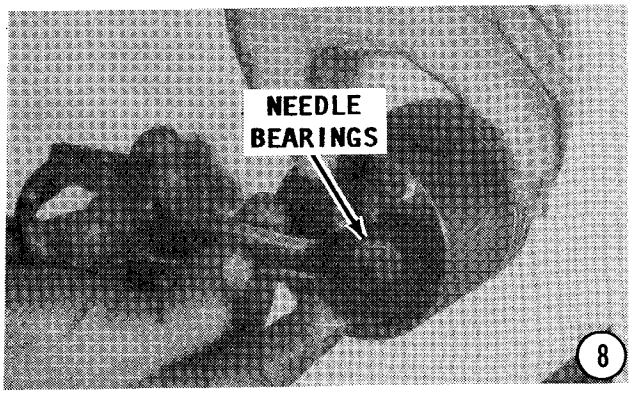
threads of the two bolts with a thin film of light-weight oil. Install and tighten the bolts to a torque value of 27 in lb (3Nm).

7- Place the piston in a container of hot water, approximately 190°F. Leave the piston in the hot water, ready for installation later in Step 9.

8- To replace the piston pin and the needle bearings into the piston, first lay the needles on a clean piece of paper. Next, coat the sleeve portion of a piston pin installation tool with a small amount of Multipurpose Lubricant, or equivalent. If a piston pin tool is not available, a drift slightly smaller in diameter than the pin, may be used. Install the retainer and the needle bearings onto the end of the tool. Leave **ONE** needle bearing **OUT.** Push the bearings and the tool into the rod piston pin bore. Now, install the last needle bearing. Place the top retainer on the side of the rod. Finally, ease the tool out of the rod, and at the same time hold onto the needle bearing retainer washers.

9- Carefully position the piston over the end of the rod, paying attention that the

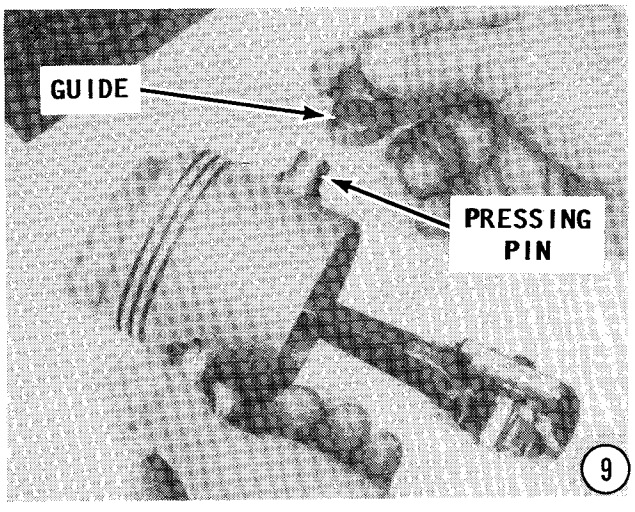




retainer washers remain in place, and at the same time ease the needle bearing tool down through the piston pin bore and through the rod. **DO NOT** force the tool through the needle bearings. **STOP:** Check to be sure the piston is facing the proper direction, the slope area towards the exhaust port of the block and the intake side of the deflector towards the intake port.

10- Now, bring the piston pin up to the bottom side of the piston and through the pin bore of the piston. Hold the pin tool tightly down against the piston pin, and at the same time use a mallet and drive the pin up and through the piston and rod bearing. As soon as the pin is almost flush with the piston surface, remove the piston pin tool and use it to drive the pin upward until the backing ring grooves are visible.

11- Piston pin lockrings should not be used a second time. Therefore, snap **NEW** lockrings into the groove of the piston pin bore in the piston. **WEAR** eye protection glasses while installing the piston pin lockrings, because the lockring is made of spring steel and may slip out of the pliers or pop out of the groove with considerable force. Install the two lockrings using a pair of



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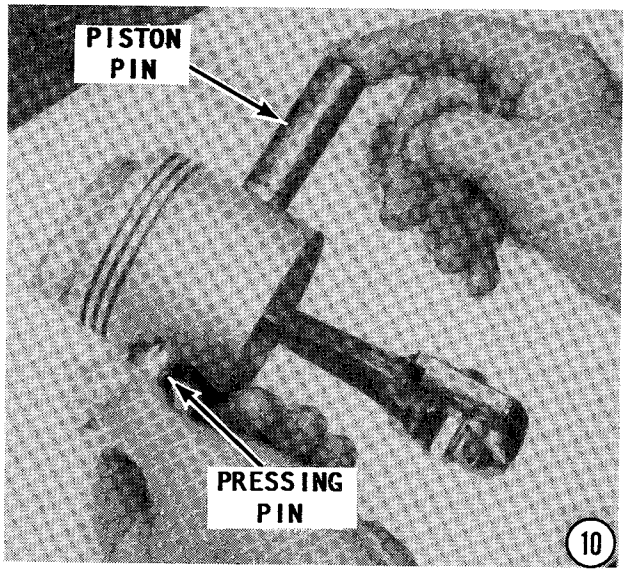
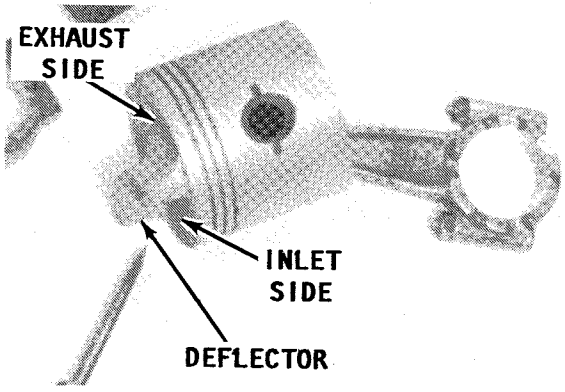


needle-nose pliers. A lockring tool part C-91-5252A1, may be used to install the lockrings. The clip retains the piston pin in place after the piston becomes hot during operation.

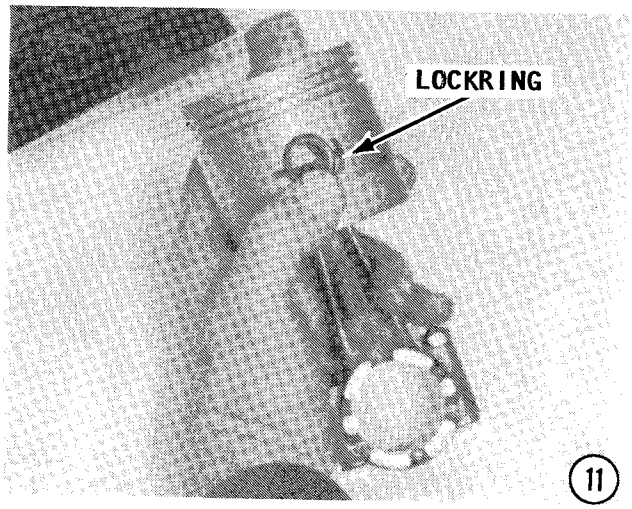
12- Expand the ring slightly with the fingernail of each of your thumbs and at the same time support the back of the ring with your fingers. Now, slide the ring down over the piston and into its proper groove. After the rings are in place, each ring should rotate freely. Lubricate the piston, the rings, and the cylinder bore with a good grade of outboard motor oil. Rotate the rings in their grooves until the ends of each ring is over the locating pin in the groove of the piston.

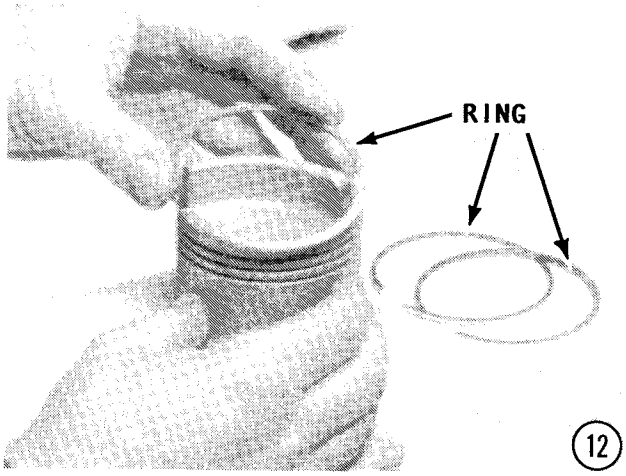
Repeat Steps 7 thru 12 for the other pistons and rods.

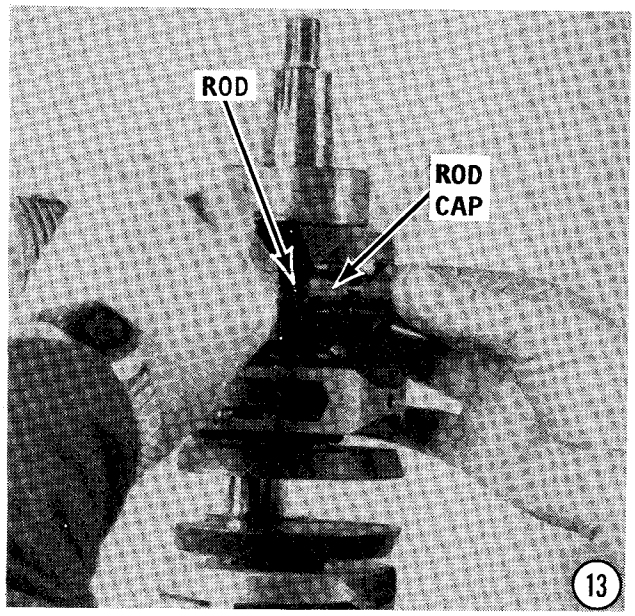
13- Work each piston one at-a-time. Remove the rod cap from the rod. (The caps were temporarily attached to the rods immediately after removal to ensure they would not become separated.) The manufacturer recommends new rod cap bolts and nuts. The small cost involved is justified compared with the time and expense of the powerhead overhaul work. Therefore, **DISCARD** the cap bolts and nuts. Apply a small



Assembled piston and rod ready for installation into the powerhead. Notice the relationship of the intake and exhaust deflector on the piston crown to the position of the rod.







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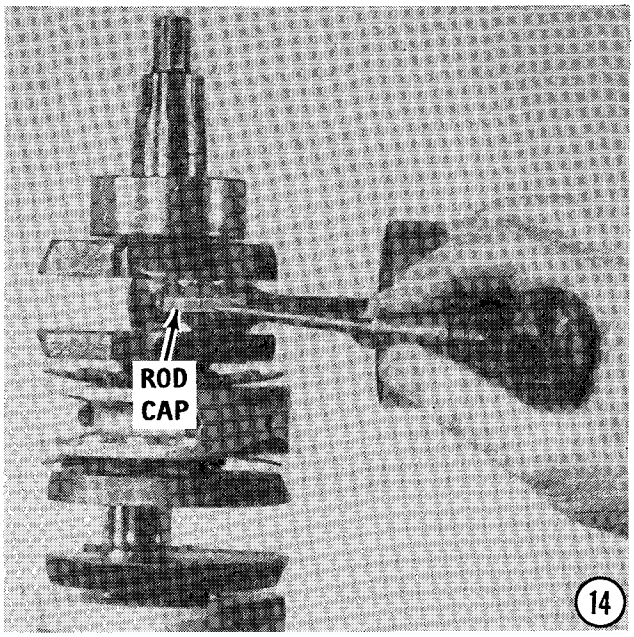

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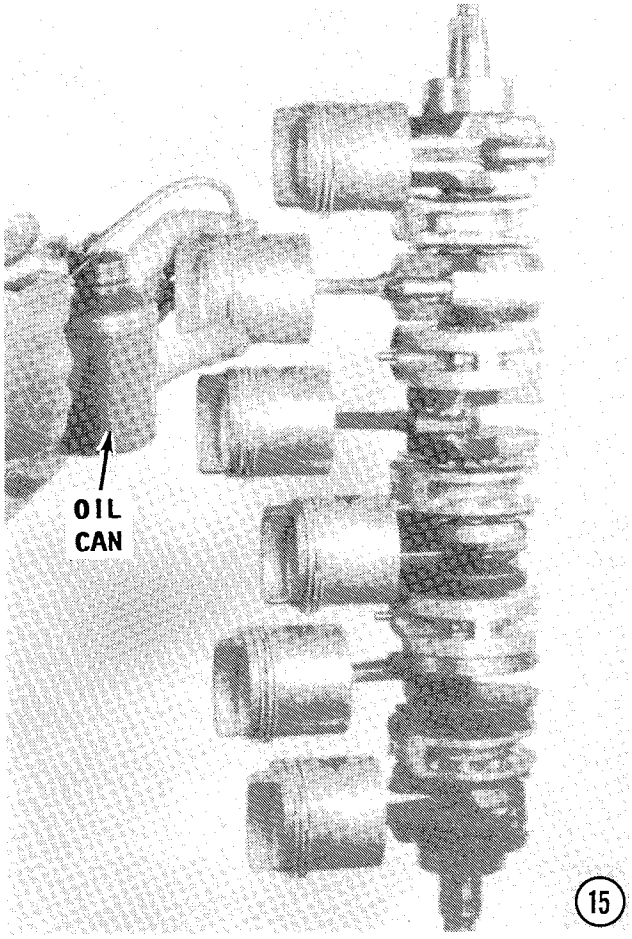
amount of Multipurpose Lubricant, or equivalent, onto each bearing race half to hold the roller bearings and retainers in place. Insert the retainer into the race, and then insert the roller bearings into the retainers.

NEVER mix new roller bearings with used bearings in the same race. If some of the bearings require replacement, **ALL** bearings must be replaced. Position the connecting rod and cap onto the crankshaft throw with the etched marks aligned. **ALWAYS** clean new or old connecting rod bolts and nuts with solvent. New bolts and nuts have a protective coating to protect the threads during shipment. This coating **MUST** be removed. Blow them dry with compressed air.

NEVER oil the nuts or bolts prior to installation. Install the new cleaned rod bolts and nuts and bring them up snug. Tighten the nuts alternately in three stages, to a torque value of 180 in lb (20Nm). On the first stage, tighten to 1/3 the torque value. On the second stage, tighten to 2/3 the total torque value. Finally, on the third and last stage, tighten to the full torque value.

14- After the nuts have been tightened properly, rotate the connecting rod and verify that it turns freely without any evidence of binding or "rough" spots. If a "rough" spot is felt, remove the rod cap, check the roller bearings, retainer, and race, then install the cap again. Repeat the procedure in this step for each connecting rod.

15- Apply a liberal amount of lubrication to all crankshaft assembly parts prior to installation into the powerhead.



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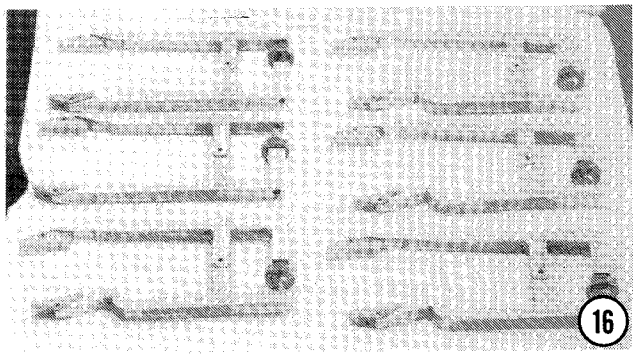
WORDS FROM EXPERIENCE

There is no easy way to install the assembled pistons and crankshaft into the block. Without ring compressor tools, the job is even more difficult. Six compressors, two straight ones, and four off-set, are needed. Marine ring compressor tools are usually available at modest cost from the local dealer.

16- Use the straight ring compressors on the No. 1 and No. 2 pistons. Use the off-set ring compressors on the remaining four pistons.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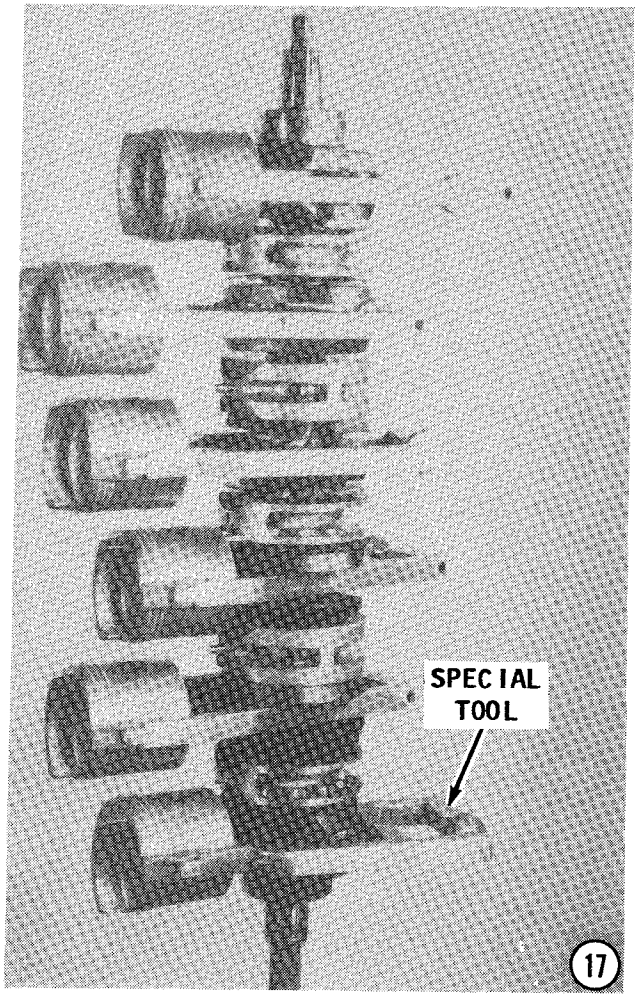
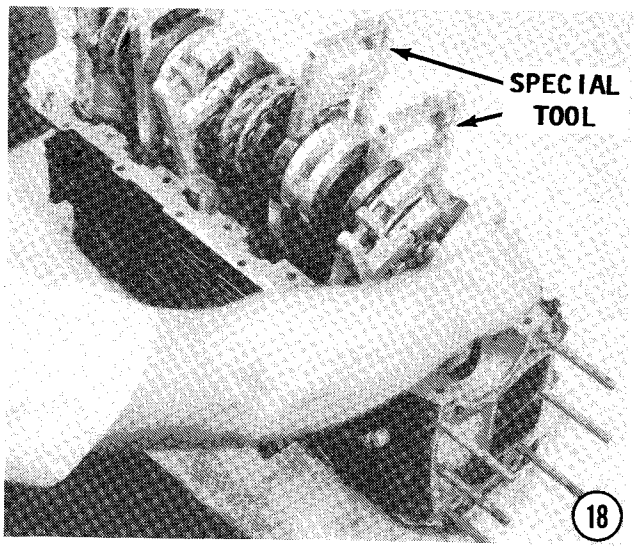
17- Place the ring compressor tool over the crankshaft and down the skirt of the piston onto the rings. Begin to tighten the tool onto the rings, and at the same time, check to be sure the ring ends are over the piston pin. Continue to tighten the tool until the rings are almost flush with the surface of the piston. Repeat the procedure for the other pistons.

18- Insert the reed block locating pins into the block, if they were removed. **CHECK** to be sure the flywheel end of the crankshaft is facing the top of the engine. (Would you believe, the crankshaft could be installed upside down?) Check to be sure **EACH** piston is facing the proper direction, the slope area toward the exhaust port of the block and the intake side of the deflector toward the intake port. If a piston has been installed onto the rod improperly, the piston pin will have to be removed, the piston rotated 180°, and the piston pin installed again.

Now, lower the piston and crankshaft assembly into the cylinder block with one

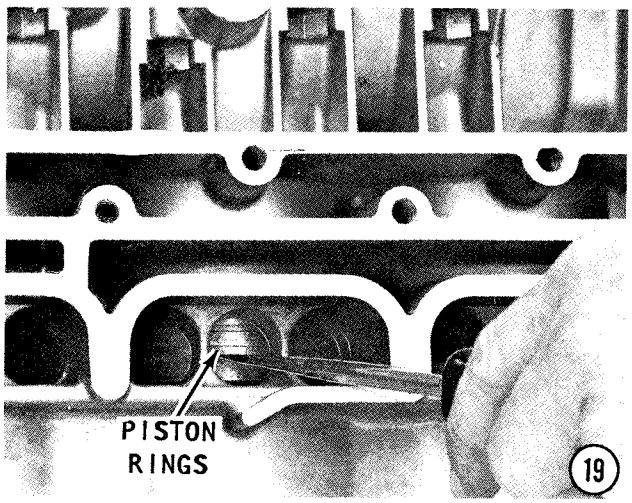




piston down. Work the "down" piston into the cylinder bore and at the same time, lower the crankshaft, reed block, and the other pistons downward. When the second piston reaches the cylinder bore in the cylinder block, work both pistons and the crankshaft assembly downward. When the third piston reaches the cylinder, work all three into the cylinder bores. Continue until each piston is worked into the cylinder bore. As a piston is worked into the cylinder bore, remove the ring compressor from that piston. Continue working the pistons into the cylinder bores until the reed blocks make contact with the cylinder block.

Align each reed block with the locating pin in the cylinder block, and then push the complete crankshaft assembly into final position in the block.

19- Check to be sure each piston ring has spring tension. This is accomplished by **CAREFULLY** pressing on each ring with a screwdriver extended through the intake



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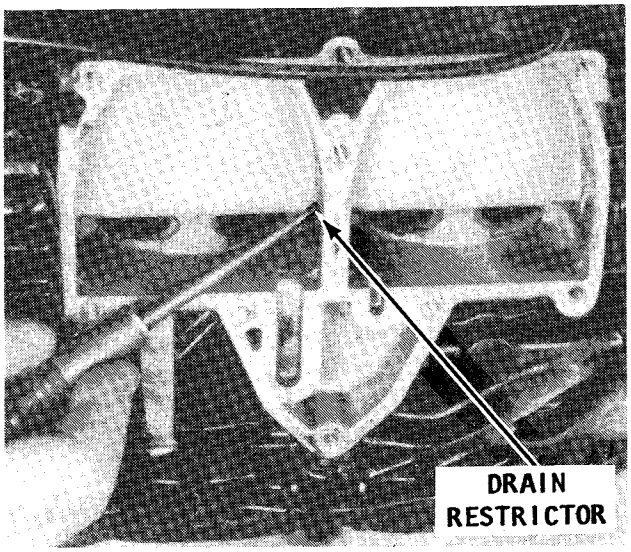
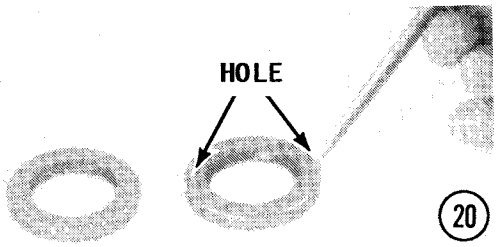
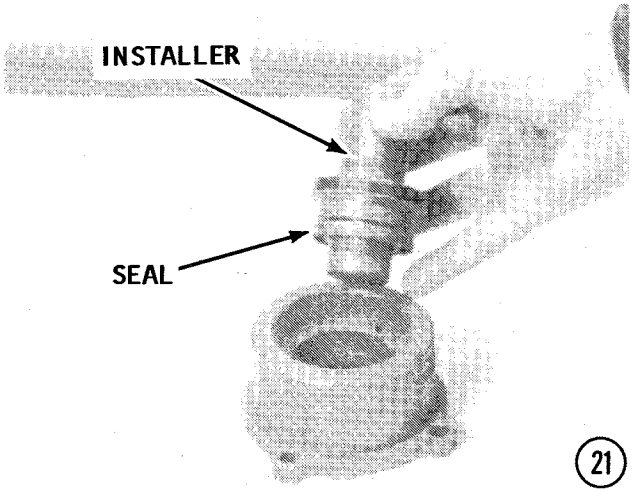
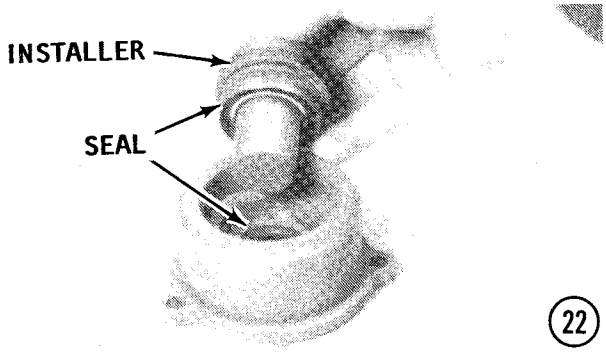


Checking to be sure the drain restrictor is in place.



Lower crankshaft oil seals. If one of the seals has holes, as shown, then that seal must be installed as the bottom one of the two.





ports. If spring tension cannot be felt (the spring fails to return to its original position) the ring was probably broken during the piston and crankshaft installation process. **TAKE CARE** not to burr the piston rings while checking for spring tension.

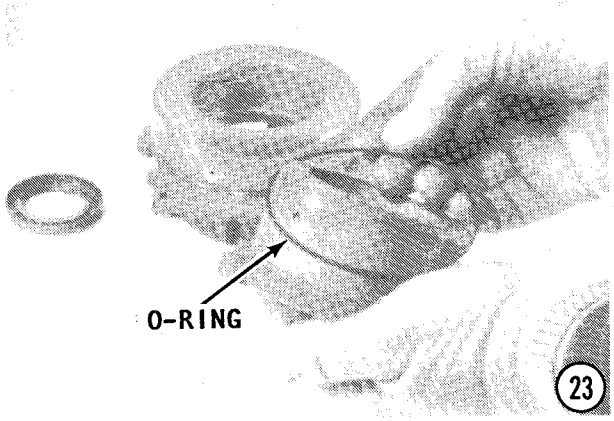
20- Apply a coating of Loctite Type "A" to the outer diameter of all the oil seals. The proper size mandrel from Bearing Removal and Installation Kit C-91-31229A1, must be used for seal installation. Press the seal into the upper end cap with the lip of the seal toward the **INSIDE** of the cylinder block. Clean away any excess Loctite.

21- Press the outer seal into the lower end cap with the lip of the seal toward the **OUTSIDE** of the cylinder block. Clean away any excess Loctite.

22- Press the inner oil seal into the lower end cap with the lip of the seal toward the **OUTSIDE** of the cylinder block. Continue pressing the seal into place until the seal surface is flush with the bottom of the bearing. Clean away any excess Loctite.

23- Place the O-rings onto the end caps. Apply a coating of Multipurpose Lubricant to the O-rings and lips of the oil seals. With the original shims intact, temporarily install the upper and lower end caps onto the crankshaft and secure the crankshaft to the cylinder block with the end cap bolts. **DO NOT** install the crankcase cover.

24- Determine the crankshaft end play in the following manner: With one hand, hold the crankshaft from bouncing back. With the other hand and a soft-headed mallet, tap the crankshaft toward the stud end of the cylinder block. Hold the crankshaft in this position and measure the distance between the inner face of the end cap and the top (first) counterweight of the crankshaft with a feeler gauge. This measure-



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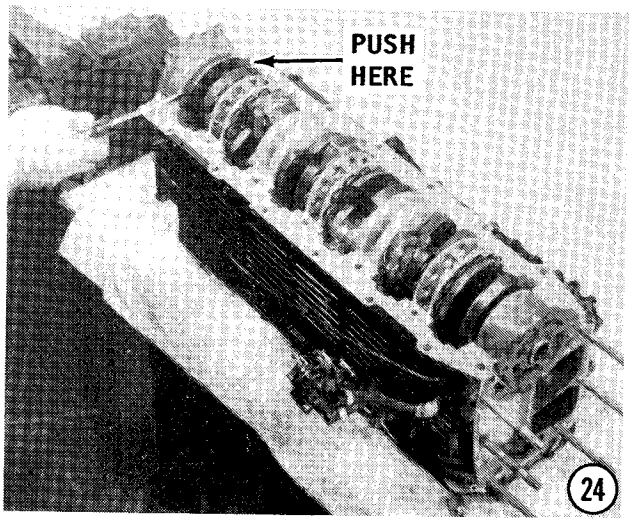
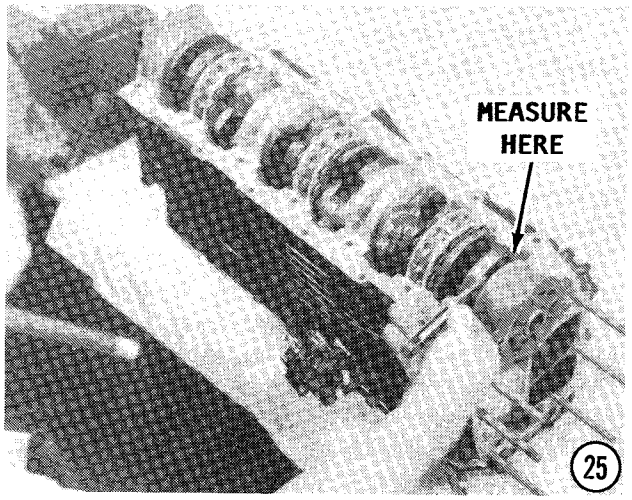


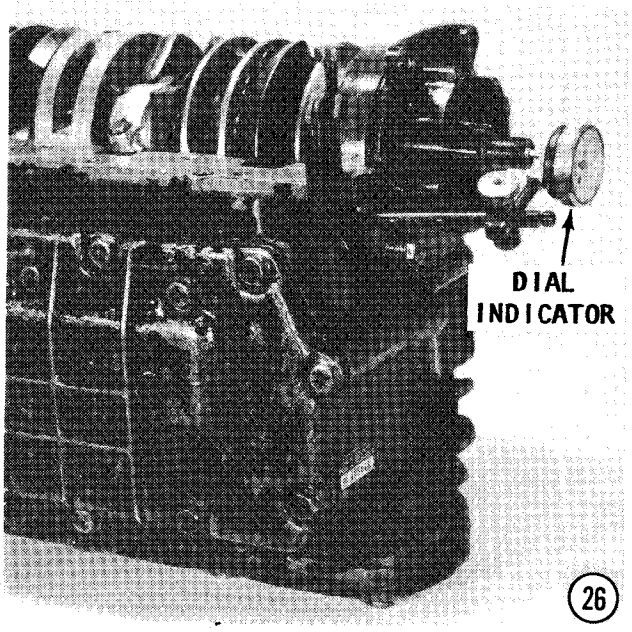
ment should be approximately 0.050" (1.27mm).

25- Now, tap the crankshaft in the opposite direction, and again measure the distance between the inner face of the end cap and the top counterweight of the crankshaft. Subtract the first measurement from the second. The difference between the two measurements is the crankshaft end play. The end play should be 0.004 - 0.012" (0.10 - 0.30mm). If the final end play measurement is not within this tolerance, adjust the end play by adding shim material to increase end play or removing shim material to decrease end play.

Alternate Method

26- A more accurate method, and one recommended by the manufacturer, is to install a dial indicator at the upper end of the crankshaft, as shown. Now, move the crankshaft as far as possible in both directions and record the amount of movement.

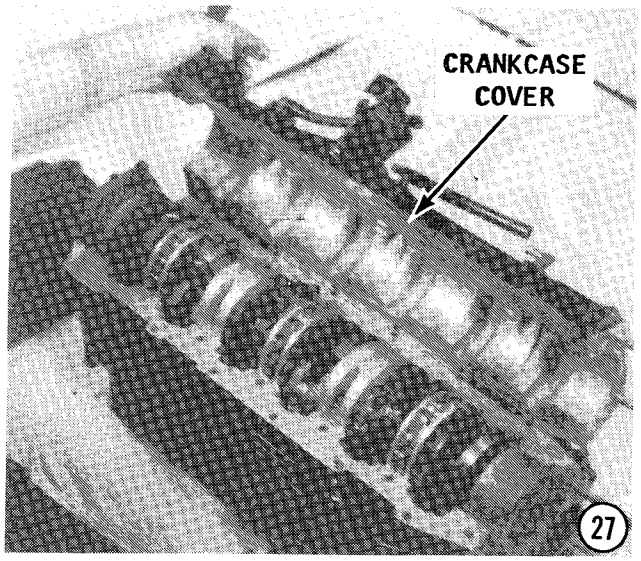




Remember, to insert an equal amount of shim material at both ends to ensure each throw will be aligned with the center of the cylinder.

CRITICAL WORDS: The amount of shim material between the upper end cap and the cylinder block, and the amount of shim material between the lower end cap and cylinder block should be approximately the same. This is the **ONLY** way to ensure the crankpin throws are centered over the cylinder bores.

After the end play adjustment has been satisfactorily completed, loosen the end cap to cylinder block bolts several turns. Slide the end caps away from the cylinder block to permit the crankcase cover to be installed.



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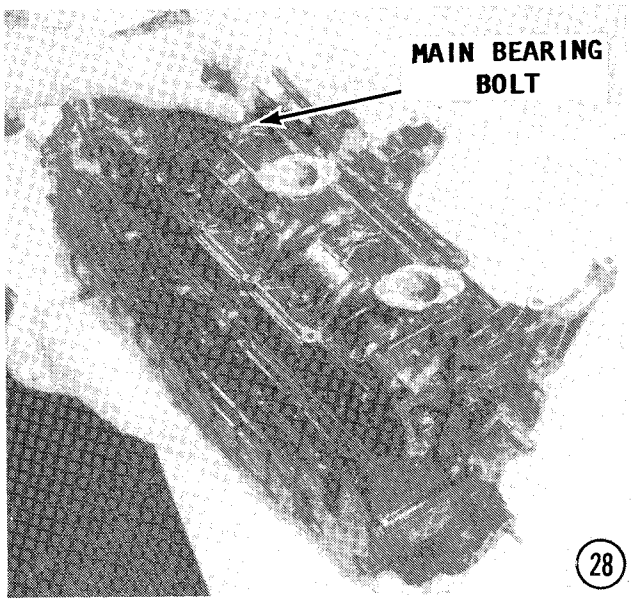


POWERHEAD ASSEMBLING

27- Before mating the crankcase cover and the block, check to be sure:

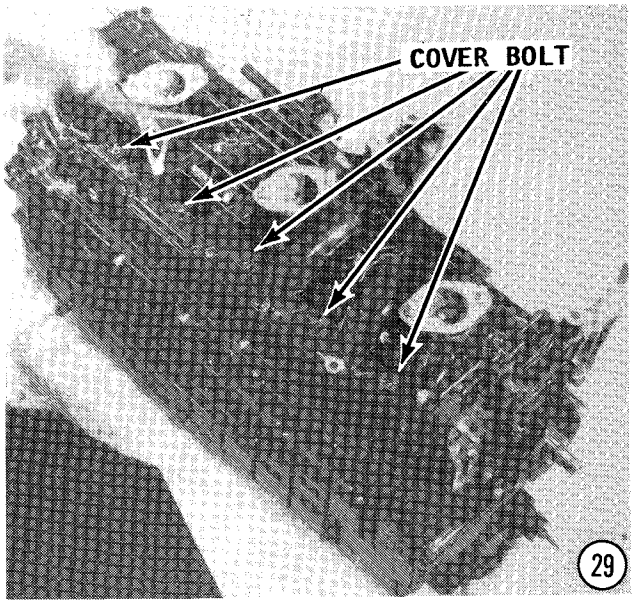
a- The mating surfaces are clean. **NEVER** use any kind of tool or abrasive material to clean the surfaces. Use only solvent and elbow grease.

b- The crankshaft is properly seated.

c- The rod caps have been correctly installed.

d- The reed blocks are properly seated into the cylinder block.

Use Loctite Primer "T" to clean the crankcase cover and cylinder block surfaces. Coat the mating surfaces of the crankcase cover and the cylinder block with a thin coating of Permatex 2C-12 Sealer, or equivalent. Apply the sealer sparingly, and **TAKE CARE** not to get any sealer near the bleed system holes. Position the crankcase cover in place on the cylinder block.

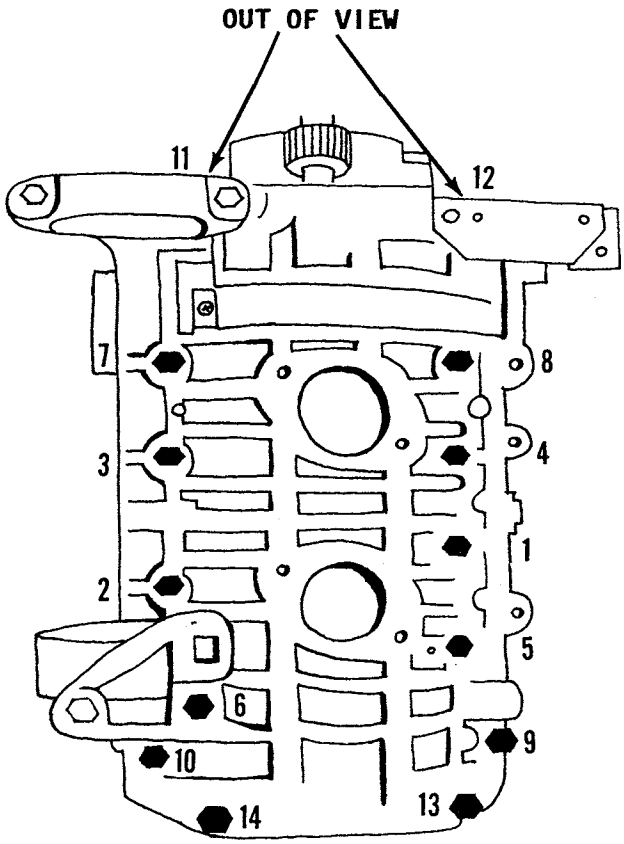


Center the reed cage in the carburetor inlet.

28- Install and tighten the cover bolts to a torque value of 200 in lb (22Nm).

A torque wrench is essential to correctly assemble the powerhead. **NEVER** attempt to assemble a powerhead without a torque wrench. Attaching bolts **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. Tighten all bolts to 1/3 the torque value, then repeat the sequence tightening to 2/3 the torque value. Finally, on the third and last sequence, tighten to the full torque value.

Clean off any excess sealer from the crankcase cover and cylinder block. Install and tighten the end cap bolts to a torque value of 150 in lb (16.5Nm).



Tightening sequence for the crankcase cover of a 4-cylinder powerhead. The sequence is similar for any in-line powerhead. Actually, since about 1985, the manufacturer has given general instructions for the tightening sequence for almost any item as: "Begin in the center and work alternately and evenly toward both ends, in three sequences", as explained in the text.

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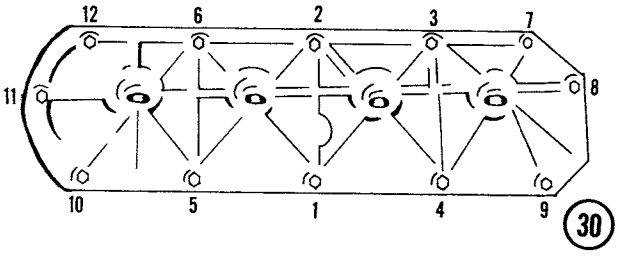


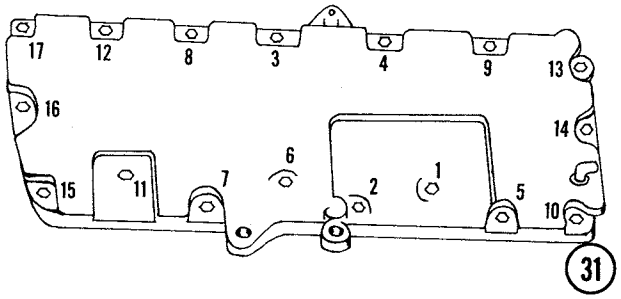
Insert the flywheel key into the crankshaft keyway, and then slide the flywheel into place. Now, rotate the crankshaft several turns and check to be sure it turns freely with no binding or "rough" spots. Blow compressed air through the bleed system to prevent any sealer that may have entered the bleed system, from blocking the system. Remove the flywheel and key.

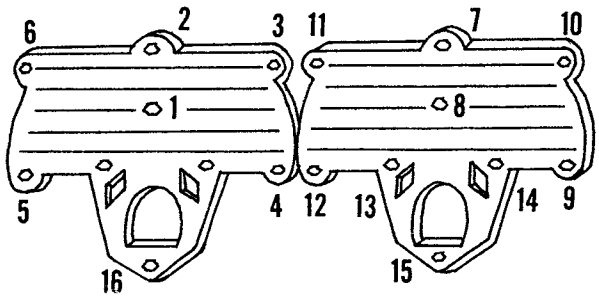
29- Check to be sure the restrictors are in place in the drilled passages of the transfer ports. Install the transfer port cover gasket and cover. Tighten the attaching hardware to a torque value of 60 in lb (6.6Nm) for models under 80hp or 85 in lb (10Nm) for models 80hp and above.

Attaching bolts **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. Tighten all bolts to 1/3 the torque value, then repeat the sequence tightening to 2/3 the torque value. Finally, on the third and last sequence, tighten to the full torque value.

30- Install the cylinder block cover gasket and cover. Tighten the attaching bolts in the sequence shown in the accompanying illustration, to a torque value of 70 in lb (7.7Nm) for models under 80hp or 85 in lb (10Nm) for models 80hp and above.

Attaching bolts **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. Tighten all bolts to 1/3 the torque value, then repeat the sequence tightening to 2/3 the torque value. Finally, on the third and last sequence, tighten to the full torque value.





Tightening sequence for the transfer cover bolts.

31- Apply a small amount of Anti-Corrosion Grease in the following areas to prevent corrosion damage:

Onto each exhaust baffle gasket.

Into each baffle.

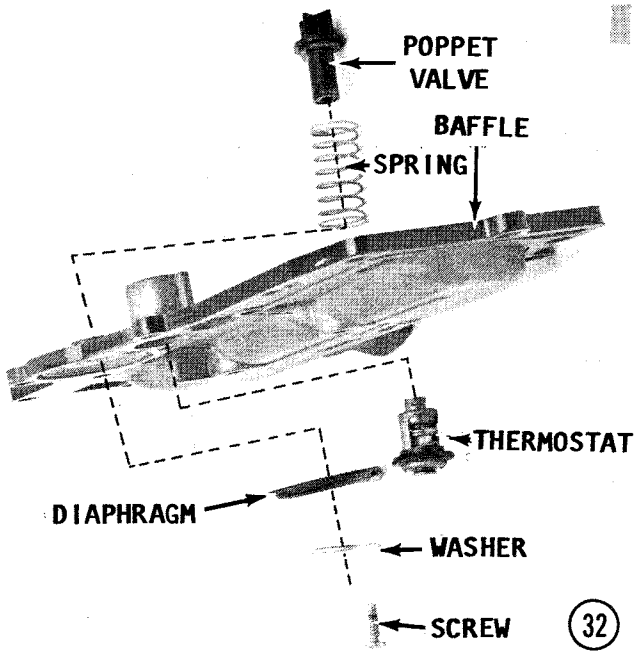
Onto all bolt threads.

Install the exhaust baffle gasket, the baffle, the cover gasket and the exhaust cover. Tighten the cover bolts to a torque value of 200 in lb (22Nm) for models under 80hp or 250 in lb (29Nm) for models 80hp and above.

Attaching bolts **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. Tighten all bolts to 1/3 the torque value, then repeat the sequence tightening to 2/3 the torque value. Finally, on the third and last sequence, tighten to the full torque value.

32- If the thermostat was removed, install the poppet valve, thermostat, and cover.

Tighten the attaching screws alternately to a torque value of 150 in lb (17Nm).



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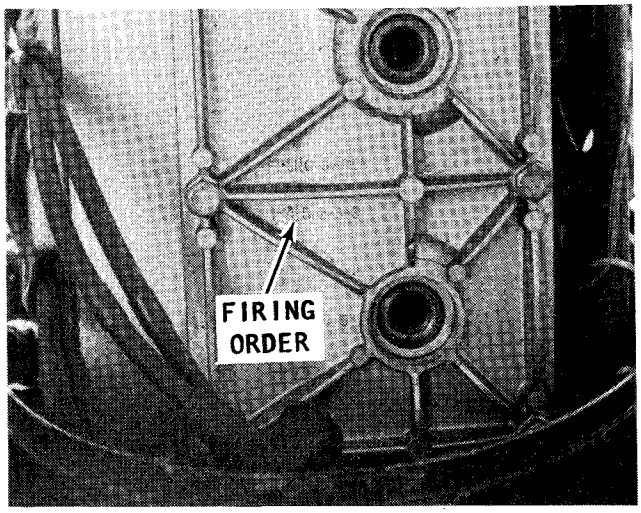
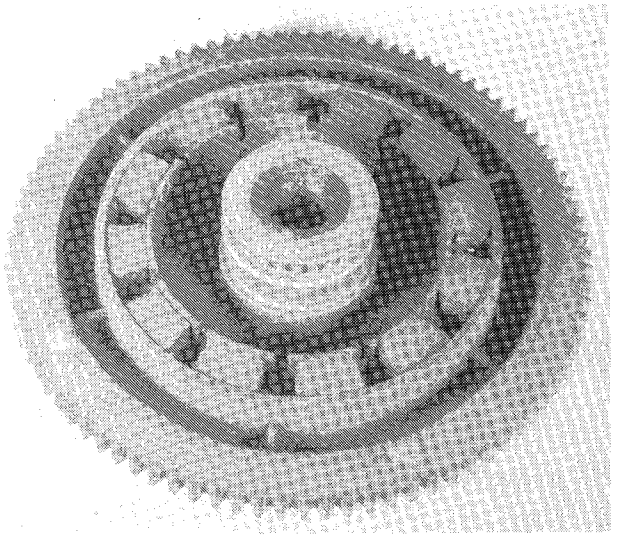


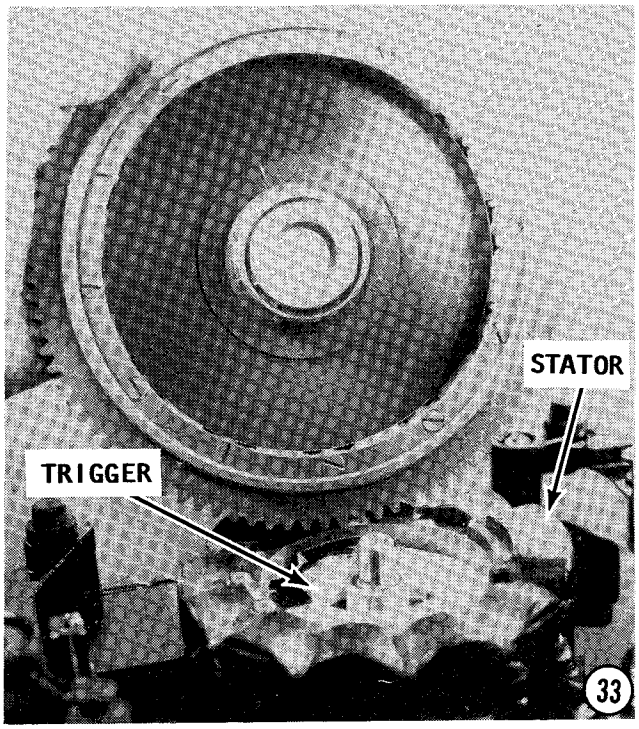
The firing order is embossed on the water cover plate for the powerheads covered in this manual.

Position **NEW** gaskets onto the carburetor mounting studs. Install the carburetor assemblies onto the crankcase and tighten the nuts alternately to a torque value of 150 in lb (17Nm). Install the starter, and tighten the attaching bolts to a torque value of 180 in lb (20Nm). Install the fuel pump and tighten the attaching screws to a torque value of 30 in lb (3Nm). If a distributor is used, install the distributor onto the crankcase and secure it with the two bolts. See Chapter 6.

33- If a trigger assembly is used, place the assembly over the crankshaft onto the block. If a timing belt is used, be sure to install the belt before the stator is installed. Install the stator. Apply a coating of "Blue" Loctite, product No. 21, or equivalent, to the stator attaching screws, and then install



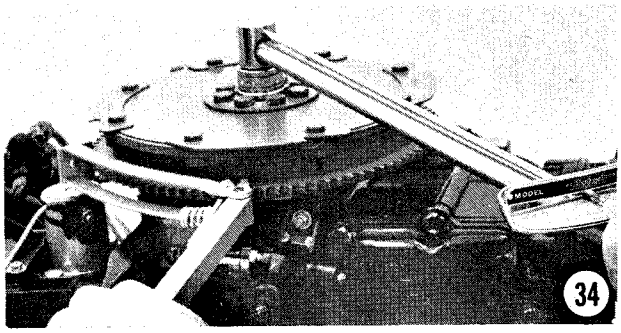
Always check the flywheel carefully to be sure particles of metal have not become stuck to the magnets.



the screws and tighten them to a torque value of 60 in lb (7Nm).

Insert the flywheel key in the crankshaft keyway. Check the inside rim of the flywheel to be sure metal particles are not stuck to the flywheel magnets. Check to be sure the inside taper of the flywheel and the taper on the crankshaft are clean of dirt or oil, to prevent the flywheel from "walking" on the crankshaft during operation. Slide the flywheel down the crankshaft with the keyway in the flywheel aligned with the key on the crankshaft. Rotate the flywheel clockwise and check to be sure the flywheel does not contact any part of the magneto or the wiring. If a belt is used, work the flywheel pulley around the belt. Slide a flat washer onto the crankshaft, and then thread the flywheel nut onto the crankshaft.

34- Tighten the flywheel nut to a torque value of 65 ft lb (85Nm) for all models under 80hp or 100 ft lb (136Nm) for all models 80hp and above.



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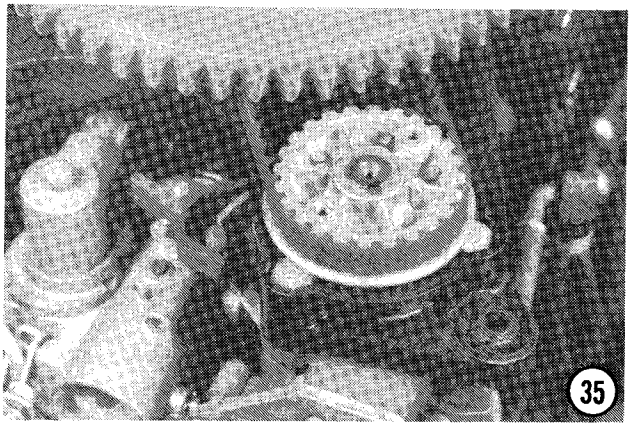
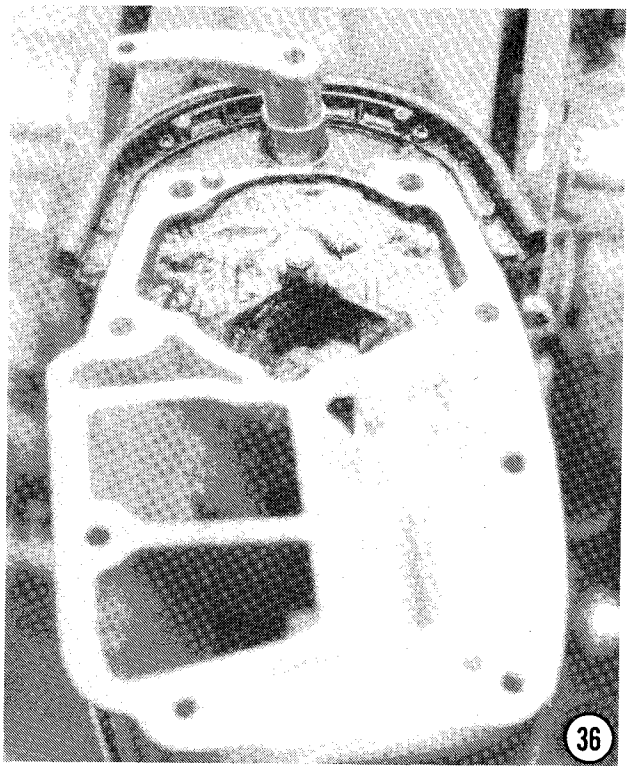


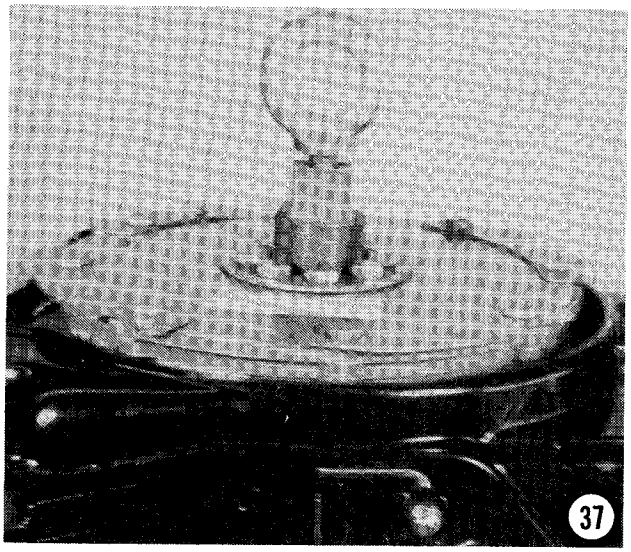
35- If a distributor is used, install the belt according to the procedures and specifications outlined in Chapter 6. After the belt is properly in place, per Chapter 6, install the pulley cover and attaching nut.

POWERHEAD INSTALLATION

36- Check to be sure old gasket material has been removed from the intermediate housing extension plate and the powerhead. These two mating surfaces **MUST** be clean. Position a **NEW** gasket in place.

37- Thread a lifting eye onto the end of the crankshaft as far as it will go. Use a suitable hoist and lower the power head onto the intermediate housing plate with the studs on the powerhead aligned with the holes in the intermediate housing. Use care





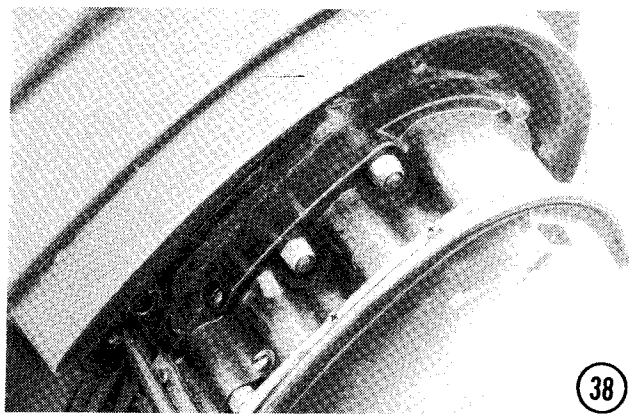
to prevent the studs from damaging the gasket. As the powerhead is slowly lowered, it will probably be necessary to rotate the flywheel slightly to allow the splines of the driveshaft to index with the crankshaft.

38- Thread the nuts onto the powerhead studs. Tighten the nuts alternately to a torque value of 180 in lb (20Nm) for models under 80hp or 240 in lb (27Nm) for all models 80hp and above.

The nuts **MUST** be tightened to the required torque value in three progressive stages. Tighten all bolts to 1/3 the torque value, then repeat the sequence tightening to 2/3 the torque value. Finally, on the third and last sequence, tighten to the full torque value.

Remove the lifting eye from the crankshaft.

Install the rear cowl bracket. Connect the water hose to the tattle-tale on the bracket. Connect the water hose to the exhaust extension plate connection. Connect the fuel line to the fuel pump. Connect the shift link. Install and tighten the nut to the shift bracket.



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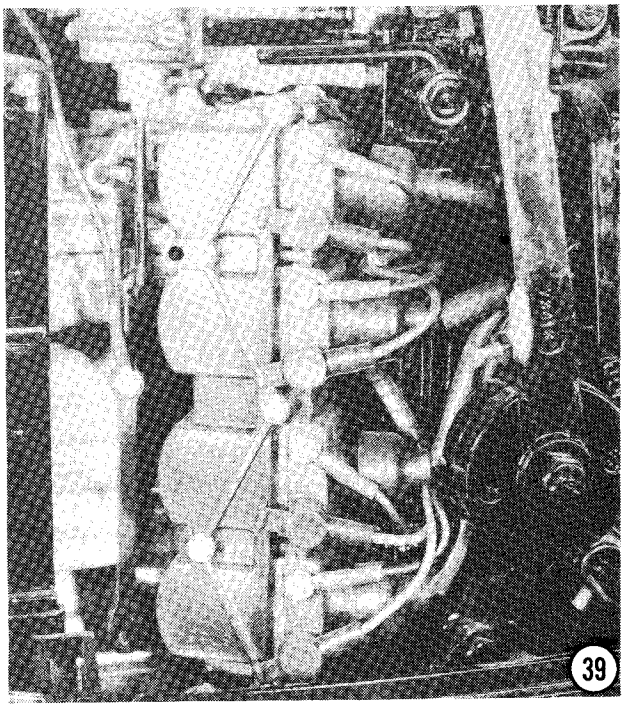
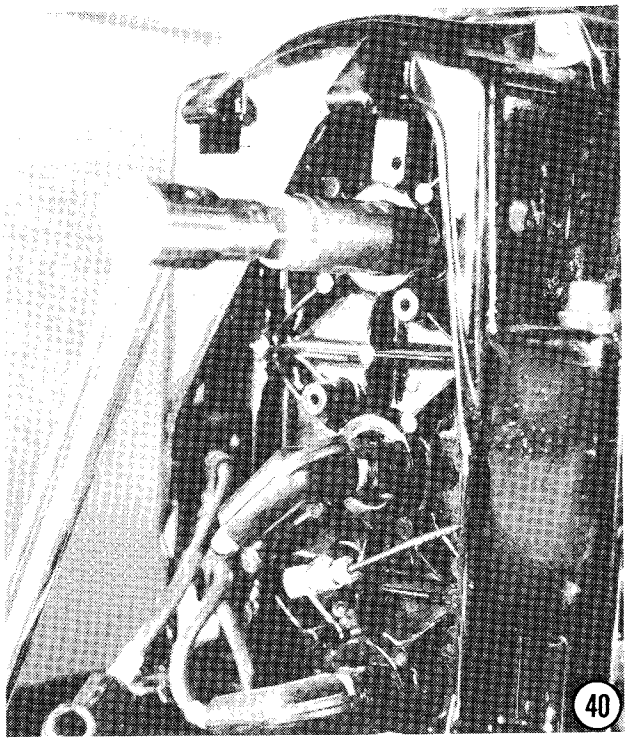


39- Connect the electrical wires to their proper terminals. Use the notes or photographs taken prior to disassembly as a guide. Refer to the wiring diagram in the Appendix for further assistance. Cover all connections with liquid Neoprene. Install all of the Sta-straps to the wiring and fuel lines. Place the wire harness in its original position prior to disassembly.

40- Install the spark plugs and tighten them to a torque value of 20 ft lb (26Nm).



Connect the high-tension leads to the proper spark plugs.

41- Mount the engine in a test tank. Connect the fuel lines. Start the engine and follow the break-in procedures given after the caution.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Break-in Procedures

As soon as the engine starts, **CHECK** to be sure the water pump is operating. If the water pump is operating, a water mist will be discharged from the exhaust relief holes at the rear of the drive shaft housing.

During the first 10 hours of operation, **DO NOT** operate the engine at full throttle (except for **VERY** short periods). Perform the break-in as follows:

a- Operate at 1/2 throttle, approximately 2500 to 3500 rpm, for 2 hours.

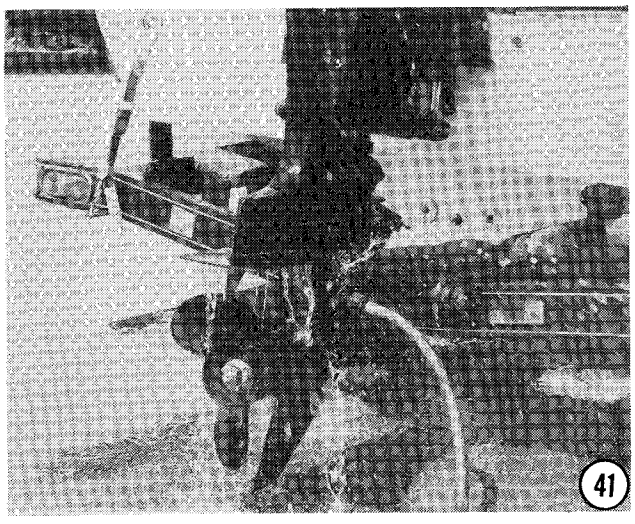
b- Operate at any speed after 2 hours **BUT NOT** at sustained full throttle until another 8 hours of operation.

c- Mix gasoline and oil during the break-in period, total of 10 hours, at a ratio of 25:1.

d- While the engine is operating during the initial period, check the fuel, exhaust, and water systems for leaks.

e- Refer to Chapter 6 for synchronizing procedures.

After the test period, disconnect the fuel line. Remove the engine from the test tank. Install the engine cowl.



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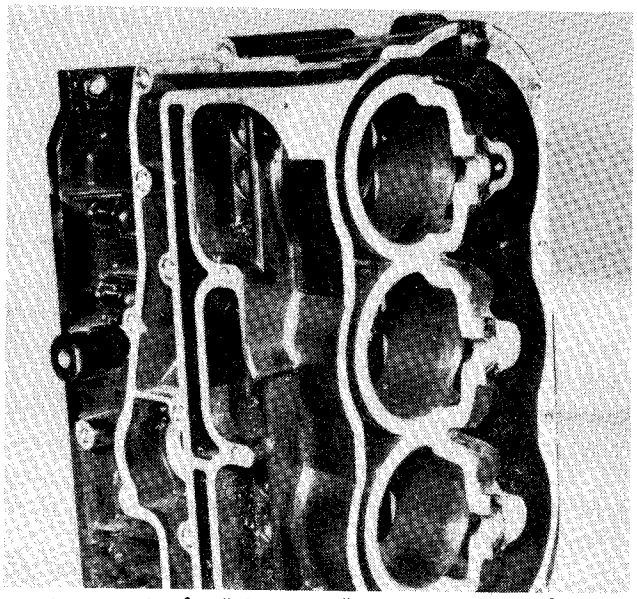
8-3 REDESIGNED BLOCK ON 75HP & 90HP 3- CYLINDER AND 100HP & 115HP 4- CYLINDER POWERHEADS

ADVICE

Before commencing any work on the powerhead, an understanding of two-cycle engine operation will be most helpful. Therefore, it would be well worth the time to study the principles of two-cycle engines, as outlined briefly in Section 8-1 of this chapter. A Polaroid, or equivalent instant-type camera is an extremely useful item, providing the means to accurately record the arrangement of parts and wire connections **BEFORE** the disassembly work begins. Such a record is most valuable during the assembly work.

In order to obtain the maximum results from the overhaul work, the instructions outlined in this section for removal, disassembly, assembling and installation should be followed in the sequence given. If complete disassembly is not required, begin the assembling sequence at that point, after following the Cleaning and Inspecting procedures for the items disassembled. Cleaning and Inspecting procedures are given at the end of the chapter beginning on Page 8-95.

Complete disassembly of the powerhead is usually not necessary to perform some tasks, such as one or more of the following:



Photograph of a "classroom" type cutaway redesigned cylinder block, used on large bore 3- and 4-cylinder powerheads since 1987. The block and head are cast in one piece. Only the cylinder cover is removable to gain access to the water jacket surrounding the cylinder walls.

a- To inspect the cylinder walls and pistons.

b- Minor repairs on supporting components. Example, the ignition system, carburetors, and the reed blocks.

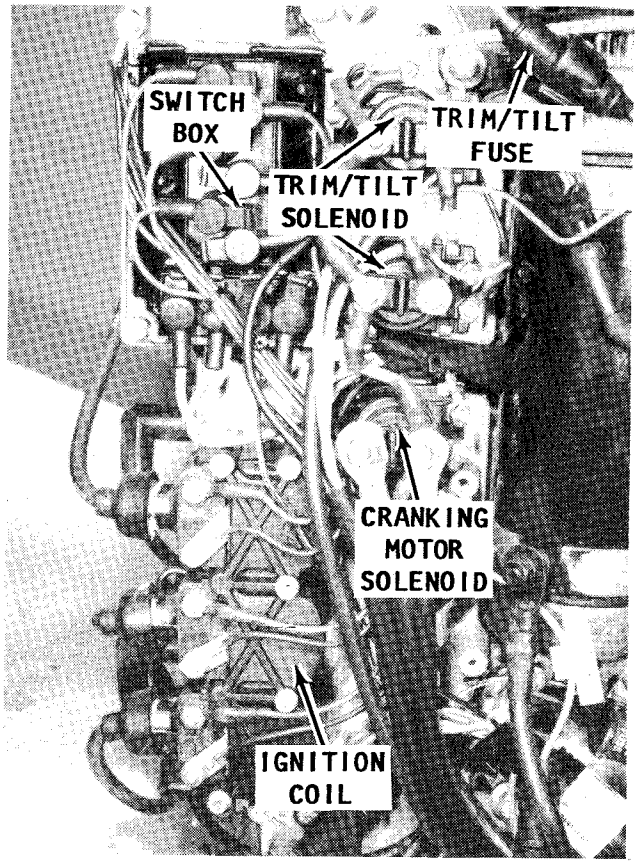
c- Operational check of the thermostat and temperature sender.

POWERHEAD REMOVAL

The following procedures are accompanied by a series of captioned illustrations rather than sequential steps.

Disconnect the engine battery cables from the battery terminals. Disconnect the engine fuel line from the fuel tank. Remove the front engine cowling cover. Remove the port and starboard halves of the engine cowling. Separate the electrical extension harness connectors. Disconnect the remote control cables from the powerhead.

STOP, and carefully observe the wiring and hose connections before proceeding. Because there are so many different powerheads and the arrangement is slightly different on each, it is not possible to illustrate



*Take time to study and **TAG** any wire leads disconnected from the ignition plate and surrounding electrical components. The tags will help ensure the leads are reconnected to the proper terminals.*

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each and every one. Even if they were shown, the reader would not be able to identify the powerhead being serviced. Therefore, **TAKE TIME** to make notes and tag the wire leads and hoses. You may elect to follow the practice of many professional mechanics by taking a series of photographs of the powerhead, one from the top, and a couple from the sides showing the wiring and arrangement of parts.

Snip the Sta-strap from the tattle-tale hose at the aft cowl support bracket.

Remove the bolts securing the bracket to the powerhead.

Remove the bolts securing the ignition plate cover to the powerhead.

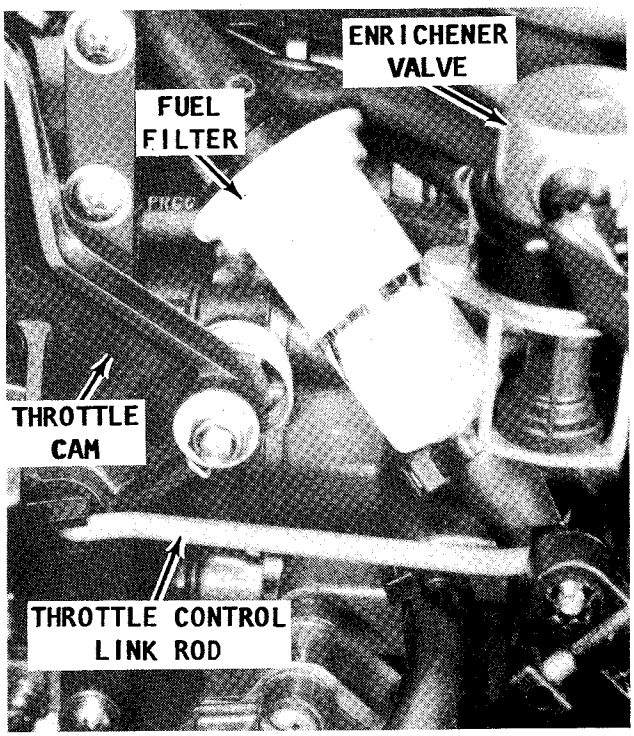
Disconnect the large Black lead from the cranking motor and the large Red lead from the cranking motor solenoid.

Unplug the power trim fuse mounted on the cranking motor.

Loosen, but do **NOT** remove the two Phillips head screws on the clamp securing the main harness to the powerhead. Slide the harness from its retaining clamp.

Disconnect the throttle cable from the throttle lever. Disconnect the shift cable and the shift arm from the shift bracket. Remove the two bolts and the bracket from the powerhead.

Remove a total of eight bolts securing the powerhead to the intermediate housing.



Fuel system and throttle control components on the portside of the powerhead.

Three nuts are located on each side of the powerhead and two more are located on the aft side.

Disconnect the oil inlet hose from the oil pump and plug the line quickly to prevent oil from draining from the oil reservoir. Remove the attaching hardware and lift the reservoir free of the powerhead.

Remove the plastic cap from the end of the crankshaft. Thread a lifting eye on the end of the crankshaft as far as it will go. Using a suitable hoist, lift the powerhead assembly clear of the intermediate housing. Remove all traces of the base gasket.

Disconnect the high tension leads from the spark plugs. **ALWAYS** use a pulling and twisting motion as a precaution against damaging the connection. Remove the spark plugs.

Mount the powerhead onto some type of stand, to facilitate easy access to all parts. **NEVER** attempt to mount the powerhead in a stand secured in a vise. Such an attempt will only lead to damage of the powerhead and possible personal injury. Remove the lifting eye from the crankshaft.

Disconnect the Tan and Black leads from the oil level warning horn at the terminal block on the ignition plate. If the powerhead is also equipped with an oil warning module, disconnect the Purple and Light Blue leads at their quick disconnect fittings. Disconnect the Black lead from the temperature sensor just below the thermostat.

Disconnect the large Yellow cable from the solenoid to the cranking motor.

Remove the four bolts securing the cranking motor to the powerhead and lift the motor free.

Remove the two cowl support bracket bolts from the top of the air box and the two bottom cowl support bracket bolts from the forward end of the powerhead.

Remove the bolt at the fuel joint support and remove the bottom cowling support bracket.

Remove the Phillips head screws securing the air box cover and remove the cover.

Remove the nuts and washers securing the air box to the powerhead, and then remove the air box.

Disconnect the fuel supply line from the fuel filter. Disconnect the inlet hose for the fuel enrichener valve at the **"T"** fitting between the No. 1 and No. 2 carburetors.

On 4-cylinder powerheads, disconnect the the accelerator pump inlet hose from

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the **"T"** fitting between No. 1 and No. 2 carburetors. Disconnect the hoses from the accelerator pump to the No. 3 and No. 4 cylinder check valve fittings. Remove the bolts securing the pump to the block and lift the pump clear.

Snip the Sta-strap from the vapor return hose and remove the hose from the fitting next to the fuel pump.

On all models: Pry the oil pump link rod from the ball joint on the No. 2 carburetor throttle lever.

The carburetors are now only held together with the throttle tie bar. Slide the entire carburetor assembly off the mounting studs.

Disconnect the throttle control link rod between the throttle cam and the throttle lever.

Remove the two hoses from the enrichener valve at their fittings on the intake manifold. Disconnect the Black and Yellow/Black leads from the valve and remove the two securing bolts. Lift the valve, with hoses still attached free from the powerhead.

Remove the three wing nuts securing the plastic flywheel cover to the powerhead. Hold the flywheel from turning with a flywheel strap or with a Flywheel Holder, C-91-52344. Remove the 5/16" flywheel nut and washer.

Install a crankshaft Protector Cap, C-91-24161, onto the end of the crankshaft. Install Flywheel Puller, C-91-73687A1 into the flywheel. These two items are necessary and may be obtained from the local dealer.

BAD NEWS

The crankshaft may very likely be damaged if the protector cap is not used between the crankshaft and the flywheel puller. **NEVER** attempt to use a puller which pulls on the outside edge of the flywheel, or the flywheel may be damaged. **NEVER** hammer on the end of the center bolt of the puller, because such action will surely cause damage either to the crankshaft, or the bearings, or both. **NEVER** use heat as an aid to removing the flywheel. Applying heat may actually seize the flywheel to the crankshaft.

Take up on the puller until the flywheel breaks loose from the crankshaft. Remove the flywheel key from the crankshaft.

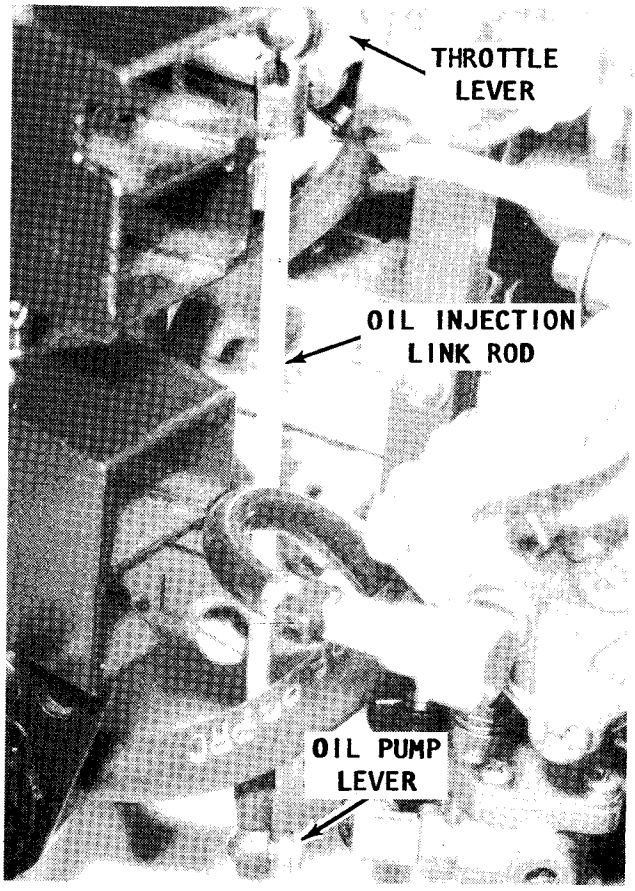
Disconnect the stator wires and trigger wires from the terminals of the switch boxes. Remove the stator assembly from the engine. The stator assembly attaching bolts have been secured in place with Loctite, therefore, they will not back out easily. Remove the locknut securing the trigger plate link rod to the upper end of the vertical throttle lever. Now, pull the link rod swivel clear of the throttle lever.

Remove the trigger and stator plate assembly from the upper end cap.

Remove the three bolts securing the ignition plate to the cylinder block. Lift the ignition plate, together with the electrical components, clear of the cylinder block.

Remove the locknut, and then the throttle cam and bushings from the reed block housing stud. Remove the pivot bolt, and then lift the vertical throttle lever from the cylinder block. **REMEMBER,** a flat washer is installed between the vertical throttle lever and the cylinder block.

Remove the attaching bolts securing the fuel pump assembly to the reed block housing. **TAKE CARE** not to separate the fuel



Make every effort not to disturb the length of the oil injection link rod, when removing the rod from the carburetor and oil pump lever ball joints.

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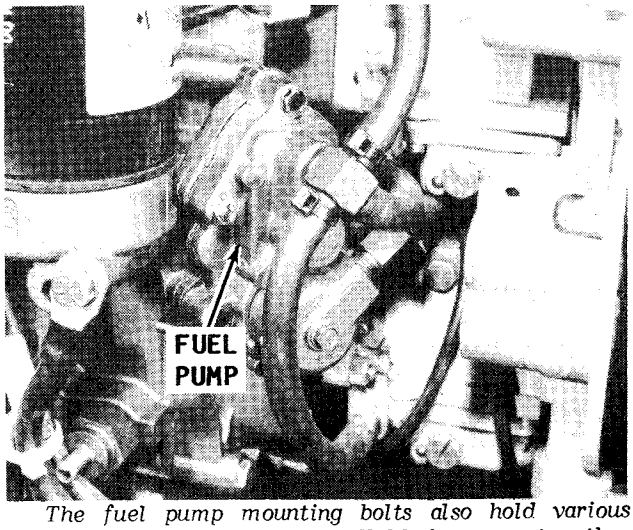
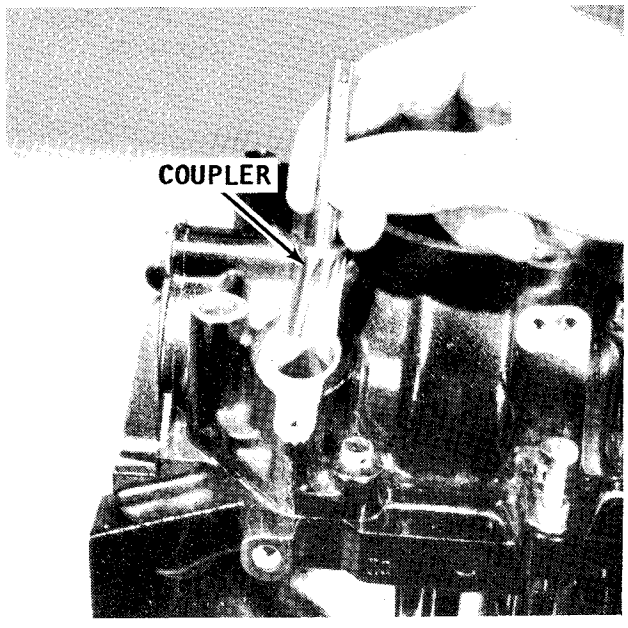


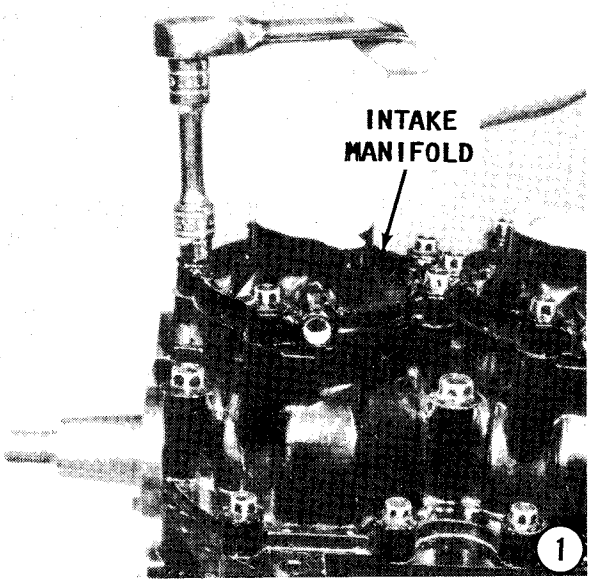
The fuel pump mounting bolts also hold various layers of the pump together. Hold the pump together firmly when removing these bolts.

pump components, and lift the fuel pump assembly from the reed block housing. Insert two of the attaching bolts back through the fuel pump assembly, and then thread a 10-32 nut onto each bolt to prevent the fuel pump parts from separating during the remainder of the powerhead disassembly work.

Disconnect the outlet hose from the oil pump. Plug the end of the hose to prevent foreign matter from entering. Remove the two retaining bolts from the oil pump. Lift the oil pump clear of the powerhead. Remove the O-ring from around the coupler. Reach into the block with a pair of needle nose pliers and withdraw the coupler. **TAKE CARE** not to lose the small plug and



Removing the oil pump coupler from the block.



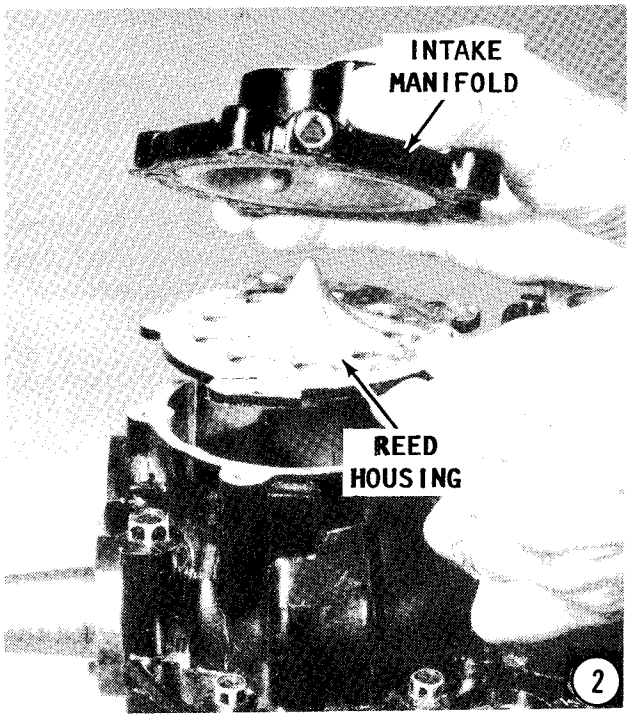
the magnet from the recess in the coupler. Reach in again with the needle nose pliers, and grasp the oil pump shaft. Pull and rotate the shaft slightly **CLOCKWISE** to withdraw the shaft.

Disconnect the bleed hose from the No. 1 cylinder fitting and the lower end cap fitting.

CYLINDER BLOCK DISASSEMBLY

1- Remove the bolts securing the reed housing cover and reed housing to the powerhead.

2- Insert a flat blade screwdriver behind



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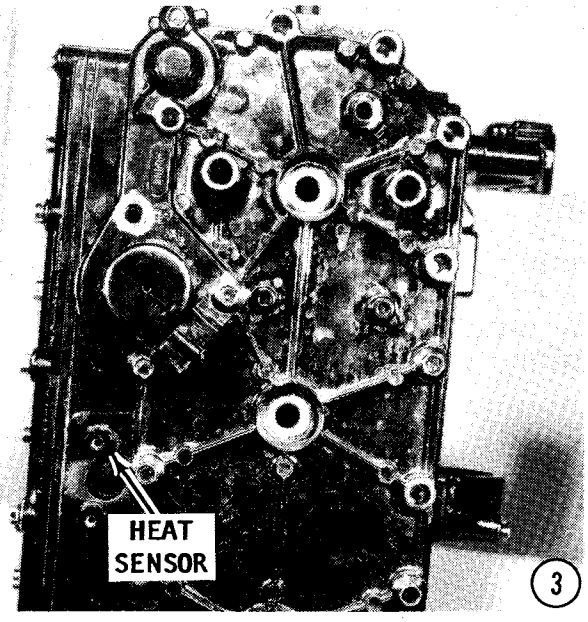


the pry area on the starboard side of the block and pry the cover and housing free.

Remove and discard the gasket on each side of the reed housing.

GOOD WORDS

It is not necessary to disassemble the reed assemblies in order to inspect them. If inspection indicates replacement of a reed assembly component is required, see the Cleaning and Inspecting portion of this chapter, beginning on Page 8-95.

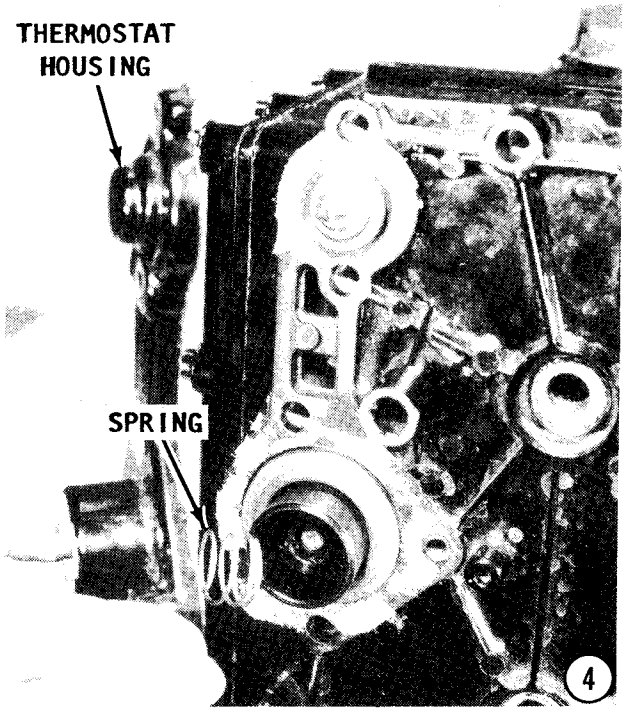
3- Remove the screw on the heat sensor retaining bracket. Insert a small flat blade screwdriver between the sensor and the block and pry the sensor from the sealing grommet.

4- Remove the bolts securing the thermostat housing to the block. If the housing is stuck to the powerhead, tap it lightly with a soft head mallet to jar it free. Remove the spring.

5- Lift out the thermostat and at the same time note the direction the thermostat faces, as an assist in later installation. Remove and discard the thermostat rubber sealing ring. The spring should always face the powerhead. If the thermostat was not installed properly, serious heating problems may have developed in the powerhead.

If **NO** thermostat is found under the housing, purchase and install a new thermostat. Scrape all traces of gasket material from both sealing surfaces to prevent a water leak at this location.

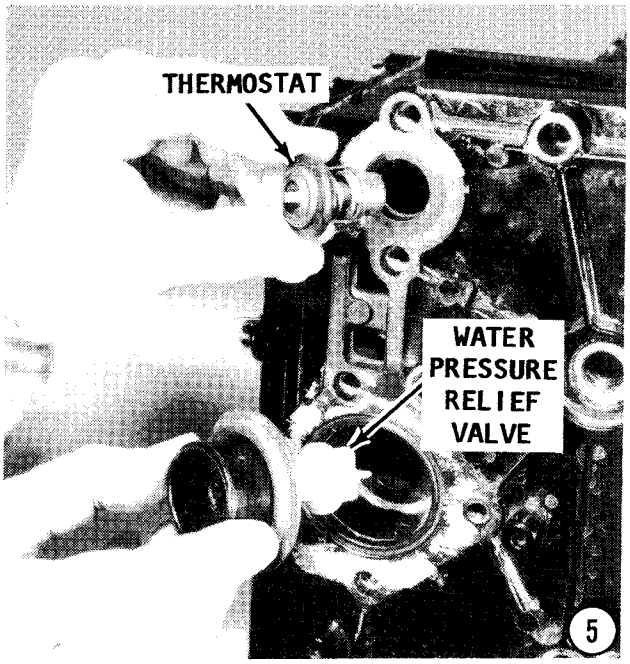
Loosen, but do **NOT** remove the Phillips head screw on the water pressure relief (poppet) valve. Pull the valve assembly from the block.



Water Pressure Relief Valve Removal

FIRST, THESE WORDS

When water pressure in the cooling system reaches a predetermined figure, a pressure relief valve, also referred to as a "poppet valve" is lifted off its seat. While the valve is off its seat, additional cooling water is permitted to bypass the thermostat and circulate through the water jacket.



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If the pressure relief valve is stuck shut due to scale, corrosion, etc., the powerhead will overheat at high rpm. This is a **VERY** common problem on older powerheads, especially units operated in salt water.

Procedures to free a stuck relief valve are drastic, but worth the effort.

Penetrating oil, heat, brute force, any method is acceptable to free a stuck valve. Once a valve is in this condition it must be replaced. Therefore, if removal calls for destroying it with a chisel -- so be it. The valve bore must be cleaned free of any deposits to allow free flow of coolant, essential to powerhead longevity.

6- Note the locations of the clips under two of the cylinder cover retaining bolts, as an assist in later installation. Remove the bolts from the cylinder cover. Special pry areas are provided at the top and bottom of the cover to assist in cover removal. Scrape all traces of gasket material from both sealing surfaces to prevent a water leak at this location.

SPECIAL WORDS

This design block has no head. The combustion chambers of the cylinders are an integral part of the block. Only the cylinder cover is removable to provide access to the water jacket for cleaning and inspecting purposes.

Exhaust Cover Removal

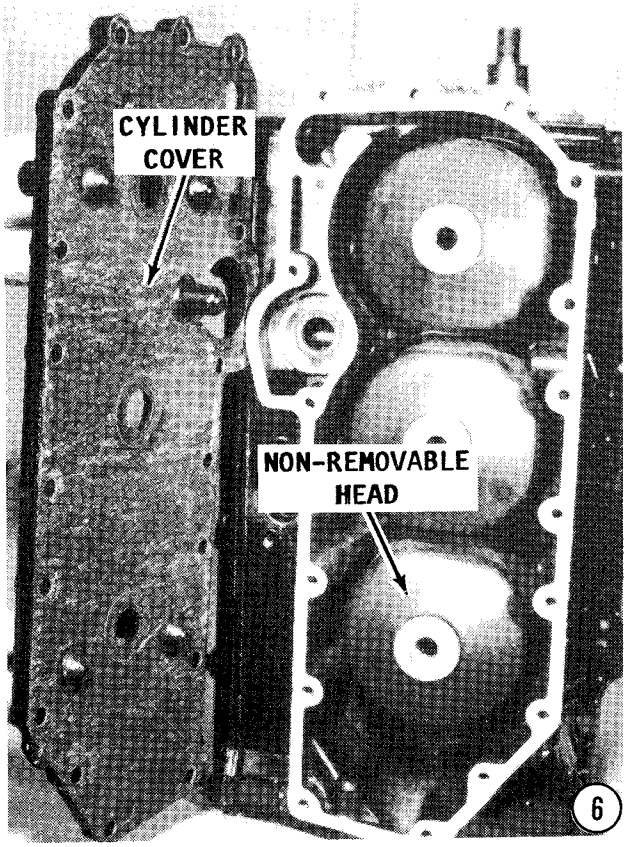
7- Remove the bolts securing the exhaust cover to the powerhead.

8- Remove the exhaust cover, gasket, inner plate, and another gasket. Inspect the inner plate for small pin holes in areas of corrosion. Water in a cylinder could be caused by a defective cover or gasket.

SPECIAL WORDS ON EXHAUST COVERS

The exhaust cover is one of the most neglected items on any outboard powerhead. Seldom are they checked and serviced. Many times a powerhead may be overhauled and returned to service without the exhaust cover ever having been removed.

One reason the exhaust cover is not removed is because the attaching bolts usually become corroded in place. This means the bolts are very difficult to remove, but the work should be done. Heat applied to the bolt head and around the exhaust cover will help in removal. However, some bolts may still be broken. If the bolt is broken it



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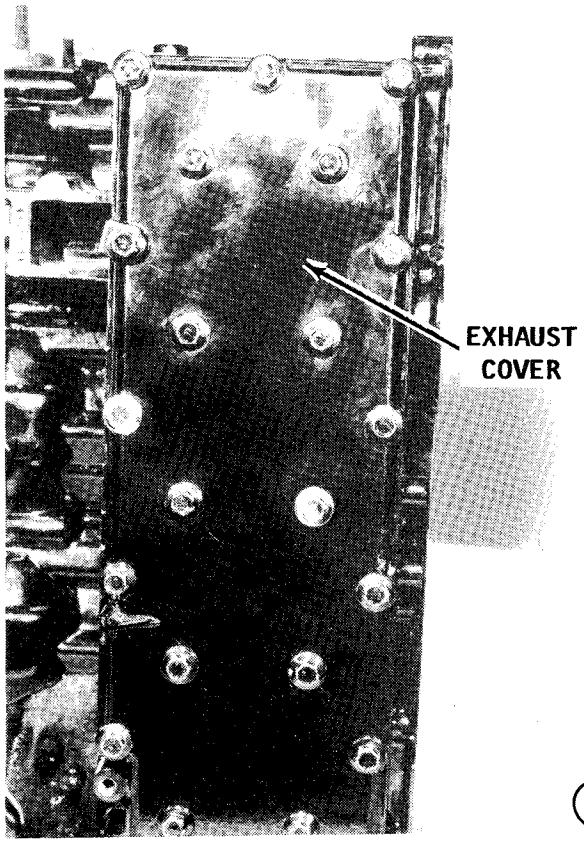

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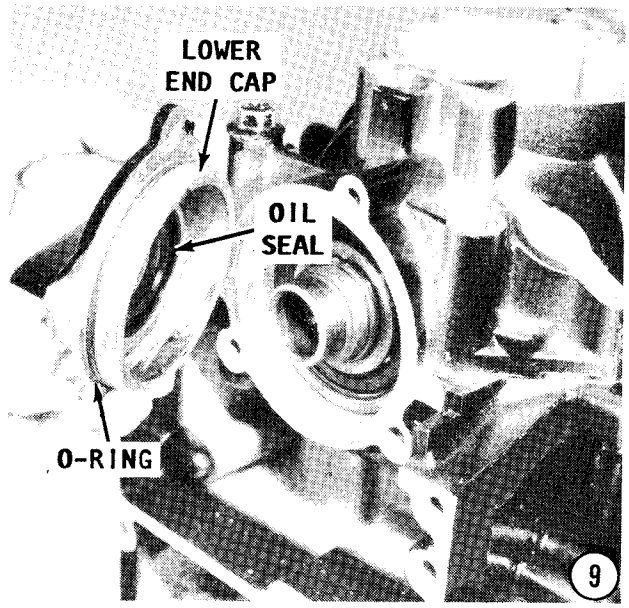
must be drilled out and the hole tapped with new threads.

An exhaust cover is installed over the exhaust ports to allow the exhaust to leave the powerhead and be transferred to the exhaust housing. If the cover was the only item over the exhaust ports, they would become so hot from the exhaust gases they might cause a fire or a person would be severely burned if they came in contact with the cover.

Therefore, an inner plate is installed to help dissipate the exhaust heat. Two gaskets are installed -- one on either side of the inner plate. Water is channeled to circulate between the exhaust cover and the inner plate. This circulating water cools the exhaust cover and prevents it from becoming a hazard.

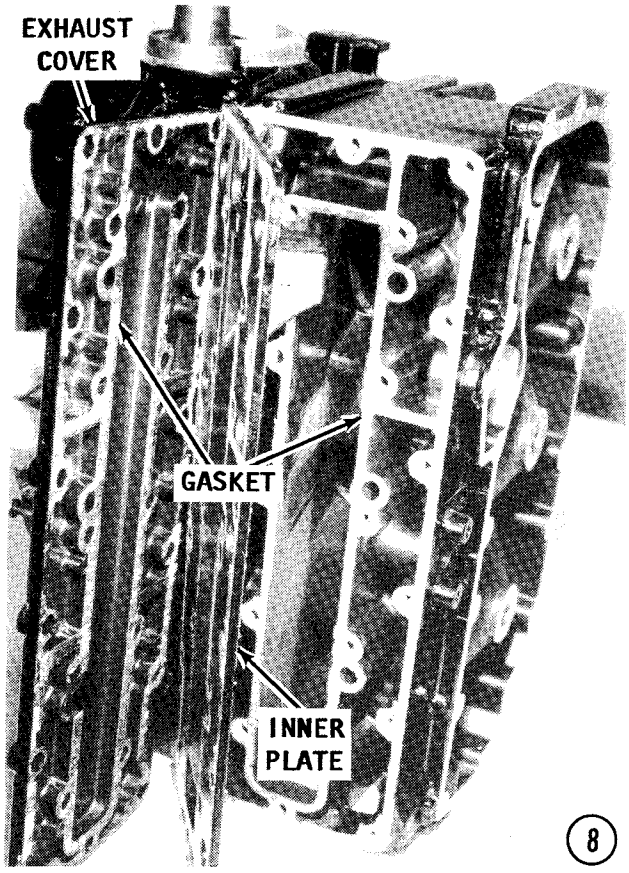
A thorough cleaning of the inner plate behind the exhaust covers should be performed during a major engine overhaul. If the integrity of the exhaust cover assembly is in doubt, replace the inner plate.

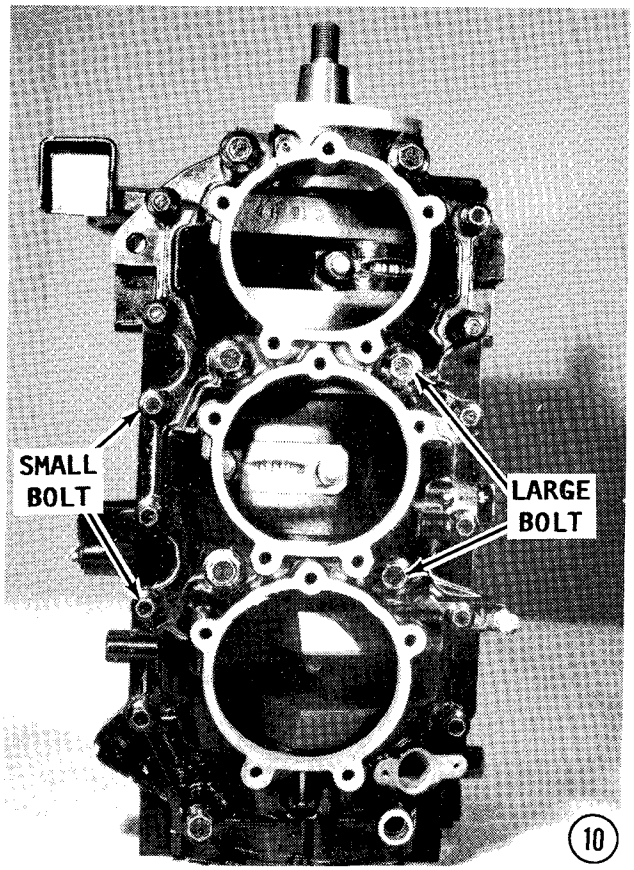
9- Remove the three bolts from the lower end cap, and then remove the end cap. Discard the O-ring around the cap. Inspect the condition of the oil seal. If the seal is no longer fit for service, pry the seal out with a screwdriver.



Crankcase Removal

10- Lay the powerhead on the work surface with the crankcase cover facing **UP.** Remove the crankcase bolts. Two different size bolts are used. Larger bolts are used on the two inner rows and smaller bolts are used on the outer edges of the crankcase.





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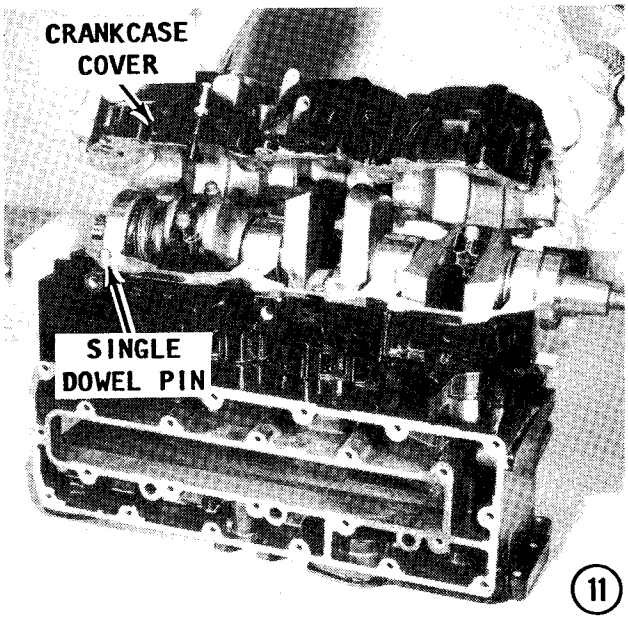


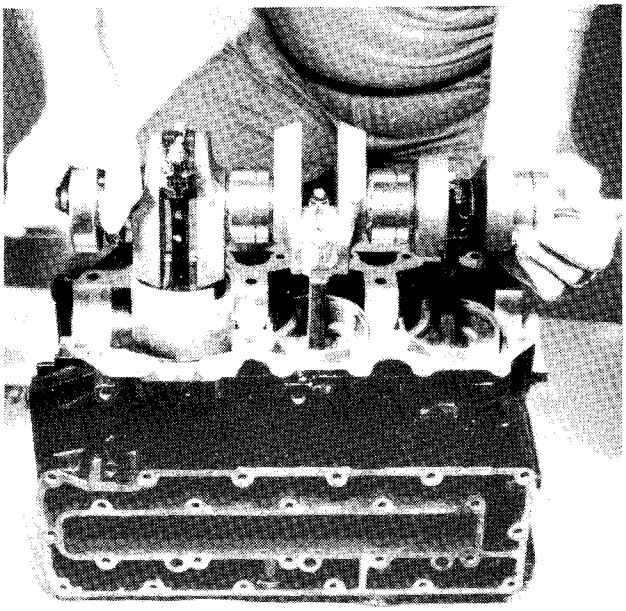
11- Tap on the bottom side of the crankshaft with a soft head mallet, alternately at both ends. The sound of the mallet on the crankshaft will change. A muffled hollow sound should be heard when the cover breaks loose from the crankcase.

If this sound is not heard, check to be sure all bolts have been removed. **NEVER** pry between the cover and the crankcase or the cover will surely be distorted. If the cover becomes distorted, it will fail to make a proper seal following installation. Such a condition would damage both crankcase halves and render both unfit for further service -- an expensive replacement.

Once the crankshaft has been tapped, as described, and the proper sound heard, the cover will be jarred loose and may be removed.

Separate the crankcase from the block. Take care not to lose the single dowel pin.

CAREFULLY remove all traces of sealant from the mating surface between the crankcase and the block without marring the surface, which **MUST** form an airtight seal.



The crankshaft assembly may be lifted clear of the powerhead, as shown, and the remainder of the work completed on the bench, or the crankshaft components may be removed one-by-one from the block.

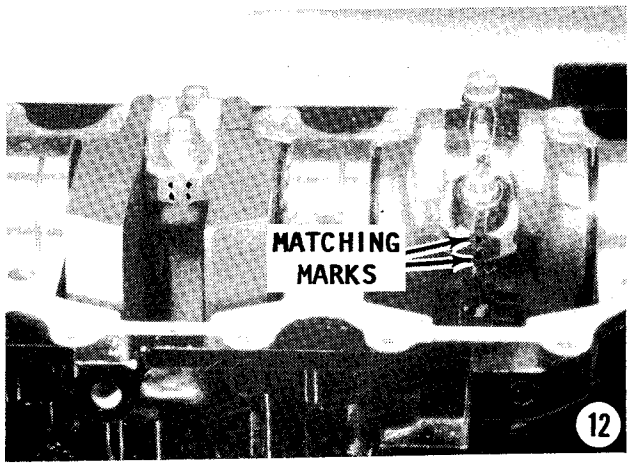
Crankshaft and Connecting Rod Removal

The crankshaft assembly may now be lifted clear of the powerhead and the work completed on the bench, or the components may be removed one by one from the block.

WORDS FROM EXPERIENCE

CLEANLINESS is the password, when handling roller bearings. Take care to prevent any dirt, lint or other contaminents from getting onto the bearings or in the cages. If the bearings are to be used again, store them in a numbered container to ensure they will be installed with the same rod and cap from which they were removed. **NEVER** intermix roller bearings from one rod to another. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for further service, the entire set **MUST** be replaced.

New bearings should be installed in the connecting rods, even though they may appear to be in serviceable condition. New bearings will ensure lasting service after the overhaul work is completed. If it is necessary to install the used bearings, keep them separate and identified to **ENSURE** they will be installed onto the same crankpin



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throw and with the same connecting rod from which they were removed.

12- TAKE TIME to mark the cylinder number on both halves of the connecting rod caps. This mark should be made with a marker, whiteout, paint, or any substance which will adhere to a metal surface. **UNDER NO CIRCUMSTANCES** should the mark be a series of notches, gouges, or even scribed. Such a mark can cause "stress risers", and under heavy powerhead load can cause parts to crack and even fail.

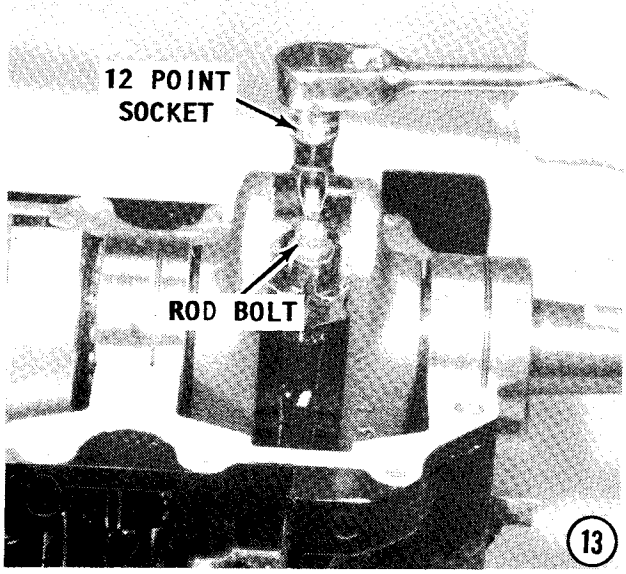
SPECIAL WORDS

The connecting rods and caps are a matched set and **MUST** be kept together, not only as a pair, but also in the direction of installation.

13- Obtain a 12 point socket the same size as the rod bolts. Loosen each bolt just a little, alternately, and evenly. This procedure will prevent one bolt from being completely removed while the other is still tightened to its recommended torque value. Such action would very likely warp the cap.

ADVICE

New connecting rod bearings should be installed around the crankshaft journals, even though the bearings may appear to be in serviceable condition. New bearings will ensure lasting service after the overhaul work is completed. However, if it is necessary to install the used bearings and bearing cages, keep them separate and identified to **ENSURE** they will be installed in the same location from which they were removed.



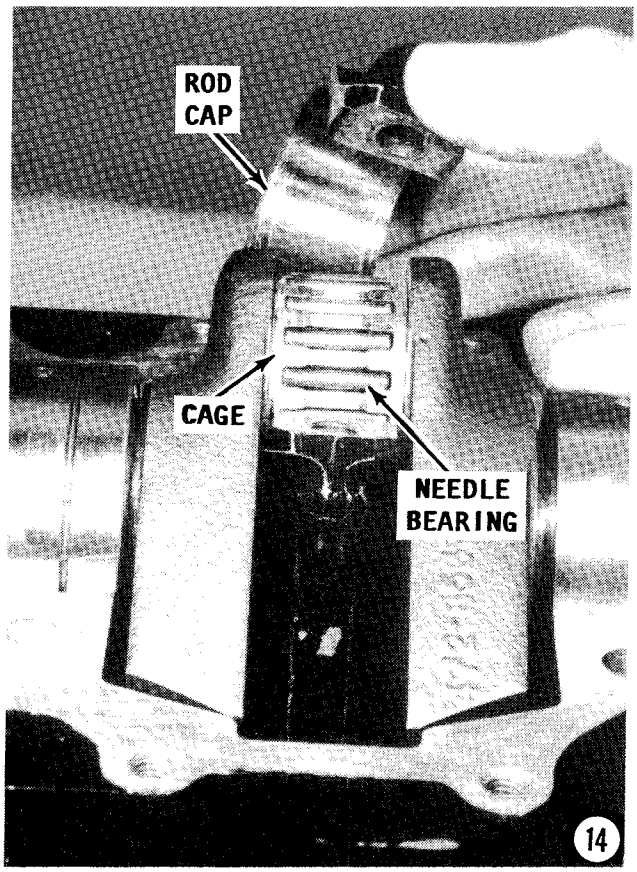
14- Remove the bolts as described in the previous paragraph, and then **CAREFULLY** remove the rod cap. Remove the needle bearings and cages from around the crankshaft. Count the needle bearings and insert them into a separate container -- one container for each rod. Label the container clearly to ensure the bearings will be installed with the proper rod at the crankshaft journal from which they were removed.

Lift the crankshaft from the block. The crankshaft should have been jarred loose when the crankcase cover was removed.

SPECIAL CENTER MAIN BEARING WORDS

When the crankshaft is removed, observe closely how the center main bearings have a hole in the outside circumference. The bearings are held in place by a locating pin indexing in the hole in the bearing. The purpose of this arrangement is to prevent the bearing shell from rotating.

Close inspection will reveal the hole to be off center. If the bearing is to be removed from the crankshaft, make a critical identification mark to ensure the bearing is installed back into the same position from which it was removed. Only in this manner can the pin be indexed into the hole.



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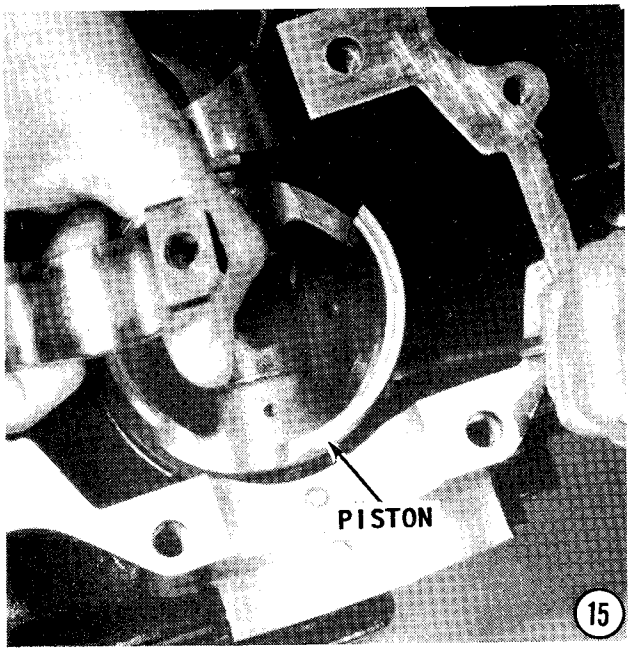
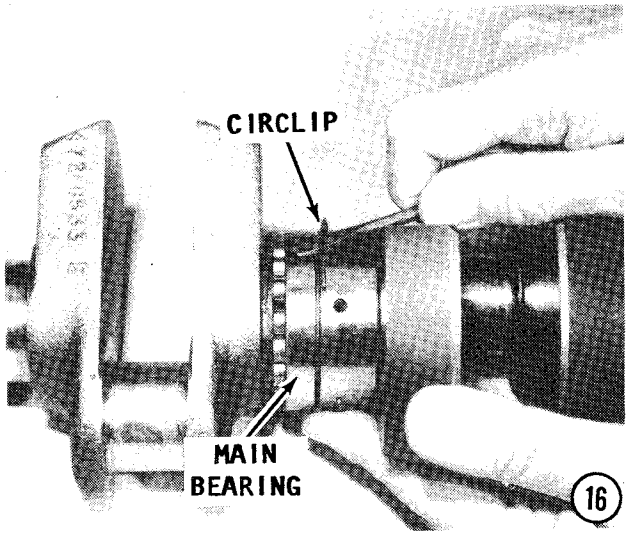


Piston Removal

15- Pull each piston and connecting rod out from the crankshaft end of the block. If water has been allowed to enter the cylinder, the piston may be "frozen" in the bore. Inject penetratating oil through the exhaust ports and allow the oil to "work" for a short time, before making another attempt to remove the piston.

CRITICAL WORDS

Once the piston is out of the block, immediately attach the proper rod cap to the rod, matching ridge to ridge, and hold it in place with the rod bolts. The few minutes involved in securing the cap with the rod will ensure the matched cap remains with its mating rod during the cleaning and assembling work.



Make an identifying mark on the outside edge of each rod "I" beam and a matching mark on the inside of each piston skirt. The identification mark must match the cylinder from which the piston and rod were removed.

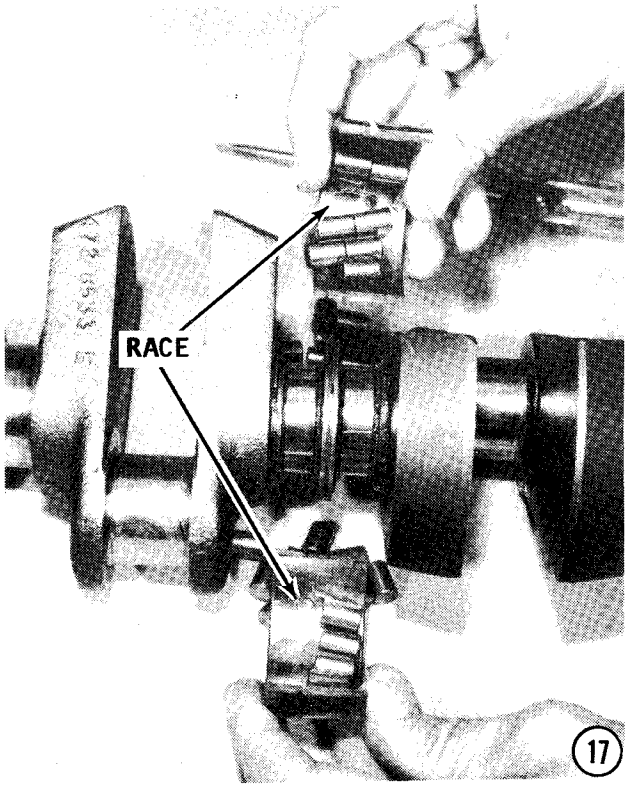
This mark should be made with a marker, whiteout, paint or any substance which will adhere to a metal surface. **UNDER NO CIRCUMSTANCES** should the mark be a series of notches, gouges, or even scribed. Such marks could be considered "damage" and cause "stress risers". Under heavy powerhead load a "stress riser" could cause parts to crack and even fail.

Crankshaft Disassembling

ADVICE

New main bearings should be installed, even though they may appear to be in serviceable condition. New bearings will ensure lasting service after the overhaul work is completed. If it is necessary to install the used bearings, keep the bearings, circlips, bearing shells, and crankshaft sealing rings separate and identified to **ENSURE** they will be installed in the same location from which they were removed.

16- Remove the large crankshaft circlip from around each set of main bearings by



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gently spreading each ring enough to ease it over the top of the main bearing shells. Take care not to scratch the highly polished bearing surface as each ring is removed.

Remove all the rings in a similar manner. These rings are **EXTREMELY** brittle and **MUST** be handled with care if they are intended for further service.

17- Remove the two halves of the bearing race and the roller bearings from the crankshaft. The bearing race halves are a matched set and **MUST** be kept together.

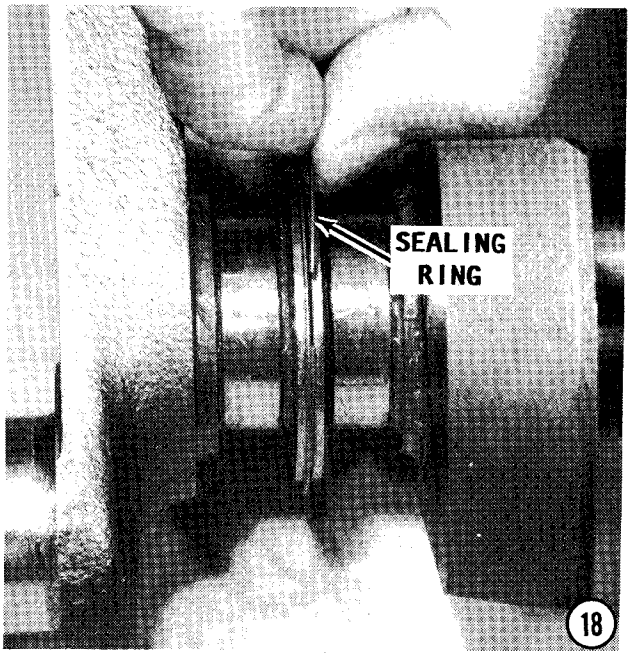
18- Remove the two large sealing rings from around each set of main bearings by gently spreading each ring enough to ease it over the crankshaft surface. Take care not to scratch the highly polished bearing surface as each ring is removed.

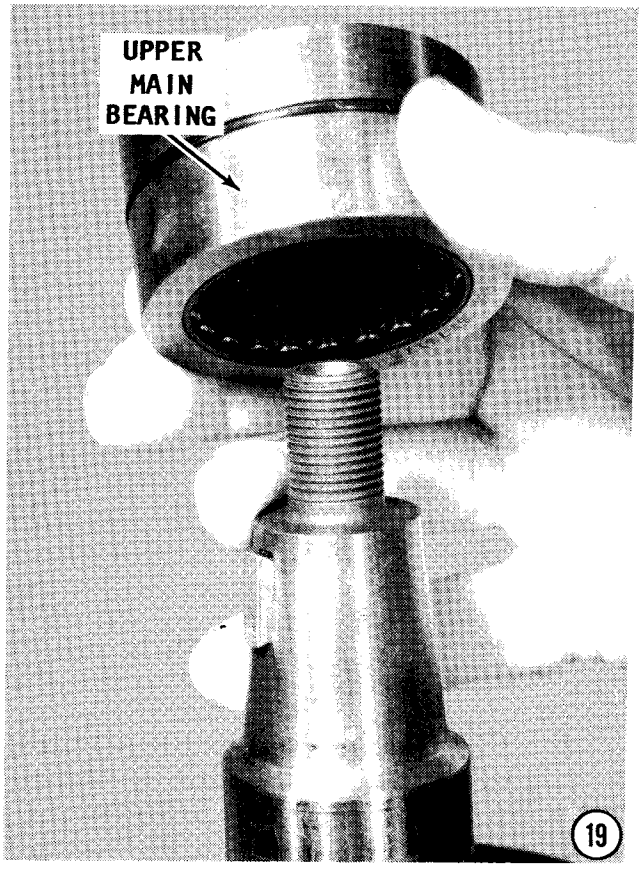
Remove all the rings in a similar manner. These rings are **EXTREMELY** brittle and **MUST** be handled with care if they are intended for further service.

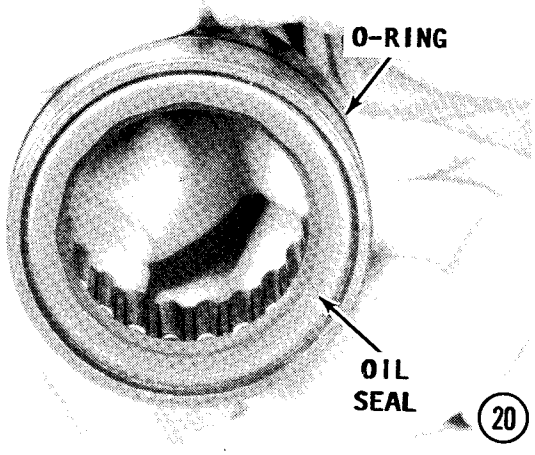
19- Slide the upper main roller bearing free of the crankshaft.

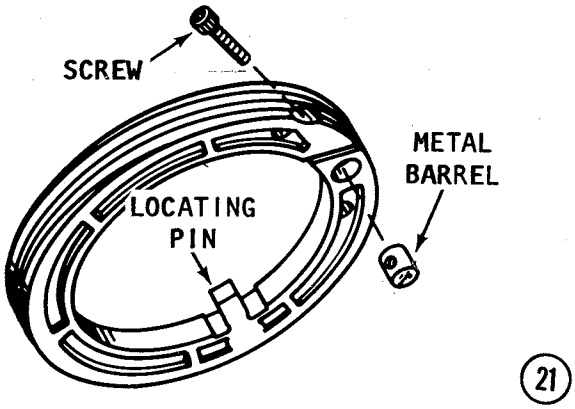
20- Inspect the condition of the oil seal housed within the bearing. If the seal is no longer fit for service, pry the seal out with a screwdriver. Remove and discard the O-ring around the bearing.

21- Remove the Allen screw from the oil pump drive gear. Extract the metal barrel from the gear. **CAREFULLY** spread the two ends of the gear apart enough to clear the crankshaft journal. **DO NOT** spread the gear any more than absolutely necessary.









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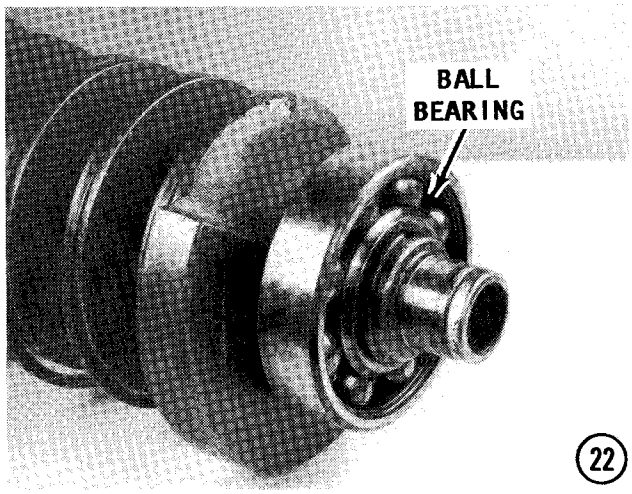
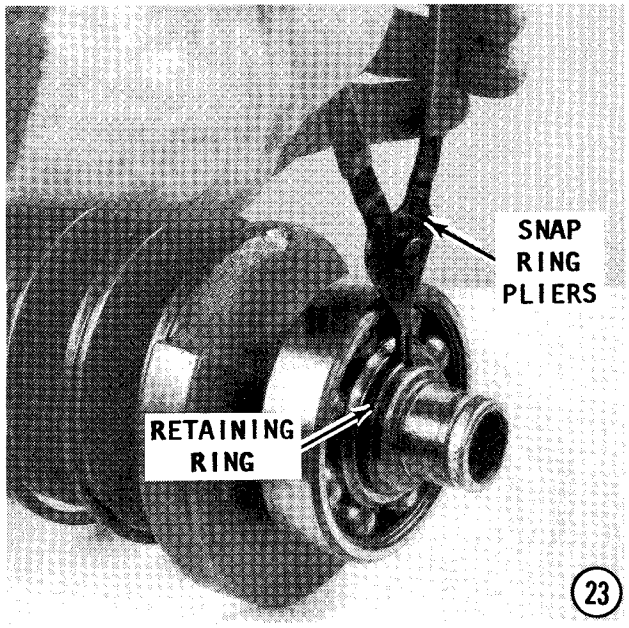


22

22- Inspect the crankshaft ball bearing installed on the lower end of the crankshaft as outlined in the Cleaning and Inspecting section at the end of this chapter. **DO NOT** remove the lower crankshaft ball bearing unless it is unfit for service and it is to be replaced.

23- If the bearing is to be replaced, remove the retaining ring with a suitable pair of expanding type snap ring pliers.

24- Install Universal Puller Plate, C-91-37241, between the crankshaft ball bearing and the crankshaft counterweight. Position the crankshaft assembly in an arbor press. The crankshaft will be supported by the puller plate. Place a metal plate over the end of the crankshaft, and then press the crankshaft out of the bearing. **TAKE CARE** to prevent the crankshaft from falling to the floor and being damaged when it clears the bearing.



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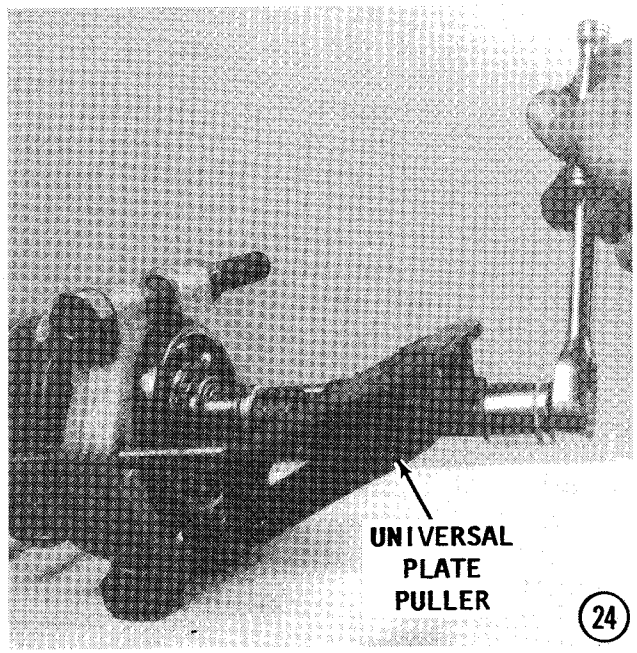
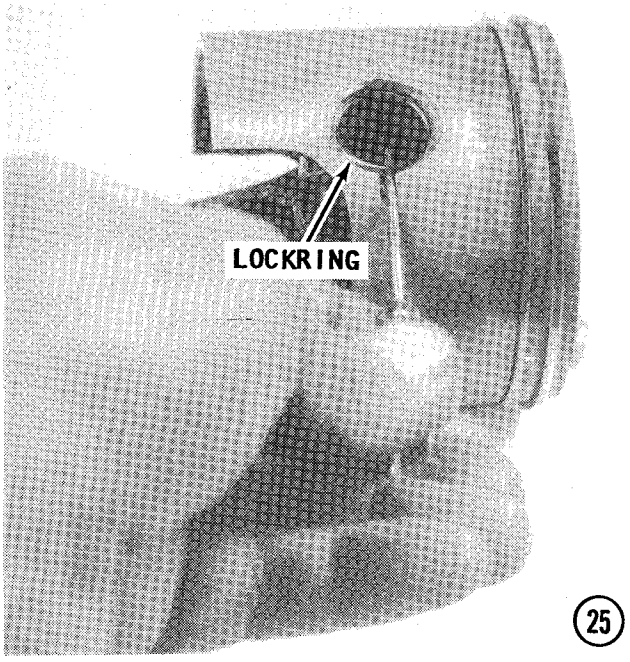


24

SAFETY WORDS

WEAR eye protection glasses while removing the piston pin lockrings, because the lockring is made of spring steel and may slip out of the pliers or pop out of the groove with considerable force.

25- Remove the two G-type lockrings using a pair of needle-nose pliers. A lockring tool, C-91-5252A1, may be used to remove the lockring. A third alternative, is to use a punch to pop the ring out. If a punch is used **TAKE CARE** not to damage the piston. **DISCARD** the lockrings, because they should not be used a second time.



25

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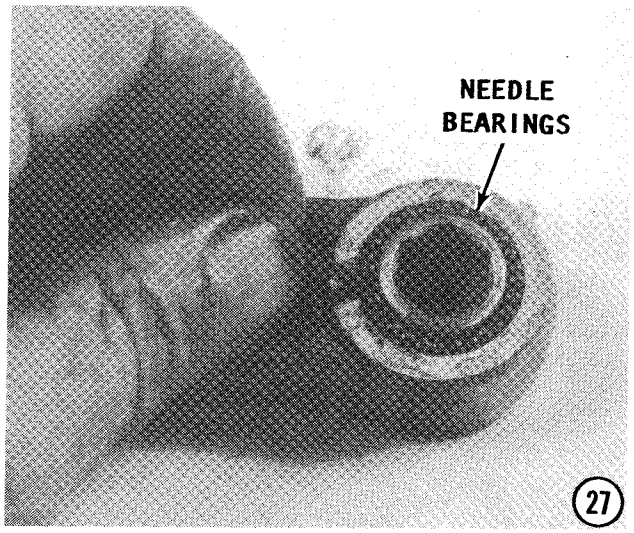
26- Heat the piston dome to approximately 190° by submerging the piston in hot water, or by heating it with a heat lamp.

Three tools are required to remove the piston pin from a piston without damage to the piston, the pin, or the rod: An arbor press, a Piston Support Block, C-91-77005, and a Piston Pin Tool, C-91-74607A2. Position the piston and rod assembly in place on the support block. The piston may be placed on the block with either hole facing up. Use the piston pin tool and the arbor press to press the piston pin down and free of the piston.

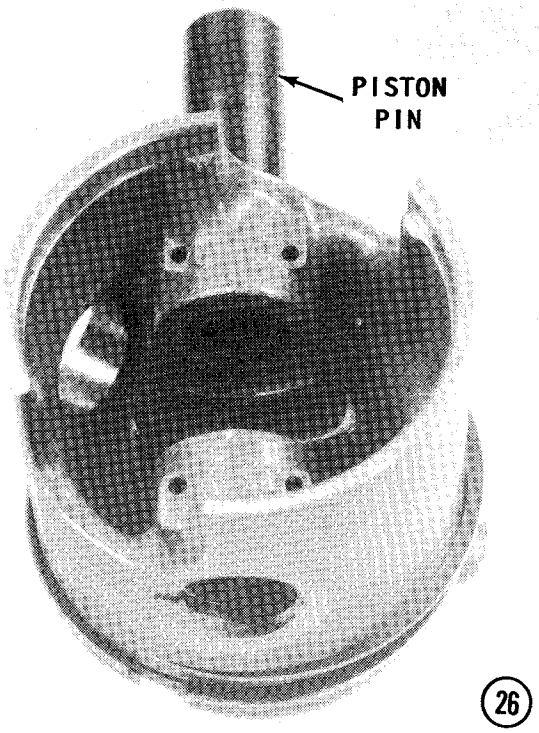
27- If the connecting rod is to be used again, save the needle bearings, 29 by count, on each piston end of the rod and the two locating washers.

CLEANLINESS is the password, when handling needle bearings. Take extra care to prevent any dirt, lint, or other contamination from getting onto the bearings or in the cages. If the bearings are to be used again, store them in a numbered container to ensure they will be installed with the same rod and rod cap from which they were removed. **NEVER** intermix roller bearings from one rod to another. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for service, the entire set **MUST** be replaced. Handle the piston with care, because the skirt can be easily bent out-of-round if it is handled roughly.



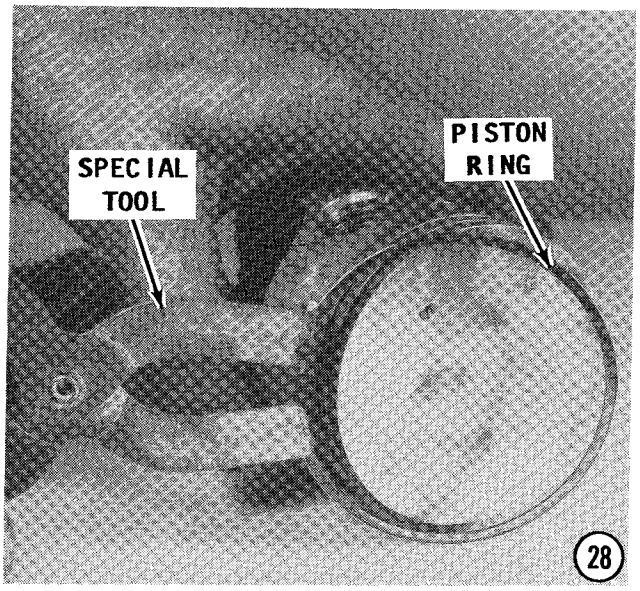
Piston Disassembling

28- Remove and **DISCARD** the rings, as each piston and rod assembly is removed. Use a Piston Ring Expander, C-91-24697, to remove the rings. If this special tool is not available, remove them with your hands. After the rings have been removed from all pistons, carefully inspect each piston and rod assembly according to the procedures outlined in the Cleaning and Inspecting section at the end of this chapter.



CLEANING AND INSPECTING

See the last portion of this chapter, Section 8-5, for detailed, comprehensive procedures to clean and inspect all components of the powerhead.



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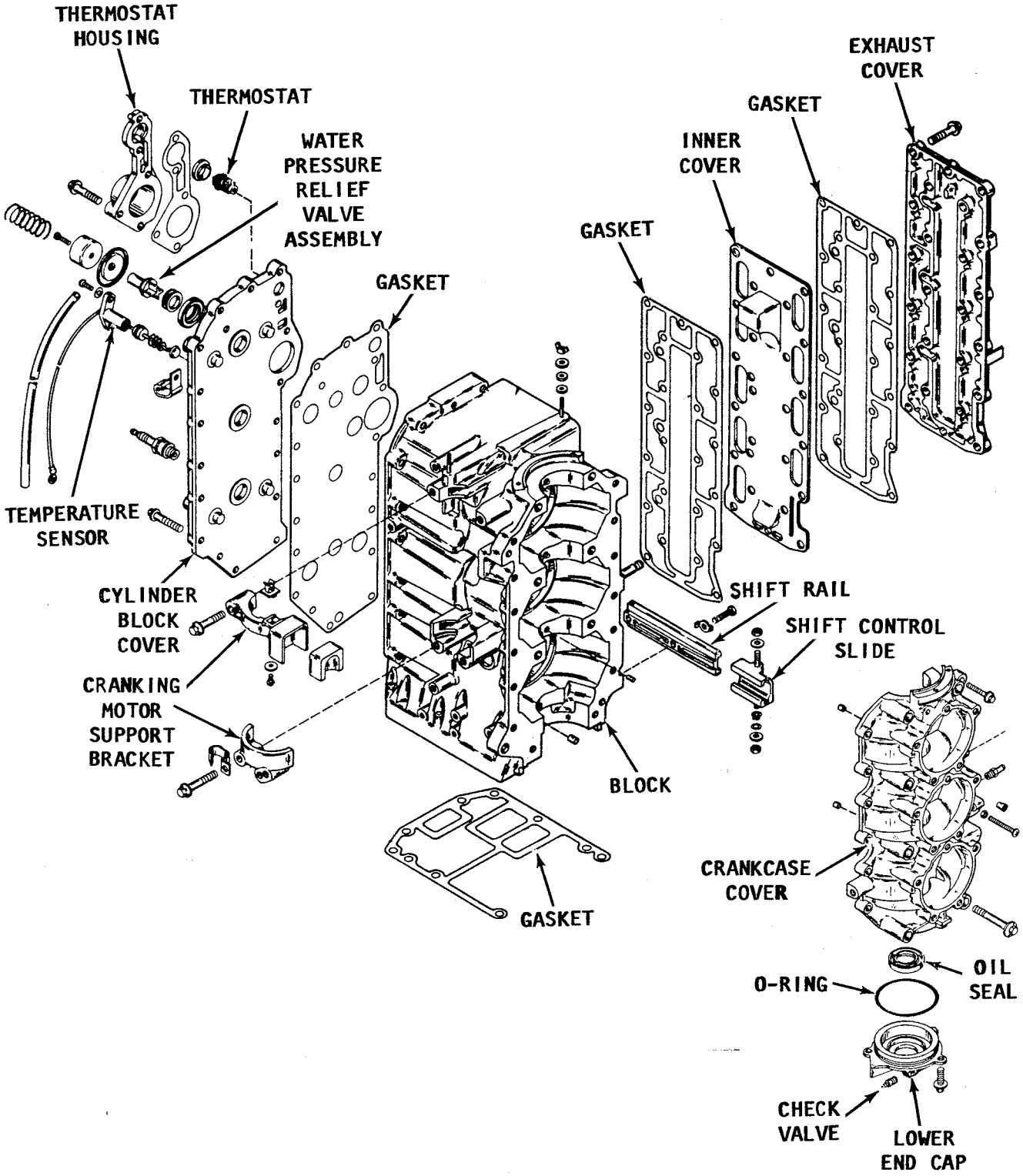

Exploded drawing of the redesigned, large bore 3-cylinder block, with major parts identified.

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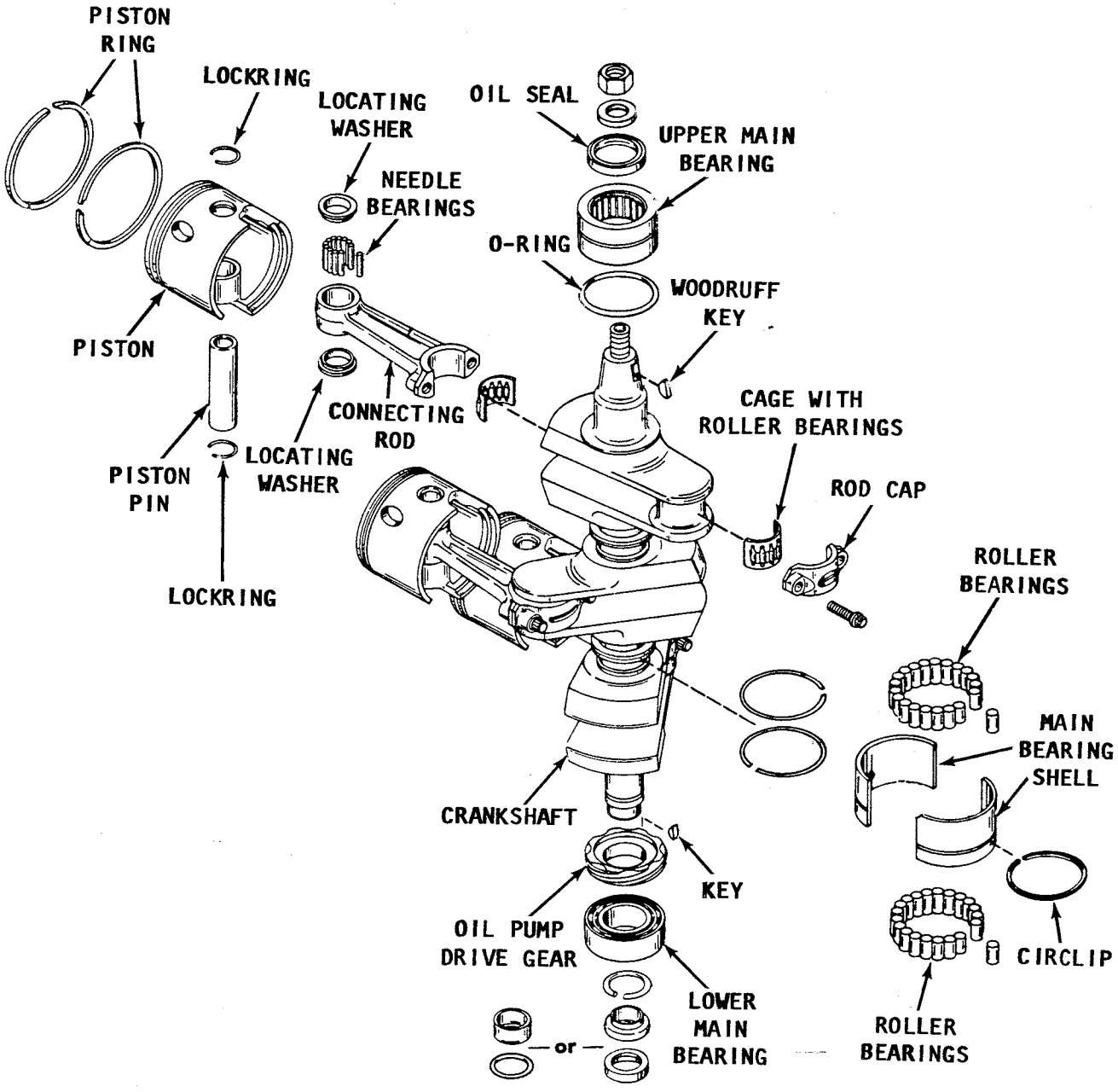

Exploded drawing of the redesigned, large bore 3-cylinder crankshaft assembly, with major parts identified.

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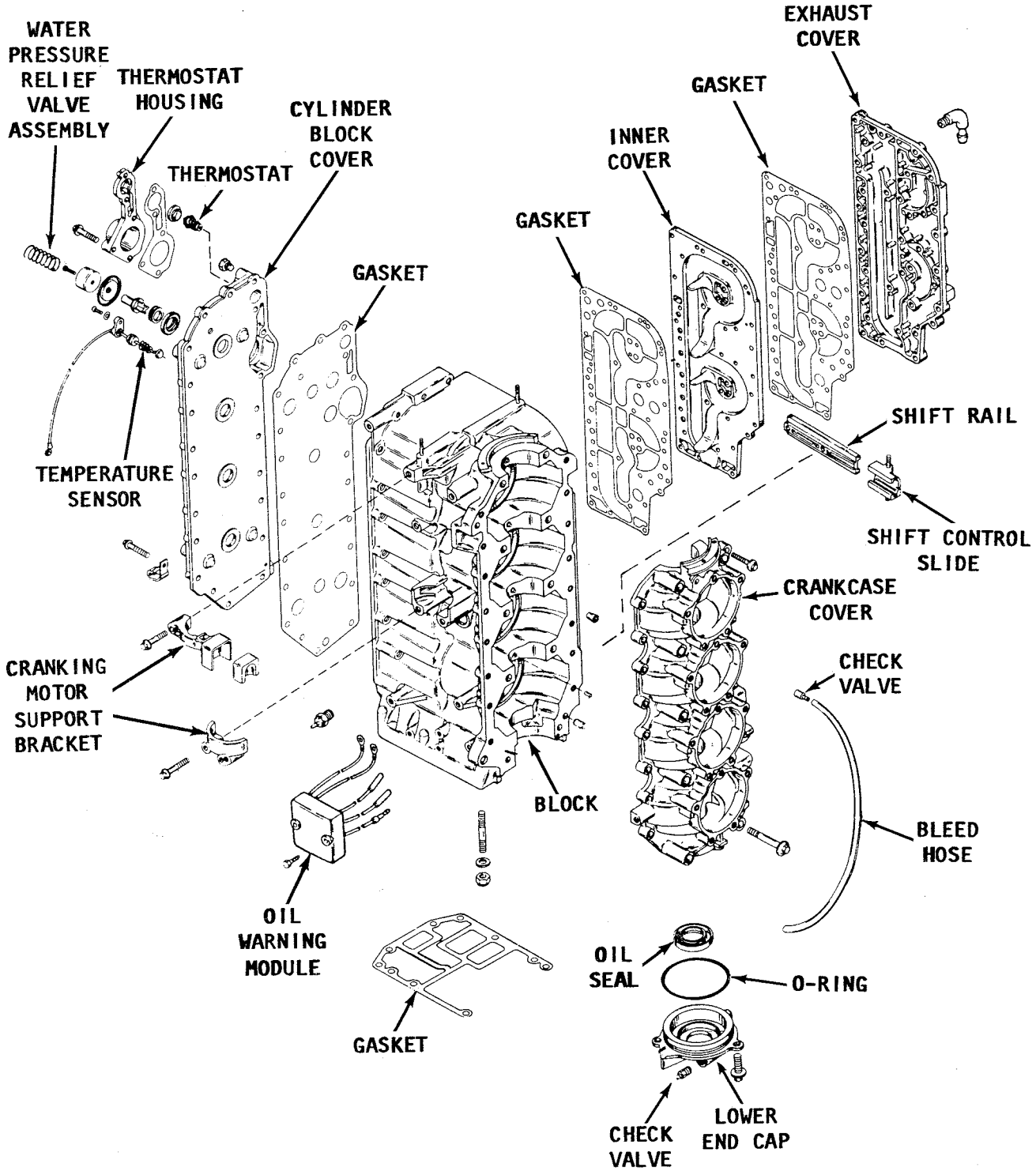

Exploded drawing of the redesigned, large bore 4-cylinder block, with major parts identified.

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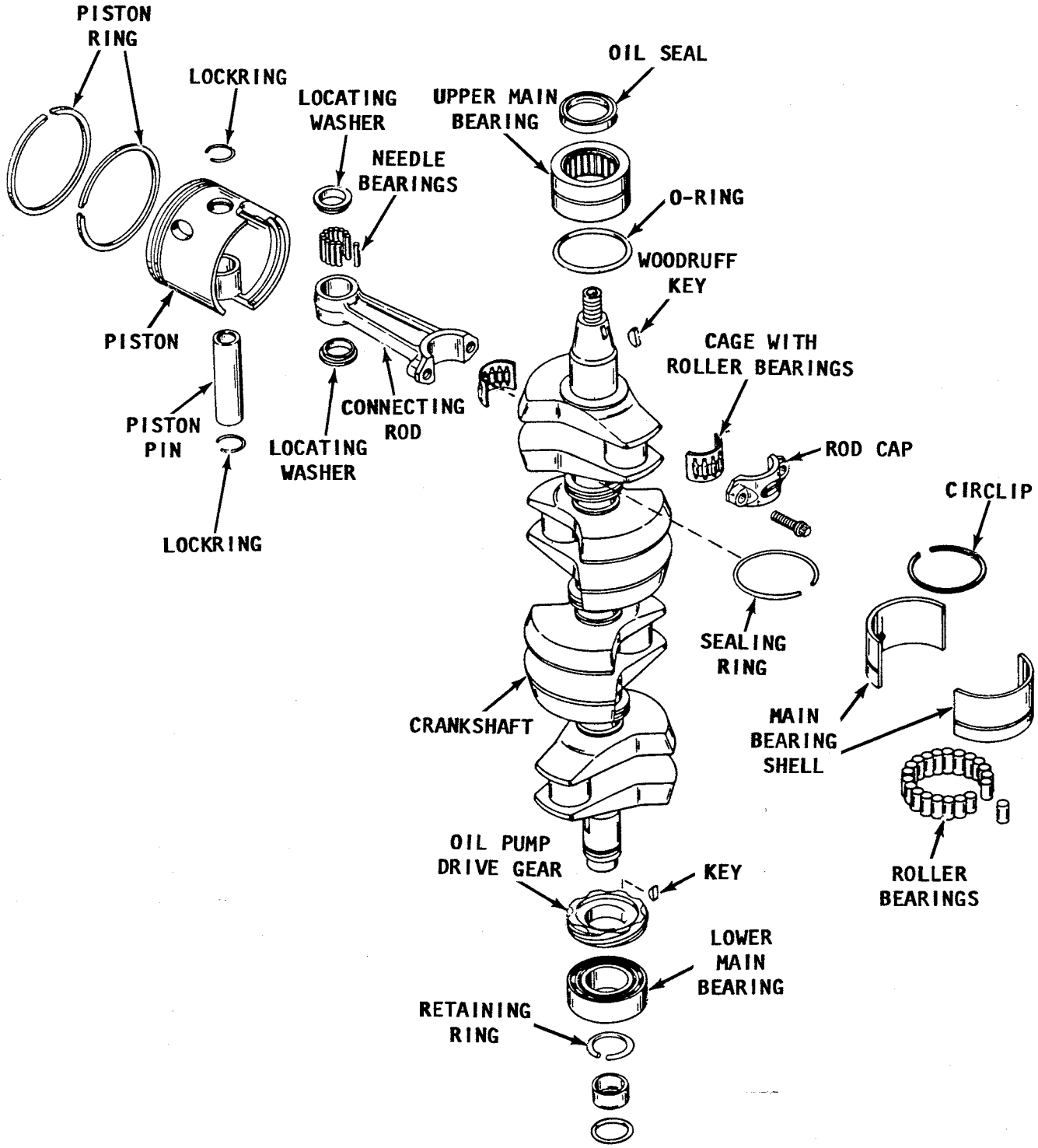

Exploded drawing of the redesigned, large bore 4-cylinder crankshaft assembly, with major parts identified.

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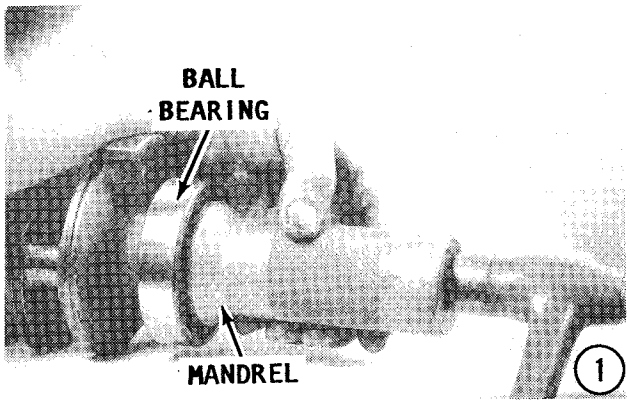


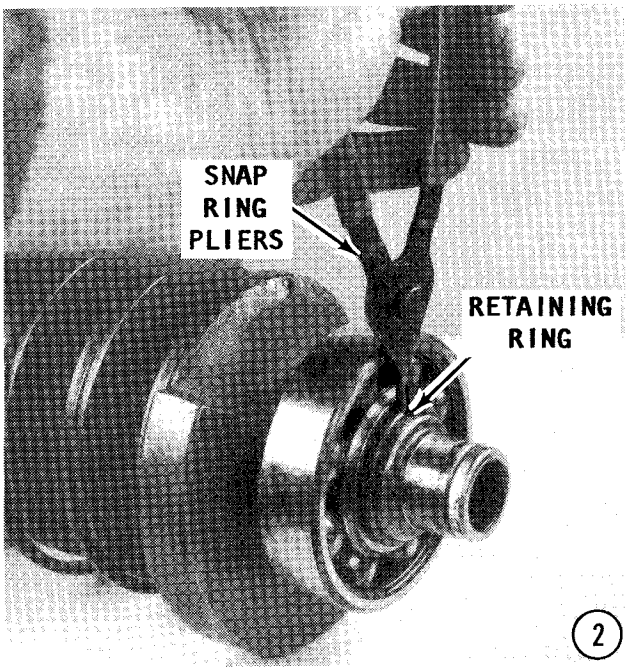
ASSEMBLING

FIRST, THESE WORDS

Be sure all parts to be reused have been carefully cleaned and thoroughly inspected. Parts not properly cleaned, or parts not suitable for service can damage a good powerhead within a few minutes after starting the engine.

NEW gaskets **MUST** always be used during an overhaul.

A torque wrench is essential to correctly assemble the powerhead. **NEVER** attempt to assemble a powerhead without a torque wrench. Attaching bolts for covers **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. On the first stage, tighten to 1/3 the torque value. On the second stage, tighten to 2/3 the total torque value. Finally, on the third and last stage, tighten to the full torque value.



Crankshaft Assembling

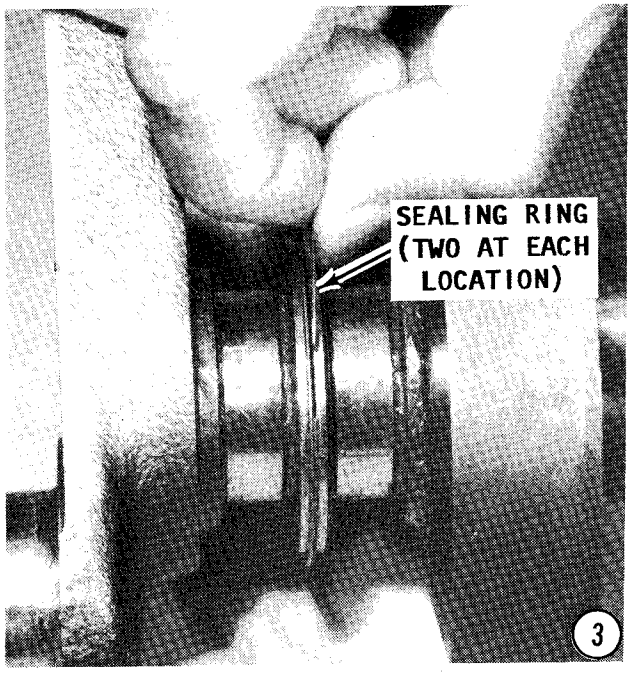
1- If the ball bearing on the driveshaft end of the crankshaft was removed, install the bearing as follows: Support the crankshaft assembly in a press with the support between the counterweights and directly under the lower crankshaft end. Press the lower ball bearing onto the crankshaft, using a piece of tubing as a mandrel. **BE SURE** the tubing is the proper size so the force is only applied onto the inner race of the bearing. Continue to press the bearing into place until it is firmly seated against the counterweight. Remove the crankshaft assembly from the press. Using a press is the preferred method as a precaution against damaging the bearing, however, an installer and hammer may be used, as shown.

2- Use a pair of expanding type snap ring pliers and install the retaining ring to secure the lower crankshaft ball bearing in place.

3- Spread the ends of a crankshaft sealing ring and install it around the crankshaft main bearing. **TAKE CARE** not to scratch the highly polished bearing surface. Install two rings at each location and position their end gaps at 180° to each other. Continue, until all rings are in place. Lubricate the crankshaft sealing rings with light weight oil.

SPECIAL WORDS

The following paragraphs decribe procedures to install a large number of small



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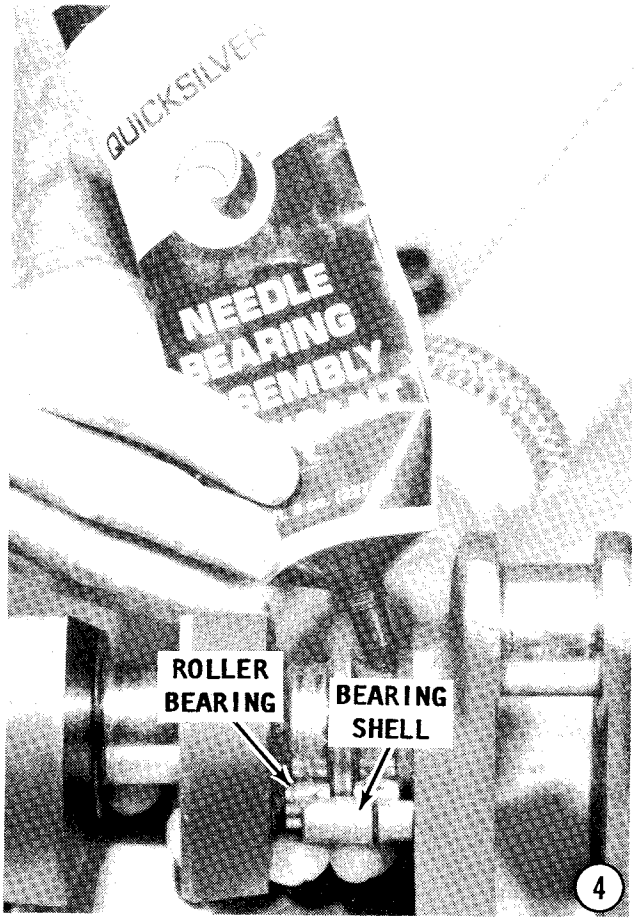
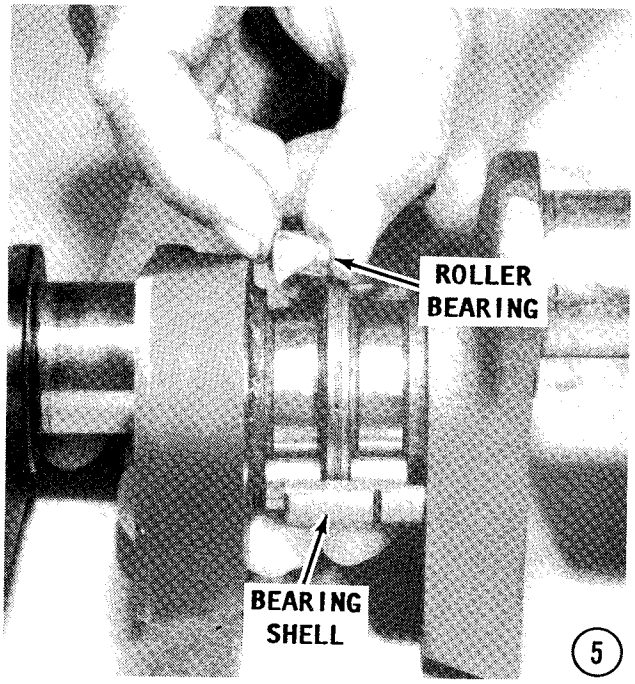
roller bearings around a bearing surface. In order for the installed bearings to stay "put" apply a coating of Quicksilver Needle Bearing Assembly Lubricant C-92-42649A-1 and **NO** other type "goopus".

Any lubricant applied on the crankshaft bearing surface **MUST** be soluble in gasoline. Unfortunatetly, most lubricants are not.

4- Apply a liberal coat of Quicksilver Needle Bearing Assembly Lubricant to the crankshaft journal to hold the roller bearings in place. Hold a bearing shell up against the crankshaft sealing ring, with the groove for the circlip facing toward the top (tapered) end of the crankshaft. Insert the bearings around the two crankshaft grooves, pushing them in between the bearing shell and the crankshaft.

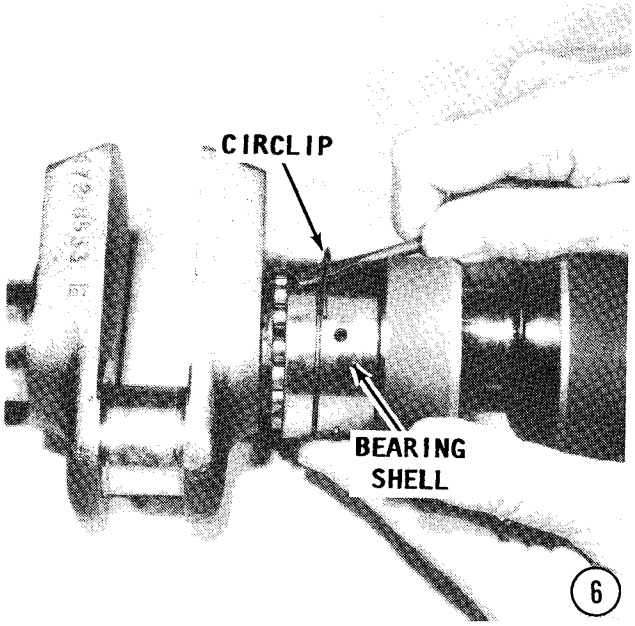
5- Continue installing the roller bearings around the crankshaft until a total of 32 -- two sets of 16 -- are in place. Install the other matching bearing half over the half already in place, with the groove for the circlip facing toward the top (tapered) end of the crankshaft. Check to be sure the circlip groove is matched on the two bearing shell halves.





6- Secure the bearing halves in place with the circlip. Lubricate the crankshaft main roller bearings by injecting lightweight oil through one of the holes in the bearing race.

7- Soak the oil pump drive gear in hot water for approximately four minutes, until it is somewhat pliable. Separate the two ends of the gear and install the gear over the crankshaft journal next to the main bearing, with the lip facing toward the upper (tapered) end of the crankshaft. Slide the gear lip into the groove in the crankshaft. The locating pin **MUST** index into the crankshaft slot.



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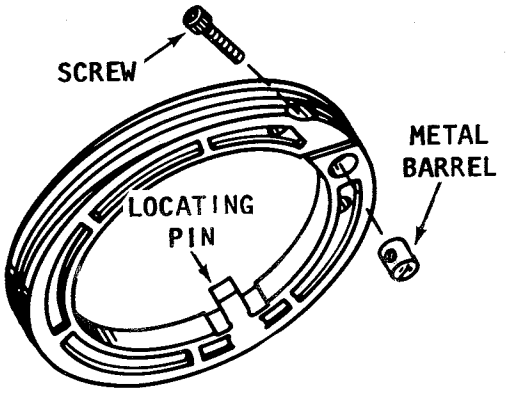

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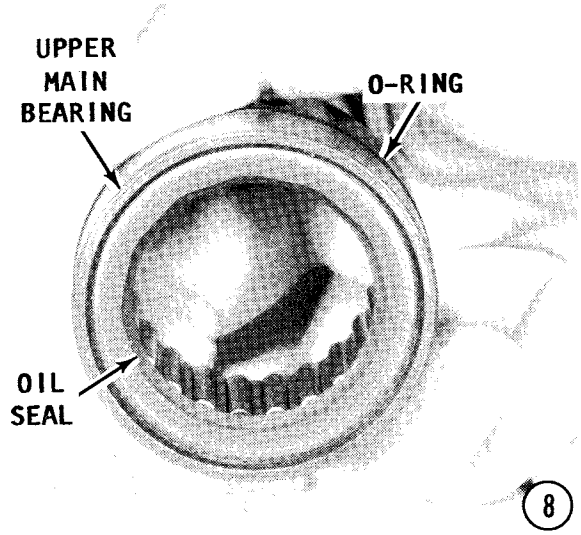
Insert the metal barrel into the center hole of the gear and align the threaded hole with the hole for the screw in the gear. Thread the screw into the hole in the gear teeth and into the metal barrel. Tighten the screw to 8 in lb (.9Nm). The two ends of the gear should now be tightly together and the gear mismatch at the joint line must not exceed .030" (.76mm). Excess mismatch will result in premature gear failure. Excess mismatch may be caused by the gear lip not being properly seated in the crankshaft groove.

8- If the upper main bearing oil seal was removed in Step 20 of disassembling, pack the lip of a new oil seal with 2-4-C Quicksilver Marine Lubricant C-92-90018A12 and install the seal into the top (closest to the groove) end of the bearing with the lip facing **DOWN.** Apply the same lubricant to a new O-ring and install the O-ring into the bearing groove.

9- Slide the upper main bearing over the top of the crankshaft with the oil seal facing **UP** -- toward the threads of the crankshaft.



8

SPECIAL WORDS ON PISTON RINGS

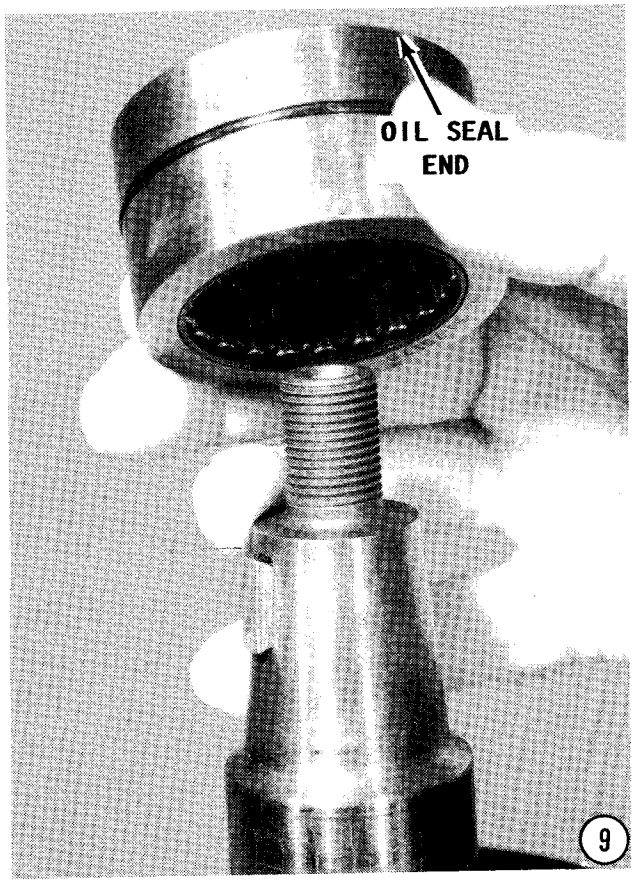
All powerheads covered in this section, with the new redesigned in-line block, are equipped with 2-ring pistons. Both rings are tapered on the top side and rectangular on the under side, which designates them as semi-keystone rings. The only critical part of the installation procedure is to be sure the **"T"** on the side of each ring is facing **UPWARD, TOWARD** the piston crown. Installation procedures are the same as for other standard pistons.

Oversize Pistons and Rings:

All oversize pistons for these powerheads are manufactured to use two semi-keystone rings. Again, the only critical procedure during installation is to be sure the **"T"** on the side of the ring faces **TOWARD** the piston crown.

GOOD WORDS

OBSERVE the pin in each ring groove of the piston. The ends of the ring **MUST** straddle this pin. The pin prevents the ring from rotating while the powerhead is operating. This fact is the direct opposite of a four-cycle engine where the ring must ro-



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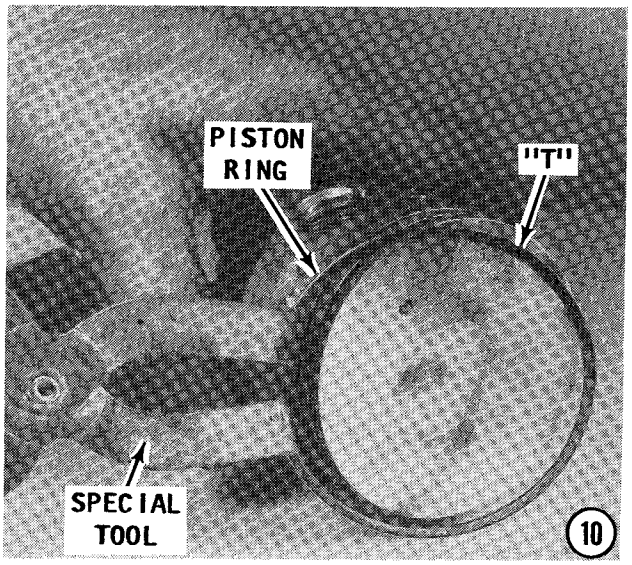
tate. In a two-cycle engine, if the ring is permitted to rotate, at one point, the opening between the ring ends would align with either the intake or exhaust port in the cylinder. At that time, the ring would expand slightly, catch on the edge of the port, and **BREAK.**

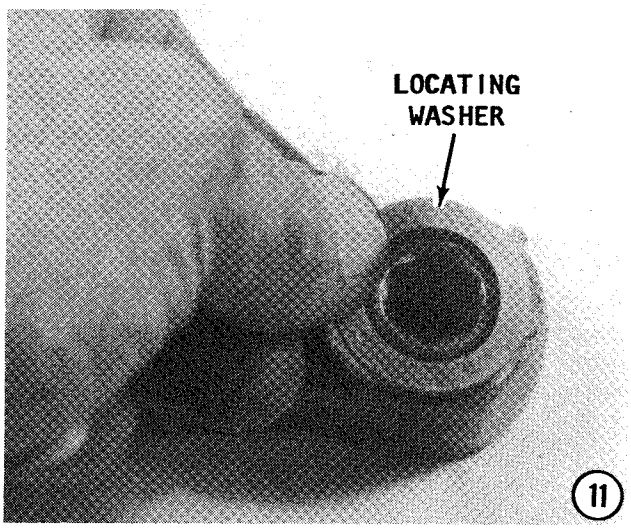
Therefore, when checking the condition of the piston, **ALWAYS** check the pin in each groove to be sure it is tight. If one pin is the least bit loose, the piston **MUST** be replaced, without question. Never attempt to replace the pin, it is **NEVER** successful.

10- Use a ring expander and install the ring set identified for the No. 1 piston and cylinder onto the piston. Adjust the ring expander in small increments until the ring will just barely fit over the top of the piston. If the expander is adjusted to open the ring more than necessary, the ring may break. Work **SLOWLY,** and check each ring to be sure it is installed properly with the **"T"** on the side of the ring facing the top of the piston. After the rings are in place, attempt to rotate the ring in its groove. The attempt **MUST FAIL.** If the ring is free to rotate, the locating pin is not performing its function and the piston must be replaced.

Piston/Rod Assembling

11- Lay a clean towel on the work surface. Lay out the 29 piston pin needle bearings in a line. **NEVER** intermix needle bearings from one piston assembly with those from another piston. **NEVER** intermix used needle bearings with new bearings. If just one bearing is unfit for service or is lost, the entire set **MUST** be replaced. Lay

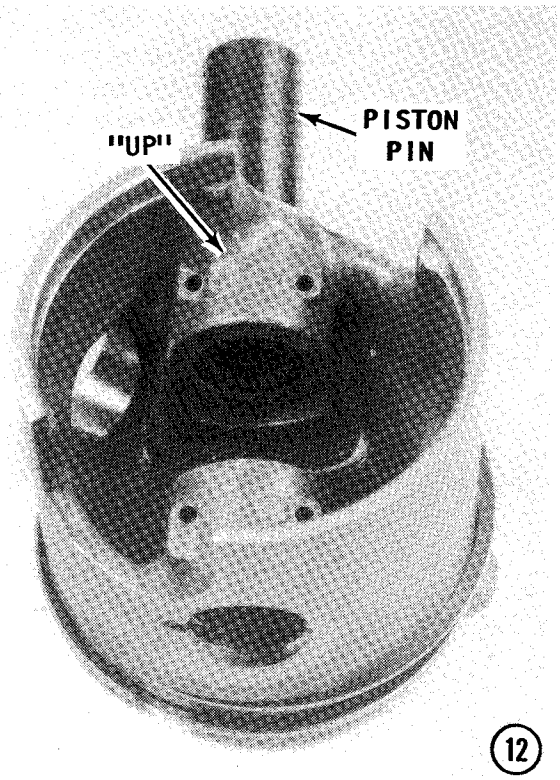




down a bead of Quicksilver Needle Bearing Assembly Lubricant C-92-42649A-1 onto the sleeve portion of Piston Pin Tool C-91-74607A1.

Always handle pistons with great care because the skirt can be bent out of round if the piston is handled roughly. Place the lower locating washer onto the piston pin tool with the shoulder on the washer toward the bearings.

If a piston pin tool is not available, a drift slightly smaller in diameter than the pin, may be used. Install the retainer and the needle bearings onto the end of the tool. Push the bearings and the tool into the rod



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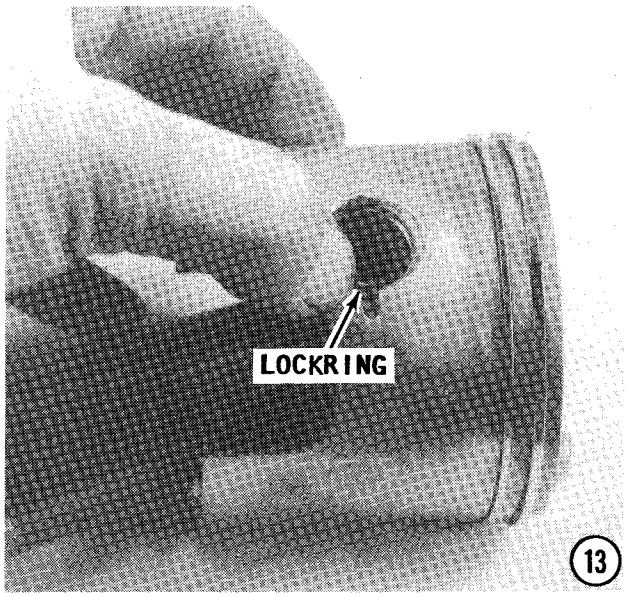
piston pin bore. Place the top retainer on the side of the rod. Ease the tool out of the rod, and at the same time hold onto the needle bearing retainer washers.

12- Notice the word **"UP"** on the piston pin boss inside the piston skirt. This word indicates the side of the piston that **MUST** face upward, toward the top of the powerhead, the tapered end of the crankshaft, when it is installed. The **"UP"** side of the piston **MUST** face downward on the support block when the piston pin is pressed in. Place the piston in a container of hot water, approximately 190°F. The piston may also be heated with a heat lamp to approximately 190°F.

Place the heated piston, in an arbor press, in position on the Piston Support Block, C-91-77005, with the side marked **"UP"** on the piston pin boss down against the block. Use one hand to hold the sleeve, bearings, and locating washers in place. At the same time, with the other hand, insert the connecting rod into position in the piston, with the two bumps on the crankshaft end of the rod **TOWARD** the word **"UP"** on the piston. Once the rod is in place, slide the handle portion of the piston pin tool up through the hole in the support block and on through the lower piston pin boss into the sleeve.

Hold the piston pin needle bearings in place with the piston pin tool, and press the piston pin into position as far as possible with the arbor press. Use the piston pin tool between the arbor press and the piston pin to position the piston pin the rest of the way into the piston.



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SAFETY WORD

WEAR eye protection glasses while installing the piston pin lockrings, because the lockrings are made of spring steel and may slip out of the tool or pop out of the groove with considerable force. **DO NOT** use a lockring the second time. Use new lockrings and check to be sure they are properly seated in the piston grooves.

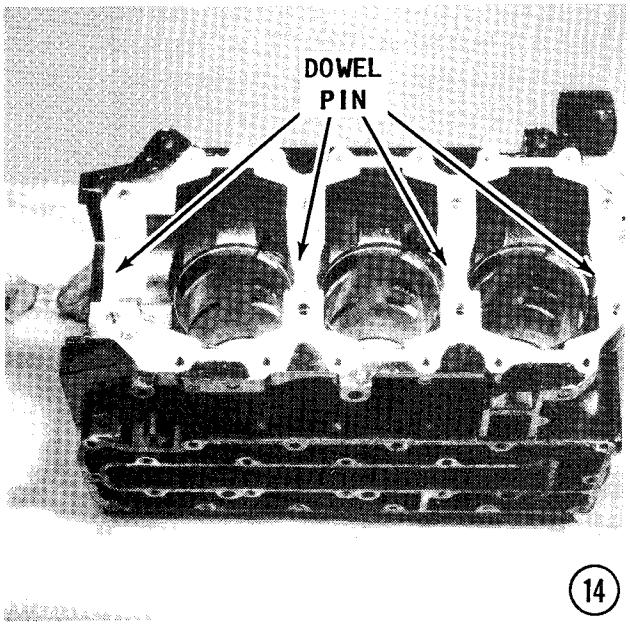
13- Install a G-type piston pin lockring at each end of the piston pin using Lockring Installation Tool, C-91-77109A1, or a pair of needle-nose pliers. Check and double check, to be sure each lockring is properly seated in the piston groove.

Lubricate the piston, the rings, and the cylinder bore with a good grade of 50-weight oil.

14- Check the cylinder block to be sure the crankshaft main bearing dowel pins are in place. If they are not in place, install new pins.

15- Check to be sure the number painted onto the connecting rod during disassembly matches the cylinder number into which the piston assembly is to be installed.

OBSERVE the identification marks on the crown of each piston. The word **UP** embossed on the crown, as shown in the accompanying illustration, indicates the side of the piston that **MUST** face upward, toward the top, the flywheel end, of the powerhead when it is installed. This position will place the large hole in the piston skirt directly opposite the exhaust port in the cylinder wall.



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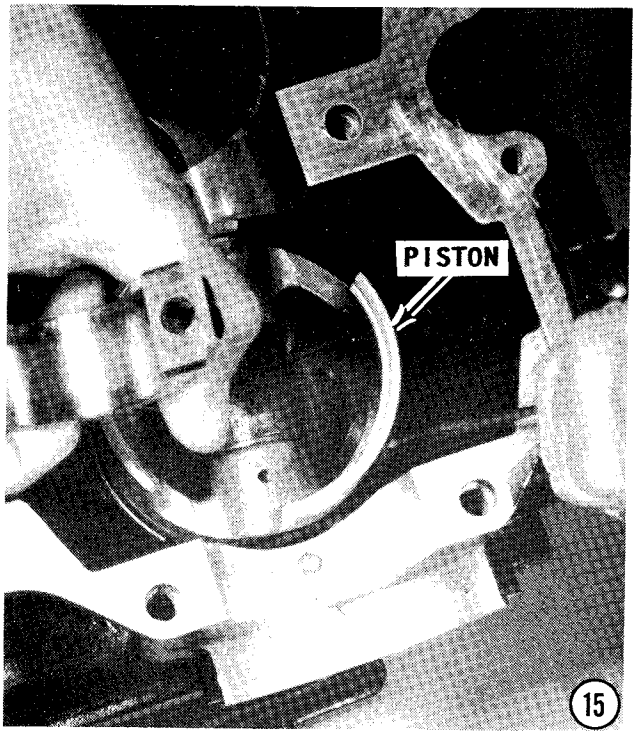

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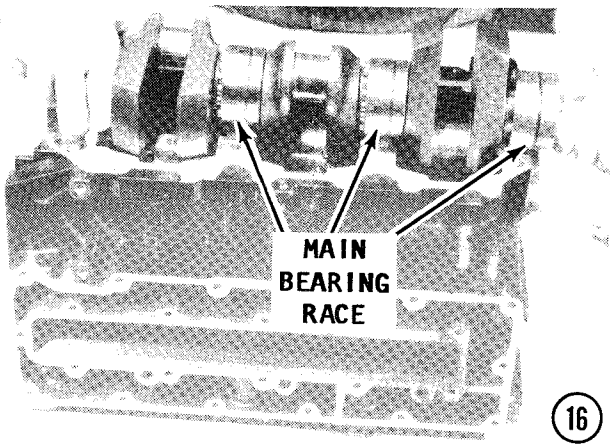
The piston can be inserted down through the bottom of the cylinder bore **WITHOUT** the use of any special tools. Position the piston squarely over the bore. Compress each ring, one at a time, and push down little by little until the piston slides easily into the cylinder bore.

If, after repeated attempts, the piston cannot be installed into the bore, pull the piston out and inspect the alignment of the rings with the locating pins. **DO NOT** use force to push the piston into the bore. A piston ring will easily break if the end has jumped over the locating pin and is forced against the cylinder wall. The installer may not even realize the ring has broken during piston installation. The ring tension is checked later in Step 27 to verify the rings have been correctly installed.



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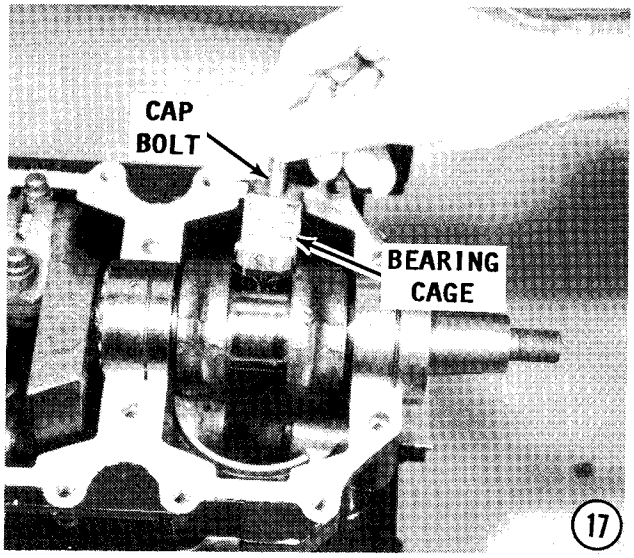


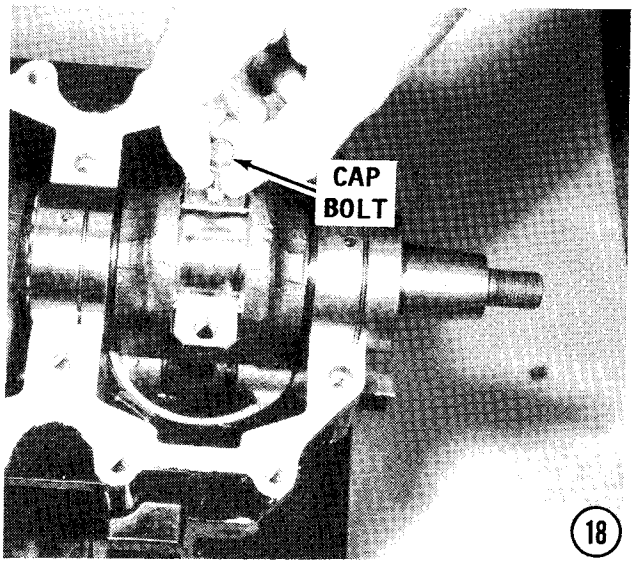
17

Crankshaft Installation

16- Lower the crankshaft assembly into the cylinder block, with the flywheel end toward the top of the powerhead. Rotate the main bearing races very slightly, until the dowel pin hole in each race indexes the dowel pins in the block. Gently push the crankshaft down into position.

Installing Rods to Crankshaft

17- Apply a coating of Quicksilver Needle Bearing Assembly Lubricant C-92-42649A-1 to the bearing surface of the connecting rod. Thread one of the cap bolts into the connecting rod. The bolt can then be used as a tool, to move the connecting rod around, while performing the delicate task of installing the needle bearings and race to the crankshaft. Install the bearing cage and the roller bearings into the lubricant.



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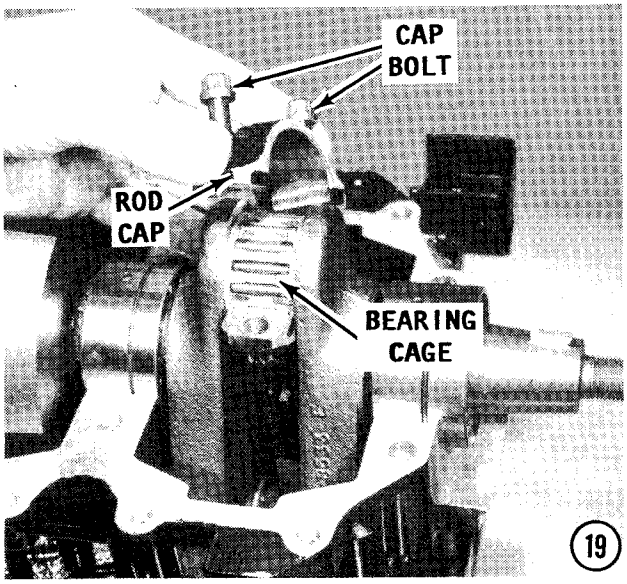
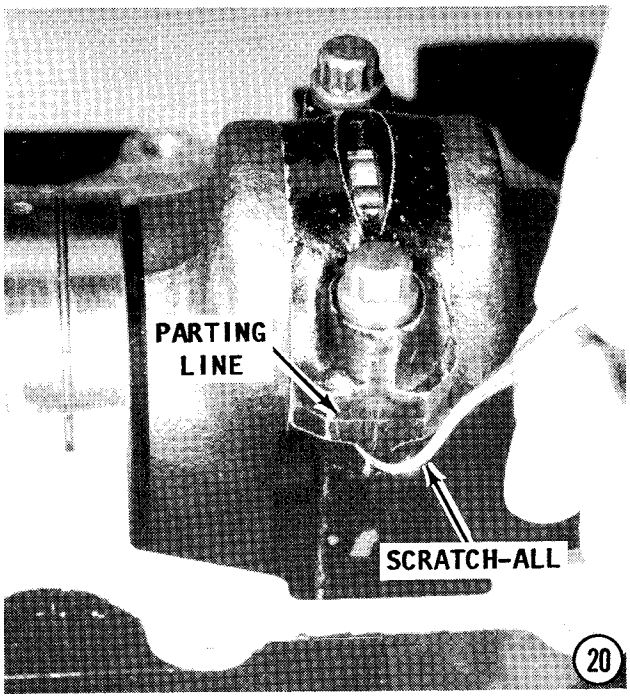


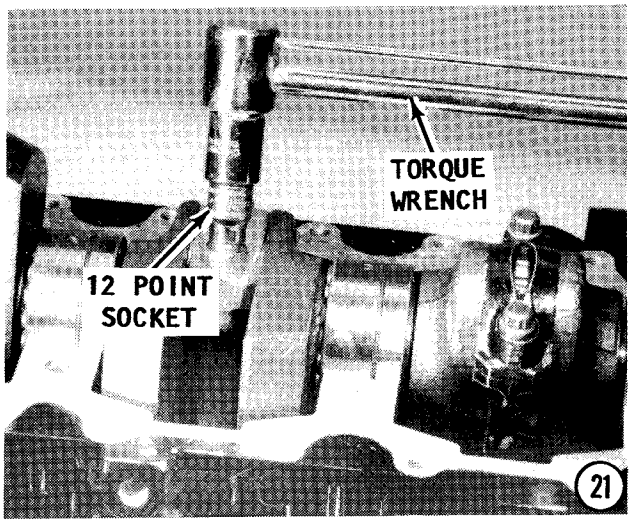
NEVER intermix roller bearings from one connecting rod cage with those from another rod cage. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for service or is lost, the entire set **MUST** be replaced.

18- Move the connecting rod up to the crankshaft journal. Support the rod in place with one hand and remove the cap bolt.

Apply a coating of Quicksilver Needle Bearing Assembly Lubricant C-92-42649A-1 to the crankshaft journal. Install the other bearing cage and the remaining roller bearings into the lubricant.

19- Thread the cap bolts into the cap until the bolt end is flush with the mating



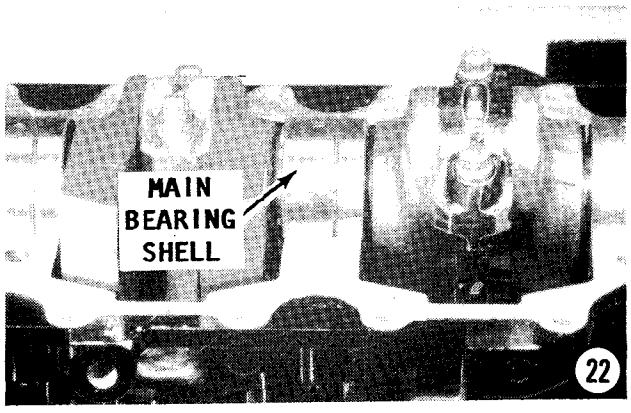


surface of the cap. The manufacturer recommends the connecting rod bolts be installed **DRY**, with no oil or sealer applied to the threads. Place the rod cap in position with the marks on the connecting rod and cap aligned. Hold the two halves of the connecting rod cap tightly together and thread the rod bolts as far as possible by hand.

20- Check the alignment between the rod cap and the rod by moving a scratch-all back and forth on the chamfered corners between the rod cap and the rod. If a ridge is felt, the rod cap is not aligned properly. The cap **MUST** be aligned before proceeding.

21- Use a 12-point socket and tighten the rod bolts alternately in three progressive stages to a torque value of 30ft lb (41Nm). Tighten to 1/3 the torque value on the first sequence; to 2/3 the value on the second sequence; and to the full torque value on the third and final sequence. Again check the alignment between the cap and the rod.

22- Make a final inspection of the main bearings. All bearing shells **MUST** be firmly seated against the block -- indexed with lo-



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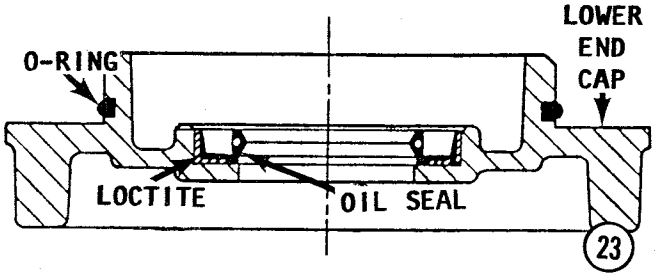


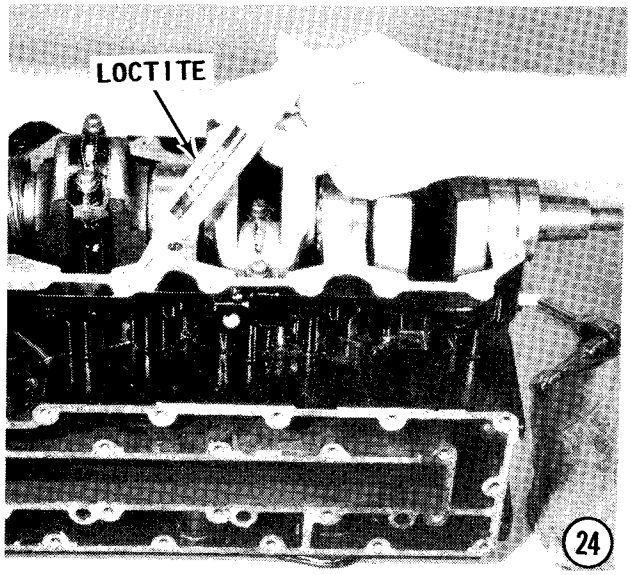
cating posts on the bearing mating surface. Do **NOT** attempt to rotate the crankshaft at this point, as the bearing shells may unseat. Exert a slight downward hand force on the crankshaft, and at the same time attempt to rotate the main bearing shells -- one at a time. The attempt should fail. If a shell can be rotated, the bearing is not seated properly -- the locating pin in the block is not indexed in the hole in the bearing shell.

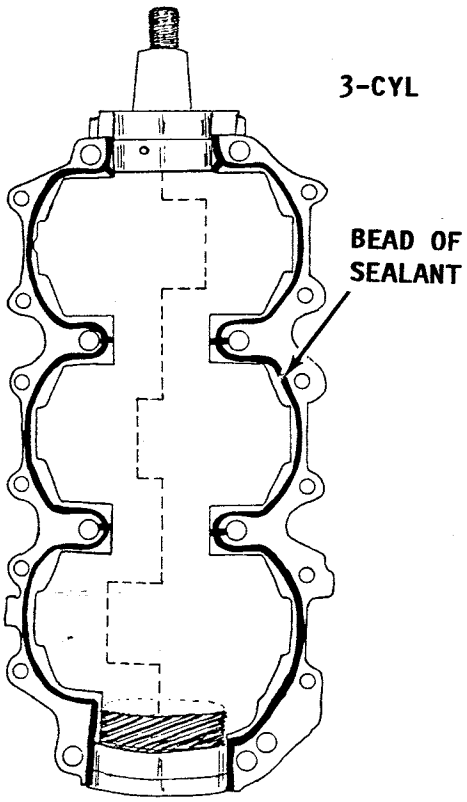
Lower End Cap Assembling

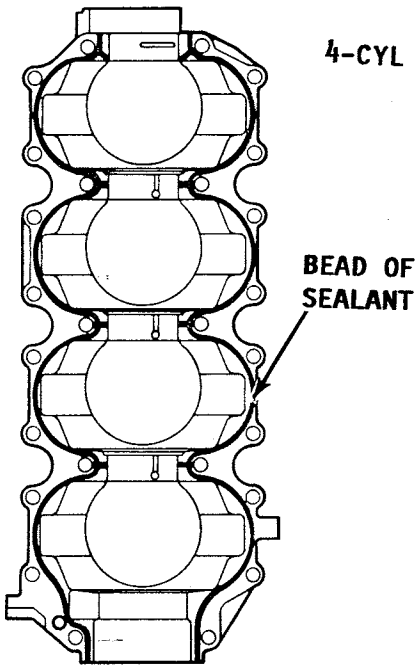
23- Lay down a thin bead of Loctite "A", or equivalent, to the outer diameter of the lower end cap oil seal. This outer diameter is the area making contact with the end cap. Use a suitable driver and press the oil seal into the lower end cap with the lip of the seal **UP.** The lip will then face toward the cylinder block when it is installed. Continue to press the seal into place until the seal is firmly seated on the end cap shoulder. Clean away any excess Loctite.

Lubricate the surface of the end cap making contact with the cylinder block, and the lower end cap **O**-ring with light weight oil. Install the lubricated **O**-ring around the lower end cap.

Install the lower end cap over the crankshaft.







Lay down a bead of sealant around the perimeter of the crankcase, following the dark lines indicated. Extend the bead to each center main bearing journal to prevent "blow-by" between cylinders.

Crankcase Cover Installation

24- Obtain Loctite Master Gasket Sealant kit, C-92-12564-1.

Before mating the crankcase cover and the cylinder block, check to be sure:

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a- The mating surfaces are clean. **NEVER** use any kind of tool or abrasive material to clean the surfaces. Use only solvent and "elbow grease".

b- The crankshaft is properly seated.

c- The rod caps have been correctly installed.

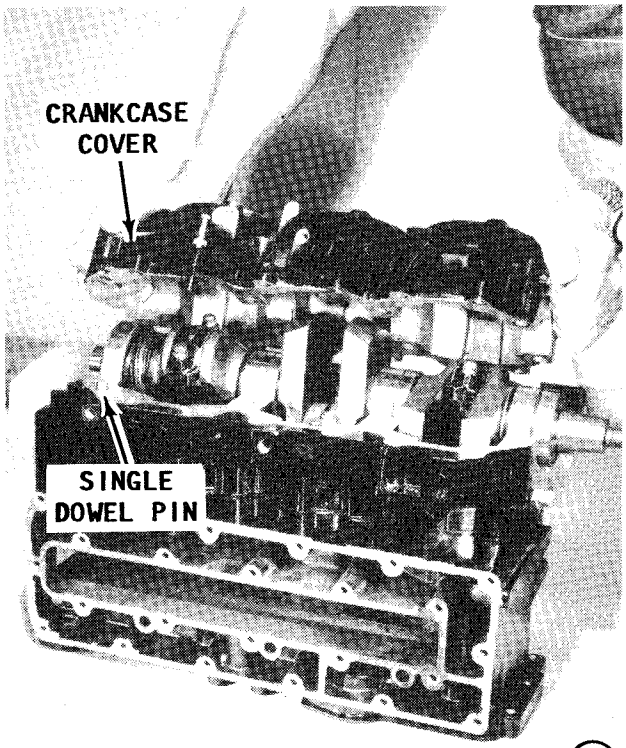
d- The single dowel pin is in place on the block mating surface.

Follow the directions in the kit and lay a bead of sealant onto the contact surface of the crankcase, as indicated by the dark line, in the accompanying illustrations. Extend the bead of sealer to each center main journal to prevent "blow-by" between cylinders.

25- Lower the crankcase cover over the block, indexing the single dowel pin. Align the holes, before the sealant has time to set.

26- Notice the bolts are of two different sizes, with the larger bolts located in the two center rows and the smaller bolts on the outer edges of the crankcase. Insert and hand tighten the bolts to be sure all are accounted for. There is a torquing sequence for each size bolt, as shown in the accompanying illustration.

First, tighten the larger bolts of the crankcase cover in the pattern shown to the required torque value. Tighten in two sta-



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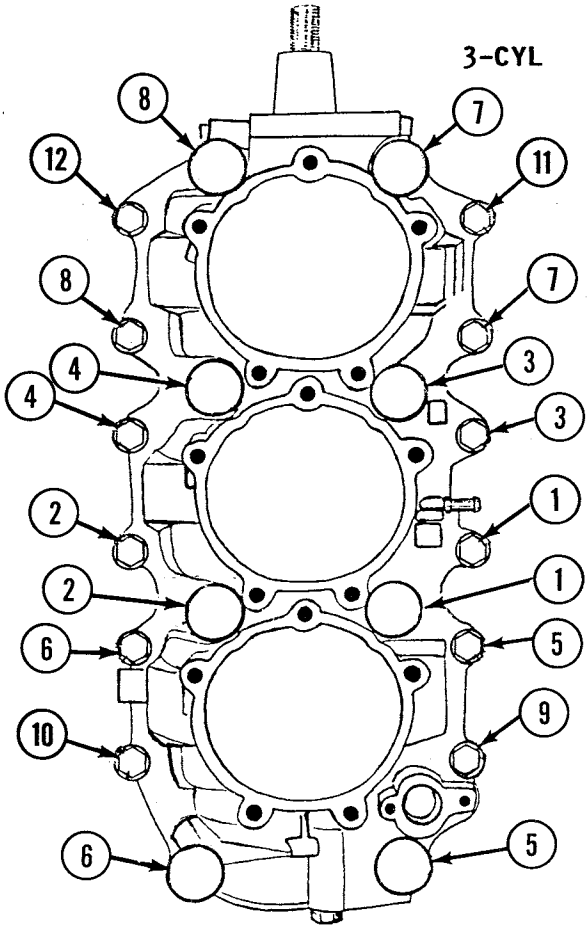

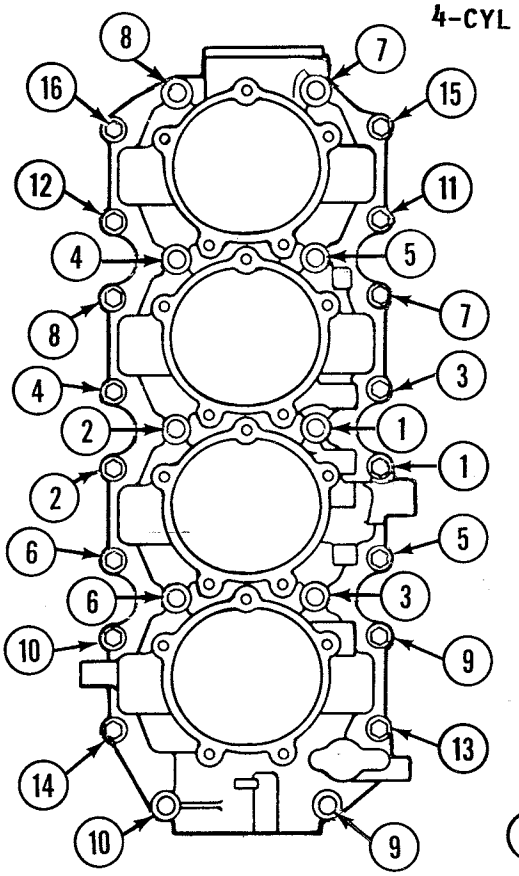

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ges, to a final torque value of 25 ft lb (34Nm).

Next, tighten the smaller bolts of the crankcase cover in the pattern shown to the required torque value. Tighten in two stages, to a final torque value of 12 ft lb (17Nm) for 3-cylinder models or 15 ft lb (20Nm) for 4-cylinder models.

Finally, tighten the bolts securing the lower end cap to a torque value of 150 in lb (16Nm) for 3-cylinder models or 180 in lb (20Nm) for 4-cylinder models.

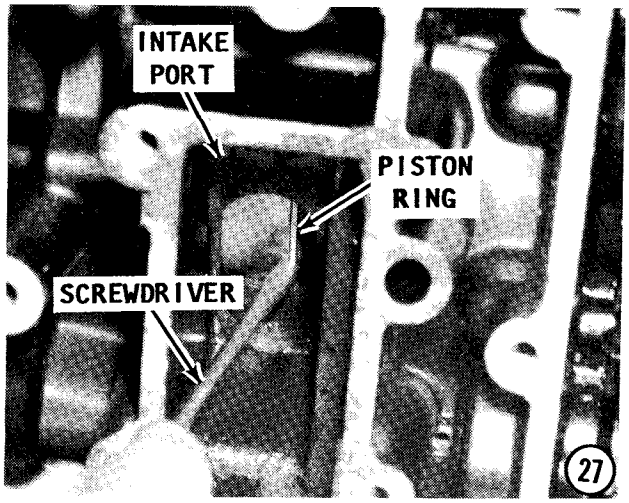
27- Check to be sure each piston ring has spring tension. This is accomplished by **CAREFULLY** pressing on each ring with a screwdriver extended through the intake ports. If spring tension cannot be felt (the spring fails to return to its original position) the ring was probably broken during the piston installation process. **TAKE CARE** not to "burr" the piston rings while checking for spring tension. Thread the flywheel nut onto the end of the crankshaft. Rotate the crankshaft several times with a wrench on the nut and check the installation work thus far. The crankshaft should turn freely with no indication of binding or "rough" spots.

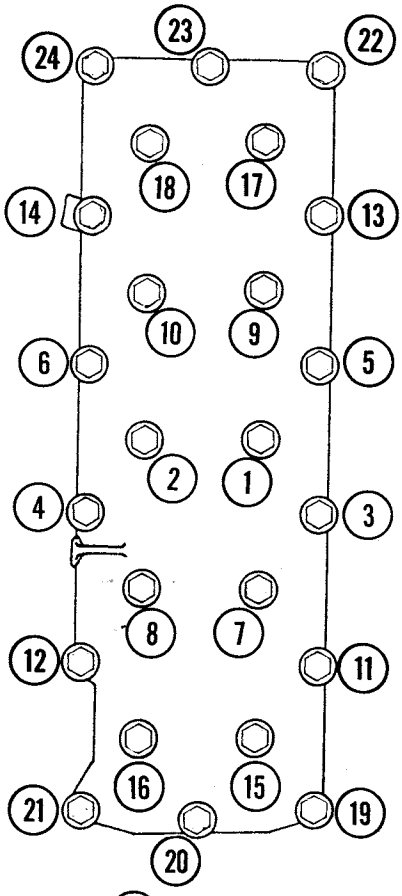
Exhaust Cover Installation

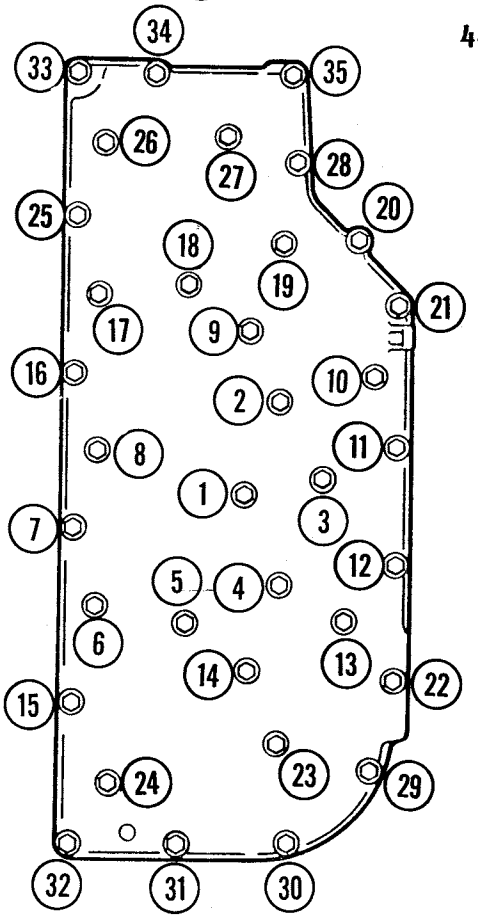
CRITICAL CAUTION

New gaskets must be used and must be properly installed to allow adequate water flow through the powerhead. If the water flow is restricted or blocked by a gasket improperly installed, the powerhead will be severely damaged in a matter of minutes after startup.

28- Position a **NEW** gasket on each side of the exhaust inner plate with the holes in







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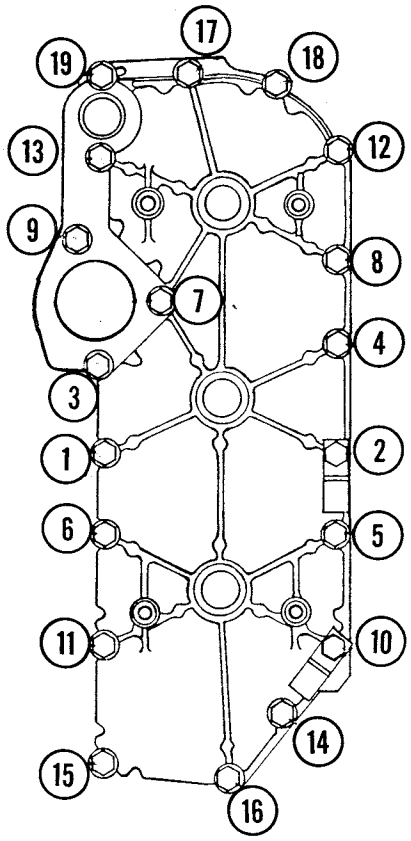

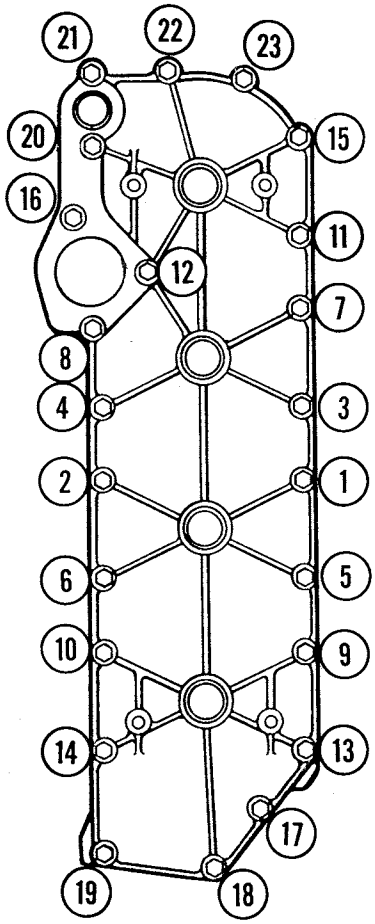

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the gasket aligned with the holes in the inner plate. Install the plate and gaskets onto the cylinder block.

Install the exhaust manifold cover over the inner plate gasket and secure it in place with the attaching bolts. Tighten the bolts to a torque value of 165 in lb (17Nm) for 3-cylinder models or 180 in lb (20Nm) for 4-cylinder models. Follow the sequence pattern given in the accompanying illustration.

Cylinder Cover Installation

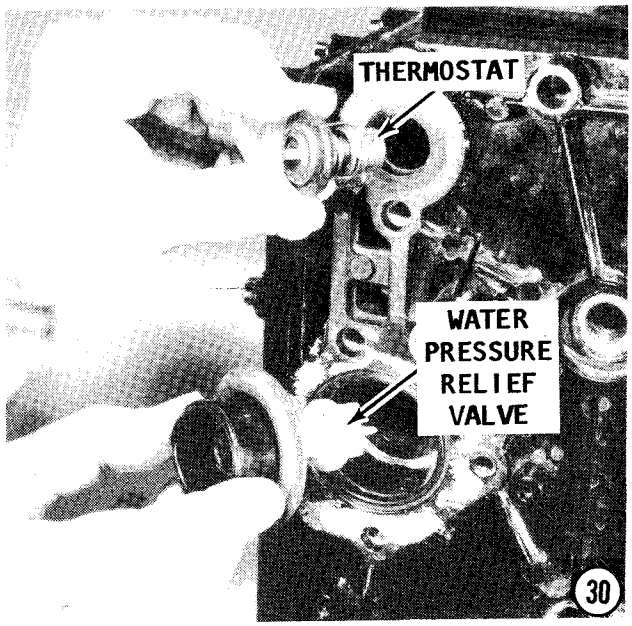
29- Position a new gasket over the water jacket. Install the cylinder cover and position the two retaining clips in the locations indicated in the accompanying illustration. Install and hand tighten the bolts. Tighten the bolts to a torque value of 165 in lb (17Nm) for 3-cylinder models or 180 in lb (20Nm) for 4-cylinder models in the sequence shown.

Thermostat and Water Pressure Relief Valve Installation

30- Install the water pressure relief valve into the recess in the block and secure it with the Phillips head screw. Install the thermostat into the block with the spring end going in first.

31- Install the spring over the water pressure relief valve, the rubber sealing ring around the thermostat, the larger thermostat gasket and the housing. Hold the housing down against the spring pressure, while installing and tightening the bolts.

Tighten the bolts to a torque value of 15 ft lb (20Nm).



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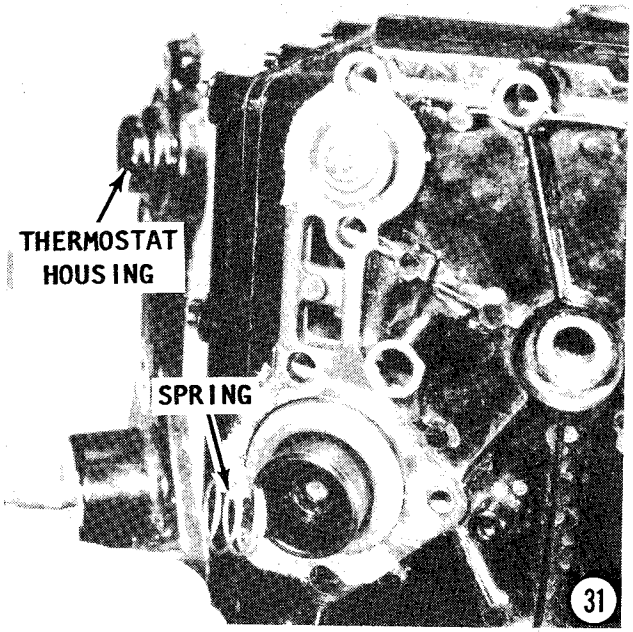

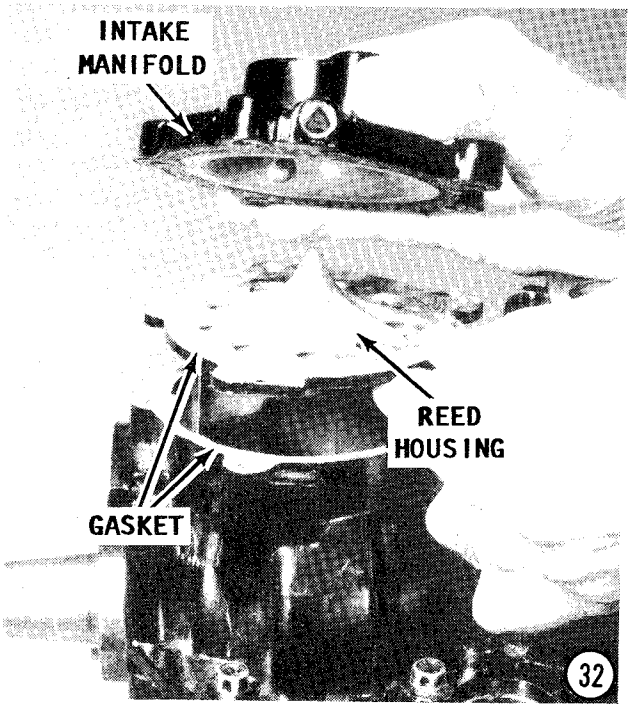

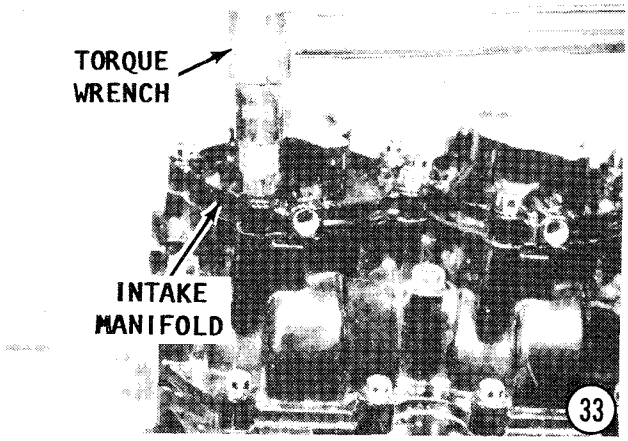

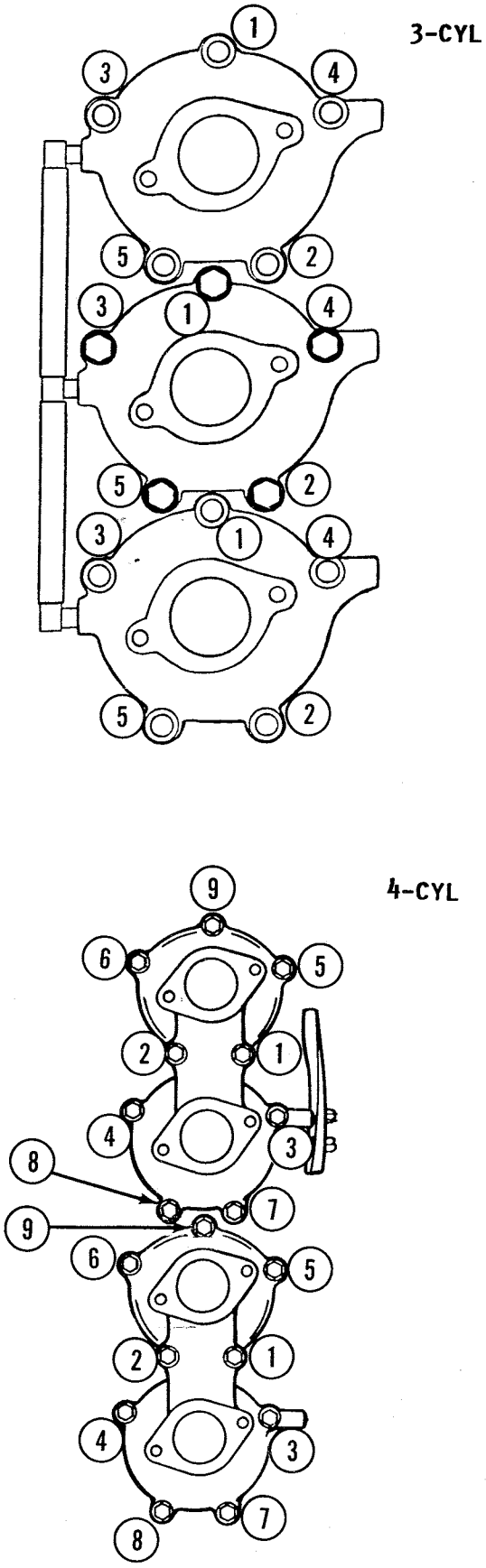

Tightening sequence for the intake manifold bolts on a 3- and 4-cylinder powerhead.

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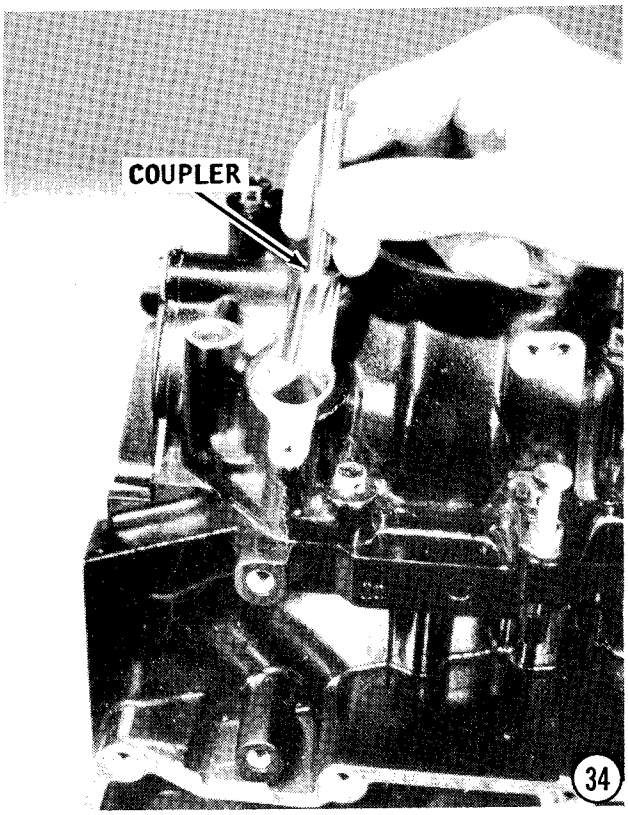

Reed Block Housing Installation

32- Position a new gasket on both sides of the reed housing. Place the intake manifold over the upper gasket. Check to be sure all bolt holes are aligned.

33- Install and tighten the securing bolts alternately and evenly to a torque value of 150 in lb (16Nm) for 3-cylinder models or 180 in lb (20Nm) for 4-cylinder models.

Oil Pump Installation

34- Insert the oil pump shaft into the block with a **COUNTERCLOCKWISE** rotation to ensure the splines on the shaft index with the teeth of the oil pump gear on the crankshaft. The top of the shaft has a flat edge to mate with the coupler. If the plug and magnet were removed from the coupler, a directional compass is required for assembly. Identify the **SOUTH** end of the magnet. Apply a thin coating of Multi-purpose Lubricant to the magnet and the plug, to hold them in place during installation of the coupler. Now, insert the magnet into the coupler with the **SOUTH** end of the magnet going in first. Insert the plug into the opening with the flat side of the plug going in first to bear against the magnet.

Lower the coupler onto the oil pump shaft. When the coupler has mated with the shaft correctly, the coupler cannot be rotated. Place the O-ring over the coupler and index the shaft of the oil pump into the top recess of the coupler. Secure the oil pump to the block with the attaching hardware. Tighten the bolts to a torque value of 60 in lb (7Nm).

POWERHEAD INSTALLATION

Install the trigger plate assembly in the upper end cap and insert the link rod swivel into the vertical throttle lever. Secure the link rod to the throttle lever. Apply a drop of Loctite Type "A" onto the threads of the stator attaching screws. Install the stator assembly in the upper end cap. Tighten the attaching Allen head screws to a torque value of 60 in lb (7Nm).

Insert the flywheel key in the crankshaft keyway. Check the inside rim of the flywheel to be sure metal particles are not stuck to the flywheel magnets. Check to be sure the inside taper of the flywheel and the taper on the crankshaft are clean of dirt or oil, to prevent the flywheel from "walking" on the crankshaft during operation. Slide the flywheel down the crankshaft with the keyway in the flywheel aligned with the key on the crankshaft. Rotate the flywheel **CLOCKWISE** and check to be sure the flywheel does not contact any component or any of the wiring. Slide a flat washer onto the crankshaft, and then thread the flywheel nut onto the crankshaft. Hold the flywheel with a flywheel strap and tighten the nut to a torque value of 120 ft lb (163Nm).

Thread a lifting eye onto the end of the crankshaft as far as it will go. For **SAFETY,** check to be sure the lifting eye is properly installed. Using a suitable hoist, lift the powerhead. Place a **NEW** gasket around the powerhead studs and into position on the base of the intermediate housing. Lubricate the driveshaft splines with Multi-purpose Lubricant. Slowly lower the powerhead down onto the intermediate housing. It may be necessary to rotate the flywheel slightly to index the crankshaft splines with the driveshaft splines. Once the splines index, lower the powerhead fully into place on the intermediate housing.

Secure the powerhead to the intermediate housing with the eight flat washers and locknuts. Tighten the locknuts in three stages to the following torque value:

75 and 90hp	165 ft lb (19Nm)
100 and 115hp	350 ft lb (40Nm)

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Disconnect the hoist from the lifting eye, and then remove the eye from the crankshaft. Install the plastic cap onto the end of the crankshaft. Install the flywheel cover and secure it in place with flat washers and wingnuts.

Install the throttle lever to the reed housing, with the flat washer between the lever and the housing. Secure the lever with the 17mm nut. The manufacturer does not give a torque value for this nut, but states "the nut must be tight, but the joint must still be free to pivot".

Attach the ignition plate, with the electrical components, to the starboard side of the powerhead with the four bolts and flat washers. Check to be sure the ground wires are properly installed, and then tighten the bolts securely.

Connect the stator wires and trigger wires to the proper terminals of the switch boxes.

Push the temperature sender into the sealing grommet under the thermostat housing. Secure the sender retainer with a single Phillips head screw. Connect the Black lead to the terminal block.

Connect the Purple and Light Blue leads at their quick disconnect fittings. Connect the Tan and Black leads from the oil level warning horn to the terminal block on the ignition plate.

Install the oil level warning module, if so equipped, under the ignition plate. Tighten the two securing bolts to a torque value of 80 in lb (4.5Nm).

Install the shift bracket to the powerhead. Tighten the two bolts to a torque value of 180 in lb (20Nm).

Attach the shift arm to the under side of the shift bracket. Connect the throttle cable to the throttle lever.

Install the cranking motor to the powerhead. Tighten the four attaching bolts to a torque value of 165 ft lb (18.6Nm) for 3-cylinder powerheads or 180 ft lb (20Nm) for 4-cylinder powerheads.

Position new carburetor gaskets onto the carburetor mounting flanges of the reed block housing. Install the carburetors, and then the air box onto the powerhead as an assembly. Secure the assembly with locknuts to the intake manifold. Tighten the nuts to a torque value of 100 in lb (11Nm). Install the fuel filter and connect the inlet fuel hose to the top carburetor. Connect the fuel hose from the enrichener valve to the **"T"** fitting between carburetor No. 1 and carburetor No. 2.

On 4-cylinder powerheads: Install the accelerator pump to the block and tighten the attaching bolts securely. Connect the inlet hose to the forward fitting on the pump and route the aft hose to the **"T"** fitting on the starboard side of the powerhead to supply fuel to the check valves on the No. 3 and No. 4 cylinders. Connect the fuel inlet hose from the accelerator pump to the **"T"** fitting between carburetors No. 2 and No. 3. Connect the vapor return hose from the accelerator pump to the **"T"** fitting next to the fuel pump.

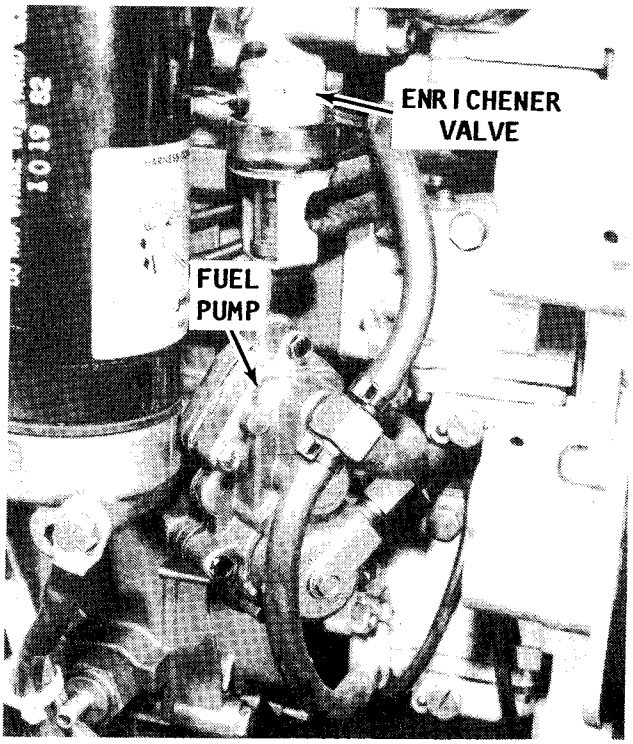
All models: Connect the bleed hose from the No. 1 cylinder fitting to the check valve located at the lower end cap.

Install the fuel pump gaskets and diaphragm. Assemble the fuel pump to the reed block housing. Secure the fuel pump assembly in place with the five screws tightened to a torque value of 40 in lb (4.5Nm).

Snap the oil control link rod onto the ball joint of the No. 2 carburetor throttle lever.

Connect the throttle control link rod between the throttle cam and the throttle lever.

Install the oil tank, first securing it to the powerhead with the bottom oil tank support bracket. Hold the tank to prevent it



Location of the enrichener valve and fuel pump, showing hose routing.

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from tipping over until the upper air box mount plate can be installed and secured. Install the mount plate with the attaching hardware and tighten the bolts to a torque value of 100 in lb (11Nm). Then install the upper tank support bracket across the filler cap. Connect the oil supply hose to the oil pump.

Install the air box cover and tighten the attaching screws securely. Install the fuel joint connector to the front lower cowling bracket with the single bolt. Secure the front cowl mount bracket to the air box mount plate. Tighten the two attaching bolts to a torque value of 150 in lb (17Nm).

Connect the large Red battery cable to the cranking motor solenoid. Connect the large Black battery cable to the lower front cranking motor mount bracket. Tighten this grounding bolt to a torque value of 180 in lb (20Nm). Connect the large Yellow cable from the solenoid to the cranking motor. Connect the two halves of the power trim fuse mounted on the cranking motor.

Check to see all connections to the terminal block on the ignition plate have been made. Refer to the diagram in the Appendix, if necessary, and then install the ignition plate cover. Secure the control box wiring harness to the side of the powerhead cowling mount bracket with the retaining strap and two Phillips head screws.

Install the aft cowling bracket and tighten the securing bolts to a torque value of 150 in lb (17Nm). Attach the tattle-tale hose to the aft cowling support bracket.

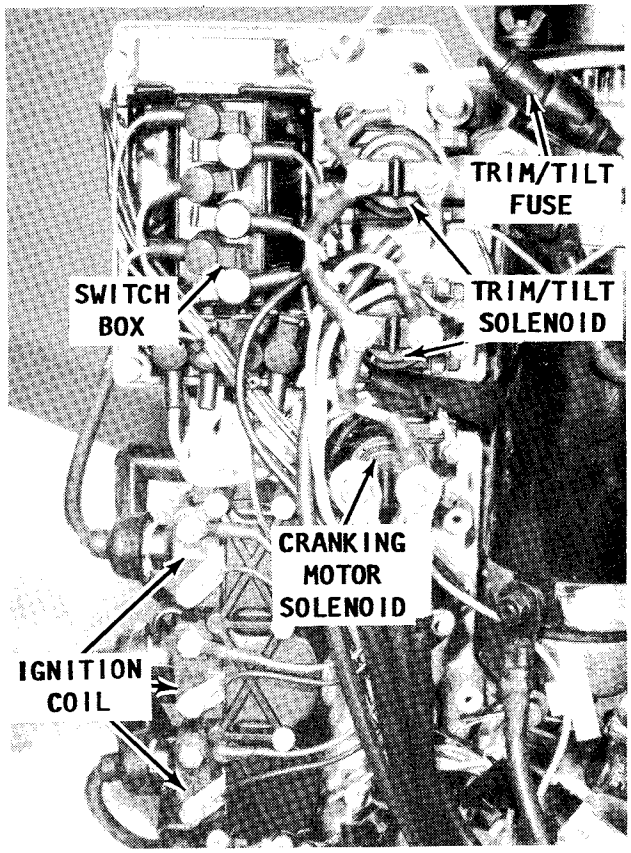
Install and tighten the spark plugs to a torque value of 20 ft lb (27Nm).

Connect the ignition coil high tension leads to their respective spark plugs. Connect the remote control cables to the powerhead. Connect the engine battery cables to the battery terminals. Check to be sure the system polarity is maintained.

Connect the powerhead and fuel tank lines.

For complete detailed timing and synchronizing procedures, see Chapter 7.

Mount the outboard unit in a test tank or on a boat in a body of water. Turn the fuel shut off valve to the **ON** position. Start the powerhead and follow the break in procedures given after the Caution.



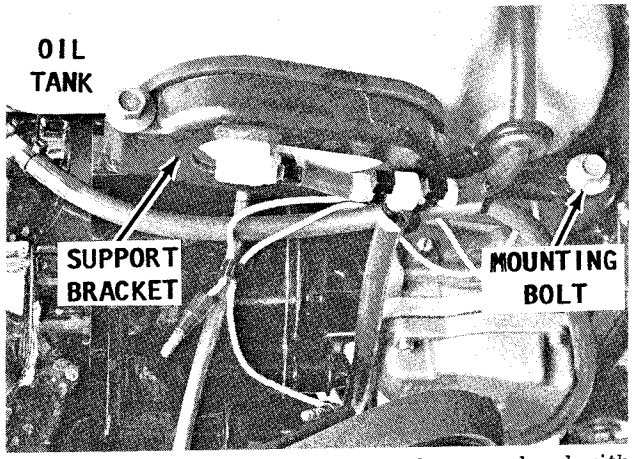
Hopefully, wire leads were tagged prior to being disconnected. If not, refer to the wiring diagrams in the Appendix to make the correct connections on the ignition plate.

CAUTION

Water must circulate through the lower unit to the powerhead anytime the powerhead is operating to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump impeller.

Break In Procedures

As soon as the powerhead starts, **CHECK** to be sure the water pump is operating. If



The oil tank is first secured to the powerhead with the lower support bracket. The tank must be supported while the upper bracket is installed.

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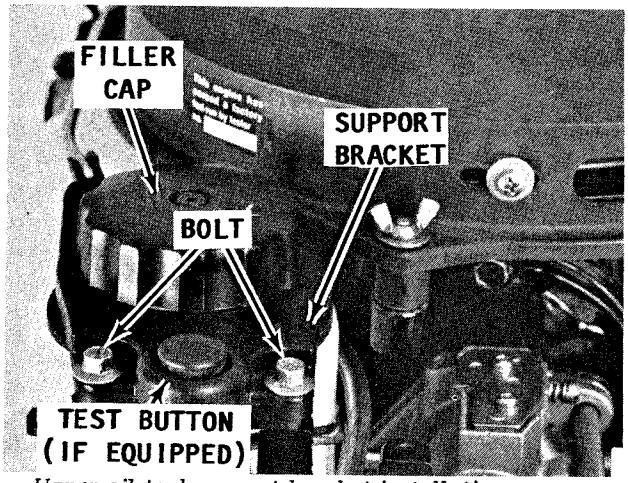


Upper oil tank support bracket installation.

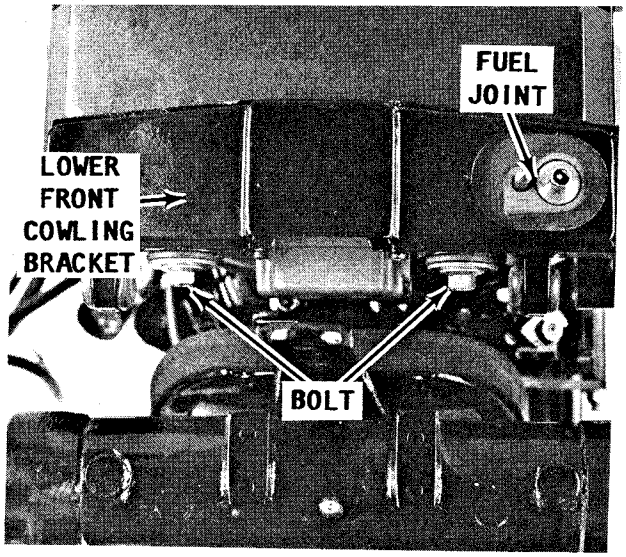
the water pump is operating, a water mist will be discharged from the exhaust relief holes at the rear of the intermediate housing.

Check the cylinder cover, the exhaust manifold cover, and the thermostat cover for water leaks. Make a thorough check for fuel and exhaust leaks. If a powerhead leak is detected, the problem area **MUST** be corrected before placing the engine in service.

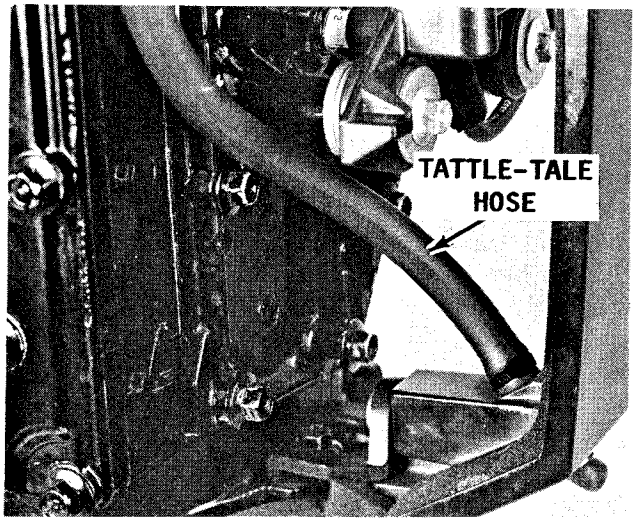
During the first 10 hours of operation, **DO NOT** operate the powerhead at full throttle (except for **VERY** short periods) as follows:

a- Operate at 1/2 throttle, approximately 2500 to 3500 rpm, for 2 hours.

b- Operate at any speed after 2 hours **BUT NOT** at sustained full throttle until another 8 hours of operation.



Installation of the lower front cowling bracket with the fuel joint installed.



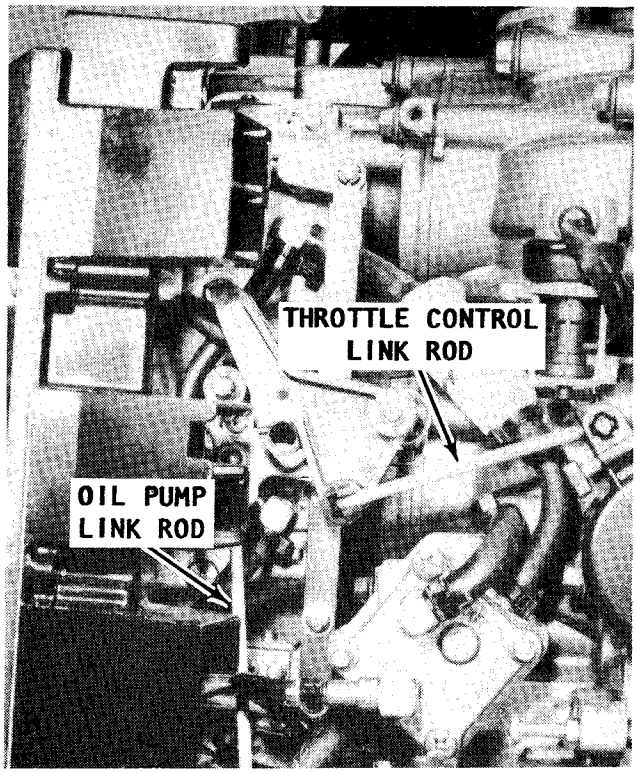
The tattle-tale hose attached to the aft cowling support bracket.

c- Mix gasoline and oil during the break in period, total of 10 hours, at a ratio of 50:1 for **ALL** units including powerheads with oil injection.

d- While the engine is operating during the initial period, check the fuel, exhaust, and water systems for leaks.

e- Refer to Chapter 7 for synchronizing procedures.

After the test period, disconnect the fuel line. Remove the engine from the test tank. Install the engine cowling.



Make a final check of hoses, link rods, and electrical connections before starting up the powerhead.

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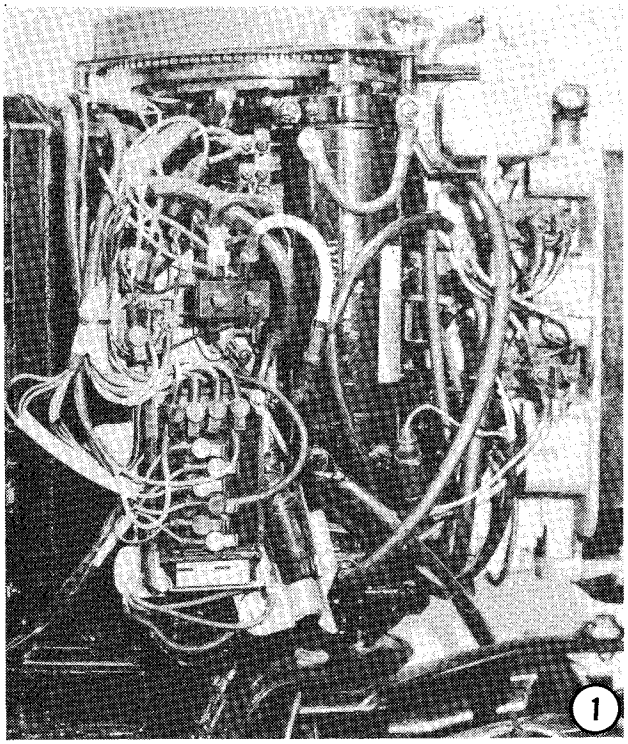
8-4 V6 POWERHEADS

ADVICE

Before commencing any work on the powerhead, an understanding of two-cycle engine operation will be most helpful. Therefore, it would be well worth the time to study the principles of two-cycle engines, as outlined briefly in Section 8-1. A Polaroid, or equivalent instant-type camera is an extremely useful item, providing the means of accurately recording the arrangement of parts and wire connections **BEFORE** the disassembly work begins. Such a record is invaluable during the assembly work.

In order to obtain the maximum results from the overhaul work, the instructions outlined in this section for removal, disassembly, assembling and installation should be followed in the sequence given. If complete disassembly is not required, begin the assembling sequence at that point, after following the Cleaning and Inspecting procedures at the end of this chapter in Section 8-5, for the items disassembled. Complete disassembly of the powerhead is usually not necessary. For instance:

To inspect the cylinder walls and pistons.
Minor repairs on supporting components, such as, the ignition system, carburetors, reed blocks, and the cylinder heads.
Operational check of the thermostats and temperature sender.



POWERHEAD REMOVAL

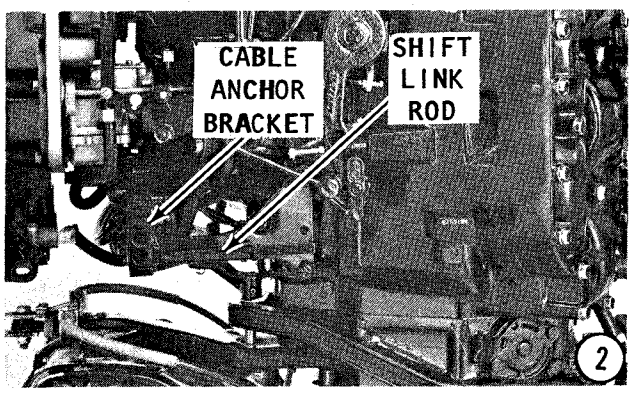
1- Disconnect the engine battery cables from the battery terminals. Disconnect the engine fuel line from the fuel tank. Remove the front engine cowling cover. Remove the port and starboard halves of the engine cowling. Separate the electrical extension harness connectors. Disconnect the remote control cables from the powerhead.

STOP, and carefully observe the wiring and hose connections before proceeding. Because there are so many different engines and the arrangement is slightly different on each, it is not possible to illustrate all of them. Even if they were shown, you would not be able to identify the engine being serviced. Therefore, **TAKE TIME** to make notes and tag the wiring and hoses. You may elect to follow the practice of many professional mechanics by taking a series of photographs of the engine, one from the top, and a couple from the sides showing the wiring and arrangement of parts.

2- Remove the locknut, washer, latch, and wear plate securing the shift link rod assembly to the control cable anchor bracket.

Disconnect the water hose from the tattle-tale nozzle. Remove the three locknuts and flat washers securing the rear cowling bracket assembly to the exhaust manifold cover, and then lift the cowling bracket assembly from the powerhead. Remove the locknuts and flat washers, five on each side securing the powerhead to the intermediate housing.

Disconnect the oil inlet hose from the oil pump and plug the line quickly to prevent oil from draining from the oil reservoir. Remove the attaching hardware and lift the reservoir free of the powerhead. The line from the remote oil tank need not be disconnected. Set the tank aside out of the way.



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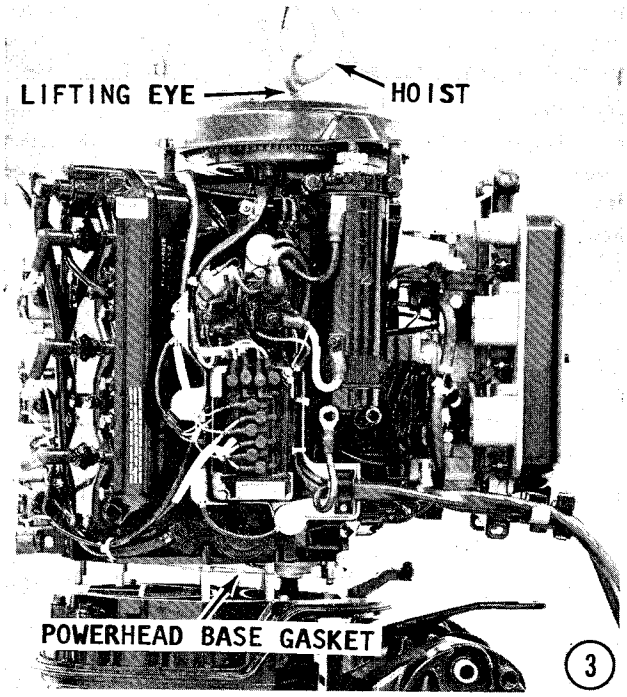
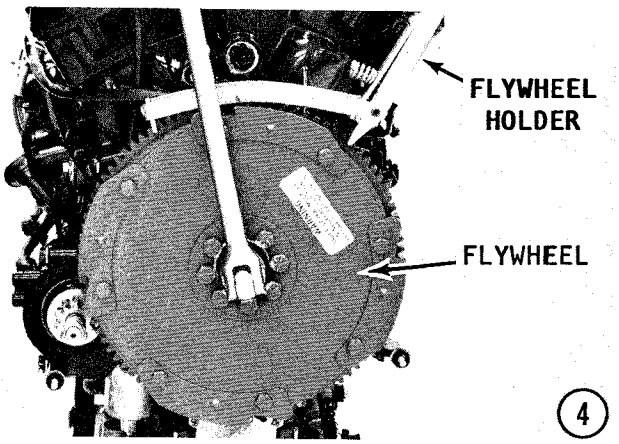


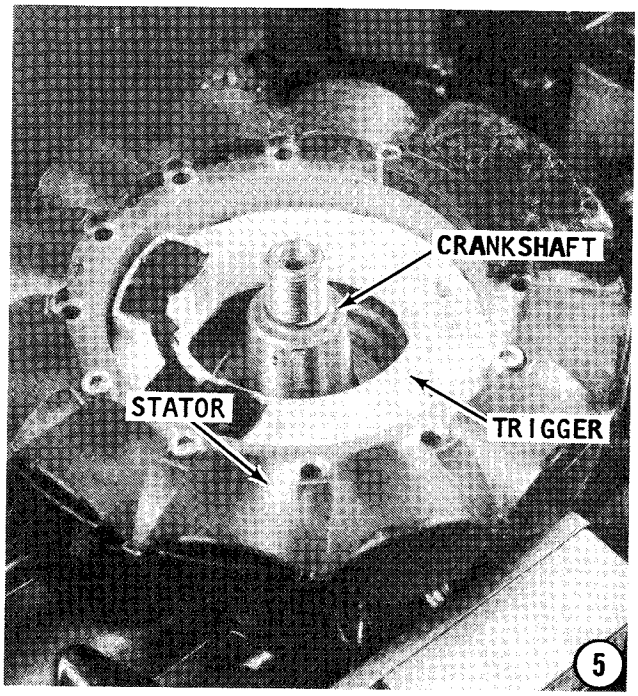
3- Remove the plastic cap from the end of the crankshaft. Thread a lifting eye into the crankshaft end as far as it will go. Using a suitable hoist, lift the powerhead assembly clear of the engine.

Disconnect the high-tension leads from the spark plugs. **ALWAYS** use a pulling and twisting motion as a precaution against damaging the connection. Remove the spark plugs from both heads.

4- Mount the powerhead onto some type of stand, to facilitate easy access to all parts. **NEVER** attempt to mount the powerhead in a stand secured in a vise. Such an attempt will only lead to damage of the powerhead and possibly to personal injury. Remove the lifting eye from the crankshaft.

Remove the flywheel cover from the engine. Hold the flywheel from turning with a flywheel strap or with a Flywheel Holder,





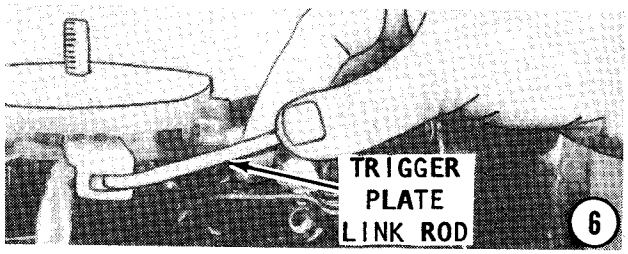
C-91-52344. Remove the flywheel nut and washer.

5- Install a crankshaft Protector Cap, C-91-24161, onto the end of the crankshaft. Install Flywheel Puller, C-91-73687A1 into the flywheel. These two items are necessary and may be obtained from the local dealer.

BAD NEWS

The crankshaft may very likely be damaged if the protector cap is not used between the crankshaft and the flywheel puller. **NEVER** attempt to use a puller which pulls on the outside edge of the flywheel, or the flywheel may be damaged. **NEVER** hammer on the end of the center bolt of the puller, because such action will surely cause damage either to the crankshaft, or the bearings, or both. **NEVER** use heat as an aid to removing the crankshaft. Applying heat may seize the flywheel to the crankshaft.

Take up on the puller until the flywheel breaks loose from the crankshaft. Remove the flywheel key from the crankshaft.



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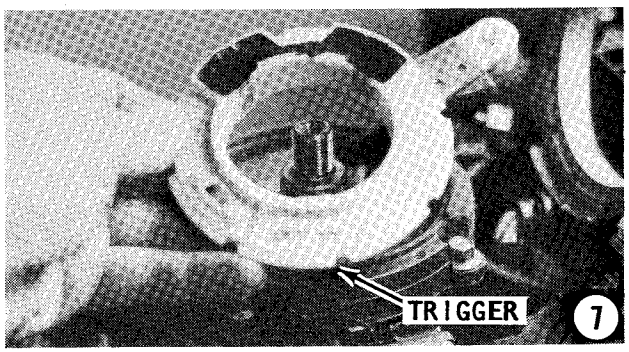


6- Disconnect the stator wires and trigger wires from the terminals of the switch boxes. Remove the stator assembly from the engine. The stator assembly attaching bolts have been secured in place with Loctite, therefore, they will not back out easily. Remove the locknut securing the trigger plate link rod to the upper end of the vertical throttle lever. Now, pull the link rod swivel clear of the throttle lever.

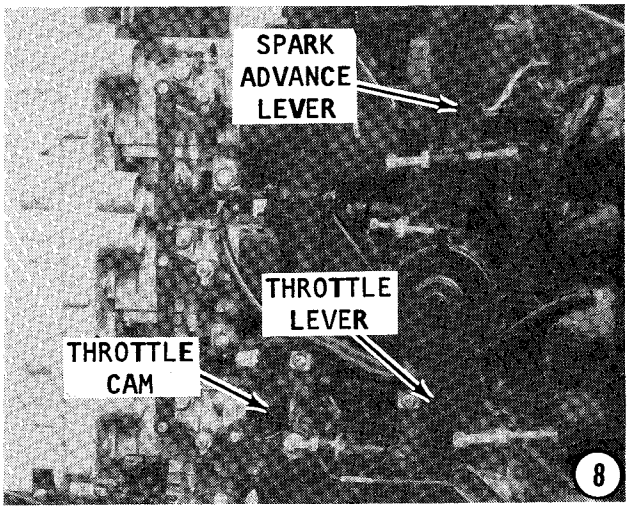
7- Remove the trigger and stator plate assembly from the upper end cap. Disconnect the electrical cables from the starter motor. Remove the upper and lower covers securing the cranking motor to the crankcase cover. Remove the cranking motor.

Disconnect the electrical wiring as follows:

a- The gray powerhead harness wire from the choke solenoid terminal, if so equipped.

b- The white/green powerhead harness wire from the terminal block with the cylinder head temperature sender wires attached.

c- The green, green/white, and green-red switch box wires from the positive (+) terminals of the secondary ignition coils.

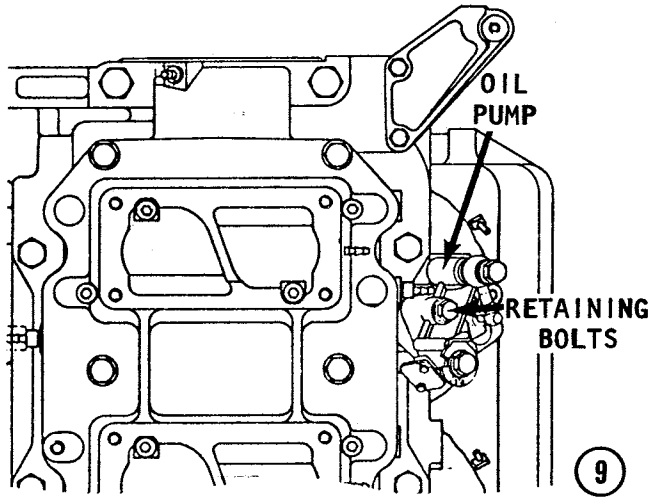


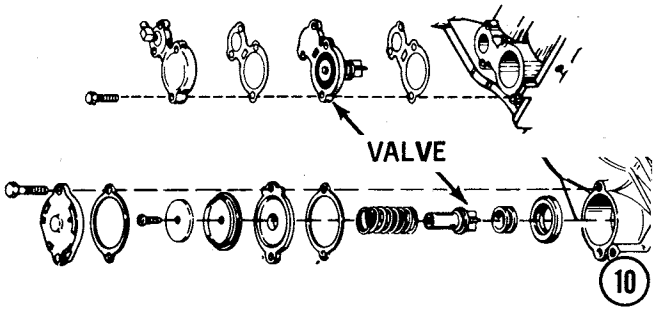
8- Remove the choke solenoid, if so equipped, from the reed block housing. Remove the screws securing the secondary ignition coil covers and the ignition coils to the exhaust manifold cover. Remove the coil assemblies from the engine. The screw threads were coated with Loctite during the previous assembling work, therefore, they will not back out easily.

Remove the three bolts securing the ignition plate to the cylinder block. Lift the ignition plate, together with the electrical components, from the cylinder block.

Remove the locknut, and then the throttle cam and bushings from the reed block housing stud. Remove the pivot bolt, and then lift the vertical throttle lever from the cylinder block. **REMEMBER,** a flat washer is installed between the vertical throttle lever and the cylinder block.

Remove the three bolts securing the control cable anchor bracket to the crankcase cover, and then remove the anchor bracket. Remove the five attaching screws securing the fuel pump assembly to the reed block housing. **TAKE CARE** not to separate the fuel pump components, and lift the fuel pump assembly from the reed block housing. Insert two of the attaching screws back through the fuel pump assembly, and then thread a 10-32 nut onto each screw to





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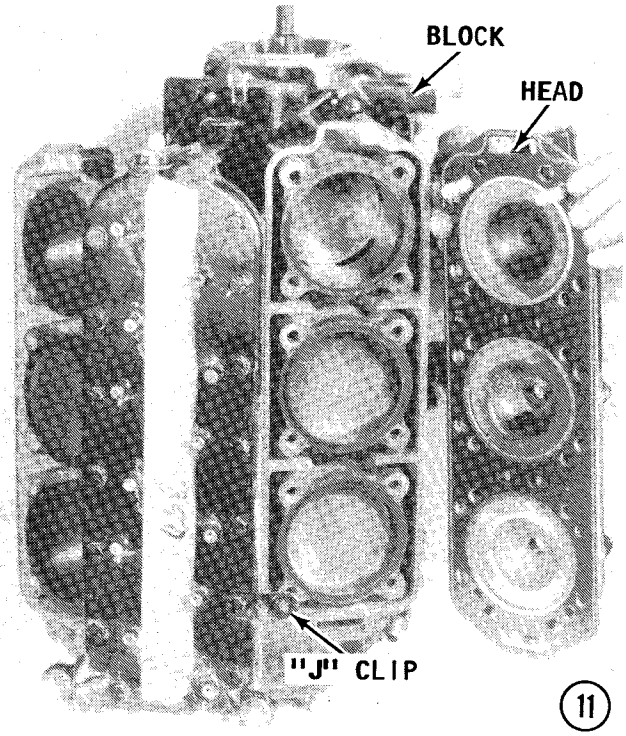
prevent the fuel pump parts from separating during the remainder of the powerhead disassembly work.

9- Disconnect the outlet hose from the oil pump. Plug the end of the hose to prevent foreign matter from entering. Remove the two retaining bolts from the oil pump. Lift the oil pump clear of the powerhead. Remove the **O**-ring from around the coupler. Reach into the block with a pair of needle nose pliers and withdraw the coupler. **TAKE CARE** not lose the small plug and the magnet from the recess in the coupler. Reach in again with the needle nose pliers, and grasp the oil pump shaft. Pull and rotate the shaft slightly **CLOCKWISE** to withdraw the shaft.

GOOD WORDS

It is not necessary to disconnect the fuel hoses from the fuel pump, because the pump will be removed with the carburetors.

10- Disconnect the bleed hose from the check valve located on the port side lower corner of the air intake box. At the switch box, disconnect the wiring harness from the idle stabilizer, or ignition module, if so equipped. Remove the four locknuts securing each carburetor to the reed block housing. Lift the carburetors, choke plate/air box, fuel pump, and cowling brackets from the powerhead as an assembly.



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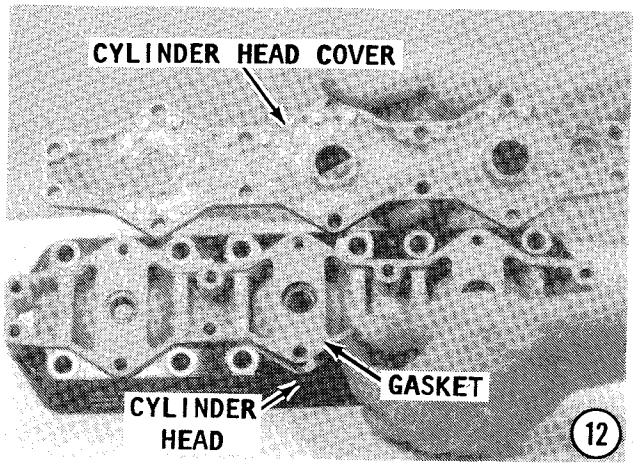


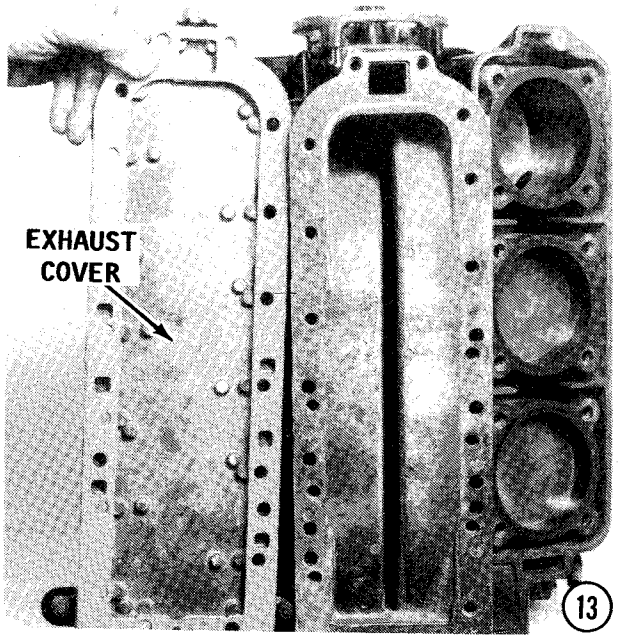
12

SPECIAL WORDS

It may be necessary to disconnect one or two bleed hoses, depending on the bleed hose routing, to permit removal of the carburetor assembly. If it **IS** necessary to disconnect a bleed hose, disconnect it from the cylinder block elbow, **NOT** from the reed block housing check valve.

Disconnect the water distribution hose from the pressure relief valve cover fitting. Remove the bolts securing the thermostat covers to the cylinder head covers. Remove the thermostat cover and the thermostat from each cylinder head cover.

11- As an aid during assembly, observe and identify, the location of the "J" clips on the cylinder head cover bolts. Remove the head bolts from both heads. Remove the heads and head gaskets from the block. Remove the temperature sender from the starboard side cylinder head. As an aid to



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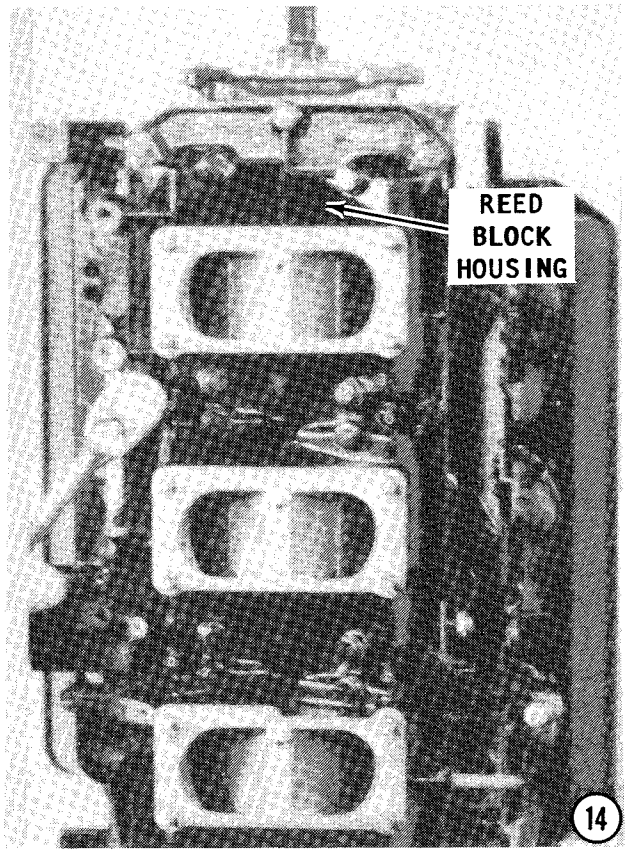
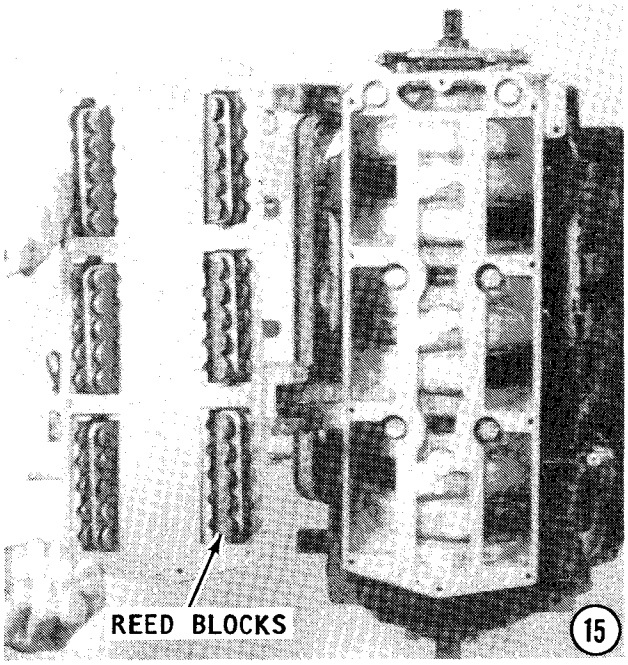


assembly, mark the location of the wiring harness support plate on the exhaust manifold cover bolt.

12- Remove the bolts, gaskets, and covers from each cylinder head. Disconnect the temperature sender wires from the terminals on the starboard side of the powerhead.



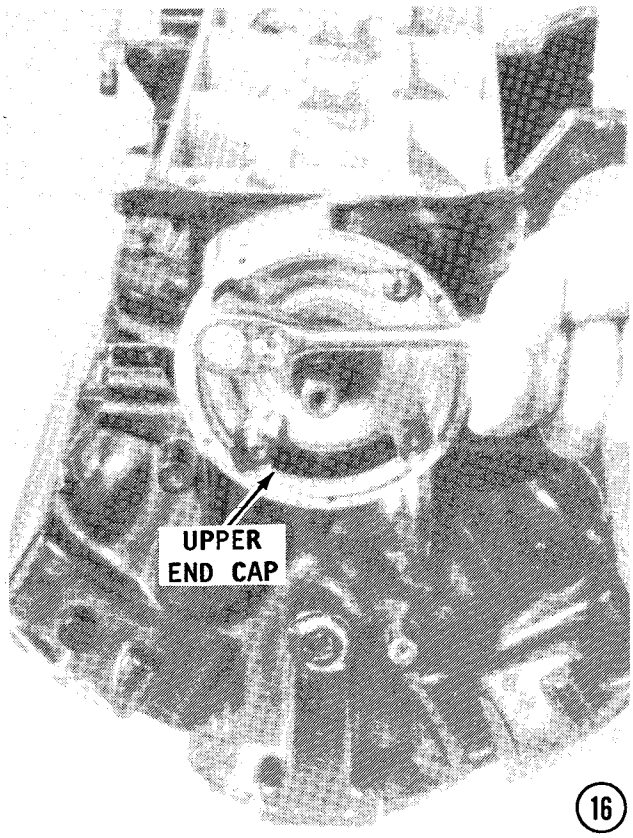
13- Remove the bolts from the exhaust manifold cover. One of the bolts also secures a wiring harness support plate assembly. Make an identification mark on the cover to indicate this bolt as an aid during assembling. Remove the exhaust manifold cover, exhaust divider plate, and the divider plate seal from the cylinder block. Inspect the divider plate for small pin holes or rust. Water in a cylinder could be caused by a defective plate or gasket.

14- Disconnect the bleed hoses from the fittings on the side of the cylinder block. One bleed hose is connected from the reed block housing to each cylinder.

GOOD WORDS

It is not necessary to remove the bleed hoses from the fittings on the reed block housing. **LOOSEN,** but do not remove the bolts securing the reed blocks to the housing. These bolts are located directly above and below the carburetor mounting flanges. Remove the bolts securing the reed block housing to the crankcase cover.

15- Remove the housing and the reed blocks as an assembly. Remove the bolts securing the reed blocks to the housing, and then remove the reed blocks.



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GOOD WORDS:

It is not necessary to disassemble the reed blocks in order to inspect them. If inspection indicates replacement of a reed block part is required, see the Cleaning and Inspection section beginning on Page 8-95.

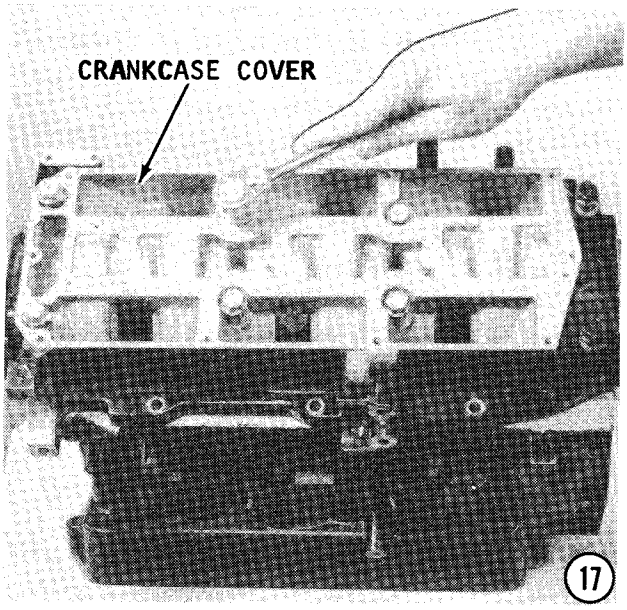
16- LOOSEN the upper and lower attaching bolts, but do not remove the bolts attaching the end caps to the cylinder block. **EXPLANATION:** The end cap bolts are threaded into the cylinder block. These bolts should **NOT** be removed at this time in order to hold the crankshaft in position until the connecting rods are removed from the crankshaft.

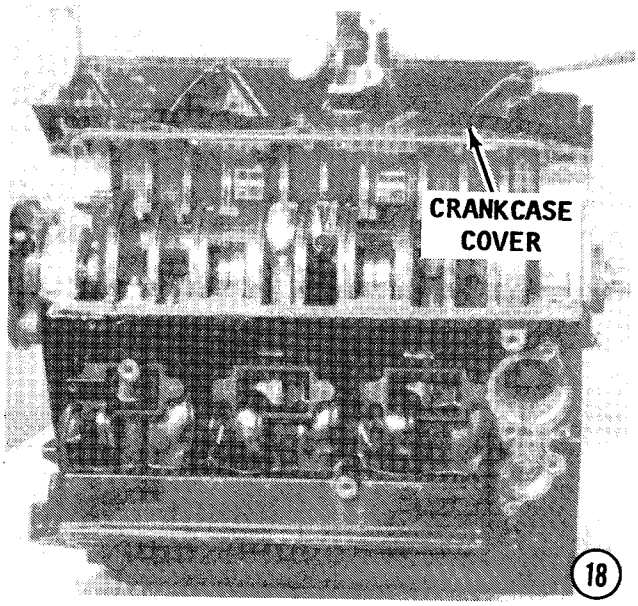
17- Remove the bolts securing the crankcase cover to the cylinder block, and then remove the crankcase cover. **TAKE CARE** not to damage the sealing surfaces or the crankshaft. A sealant is used between the cylinder block and the crankcase cover.

18- Pry the crankcase cover off the cylinder block, if necessary. Use **ONLY** the special recesses provided. **NEVER** pry in any other area or the sealing surfaces may be damaged. A damaged surface will not provide the necessary seal.

CRITICAL WORDS:

The crankcase cover and the cylinder block are a matched, line bored assembly. Therefore, they should **ALWAYS** be kept as a matched set and **NEVER** interchanged with another block or cover.

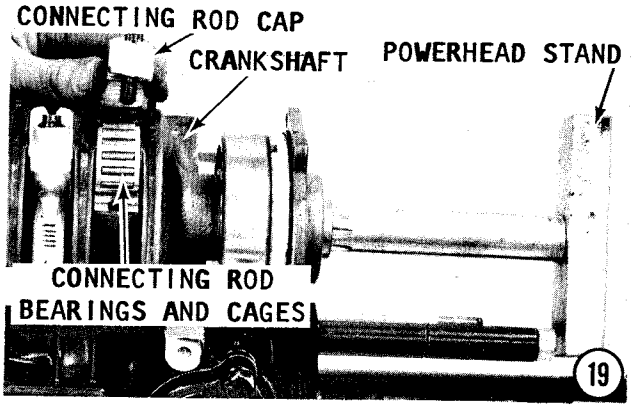




CRANKSHAFT DISASSEMBLING

19- Install Powerhead Stand, C-91-30591A1, into the driveshaft end of the crankshaft. Use the Powerhead Stand to turn the crankshaft to the desired positions when removing connecting rods from the crankshaft. If a powerstand is not available, lay the block on a workbench. Insert the flywheel key into the keyway of the crankshaft, and then slide the flywheel onto the crankshaft with the keyway in the flywheel indexed with the key. Use the flywheel to turn the crankshaft to the required location during removal of the connecting rods.

TAKE TIME to make an identification mark on the outside edge of each rod "I" beam and a matching mark on the inside of the piston skirt. This mark should be made with a marker, whiteout, paint, or any substance which will adhere to a metal surface. **UNDER NO CIRCUMSTANCES** should the mark be a series of notches, gouges, or even scribed. Such a mark can cause "stress



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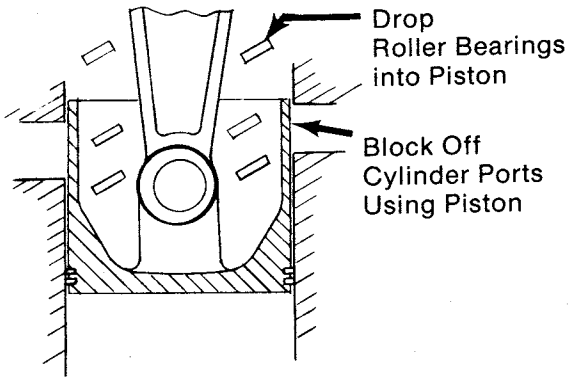


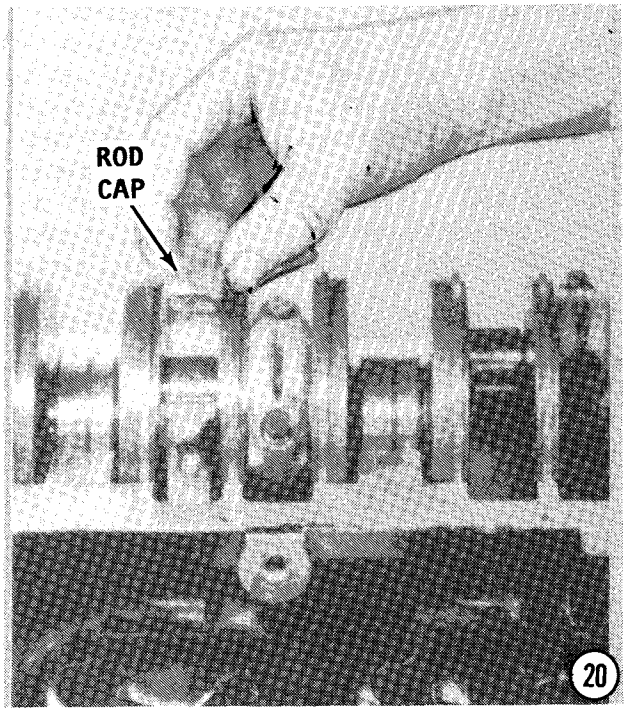
To prevent roller bearings from falling into cylinder ports, first raise the piston to block the ports, then use the inverted piston to catch and hold the bearings as they are removed.

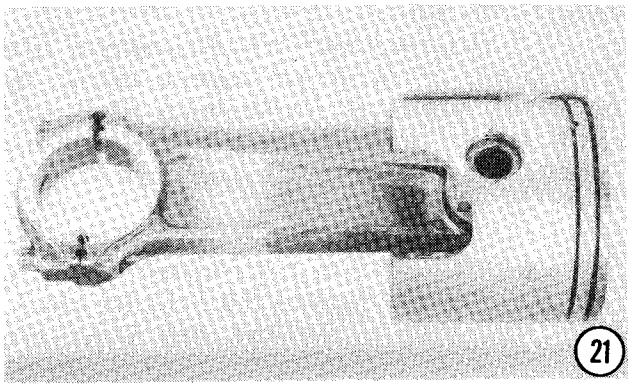
risers", and under heavy powerhead load can cause parts to crack and even fail. The identification mark must match the cylinder from which the piston and rod were removed. From the top of the engine, the cylinders are numbered 1, 3, 5 on the starboard bank, and 2, 4, 6 on the port bank.

20- Remove the connecting rod cap bolts with a 5/16" 12-point socket, and then lift the rod cap, connecting rod bearings and cages from the connecting rod and crankshaft. Raise the piston upward into the cylinder to block off the ports. This maneuver will prevent the roller bearings from being lost inside the powerhead.

Repeat the procedure for each piston.

21- IMMEDIATELY after removing the piston and rod assembly, temporarily assemble the rod cap back onto the rod to keep it as a matched set. Identify and keep the rod bearings and cages together with the rod and piston assembly.



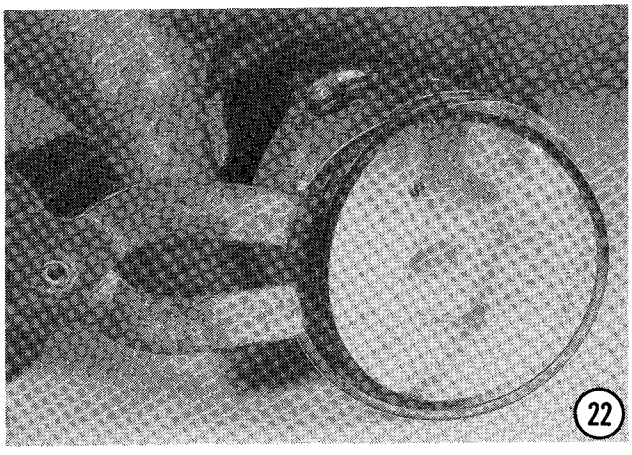


WORDS FROM EXPERIENCE

CLEANLINESS is the password, when handling roller bearings. Take extra care to prevent any dirt, lint, or other contamination from getting onto the bearings or in the cages. If the bearings are to be used again, store them in a numbered container to ensure they will be installed with the same rod and rod cap from which they were removed. **NEVER** intermix roller bearings from one rod to another. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for service, the entire set **MUST** be replaced. Handle the piston with care, because the skirt can be easily bent out-of-round if handled roughly.

Continue removing the rod caps, bearings, and piston assemblies until all have been removed from the crankshaft and the cylinder bores.

22- Remove and **DISCARD** the rings, as each piston and rod assembly is removed. Use a Piston Ring Expander, C-91-24697, to remove the rings. If this special tool is not available, remove them with your hands.



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After the rings have been removed from all of the pistons, carefully inspect each piston and rod assembly according to the procedures outlined in the Cleaning and Inspecting section at the end of this chapter.

PISTON DISASSEMBLING

Three-ring Piston

A 3-ring piston was used on early model V6 engines. If the 3-ring piston is to be used again, **DO NOT** remove it from the rod. Once a 3-ring piston is removed from the rod, it **CANNOT** be used again.

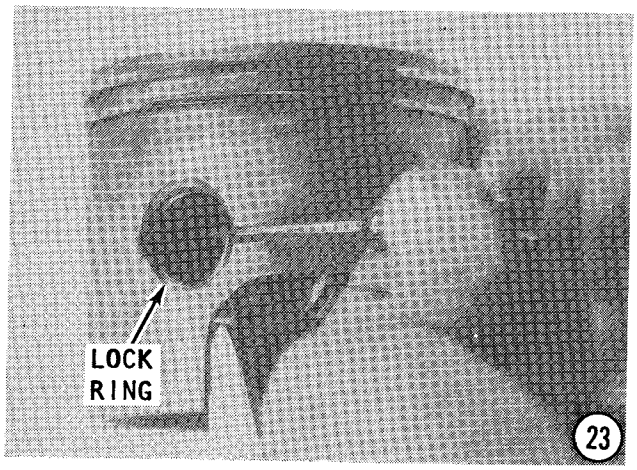
Two-ring Piston

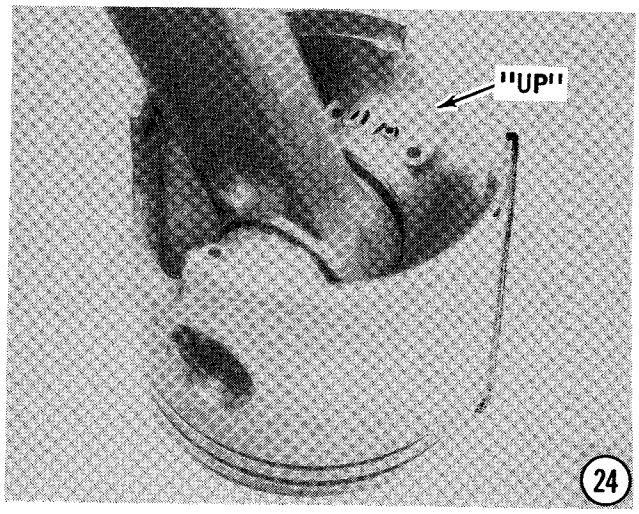
A standard 2-ring piston can be removed from the connecting rod and used a second time. This is the major difference, aside from the number of rings, between the 2- and 3-ring pistons.

The following procedures apply to removal of both types from the rod. Where differences exist, they are clearly indicated. If the determination is made to replace the 3-ring piston, but to use the rod again, **OR** if the condition of the piston pin end of the connecting rod of a standard 2-ring piston assembly is questionable, **OR** if the connecting rod is suspected of being bent, but the piston is to be used again, remove the piston pin per Step 25.

SAFETY WORDS: **WEAR** eye protection glasses while removing the piston pin lockrings, because the lockring is made of spring steel and may slip out of the pliers or pop out of the groove with considerable force.

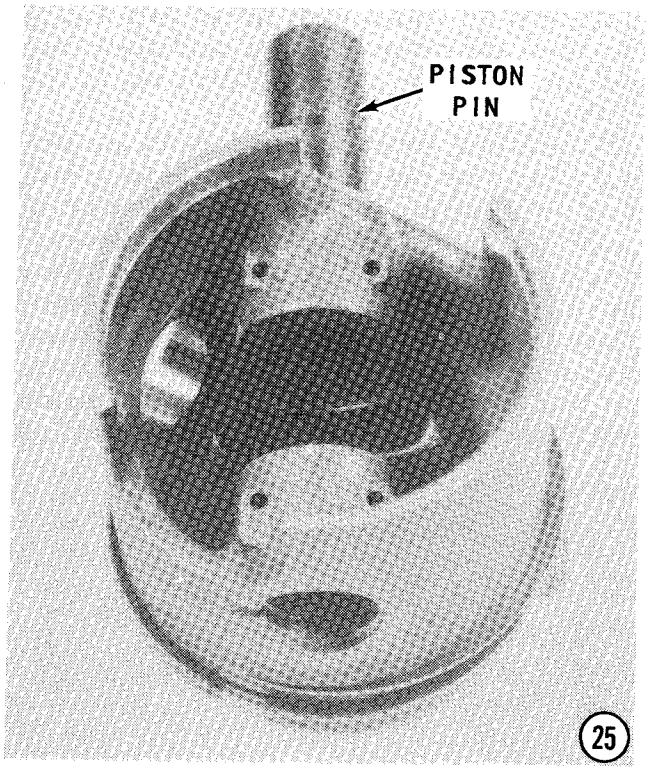
23- Remove the two G-type lockrings using a pair of needle-nose pliers. A lockring tool, C-91-5252A1, may be used to remove the lockring. A third alternative, is to use a punch to pop the ring out. If a punch is used **TAKE CARE** not to damage the piston. **DISCARD** the lockrings, because they should not be used a second time.





24- Heat the piston dome to approximately 190° by submerging the piston in hot water, or by heating it with a heat lamp.

STOP: The piston pin hole on the 3-ring piston is smaller on one side of the piston than on the other. Therefore, the piston pin can only be driven out **ONE** way. Observe the word **UP** on the piston pin boss on one side of the piston. The hole on this side is



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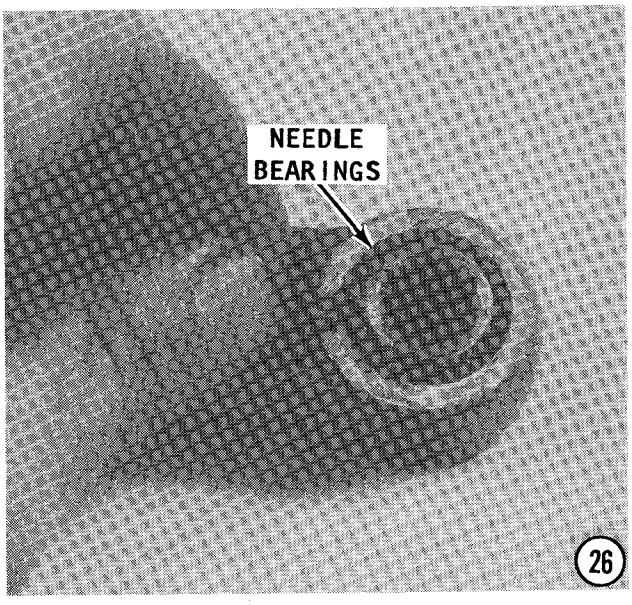
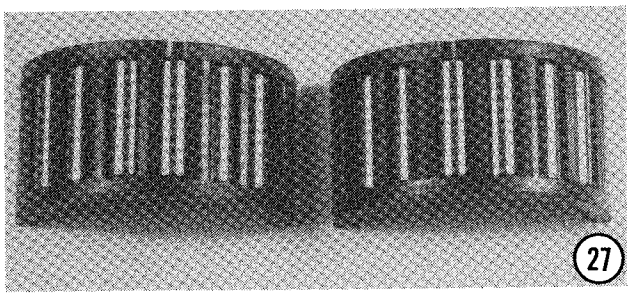


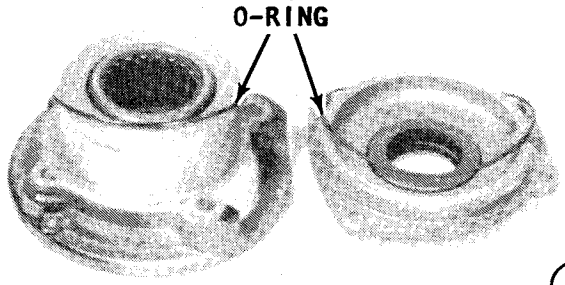
smaller than the hole on the other side. This causes a tighter piston pin fit on the **UP** side of the piston. The pin can only be driven out through the other hole.

25- Three tools are required to remove the piston pin from a 2- or 3-ring piston without damage to the piston, the pin, or the rod: An arbor press, a Piston Support Block, C-91-77005, and a Piston Pin Tool, C-91-74607A1. Position the piston and rod assembly in place on the support block. Place the 3-ring piston on the block with the side of the piston with the word **UP** on the pin boss facing **UP.** A 2-ring piston may be placed on the block with either hole facing up. Use the piston pin tool and the arbor press to move the piston pin down out of the piston.

26- If the connecting rod is to be used again, save the needle bearings, 29 by count, on each piston and two locating washers.

27- CLEANLINESS is the password, when handling needle bearings. Take extra care to prevent any dirt, lint, or other contamination from getting onto the bearings or in the cages. If the bearings are to be used again, store them in a numbered container to ensure they will be installed





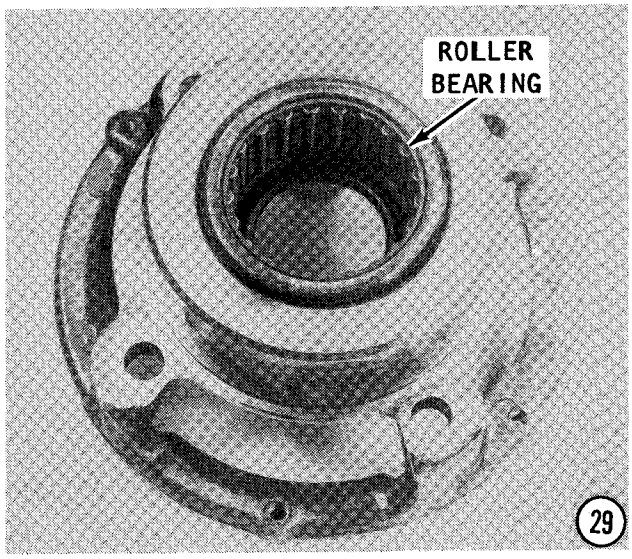
with the same rod and rod cap from which they were removed. **NEVER** intermix roller bearings from one rod to another. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for service, the entire set **MUST** be replaced. Handle the piston with care, because the skirt can be easily bent out-of-round if it is handled roughly.

END CAP DISSASSEMBLING

28- Remove the bolts securing the upper and lower end caps to the cylinder block. These bolts were loosened earlier to permit removal of the crankcase cover. Remove the upper and lower end caps from around the crankshaft. Remove and **DISCARD** the O-ring from each end cap.

29- Inspect the crankshaft roller bearings installed in the upper end cap, as outlined in the Cleaning and Inspecting section at the end of this chapter. **DO NOT** remove the crankshaft roller bearing from the upper end cap unless it is unfit for service and a new bearing is to be installed.

30- Remove the seal from the upper and lower end cap with a punch, as shown.



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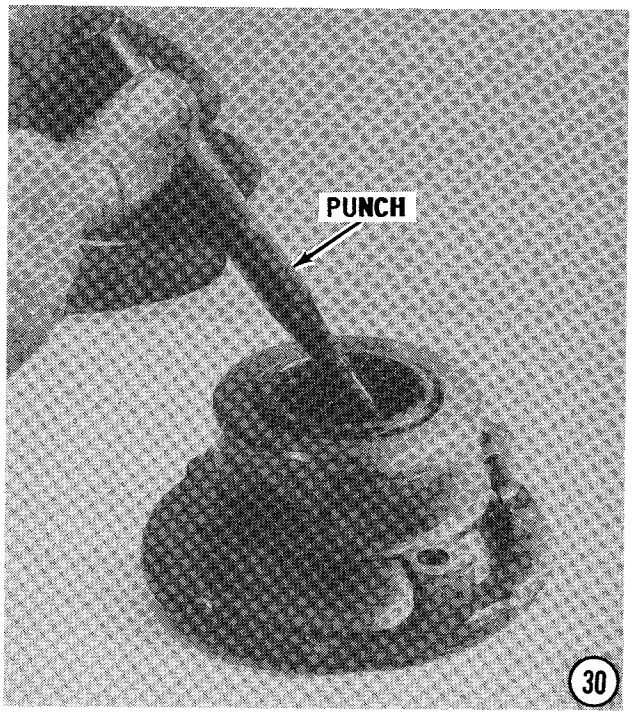
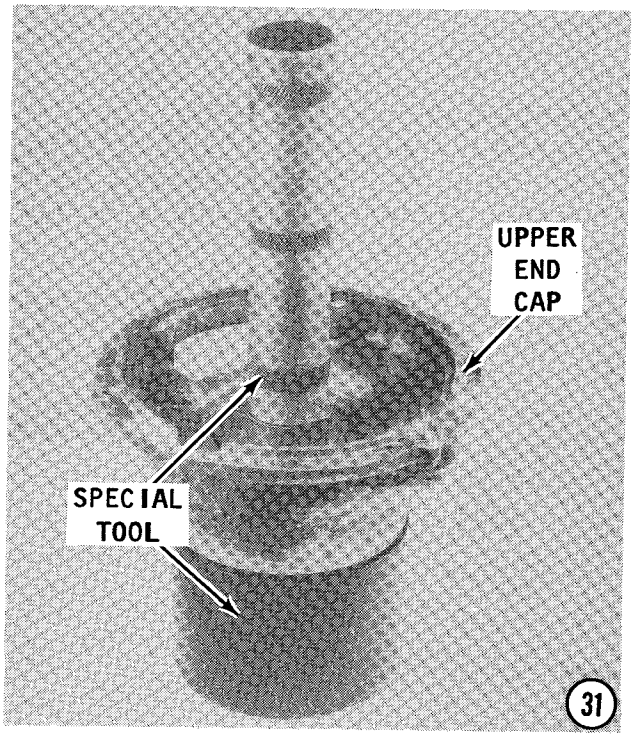
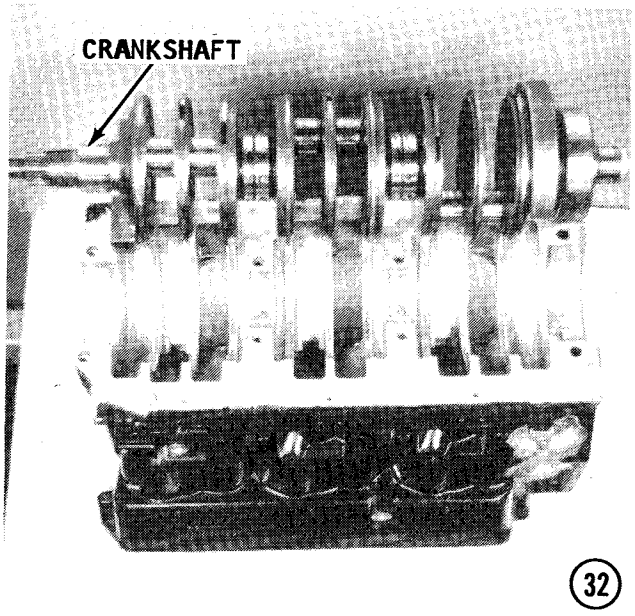


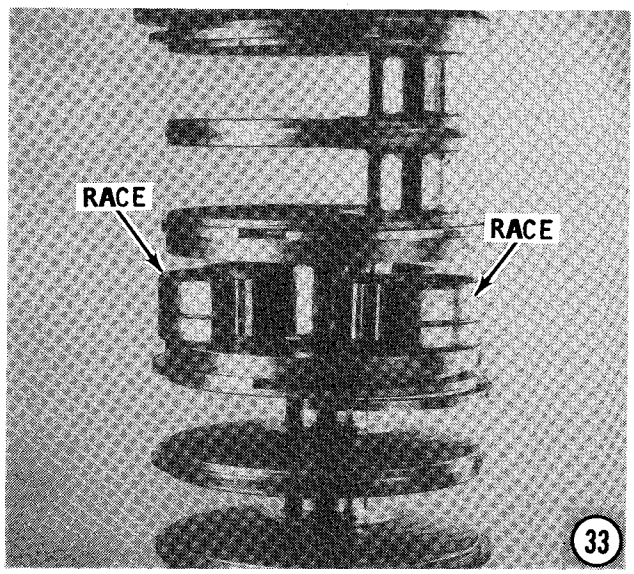
31- Remove the upper end cap bearing by pressing it out with Driver Head, C-91-55919, and Drive Rod, C-91-37323, as shown.

32- Lift the crankshaft assembly from the cylinder block. **DO NOT** remove the crankshaft sealing rings from the crankshaft, unless the sealing ring/s is unfit for service and a new ring/s is to be installed. The sealing rings usually do not require replacement **UNLESS** they are broken.





CLEANLINESS is the password, when handling roller bearings. Take extra care to prevent any dirt, lint, or other contamination from getting onto the bearings or in the cages. If the bearings are to be used again, store them in a marked container to ensure they will be installed in the same position from which they were removed. **NEVER** intermix roller bearings from the upper crankshaft main bearing with those from the lower main bearing. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for service or is lost, the entire set **MUST** be replaced. Work the pointed end of an awl under the retaining ring of the upper crankshaft main bearing, and then pop the ring out.



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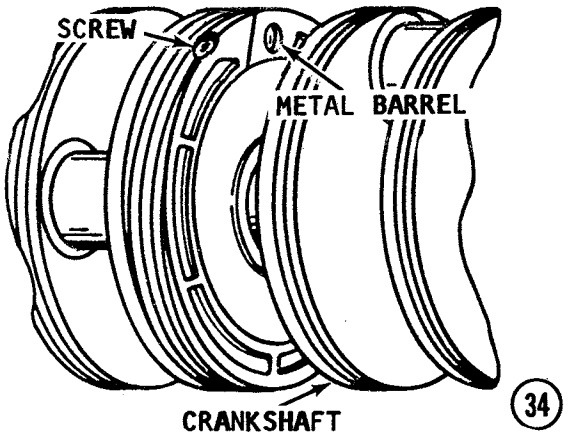
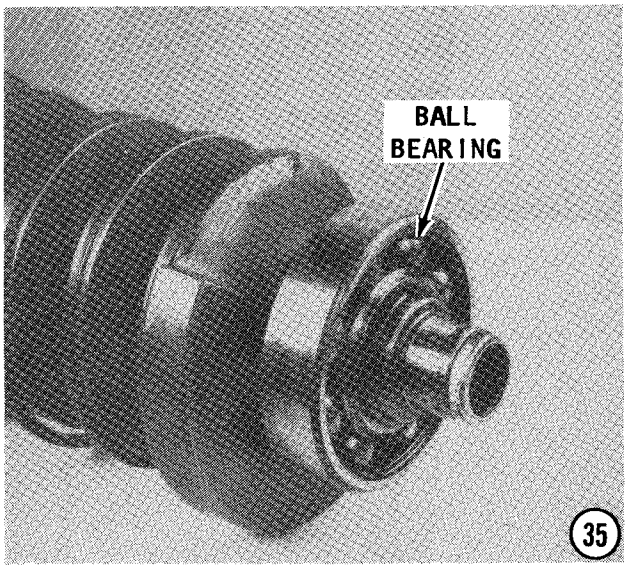


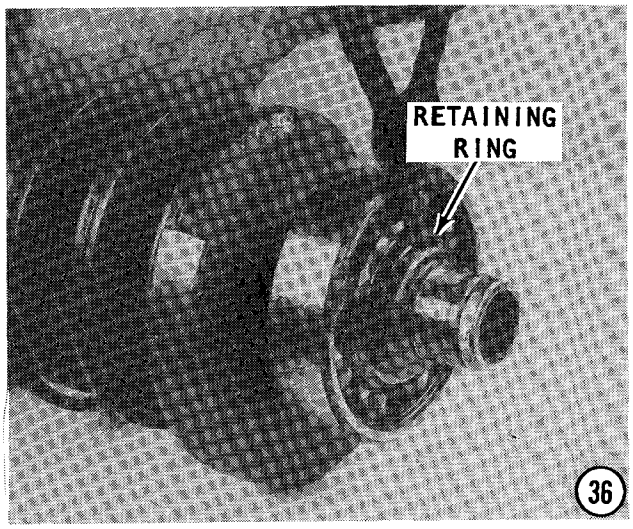
33- Remove the two bearing race halves and the roller bearings from the crankshaft. **TAKE CARE** not to distort the snap ring during removal. The bearing race halves are matched sets and **MUST** be kept together. Therefore, **IMMEDIATELY** after removal, assemble the two bearing halves and hold them together with the retaining ring. Identify the race and keep the roller bearings with it to ensure proper installation during assembly.

Repeat these last two steps for the other main bearing race.

34- Remove the Allen screw from the oil pump drive gear. Extract the metal barrel from the gear. **CAREFULLY** spread the two ends of the gear apart enough to clear the crankshaft journal. **DO NOT** spread the gear any more than absolutely necessary.

35- Inspect the crankshaft ball bearing installed on the lower end of the crankshaft as outlined in the Cleaning and Inspecting section at the end of this chapter. **DO NOT** remove the lower crankshaft ball bearing unless it is unfit for service and it is to be replaced.



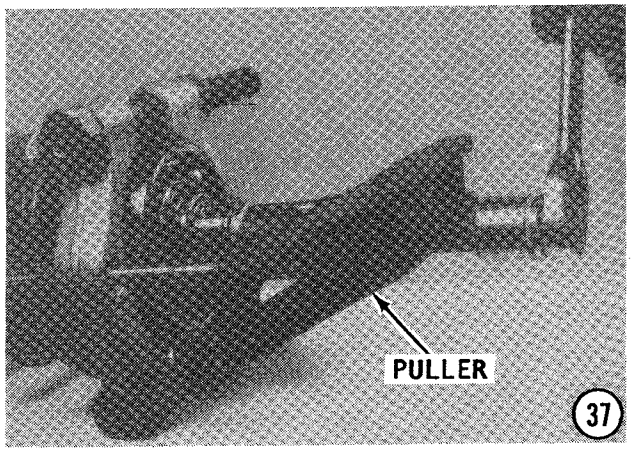


36- If the bearing is to be replaced, remove the retaining ring with a suitable pair of expanding type snap ring pliers.

37- Install Universal Puller Plate, C-91-37241, between the crankshaft ball bearing and the crankshaft counter weight. Position the crankshaft assembly in an arbor press. The crankshaft will be supported by the puller plate. Place a metal plate over the end of the crankshaft, and then press the crankshaft out of the bearing. **TAKE CARE** to prevent the crankshaft from falling to the floor and being damaged when it clears the bearing.

CLEANING AND INSPECTING

See the last portion of this chapter, Section 8-5, for detailed comprehensive procedures to clean and inspect all components of the powerhead.



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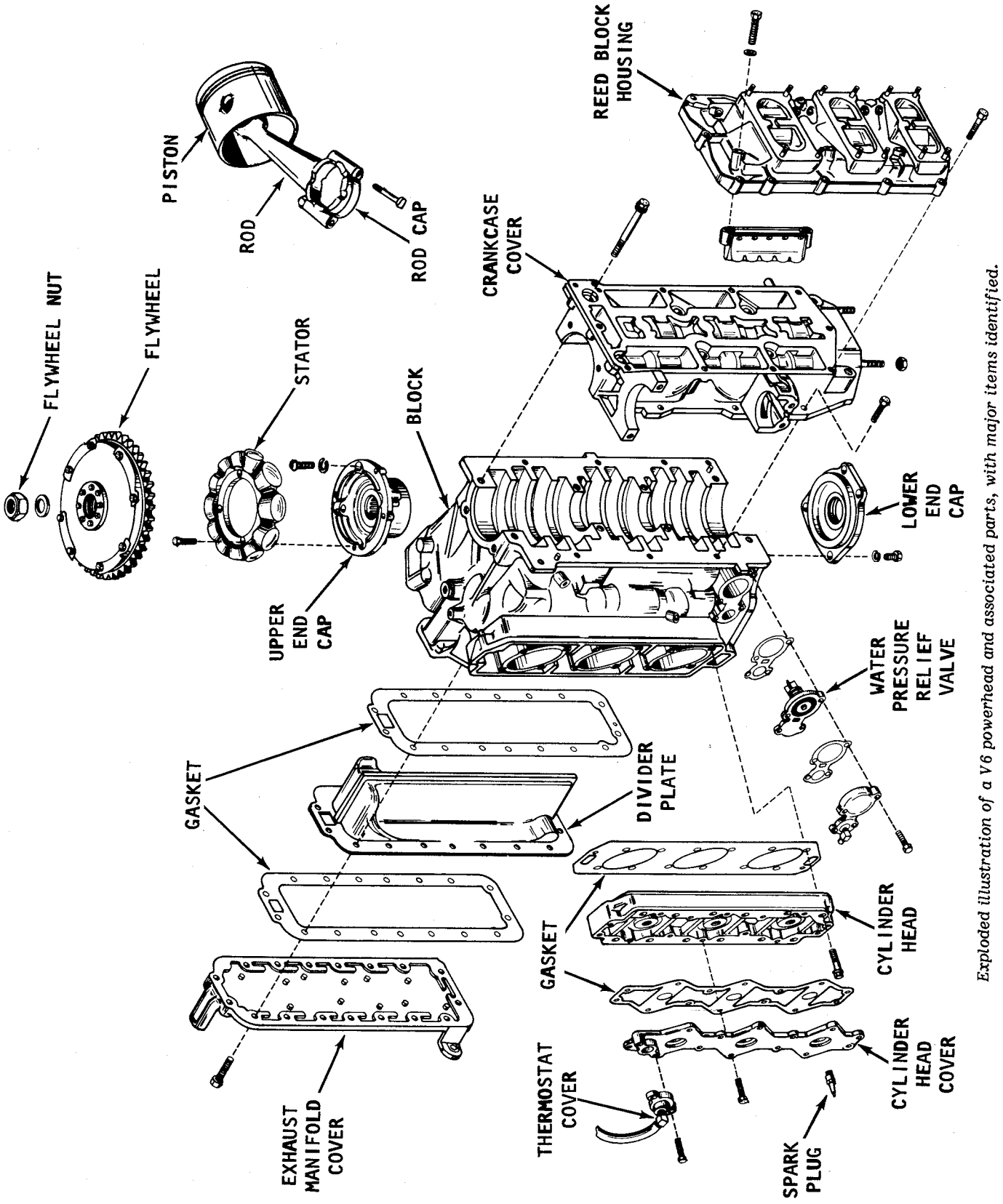

Exploded illustration of a V6 powerhead and associated parts, with major items identified.

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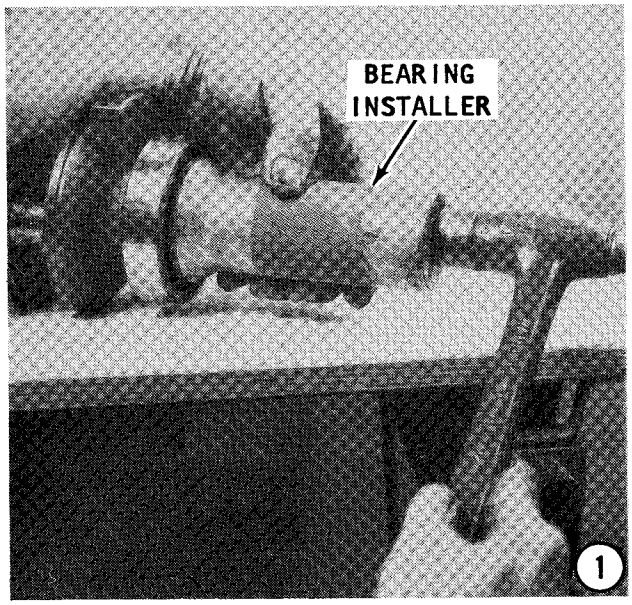


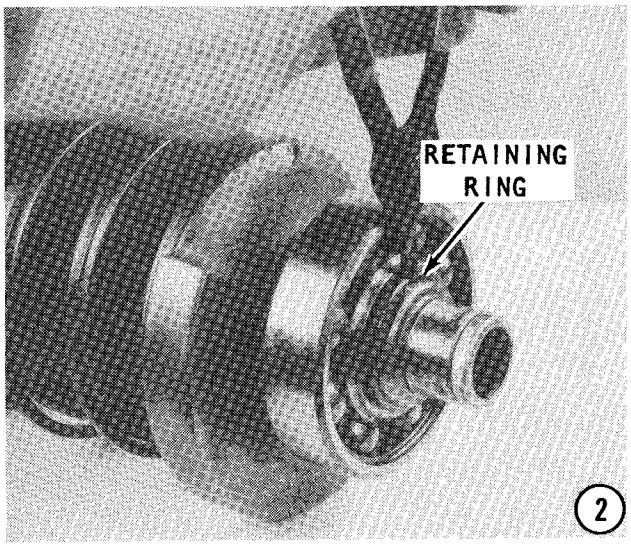
ASSEMBLING

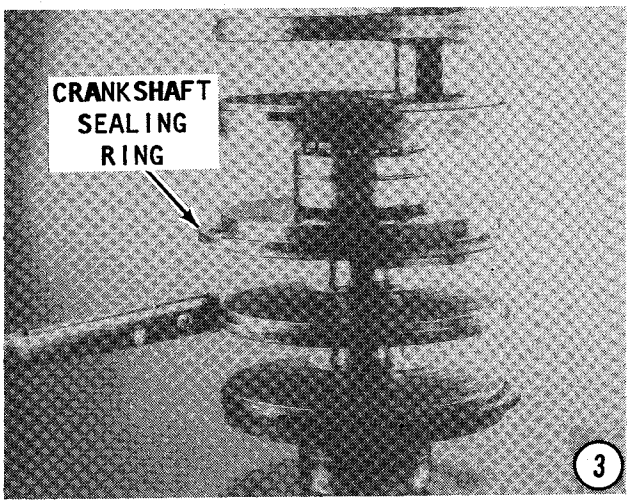
FIRST, THESE WORDS

Be sure all parts to be reused have been carefully cleaned and thoroughly inspected. Parts not properly cleaned, or parts not suitable for service can damage a good powerhead within a few minutes after starting the engine.

NEW gaskets **MUST** always be used during an overhaul.

A torque wrench is essential to correctly assemble the powerhead. **NEVER** attempt to assemble a powerhead without a torque wrench. Attaching bolts for covers **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. On the first stage, tighten to 1/3 the torque value. On the second stage, tighten to 2/3 the total torque value. Finally, on the third and last stage, tighten to the full torque value.



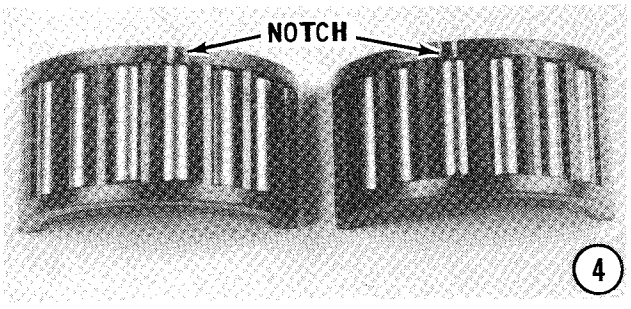


Crankshaft Assembling

1- If the ball bearing on the driveshaft end of the crankshaft was removed, install the bearing as follows: Support the crankshaft assembly in a press with the support between the counterweights and directly under the lower crankshaft end. Press the lower ball bearing onto the crankshaft, using a piece of tubing as a mandrel. **BE SURE** the tubing is the proper size so the force is only applied onto the inner race of the bearing. Continue to press the bearing into place until it is firmly seated against the counterweight. Remove the crankshaft assembly from the press. Using a press is the preferred method as a precaution against damaging the bearing, however, an installer and hammer may be used, as shown.

2- Use a pair of expanding type snap ring pliers and install the retaining ring to secure the lower crankshaft ball bearing in place.

3- Secure a powerhead stand in a vise, and then place the crankshaft assembly on the stand. If the crankshaft sealing ring/s was removed, spread the ring and install it around the nearest crankshaft journal. Continue, until all of the rings are in place. Use



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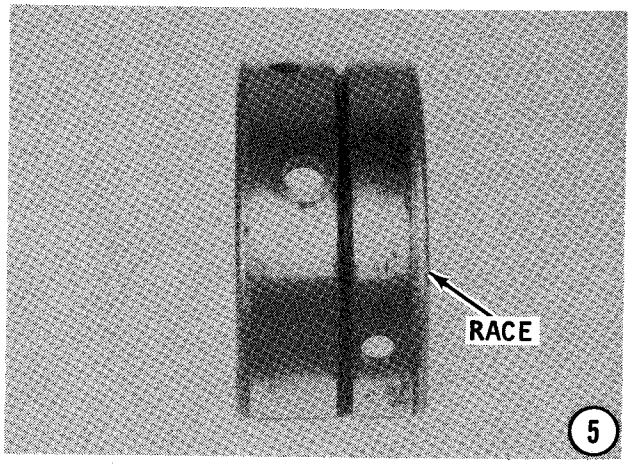
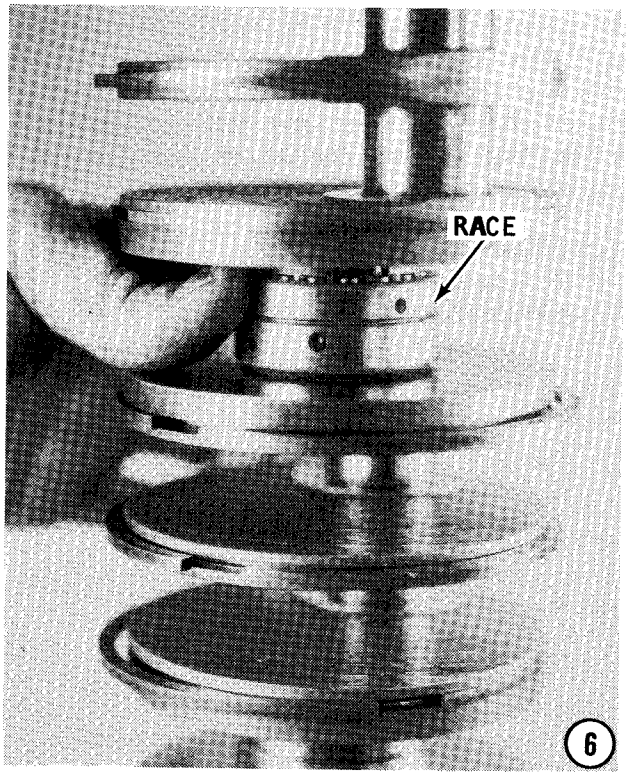
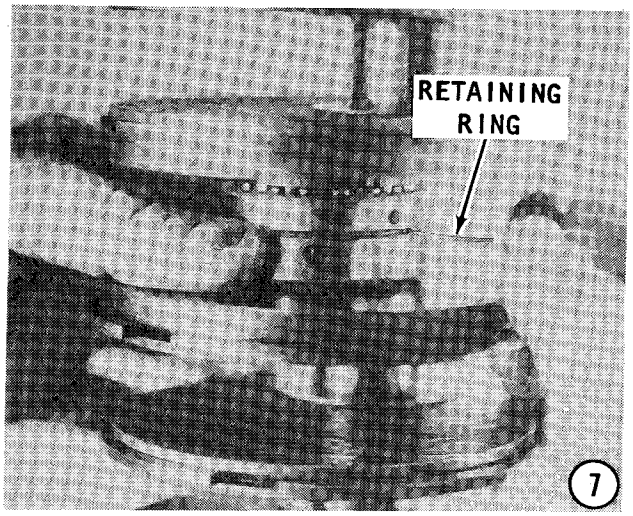


a piston ring expander, C-91-24697 and install the crankshaft sealing ring into the crankshaft groove. Lubricate the crankshaft sealing rings, crankshaft ball bearing, and the crankshaft main roller bearings with light weight oil.

4- Observe the notch in the main bearing journal cages. With the crankshaft in the vertical position and the flywheel end up, place the crankshaft roller bearings around the upper and lower main bearing journals with the notch in the bearing cages facing **UP.**

5- Observe the three holes in the main crankshaft roller bearing race. Notice that one hole is larger than the others. This hole is referred to as the dowel pin hole.



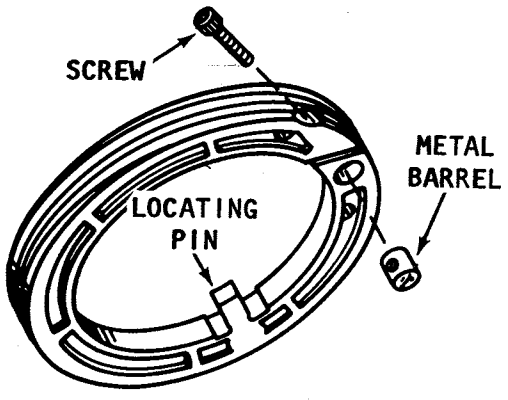


6- Install the bearing race halves around the main crankshaft roller bearings with the dowel pin hole **TOWARD** the driveshaft end of the crankshaft (the lower end).

7- Secure the bearing halves in place with the retaining ring. Lubricate the crankshaft main roller bearings by injecting lightweight oil through one of the holes in the bearing race.

8- Soak the oil pump drive gear in hot water for approximately four minutes, until it is somewhat pliable. Separate the two ends of the gear and install the gear over the crankshaft journal next to the main bearing, with the lip facing toward the upper end of the crankshaft. Slide the gear lip into the groove in the crankshaft. The locating pin **MUST** index into the crankshaft slot.

Insert the metal barrel into the center hole of the gear and align the threaded hole with the hole for the screw in the gear. Thread the screw into the hole in the gear teeth and into the metal barrel. Tighten the screw to 8 in lb (.9Nm). The two ends of the gear should now be tightly together and the



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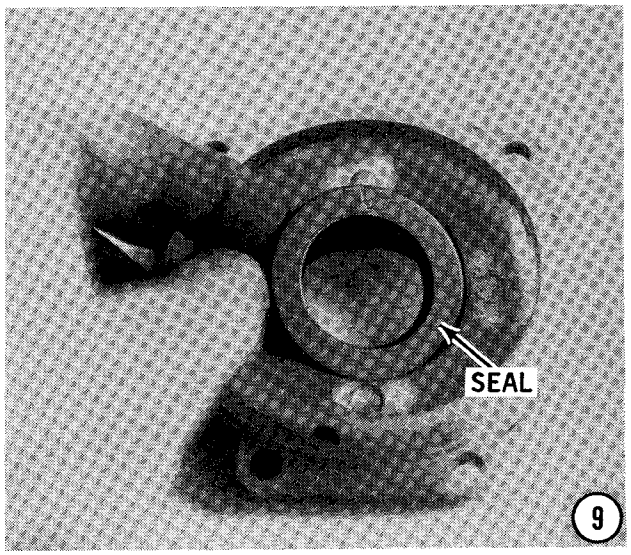
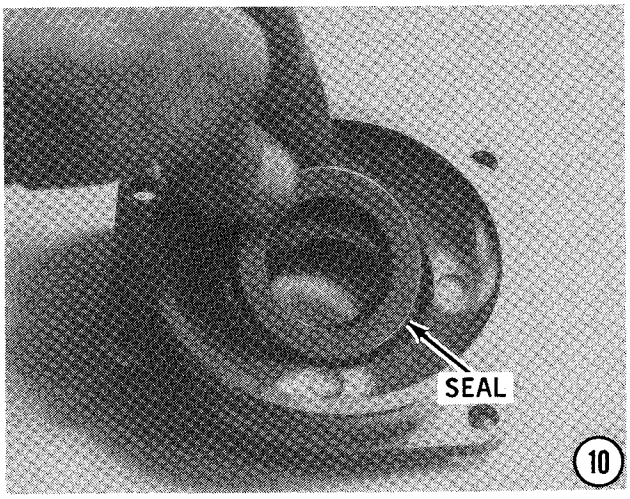
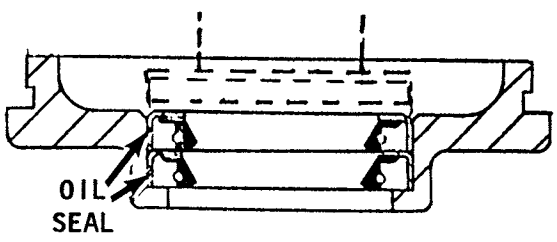


gear mismatch at the joint line must not exceed .030" (.76mm). Excess mismatch will result in premature gear failure. Excess mismatch may be caused by the gear lip not being properly seated in the crankshaft groove.

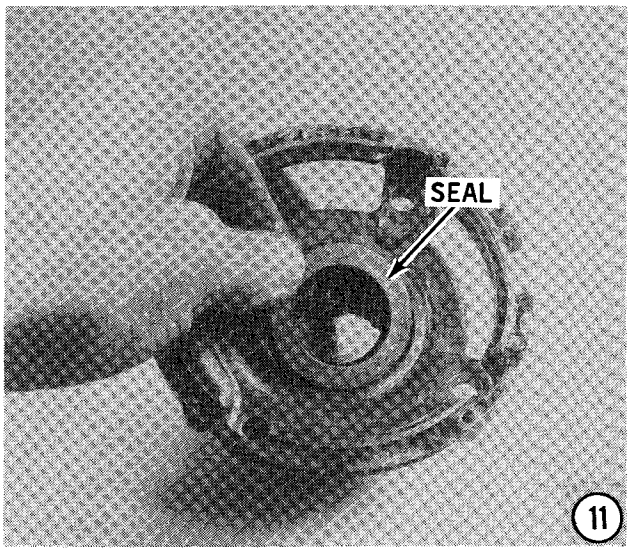
Lower End Cap Assembling

9- Lay down a thin bead of Loctite "A", or equivalent, to the outer diameter of the two lower end cap oil seals. This outer diameter is the area making contact with the end cap. Use Driver Head C-91-55919,





Cross section drawing to illustrate installation of the two seals in the lower end cap.

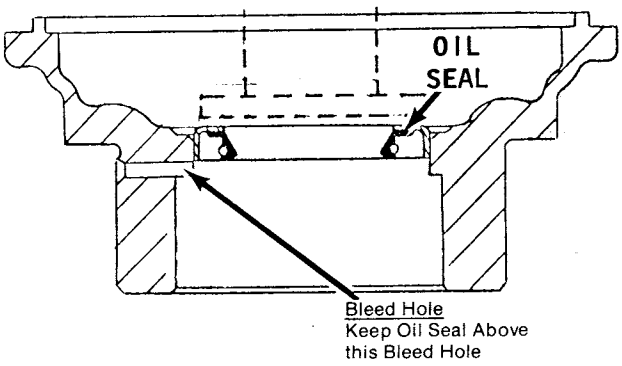


and press one oil seal into the lower end cap with the lip of the seal **DOWN.** The lip will then be away from the cylinder block when it is installed. Continue to press the seal into place until the seal is firmly seated on the end cap shoulder. Clean away any excess Loctite.

10- Press the second oil seal into the lower end cap with the lip of the seal also **DOWN.** Continue to press the seal into place until the seal is firmly seated against the first oil seal. Clean away any excess Loctite. Lubricate the lips of the lower end cap oil seals, the surface of the end cap making contact with the cylinder block, and the lower end cap O-ring with light-weight oil. The larger of the two O-rings is used with the lower end cap. The smaller O-ring is used with the upper end cap and installed in Step 11. Install the larger lubricated O-ring around the lower end cap.

Upper End Cap

11- Lay down a thin bead of Loctite "A", or equivalent, to the outer diameter of the



Cross section drawing to illustrate installation of the single oil seal in the upper end cap.

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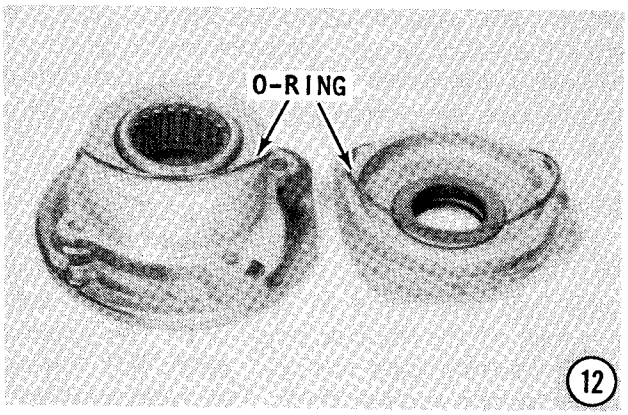
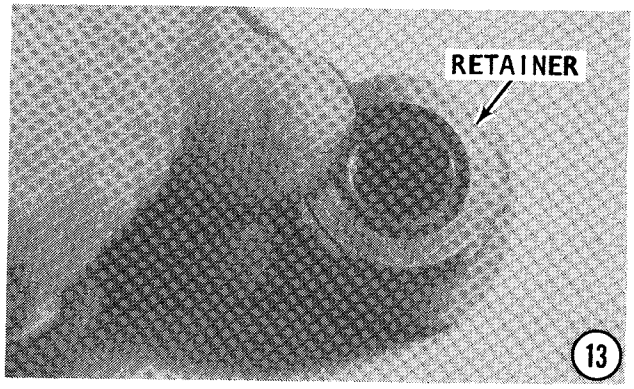


upper end cap oil seal. This outer diameter is the area making contact with the end cap. Use a suitable mandrel, and press the oil seal into the upper end cap with the lip of the seal **DOWN.** This position will place the lip of the seal **TOWARD** the cylinder block when installed. Continue to press the seal into place until the seal surface is flush with the surface of the end cap. Clean away any excess Loctite.

BAD NEWS

If the end cap oil seal is pressed into the upper end cap too far, the end cap bleed passage could become blocked. **TAKE TIME** to be sure the oil seal is properly installed.

12- Install the crankshaft roller bearing into the upper end cap. Press the roller bearing into the end cap until the bearing is firmly seated against the end cap shoulder. Lubricate the lip of the upper end cap oil seal, the end cap roller bearing, and the surface of the end cap that contacts the cylinder block with light weight oil. Apply a coating of light weight oil to the O-ring. The smaller of the two O-rings is used with the upper end cap. The larger O-ring was used with the lower end cap in Step 9. Install the lubricated O-ring around the upper end cap.



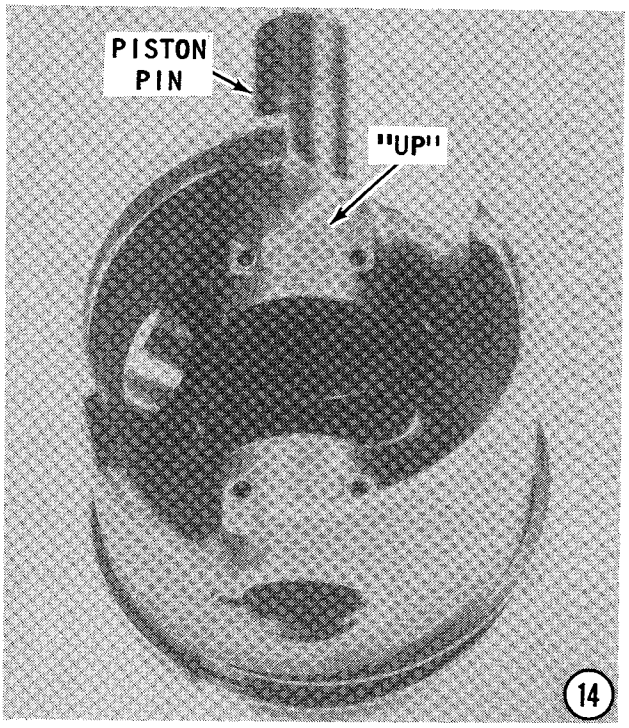
Piston/Rod Assembling

CRITICAL WORDS

Do not attempt to use a 3-ring piston if it has been removed from the rod. Removal of the piston pin from a 3-ring piston will cause damage to the piston and render the assembly unfit for service. A new 2-ring piston **MUST** be installed. Mixing 2-ring and 3-ring pistons in the same engine is **PERMISSIBLE** and will not affect performance.

Lay down a clean towel on the work surface. Lay out the 29 piston pin needle bearings in a line. **NEVER** intermix needle bearings from one piston assembly with those from another piston. **NEVER** intermix used needle bearings with new bearings. If just one bearing is unfit for service or is lost, the entire set **MUST** be replaced. Lay down a bead of Multi-purpose Lubricant onto the sleeve portion of Piston Pin Tool C-91-74607A1.

13- Always handle pistons with great care because the skirt can be bent out of round if the piston is handled roughly. Place the lower locating washer onto the piston pin tool with the shoulder on the washer toward the bearings. If a piston pin tool is not available, a drift slightly smaller in diameter than the pin, may be used. Install the retainer and the needle bearings onto



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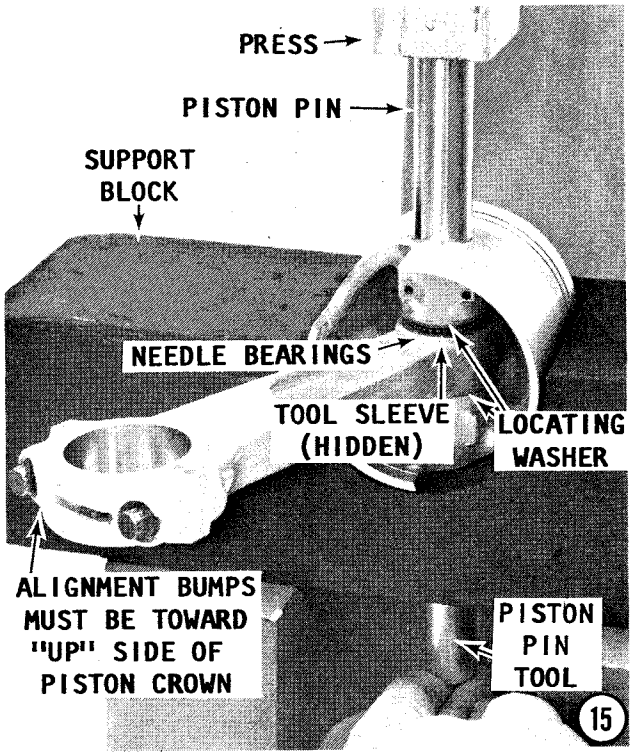
the end of the tool. Place the top retainer on the side of the rod. Ease the tool out of the rod, and at the same time hold onto the needle bearing retainer washers.

14- Notice the word **"UP"** on the piston pin boss inside the piston skirt. This word indicates the side of the piston that **MUST** face upward, toward the top of the engine, when it is installed. The **"UP"** side of the piston **MUST** face downward on the support block when the piston pin is pressed in. Place the piston in a container of hot water, approximatley 190°F. Leave the piston in the hot water, ready for installation later in Step 24. The piston may also be heated with a heat lamp to approximately 190°F.

15- In an arbor press, place the heated piston, per Step 13, in position on the Piston Support Block, C-91-77005, with the side marked **"UP"** on the piston pin boss down against the block. Use one hand to hold the sleeve, bearings, and locating washers in place. At the same time, with the other hand, insert the connecting rod into position in the piston, with the two bumps on the crankshaft end of the rod **TOWARD** the word **"UP"** on the piston. Once the rod is in place, slide the handle portion of the piston pin tool up through the hole in the support block and on through the lower piston pin boss into the sleeve.

Hold the piston pin needle bearings in place with the piston pin tool, and press the piston pin into position as far as possible with the arbor press. Use the piston pin tool between the arbor press and the piston pin to position the piston pin the rest of the way into the piston.



SAFETY WORD

Wear eye protection glasses while installing the piston pin lockrings, because the lockrings are made of spring steel and may slip out of the tool or pop out of the groove with considerable force. **DO NOT** use a lockring the second time. Use new lockrings and check to be sure they are properly seated in the piston grooves.

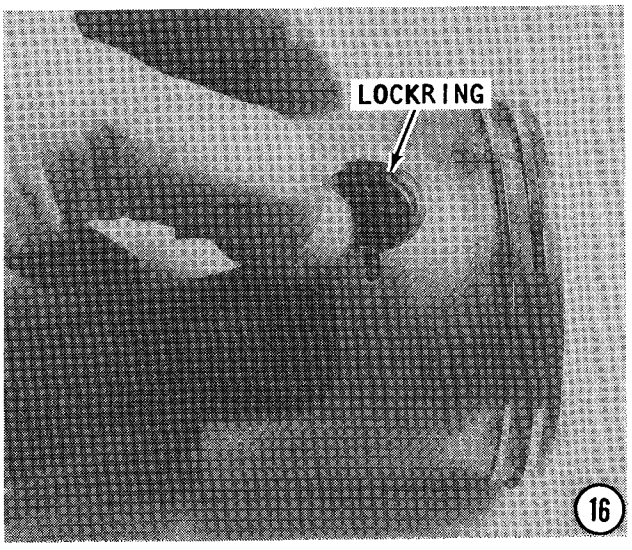
16- Install a G-type piston pin lockring at each end of the piston pin using Lockring Installation Tool, C-91-77109A1, or a pair of needle-nose pliers. Check and double check, to be sure each lockring is properly seated in the piston groove.

RING AND PISTON EXPLANATION

This step does not involve any action with tools or equipment. However, these words must be **READ** and **UNDERSTOOD** before beginning the ring installation work. Mariner V6 powerheads are in a constant state of change, due to improved materials and engineering design. As a result, three different type pistons have been used.

Three-ring Pistons

The 3-ring piston was used only on early model 175hp V6 engines. Once a 3-ring piston is removed from the rod, it **CANNOT** be used again. Removal of the piston pin



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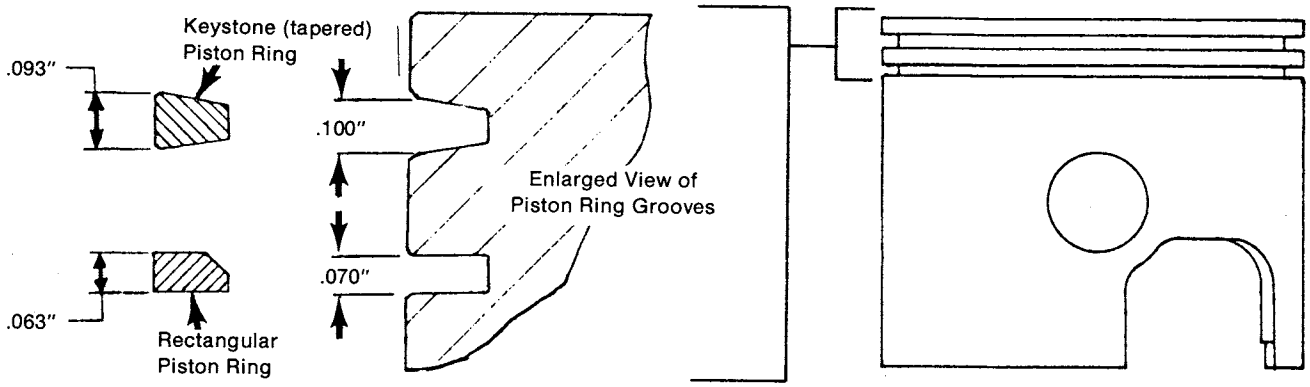
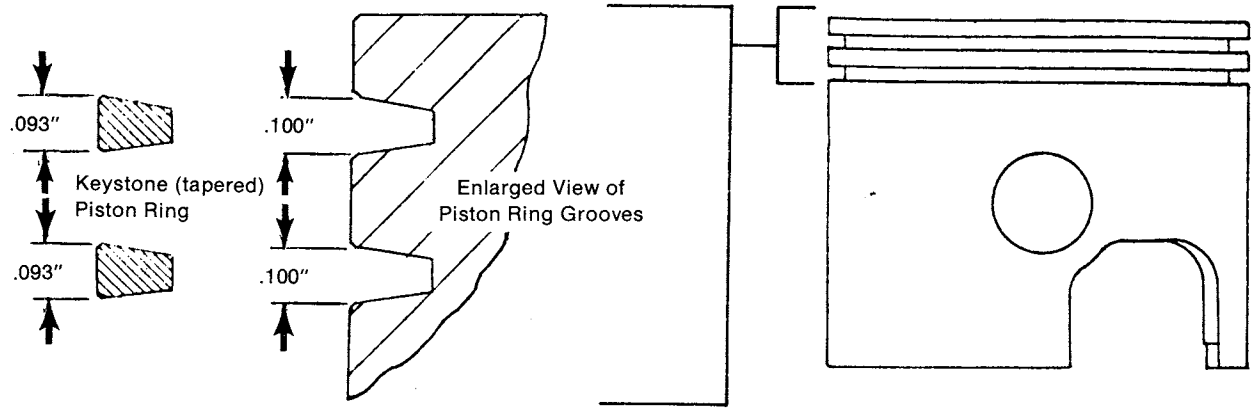


Piston with the top ring a keystone (tapered) ring and the bottom ring rectangular.



Piston with both the top and bottom ring a keystone (tapered) ring.

from a 3-ring piston will cause damage to the piston and render the assembly unfit for service. All three rings of a 3-ring piston are identical and the only critical part of the installation procedure is to be sure the **DOT** on the side of each ring is facing **UPWARD, TOWARD** the piston crown. Actual installation procedures are the same as for other standard pistons.

Two-ring Pistons

Most V6 powerheads are equipped with 2-ring pistons. Both are keystone, tapered, rings. The only critical part of the installation procedure is to be sure the **DOT** on the side of each ring is facing **UPWARD, TOWARD** the piston crown. Installation procedures are the same as for other standard pistons.

Two different types of 2-ring pistons are installed in 175hp and 150hp V6 powerheads. One type is designed to use one keystone, tapered, ring and one rectangular ring. The other piston type is designed to use 2 keystone, tapered, rings. When one keystone ring and one rectangular ring are used, the keystone ring is **ALWAYS** installed as the top ring. The only way to identify the keystone ring is to measure both rings and determine which has the taper. The rings of **ALL** 2-ring pistons are installed in the same manner. The only critical part of the installation procedure is to be sure the **DOT** on the side of each ring is facing **UPWARD TOWARD** the piston crown.

Oversize Pistons and Rings

All oversize pistons for 175hp and 150hp V6 powerheads are manufactured to use two keystone, tapered, rings. As with other pistons using keystone rings, the only critical procedure during installation is to be sure the dot on the side of the ring faces **TOWARD** the piston crown.

Ring Check In The Bore

17- Insert each new ring, one at a time, into the cylinder bore to which the piston will be installed. Move the ring down about 1/2" (12.7mm) using a piston to ensure the ring is positioned properly. With the ring in this position, use a feeler gauge and measure the end gap of the ring, the distance between the ends when the ring is installed.

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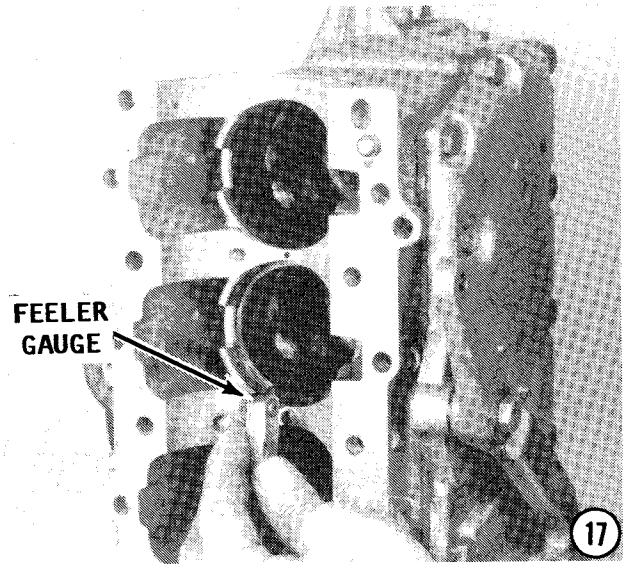
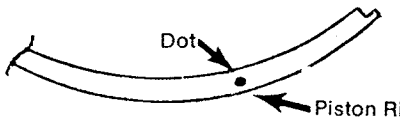
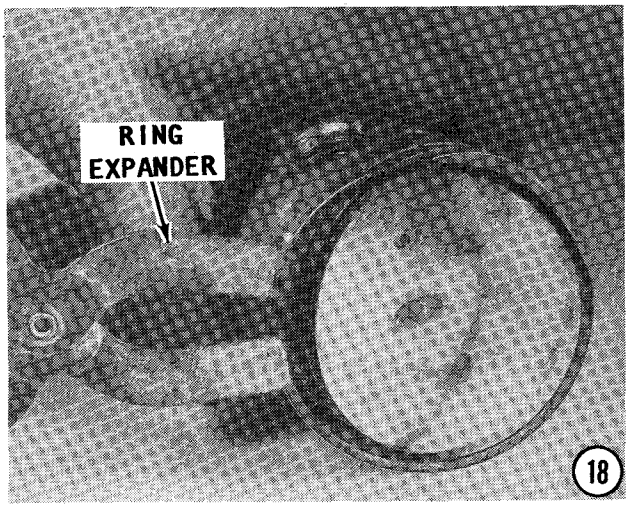


The end gap **MUST** be 0.018 - 0.025" (.46-.63mm). If the end gap is greater check other new rings in that cylinder bore until a ring within the designated tolerance is found. If the end gap is less than the specified tolerance, and another ring with tolerance cannot be found, it may be necessary to file some of the material from the ring end in order to meet the required tolerance.

If it is necessary to file the end of the ring, take time to remove any rough edges to prevent damage to the cylinder wall. Once a set has been checked or made for the cylinder, remove and **IDENTIFY** the set to ensure the correct set will be installed onto the proper piston for that cylinder.



*Piston ring side with the dot **MUST** face **UP**.*



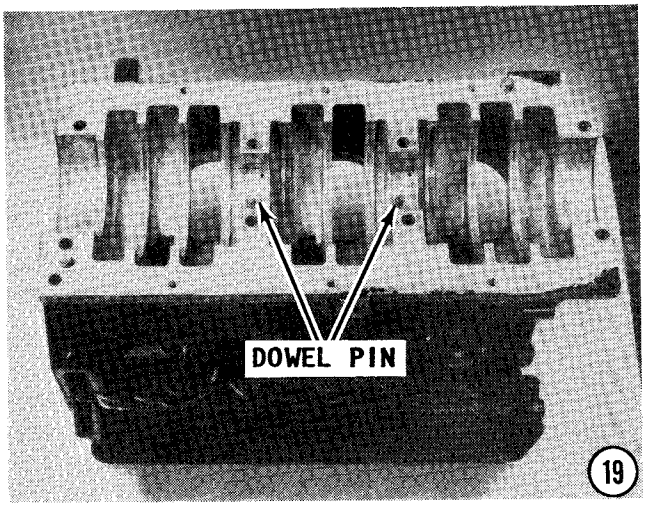
Continue to check rings for each cylinder until a set has been found or made for all cylinders.

18- Use a ring expander and install the ring set identified for the No. 1 piston and cylinder onto the piston. Adjust the ring expander in small increments until the ring will just barely fit over the top of the piston. If the expander is adjusted to open the ring more than necessary, the ring may break. Work slowly, and check each ring to be sure it is installed properly with the dot on the side of the ring facing the top of the piston and in the proper ring groove for the type of piston being installed. **CHECK** the paragraphs following Step 16 for the correct rings to be installed on 2-ring and 3-ring pistons. After the rings are in place, each ring should rotate freely in the ring groove. Lubricate the piston, the rings, and the cylinder bore with a good grade of 50-weight oil. Lay the assembled piston aside, ready for later installation.

CRANKSHAFT INSTALLATION

19- Cover the work surface with a clean towel. Lay the powerhead on the towel with the crankshaft side up and the top of the powerhead to your **LEFT.** In this position the cylinder bores closest to you are No. 1, 3, and 5 in the port bank. The cylinder bores on the far side of the block are No. 2, 4, and 6 in the starboard bank. Check the cylinder block to be sure the crankshaft main bearing dowel pins are in place. If they are not in place, install new pins.

20- Rotate the crankshaft seal rings until the ring gap of each ring is straight up. Lower the crankshaft assembly into the cylinder block, with the flywheel end toward



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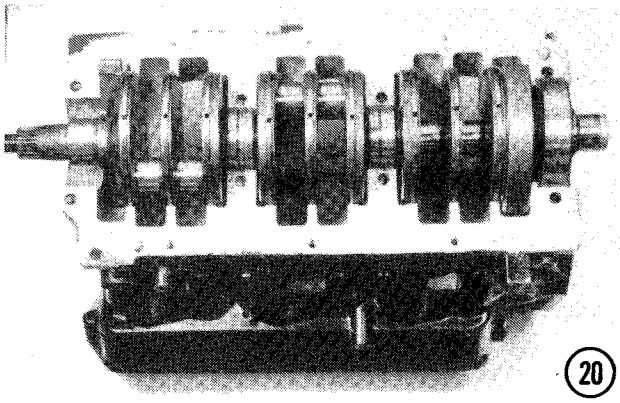
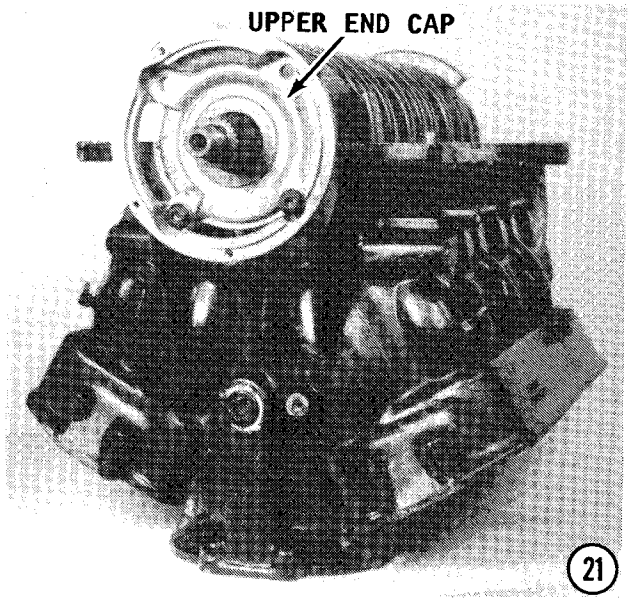

20

the top of the powerhead. The top of the powerhead is still to your **LEFT.** Gently push the crankshaft down into position. Position each bearing race until the center of the dowel pin hole is aligned with the edge of the cylinder block. Now, use a grease pencil and make a mark exactly at the top of each bearing race. Next, rotate each bearing race until the grease pencil mark is aligned with the edge of the cylinder block. The dowel pin hole of each race will now be very close to the dowel pin in the block. Push down on the crankshaft and at the same time, if necessary, rotate the main bearing races very slightly, until the dowel pin hole in each race indexes the dowel pins in the block. Compress the crankshaft seal rings with your fingers and, at the same time, push the crankshaft downward until it is fully seated in the cylinder block.

21- Lubricate the oil seal areas of the top upper crankshaft end with light weight oil. Install the upper end cap and hold it in place with the attaching bolts. **DO NOT** tighten the bolts at this time.



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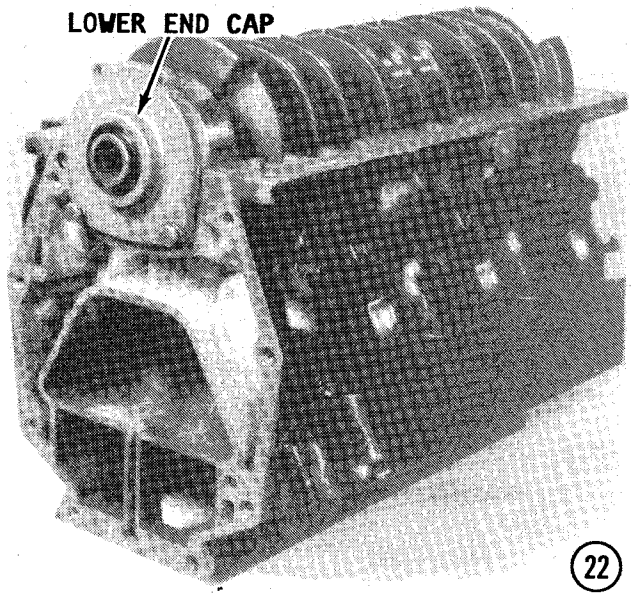

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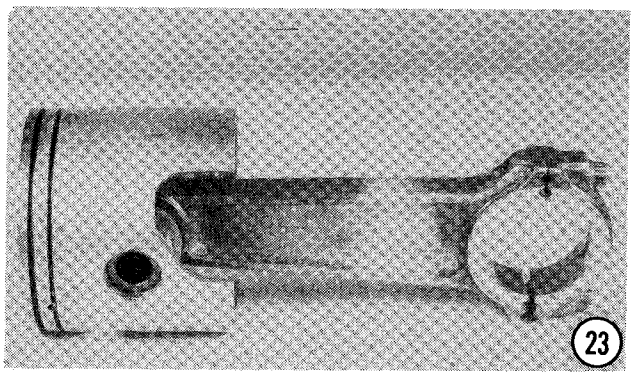
22- Lubricate the oil seal area of the lower crankshaft end with light weight oil. Install the lower end cap and hold it in place with the attaching bolts. **DO NOT** tighten the bolts at this time.

23- Check to be sure the number marked onto the connecting rod during disassembly matches the cylinder number into which the piston assembly is to be installed. Use the marine ring compressor and install the pistons one at a time into their designated cylinder bores. If a marine ring compressor is not available, a suitable size hose clamp, a Volkswagen type ring compressor, or an automotive type compressor may be used. Use of the automotive-type compressor is the **LEAST** desirable because, as the compressor is tightened, the rings will rotate and the ring gap will not remain at the locating pin. The procedures for using the hose clamp are outlined in Step 25. Use of the Volkswagen compressor in Step 27, and the automotive type compressor in Step 28.

24- OBSERVE the identification marks on the crown of each piston. On the crown,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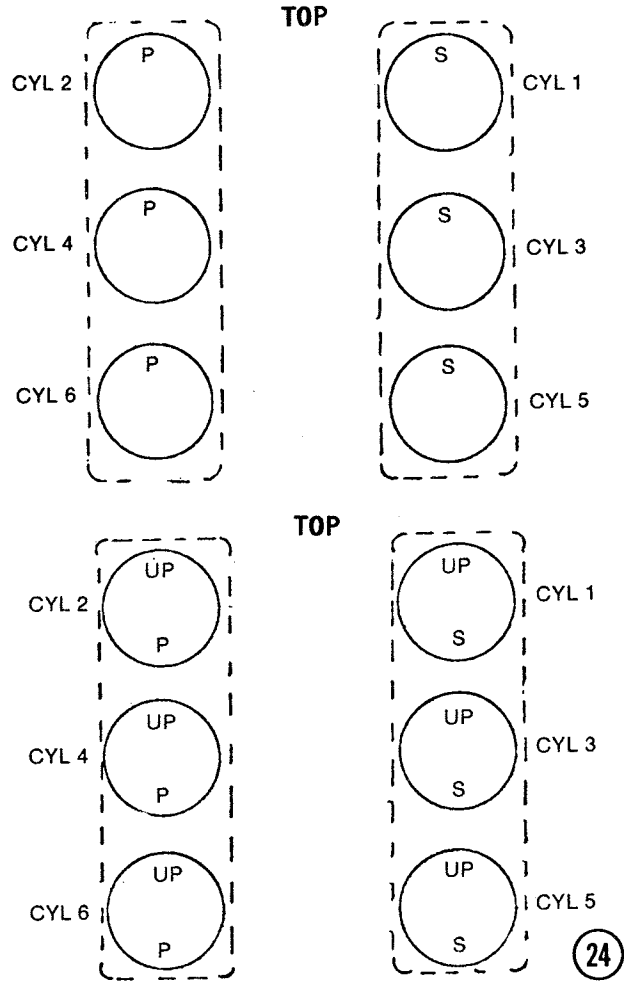
the letter **"S"** indicates the piston **MUST** be installed in cylinder No. 1, 3, or 5 of the starboard bank. The letter **"P"** indicates the piston **MUST** be installed in cylinder No. 2, 4, or 6 of the port bank.

Some piston sets have the word **UP** embossed on the crown, as shown in the accompanying illustration. This word indicates the side of the piston that **MUST** face upward, toward the top, the flywheel end, of the powerhead when it is installed. This position will place the large hole in the piston skirt directly opposite the exhaust port in the cylinder wall.

Lubricate the piston rings, piston skirt, piston pin needle bearings, and the respective cylinder wall with light weight oil. Rotate each piston ring in the piston groove until the open ring gap is positioned at the pin in the groove.

CRITICAL WORDS

The ring **MUST** be positioned as just stated or the ring will be **BROKEN** when the ring compressor is installed, or when the piston is inserted into the cylinder bore.



PROCEDURE: Install one piston using the procedures outlined in Step 25 and 26, **OR** 27, **OR** 28, depending on the type of ring compressor being used, then move to Steps 29 thru 33. Repeat the steps for each piston and rod until all six are installed.

Ring Installation Using Hose Clamp

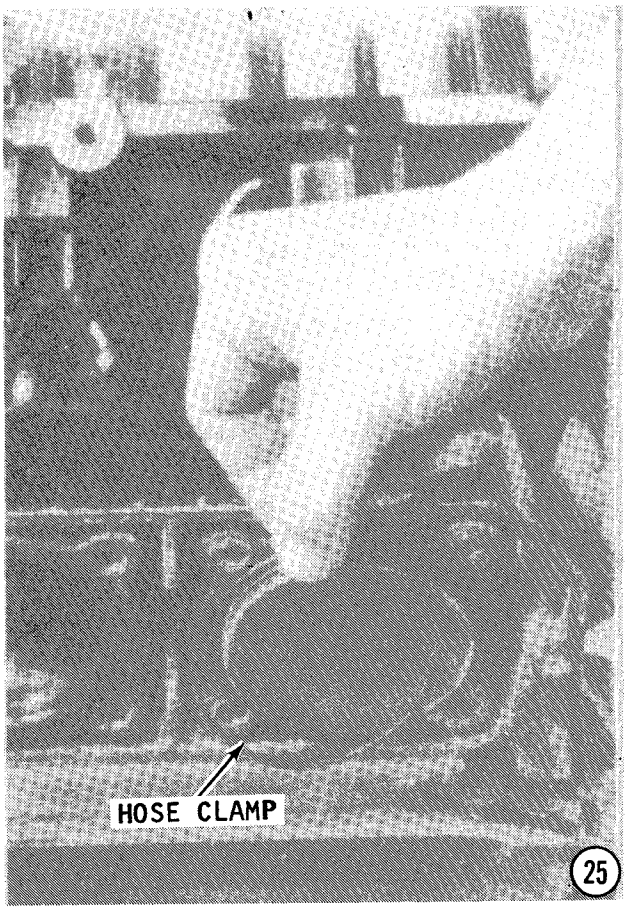
25- If a standard marine type ring compressor is not available, install the rings onto the piston and the piston into the cylinder bore as follows: Install **ONLY** the lower ring onto the piston. Tighten the hose clamp over the ring and at the same time, rotate the ring until the ring gap is at the locating pin in the piston groove. Remove the rod cap from the rod.

CRITICAL WORDS

Install the piston into the cylinder bore in the correct position as indicated in the previous step.

Gently tap the piston into the cylinder with the wooden handle of a tool until the ring enters the bore. Remove the hose clamp.

26- Install the next ring onto the piston. Install the hose clamp and at the same time



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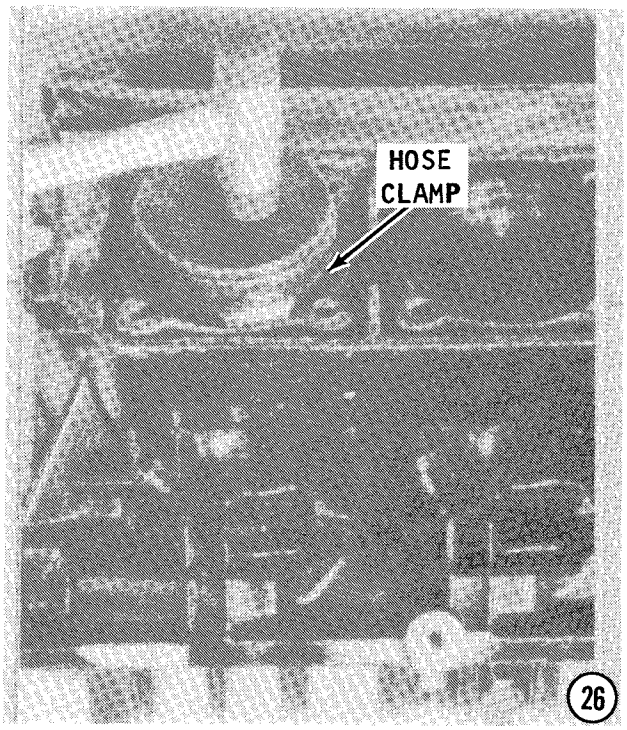
rotate the ring until the ring gap is at the locating pin in the groove. Tighten the hose clamp and tap the piston into the bore until the ring enters the bore. Align the connecting rod with the cylinder block opening, and then push on the piston crown until the piston is installed into the bore. Remove the hose clamp and repeat the procedure for the third ring, if one is used. You may now skip to Step 29.

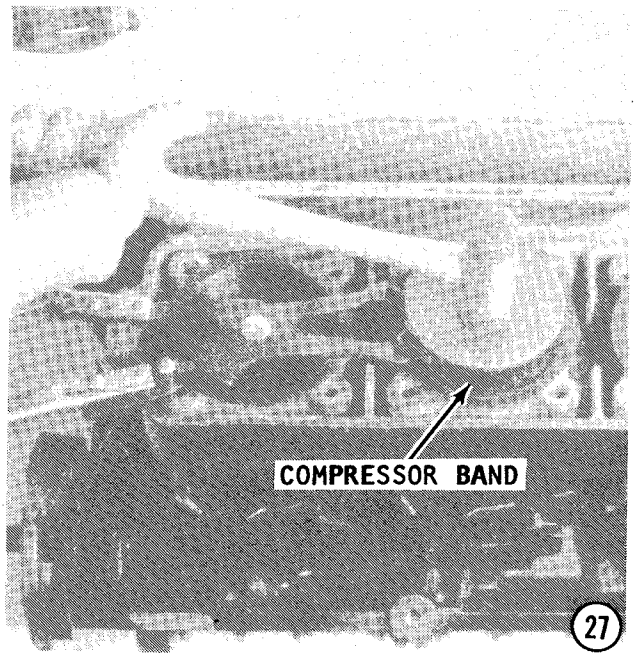
Ring Installation Using Volkswagen Type Ring Compressor

27- After all of the rings have been properly installed onto the piston, place the position the Volkswagen type ring compressor band around the rings on the piston. Now, using the ring compressor pliers, squeeze the band together, and at the same time, rotate the piston back-and-forth to be sure the ring ends remain between the piston dowel pins. Once the compressor band is snug against the piston, remove the rod cap from the rod and install the piston into the cylinder bore. Align the connecting rod with the cylinder block opening, and then push on the piston crown until the piston is installed into the bore. When utilizing this method of piston installation, you may now skip to Step 29.

Ring Installation Using Automotive Type Ring Compressor

28- As explained earlier, an automotive-

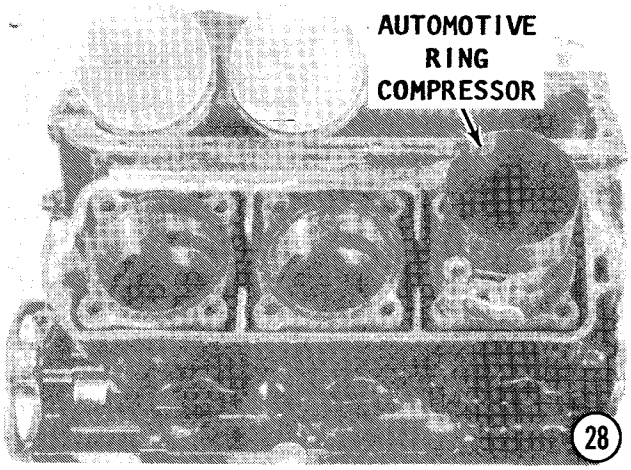




type ring compressor should **ONLY** be used as a last resort when no other method is possible. The reasoning is: as the ring compressor is tightened, the rings will rotate and the ring gap will not remain at the locating pin. To use this type of ring compressor for a marine application: after the rings have been properly installed as outlined in Step 18, position the compressor over the rings and begin to tighten the band. As the band is tightened, rotate the piston back-and-forth to ensure the ends of the rings remain in position between the piston locating pin. Align the connecting rod with the cylinder block opening, and then push on the piston crown until the piston is installed into the bore.

Installing Rods to Crankshaft

29- Bear in mind, the cylinder bores closest to you are still No. 1, 3, and 5 in the



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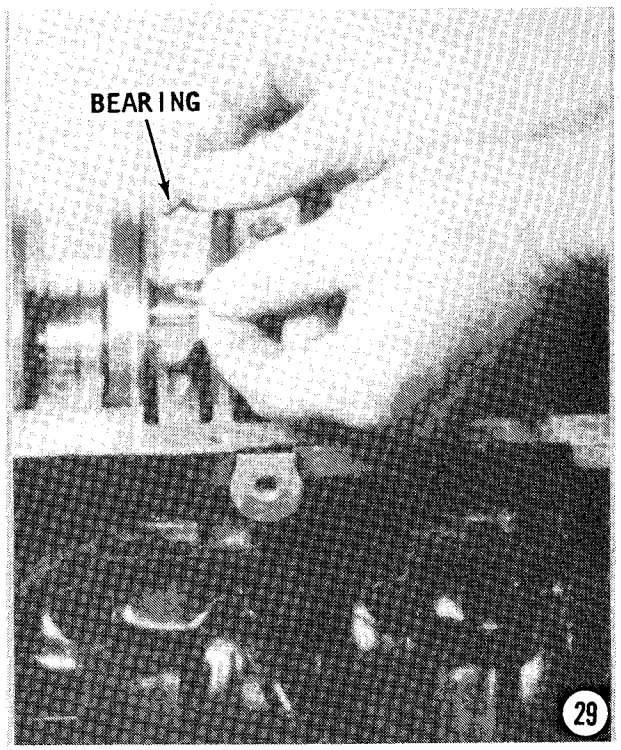


starboard bank. The flywheel end, top, of the powerhead is still to your **LEFT.** Begin with the No. 1 rod, the rod to the far left. Apply a coating of Multi-purpose Lubricant to the bearing surface of the connecting rod, and then install the bearing cage and the roller bearings into the lubricant. **NEVER** intermix roller bearings from one connecting rod cage with those from another rod cage. **NEVER** intermix used roller bearings with new bearings. If just one bearing is unfit for service or is lost, the entire set **MUST** be replaced. Move the connecting rod up to the crankshaft journal.

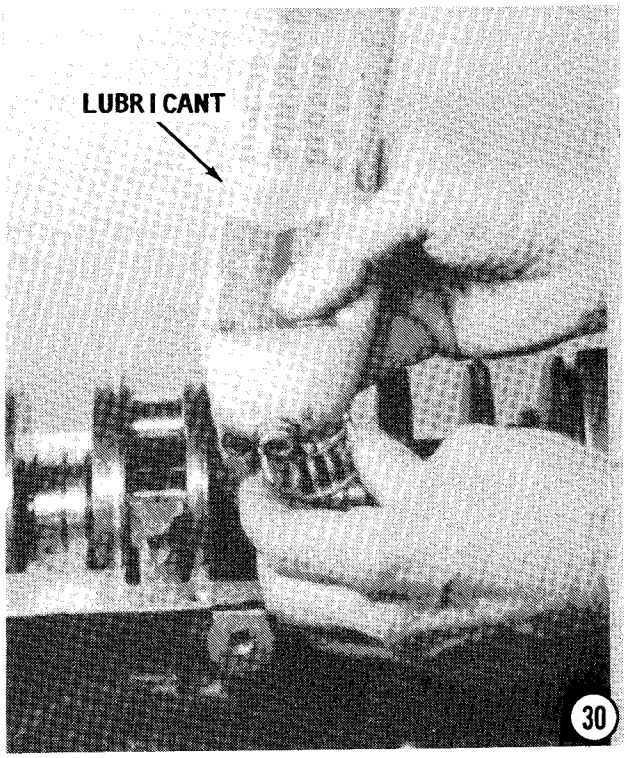
After the rod is in position on the crankshaft, install one needle bearing on each side of the crankshaft in the end of the needle bearing cage, as shown.

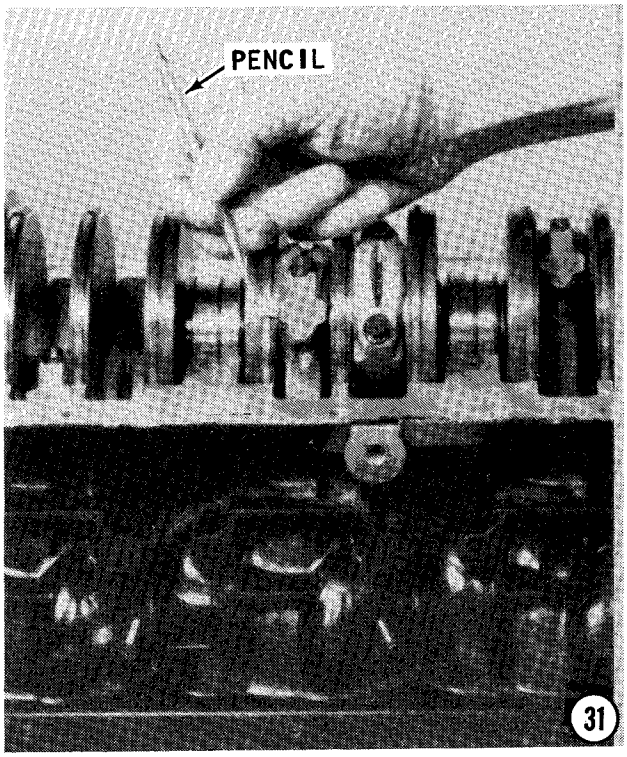
30- Apply a coating of Multi-purpose Lubricant to the crankshaft journal. Install the other bearing cage and the remaining roller bearings into the lubricant. Clean the connecting rod bolts with solvent, and then blow them dry with compressed air.

31- Apply a drop of Loctite Type "A", or equivalent, to the threads of each connecting rod bolt. Place the rod cap in position with the marks on the connecting rod and cap aligned. Install the rod bolts as far as possible by hand.

Check the alignment between the rod cap and the rod by moving a pencil point back and forth on the chamfered corners between the rod cap and the rod. If a ridge is felt, the rod cap is not aligned properly. The cap **MUST** be aligned before proceeding.

32- Use a 5/16", 12-point socket and tighten the rod bolts alternately in three progressive stages to a torque value of 30 ft lb (41Nm). Tighten to 1/3 the torque value on the first sequence; to 2/3 the value on the second sequence; and to the full torque





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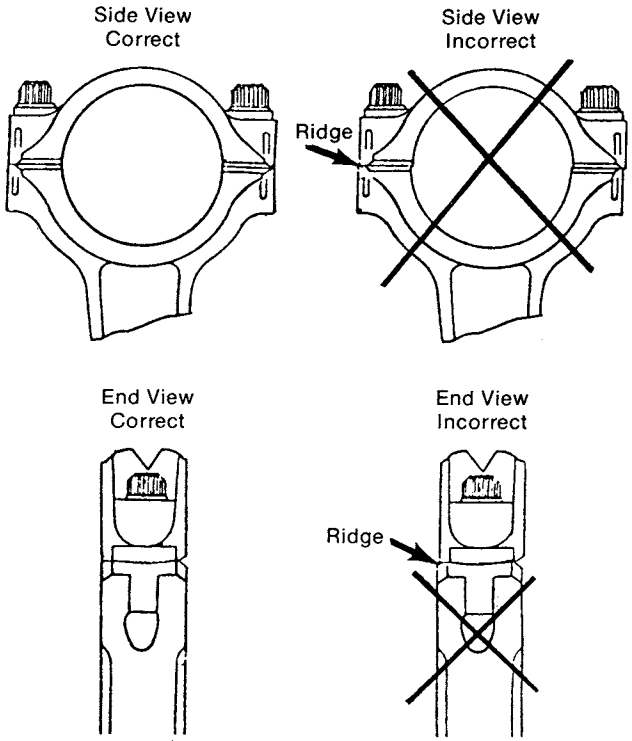
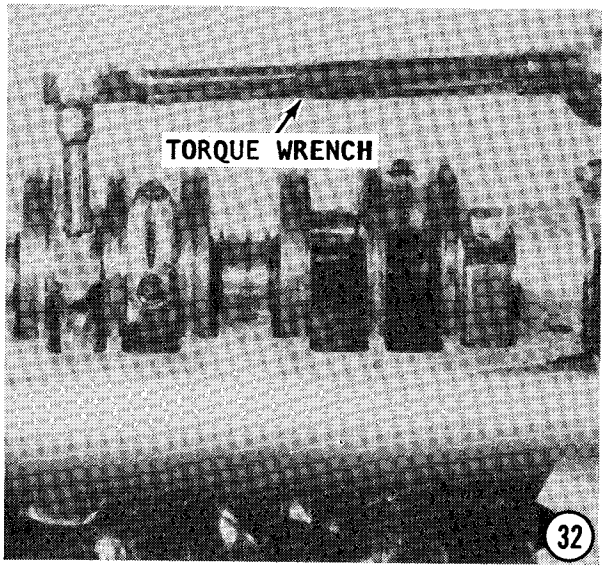
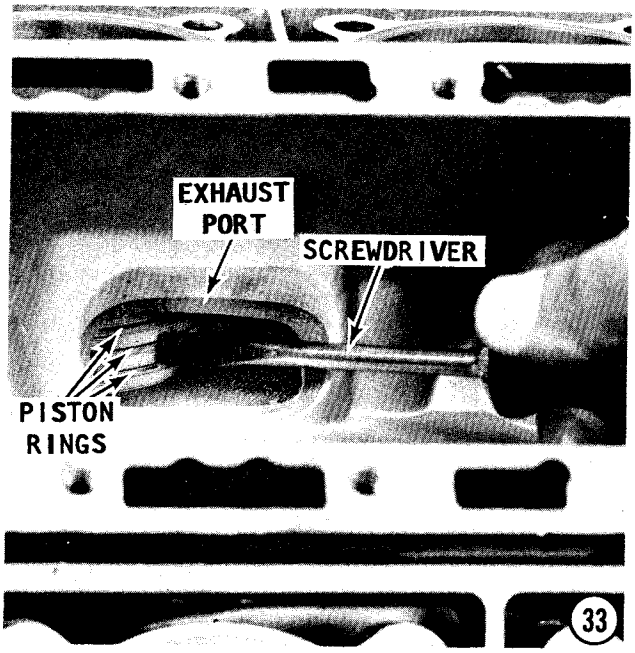


Correct (left) and incorrect (right) rod cap alignment. A ridge can be seen or felt if incorrect.

value on the third and final sequence. Again check the alignment between the cap and the rod.

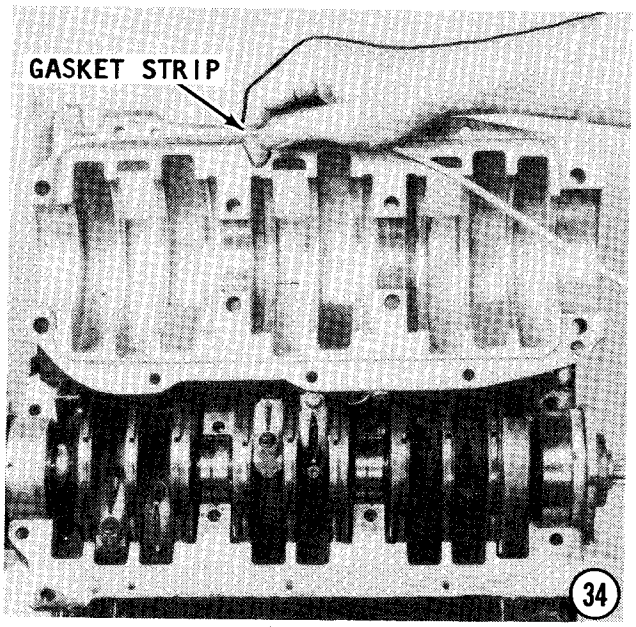
Check to be sure all of the roller bearings have been properly installed. This can be done by inserting a small tool through the slot in the connecting rod cap and rotating the cage. **TAKE CARE** not to scratch the bearings. Install the remaining pistons, rods, and rod caps, one at a time, **IN ORDER** by repeating Steps 25 thru 31, completely for each piston before proceeding to the next. Work each rod onto the next crankshaft connecting rod journal,





WITHOUT skipping a rod or journal. Continue until all pistons have been properly installed.

33- Check to be sure each piston ring has spring tension. This is accomplished by **CAREFULLY** pressing on each ring with a screwdriver extended through the intake ports. If spring tension cannot be felt (the spring fails to return to its original position) the ring was probably broken during the piston installation process. **TAKE CARE** not to burr the piston rings while checking for spring tension. Thread the flywheel nut onto the end of the crankshaft. Rotate the crankshaft several times with a wrench on the nut and check the installation work thus



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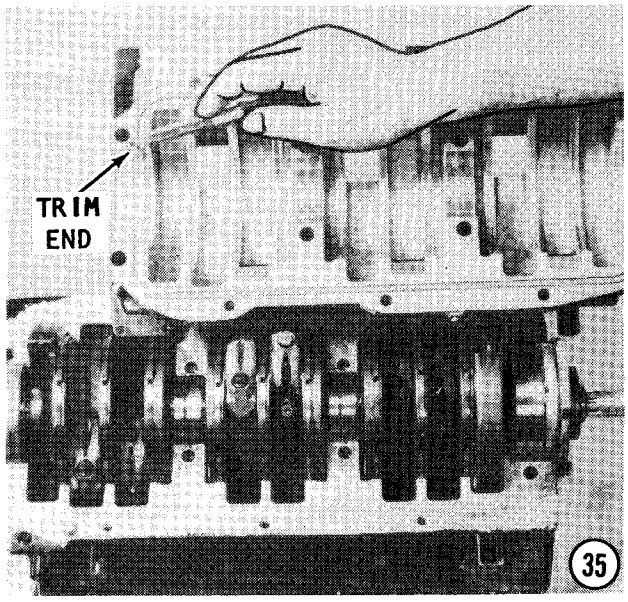


far. The crankshaft should turn freely with no indication of binding or "rough" spots. Leave the flywheel nut on the crankshaft, because it will be used again before the flywheel is installed.

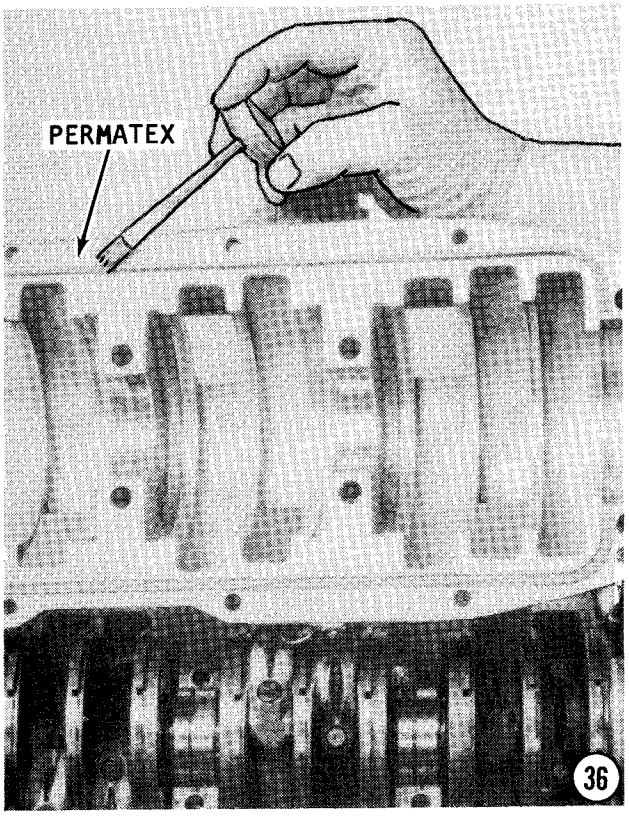
Crankcase Cover Installation

34- Before mating the crankcase cover and the cylinder block, check to be sure:

a- The mating surfaces are clean. **NEVER** use any kind of tool or abrasive material to clean the surfaces. Use only solvent and elbow grease.

b- The crankshaft is properly seated.

c- The rod caps have been correctly installed.

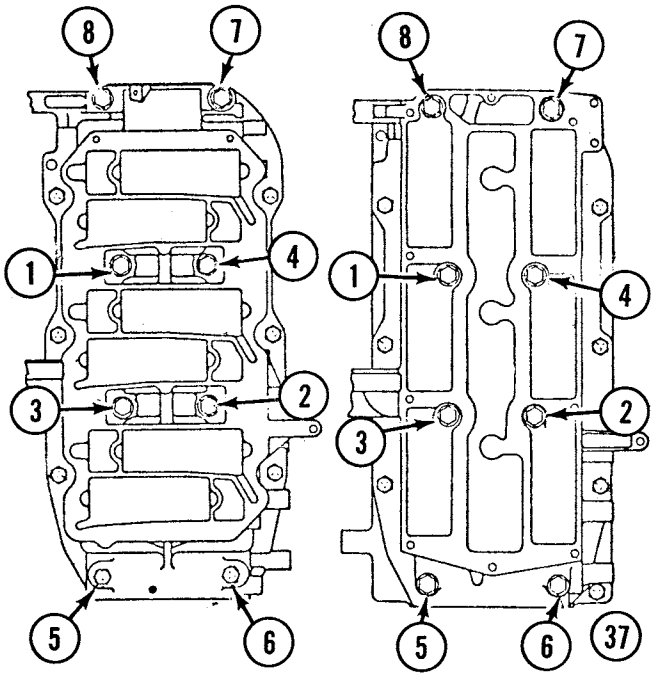


Install gasket strips into the grooves in the crankcase cover.

35- Trim the end of each gasket strip flush with the edge of the cover.

36- Apply a coating of Permatex 2C-12 to the gasket strips and the gasket contact surface of the crankcase cover prior to installation of the cover.

37- Tighten the bolts of the crankcase cover in the pattern shown to the required torque value. Tighten in three stages.



3/8" - 16 Bolts	35 ft lb (41Nm)
(coating threads with light oil)	
5/16" - 18 Bolts	17 ft lb (22Nm)

38- Install the reed block housing and gasket onto the powerhead and secure it in place with the attaching bolts. Tighten the bolts to a torque value of 60 in lb (7Nm), in three stages. Follow the sequence given in the accompanying illustration.

SPECIAL WORDS

Three different reed block designs are used on the powerheads covered in this section. Therefore, identify the design in the illustration. Tightening sequence is indicated on the gasket for clarity.

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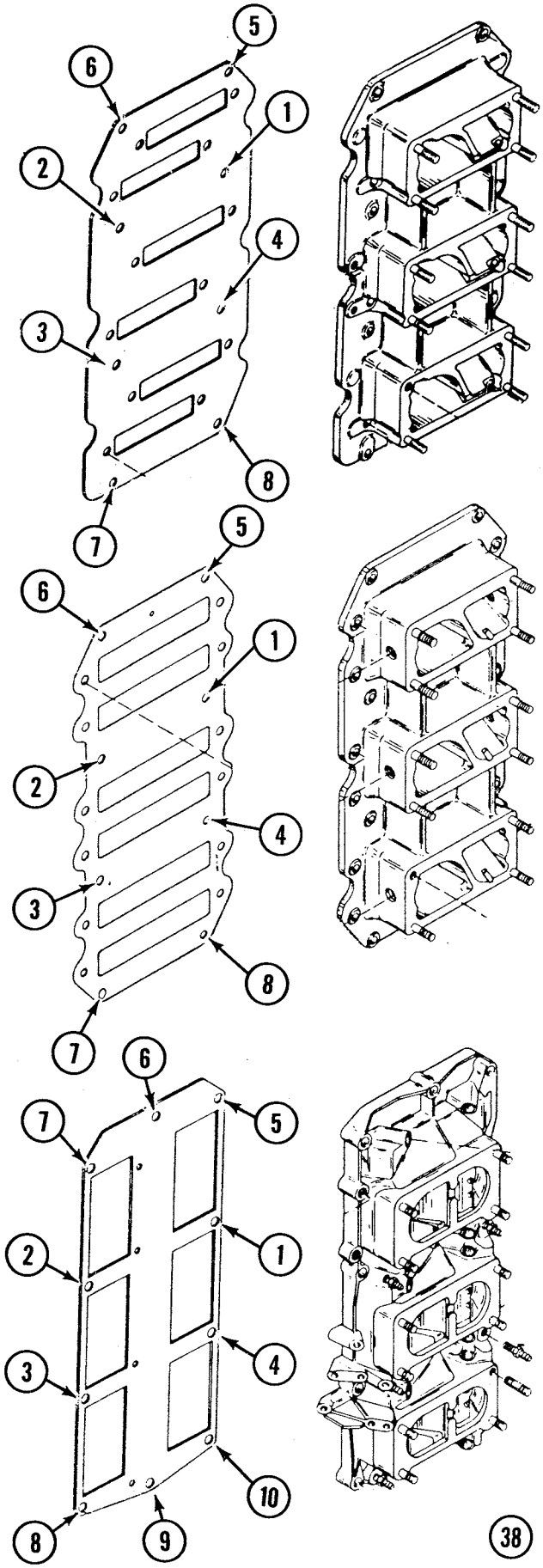


39- Route the bleed hoses through the bleed hose clamps. Connect the hoses from the reed block housing to the fittings on the side of the cylinders. One bleed hose extends from the reed block housing to each cylinder. The fittings on the side of the cylinder block are marked with a stamped letter.

CRITICAL WORDS

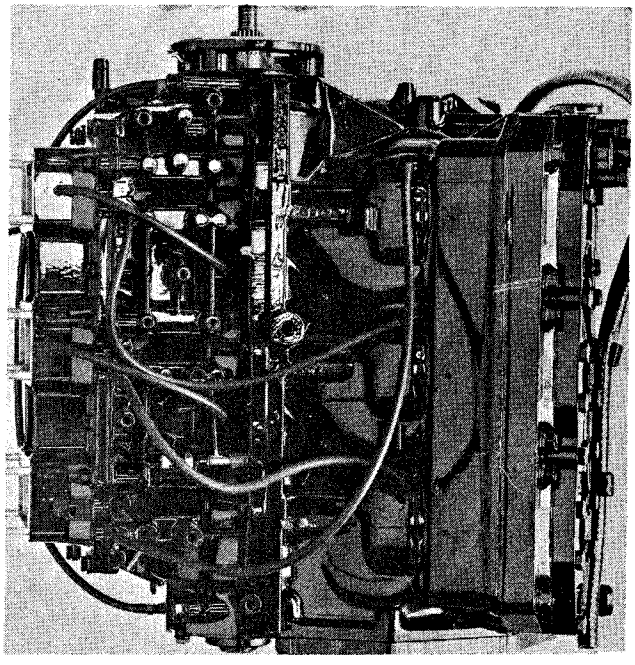
The bleed hoses are properly installed when the hose from check valve "A" is connected to the cylinder fitting marked "A", "B" is connected to "B", etc.

Check a second time, to ensure the bleed hoses are connected properly. If the hoses are not connected correctly, the powerhead will not function **SATISFACTORILY.** The accompanying bleed system flow general diagram V6 powerheads will be helpful, if the identification marks on the block or check valves are illegible.

40- Place the exhaust divider plate seal into the cylinder block slot between the exhaust ports.

CRITICAL CAUTION

New gaskets must be used and must be properly installed to allow adequate water flow through the powerhead. If the water flow is restricted or blocked by a gasket improperly installed, the powerhead will be severely damaged in a matter of minutes after start up.



Bleed line routing on the port side of a Model 200.

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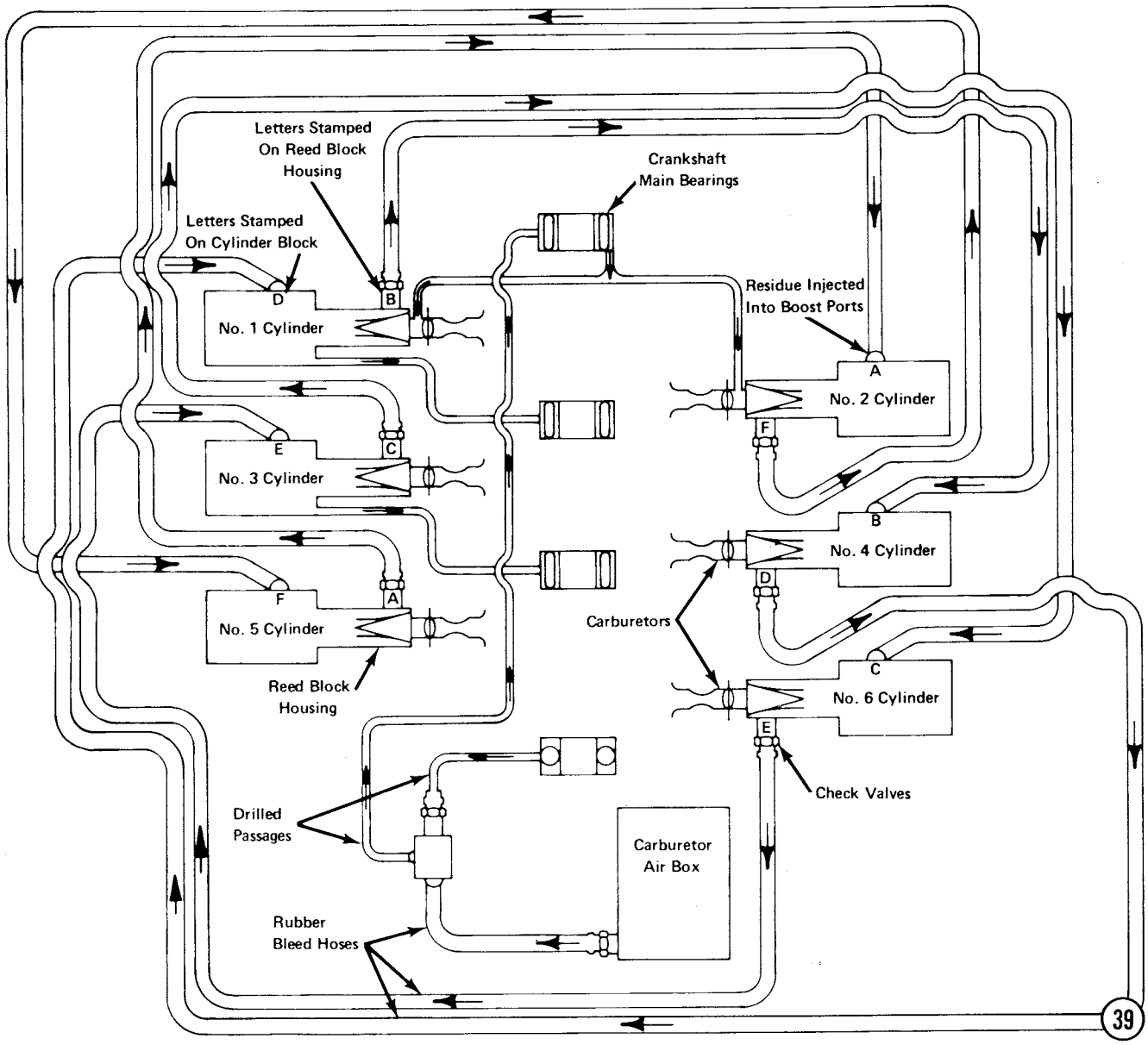

41- Position a **NEW** divider plate gasket on each side of the exhaust divider plate with the holes in the gasket aligned with the holes in the divider plate. Install the exhaust divider plate and gaskets onto the cylinder block.

42- Install the exhaust manifold cover over the divider plate gasket and secure it in place with the attaching bolts. Tighten the bolts to torque value of 180 ft lb (20Nm), in three stages. Follow the pattern given in the accompanying illustration. One of the exhaust manifold cover bolts also secures a wiring harness support plate assembly. The location of this bolt was identified during disassembly in Step 11. Install the wiring harness support plate assembly under this bolt.

43- Install the cylinder head cover gasket and head cover over each cylinder head, with the thermostat openings **TOWARD** the flywheel end of the powerhead.

44- Install the cylinder head gasket over the starboard bank of cylinders with the numbered side of the gasket toward the outside of the block, as shown.

45- Place the cylinder head over the starboard bank of cylinders with the hole for the temperature sender toward the flywheel end of the cylinder block. Install the temperature sender with the bracket into the starboard side cylinder head.

46- Install and tighten the head bolts to a torque value of 30 ft lb (40Nm) for Type 1 cylinder head design, or 40 ft lb (52Nm) for Type 2 head design, as shown in the accom-

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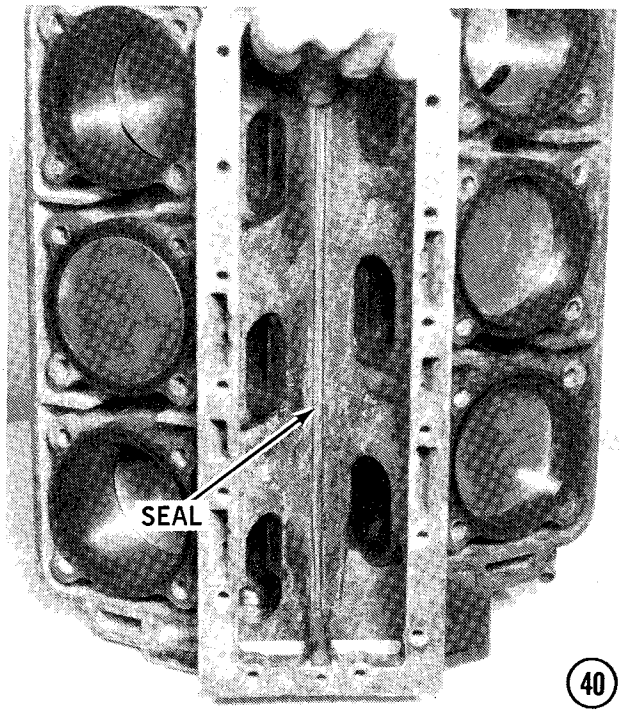

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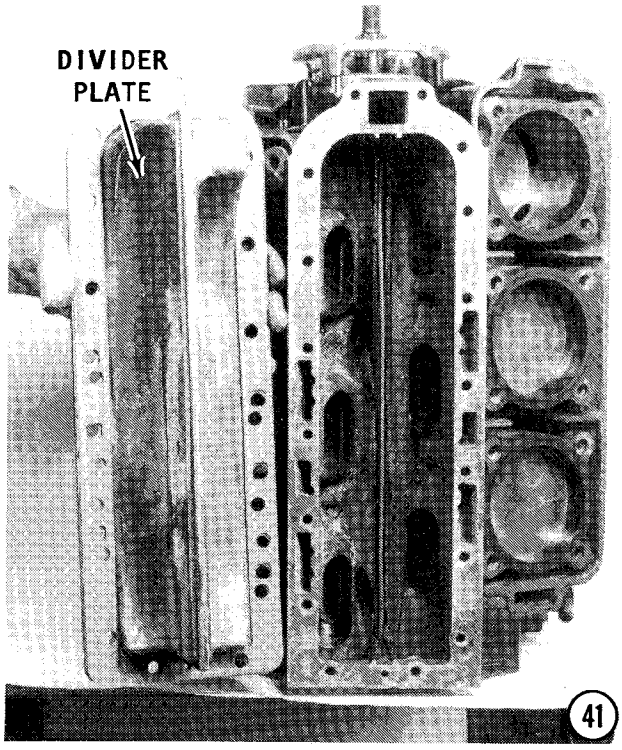

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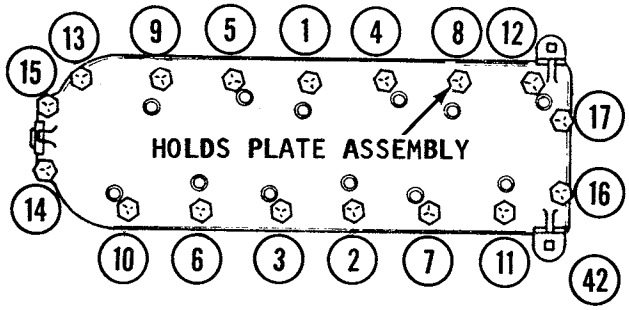

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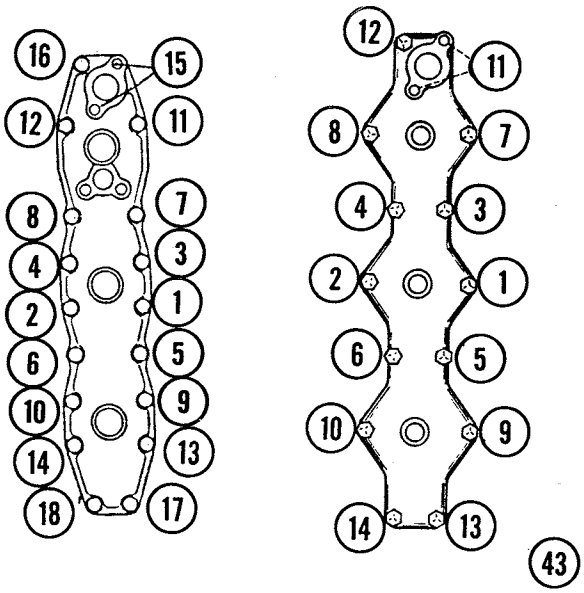

43

panying illustration. Tighten the bolts in three stages following the pattern shown in the illustration. Install the cylinder head cover gasket and cylinder head cover over the port bank of cylinders. The port bank head does not have a temperature sender. Install and tighten the cover bolts to a torque value of 150 in lb (7Nm) for both Type 1 and Type 2 head design. Tighten the bolts in three rounds following the sequence given in the accompanying illustration.



44

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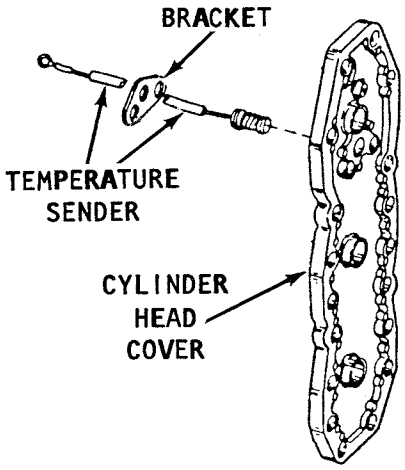

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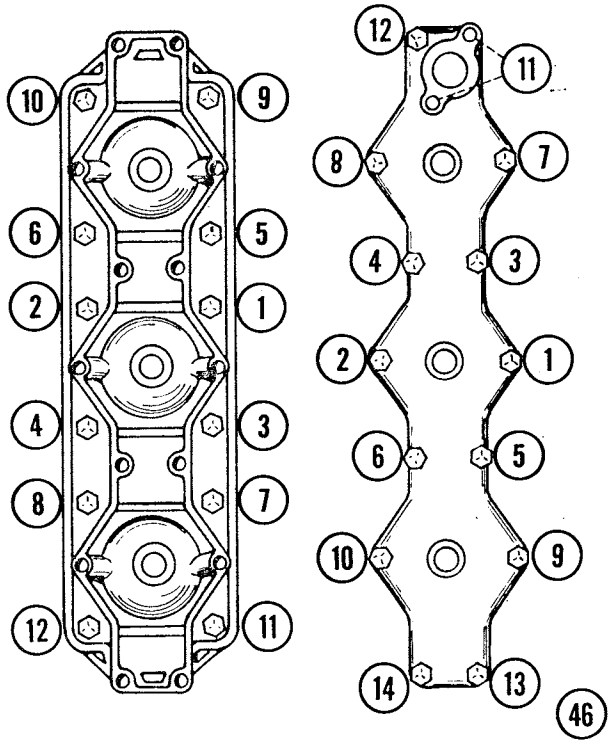
Connect the temperature sender leads to the terminal block on the head of the starboard bank.

Powerhead Buildup

47- Install a new thermostat gasket around each thermostat with the shoulder of the gasket **AGAINST** the cylinder head cover. Install the thermostat, and then the thermostat covers with the water distribution hoses onto the cylinder head covers. Install and tighten the attaching bolts to a torque value of 150 in lb (17Nm).

48- Connect the water distribution hoses from the starboard side thermostat cover to



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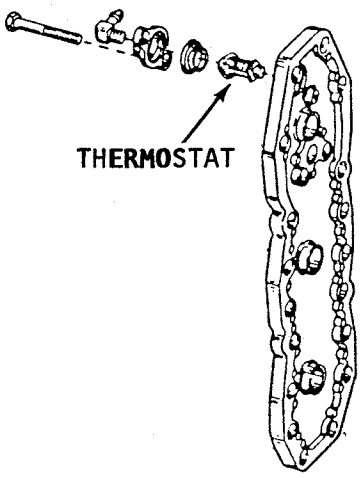

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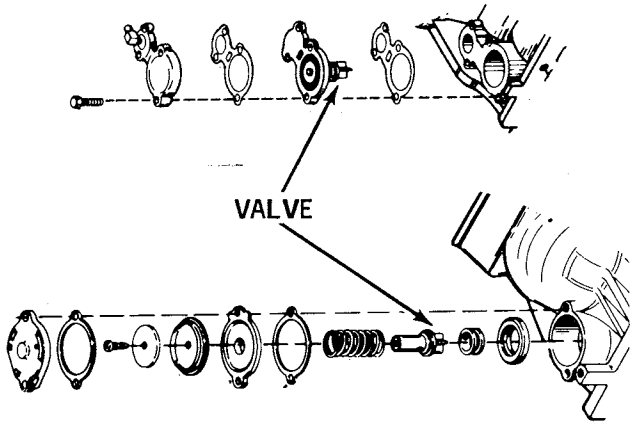
the discharge fitting on the pressure relief valve cover. Secure the hose to the fitting with a hose clamp. The accompanying illustration, on the following page, indicates the cooling system water flow.

49- Insert the oil pump shaft into the block with a **COUNTERCLOCKWISE** rotation to ensure the splines on the shaft index with the teeth of the oil pump gear on the crankshaft. The top of the shaft has a flat edge to mate with the coupler. If the plug and magnet were removed from the coupler, a directional compass is required for assembly. Identify the **SOUTH** end of the magnet. Apply a thin coating of Multipurpose Lubricant to the magnet and the plug, to hold them in place during installation of the coupler. Now, insert magnet into the coupler with the **SOUTH** end of the magnet going in first. Insert the plug into the opening with the flat side of the plug going in first to bear against the magnet.



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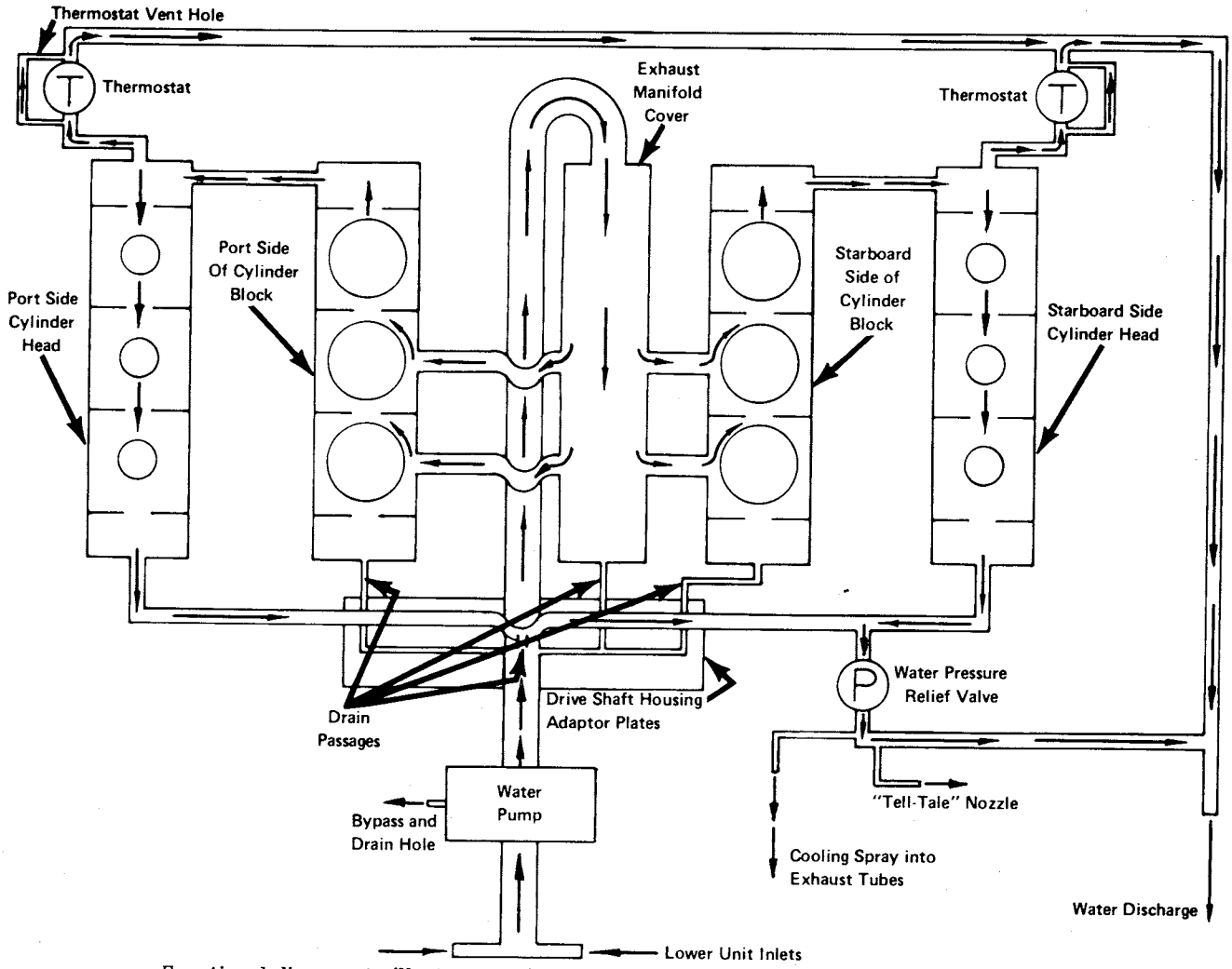
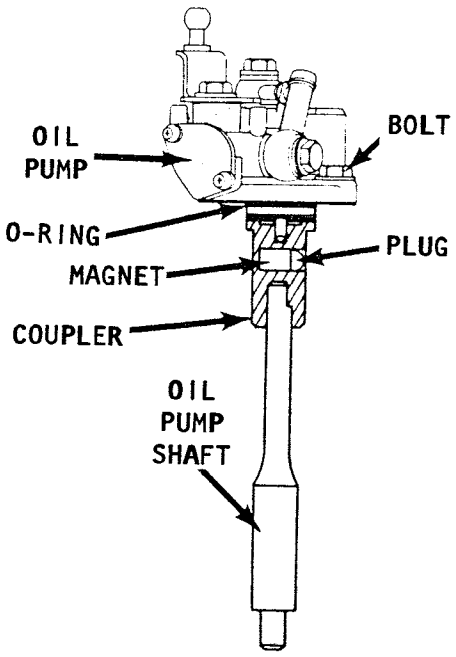


Functional diagram to illustrate typical water circulation through a V6 powerhead.



Lower the coupler onto the oil pump shaft. When the coupler has mated to the shaft correctly, it will not be possible to rotate the coupler. Place the O-ring over the coupler and index the shaft of the oil pump into the top recess of the coupler. Secure the oil pump to the block with the attaching hardware. Connect the outlet hose.

50- Position new carburetor gaskets onto the three carburetor mounting flanges of the reed block housing. Install the carburetors, choke plate/air box, fuel pump and cowling brackets onto the powerhead as an assembly. Secure the carburetors with the 12 locknuts, four on each carburetor. Tighten the nuts to a torque value of 15 ft lb (20Nm). Connect the bleed hose from the reed block housing fitting to the check valve located at the lower port side corner of the air intake box.

Install the fuel pump gaskets and diaphragm. Assemble the fuel pump to the

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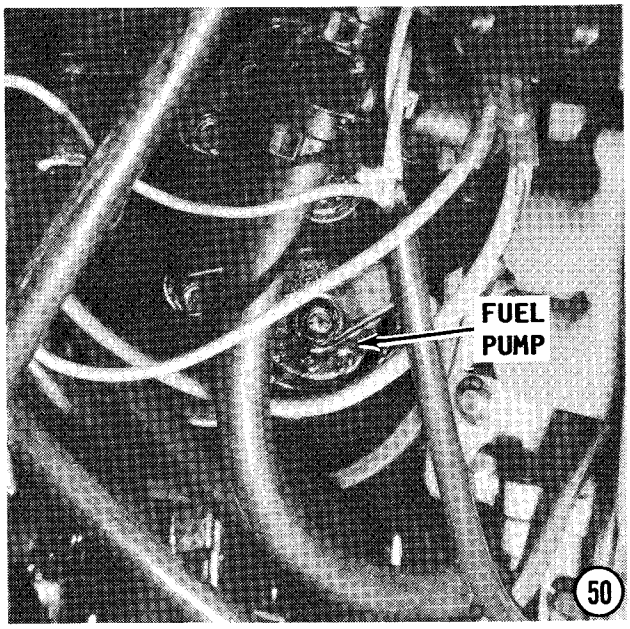
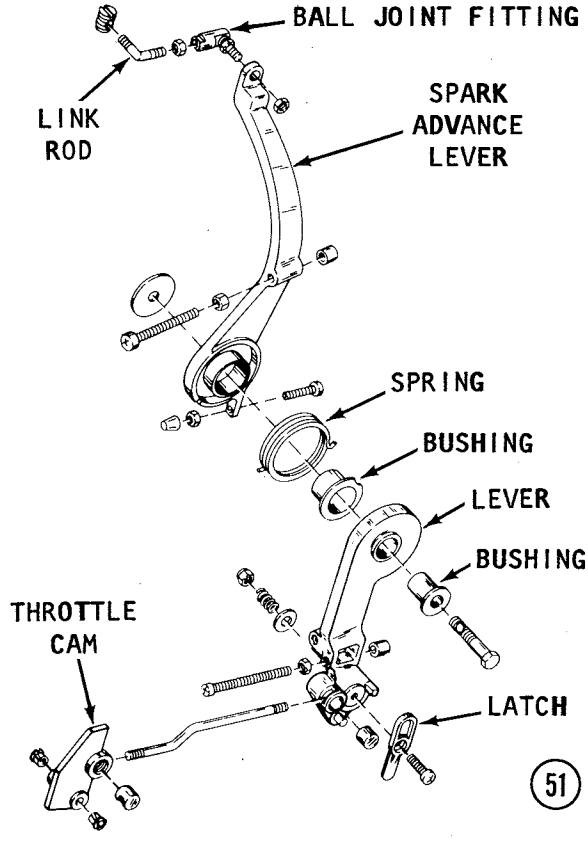


reed block housing. Secure the fuel pump assembly in place with the five screws tightened to a torque value of 12.5 ft lb (17Nm).

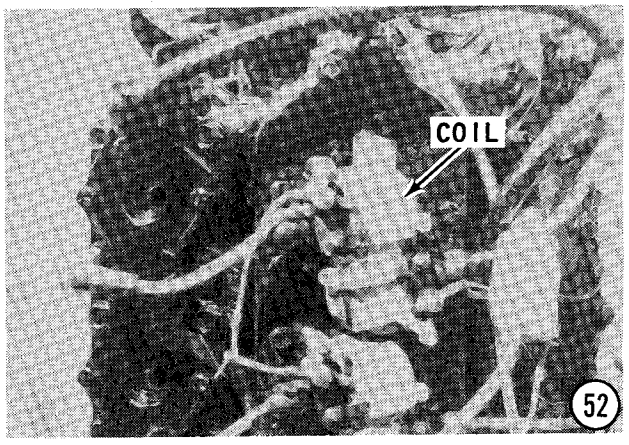
51- Install the control cable anchor bracket to the crankcase cover with the three attaching bolts. Apply a coating of Multipurpose Lubricant to the bushing in the vertical throttle lever. Install a flat washer around the pivot bolt. Attach the vertical throttle lever assembly to the cylinder block with the pivot bolt. The flat washer **MUST** be installed between the throttle lever and the cylinder block. Tighten the pivot bolt securely. Lubricate the two throttle cam bushings with Multipurpose Lubricant. Install the throttle cam, with one bushing on each side of the cam, onto the reed block housing stud. Secure the throttle cam with the locknut. Thread the locknut onto the stud until two or three stud threads can be seen on the outside of the locknut. **DO NOT** tighten the locknut, because the cam must be **FREE** to swivel.



52- Attach the ignition plate, with the electrical components, to the starboard side of the powerhead with the three bolts and flat washers. Check to be sure the ground wires and "J" clips are properly installed, and then tighten the bolts securely. Apply a drop of Loctite Type "A" onto the threads of the secondary ignition coil attaching screws. Install the six secondary ignition coils and the coil covers onto the exhaust manifold cover. Connect the ground wires, the negative terminals of the coils around the appropriate screws, and then secure the coils and coil covers with the screws. Connect the green, green/white and green/red switch box wires to the positive terminals of the respective secondary ignition coils. Secure the connection with a lockwasher and nut. Cover the coil terminals with the rubber boots.

CRITICAL WORDS

The green, green/white and green/red switch box wires have numbered tape flags attached. The switch box wire identified with the **"1"** on it **MUST** be attached to the ignition coil to fire the No. 1 cylinder. The same is true for the other wires, coils and cylinders.



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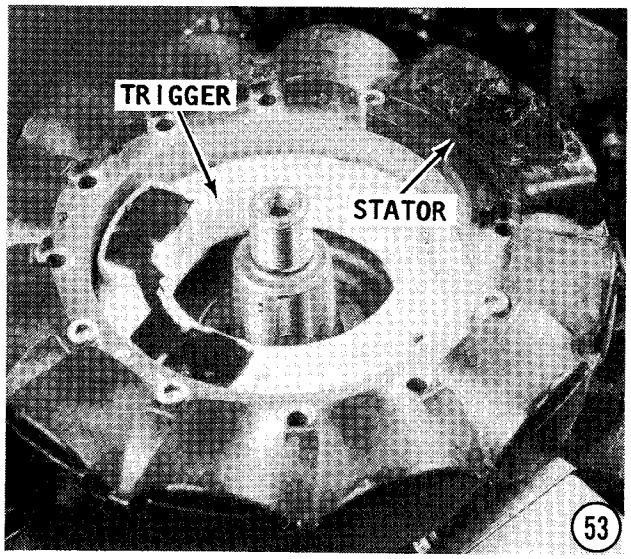
Connect the white/green engine harness wire to the terminal block with the temperature sender wires attached. Connect the wire to the terminal that is **NOT** grounded. Insulate the terminals with Liquid Neoprene.

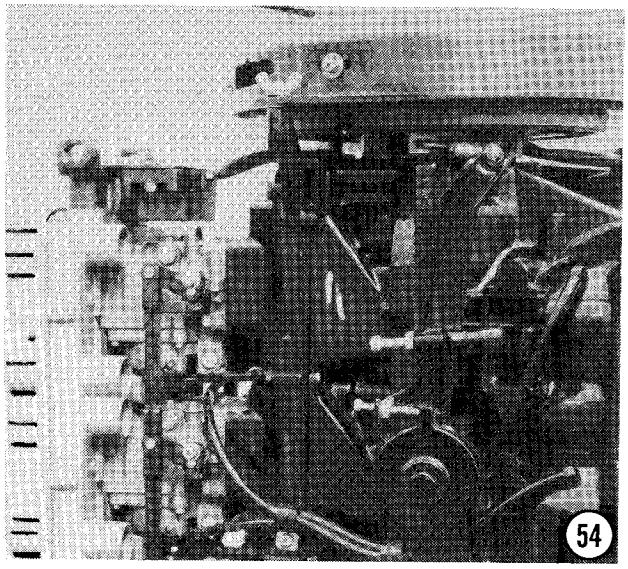
Insert the choke plunger inside the choke solenoid and attach the solenoid to the reed block housing with lockwashers and the attaching bolts. Connect the idle stabilizer or the ignition module to the switch box. Refer to the wiring diagram in the Appendix, if necessary.

Connect the gray engine harness wire to the choke solenoid terminal. Secure the connection with a lockwasher and nut. Insulate the terminal with Liquid Neoprene. Place the starter motor, with rubber collars, in position on the crankcase cover. Secure the motor in place with the upper and lower covers. Check to be sure the ground wire is installed on the mounting bolt, and then tighten the bolts to a torque value of 15 ft lb (20Nm). Connect the electrical cables to the starter motor. Insulate the cable ends with Liquid Neoprene.

53- Install the trigger plate assembly in the upper end cap and insert the link rod swivel into the vertical throttle lever. Secure the link rod to the throttle lever with a locknut tightened securely. Apply a drop of Loctite Type "A" onto the threads of the stator attaching screws. Install the stator assembly in position in the upper end cap and secure it in place with the attaching screws. Tighten to a torque value of 30 in lb (3.4Nm).

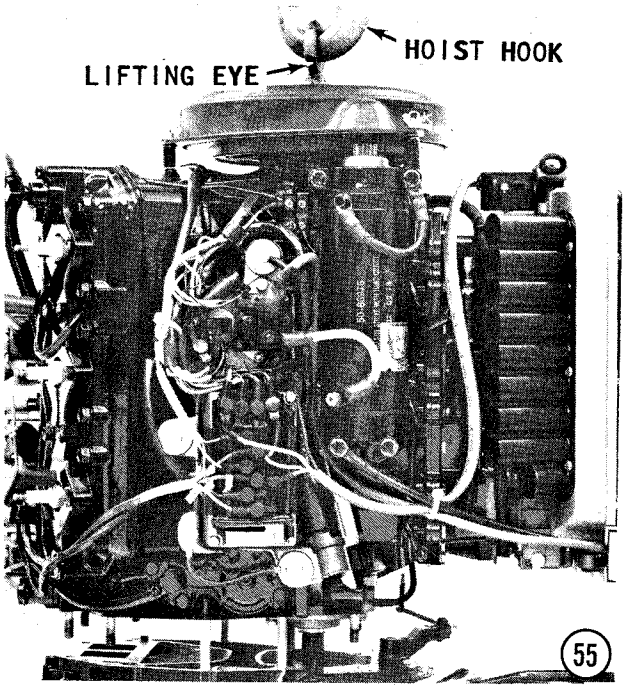
Connect the stator wires and trigger wires to the proper terminals of the switch boxes. Wires with a yellow identification





sleeve around them **MUST** be connected to the outer switch box. The outer switch box fires cylinders No. 2, 4 and 6. Install the necessary sta-straps to secure the wiring. Install the wiring into the proper "J" clips, and then close the clips.

54- Insert the flywheel key in the crankshaft keyway. Check the inside rim of the flywheel to be sure metal particles are not stuck to the flywheel magnets. Check to be sure the inside taper of the flywheel and the taper on the crankshaft are clean of dirt or oil, to prevent the flywheel from "walking" on the crankshaft during operation. Slide the flywheel down the crankshaft with the keyway in the flywheel aligned with the key on the crankshaft. Rotate the flywheel



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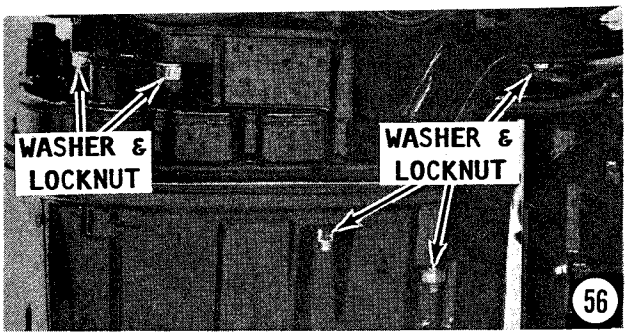
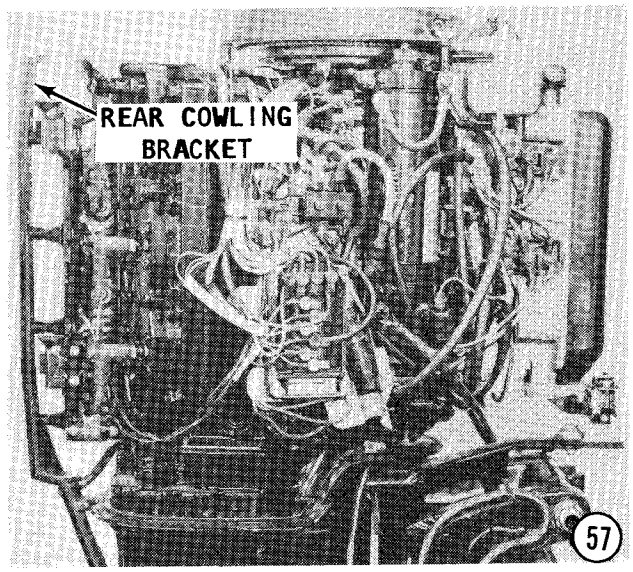


clockwise and check to be sure the flywheel does not contact any component or any of the wiring. Slide a flat washer onto the crankshaft, and then thread the flywheel nut on the crankshaft. Hold the flywheel with a flywheel strap and tighten the nut to a torque value of 100 ft lb (136Nm).

Install the flywheel cover and secure it in place with flat washers and wingnuts.

55- Thread a lifting eye into the crankshaft as far as it will go. For **SAFETY,** check to be sure the lifting eye is properly installed. Using a suitable hoist, lift the powerhead. Place a **NEW** gasket into position on the base of the intermediate housing. Lubricate the driveshaft splines with Multi-purpose Lubricant. Slowly lower the powerhead down onto the intermediate housing. It may be necessary to rotate the flywheel slightly to index the crankshaft splines with the driveshaft splines. Once the splines index, lower the powerhead fully into place on the intermediate housing.

56- Secure the powerhead to the intermediate housing with 10 flat washers and 10 locknuts. Tighten the locknuts in three stages to a torque value of 45 ft lb (61Nm). Disconnect the hoist from the lifting eye, and then remove the eye from the crankshaft. Install the plastic cap into the end of the crankshaft.



57- Install and secure the rear cowling bracket assembly to the exhaust manifold cover with three flat washers and three locknuts. Connect the water hose from the port side of the exhaust adaptor plate to the tattletale nozzle. Secure the hose to the nozzle with a hose clamp. Install the spring and guide block onto the shift link rod with the anchor pin **FORWARD,** and then insert the shift link rod into the control cable anchor bracket. Secure the shift link rod assembly with the wear plate, latch, washer and locknut. Thread the locknut onto the shift link rod until 2 or 3 threads are exposed beyond the top of the nut. **DO NOT** tighten the locknut.

Install the oil reservoir and connect the outlet hose to the inlet side of the oil pump. To bleed the oil injection system, see Chapter 5.

Install the spark plugs into both cylinder heads and tighten them to a torque value of 20 ft lb (27Nm).

Connect the ignition coil high tension leads to their respective spark plugs. Connect the remote control cables to the engine. Connect the engine battery cables to the battery terminals. Check to be sure the system polarity is maintained.

Plug the engine harness into the extension harness and secure the connection with the clamps.

Connect the engine and fuel tank lines.

For complete detailed timing and synchronizing procedures, see Chapter 7.

Mount the engine in a test tank. Turn the fuel shut off valve to the **ON** position. Start the engine and follow the break in procedures given after the Caution.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Break In Procedures

As soon as the engine starts, **CHECK** to be sure the water pump is operating. If the water pump is operating, a water mist will be discharged from the exhaust relief holes at the rear of the intermediate housing.

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Check the cylinder block, both cylinder heads, both cylinder head covers, the exhaust manifold cover, and the thermostat covers for water leaks. Make a thorough check for fuel and exhaust leaks. If a powerhead leak/s is detected, the problem area **MUST** be corrected before placing the engine in service.

After three hours of powerhead operation, tighten the head bolts again to the torque value listed in Step 46 of assembling procedures.

During the first 10 hours of operation, **DO NOT** operate the engine at full throttle (except for **VERY** short periods). Perform the break in as follows:

a- Operate at 1/2 throttle, approximately 2500 to 3500 rpm, for 2 hours.

b- Operate at any speed after 2 hours **BUT NOT** at sustained full throttle until another 8 hours of operation.

c- Mix gasoline and oil during the break in period, total of 10 hours, at a ratio of 50:1.

d- While the engine is operating during the initial period, check the fuel, exhaust, and water systems for leaks.

e- Refer to Chapter 7 for synchronizing procedures.

After the test period, disconnect the fuel line. Remove the engine from the test tank. Install the engine cowling.

8-5 CLEANING AND INSPECTING ALL MODELS

The success of the overhaul work is largely dependent on how well the cleaning and inspecting procedures are completed. If some parts are not thoroughly cleaned, or if an unsatisfactory unit is allowed to be returned to service through negligent inspection, the time and expense involved in the work will not be justified with peak engine performance and long operating life. Therefore, the procedures in the following sections should be followed in detail and the work performed with patience and attention to detail.

THERMOSTAT SERVICE

Inspect the thermostat cover and the thermostat opening in the cylinder head cover for cracks and corrosion damage. Such damage could cause leakage. Remove and **DISCARD** the old thermostat gasket. Wash the thermostat with clean water.

Obtain a thermostat tester or similar device, as shown in the accompanying illustration. Test the thermostat as follows:

a- Open the thermostat valve. Insert a length of thread between the valve and the thermostat body. Allow the valve to close against the thread.

b- Suspend the thermostat by the thread inside the tester. Do not allow the thermostat to touch the bottom or sides of the tester.

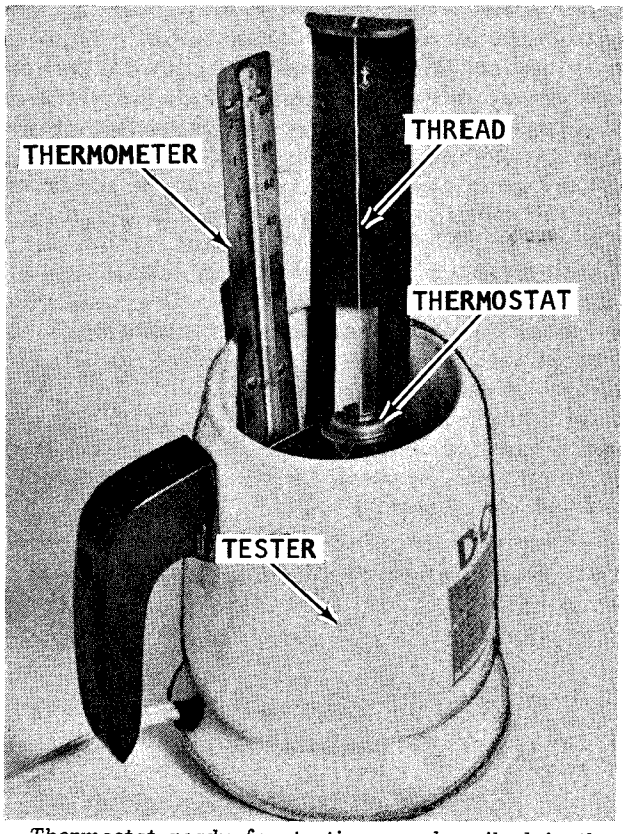
c- Suspend a thermometer inside the tester, with the bottom of the thermometer even with the bottom of the thermostat. Do not allow the thermometer to touch the bottom or sides of the tester.

d- Fill the tester with water to cover the thermostat. Plug the tester into an electrical outlet.

e- Observe the temperature at which the thermostat begins to open. As soon as the thermostat starts to open, it will drop off the thread. The thermostat **MUST** begin to open at 140° to 145°F.

f- Continue to heat the water until the thermostat is completely open. Unplug the tester.

g- Allow the water in the tester to cool before testing the next thermostat.



Thermostat ready for testing, as described in the text.

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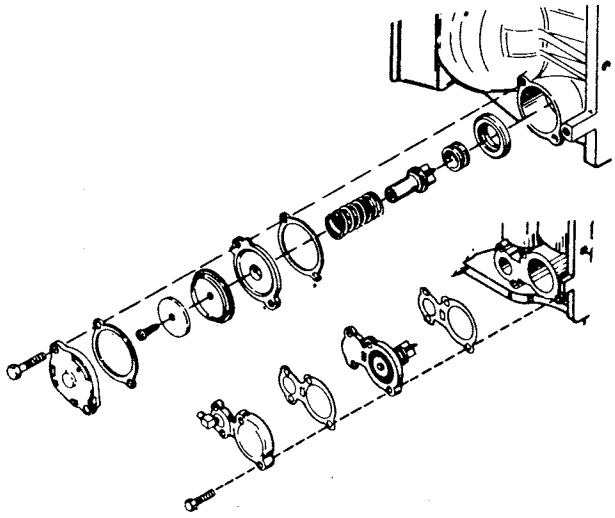
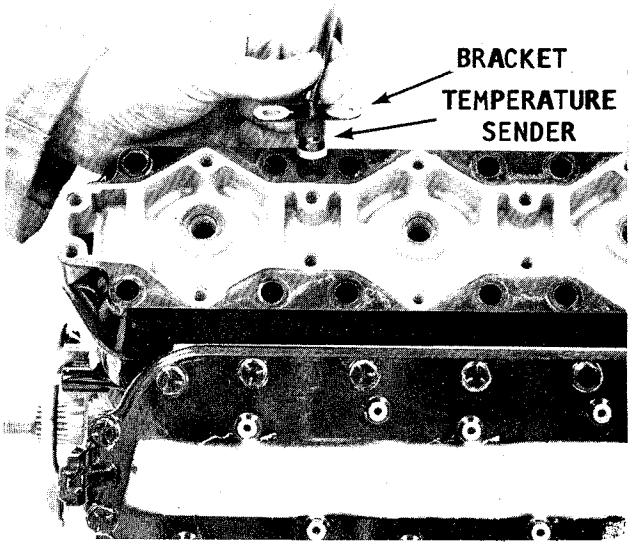


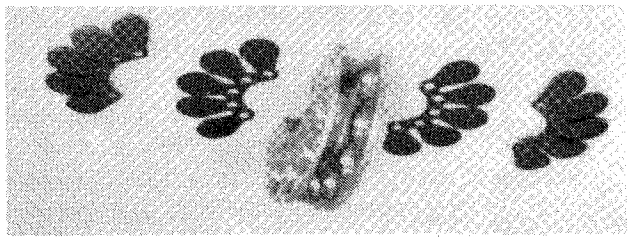
Exploded drawing to show the internal parts of the two different designed water pressure relief valves installed on V6 powerheads covered in this manual.

Replace the thermostat, if it fails to open at the specified temperature, or if it does not fully open.

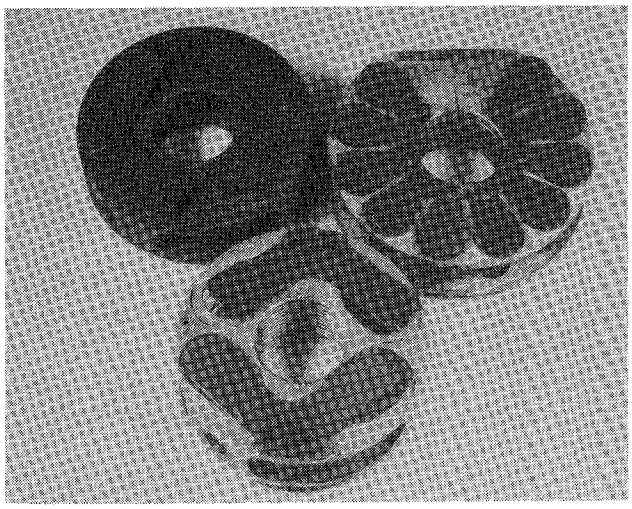
Two different temperature senders may be installed on the V6 powerheads covered in this manual. The sender is actually an electrical switch designed to close at a preset temperature and allow current to flow. One unit is a 190°F, the other, a 240°F sender. The location of the temperature sender on the powerhead determines the heat range of the sender. A sender installed directly below the spark plug opening is rated at 240°F and will activate the overheating alarm at 248°F. The 190°F sender is installed on the outer side of a cylinder head and will activate the overheating alarm at 198°F.



A 190°F temperature sender installed on the outer side of the cylinder head.



Arrangement of reed box parts. The reed box is in the center with the reed and reed plate on each side.



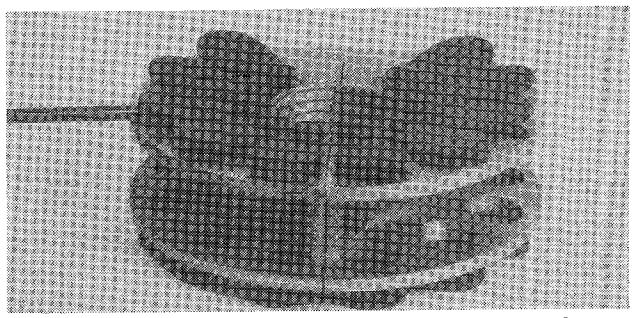
Typical reed boxes used on the powerheads for the outboard units covered in this manual.

Because of their heat range, the sender cannot be tested in the same manner as a thermostat. Therefore, if the sender is suspected as being faulty, remove the unit and replace it with a new one.

REED BLOCK SERVICE INTEGRAL-TYPE

Secure the reed blocks together with screws and nuts tightened to torque value of 85 in lb (7Nm).

Check for chipped or broken reeds. Observe that the reeds are not preloaded or



Using a drill bit shank to measure the reed stop height, if a measurement scale is not available. Refer to the Specifications in the Appendix for the proper height.

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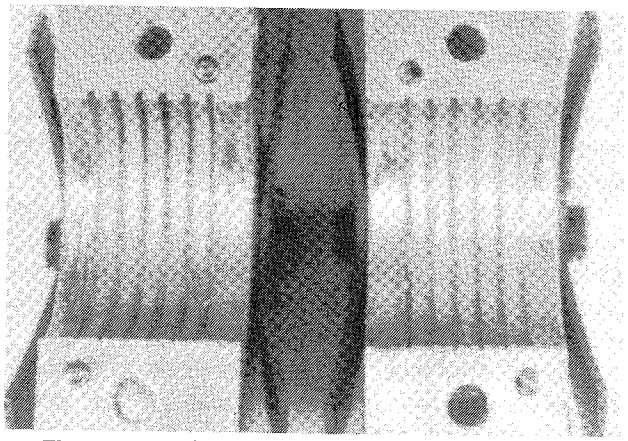


*The grooves inside the reed block must be in good condition in order to form an effective seal between cylinders. The groove should be checked for wear. The grooves in the block half on the right show excessive wear. Therefore, both halves of the reed block **MUST** be replaced. The crankshaft throw may be out-of-round, the main bearing may be worn, insufficient lubrication, or a worn block may cause such damage. The reed block half on the left is satisfactory. Therefore, if both halves are in this condition, the reed block may be used again.*

standing open. Satisfactory reeds will not adhere to the reed block surface, but still there is not more than 0.007" (0.18mm) clearance between the reed and the block surface.

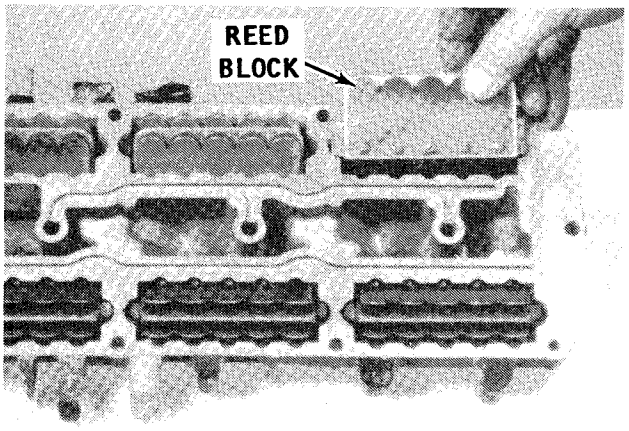
DO NOT remove the reeds, unless they are to be replaced. **ALWAYS** replace reeds in sets. **NEVER** turn used reed over to be used a second time.

Check the reed location over the reed block openings to be sure the reed is centered.

See "Reed Stop Settings" in the Specifications in the Appendix and adjust the reed stops as required.

GOOD WORDS

If the powerhead shows evidence of having overheated, check the condition of the plastic locating pins. If the pins are damaged (melted) the pins will affect engine performance by poor idle, hard starting, etc.



Reed block housing with vertical mounted reeds.

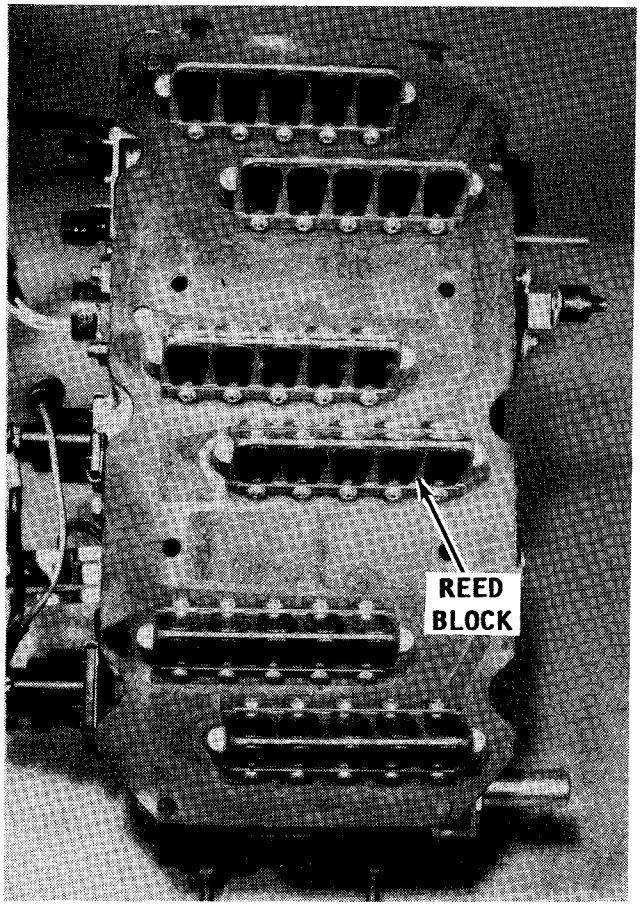
REED BLOCK SERVICE SEPARATE REED BLOCK HOUSING NEW RE-DESIGNED INLINE AND V6 BLOCKS

DO NOT remove the reeds, unless they are to be replaced. **ALWAYS** replace reeds in sets. **NEVER** turn used reed over to be used a second time.

Clean the gasket surfaces of the reed blocks and the reed block housing. Inspect the surfaces for any signs of damage, deep grooves, cracks or distortion that might cause leakage. Check the face of each reed block to be sure a reed has not made an indentation. Check for chipped or broken reeds. Replace any damaged parts.

Assembling

Place the reeds and the reed stops in position on the reed blocks. Secure the reeds and stops in place with the screws and lockwashers. Tighten the screws to a torque



Reed block housing with horizontal mounted reeds.

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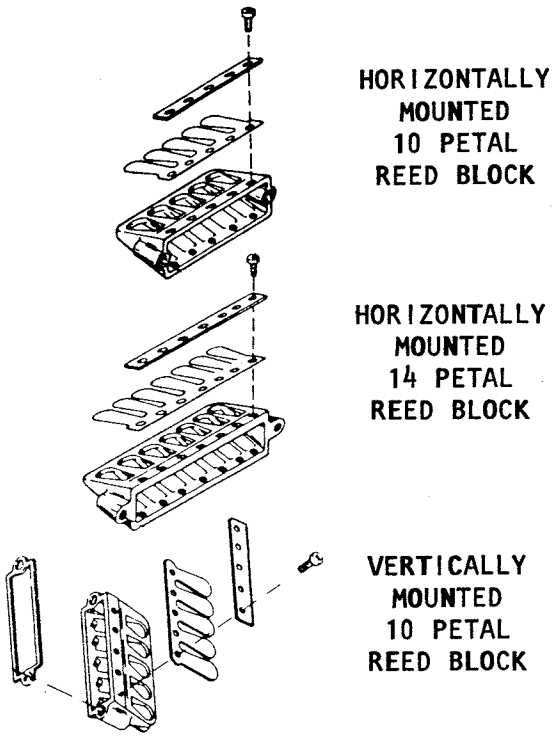
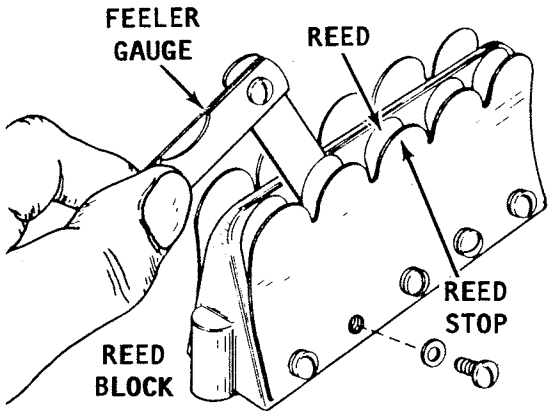
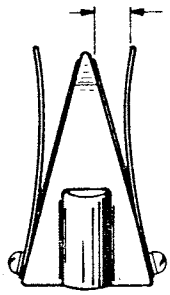


Three different reed designs are used on the powerheads covered in this manual.



Measuring the reed opening with a feeler gauge.



The dimension shown indicates the reed stop opening.

value of 25 in lb (3Nm). Check to be sure the reeds are preloaded. They should not adhere to the reed block and still there should not be more than 0.020" (.51mm) clearance between the reed and the reed block surface.

Check each reed stop to be sure they are not bent sideways. Refer to the reed stop opening chart in the Appendix for the correct dimension for the powerhead being serviced.

Place the reed block gaskets, and then the reed blocks into position in the reed block housing. Tighten the attaching screws to a torque value of 60 in lb (7Nm).

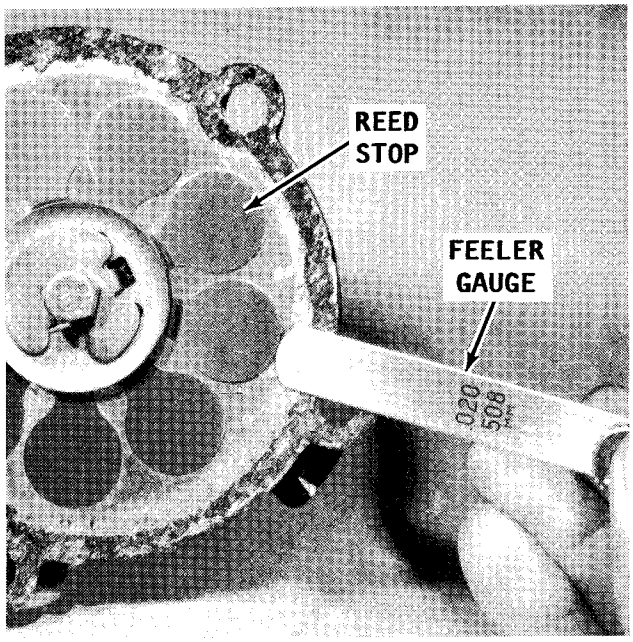
CRITICAL WORDS

When one "teardrop" reed and one "straight cut" reed are used, the reed block **MUST BE** installed in the reed block housing with the "teardrop" reed toward the center (inside) the reed block housing.

Check the reed location over the reed block openings to be sure the reed is centered.

CRANKSHAFT SERVICE

Inspect the splines for signs of abnormal wear. Check the crankshaft for straightness. Inspect the crankshaft oil seal surfaces to be sure they are not grooved, pitted or scratched. Replace the crankshaft if it is severely damaged or worn. Check all crank-



Measuring the reed opening on a "rose petal" design reed block housing, installed on the large bore 3- and 4-cylinder powerheads.

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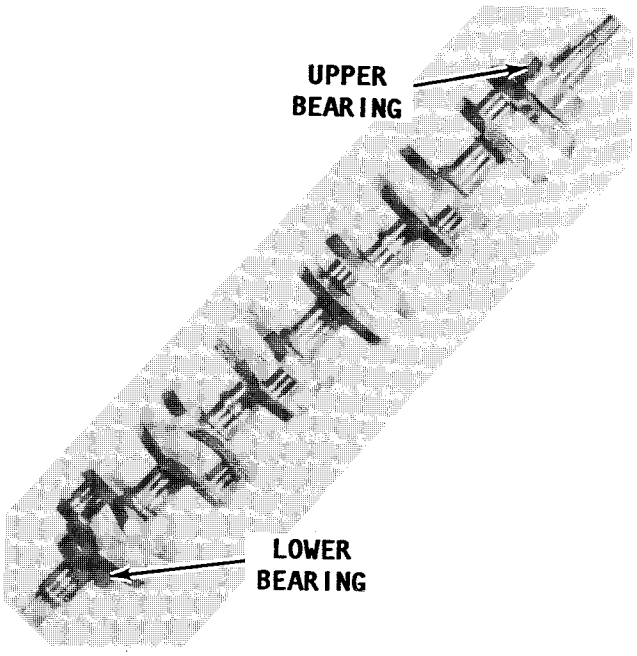
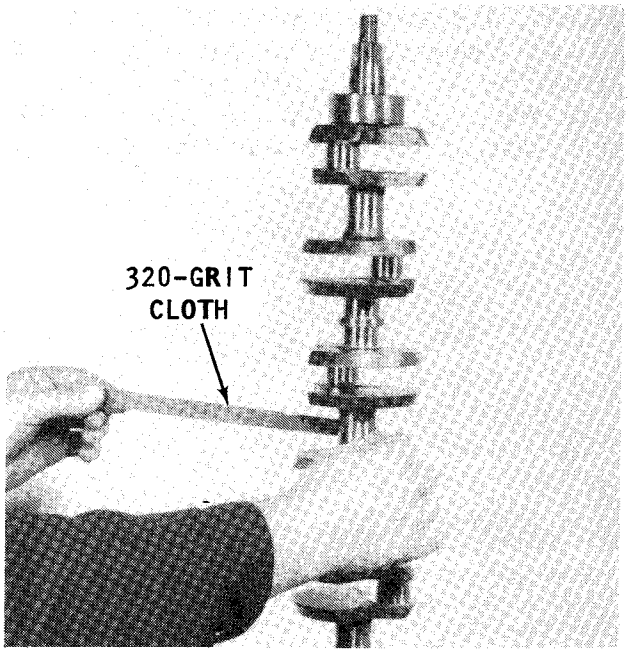


Crankshaft with the upper and lower bearings clearly visible. The bearings should be carefully checked to ensure satisfactory performance. Excessive wobble or "play" in the bearing is cause for replacement.

shaft bearing surfaces for rust, water marks, chatter marks, uneven wear or overheating. Clean the crankshaft surfaces with 320-grit carborundum cloth. **NEVER** spin-dry a crankshaft ball bearing with compressed air.

Clean the crankshaft and crankshaft ball bearing with solvent. Dry the parts, but not the ball bearing with compressed air. Check the crankshaft surfaces a second time. Replace the crankshaft if the surfaces cannot be cleaned properly for satisfactory service. If the crankshaft is to be installed for service, lubricate the surfaces with light oil. **DO NOT** lubricate the crankshaft ball bearing at this time.



Cleaning the crankshaft with crocus cloth.

CRANKSHAFT AND END CAP BEARINGS

After the crankshaft has been cleaned, grasp the outer race of the crankshaft ball bearing installed on the lower end of the crankshaft, and attempt to work the race back-and-forth. There should not be excessive "play". A very slight amount of side "play" is acceptable because there is only about 0.001" (.025mm) clearance in the bearing.

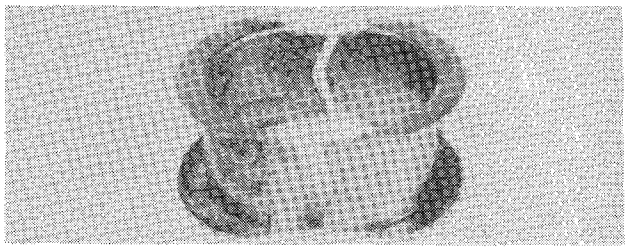
Lubricate the ball bearing with light oil. Check the action of the bearing by rotating the outer bearing race. The bearing should have a smooth action and no rust stains. If the ball bearing sounds or feels rough or catches, the bearing should be removed and discarded.

Clean the crankshaft center main roller bearings with solvent, and then dry them thoroughly, **BUT NOT** with compressed air. Lubricate the bearings with light weight oil. **NEVER** intermix halves of upper and lower crankshaft center main roller bearings. The bearings **MUST** be replaced only in pairs.

Inspect the center main roller bearings. Replace the bearings in pairs if they are rusted, fractured, worn, galled or badly discolored.

Clean the crankshaft roller bearings installed in the upper end cap with solvent, and then dry them, **BUT NOT** with compressed air. Lubricate the bearings with lightweight oil.

Inspect the upper end cap roller bearing to be sure it is not rusted, fractured, worn, galled, or badly discolored. If the bearing is damaged, it should be removed and discarded.



*Bearing liners showing the matching **V** marks for proper alignment. The inside diameter of the liners should be cleaned with crocus cloth.*

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Cleaning the inside diameter of the rod and rod cap with crocus cloth.

CONNECTING ROD SERVICE

Stand each connecting rod upright on a surface plate and check the alignment. The rod is bent and unfit for further service, if:

a- Light can be seen under any portion of the machined surfaces -- the surfaces which mate with the rod cap.

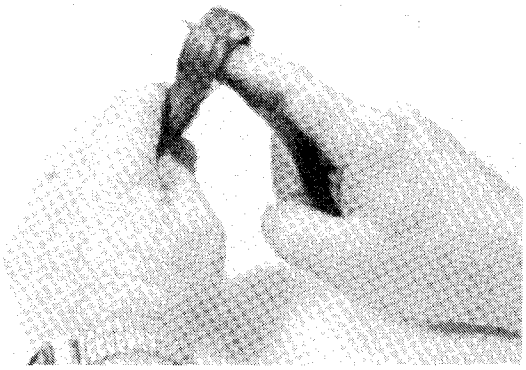
b- The rod has a slight wobble on the plate.

c- A 0.002" (.05mm) feeler gauge can be inserted between the machined surface and the surface plate.

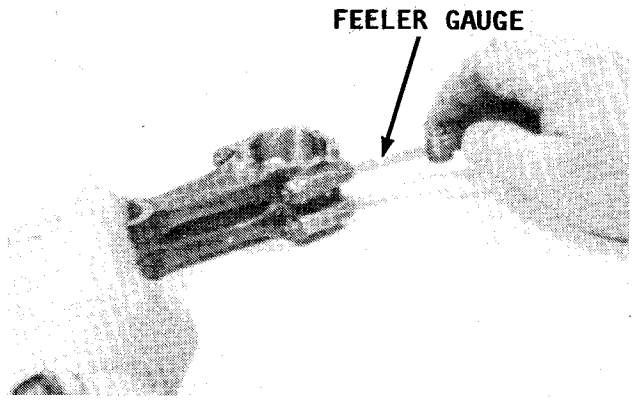
Inspect the connecting rod bearings for rust or signs of bearing failure. **NEVER** intermix new and used bearings. If even one bearing in a set needs to be replaced, all bearings at that location **MUST** be replaced.

Inspect the bearing surface of the rod and the rod cap for rust and pitting.

Inspect the bearing surface of the rod and the rod cap for water marks. Water marks are caused by the bearing surface being subjected to water contamination, which causes "etching". The etching resembles the size of the bearing as shown in the accompanying illustration.



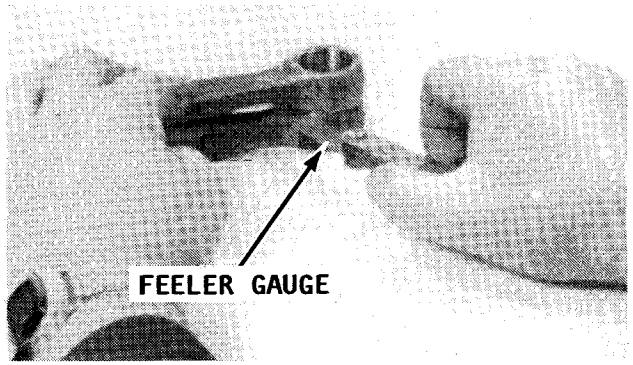
Cleaning the inside diameter of the piston pin end with crocus cloth.



*Check for rod warpage by placing one on top of a known good rod, and then attempting to insert a feeler gauge between the two surfaces. There should be **NO** clearance between the two rods.*

Inspect the bearing surface of the rod and rod cap for signs of spalling. Spalling is the loss of bearing surface, and resembles flaking or chipping. The spalling condition will be most evident on the thrust portion of the connecting rod in line with the **I**-beam. Bearing surface damage is usually caused by improper lubrication.

Check the bearing surface of the rod and rod cap for signs of chatter marks. This condition is identified by a rough bearing surface resembling a tiny washboard. The condition is caused by a combination of low-speed low load operation in cold water, and is aggravated by inadequate lubrication and improper fuel. Under these conditions, the crankshaft journal is hammered by the connecting rod. As ignition occurs in the cylinder, the piston pushes the connecting rod with tremendous force, and this force is transferred to the connecting rod journal. Since there is little or no load on the crankshaft, it bounces away from the con-



*Checking for rod warpage at the piston pin end. This is accomplished by laying one rod on top of a known good rod, and then checking for clearance between the two with a feeler gauge. There should be **NO** clearance.*

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necting rod. The crankshaft then remains immobile for a microsecond, until the piston travel causes the connecting rod to catch up to the waiting crankshaft journal, then hammers it. In some instances, the connecting rod crankpin bore becomes highly polished.

While the powerhead is running, a "whirr" and/or "chirp" sound may be heard during rapid acceleration from idle speed to about 1500 rpm, then quickly returned to idle. If chatter marks are discovered, the crankshaft and the connecting rods should be replaced.

Inspect the bearing surface of the rod and rod cap for signs of uneven wear and possible overheating. Uneven wear is usually caused by a bent connecting rod or by improper shimming for crankshaft end "play" -- failure to maintain the same amount of shim material under each end cap. Improper shimming causes the crankshaft journal to be off-center under the cylinder bore.

Overheating is identified by a bluish bearing surface color and is caused by inadequate lubrication or operating the powerhead at excessively high rpm.

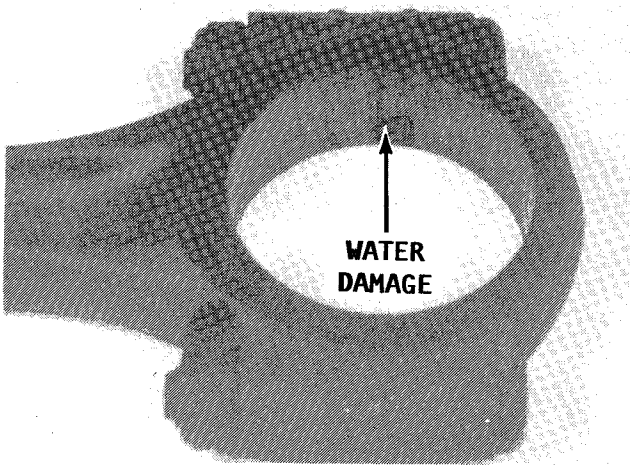
Connecting Rod Bearing Surfaces

Service the connecting rod bearing surfaces according to the following procedures and precautions.

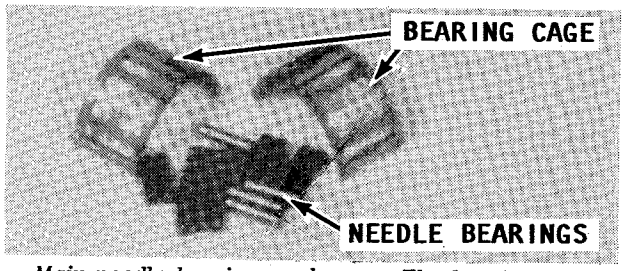
a- Align the etched marks on the connecting rod with the etched marks on the connecting rod cap.

b- Tighten the connecting rod cap attaching bolts securely.

c- Two types of bearings are used on the crankpin end of the rod. One is a noncaged type with individual needles. The other is a caged type with separate rollers. Clean the caged type with 320-grit carborundum cloth.



*Water scoring on the inside of the rod and rod cap. Such damage is caused by water in the crankcase. This rod set **MUST** be replaced.*



Main needle bearings and cage. The bearings should be thoroughly cleaned and closely inspected.

d- Use **ONLY** crocus cloth to clean the bearing surface at the crankshaft end of the connecting rod. **NEVER** use any other type abrasive material.

e- Insert the cloth in a slotted 3/8" (9.5mm) diameter shaft. Chuck the shaft in a drill press and operate the press at high speed and at the same time, keep the connecting rod at a 90° angle to the slotted shaft.

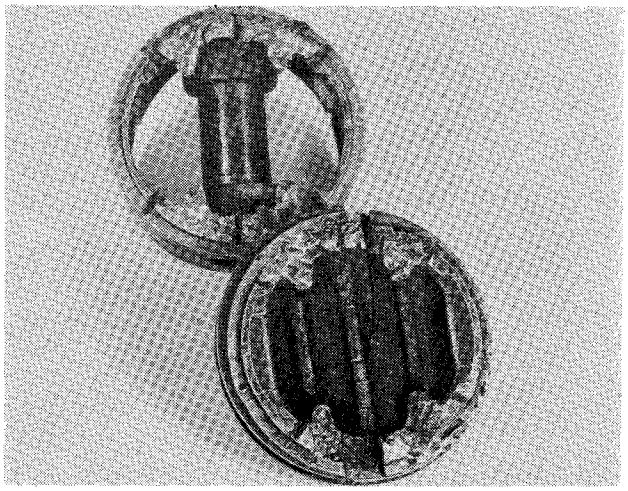
f- Clean the connecting rod **ONLY** enough to remove marks. **DO NOT** continue, once the marks have disappeared.

g- Clean the piston pin end of the connecting rod using the method described in Step "e", above, using 320 grit carborundum cloth.

h- Thoroughly wash the connecting rods to remove abrasive grit. After washing, check the bearing surfaces a second time.

i- If the connecting rod cannot be cleaned properly, it should be replaced.

j- Lubricate the bearing surfaces of the connecting rods with light weight oil to prevent corrosion.



It is believed, this crown seized with the cylinder wall when the unit was operated at high rpm and the timing was not adjusted properly. At the same instant, the rod apparently pulled the lower part of the piston downward, severing it from the crown.

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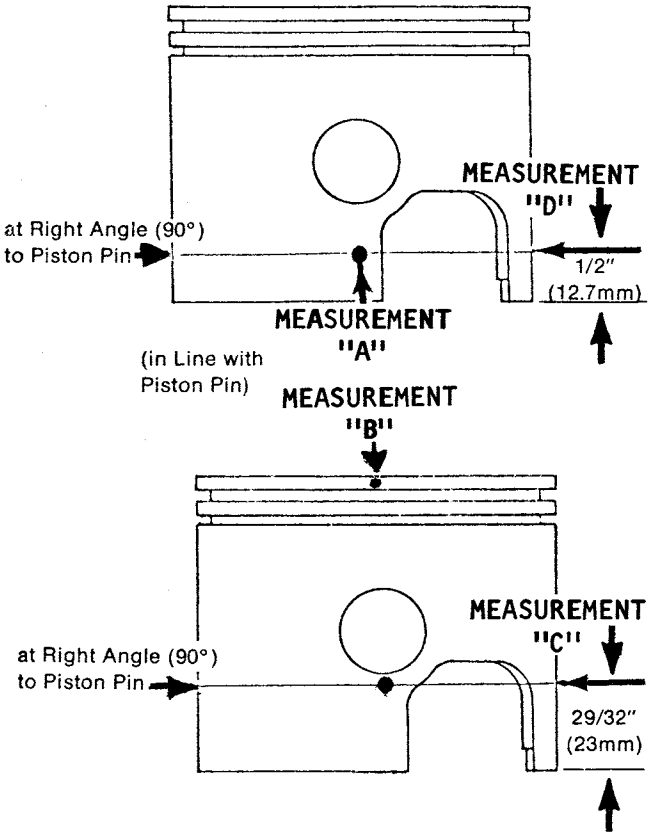
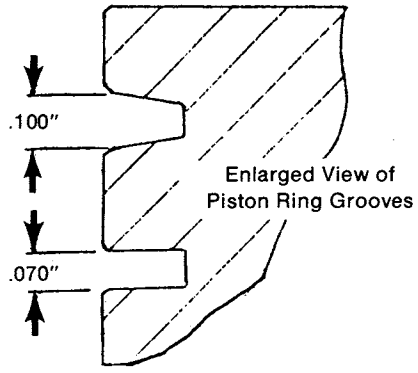
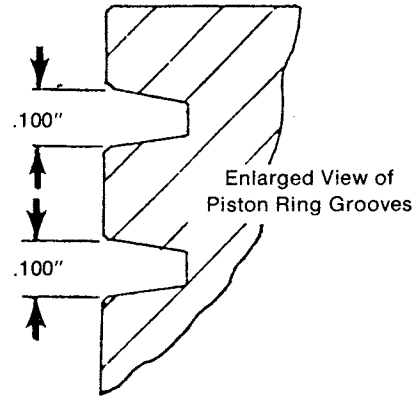


The pistons used in a V6 powerhead can be determined by measurement, as outlined in the text.



Piston with the top ring a keystone (tapered) ring and the bottom ring rectangular.



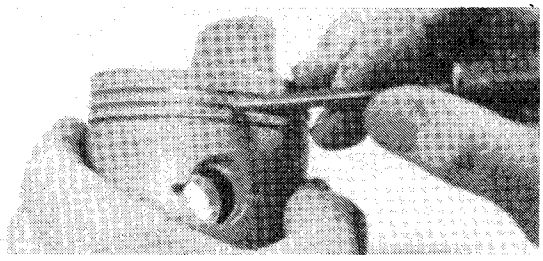
Piston with both the top and bottom ring a keystone (tapered) ring.

PISTON SERVICE

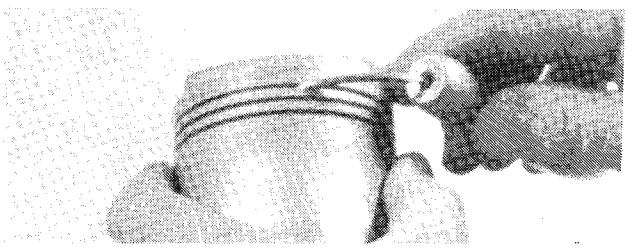
CRITICAL WORDS

NEVER attempt to reuse a 3-ring piston once it has been removed from a connecting rod. When the piston is removed, from the rod, the piston is damaged and unfit for further service. **ALSO,** if the engine was submerged while it was running, the piston pin and/or the connecting rod may be bent. If the piston pin is bent, the piston **MUST** be replaced. Piston pins are **NOT** sold separately, because they are a matched fit with the piston. If the piston pin is bent, the connecting rod **MUST** be checked for straightness as described in earlier paragraphs of this section.

Inspect each piston for evidence of scoring, cracks, metal damage, cracked piston pin boss, or worn pin boss. Be especially critical during inspection if the engine has been submerged. If a piston pin is bent, the pin and piston **MUST** be replaced as a set, because the pin will damage the boss when it is removed. Clean carbon deposits from the top of the piston using a soft wire brush, carbon removal solution, or by sand blasting. If a wire brush is used, **TAKE CARE** not to



*The pick is pointing to the locating pin in the piston ring groove. The ring **MUST** straddle this pin to prevent it from rotating around the piston. If the open end of the ring is not properly positioned, the ring will break when the piston is installed into the cylinder.*



Cleaning the piston ring grooves using the end of a broken ring inserted into a wooden handle, for safety.

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burr or round machined edges. Clean the piston skirt with crocus cloth. After the pistons have been cleaned, check each piston for size and roundness using a micrometer as follows:

FIRST, THESE WORDS

Two different shaped piston are used on V6 powerheads -- tapered and barrel profile. The difference can **ONLY** be determined by accurate measurement.

a- Measure the outside of the piston skirt. Make this measurement at the bottom of the skirt in line with the piston pin and at right angle (90°) to the piston pin.

b- Measure the outside of the piston above the top piston ring in line with the piston pin and again at right angle (90°) to the piston pin.

c- Measure the outside of the piston 29/32" (23mm) up from the bottom of the piston in line with the piston pin and again at right angle (90°) to the piston pin.

d- Measure the outside of the piston 1/2" (12.7mm) up from the bottom of the piston in line with the piston pin and again at right angle (90°) to the piston pin.

Piston Ring Identification

CRITICAL WORDS

Powerheads covered in this manual contain two different type 2-ring pistons.

Some pistons contain one keystone, tapered, ring. This tapered ring is always used in the top ring groove. This same piston also uses one rectangular ring which is used in the bottom ring groove.

Other 2-ring pistons contain two keystone rings.

Therefore, it will be necessary to measure ring thickness in order to identify each ring, as shown in the accompanying illustration. This information must be kept in mind when using a broken ring to clean piston ring grooves.

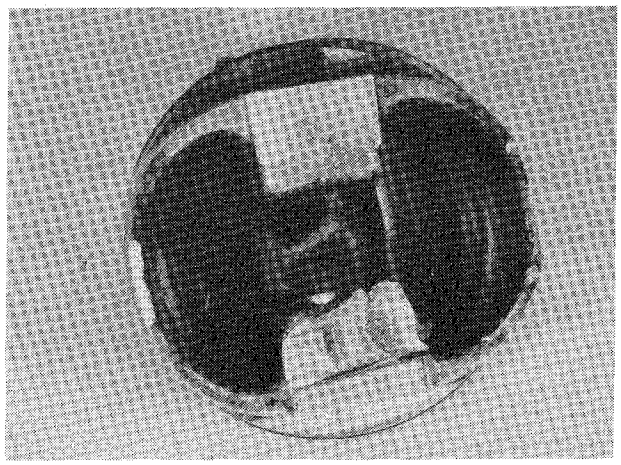
Measure and identify the type of rings used on the pistons being serviced.

Inspect the piston ring locating pins to be sure they are tight. There is one locating pin in each ring groove. If the locating pins are loose, the piston must be replaced.

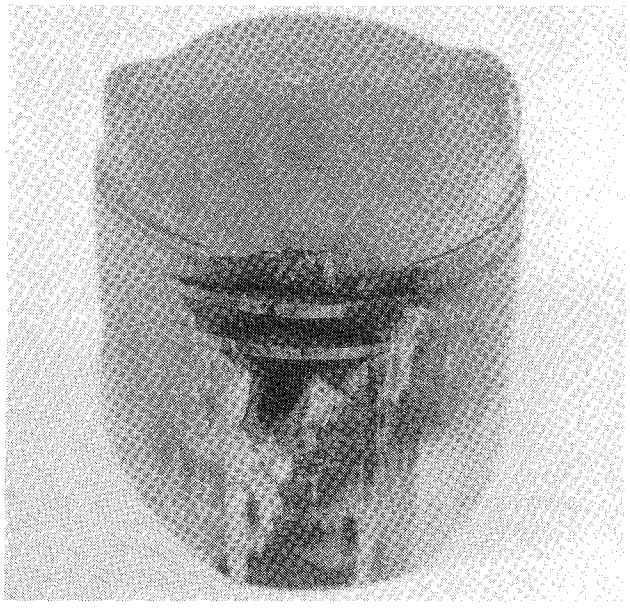
Ring End Gap Clearance

Check each ring to be sure the end gap is not excessive. The end gap may be checked by placing the ring squarely in the cleaned cylinder bore, and then measuring the end gap with a feeler gauge, as shown in the accompanying illustration on this page. Standard acceptable end gap is 0.005" (0.13mm) per inch of bore. To determine the exact amount of end gap, simply multiply the cylinder bore by 0.005" (0.13mm).

Example: Bore = 3.00" times 0.005" equals an acceptable end gap of 0.015" (0.33mm)



This connecting rod from an automotive piston assembly was bent, and then snapped due to the tremendous forces exerted on the rod when the engine "ranaway" from excessive rpm under a very light or no-load on the engine. The same type of damage can be sustained in a marine unit with too small a propeller or with a flush attachment connected and operating the unit at too high rpm.



This piston was damaged when the water pump failed to deliver sufficient coolant to the powerhead.

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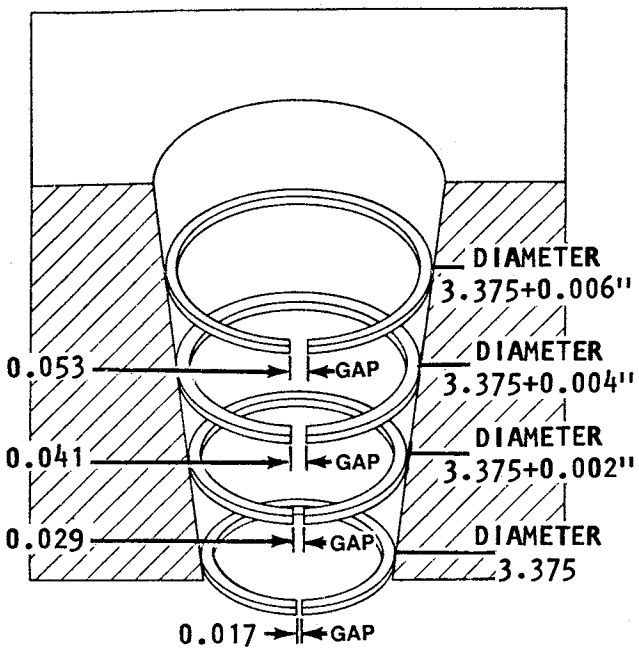
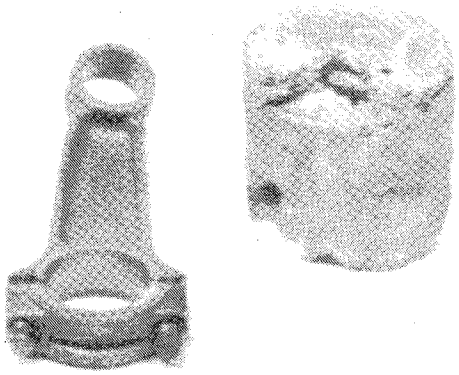


The cylinder taper drastically affects ring end gap, as shown in this cross section line drawing.

CYLINDER BLOCK SERVICE

FIRST THESE WORDS

The crankcase cover and the cylinder block are a matched, line bored assembly. Therefore, the cover and the block should **ALWAYS** be kept together and **NEVER** mismatched with a part from another set. If the crankcase cover or cylinder block is to be submerged in a very strong cleaning solution, the crankcase cover/cylinder block bleed system **MUST** be removed to prevent damage to the hoses and check valves.



Piston and rod damaged from operating the engine at too high an rpm without sufficient load on the propeller shaft. This combination caused the powerhead to literally "blow apart". Operating the engine above an idle speed with a flush attachment connected to the lower unit could result in the same type of internal destruction.

Clean the cylinder block and crankcase cover. Pay particular attention to remove all sealant and old gasket material from matching surfaces. Remove all carbon deposits from the exhaust ports.

Inspect the cylinder block and crankcase cover for cracks or fractures.

Inspect the gasket surfaces for nicks, deep grooves, cracks or any distortion which might cause a compression leak.

Check all water and oil passages in the cylinder block and crankcase cover to be sure they are not obstructed. Check to be sure the plugs are in place and tight.

On 4-cylinder powerheads equipped with the "2+2" concept, accelerator pump check valves are located at cylinder No. 3 and No. 4 on the starboard side of the block. These check valves **MUST** be removed if the block is to be honed or cleaned to avoid damage or blockage of the valve.

Cylinder Bore Cleaning and Inspecting CRITICAL WORDS

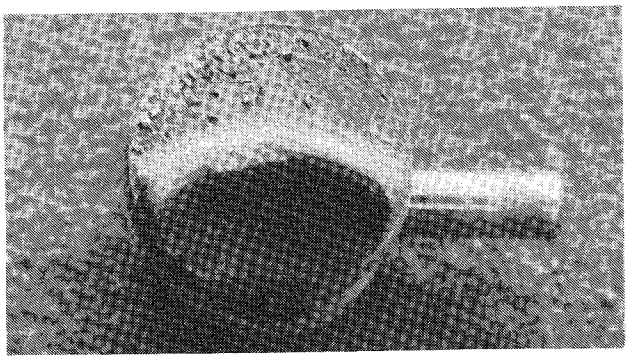
The cylinder bores of the Model 175hp (1985 & on) and 200hp have a chrome finish. Therefore, the inspection and cleaning procedures for these cylinder bores are different from those for most powerheads, which have hardened steel cylinder sleeves. Note and **FOLLOW** these differences closely.

HARDENED STEEL CYLINDER BORES

Inspect the cylinder bores for scoring. Scoring is considered the transfer of aluminum from the piston to the cylinder wall.

A scored cylinder wall can usually be returned to satisfactory service by cleaning and honing as outlined later in this section.

NEVER use the hone more than absolutely necessary to deglaze the cylinder wall during the honing process, because the hone



The pitted damage to this piston was caused by the needle bearings working loose from the piston pin.

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can remove cylinder wall material rapidly. Remove the hone frequently and check the condition of the wall.

Measure the cylinder bore diameter of each cylinder with an inside micrometer. Check for tapered, out of round, and oversize bore condition. Refer to the Specifications in the Appendix.

If a cylinder bore is tapered, out of round or worn more than 0.006" (.15mm) from standard Cylinder Block Finish Hone diameter, it will be necessary to rebore that particular cylinder to 0.015" (.38mm) or 0.030" (.76mm) oversize and install an oversize piston and ring assembly.

GOOD WORDS

Oversize piston weight is approximately the same as a standard size piston. Therefore, it is **NOT** necessary to rebore all cylinders in a block just because one cylinder requires reboring. The APBA (American Power Boat Association) accepts and permits the use of 0.015" (.38mm) oversize pistons.

HONING PROCEDURES

To ensure satisfactory powerhead performance and long life following the overhaul work, the honing work should be performed with patience, skill, and in the following sequence:

a- Follow the hone manufacturer's recommendations for use of the hone and for cleaning and lubricating during the honing operation.

b- Pump a continuous flow of honing oil into the work area. If pumping is not practical, use an oil can. Apply the oil generously and frequently on both the stones and work surface.

c- Begin the stroking at the smallest diameter. Maintain a firm stone pressure against the cylinder wall to assure fast stock removal and accurate results.

d- Expand the stones as necessary to compensate for stock removal and stone wear. The best crosshatch pattern is obtained using a stroke rate of 30 complete cycles per minute. Again, use the honing oil generously.

e- Hone the cylinder walls **ONLY** enough to deglaze the walls.

f- After the honing operation has been completed, clean the cylinder bores with hot water and detergent. Scrub the walls with a stiff bristle brush and rinse thoroughly with hot water. The cylinders **MUST** be thoroughly cleaned to prevent any abrasive material from remaining in the cylinder bore. Such material will cause rapid wear of new piston rings, the cylinder bore, and the bearings.

g- After cleaning, swab the bores several times with engine oil and a clean cloth, and then wipe them dry with a clean cloth. **NEVER** use kerosene or gasoline to clean the cylinders.

h- Clean the remainder of the cylinder block to remove any excess material spread during the honing operation.

SPECIAL WORDS

If overheating has occurred, check and resurface the spark plug area of the cylinder block, if necessary. This can be accomplished with 240-grit sandpaper. Use a circular motion to prevent leaving grooves from finger pressure through the sandpaper.

Cylinder sleeves are an integral part of the die cast cylinder block and **CANNOT** be replaced. In other words, the cylinder cannot be resleeved.

CYLINDER BLOCK SERVICE

Inspect the cylinder block and cylinder bores for cracks or other damage. Remove carbon with a fine wire brush on a shaft attached to an electric drill or use a carbon remover solution.

STOP!

If the cylinder block is to be submerged in a carbon removal solution, the crankcase bleed system **MUST** be removed from the block to prevent damage to hoses and check valves.

Use an inside micrometer or telescopic gauge and micrometer to check the cylinders for wear. Check the bore for out of round and/or oversize bore. If the bore is tapered, out of round or worn more than 0.003" - 0.004" (0.08 - 0.10mm) the cylinders should be rebored to 0.015" (0.38mm) oversize and oversize pistons and rings installed.

CHROME PLATED CYLINDER BORES

CRITICAL WORDS

The cylinder wall of a chrome plated cylinder bore **CANNOT** be rebored or efficiently honed. Honing of a chrome cylinder is not necessary or recommended by the manufacturer.

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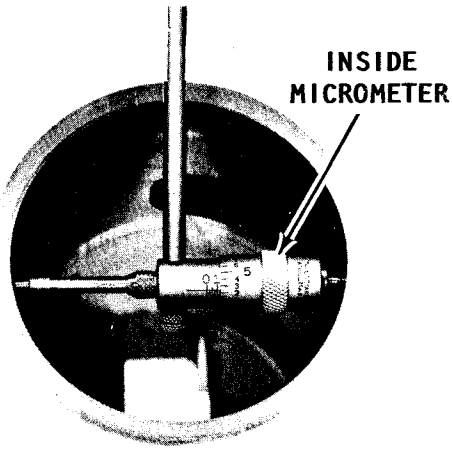
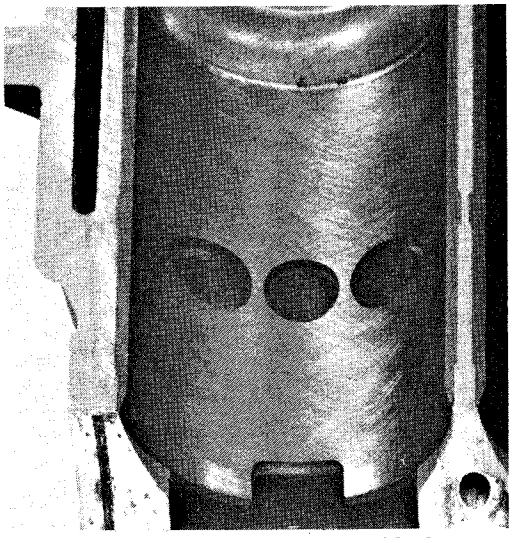


Checking the cylinder taper using an inside micrometer. One measurement should be taken near the top and another near the bottom. The difference between the two measurements is the amount of taper. Check the Specifications for allowances.

Inspect the chrome surfaced cylinder bores for signs of flaking, grooving, scoring or other damage. **DO NOT** mistake porosity for a damaged cylinder.

If inspection reveals the chrome surface is flaking, or if a groove or any other mark penetrates the chrome surfacing to the aluminum portion of the cylinder block, the cylinder block and crankcase cover **MUST** be replaced.

To determine if a groove or any other mark in the cylinder wall has penetrated the chrome surface to the aluminum, apply a very small amount of muratic acid or toilet bowl cleaner over the groove or mark. Just a "dab" will do the job. **DO NOT** allow the acid or cleaner to contact the aluminum portion of the block. Now, if a groove or mark penetrates the chrome surfacing, the acid or cleaner will "fizzle" or "bubble", indicating aluminum is being dissolved.



This sectioned cylinder shows an ideal cross hatch pattern on the cylinder wall. The pattern is necessary to seat the ring/s against the cylinder wall to provide an adequate seal for maximum compression.

If a piston is scored and has transferred aluminum to the cylinder wall, the aluminum may be removed and the cylinder wall cleaned as follows:

a- Remove all loose aluminum deposits from the cylinder wall with a stiff bristle brush.

b- Apply a small amount of muratic acid, or toilet bowl cleaner, onto the aluminum deposits. **DO NOT** allow the acid or cleaner to contact the aluminum portion of the block. The acid or cleaner will begin to "fizzle" or "bubble" indicating the aluminum is being dissolved.

c- Leave the acid or cleaner on the aluminum deposit for a couple minutes, and then wash the cylinder thoroughly with hot water and detergent.

d- Repeat Steps **b** and **c** as many times as required to remove all aluminum deposits from the cylinder wall.

Use an inside micrometer and check each cylinder for an out of round condition. Take the measurement 1/4" from the top of the cylinder bore and at right angles (90°) to each other. An out of round condition of 0.006" or less is acceptable. If the out of round is more than 0.006", the cylinder block and crankcase cover **MUST** be replaced.

After all cleaning and inspecting procedures have been completed, coat the cylinder bores several times with light weight engine oil and a clean cloth.

Be sure all parts to be reused have been carefully cleaned and thoroughly inspected. Parts not properly cleaned, or parts not suitable for service can damage a good powerhead within a few minutes after starting the engine.

NEW gaskets **MUST** always be used during an overhaul.

A torque wrench is essential to correctly assemble the powerhead. **NEVER** attempt to assemble a powerhead without a torque wrench. Attaching bolts for covers **MUST** be tightened to the required torque value in three progressive stages, following the specified tightening sequence. On the first stage, tighten to 1/3 the torque value. On the second stage, tighten to 2/3 the total torque value. Finally, on the third and last stage, tighten to the full torque value.

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9
ELECTRICAL

9-1 INTRODUCTION

The battery, gauges, horns, charging system, and the cranking system are all considered subsystems of the electrical system. Each of these units or subsystems will be covered in detail in this chapter beginning with the battery.

9-2 BATTERIES

The battery is one of the most important parts of the electrical system. In addition to providing electrical power to start the engine, it also provides power for operation of the running lights, radio, electrical accessories, and possibly the pump for a bait tank.

Because of its job and the consequences, (failure to perform in an emergency) the best advice is to purchase a well-known brand, with an extended warranty period, from a reputable dealer.

The usual warranty covers a prorated replacement policy, which means you would be entitled to a consideration for the time left on the warranty period if the battery should prove defective before its time.

Do not consider a battery of less than **70-ampere hour** or **100-minute** reserve capacity. If in doubt as to how large your boat requires, make a liberal estimate and then purchase the one with the next higher ampere rating.

MARINE BATTERIES

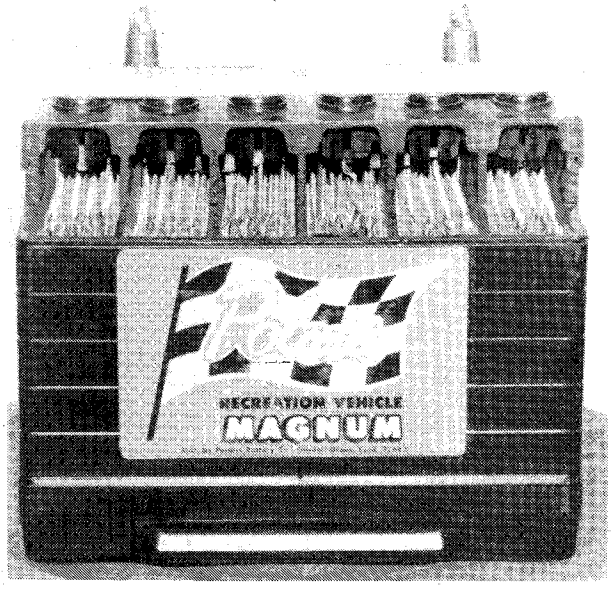
Because marine batteries are required to perform under much more rigorous conditions than automotive batteries, they are constructed much differently than those used in automobiles or trucks. Therefore, a marine battery should always be the No. 1 unit for the boat and other types of batteries used only in an emergency.

Marine batteries have a much heavier exterior case to withstand the violent pounding and shocks imposed on it as the boat moves through rough water and in extremely tight turns.

The plates in marine batteries are thicker than in automotive batteries and each plate is securely anchored within the battery case to ensure extended life.

The caps of marine batteries are "spill proof" to prevent acid from spilling into the bilges when the boat heels to one side in a tight turn, or is moving through rough water.

Because of these features, the marine battery will recover from a low charge condition and give satisfactory service over



A fully charged battery, filled to the proper level with electrolyte, is the heart of the ignition and electrical systems. Engine cranking and efficient performance of electrical items depend on a full-rated battery.

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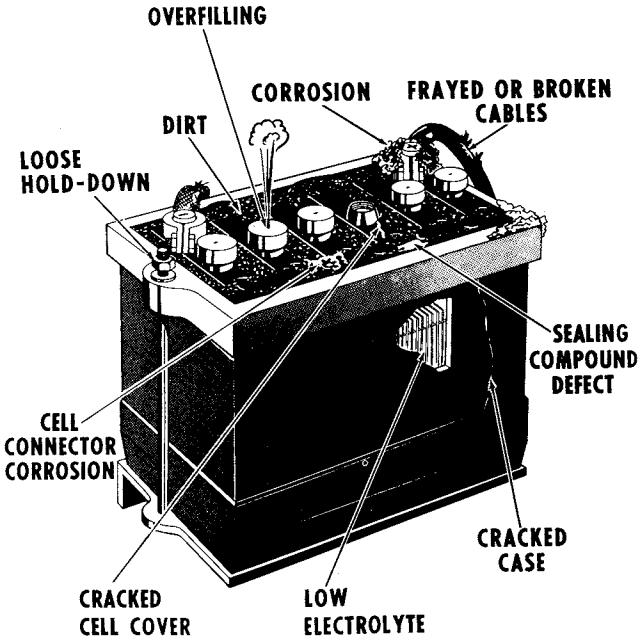
a much longer period of time than any type intended for automotive use.

NEVER use a "Maintenance Free" type battery with an outboard unit. The charging system is not regulated as with automotive installations and the battery may be quickly damaged.

BATTERY CONSTRUCTION

A battery consists of a number of positive and negative plates immersed in a solution of diluted sulfuric acid. The plates contain dissimilar active materials and are kept apart by separators. The plates are grouped into what are termed elements. Plate straps on top of each element connect all of the positive plates and all of the negative plates into groups.

The battery is divided into cells which hold a number of the elements apart from the others. The entire arrangement is contained within a hard-rubber case. The top is a one-piece cover and contains the filler caps for each cell. The terminal posts protrude through the top where the battery connections for the boat are made. Each of the cells is connected to its neighbor in a positive-to-negative manner with a heavy strap called the cell connector.



A visual inspection of the battery should be made each time the boat is used. Such a quick check may reveal a potential problem in its early stages. A dead battery in a busy waterway or far from assistance could have serious consequences.

BATTERY RATINGS

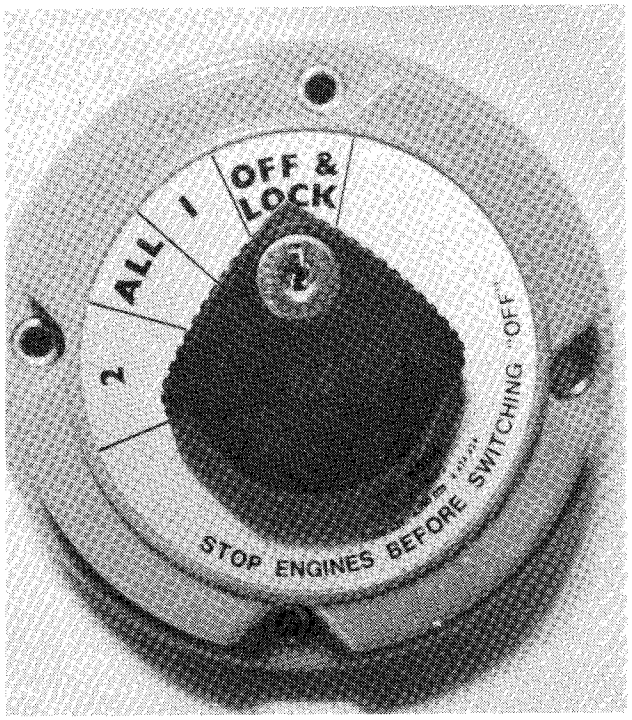
Four different methods are used to measure and indicate battery electrical capacity:

1- Ampere-hour rating
2- Cold cranking performance
3- Reserve capacity
4- Watt hour rating

The **ampere-hour** rating of a battery refers to the battery's ability to provide a set amount of amperes for a given amount of time under test conditions at a constant temperature of 80° (27°C). Amperes x hours equals ampere-hour rating. Therefore, if the battery is capable of suppling 4 amperes of current for 20 consecutive hours, the battery is rated as an 80 ampere-hour battery.

The ampere-hour rating is useful for some service operations, such as slow charging or battery testing.

Cold cranking performance is measured by cooling a fully charged battery to 0°F (-17°C) and then testing it for 30 seconds to determine the maximum current flow. In this manner the cold cranking amperes rating is the number of amperes available to be drawn from the battery before the voltage drops below 7.2 volts.



The small added expense of a top quality battery switch with a key lock is well worth the investment.

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Reserve capacity of a battery is considered the length of time -- in minutes -- at 80°F (27°C) a 25 ampere current can be maintained before the voltage drops below 10.5 volts. This test is intended to provide an approximation of how long the engine, including electrical accessories such as bilge pump, radio, running light, could continue to operate satisfactorily if the alternator or magneto did not produce sufficient current. A typical rating is 100 minutes.

Watt-hour is a very useful rating of battery power. It is determined by multiplying the number of ampere hours times the voltage. Therefore, a 12-volt battery rated at 80 ampere-hours would be rated at 960 watt-hours (80 x 12 = 960).

If possible, the new battery should have a power rating equal to or higher than the unit it is replacing.

BATTERY LOCATION

Every battery installed in a boat must be secured in a well-protected ventilated area. If the battery area lacks adequate ventilation, hydrogen gas which is given off during charging could become very explosive. This is especially true if the gas is concentrated and confined.

BATTERY SERVICE

The battery requires periodic servicing and a definite maintenance program will ensure extended life. If the battery should test satisfactorily, but still fails to perform properly, one of five problems could be the cause.

1- An accessory might have accidently been left on overnight or for a long period during the day. Such an oversight would result in a discharged battery.

2- Slow speed engine operation for long periods of time resulting in an undercharged condition.

3- Using more electrical power than the alternator can replace would result in an undercharged condition.

4- A defect in the charging system. A faulty alternator, defective rectifier, or high resistance somewhere in the system could cause the battery to become undercharged.

5- Failure to maintain the battery in good order. This might include a low level of electrolyte in the cells; loose or dirty cable connections at the battery terminals; or possibly an excessively dirty battery top.

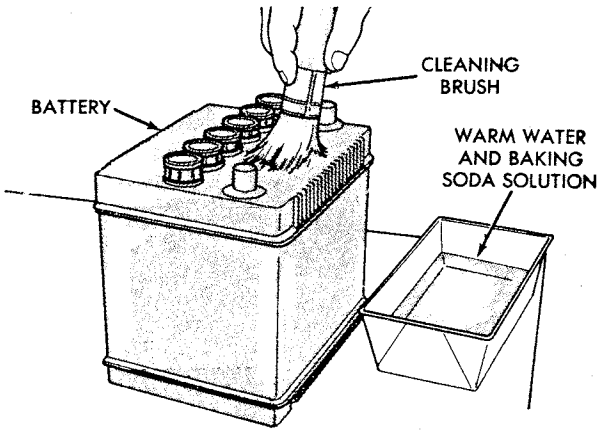
Electrolyte Level

The most common practice of checking the electrolyte level in a battery is to remove the cell cap and visually observe the level in the vent well. The bottom of each vent well has a split vent which will cause the surface of the electrolyte to appear distorted when it makes contact. When the distortion first appears at the bottom of the split vent, the electrolyte level is correct.

Some late-model batteries have an electrolyte-level indicator installed which operates in the following manner:

A transparent rod extends through the center of one of the cell caps. The lower tip of the rod is immersed in the electrolyte when the level is correct. If the level should drop below normal, the lower tip of the rod is exposed and the upper end glows as a warning to add water. Such a device is only necessary on one cell cap because if the electrolyte is low in one cell it is also low in the other cells. **BE SURE** to replace the cap with the indicator onto the second cell from the positive terminal.

During hot weather and periods of heavy use, the electrolyte level should be checked more often than during normal operation. Add potable (drinking) water to bring the level of electrolyte in each cell to the proper level. **TAKE CARE** not to overfill, because adding an excessive amount of water will cause loss of electrolyte and any loss will result in poor performance, short battery life, and will contribute quickly to corrosion. **NEVER** add electrolyte from another battery. Use only clean pure water.



The battery top should be kept clean. A water and baking soda solution applied with a brush will neutralize battery electrolyte and clean the top nicely.

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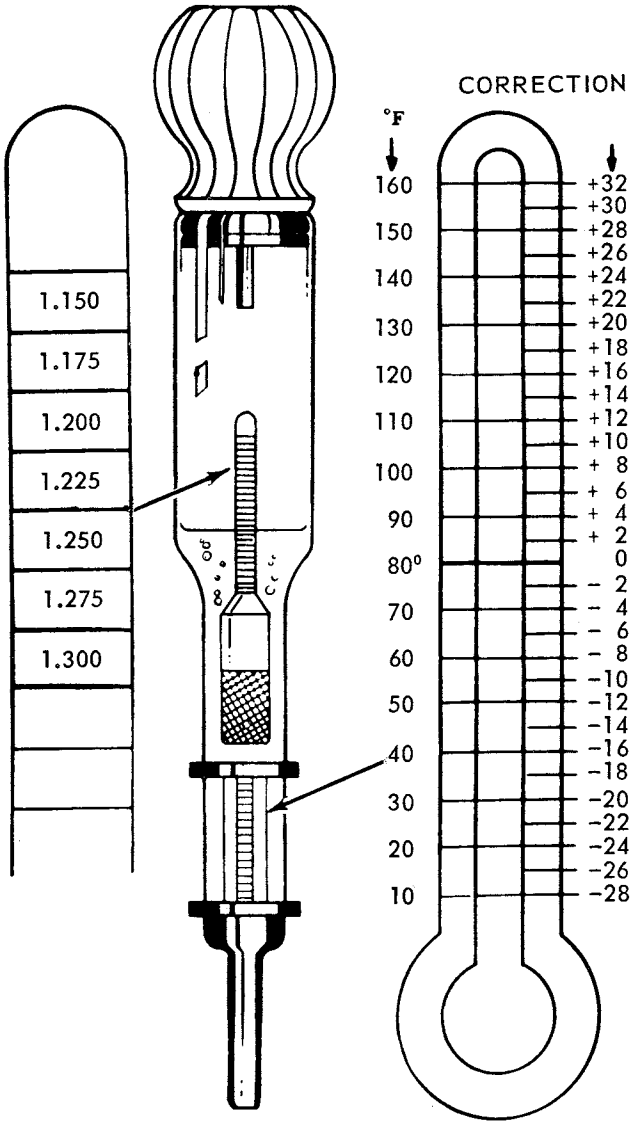
Battery Testing

A hydrometer is a device to measure the percentage of sulfuric acid in the battery electrolyte in terms of specific gravity. When the condition of the battery drops from fully charged to discharged, the acid leaves the solution and enters the plates, causing the specific gravity of the electrolyte to drop.

It may not be common knowledge, but hydrometer floats are calibrated for use at 80°F (27°C). If the hydrometer is used at any other temperature, hotter or colder, a correction factor must be applied. (Remember, a liquid will expand if it is heated and will contract if cooled. Such expansion and contraction will cause a definite change in the specific gravity of the liquid, in this case the electrolyte.)



A check of the electrolyte in the battery should be on the maintenance schedule for any boat. A hydrometer reading of 1.300, or in the green band, indicates the battery is in satisfactory condition. If the reading is 1.150 or in the red band, the battery must be charged. Observe the six safety points listed in the text when using a hydrometer.

A quality hydrometer will have a thermometer/temperature correction table in the lower portion, as shown in the accompanying illustration. By knowing the air temperature around the battery and from the table, a correction factor may be applied to the specific gravity reading of the hydrometer float. In this manner, an accurate determination may be made as to the condition of the battery.

The following six points should be observed when using a hydrometer.

1- **NEVER** attempt to take a reading immediately after adding water to the battery. Allow at least 1/4 hour of charging at a high rate to thoroughly mix the electrolyte with the new water. This time will also allow for the necessary gasses to be created.

2- **ALWAYS** be sure the hydrometer is clean inside and out as a precaution against contaminating the electrolyte.

3- If a thermometer is an integral part of the hydrometer, draw liquid into it several times to ensure the correct temperature before taking a reading.

4- **BE SURE** to hold the hydrometer vertically and suck up liquid only until the float is free and floating.

5- **ALWAYS** hold the hydrometer at eye level and take the reading at the surface of the liquid with the float free and floating.

Disregard the light curvature appearing where the liquid rises against the float stem. This phenomenon is due to surface tension.

6- **DO NOT** drop any of the battery fluid on the boat or on your clothing, because it is extremely caustic. Use water and baking soda to neutralize any battery liquid that does accidently drop.

After withdrawing electrolyte from the battery cell until the float is barely free, note the level of the liquid inside the hydrometer. If the level is within the green band range for all cells, the condition of the battery is satisfactory. If the level is within the white band for all cells, the battery is in fair condition.

If the level is within the green or white band for all cells except one, which registers in the red, the cell is shorted internally.

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No amount of charging will bring the battery back to satisfactory condition.

If the level in all cells is about the same, even if it falls in the red band, the battery may be recharged and returned to service. If the level fails to rise above the red band after charging, the only solution is to replace the battery.

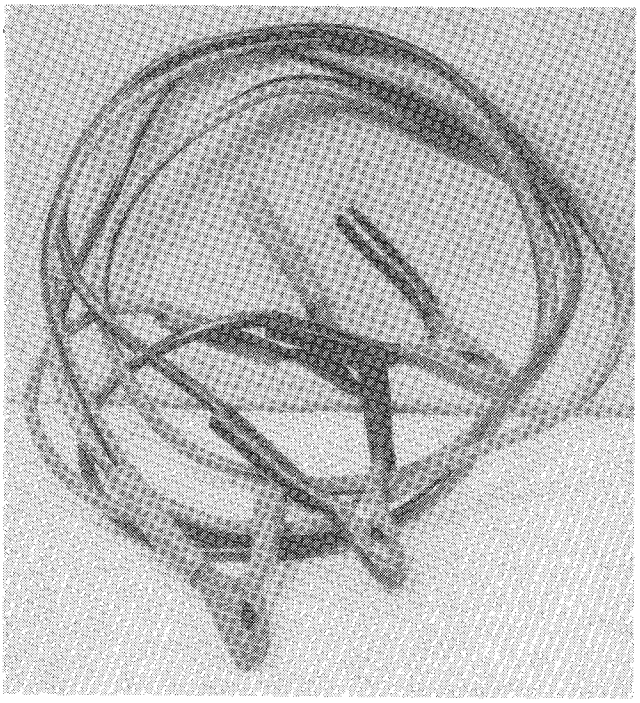
Cleaning

Dirt and corrosion should be cleaned from the battery just as soon as it is discovered. Any accumulation of acid film or dirt will permit current to flow between the terminals. Such a current flow will drain the battery over a period of time.

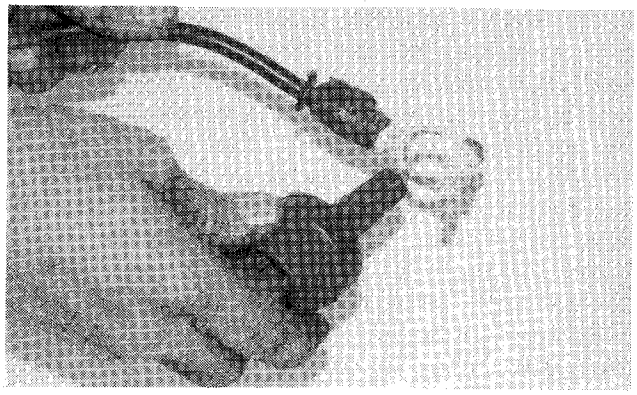
Clean the exterior of the battery with a solution of diluted ammonia or a soda solution to neutralize any acid which may be present. Flush the cleaning solution off with clean water. **TAKE CARE** to prevent any of the neutralizing solution from entering the cells, by keeping the caps tight.

A poor contact at the terminals will add resistance to the charging circuit. This resistance will cause the voltage regulator to register a fully charged battery, and thus cut down on the alternator output adding to the low battery charge problem.

Scrape the battery posts clean with a suitable tool or with a stiff wire brush.



A common set of heavy-duty jumper cables. The booster battery must be connected correctly and in the proper sequence, as outlined in the text, to prevent damage to the battery or to the alternator diodes.

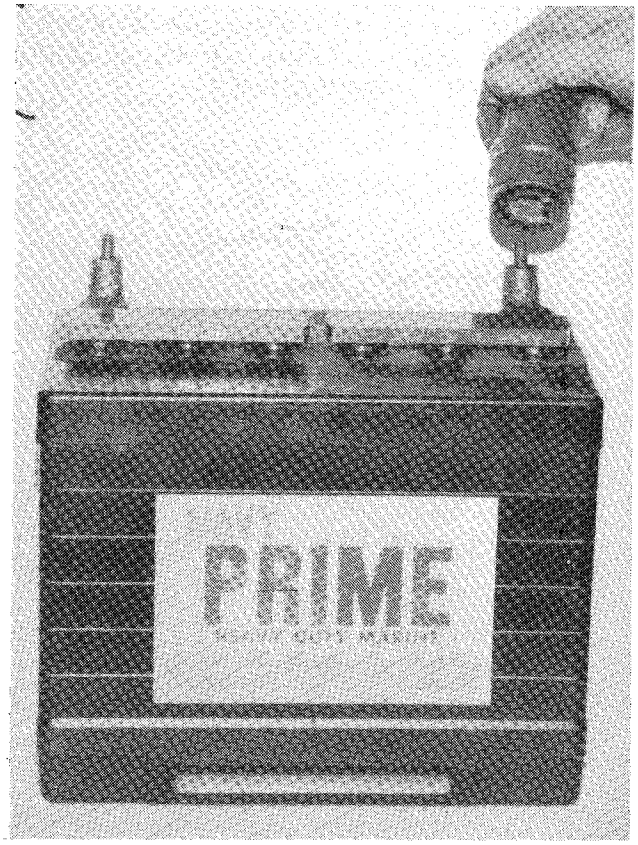


An inexpensive two-part tool will do an excellent job of cleaning the battery terminals and the inside of the cable connectors.

Clean the inside of the cable clamps to be sure they do not cause any resistance in the circuit.

JUMPER CABLES

If booster batteries are used for starting an engine the jumper cables must be connected correctly and in the proper sequence to prevent damage to either battery, or to the alternator diodes.



An inexpensive two-part brush can be purchased and used to clean both the battery cable connectors (top) and the battery terminals (bottom).

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ALWAYS connect a cable from the positive terminal of the dead battery to the positive terminal of the good battery **FIRST. NEXT,** connect one end of the other cable to the negative terminal of the good battery and the other end to a good ground on the powerhead. **DO NOT** connect the negative jumper from the good battery to the negative terminal of the low battery. Such action will almost always cause a spark which could ignite gases escaping through the vent holes in the battery filler caps. Igniting the gases may result in an explosion destroying the battery and causing severe personal **INJURY.**

By making the negative (ground) connection on the powerhead, if an arc is created, it will not be near the battery.

DISCONNECT the battery ground cable before replacing an alternator or before connecting any type of meter to the alternator.

If it is necessary to use a fast-charger on a dead battery, **ALWAYS** disconnect one of the boat cables from the battery **FIRST,** to prevent burning out the diodes in the rectifier.

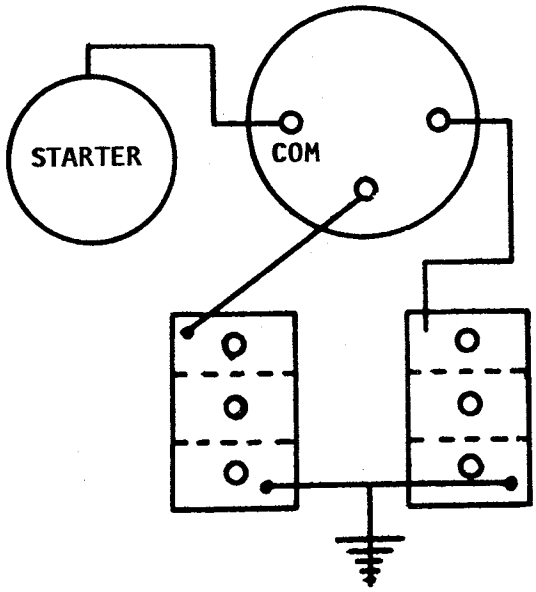
NEVER use a fast-charger as a booster to start the engine because the diodes in the alternator will be **DAMAGED.**

STORAGE

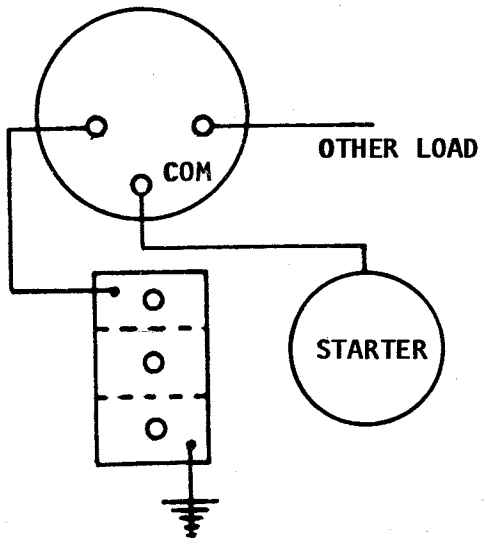
If the boat is to be laid up for the winter or for more than a few weeks, special attention must be given to the battery to prevent complete discharge or possible damage to the terminals and wiring. Before putting the boat in storage, disconnect and remove the batteries. Clean them thoroughly of any dirt or corrosion, and then charge them to full specific gravity reading. After they are fully charged, store them in a clean cool dry place where they will not be damaged or knocked over, preferably on a couple blocks of wood. Storing the battery up off the deck, will permit air to circulate freely around and under the battery and will help to prevent condensation.

NEVER store the battery with anything on top of it or cover the battery in such a manner as to prevent air from circulating around the fillercaps. All batteries, both new and old, will discharge during periods of storage, more so if they are hot than if they remain cool. Therefore, the electrolyte level and the specific gravity should be checked at regular intervals. A drop in the specific gravity reading is cause to charge them back to a full reading.

In cold climates, care should be exercised in selecting the battery storage area.



Schematic drawing for a single battery, one engine installation.



Schematic drawing for a two battery, one engine installation.

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A fully-charged battery will freeze at about 60 degress below zero. A discharged battery, almost dead, will have ice forming at about 19 degrees above zero.

DUAL BATTERY INSTALLATION

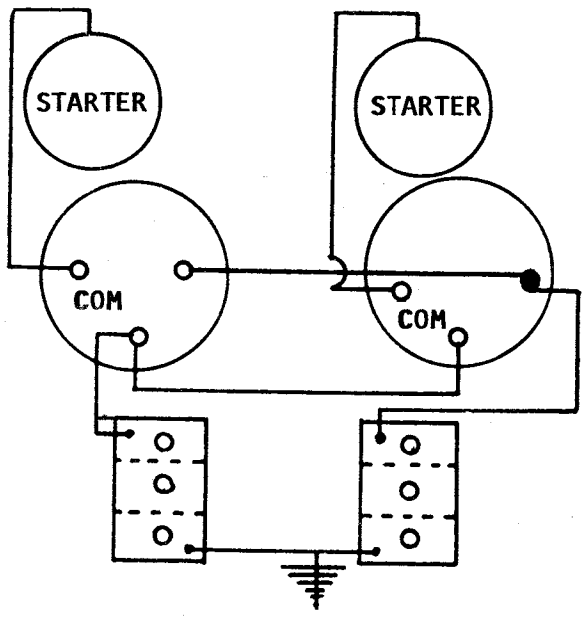
Three methods are available for utilizing a dual-battery hook-up.

1- A high-capacity switch can be used to connect the two batteries. The accompanying illustration details the connections for installation of such a switch. This type of switch installation has the advantage of being simple, inexpensive, and easy to mount and hookup. However, if the switch is accidently left in the closed position, it will cause the convenience loads to run down both batteries and the advantage of the dual installation is lost. The switch may be closed intentionally to take advantage of the extra capacity of the two batteries, or it may be temporarily closed to help start the engine under adverse conditions.

2- A relay, can be connected into the ignition circuit to enable both batteries to be automatically put in parallel for charging or to isolate them for ignition use during engine cranking and start. By connecting the relay coil to the ignition terminal of the ignition-starting switch, the relay will close during the start to aid the starting battery. If the second battery is allowed to run down, this arrangement can be a disadvantage since it will draw a load from the starting battery while cranking the engine.

One way to avoid such a condition is to connect the relay coil to the ignition switch accessory terminal. When connected in this manner, while the engine is being cranked, the relay is open. But when the engine is running with the ignition switch in the normal position, the relay is closed, and the second battery is being charged at the same time as the starting battery.

3- A heavy duty switch installed as close to the batteries as possible can be connected between them. If such an arrangement is used, it must meet the standards of the American Boat and Yacht Council, INC. or the Fire Protection Standard for Motor Craft, N.F.P.A..No. 302.



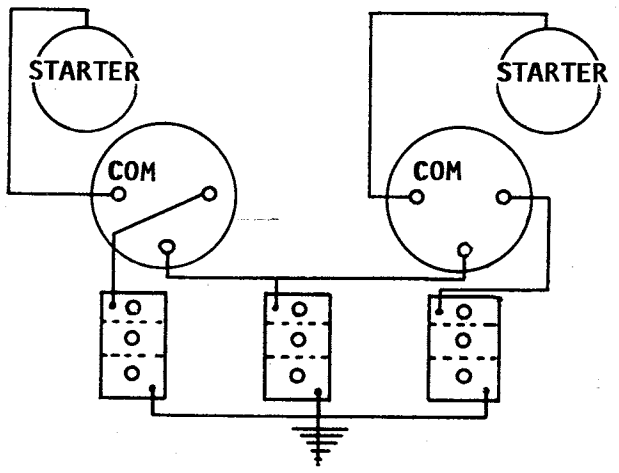
Schematic drawing for a two battery, two engine installation.

9-3 GAUGES

Gauges or lights are installed to warn the operator of a condition in the cooling and lubrication systems that may need attention. The fuel gauge gives an indication of the amount of fuel in the tank. If the engine overheats or the oil pressure drops to low for safety, a gauge or warning light reminds the operator to shut down the engine and check the cause of the warning before serious damage is done.

CONSTANT-VOLTAGE SYSTEM

In order for gauges to register properly, they must be supplied with a steady voltage.



Schematic drawing of a three battery, two engine installation.

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The voltage variations produced by the engine charging system would cause erratic gauge operation, too high when the alternator voltage is high and too low when the alternator is not charging. To remedy this problem, a constant-voltage system is used to reduce the 12-14 volts of the electrical system to an average of 5 volts. This steady 5 volts ensures the gauges will read accurately under varying conditions from the electrical system. If other accessories seem to have a higher voltage than necessary, lights burn too brightly, a voltage regulator is available from the local marine dealer.

SERVICE PROCEDURES

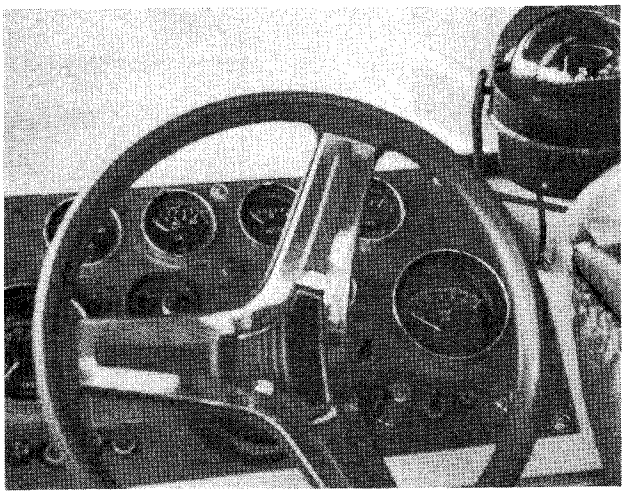
Systems utilizing warning lights do not require a constant-voltage system, therefore, this service is not needed.

Service procedures for checking the gauges and their sending units is detailed in the following sections.

9-4 TEMPERATURE GAUGES

The housing of temperature gauges must be grounded and they must be supplied with 12 volts. Many gauges have a terminal on the mounting bracket for attaching a ground wire. A tang from the mounting bracket makes contact with the gauge. **CHECK** to be sure the tang does make good contact with the gauge.

Ground the wire to the sending unit and the needle of the gauge should move to the full right position indicating the gauge is in serviceable condition.



The gauges, indicator lights, and other instruments on the control panel should be kept clean and protected from water spray as much as practical. This is especially important when operating in salt water.

WARNING LIGHTS

If a problem arises on a boat equipped with water and temperature lights, the first area to check is the light assembly for loose wires or burned-out bulbs.

When the ignition key is turned on, the light assembly is supplied with 12 volts and grounded through the sending unit mounted on the engine. When the sending unit makes contact because the water temperature is too hot, the circuit to ground is completed and the lamp should light.

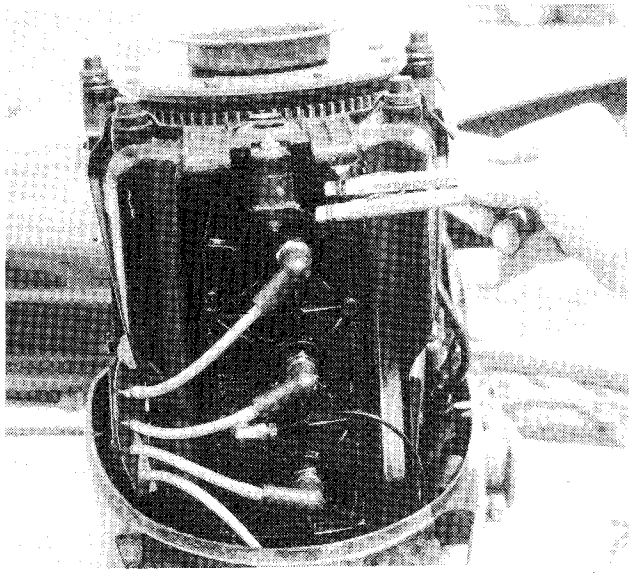
Check The Bulb: Turn the ignition switch on. Disconnect the wire at the engine sending unit, and then ground the wire. The lamp on the dash should light. If it does not light, check for a burned-out bulb or a break in the wiring to the light.

THERMOMELT STICKS

Thermomelt sticks are an easy method of determining if the engine is running at the proper temperature. Thermomelt sticks are not expensive and are available at your local marine dealer.

Start the engine with the propeller in the water and run it for about 5 minutes at roughly 3000 rpm.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.



A thermomelt stick is a quick, simple, inexpensive, and fairly accurate method of determining the operating temperature of the powerhead.

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The 140 degree stick should melt when you touch it to the lower thermostat housing or on the top cylinder. If it does not melt, the thermostat is stuck in the open position and the engine temperature is too low.

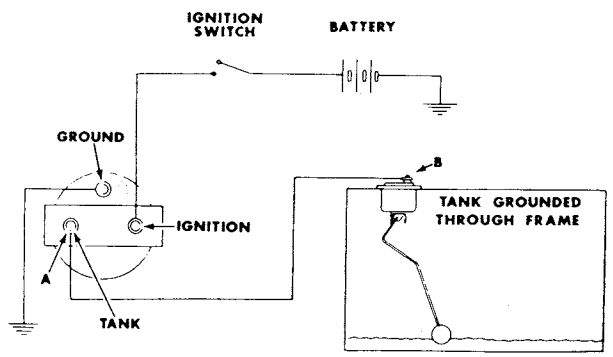
Touch the 170 degree stick to the same spot on the lower thermostat housing or on the top cylinder. The stick should not melt. If it does, the thermostat is stuck in the closed position or the water pump is not operating properly because the engine is running too hot.

If the powerhead is not equipped with a thermostat, the problem may be solved by reverse flushing to clean out the cooling system and/or servicing the water pump. For service procedures for the thermostat, see Chapter 8. For service procedures for the water pump, see Chapter 11.

9-5 FUEL GAUGES

The fuel gauge is intended to indicate the quantity of fuel in the tank. As the experienced boatperson has learned, the gauge reading is seldom an accurate report of the fuel available in the tank. The main reason for this false reading is because the boat is rarely on an even keel. A considerable difference in fuel quantity will be indicated by the gauge if the bow or stern is heavy, or if the boat has a list to port or starboard.

Therefore, the reading is usually low. The amount of fuel drawn from the tank is dependent on the location of the fuel pickup tube in the tank. The engine may cutout while cruising because the pickup tube is above the fuel level. Instead of assuming the tank is empty, shift weight in the boat to change the trim and the problem may be solved until you are able to take on more fuel.



Schematic diagram for a safe fuel tank gauge hookup. The tank must be grounded either through the frame or with a separate grounding strap.

FUEL GAUGE HOOKUP

The Boating Industry Association recommends the following color coding be used on all fuel gauge installations:

Black -- for all grounded current-carrying conductors.

Pink -- insulated wire for the fuel gauge sending unit to the gauge.

Red -- insulated wire for a connection from the positive side of the battery to any electrical equipment.

Connect one end of a pink insulated wire to the terminal on the gauge marked **TANK** and the other end to the terminal on top of the tank unit.

Connect one end of a black wire to the terminal on the fuel gauge marked **IGN** and the other end to the ignition switch.

Connect one end of a second black wire to the fuel gauge terminal marked **GRD** and the other end to a good ground. It is important for the fuel gauge case to have a good common ground with the tank unit. Aboard an all-metal boat, this ground wire is not necessary. However, if the dashboard is insulated, or made of wood or plastic, a wire **MUST** be run from the gauge ground terminal to one of the bolts securing the sending unit in the fuel tank, and then from there to the **NEGATIVE** side of the battery.

FUEL GAUGE TROUBLESHOOTING

In order for the fuel gauge to operate properly the sending unit and the receiving unit must be of the same type and preferably of the same make.

The following symptoms and possible corrective actions will be helpful in restoring a faulty fuel gauge circuit to proper operation.

If you suspect the gauge is not operating properly, the first area to check is all electrical connections from one end to the other. Be sure they are clean and tight.

Next, check the common ground wire between the negative side of the battery, the fuel tank, and the gauge on the dash.

If all wires and connections in the circuit are in good condition, remove the sending unit from the tank. Run a wire from the gauge mounting flange on the tank to the

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flange of the sending unit. Now, move the float up-and-down to determine if the receiving unit operates. If the sending unit does not appear to operate, move the float to the midway point of its travel and see if the receiving unit indicates half full.

If the pointer does not move from the **EMPTY** position one of four faults could be to blame:

1- The dash receiving unit is not properly grounded.

2- No voltage at the dash receiving unit.

3- Negative meter connections are on a positive grounded system.

4- Positive meter connections are on a negative grounded system.

If the pointer fails to move from the FULL position, the problem could be one of three faults.

1- The tank sending unit is not properly grounded.

2- Improper connection between the tank sending unit and the receiving unit on the dash.

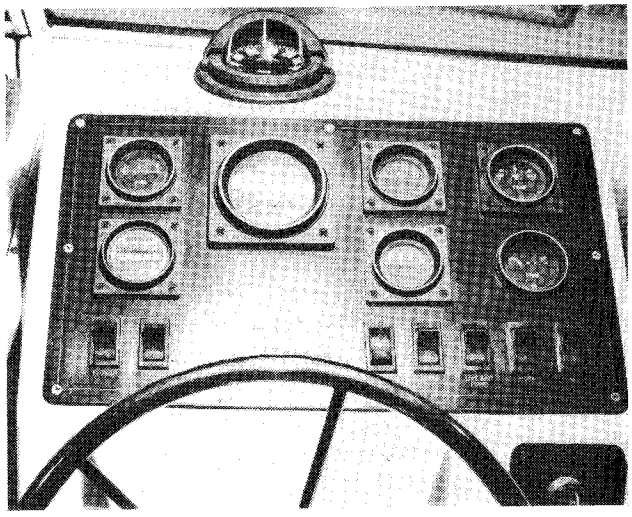
3- The wire from the gauge to the ignition switch is connected at the wrong terminal.

If the pointer remains at the 3/4 full mark, it indicates a six-volt gauge is installed in a 12-volt system.

If the pointer remains at about 3/8 full, it indicates a 12-volt gauge is installed in a six-volt system.

Preliminary Inspection

Inspect all of the wiring in the circuit for possible damage to the insulation or conductor. Carefully check:



The indicator and control panel should be kept clean and protected from water spray, especially when operating in a salt water atmosphere.

1- Ground connections at the receiving unit on the dash.

2- Harness connector to the dash unit.

3- Body harness connector to the chassis harness.

4- Ground connection from the fuel tank to the tank floor pan.

5- Feed wire connection at the tank sending unit.

GAUGE ALWAYS READS FULL when the ignition switch is **ON:**

1- Check the electrical connections at the receiving unit on the dash; the body harness connector to chassis harness connector; and the tank unit connector in the tank.

2- Make a continuity check of the ground wire from the tank to the tank floor pan.

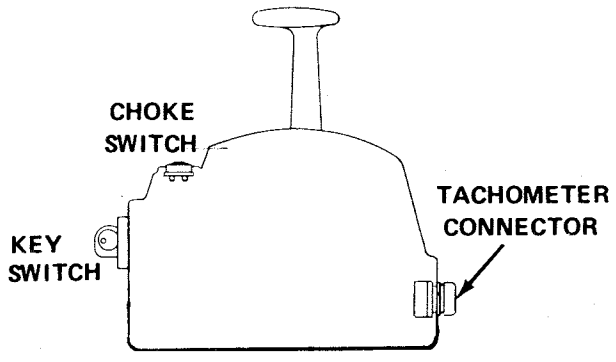
3- Connect a known good tank unit to the tank feed wire and the ground lead. Raise and lower the float and observe the receiving unit on the dash. If the dash unit follows the arm movement, replace the tank sending unit.

GAUGE ALWAYS READS EMPTY when the ignition switch is **ON:**

Disconnect the tank unit feed wire and do not allow the wire terminal to ground. The gauge on the dash should read **FULL.**

If Gauge Reads Empty:

1- Connect a spare dash unit into the dash unit harness connector and ground the unit. If the spare unit reads **FULL,** the original unit is shorted and must be replaced.



Many models of shift boxes now have a plug-in connector on the forward face for installation of a tachometer cable.

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2- A reading of **EMPTY** indicates a short in the harness between the tank sending unit and the gauge on the dash.

If Gauge Reads Full:

1- Connect a known good tank sending unit to the tank feed wire and the ground lead.

2- Raise and lower the float while observing the dash gauge. If dash gauge follows movement of the float, replace the tank sending unit.

GAUGE NEVER INDICATES FULL

This test requires shop test equipment.

1- Disconnect the feed wire to the tank unit and connect the wire to a good ground through a variable resistor or through a spare tank unit.

2- Observe the dash gauge reading. The reading should be **FULL** when resistance is increased to about 90 ohms. This resistance would simulate a full tank.

3- If the check indicates the dash gauge is operating properly, the trouble is either in the tank sending unit rheostat being shorted, or the float is binding. The arm could be bent, or the tank may be deformed. Inspect and correct the problem.

9-6 TACHOMETER

An accurate tachometer can be installed on any engine. Such an instrument provides an indication of engine speed in revolutions per minute (rpm). This is accomplished by measuring the number of electrical pulses per minute generated in the primary circuit of the ignition system.

The meter readings range from 0 to 6,000 rpm, in increments of 100. Tachometers have solid-state electronic circuits which eliminates the need for relays or batteries and contributes to their accuracy. The electronic parts of the tachometer susceptible to moisture are coated to prolong their life.

Most outboard units covered in this manual have a female plug at the forward end of the shift box as a convenience for installation of a tachometer. Therefore, when purchasing a tachometer, check to be sure the adaptor plug will mate with the fitting on the shift box.

9-7 HORNS

The only reason for servicing a horn is because it fails to operate properly or because it is out of tune. In most cases, the problem can be traced to an open circuit in the wiring or to a defective relay.

Cleaning:

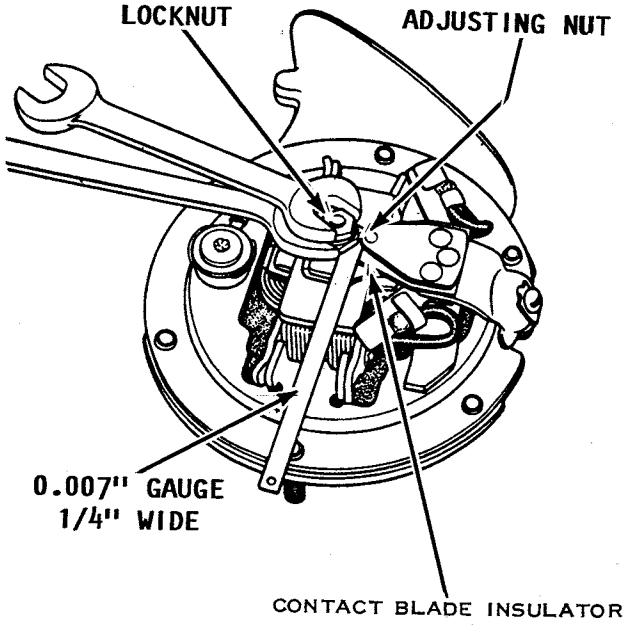
Crocus cloth and carbon tetrachloride should be used to clean the contact points. **NEVER** force the contacts apart or you will bend the contact spring and change the operating tension.

Check Relay and Wiring:

Connect a wire from the battery to the horn terminal. If the horn operates, the problem is in the relay or in the horn wiring. If both of these appear satisfactory, the horn is defective and needs to be replaced.

Before replacing the horn however, connect a second jumper wire from the horn frame to ground to check the ground connection.

Test the winding for an open circuit, faulty insulation, or poor ground. Check the resistor with an ohmmeter, or test the condenser for capacity, ground, and leakage. Inspect the diaphragm for cracks.



*The tone of a horn can be adjusted with a 0.007" feeler gauge, as described in the text. **TAKE CARE** to prevent the feeler gauge from making contact with the case, or the circuit will be shorted out.*

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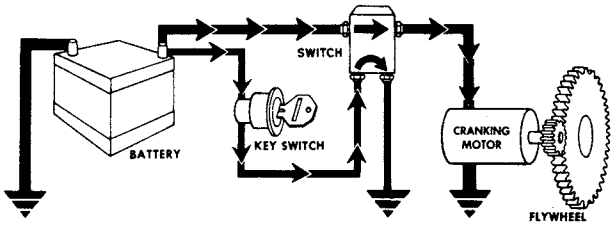
Adjust Horn Tone:

Loosen the locknut, and then rotate the adjusting screw until the desired tone is reached. On a dual horn installation, disconnect one horn and adjust each, one-at-a-time. The contact point adjustment is made by inserting a 0.007" (0.18mm) feeler gauge blade between the adjusting nut and the contact blade insulator. **TAKE CARE** not to allow the feeler gauge to touch the metallic parts of the contact points because it would short them out. Now, loosen the locknut and turn the adjusting nut down until the horn fails to sound. Loosen the adjusting nut slowly until the horn barely sounds. The locknut **MUST** be tightened after each test. When the feeler gauge is withdrawn the horn will operate properly and the current draw will be satisfactory.

9-8 ELECTRICAL SYSTEM GENERAL INFORMATION

In the early days, all outboard engines were started by simply pulling on a rope wound around the flywheel. As the manufacturers increased the size and horsepower, especially after the introduction of 4- and 6-cylinder high-compression units, it was necessary to replace the rope starter with some form of power cranking system. Today, most small engines are still started by pulling on a rope.

The system utilized to replace the rope method on larger engines was an electric



Functional diagram of a typical cranking circuit.

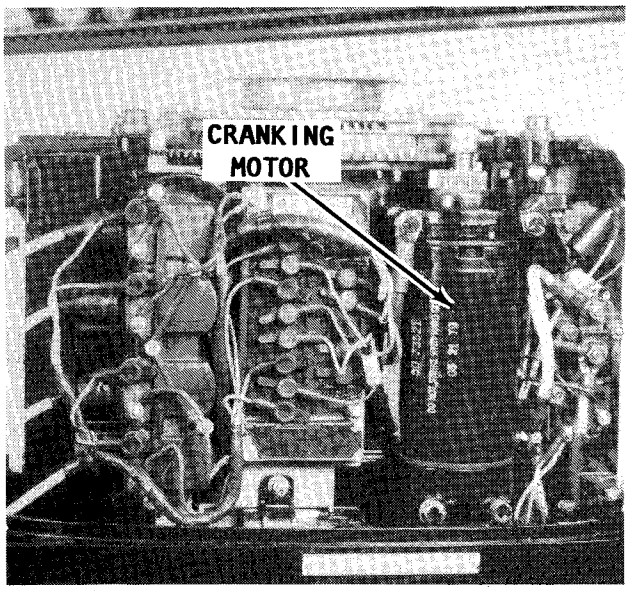
cranking motor coupled with a mechanical gear mesh between the cranking motor and the engine flywheel, similar to the method used to crank an automobile engine.

Since the starting motor requires a large amount of electrical current, it is necessary to have a fully charged battery available for the starting system. The battery can be externally charged or the engine can be equipped with an alternator to charge the battery while the engine is operating.

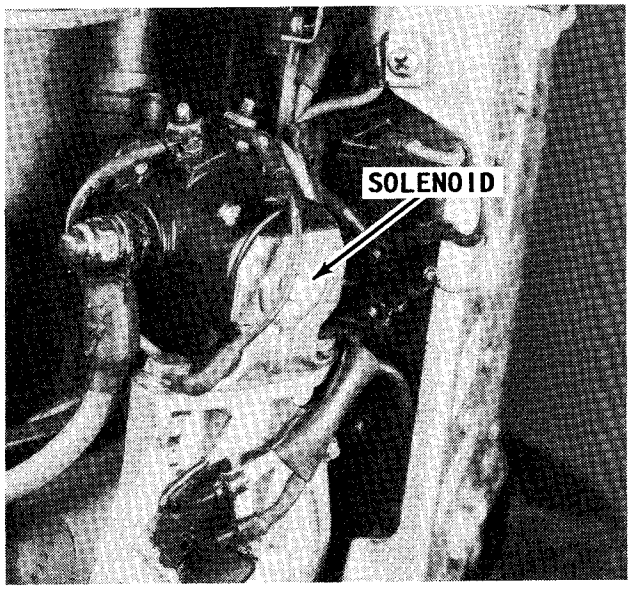
After the battery became a standard addition to the larger engines, the next logical improvement was to improve the ignition system. Since the mid 1960's, the trend has been to replace the conventional ignition system with a capacitor-discharge (CD) type system, using a solid-state amplifier. With this system, a pulse generator replaces the conventional breaker points.

The electrical system consists of four circuits:

a- Charging circuit
b- Cranking motor circuit
c- Choke circuit
d- Ignition circuit



Typical cranking motor installation on the powerhead of outboard units covered in this manual.



Typical location of a marine cranking motor solenoid. An automotive-type solenoid should never be used.

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Charging Circuit

The charging circuit consists of permanent magnets and a stator located within the flywheel; a rectifier located elsewhere on the powerhead; an external battery; and the necessary wiring to connect the units. The negative side of the rectifier is grounded. The positive side of the rectifier passes through the internal harness plug to the battery. The negative side of the battery is connected, through the connector, to a good ground on the engine.

The alternating current generated in the stator windings passes to the rectifier. The rectifier changes the alternating current (AC) to direct current (DC) to charge the 12-volt battery.

Cranking Motor Circuit

The cranking motor circuit consists of a cranking motor and a starter-engaging mechanism. A solenoid is used as a heavy-duty switch to carry the heavy current from the battery to the cranking motor. On most models, the solenoid is actuated by turning the ignition key to the **START** position.

Choke Circuit

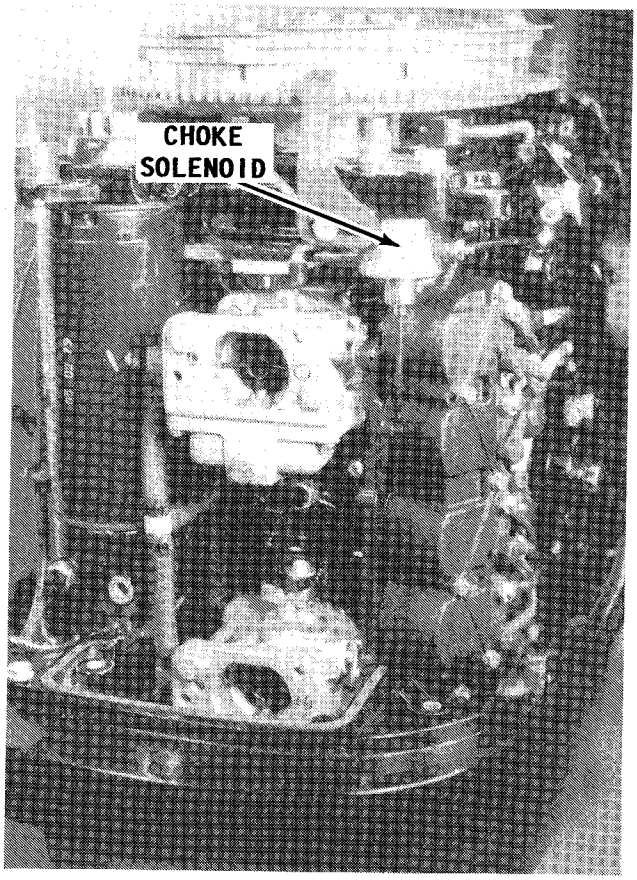
The choke is activated by a solenoid. This solenoid attracts a plunger to close the choke valves. The solenoid is energized when the ignition key is turned to the **START** position and the choke button is depressed. When using the electric choke, the manual choke **MUST** be in the **DOWN** position.

Ignition Circuit

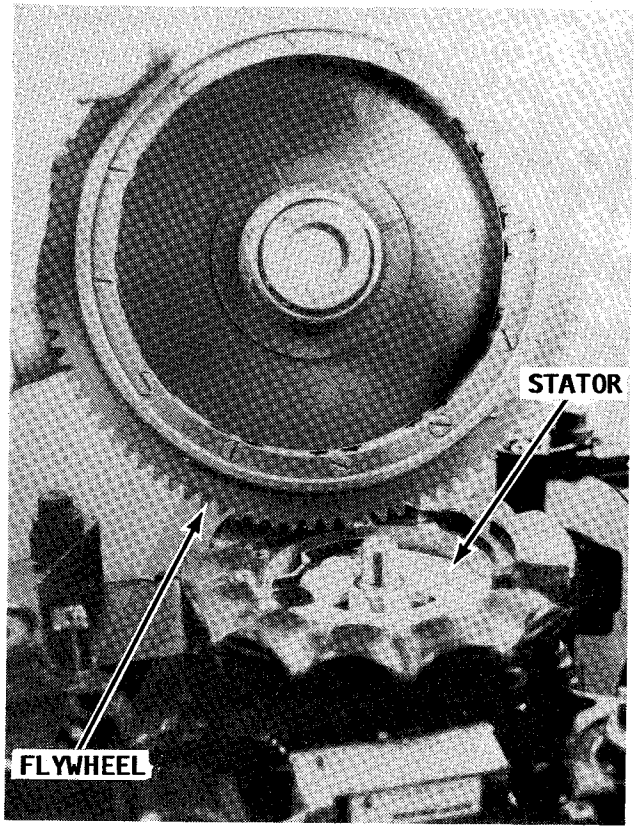
The ignition circuit is covered extensively in Chapter 6.

9-9 CHARGING CIRCUIT SERVICE

The stator is located under, and protected by, the flywheel. Therefore, the stator seldom causes problems in the charging circuit. Most problems in the charging circuit can be traced to the rectifier or to the battery. If either the stator or the rectifier fails the troubleshooting tests, the defective unit cannot be repaired, it **MUST** be replaced.



Typical location of the choke solenoid mounted on the powerhead.



Flywheel removed exposing the stator of a typical charging circuit system on the powerhead of units covered in this manual.

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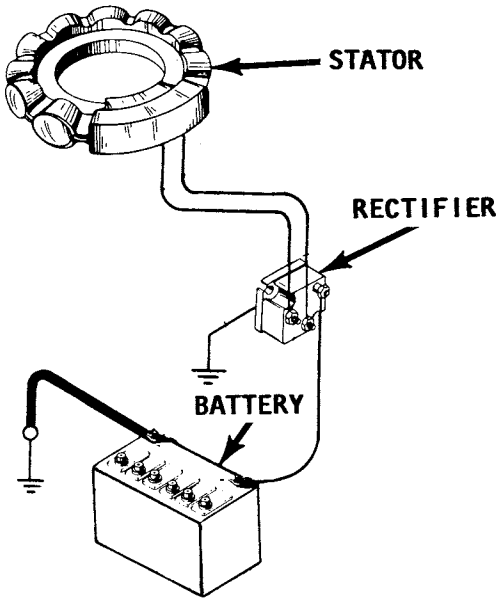
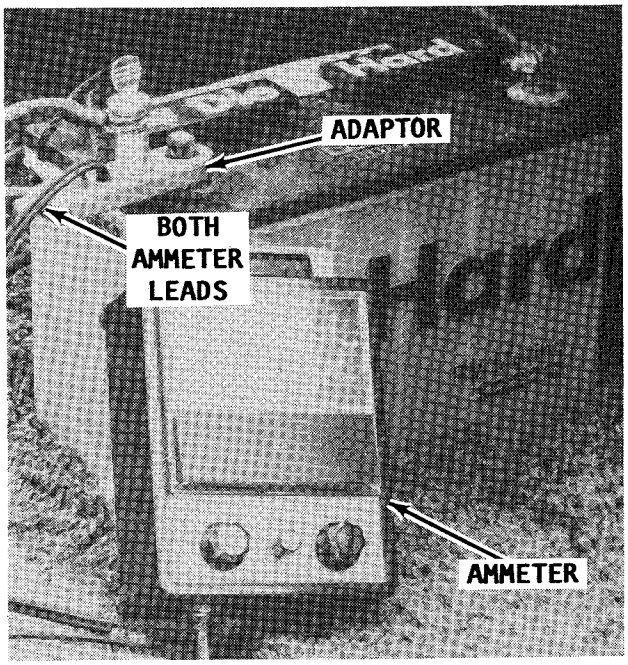


Functional diagram of a typical charging circuit showing relationship of the stator, solid state rectifier, and the battery.

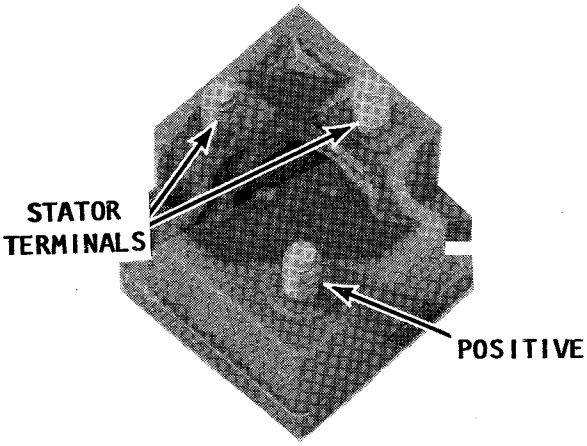
TROUBLESHOOTING

Net DC Amperage Output

With the engine not running, disconnect the red harness lead from the positive (+) battery terminal. Attach a terminal adaptor to the positive (+) battery terminal.



*To test the output amperage of the battery, without creating excessive sparking, an ammeter **MUST** be connected to the cranking circuit in series with the powerhead load through an adaptor.*



Modern solid state rectifier installed on late model powerheads with the terminals identified.

This adaptor is designed for use with an ammeter, and the ammeter connection is already made.

Reconnect the red harness lead to the the top of the adaptor, as shown. Mount the engine in a test tank or a body of water. Rotate the ignition key to the **START ENGINE** position and note the ammeter reading. **NEVER** connect an ammeter across the terminals of a battery without an engine load in series in the circuit, because the ammeter will be destroyed.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

If the battery is partially charged, the ammeter should change from discharge to charge when the engine is operating be-

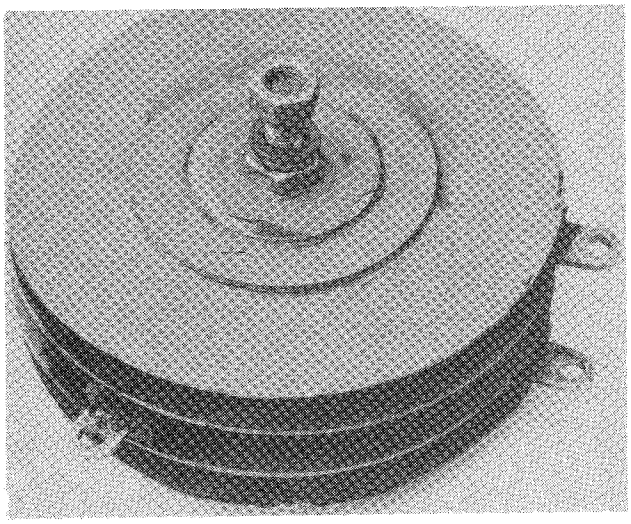


Plate-type rectifier installed on very early model powerheads. This type rectifier does not have diodes.

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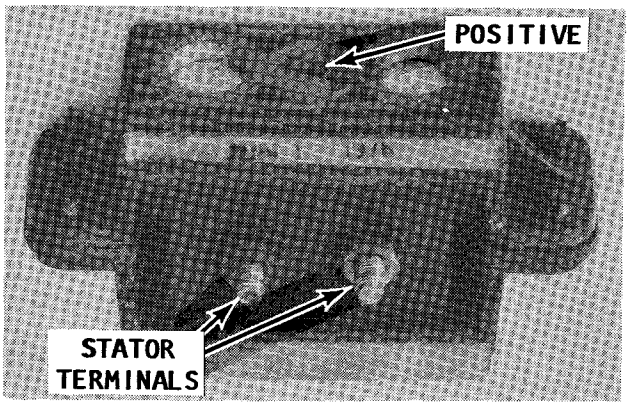
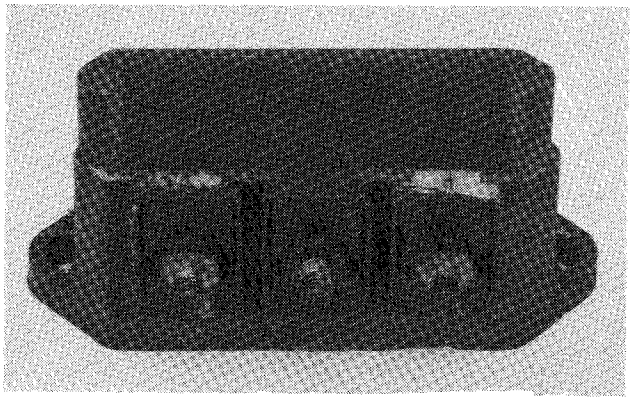


Old-style diode-type rectifier used on powerheads before the modern one at the top of the previous page was introduced.



Solid state rectifier found on some early model powerheads. This unit has been replaced by the modern one shown at the top of the previous page.

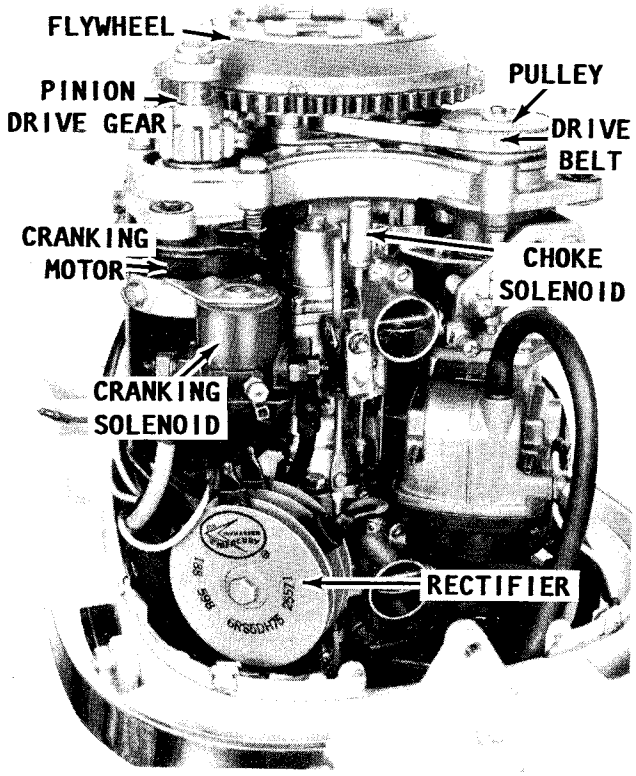
tween 800 and 1000 rpm. If the battery is fully-charged, the rpm will have to be increased before an ammeter change will be indicated. Increase engine speed to 5200 to 5300 rpm. The ammeter reading should be approximately 10 to 12 amp.

RECTIFIER REMOVAL

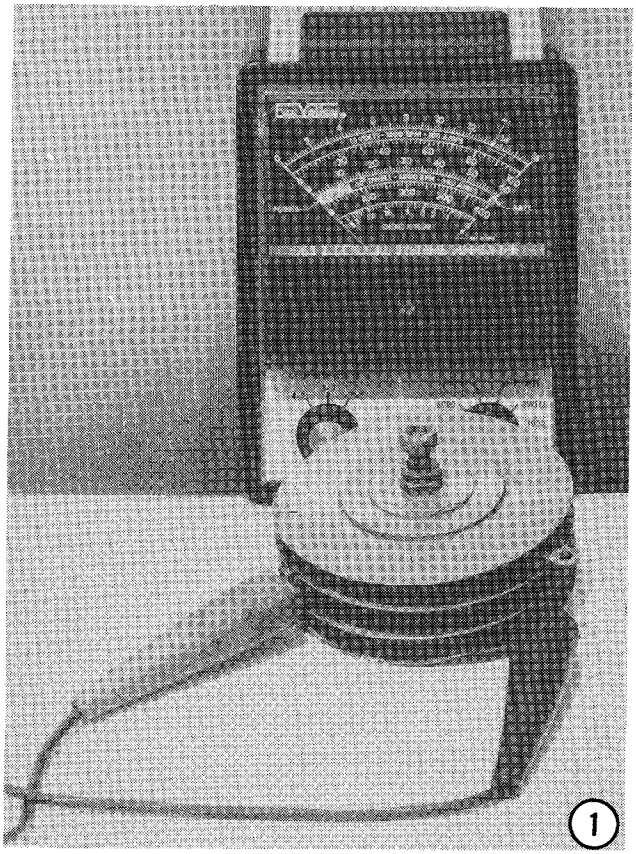
In most cases the rectifier is easily removed, because it is secured in place with a couple of bolts or nuts just in front of the carburetors. **BEFORE** removing the rectifier, **BE SURE** to disconnect the battery leads at the battery. Remove the yellow leads and positive leads to the rectifier. Remove the mounting bolts or nuts and remove the rectifier from the engine.

NEVER attempt to check the polarity of the battery leads by sparking the terminals against the battery posts. Such action will burn out the rectifier.

A burned-out rectifier will be greatly discolored, or have a definite "baked" appearance, or both. Unless the condition causing the rectifier to burn-out is correct-



Typical rectifier installation on early model powerheads. Other major parts are also identified.



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ed, simply replacing it will only result in the new one being burned-out.

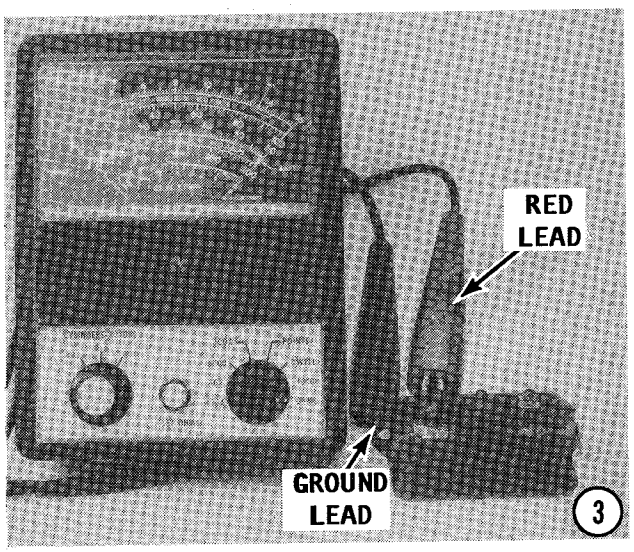
A burned-out rectifier in most cases is caused by improper procedure at the battery, or when handling the battery leads:

a- The battery leads of the electrical control harness are connected to the wrong terminals at the battery.

b- The battery leads were disconnected from the battery terminals while the engine was running.

c- On early model engines, turning the engine off with the ignition switch while the engine is running above an idle speed.

d- An open circuit resulting from a broken wire, a loose connection, corroded switch contact, or loose harness connector at the engine cowl.



Rectifier Testing

The following test may be performed when testing any of the rectifiers shown in the illustration identified with this step.

1- To test half of the rectifier:

a- Obtain an ohmmeter.

b- Connect the red test lead to the alternator terminal.

c- Connect the black test lead to the positive terminal of the rectifier.

d- The ohmmeter should indicate continuity.

2- Reverse the test lead connections.

e- The ohmmeter should indicate **NO** continuity. Half of the rectifier has now been successfully tested.

f- Repeat steps b through e for the other half of the rectifier.

Testing the Diodes

3- To test the diodes:

a- Connect the red ohmmeter test lead to the alternator terminal.

b- Connect the black test lead to the rectifier ground stud.

c- The ohmmeter should indicate **NO** continuity.

d- Reverse the test lead connections.

e- The ohmmeter should indicate continuity. Half of the rectifier has now been successfully tested.

f- Repeat steps **a** through **e** for the other rectifier half.

g- Replace the rectifier if the unit fails any part of the foregoing tests.

4- The following test may be performed when testing the rectifier shown in the illustration identified with this step.

a- Obtain an ohmmeter.

b- Connect the red (positive) ohmmeter lead to the rectifier case.

c- Connect the black (negative) ohmmeter lead alternately to the No. 1 and No. 3 rectifier terminals.

d- At each terminal (1 and 3), the meter pointer should move to the right of Scale 3. If the pointer does not move when connected, the rectifier is defective and **MUST** be replaced.

e- Connect the black meter lead to the rectifier case.

f- Connect the red lead alternately

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to the No. 1 and No. 3 rectifier terminals.

g- At each terminal (1 and 3), the meter pointer should remain stationary on the left side of Scale 3. If the pointer moves when the leads are connected to either terminal, the rectifier is defective and **MUST** be replaced. **ALWAYS** use a late-model rectifier as a replacement.

5- To continue with the testing:

h- Connect the black meter lead to the No. 2 rectifier terminal.

i- Connect the red meter lead alternately to the No. 1 and No. 3 rectifier terminals.

j- At each terminal (1 and 3), the meter pointer should move to the right of Scale 3. If the pointer does not move when the lead is conected to either terminal, the rectififer is defective and **MUST** be replaced.

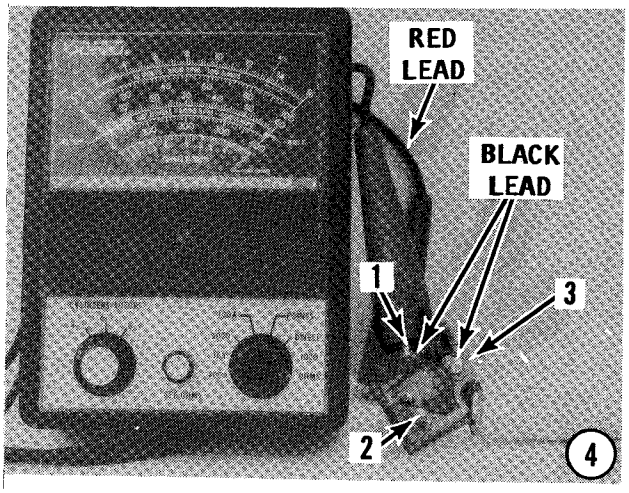
k- Connect the red meter lead to the No. 2 rectifier terminal.

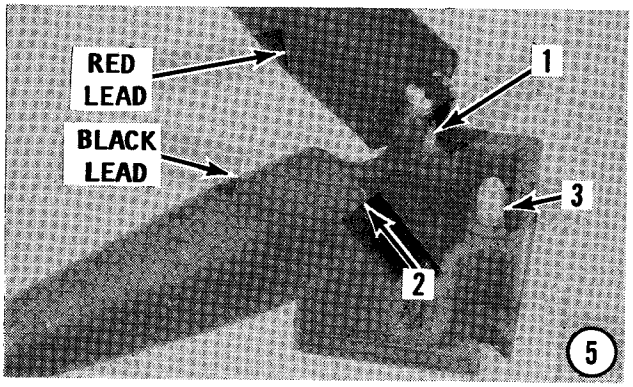
l- Connect the black lead alternatley to the No. 1 and No. 3 rectifier terminals.

m- At each terminal, the meter pointer should remain stationary on the left side of Scale 3. If the pointer moves when the lead is connected to either terminal, the rectifier is defective and **MUST** be **REPLACED. ALWAYS** use a late-model rectifier as a replacement.

RECTIFIER INSTALLATION

Place the rectifier in position on the engine and secure it with the attaching bolts or nuts. Connect the two yellow leads and the positive lead to the rectifier. Connect the battery leads securely to the battery.



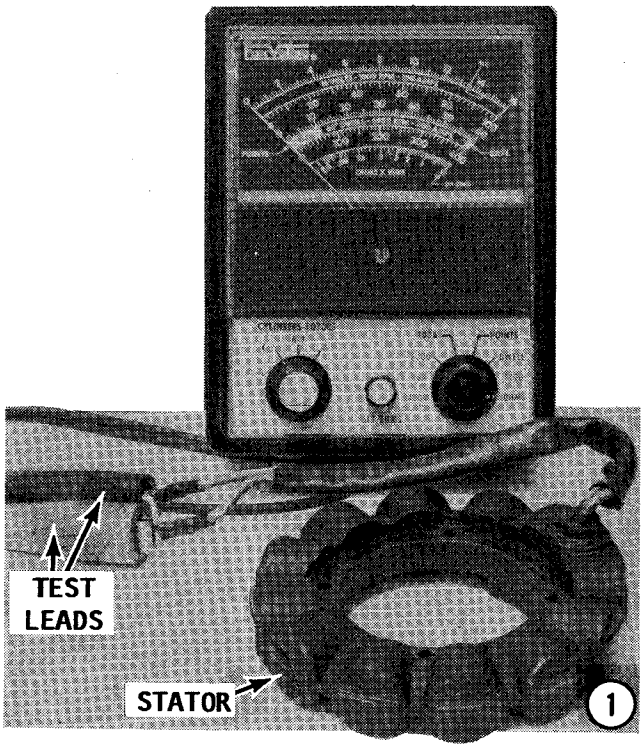


9-10 STATOR SERVICE

This section provides detailed procedures for testing, removing, and installing the stator.

Stator Testing

1- The stator may be tested without removing the flywheel, by merely disconnecting the two yellow leads from the rectifier and using an ohmmeter. Check the resistance of the stator windings against those given on Page 6-16. If the stator resistance does not meet specifications, it **MUST** be replaced.



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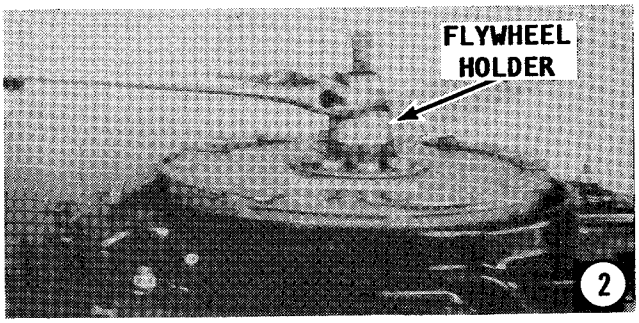
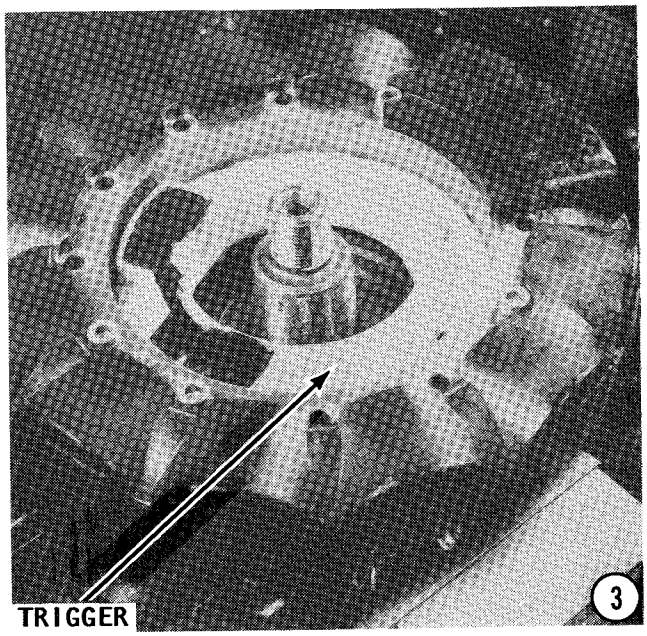


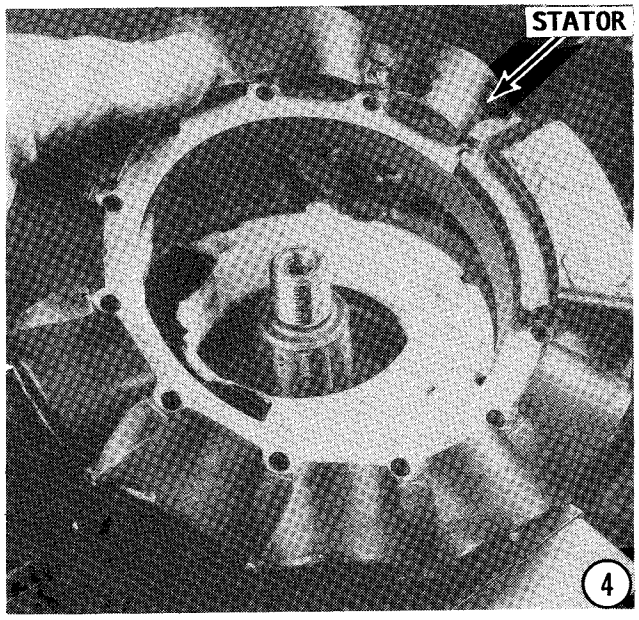
REMOVAL

BAD NEWS: The flywheel must be removed to gain access to the stator.

2- If a battery is used to crank the engine, disconnect the battery leads from the battery terminals. Remove the front cowl cover and the wrap-around cowl, if one is used. Remove the top cowl. Remove the nut on the crankshaft in the center of the flywheel. A flywheel holder may be required to prevent the flywheel from turning in order to loosen the nut.

3- Remove the timing belt from the distributor pulley. A timing belt is not used on engines equipped with CD ignition. Obtain the proper flywheel puller to pull the flywheel. **NEVER** use a puller which pulls on the outside edge of the flywheel, or the flywheel may be damaged. After the puller is installed, tighten the center screw onto the end of the crankshaft. Continue tightening the screw until the flywheel is released from the crankshaft. Remove the flywheel puller. Lift the flywheel from the crankshaft and at the same time, slide the timing belt free of the flywheel pulley.

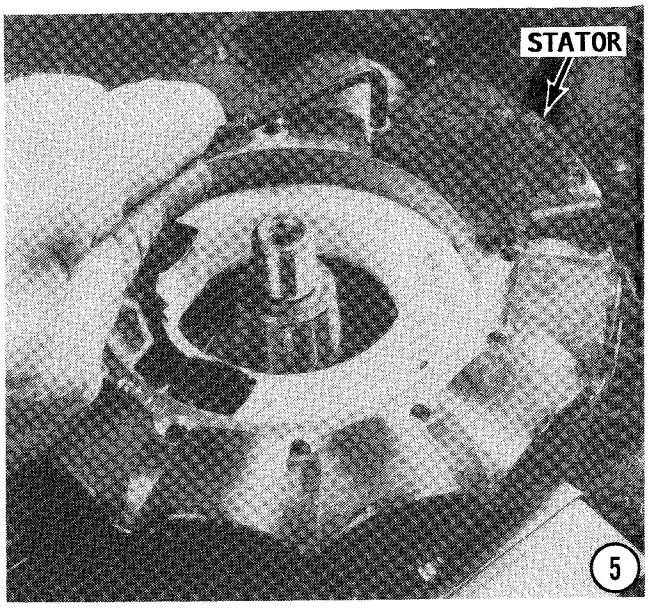




4- Remove the yellow wires leading from the stator to the black terminal on the rectifier. Remove the retaining screw from the stator and lift the stator from the engine.

INSTALLATION

5- Position the timing belt over the crankshaft and on top of the engine. Place the stator in position on the engine. Coat the threads of the stator attaching screws with blue Locktite, or equivalent. Secure the stator with the attaching screws through the stator into the engine block.



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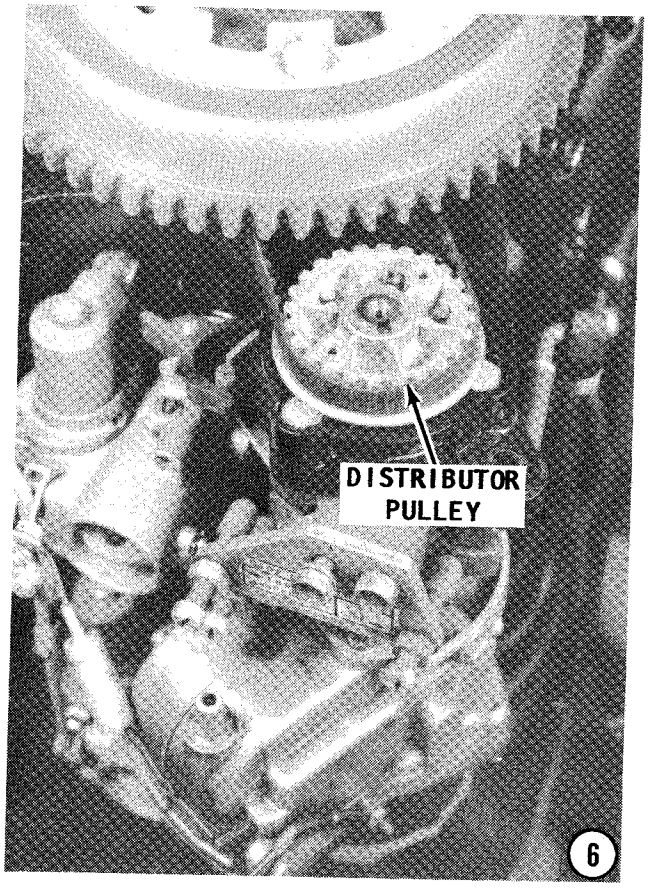
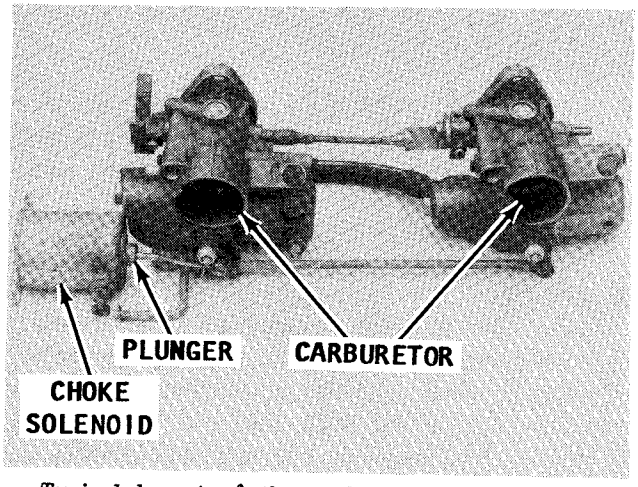
6- Insert the flywheel key into the crankshaft keyway. Check to be sure the inside taper of the flywheel and the taper on the crankshaft are clean of dirt or oil, to prevent the flywheel from "walking" on the crankshaft during operation. Slide the flywheel down over the crankshaft with the keyway in the flywheel aligned with the key on the crankshaft, and at the same time, work the timing belt around the flywheel pulley. Rotate the flywheel clockwise and check to be sure the flywheel does not contact any engine part or the wiring. Thread the flywheel nut onto the crankshaft, and then tighten it to the torque value given in the Specifications in the Appendix. Work the timing belt onto the distributor pulley. (Engines equipped with a CD ignition system will not have a timing belt.) For detailed timing procedures, see Chapter 7.

9-11 CHOKE AND ENRICHENER CIRCUITS

This short section provides instructions to test the choke circuit. The choke solenoid cannot be serviced. If the system fails the test, the attaching hardware can be removed and the choke assembly replaced.





Typical layout of the carburetors, choke plunger, solenoid, and linkage for a 4-cylinder in-line powerhead.

On almost all powerheads covered in this manual, the choke circuit has been replaced with an enrichener valve circuit. The enrichener valve system is covered in this section after the choke circuit.

Choke Circuit Testing

The choke circuit may be quickly tested to determine if it is functioning properly as follows:

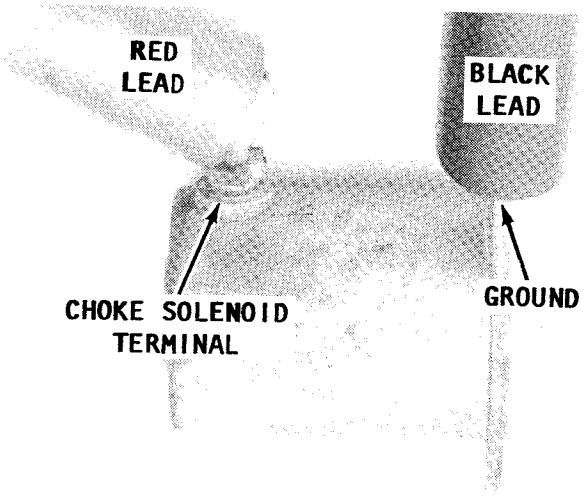
a- Obtain an ohmmeter.

b- Connect the black meter lead to an unpainted portion of the engine block for a good ground.

c- Connect the red meter lead to the choke terminal.

d- Test the circuit using the Rx1 scale of the ohmmeter. The reading should be less than 1.0 ohm.

e- After the test is completed, check to be sure the choke plunger is pulled into the choke solenoid.



Hook-up of the test leads to test the choke solenoid, as outlined in the text.

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ENRICHENER SYSTEM

Almost all powerheads covered in this manual, are equipped with an enrichener system, replacing the traditional choke system.

Description

An electrically operated enrichener valve mounted on the port side of the powerhead, as shown in the accompanying illustration, is supplied with fuel via a fuel line from the float bowl of the top carburetor.

When the ignition key is rotated to the **ON** position and pushed inward to start a cold powerhead, the enrichener system is energized. Fuel is then fed to all cylinders through short hoses and fittings at the intake manifold close to the carburetor mounting flanges.

As soon as the ignition key is released, electrical current to the system is cutoff; the valve closes; and fuel through the valve stops.

Enrichener Valve Circuit Testing

When the system is energized, the ignition switch rotated to the **ON** position and pushed inward, the valve should open. If the valve opens, an audible "click" should be heard at the valve.

If no "click" is heard indicating the valve has not opened, obtain a voltmeter and set the meter to the 12VDC scale. Make contact with the Black meter lead to a suitable ground on the powerhead. Make contact with the Red meter lead to the Yellow/Black lead (from the enrichener valve) at the terminal block on the powerhead. If the meter fails to register 12V, check for an open in the Yellow/Black lead between the ignition switch and the terminal block.

If the meter registers 12V, check for corroded or loose connections at the Yellow/Black lead and the Black lead at the terminal block.

If the enrichener valve still fails to open, no "click" is heard, when the system is energized, replace the valve.

If the "click" is heard but fuel fails to flow from the lower fuel line at the valve, the cause is most likely a blockage or leak in the fuel delivery hose.

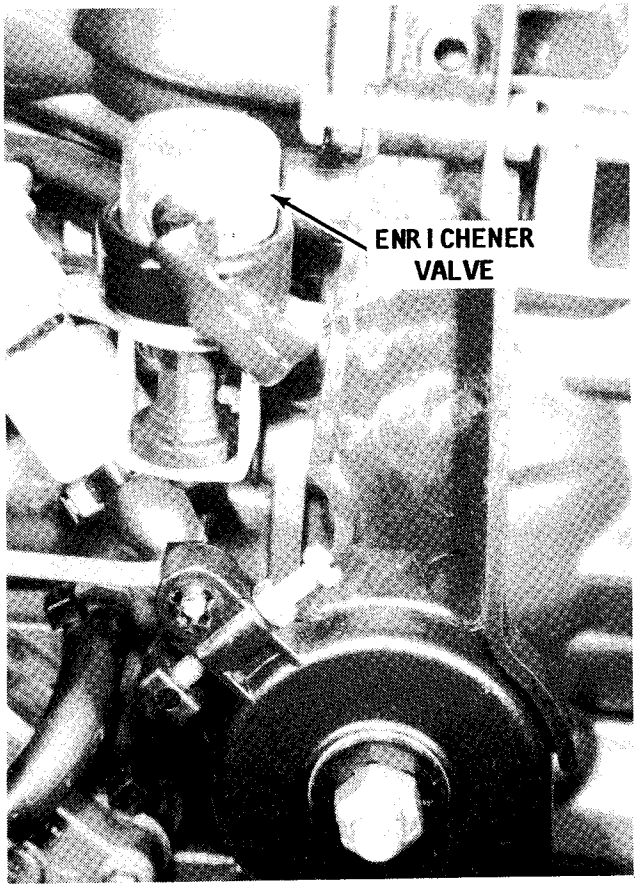
Activate the primer bulb. Disconnect the lower fuel line from the valve. Position a suitable container under the valve and then rotate and push inward on the ignition switch. Fuel should flow from the valve. If fuel flows —all is well with the valve. If the fuel is not reaching a cylinder, the delivery hose to the affected cylinder must have a blockage or leak.

If no fuel flows from the valve; remove the upper fuel delivery hose; hold the container under the disconnected line; activate the primer valve again; and verify fuel is reaching the enrichener valve. If no fuel flows from the disconnected line, the problem is in the top carburetor or delivery hose. The problem may be a blockage in the line or a leak, either in the hose or at a fitting.

If fuel flows from the disconnected delivery line, but fuel fails to flow from the lower fitting when the valve is energized, the enrichener valve is defective and **MUST** be replaced.

BAD NEWS

The enrichener valve cannot be serviced. A new valve must be purchased and installed.



Location of the enrichener valve on a late model 4-cylinder powerhead.

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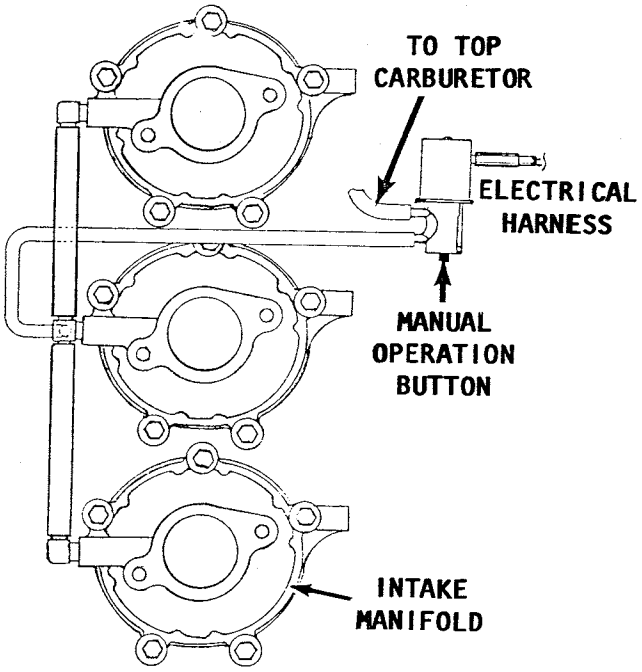
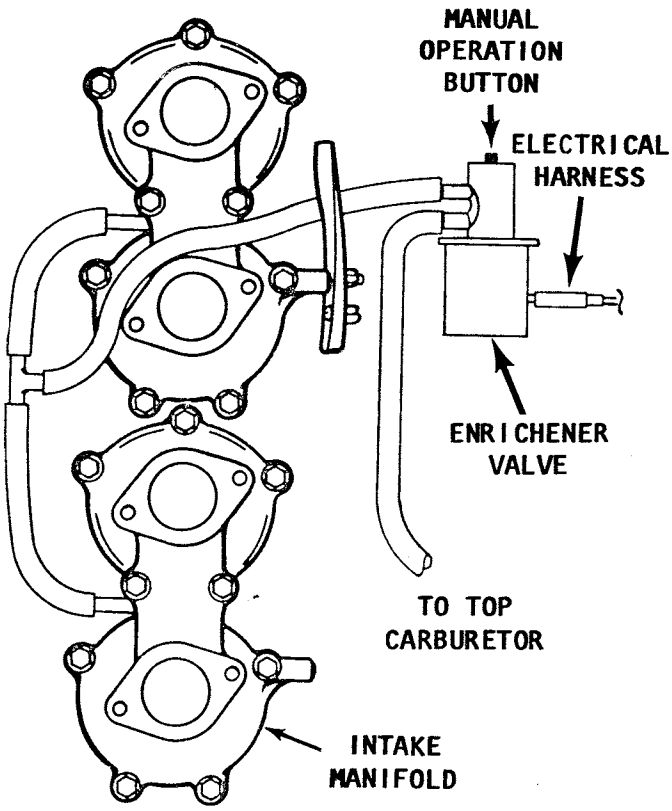
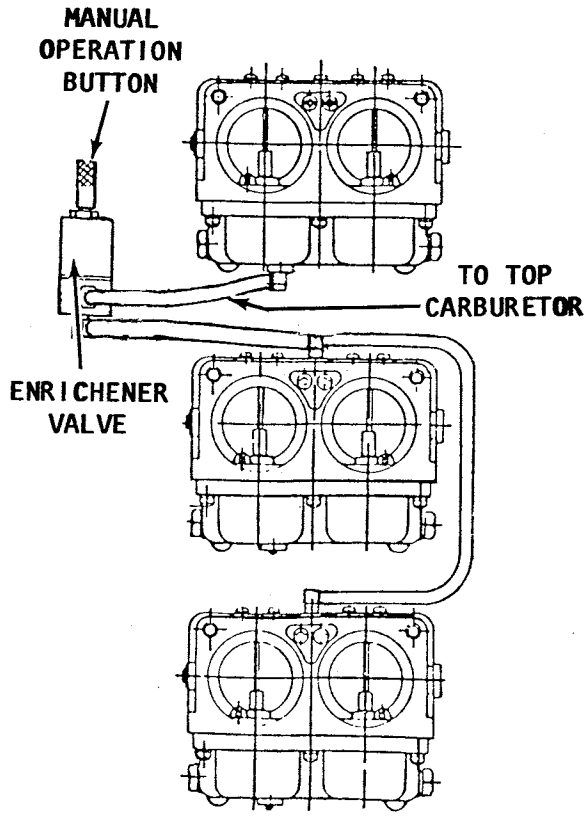
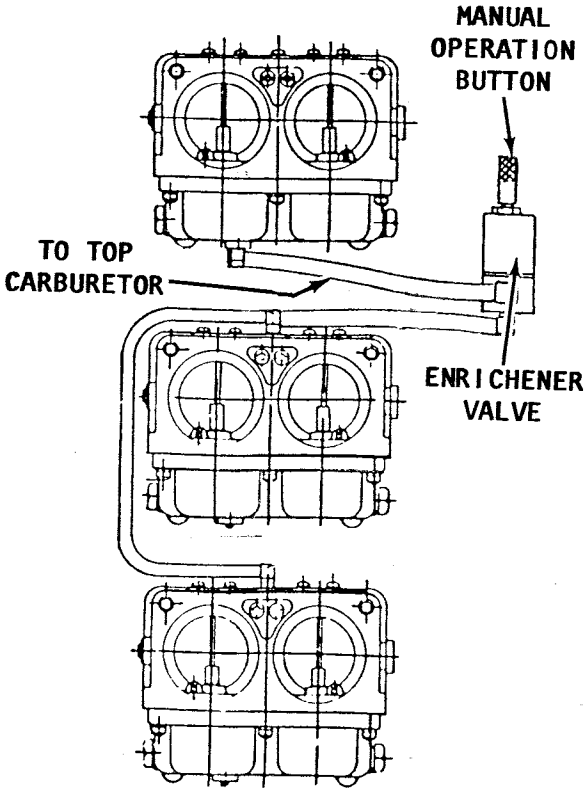


Layout of the enrichener valve and associated hoses on a 3-cylinder powerhead.



Layout of the enrichener valve and associated hoses on a 4-cylinder powerhead.





Layout of the enrichener valve and associated hoses on the port side (left), and on the starboard side (right), on a V6 powerhead. See Chapter 4, Page 4-48 for the enrichener valve and hose layout for an L6 powerhead.

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9-12 CRANKING MOTOR CIRCUIT SERVICE

DESCRIPTION

As the name implies, the sole purpose of the cranking motor circuit is to control operation of the cranking motor to crank the engine until the powerhead is operating. The circuit includes a solenoid or magnetic switch to connect or disconnect the motor from the battery. The operator controls the switch with a push button or key switch.

A neutral start switch is installed into the circuit to permit operation of the cranking motor **ONLY** if the shift control lever is in **NEUTRAL.** This switch is a safety device to prevent accidental engine start when the engine is in gear.

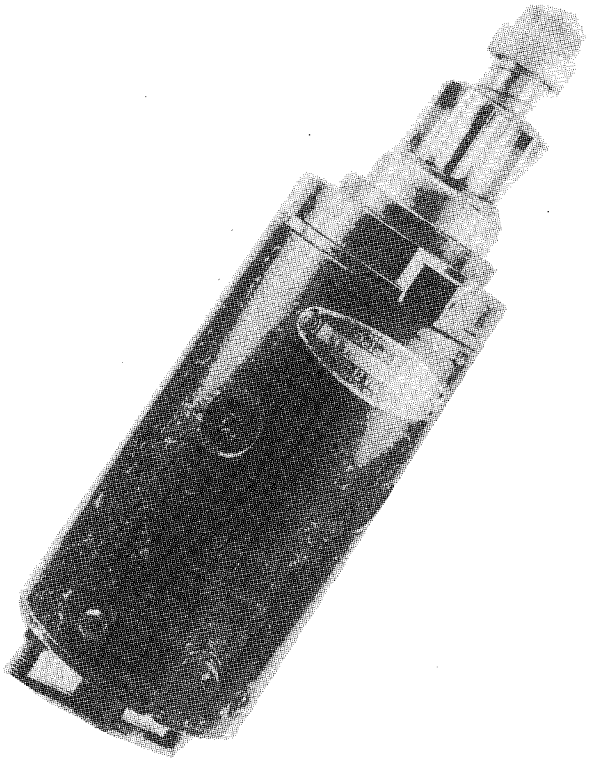
The cranking motor is a series wound electric motor which draws a heavy current from the battery. It is designed to be used only for short periods of time to crank the engine for starting. To prevent overheating the motor, cranking should not be continued for more than 30-seconds without allowing the motor to cool for at least three minutes. Actually, this time can be spent in making preliminary checks to determine why the engine fails to start.

Theory of Operation

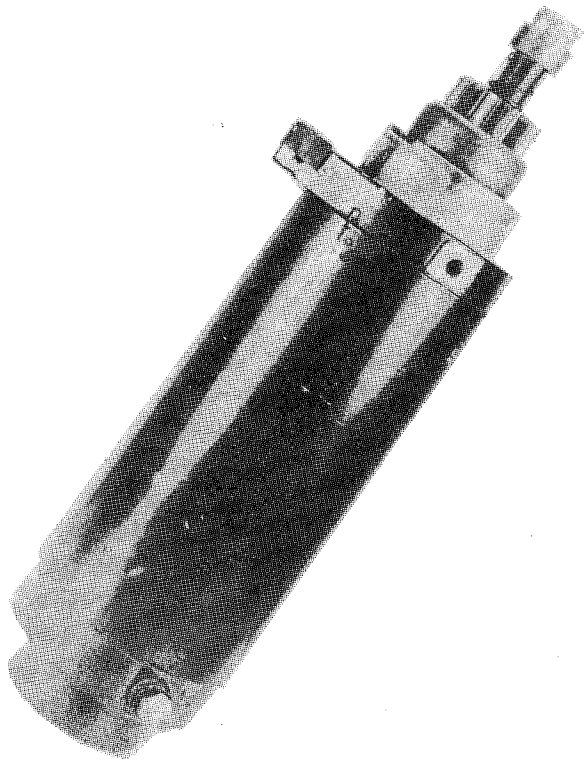
Power is transmitted from the cranking motor to the engine flywheel through a Bendix drive. This drive has a pinion gear mounted on screw threads. When the motor is operated, the pinion gear moves upward and meshes with the teeth on the flywheel ring gear.

When the engine starts, the pinion gear is driven faster than the shaft, and as a result, it screws out of mesh with the flywheel. A rubber cushion is built into the Bendix drive to absorb the shock when the pinion meshes with the flywheel ring gear. The parts of the drive **MUST** be properly assembled for efficient operation. If the drive is removed for cleaning, **TAKE CARE** to assemble the parts as shown in the accompanying illustration. If the screw shaft assembly is reversed, it will strike the splines and the rubber cushion will not absorb the shock.

The sound of the motor during cranking is a good indication of whether the cranking motor is operating properly or not. Naturally, temperature conditions will affect the speed at which the cranking motor is able to crank the engine. The speed of cranking a cold engine will be much slower than when cranking a warm engine. An experienced operator will learn to recognize the favor-



Typical Delco Remy cranking motor used with powerheads covered in this manual.



Typical Bosch cranking motor used with the powerheads covered in this manual.

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able sounds of the powerhead cranking under various conditions.

Faulty Symptoms

If the cranking motor spins, but fails to crank the engine, the cause is usually a corroded or gummy Bendix drive. The drive should be removed, cleaned, and given an inspection.

If the cranking motor cranks the engine to slowly, the following are possible causes and the corrective actions that may be taken:

a- Battery charge is low. Charge the battery to full capacity.

b- High resistance connections at the battery, solenoid, or motor. Clean and tighten all connections.

c- Undersize battery cables. Replace cables with sufficient size.

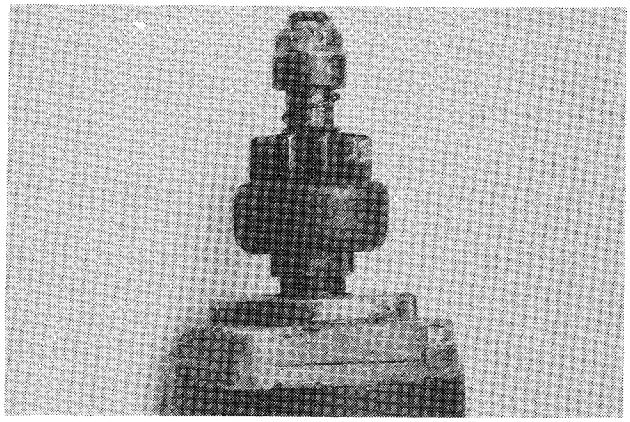
d- Battery cables too long. Relocate the battery to shorten the run to the solenoid.

Maintenance

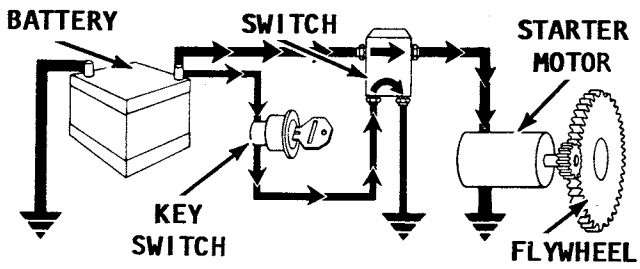
The cranking motor does not require periodic maintenance or lubrication. If the motor fails to perform properly, the checks outlined in the previous paragraph should be performed.

The frequency of starts governs how often the motor should be removed and reconditioned. The manufacturer recommends removal and reconditioning every 1000 hours.

Naturally, the motor will have to be removed if the corrective actions outlined under **Faulty Symptoms** above, does not restore the motor to satisfactory operation.



*The drive gear moves on the cranking motor shaft during motor operation. Therefore, the shaft should be lubricated with a very small amount of light-weight oil. **TAKE CARE** to prevent the lubricant from entering the cranking motor.*



Functional diagram of a typical cranking circuit.

CRANKING MOTOR TROUBLESHOOTING

Before wasting too much time trouble-shooting the cranking motor circuit, the following checks should be made. Many times, the problem will be corrected.

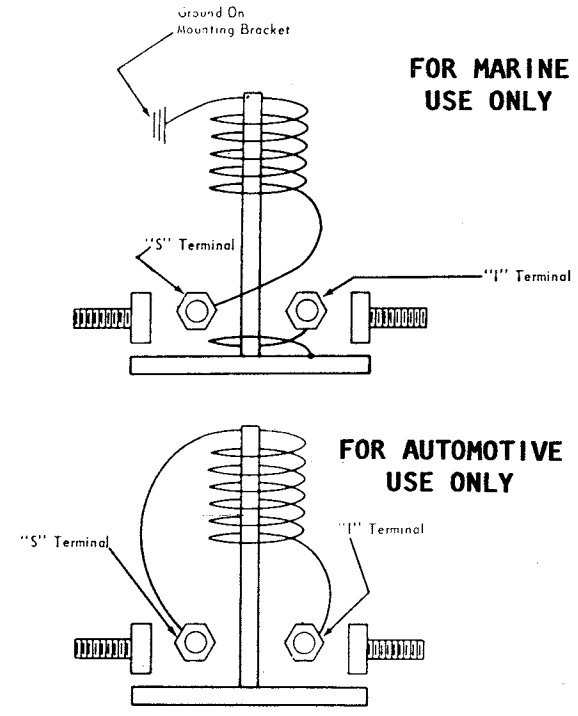
a- Battery fully charged.

b- Shift control lever in **NEUTRAL.**

c- All electrical connections clean and tight.

d- Wiring in good condition, insulation not worn or frayed.

Two more areas may cause the powerhead to crank slowly even though the cranking motor circuit is in excellent condition:



Schematic diagram of a marine solenoid (top) and an automotive solenoid (bottom). The marine solenoid has an internal ground and is therefore suitable for outboard installations.

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a tight or "frozen" powerhead and water in the lower unit. The following troubleshooting procedures are presented in a logical sequence, with the most common and easily corrected areas listed first in each problem area. The connection number refers to the numbered positions in the accompanying illustrations.

Perform the following quick checks and corrective actions for following problems:

1- Cranking Motor Rotates Slowly

a- Battery charge is low. Charge the battery to full capacity.

b- Electrical connections corroded or loose. Clean and tighten.

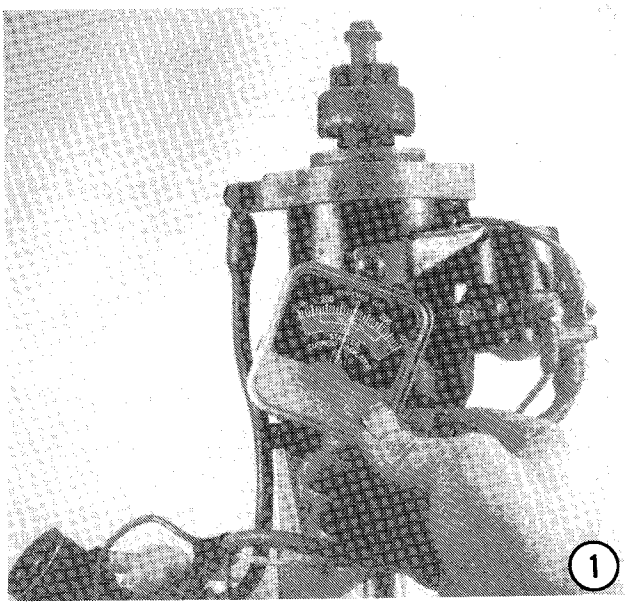
c- Defective cranking motor. Perform an amp draw test. Lay an amp draw-gauge on the cable leading to the cranking motor. Turn the key on and attempt to crank the engine. If the gauge indicates an excessive amperage draw, the cranking motor **MUST** be replaced or rebuilt.

2- Cranking Motor Fails to Crank Powerhead Test Motor

a- Disconnect the cranking motor lead from the solenoid to prevent the powerhead from starting during the testing process.

NOTE: This lead is to remain disconnected from the solenoid during tests No. 2 thru No. 7.

b- Disconnect the Black ground wire from the No. 2.



c- Connect a voltmeter between the No. 2 and a common engine ground.

d- Turn the key switch to the **START** position.

e- Observe the voltmeter reading. If there is the slightest amount of reading, check the black ground wire connection or check for an open circuit. Connect the ground wire back to the No. 2 and move to Step 7. If there is no voltmeter reading, proceed with Step 3.

3- Test Cranking Motor Solenoid

a- Connect a voltmeter between the engine common ground and the No. 3.

b- Turn the ignition key switch to the **START** position.

c- Observe the voltmeter reading. If there is the slightest indication of a reading, the solenoid is defective and must be replaced. If there is no reading, proceed with Step 4.

4- Test Neutral Start Swtich

a- Connect a voltmeter between the common engine ground and the No. 4. Turn the ignition key switch to the **START** position.

b- Observe the voltmeter. If there is any indication of a reading, the neutral start switch is open in the shift box or the Yellow or Yellow/Red wire lead is open between the No. 3 and No. 4. If there is no voltmeter reading, proceed to Step 5.

5- Test Ignition Switch

a- Connect a voltmeter between a common engine ground and No. 5.

b- Observe the voltmeter. If there is the slightest indication of a reading, the ignition switch is defective and must be replaced. If there is no reading, proceed with Step 6.

6- Test for Open Wire

a- Connect a voltmeter between the common engine ground and No. 6.

b- The voltmeter should indicate 12-volts. If the meter needle flickers (fails to hold steady), check the circuit between No. 6 and common engine ground. If meter fails to indicate voltage, replace the positive battery cable.

7- Further Tests for Solenoid

a- Connect the voltmeter between the common engine ground and No. 1.

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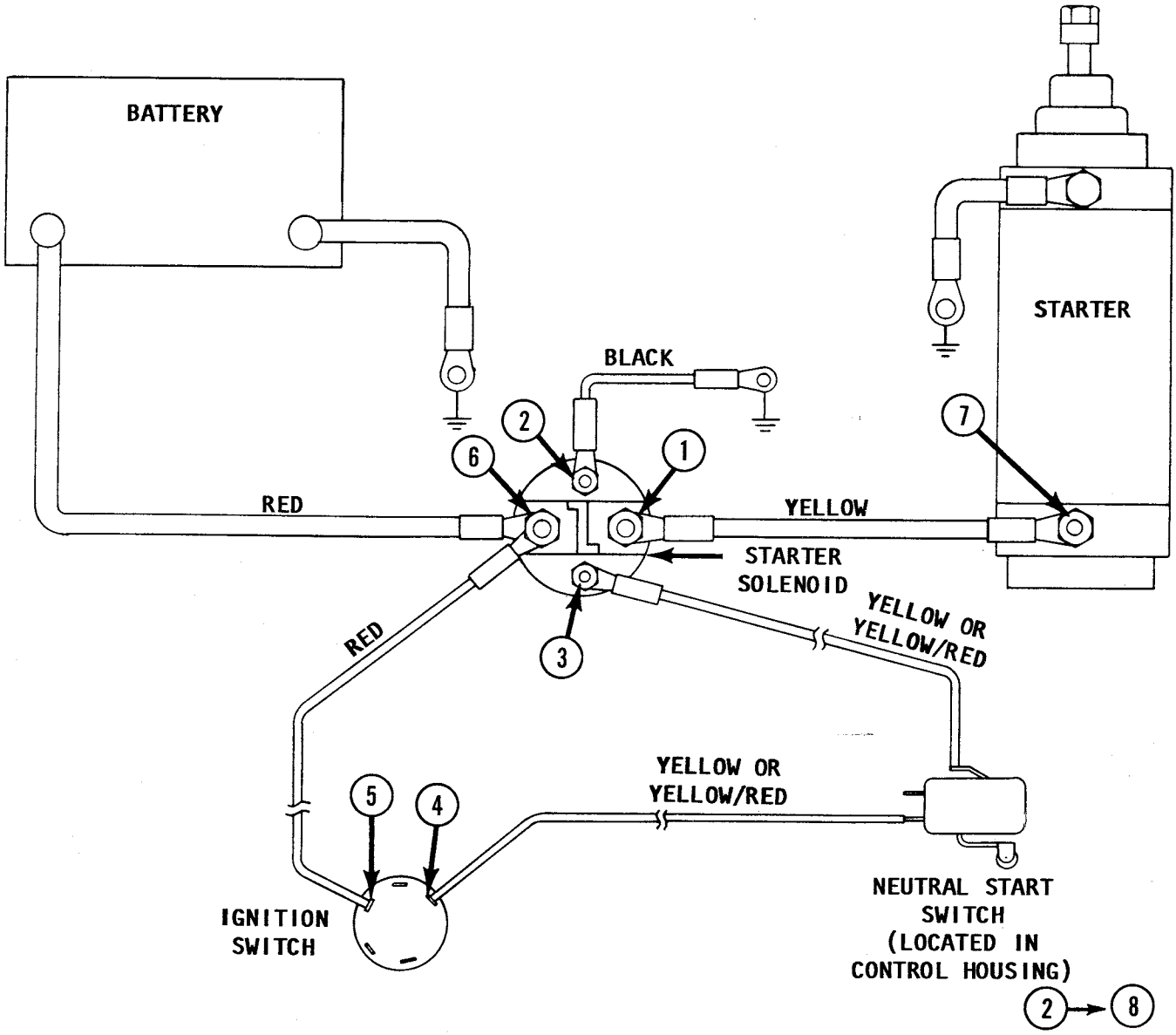
b- Turn the ignition key switch to the **START** position.
c- Observe the voltmeter. If there is no reading, the cranking motor solenoid is defective and must be replaced. If a reading is indicated and a click sound is heard, proceed to Step 8.

8- Test Yellow Cable
a- Connect the Yellow cable to the cranking motor solenoid.
b- Connect the voltmeter between the engine common ground and No. 7.
c- Turn the ignition key switch to the **START** position.
d- Observe the voltmeter. If there is no reading, check the Yellow cable for a poor connection or an open circuit. If there is any indication of a reading, and the starter does not turn, the cranking motor must be replaced.

CRANKING MOTOR SOLENOID TROUBLESHOOTING

Description

The cranking motor solenoid is a switch between the battery and the motor. Several types of solenoids are used and many look very much alike. For marine applications, a solenoid with an internal ground is used. Grounding this type solenoid is accomplished by a wire internally connected to one of the small terminals. Connecting an external wire for a ground will serve no purpose. **NEVER** attempt to use an automotive-type



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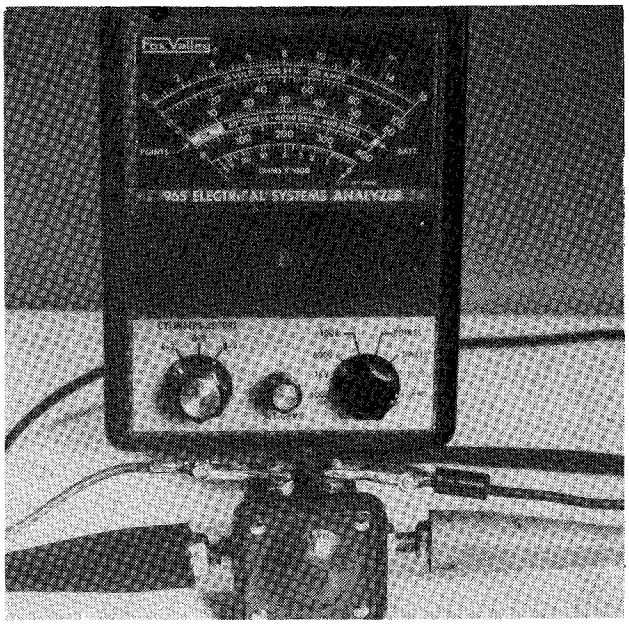


Test leads connected to a solenoid in preparation to testing as explained in the text.

solenoid, because such a unit will cause more trouble and damage than can be imagined.

When purchasing a replacement solenoid, look for a statement on the package indicating the unit is for marine use.

Illustrations of several different type solenoids are included in this section as an assist to understanding the operating functions of each type.

Solenoid Testing

The following test must be conducted with the solenoid removed from the engine.

a- Connect one test lead of an ohmmeter to each of the large solenoid terminals.

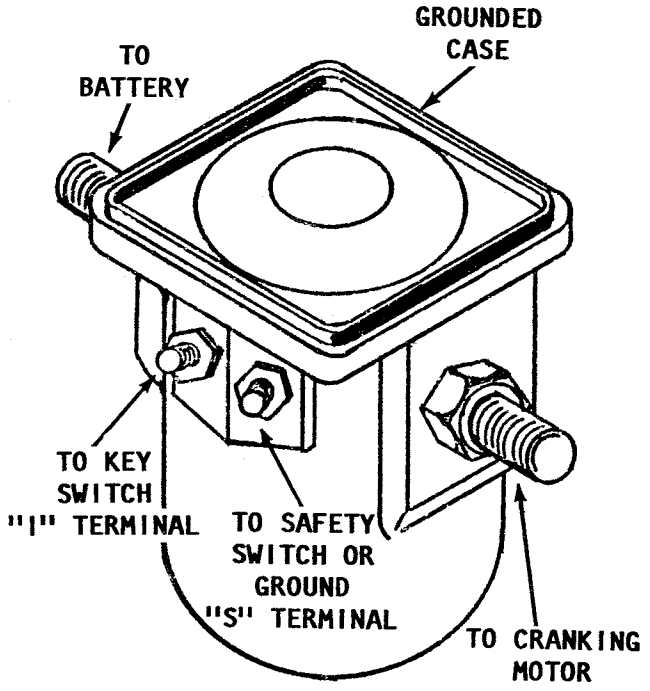
b- Connect the positive (+) lead from a fully charged 12-volt battery to the small solenoid terminal marked **S.**

c- Momentarily make contact with the ground lead from the battery to the small solenoid terminal marked **I.** If a loud "click" sound is heard, and the ohmmeter indicates continuity, the solenoid is in serviceable condition. If, however, a "click" sound is not heard, and/or the ohmmeter does not indicate continuity, the solenoid is defective and must be replaced **ONLY** with a **MARINE**-type solenoid.

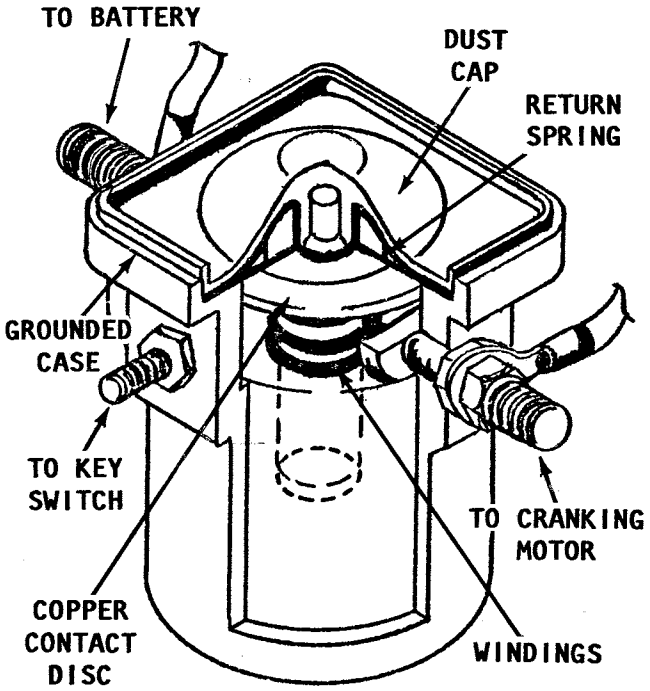
CRANKING MOTOR SERVICE

Description

The Delco-Remy cranking motor replaces the American Bosch cranking motor installed on early models. The Delco-Remy is completely interchangeable with the Bosch on all models. A new improved Bosch-type



*This solenoid acts as a relay in the cranking motor circuit. If the unit is found to be defective it **MUST** be replaced.*



A cutaway drawing of a cranking motor solenoid with major parts identified.

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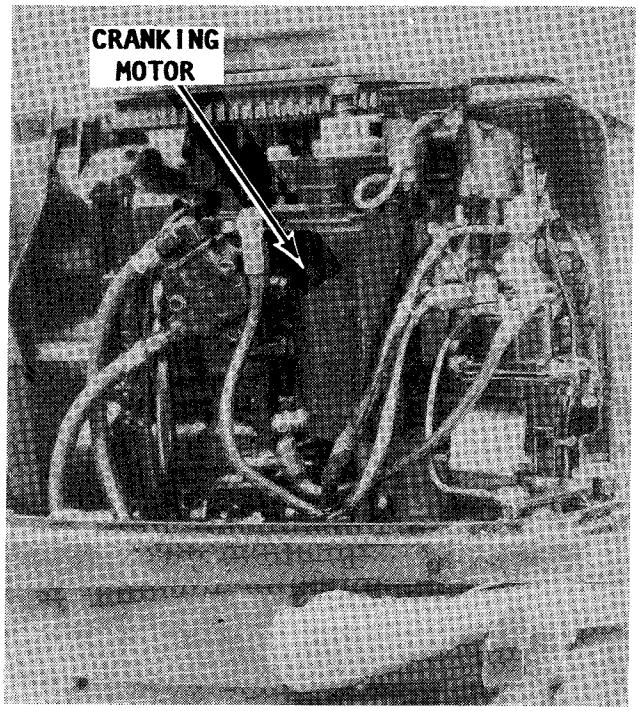
cranking motor is installed on some late model powerheads covered in this manual. A heavy duty Prestolite cranking motor is used on the larger V6 powerheads.

Marine cranking motors used on the powerheads covered in this manual, are very similar in construction and operation to the units used in the automotive industry.

These motors use an inertia-type drive assembly. This type assembly is mounted on an armature shaft with external spiral splines which mate with the internal splines of the drive assembly.

NEVER operate a cranking motor for more than 30-seconds without allowing it to cool for at least three minutes. Continuous operation without the cooling period can cause serious damage to the cranking motor.

Most cranking motors operate in much the same manner and the service work involved in restoring a defective unit to service is almost identical. Therefore, the information in this chapter is grouped together for the major components of the starter under separate headings. Differences, where they occur, between the various manufacturers, are clearly indicated.

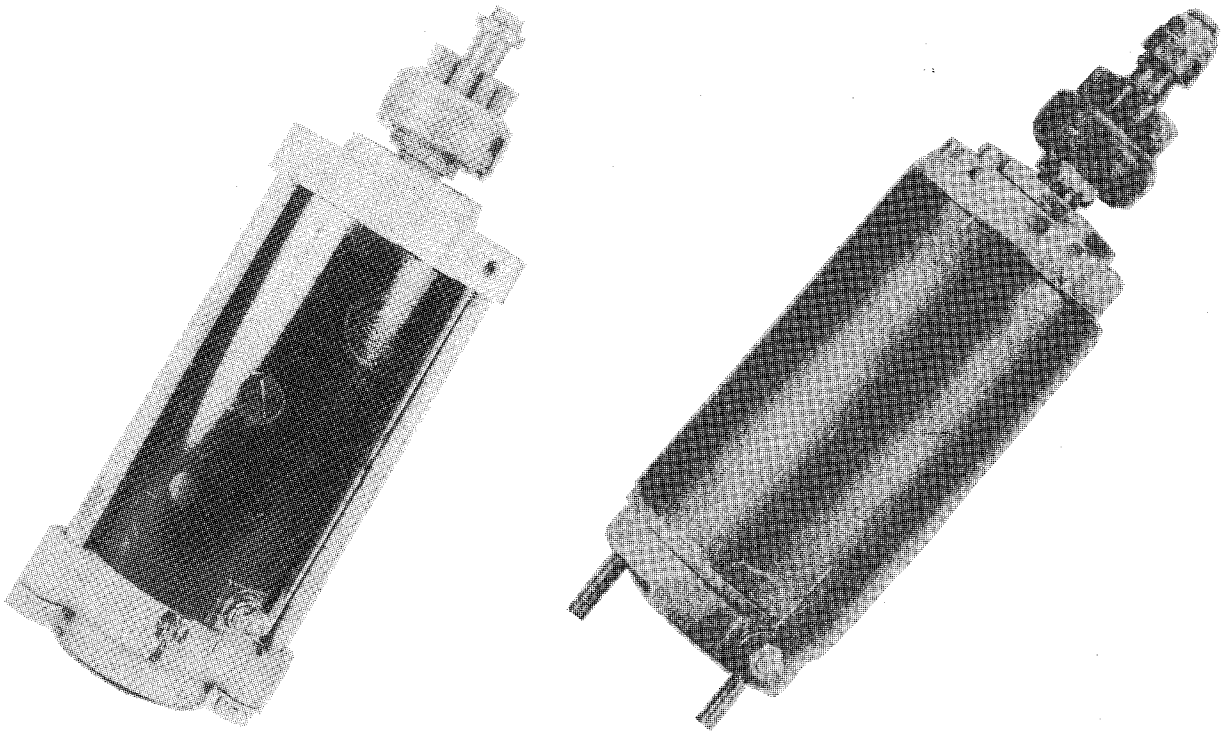


Typical cranking motor installation on the powerhead.

CRANKING MOTOR REMOVAL

Before beginning any work on the cranking motor, disconnect the positive (+) lead from the battery terminal. Remove the front cowl cover and the wrap-around cowl, if one is used. Disconnect the yellow cable at the cranking motor terminal.

Remove the solenoid from the starter motor. Remove the mounting bolts from the cranking motor housing and remove the starter from the engine.



External views comparing a Delco Remy (left) and a Bosch (right) cranking motor.

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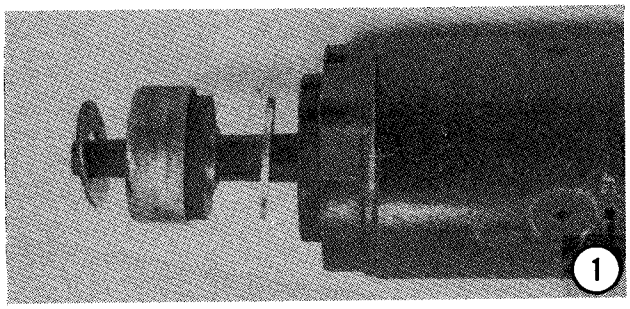
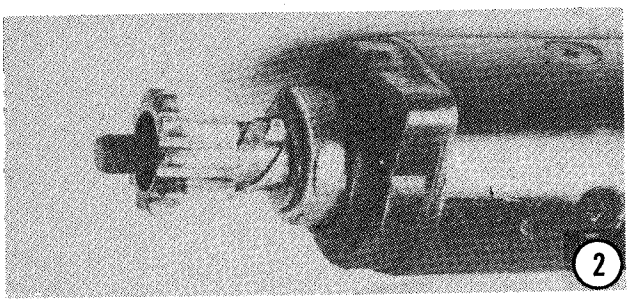
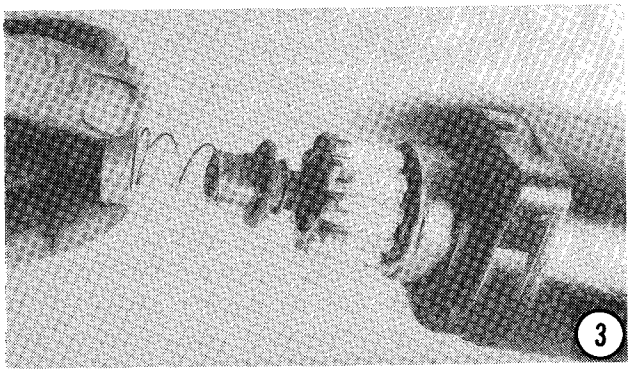
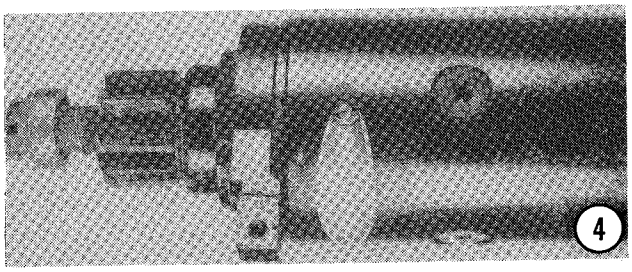








PINION GEAR DISASSEMBLING

Three different type drive gear arrangements are used on outboard cranking motors. One uses a drive gear with a rubber cushion; the second a snap ring, or nut; and the third uses a drive gear with a top spring. Detailed proceduures are presented in this section to service each type. Instructions for servicing the drive gear with rubber cushion is given first.

PINION GEAR WITH RUBBER CUSHION

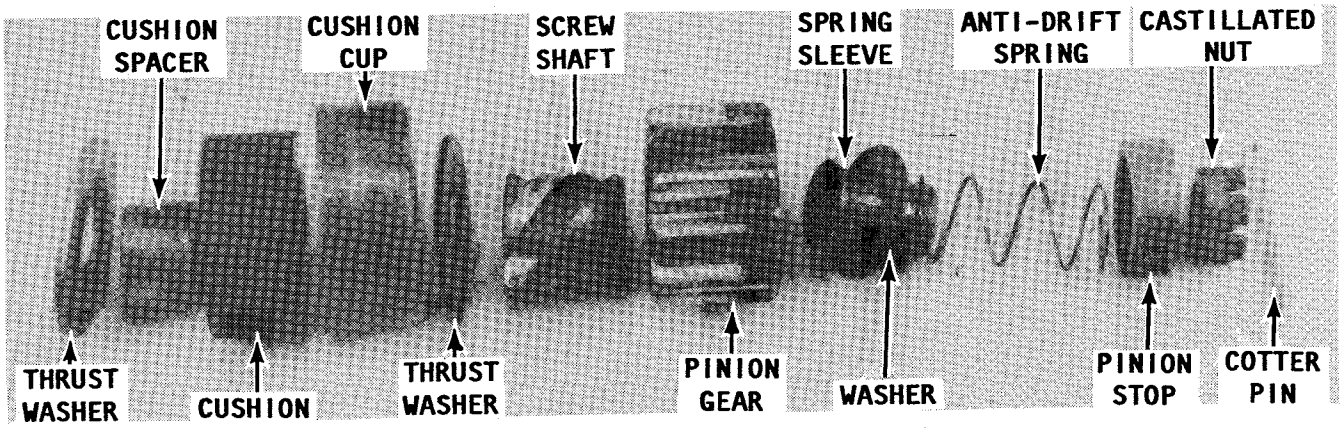
These cranking motors have the drive secured to the shaft by means of a castillated nut. Begin diassembling by removing the cotter pin from the armature shaft end, and then unscrew the castillated nut. The drive mechanism is now ready to be removed in the following sequence: pinion stop, anti-drift spring, pinion washer, anti-drift spring sleeve, pinion gear, screw shaft, thrust washer, cushion cup, cushion, cushion spacer, and thrust washer.

CLEANING AND INSPECTING

Inspect the pinion gear teeth for chips, cracks, or a broken tooth. Check the spline inside the pinion gear for burrs and to be sure the pinion gear moves freely on the armature shaft. Check to be sure the return spring is flexible and has not become distorted. Inspect the rubber cushion for cracks and for signs of oil on the cushion. Clean the armature shaft with crocus cloth.

ASSEMBLING
PINION GEAR WITH RUBBER CUSHION

1- Begin by assembling the following parts in the order given: the thrust washer,



Arrangement of parts for the drive gear with rubber cushion of a Delco Remy cranking motor.

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cushion spacer, cushion, cushion cup with the open end over the cushion, and then the thrust washer.

2- Install the screw shaft with the splined end facing **UP.** Lubricate the underside with Multipurpose Lubricant, or equivalent. Install the pinion gear with the screw end facing **DOWN.**

3- Slide the spring sleeve onto the armature shaft with the flared end facing the pinion gear. Place the washer over the sleeve, and then install the anti-drift spring, and the pinion gear stop with the recessed end facing **DOWN.**

4- Secure the assembly with the castillated nut tightened to a torque value of 200 in. lbs (22.5 Nm). Now, turn the nut slightly more until the cotter pin can be inserted through the nut and the hole in the shaft.

DISASSEMBLING
PINION GEAR WITH SNAP RING OR NUT

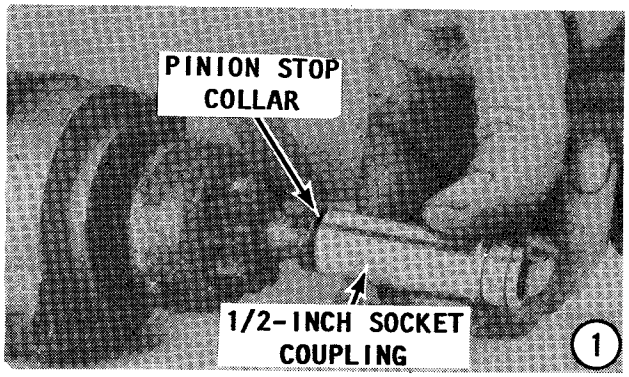
This type cranking motor has the pinion gear secured to the shaft with a snap ring.

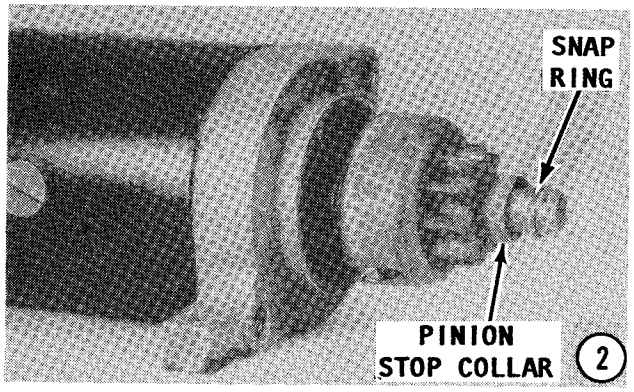
1- Remove the pinion gear from the armature. This is accomplished by sliding a deep half-inch socket onto the shaft until the end of the socket butts against the edge of the pinion stop collar. Next, tap the end of the socket to drive the stop collar away from the snap ring.

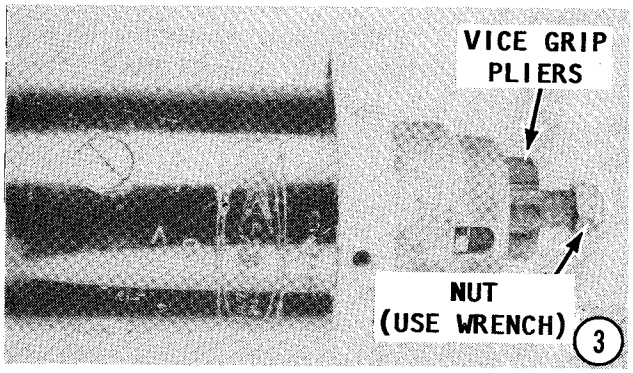
2- Remove the snap ring from the groove in the shaft.

3- If a nut is used instead of the snap ring, slide the pinion gear upward, and then place a wrench on the retaining nut. Hold the pinion gear with a pair of vise grip pliers. Hold firm and at the same time back-off the nut with the wrench. Remove and **DISCARD** the nut. **NEVER** attempt to use the same nut a second time.

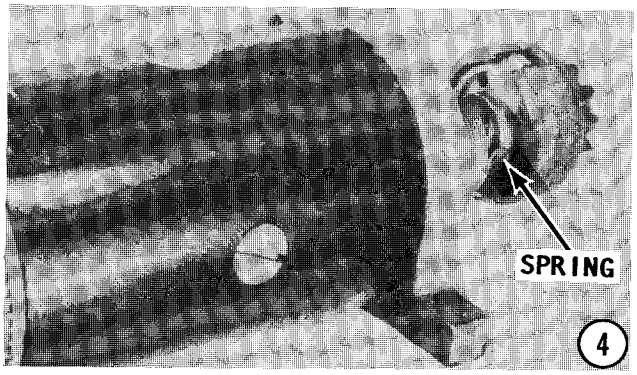
4- To remove the pinion gear and spring, move the gear upward on the shaft, and then snap the spring out of the hole on the bottom side of the gear.

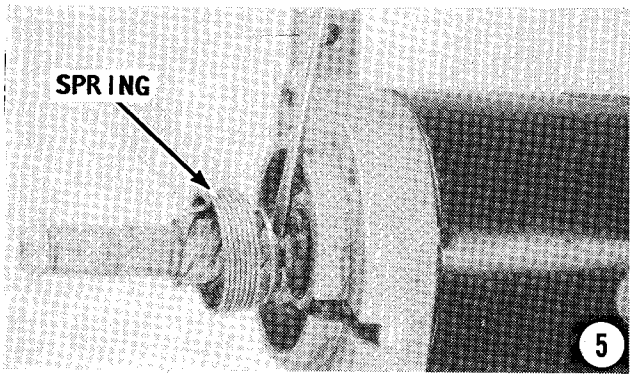






5- Use a screwdriver and lift the other end of the spring from the armature shaft. If other work is to be performed on the starter move directly to the starter repair section in this chapter.





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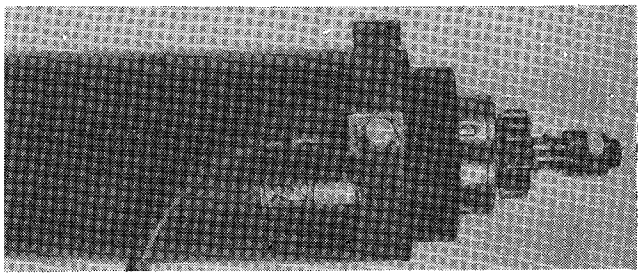


Cranking motor using a top return spring. The spring pushes the drive downward to help disengage the drive gear from the flywheel.

CLEANING AND INSPECTING

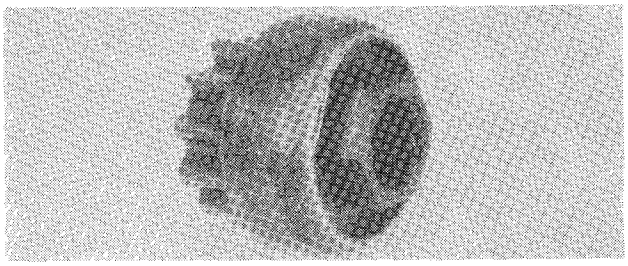
Inspect the pinion gear teeth for chips, cracks, or a broken tooth. Check the splines inside the pinion gear for burrs and to be sure the gear moves freely on the armature shaft.

BAD NEWS

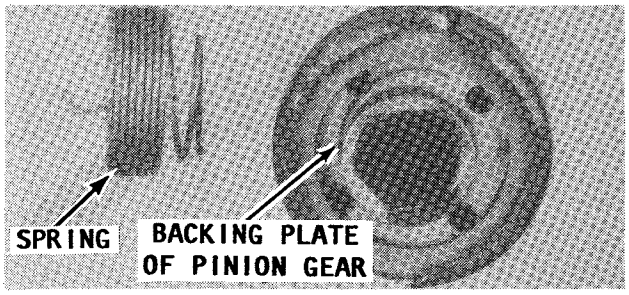
This type of cranking motor pinion gear assembly cannot be repaired if the unit is defective. Replacement as a unit is the only answer.

Check to be sure the return spring is flexible and has not become distorted. Check both ends of the spring for signs of damage.

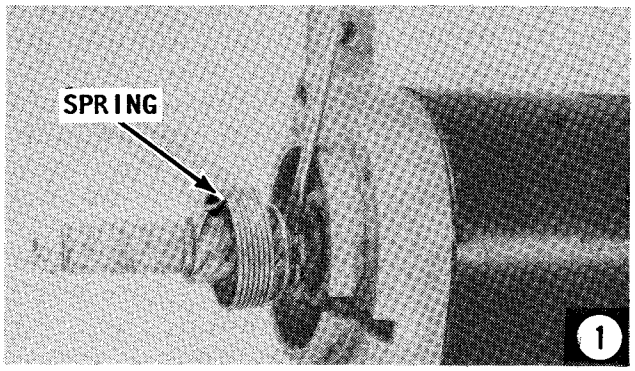
Clean the armature shaft and check to be sure the shaft is free of any burrs. If burrs are discovered, they may be removed with crocus cloth.



The teeth of the drive gear mesh with the teeth on the flywheel. Therefore, they are subjected to wear each time the cranking motor is operated. The teeth should be carefully inspected for wear or damage.



Lower end of the drive gear and return spring. The spring should appear as the one shown, without any distortion.



ASSEMBLING
PINION GEAR WITH SNAP RING OR NUT

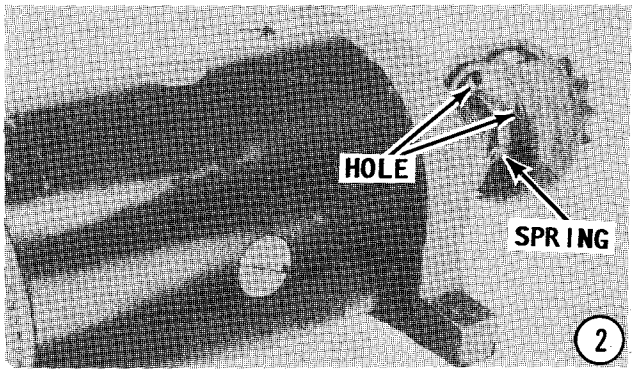
1- Lubricate the splined portion of the armature shaft with 30-weight oil. Next, place the pinion gear return spring onto the armature, with the small diameter of the spring **TOWARD** the end frame. Insert the first turn of the small end of the spring into the groove of the shaft next to the end frame. Hook the tip end of the spring into the hole at the bottom of the groove.

2- Hold the spring out of the way in its free position while the pinion gear is threaded onto the shaft in its fully disengaged position. **TAKE CARE** not to distort the spring. Wind the free end of the spring just 3/4 turn, and then hook it into the nearest of the four holes provided in the backing plate. Check to be sure the spring is securely hooked into the hole.

3- Slide the pinion stop collar onto the shaft, with the cupped surface facing **AWAY** from the pinion gear. Install the snap ring into the groove at the end of the shaft.

4- Use a pair of pliers and squeeze the snap ring to fit it into the groove properly. Position the pinion stop collar next to the snap ring, and then install a washer next to the other side of the snap ring.

GOOD WORDS: Use two pair of pliers, one on each side of the shaft, to grip the



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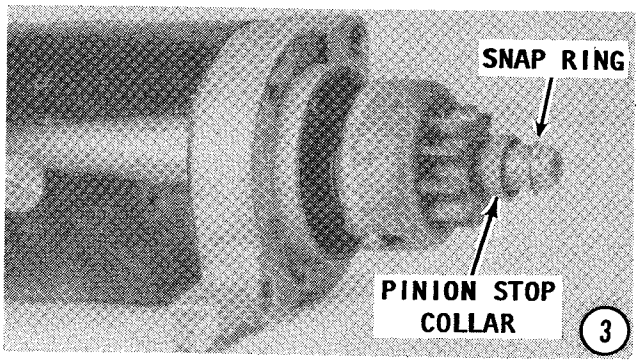
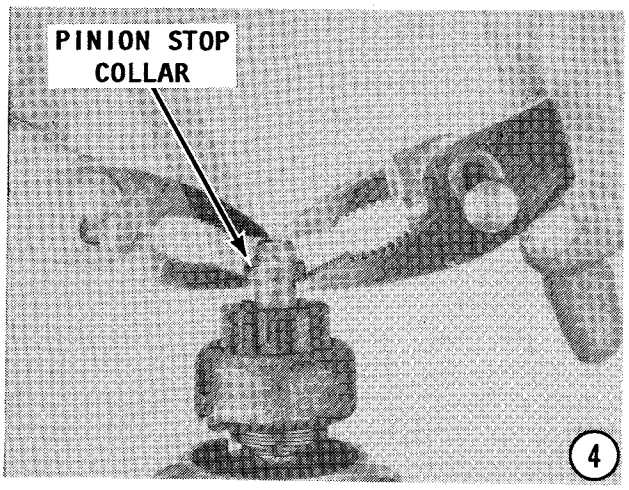
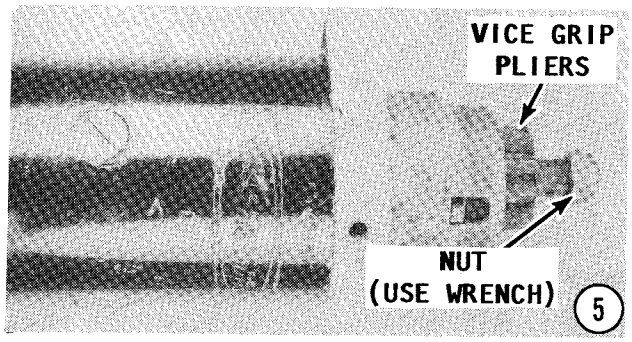


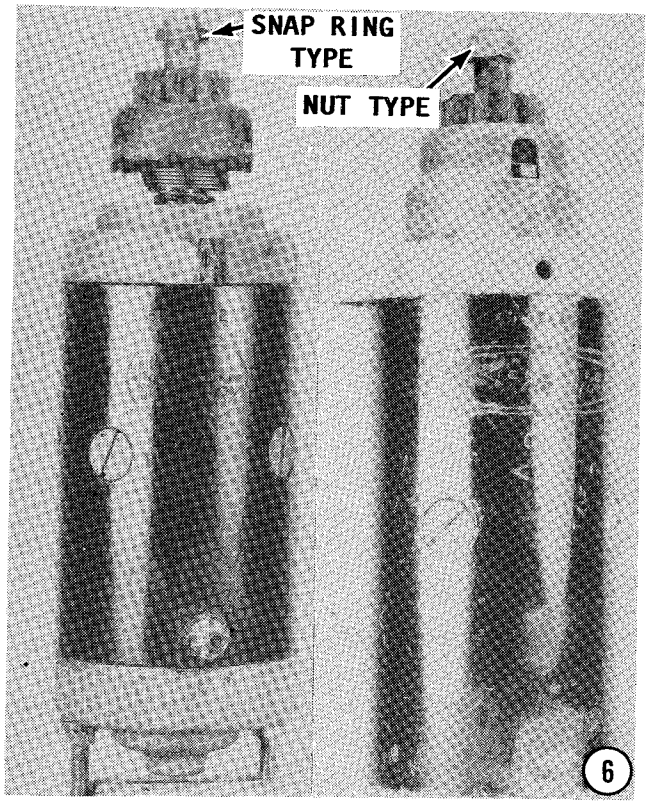


stop collar and the washer. The stop collar **MUST** rotate freely when the assembling work is complete.

5- If a nut is used instead of the snap ring, start a **NEW** nut onto the armature shaft. **DO NOT** attempt to use a nut that has been removed. Move the drive gear upward, and then clamp a pair of vise grip pliers on the drive gear. Hold the nut on top of the armature with a socket wrench. Now, hold the gear with the vise grip pliers and at the same time tighten the nut with the wrench.

6- Rotate the pinion gear against the pinion stop and relieve any turns of the spring which may be overlapping other turns. If the spring is assembled properly, the pinion gear should snap back from the engaged position.





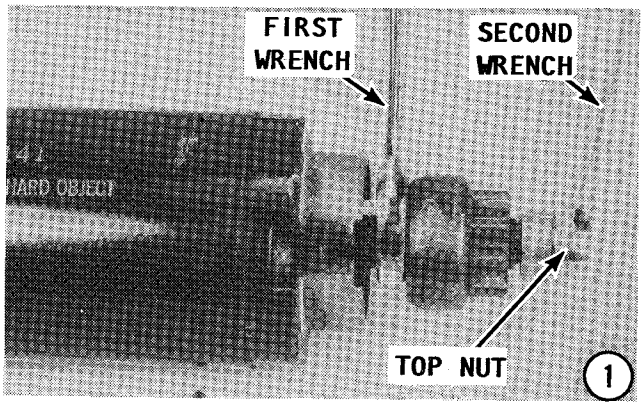
Install the cranking motor onto the powerhead. Install the cranking motor solenoid. Connect the yellow cable to the cranking motor terminal. Connect the battery cable to the battery. Install the front cowl cover and the wrap-around cowl, if one is used.

DISASSEMBLING

PINION GEAR WITH TOP SPRING

This type cranking motor uses a top spring to push the pinion gear down.

1- Move the pinion gear upward and place a wrench on the bottom side of the gear. Now, place a second wrench on the top nut. Hold firm with the first wrench and with the other wrench, back-off the nut. Remove and **DISCARD** the nut. Do not attempt to use the same nut a second time.



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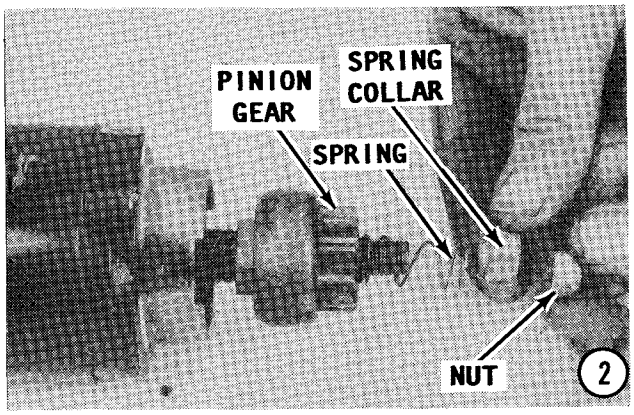


2- Remove the spring collar, spring, and pinion gear. If other work is to be performed on the cranking motor, proceed directly to the cranking motor repair section of this chapter.

CLEANING AND INSPECTING

Inspect the pinion gear teeth for chips, cracks, or a broken tooth. Check the splines inside the pinion gear for burrs and to be sure the gear moves freely on the armature shaft.

BAD NEWS

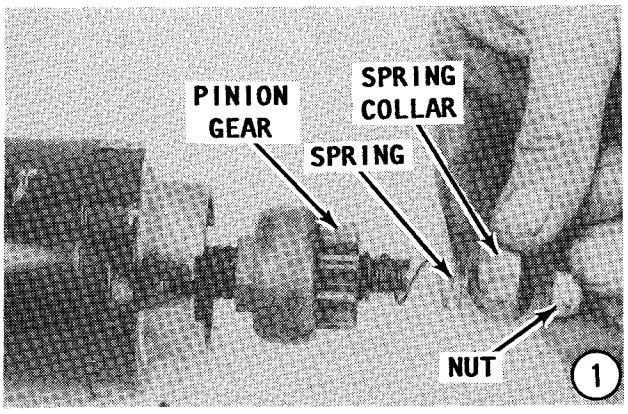
This type cranking motor pinion gear assembly cannot be repaired if the unit is defective. Replacement as a complete unit is the only answer.

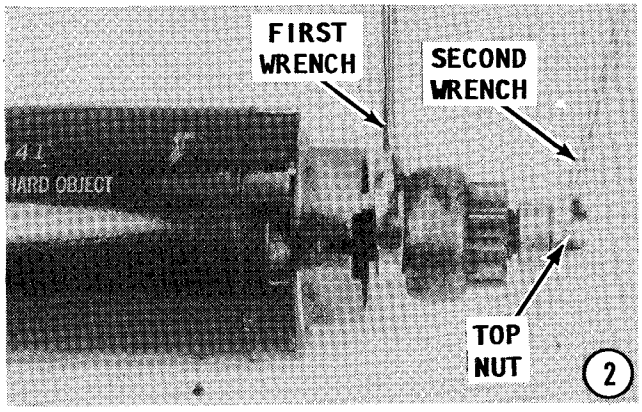
Clean the armature shaft and check to be sure the shaft is free of any burrs. If burrs are discovered, they may be removed with crocus cloth.

ASSEMBLING

PINION GEAR WITH TOP SPRING

1- Slide the pinion gear onto the armature shaft, then the spring and the spring collar. Start a **NEW** nut onto the armature shaft.





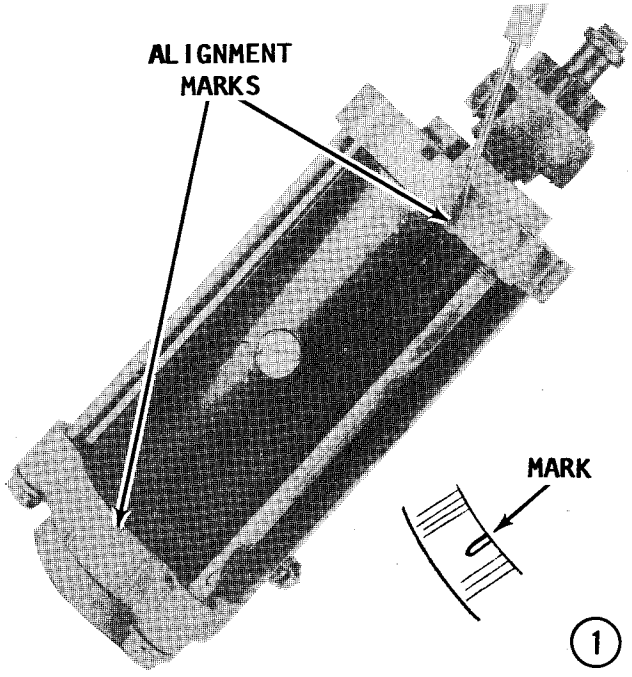
2- Place a wrench on the bottom side of the pinion gear and a second wrench on the nut. Hold firm with the first wrench and tighten the nut with the second wrench.

9-13 CRANKING MOTOR REPAIR

GOOD NEWS

If the only motor repair necessary is replacement of the brushes, the pinion gear does not have to be removed. All cranking motors have thru-bolts securing the upper and lower cap to the field frame assembly. In all cases both caps have some type of mark or boss. These marks are used to properly align the caps with the field frame assembly.

1- Observe the caps and find the identifying mark or boss on each. If the marks are not visible, make an identifying mark prior to removing the thru-bolts as an essential aid during assembling.



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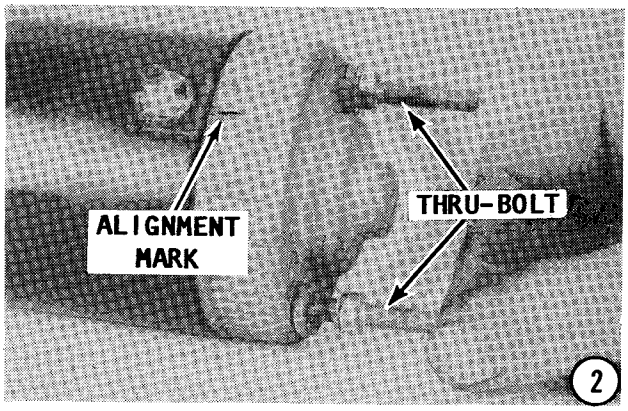
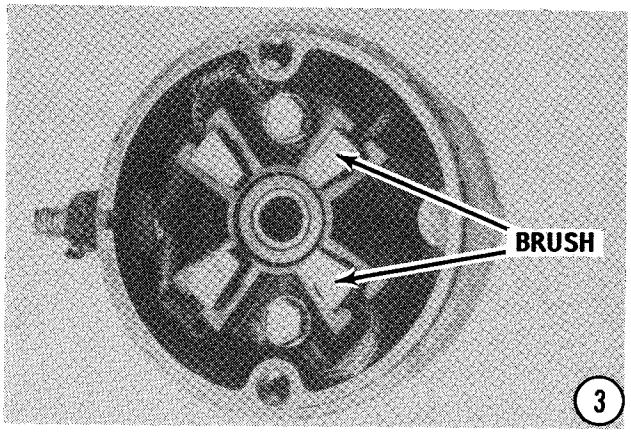




DISASSEMBLING

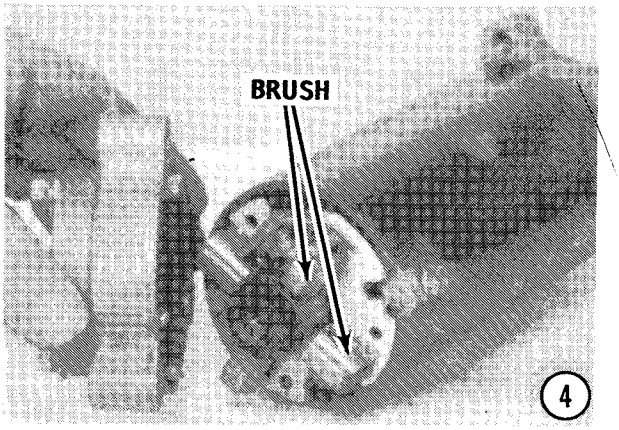
2- Remove the thru-bolts. On some models, the thru-bolts thread into the opposite cap, and on other models, a nut is used.

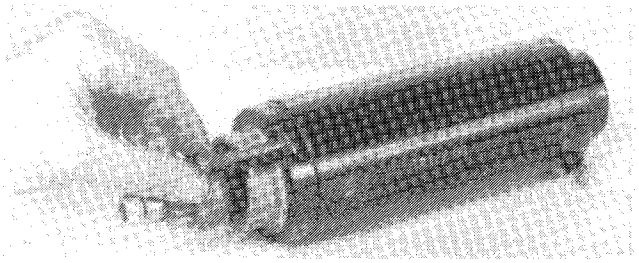
3- Remove the lower cap. On the Bosch motor, the brushes are mounted into the lower cap.

4- On the Delco Remy cranking motor, the brushes are mounted in the brush plate.

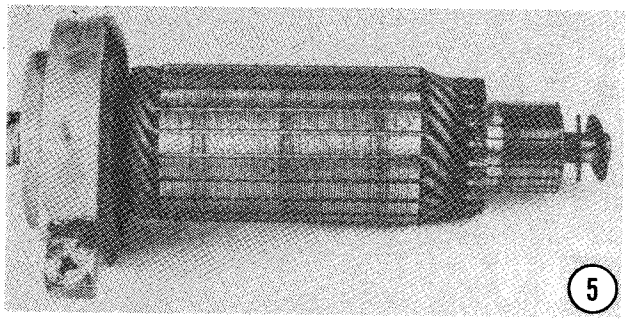
5- Pull on the armature shaft from the drive gear end and remove it from the field frame assembly.

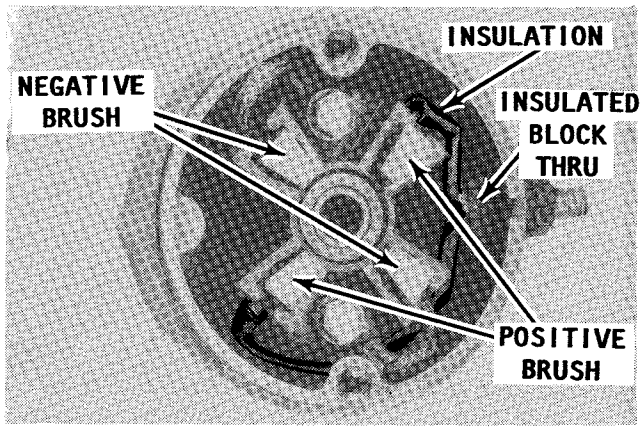
6- Remove the brushes from their holders, and then remove the brush springs.



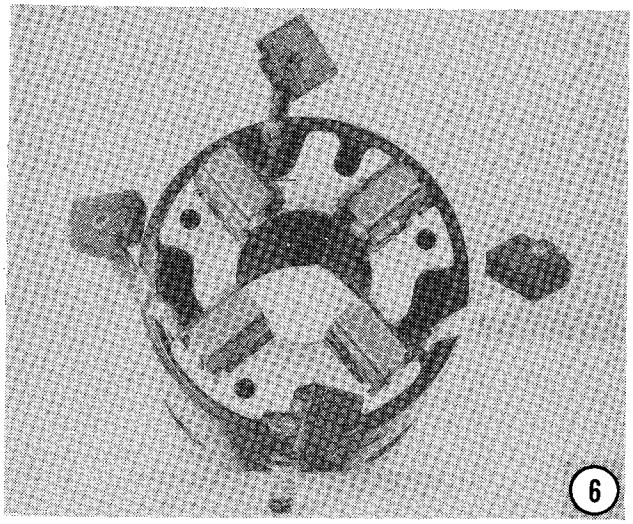


Removing the thru-bolts from the frame assembly of a Bosch cranking motor.





The end cap of a Bosch cranking motor showing arrangement of the positive and negative brushes.



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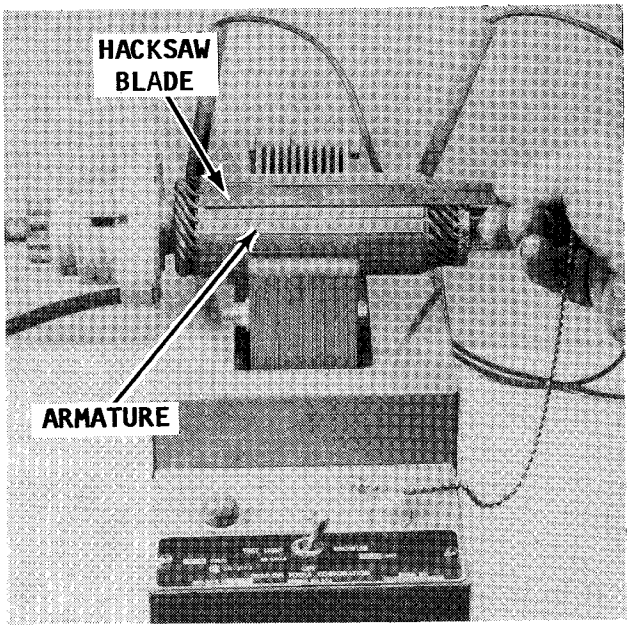


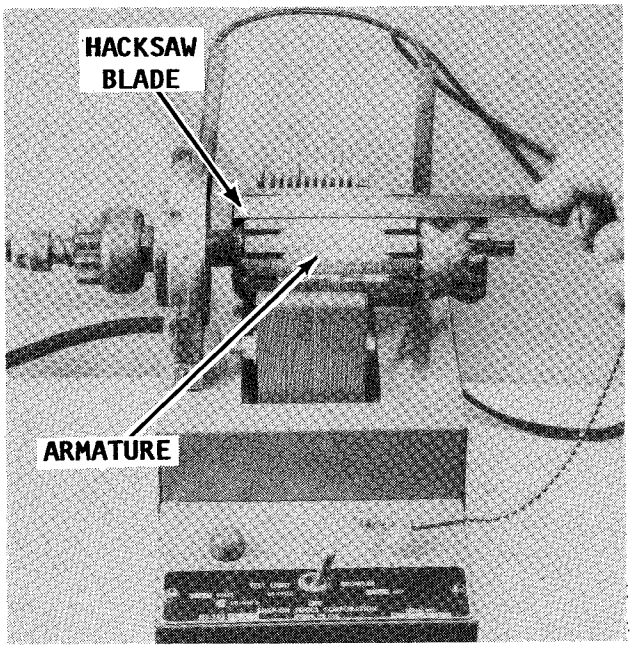
Using a hacksaw blade to check a Delco Remy armature on a growler, as explained in the text.

TESTING CRANKING MOTOR PARTS

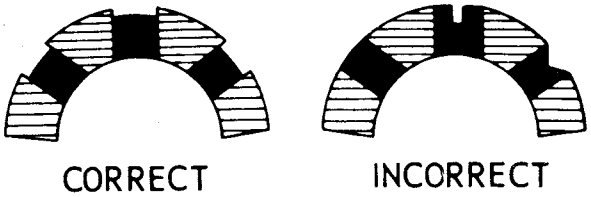
SPECIAL WORDS

Most marine shops and all electrical motor rebuild shops will test an armature for a modest charge. If the armature has a short, it **MUST** be replaced.

Check the armature for a short circuit by placing it on a growler and holding a hack saw blade over the armature core while the armature is rotated. If the saw blade vibrates, the armature is shorted. Clean between the armature bars, and then check again on the growler. If the saw blade still vibrates, the armature must be replaced. Occasionally carbon dust from the brushes will short the armature. Therefore, blow the slots in the armature clean with compressed air.



Using a hacksaw blade to check the armature of a Bosch cranking motor armature on a growler. If the hacksaw blade vibrates the armature has a short.

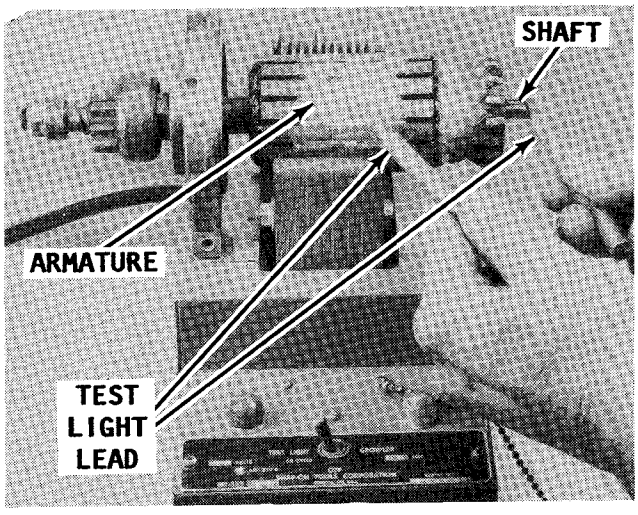


Comparison of armature segments properly cleaned (left) and improperly cleaned (right).

Make contact with one probe of the test light on the armature core or shaft. Make contact with the other probe on the commutator. If the light comes on, the armature is grounded and must be replaced.

Turning the Commutator

True the commutator, if necessary, in a lathe. **NEVER** undercut the mica because the brushes are harder than the insulation. Undercut the insulation between the commutator bars 1/32" (0.80mm) to the full width of the insulation and flat at the bottom. A triangular groove is not satisfactory. After the under-cutting work is completed, clean out the slots carefully to remove dirt and copper dust. Sand the commutator lightly with No. 00 sandpaper to remove any burrs left from the undercutt-



*Checking Bosch cranking motor armature to be sure there is **NO** continuity between the armature core and the armature shaft.*

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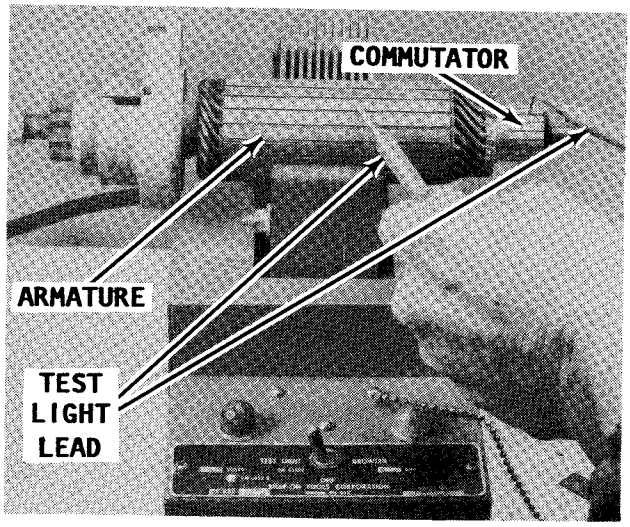
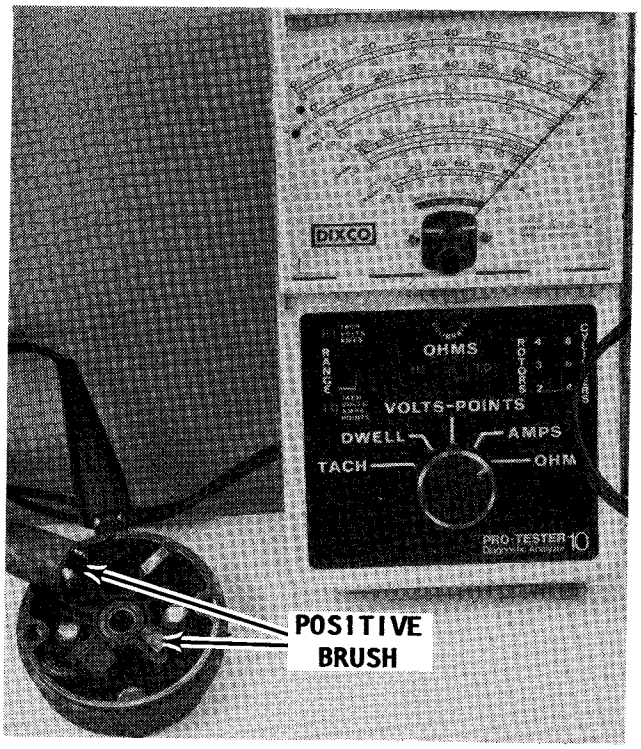


*Checking for **NO** continuity between the armature core and the commutator.*

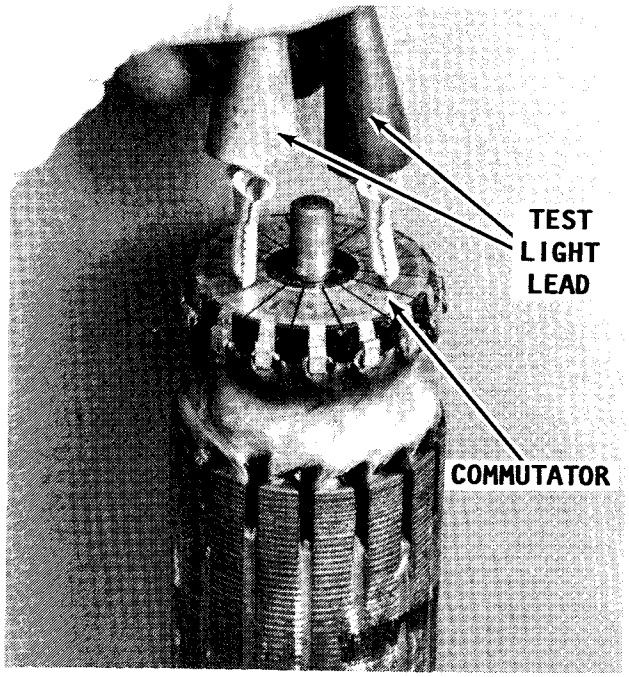
ing. Test light probes placed on any two commutator bars should light and indicate continuity. Check the armature a second time on the growler for possible short circuits.

Positive Brushes

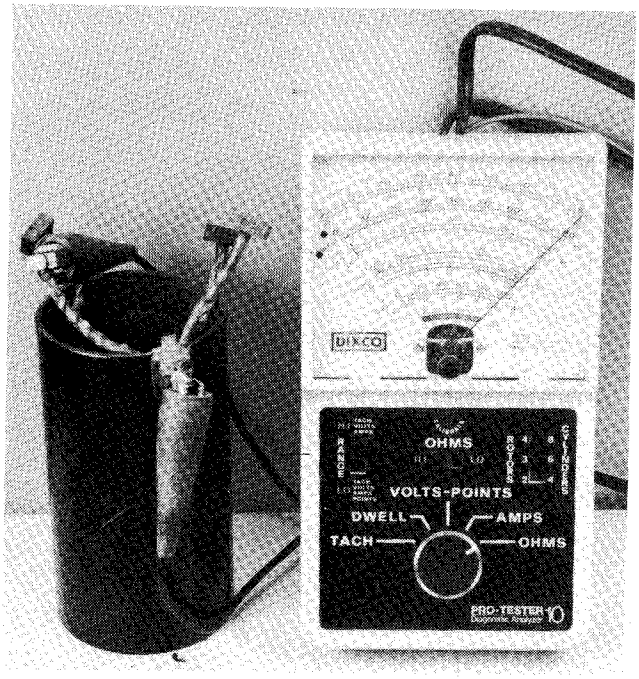
Obtain an ohmmeter. Connect each lead of the meter to the positive brushes. The ohmmeter **MUST** indicate continuity between the brushes. If the meter indicates any resistance, check the lead to the brush and the lead to the positive terminal solder connection. If the connection cannot be repaired, the brushes **MUST** be replaced.



Checking the positive brushes on the end cap of a Bosch cranking motor. One test lead is connected to the positive terminal of the cap; the other lead is alternately touched to the positive brushes. Continuity must be indicated.



Checking the continuity of the commutator bars on a Bosch cranking motor armature. If the test light leads make contact with any two bars the light should come on to indicate continuity.



Checking the positive brushes on a Delco Remy cranking motor. Each test lead is connected to a positive brush. Continuity must be indicated between the brushes.

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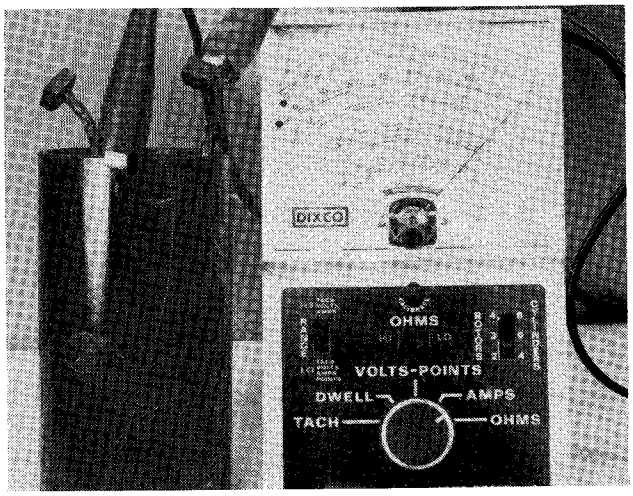


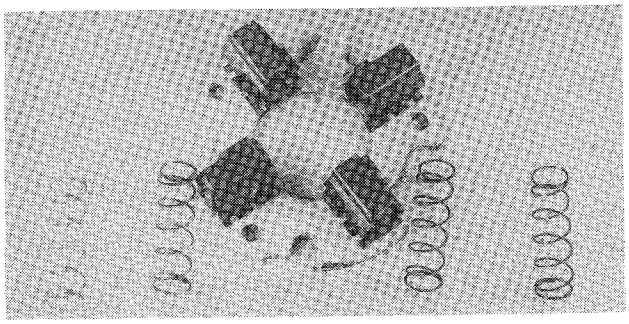
Checking the field coil and brushes, as explained in the text.

Field Coil — Negative Brush

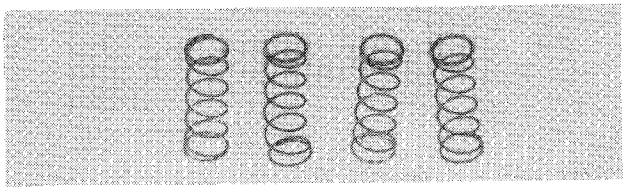
Obtain an ohmmeter. Make contact with one lead on the negative brush and make contact with the other lead on the starter frame. If the meter does not indicate continuity, the field coils are open and **MUST** be replaced.

Move the test lead from the negative brush to the other negative brush lead and again check for continuity. If the meter does not indicate continuity, the field coils are open and **MUST** be replaced.

After the field coil and brush assembly has been installed into the frame, the frame and field assembly should be carefully checked to be sure none of the soldered connections are touching the frame. The fields would be grounded if the connections make contact with the frame.



Brush holder plate and springs of a Delco Remy cranking motor. The springs must all be the same height, have the same amount of tension, and show no sign of overheating. A blueish color indicates the spring has overheated.



Springs from a Bosch cranking motor. The springs must all be the same height, have the same amount of tension and show no sign of overheating.

CLEANING AND INSPECTING

Clean the field coils, armature, commutator, armature shaft, brush-end plate and drive-end housing with a brush or compressed air. Wash all other parts in solvent and blow them dry with compressed air.

Inspect the insulation and the unsoldered connections of the armature windings for breaks or burns.

Perform electrical tests on any suspected defective part, according to the procedures outlined in Section 9-12.

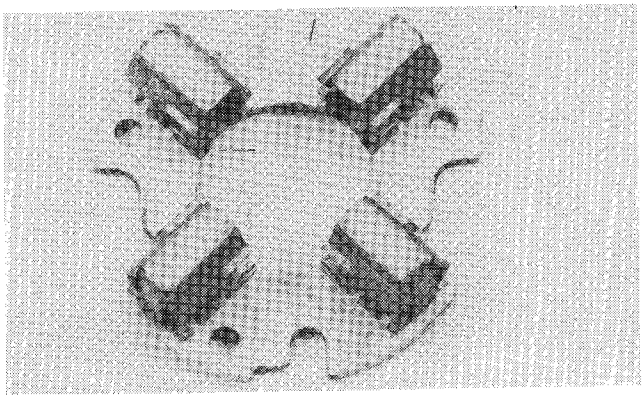
Check the commutator for run-out. Inspect the armature shaft and both bearings for scoring.

Turn the commutator in a lathe if it is out-of-round by more than 0.005" (0.13mm).

Check the springs in the brush holder to be sure none are broken. Check the spring tension and replace if the tension is not 32-40 ounces (900-1135 gm). Check the insulated brush holders for shorts to ground. If the brushes are worn down to 1/4" (6.35mm) or less, they must be replaced.

Check the field brush connections and lead insulation. A brush kit and a contact kit are available at your local marine dealer, but all other assemblies must be replaced rather than repaired.

The armature, fields, and brush holders must be checked before assembling the starter motor. See the testing section in this chapter for detailed procedures to test the cranking motor.



Delco Remy brush holder assembly. The four holders should be firmly secured to the plate. If any one holder is loose, the assembly must be replaced.

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Brushes — Field Frame Mounted

The following procedures apply to brushes mounted to the field frame assembly.

First, remove the old set of ground brushes by cutting off the rivets with a chisel or by drilling them out. Replacement brush holder kits are available at marine outlets. These kits are complete with screws, washers, and nuts for attachment to the frame. Replacement brush springs are also available. The brush spring is removed from the holder by compressing one side of the spring with a small screwdriver until the spring flips out of its seat. After the spring pops out, turn the spring clockwise until it is free of the holder.

Replacement brush sets are available and usually contain the following parts:

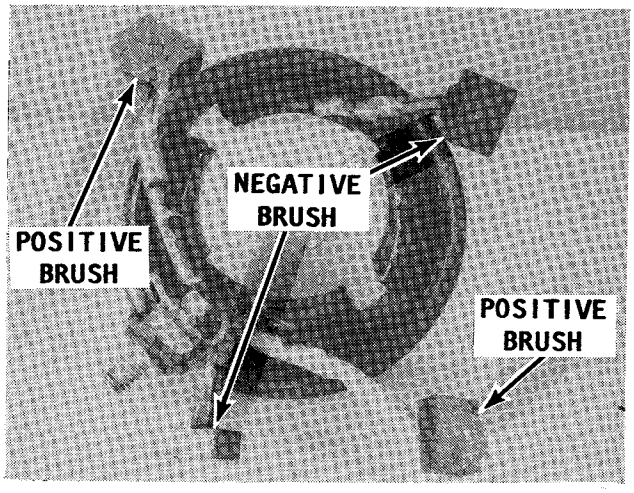
Two insulated brushes, with flexible leads attached.

Two ground brush holders with brushes and leads attached.

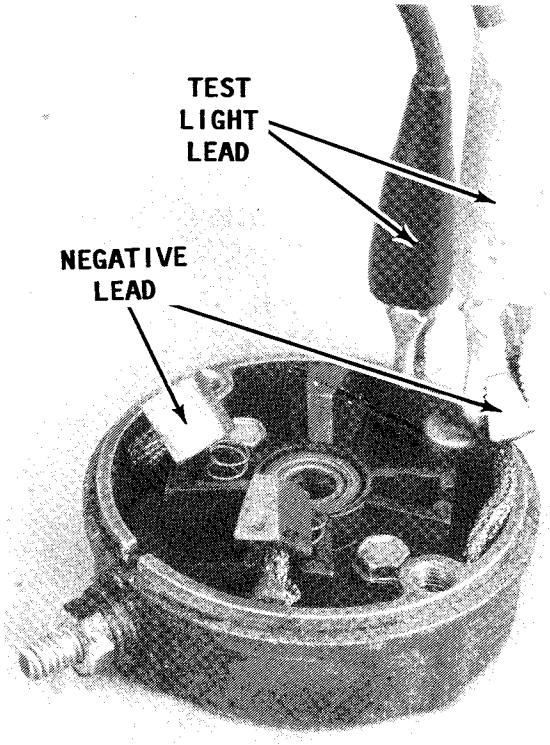
Necessary attaching screws, washers, and nuts.

Cut off the old brush leads where they are attached to the field coils. Prepare the ends of the coils for soldering the new brush lead assemblies. Clean the ends of the coils by filing or grinding off the old brush lead connections. Remove the varnish only as far back as necessary to enable a good soldered connection to be made.

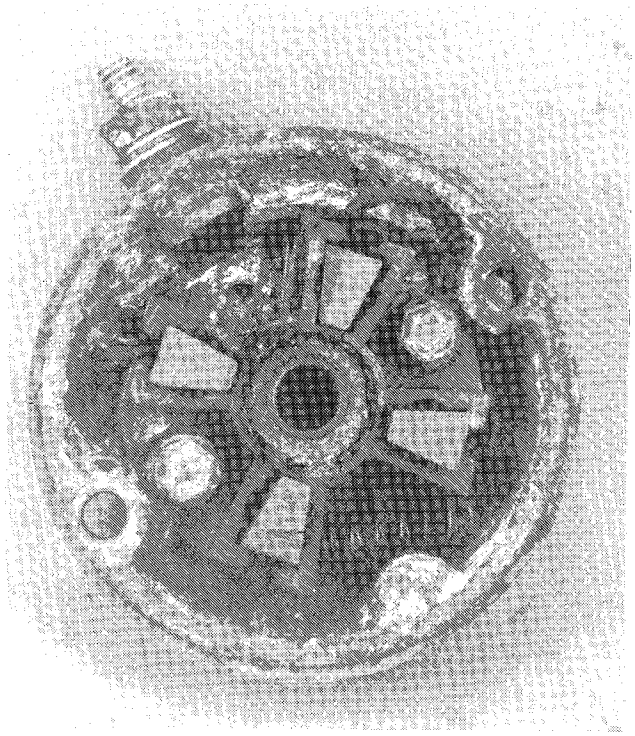
Use rosin flux and solder the leads to the **BACK SIDES** of the coil to prevent any excess solder from rubbing against the armature. Be sure the leads are in the right position to reach the brush holders. Do not overheat the leads, because the solder will run onto the lead and the lead will loose its flexibility.



The positive and negative brushes of a Delco Remy cranking motor.



Checking the field brushes on the end cap of a Bosch cranking motor. One test lead is connected to the frame; the other lead is connected alternately to the brush leads. Continuity must be indicated.



Example of a questionable end cap removed from a Bosch cranking motor. Note the loose spring escaped from beneath one of the brushes. A unit in this condition must be carefully inspected, cleaned, and worn parts replaced before returning it to service.

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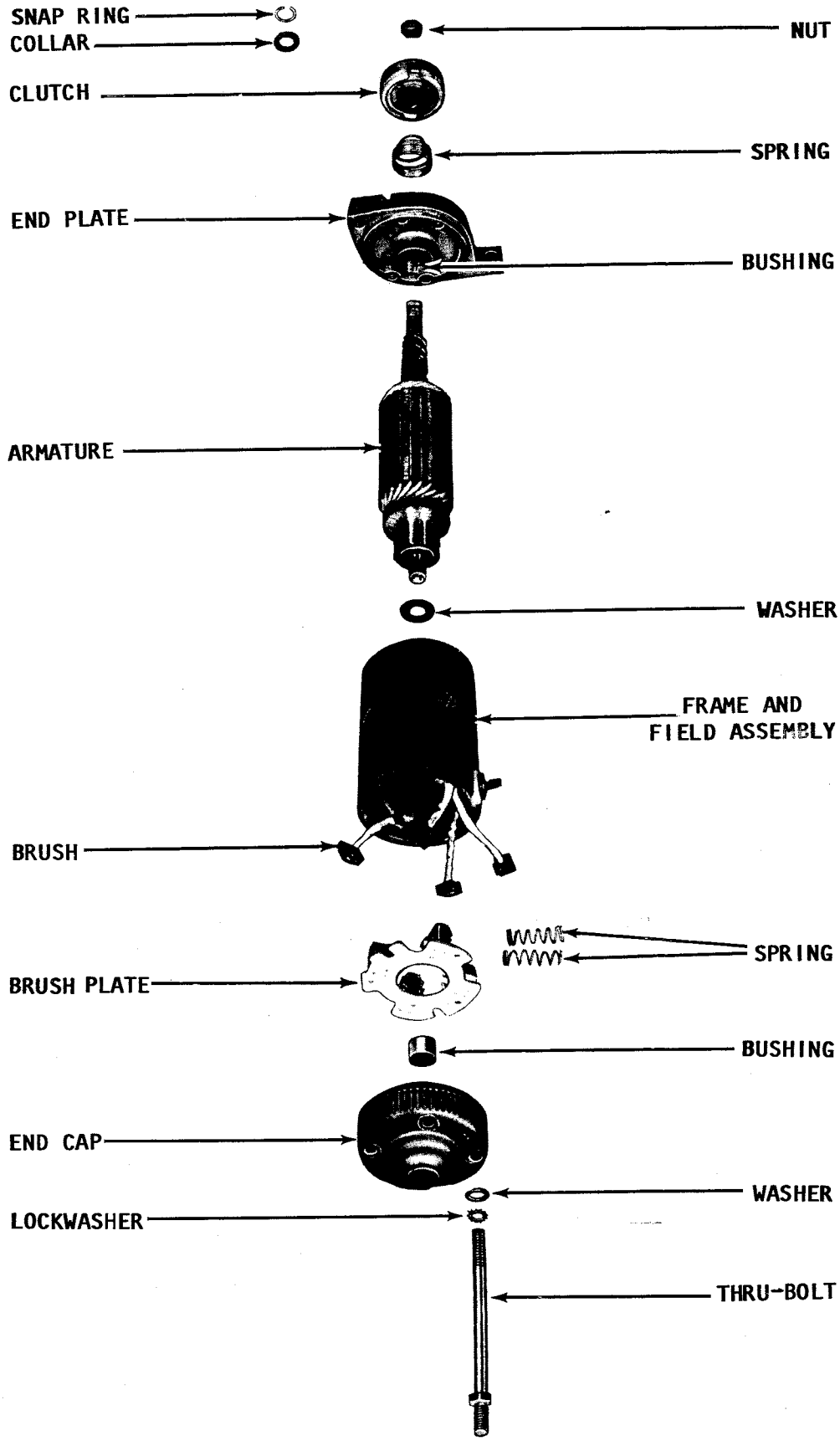

Exploded drawing of a Delco Remy cranking motor with major parts identified.

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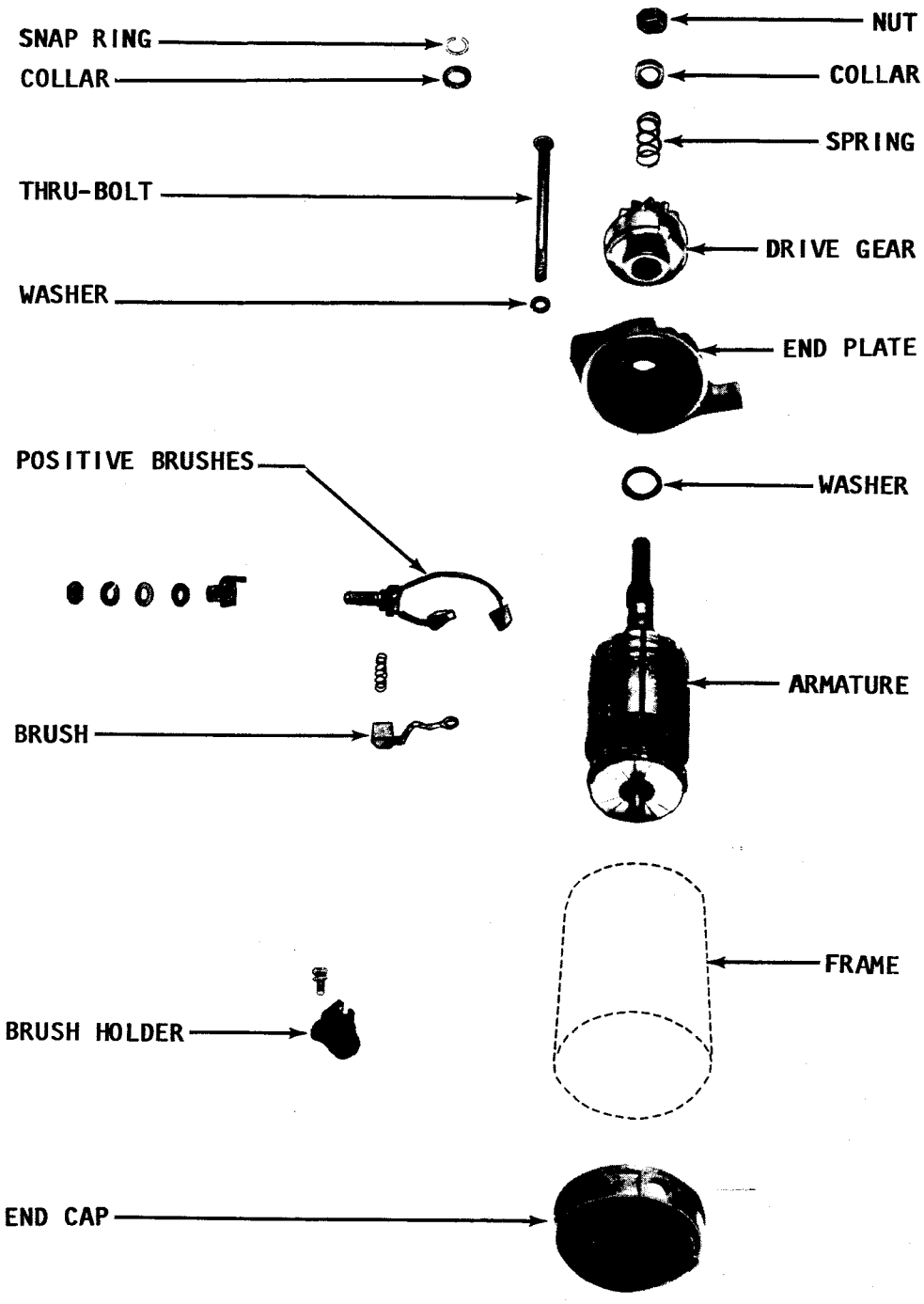

Exploded drawing of a Bosch cranking motor with major parts identified.

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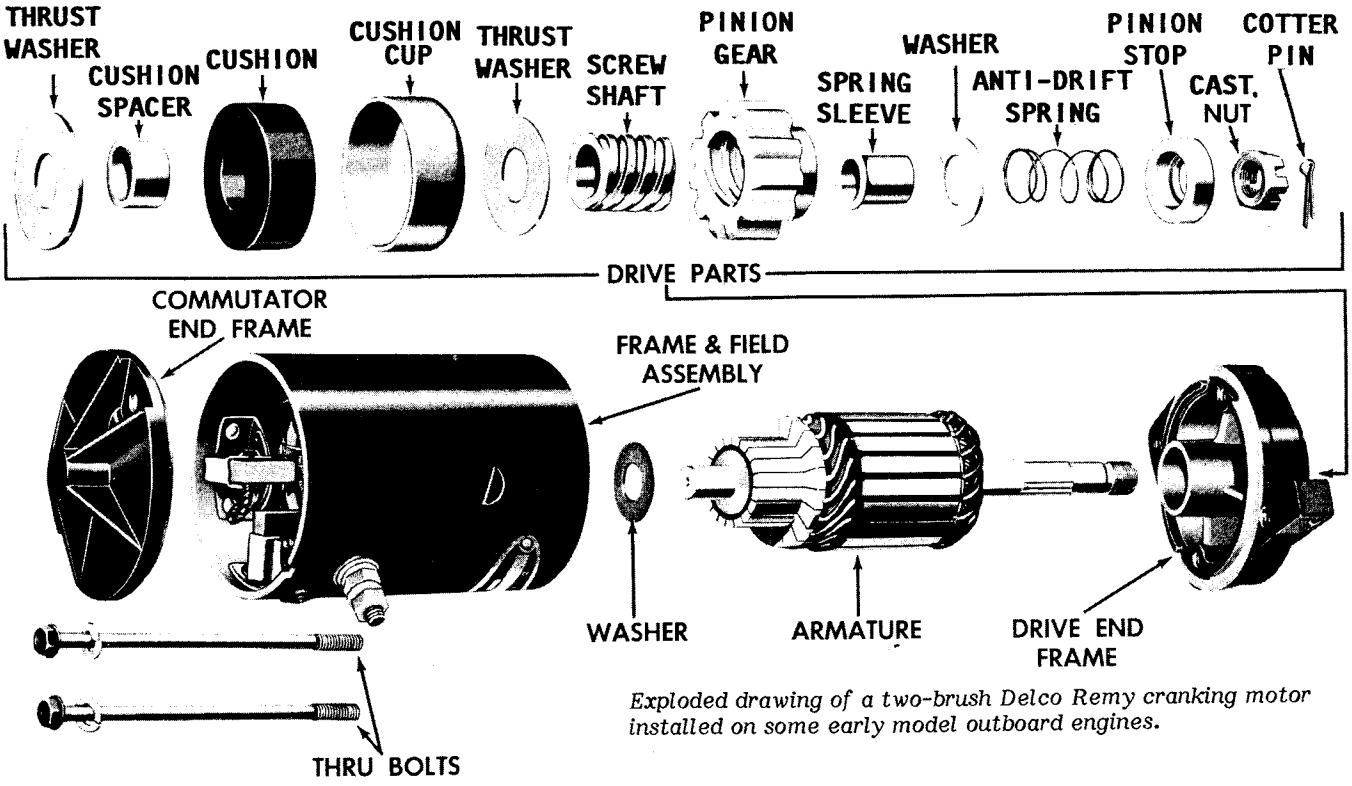
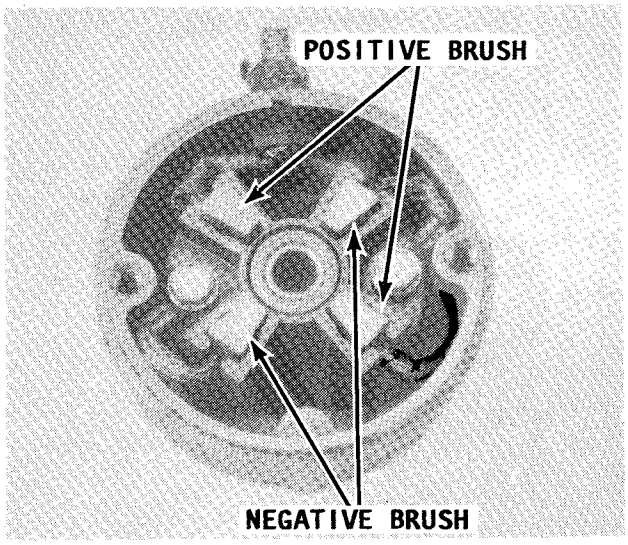


Exploded drawing of a two-brush Delco Remy cranking motor installed on some early model outboard engines.

Brushes — Delco Remy

The positive leads of the Delco Remy cranking motor are attached to the positive terminal of the motor. The terminal can be slipped out of the field frame assembly.

If the positive brushes require replacement, the brushes can be purchased with a new terminal as an assembly. The negative brushes are soldered to the field and can be removed by melting the soldered joint. The lead of the new brush is then soldered to the field terminal.



End cap of a Bosch cranking motor with the positive and negative brushes properly installed.

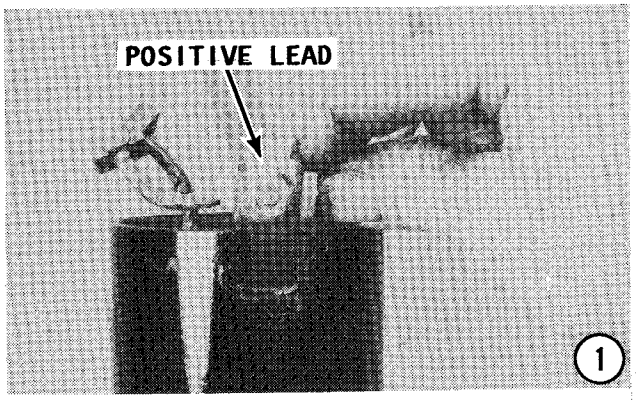
After the negative brushes are installed, slip the positive brush set into the slot of the field assembly and you're home free.

Brushes — Bosch

Both the positive and negative brushes on a Bosch cranking motor are mounted in the lower cap. The positive brushes are attached to the positive terminal and are sold as an assembled set. The negative brushes are attached to the lower cap with a bolt.

To remove the positive brushes, slip the terminal out of the slot in the cap. The negative brushes are removed by simply removing the two bolts attaching the brush lead to the lower cap.

Installation of the new positive brushes is accomplished by sliding the new positive terminal into the slot of the end cap. Install



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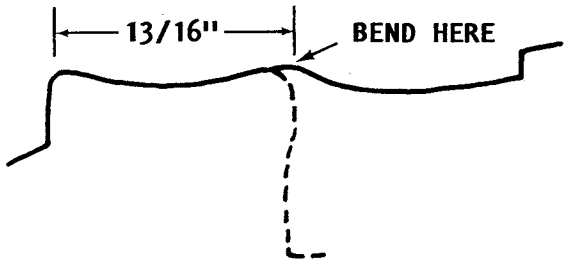


Rough sketch of a tool to hold the brushes in place while assembling a Delco Remy cranking motor.

the negative brushes by positioning them in place in the lower cap, and then securing the leads with the attaching bolts.

ASSEMBLING A BOSCH CRANKING MOTOR

Clamp the pinion gear in a vise equipped with soft jaws and with the pinion gear down. Insert the brush springs into the brush holders, and then install the brushes in place. Hold the two brushes in the holder and at the same time, lower the field frame assembly down onto the armature. Lower the field frame assembly until the brushes make contact with the commutator.

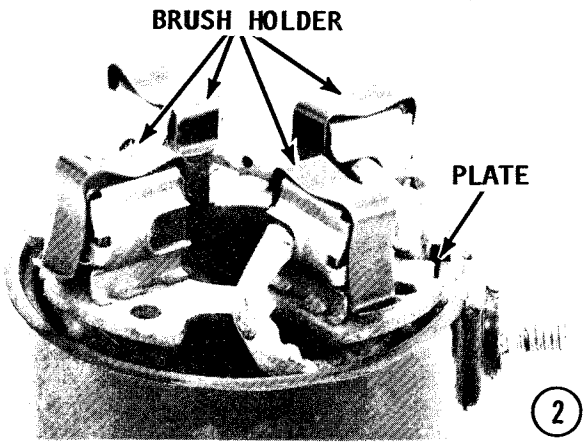
Align the mark on the upper cap with the matching mark on the field frame. Place the washer onto the commutator shaft, then place the cap onto the end of the field frame assembly. Align the mark on the lower cap with the mark on the field frame.

Install the thru-bolts and tighten them securely into the opposite end cap or with nuts, depending on the type of starter being serviced.

Place the cranking motor on the floor. To test operation of the motor, first connect one lead from a set of jumper cables to the positive terminal of a battery. Connect the other end of the same lead to the positive terminal of the motor. Connect one end of the second lead of the jumper cables to the negative terminal of the battery.

Now, hold the motor firmly on the floor with one foot, as shown, and at the same time, momentarily make contact with the other end of the second jumper lead to one of the thru-bolts. The pinion gear should spin rapidly.

Slide the rubber collars and spacer onto the starter, if they are used. Install the cranking motor onto the engine and secure it in place with the clamps and mounting bolts. Check to be sure the Black ground cable is attached with the lower mounting bolt. Connect the Black ground cable to the negative (-) cranking motor terminal and the Yellow cable to the positive (+) terminal. Install the front cowl cover and the wrap-around cowl, if one is used. Connect the positive (+) lead to the battery terminal.

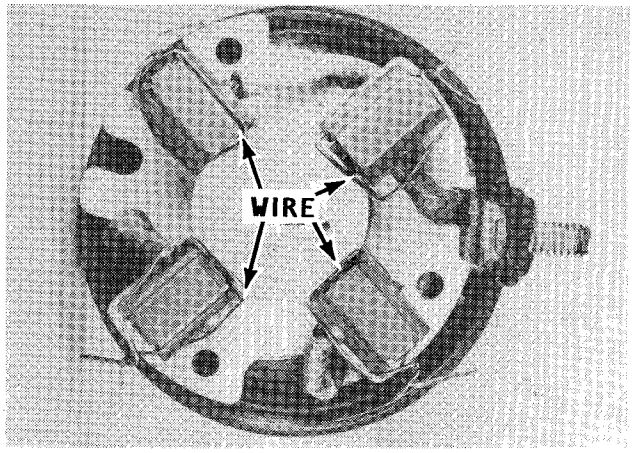


ASSEMBLING A DELCO REMY CRANKING MOTOR

1- Clamp the pinion gear in a vise equipped with soft jaws and with the drive gear down. Slide the positive terminal with the brushes attached, into the slot of the field frame assembly. Place the brush holder plate in position with the field leads and the positive brush lead inserted through the terminal holes.

ADVICE: Work one brush at-a-time.

2- Place the brush spring into the brush holder, and then install the brush. Use the



If a special tool cannot be made, the brushes may be wired in place to permit installation of the commutator on a Delco Remy cranking motor. The wire is removed later.

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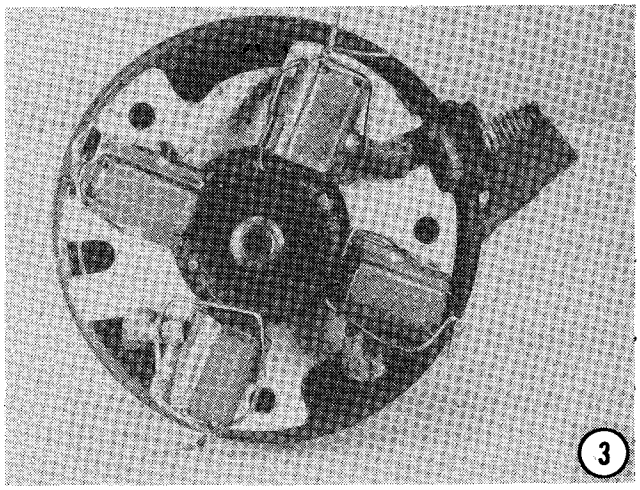


spiral tool, as shown, or tie each brush with wire to hold it down inside the holder.

Now, repeat the procedure with the other brushes.

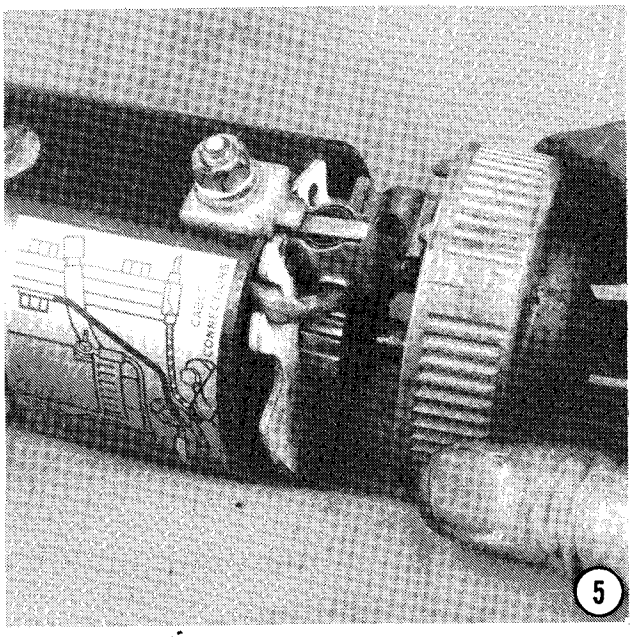
3- Lower the field frame assembly over the armature. Continue to lower the assembly until the brushes are over the commutator. Align the field frame assembly mark with the mark on the upper cap.

4- Remove the spiral brush holder or the wire tie used to hold the brushes in place. Install the washer on the armature.

5- Position the end cap onto the field frame with the dowel pins indexed into the holes of the brush holder.

6- Install the thru-bolts and tighten them securely.

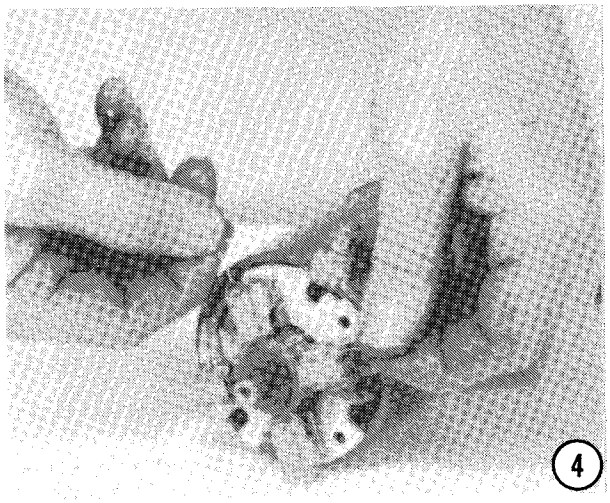
7- Place the cranking motor on the floor. To test operation of the motor, first connect one lead from a set of jumper cables to the positive terminal of a battery. Connect the other end of the same lead to the positive terminal of the motor. Connect one end of the second lead of the jumper

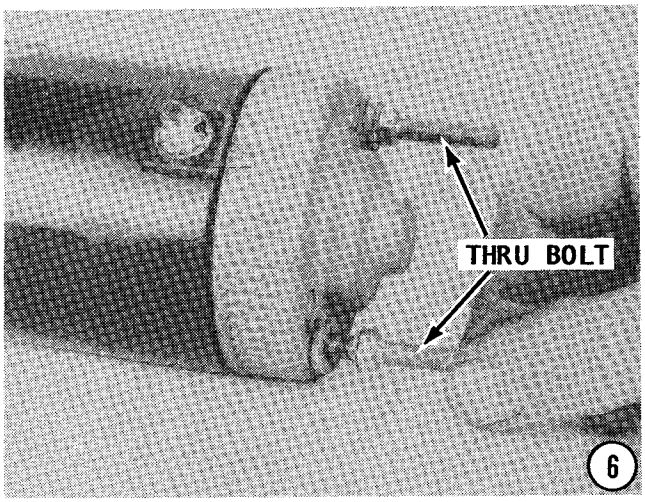


cables to the negative terminal of the battery.

Now, hold the motor firmly on the floor with one foot, as shown, and at the same time, momentarily make contact with the other end of the second jumper lead to one of the thru-bolts. The pinion gear should spin rapidly.

Slide the rubber collars and spacer onto the starter, if they are used. Install the cranking motor onto the engine and secure it in place with the clamps and mounting bolts. Check to be sure the Black ground cable is attached with the lower mounting bolt. Connect the Black ground cable to the negative (-) cranking motor terminal and the Yellow cable to the positive (+) terminal. Install the front cowl cover and the wrap-around cowl, if one is used. Connect the positive (+) lead to the battery terminal.





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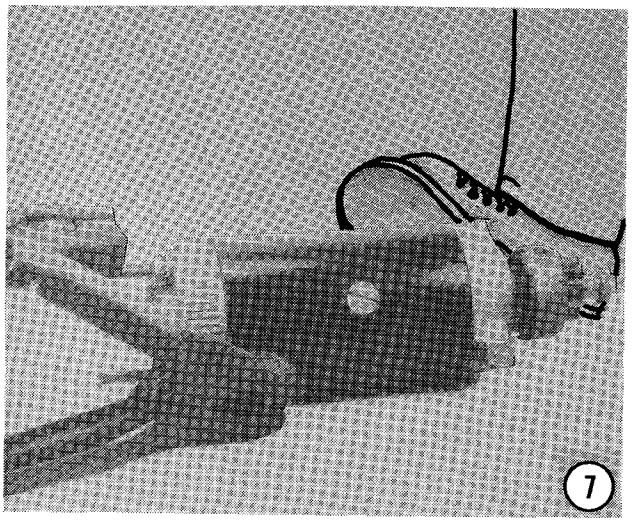
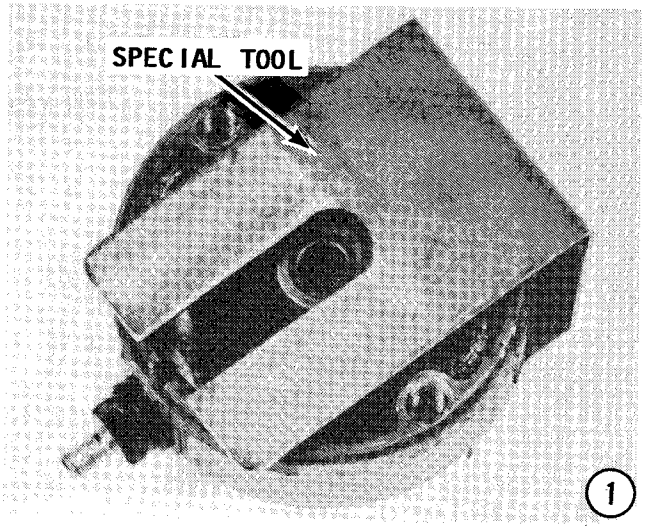




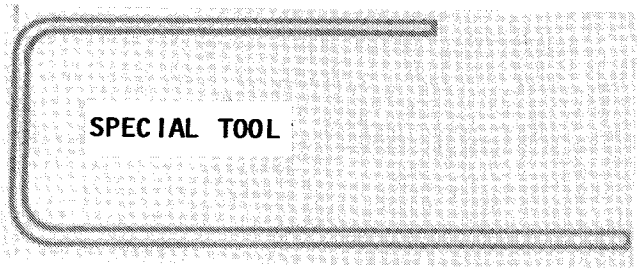
Assembling a Bosch Using Special Tool

Make a tool as shown in the accompanying illustration to prevent the brushes from being damaged during installation of the commutator end cap. If a special tool is not possible, see the next section, Assembling a Bosch Cranking Motor Without a Special Tool.

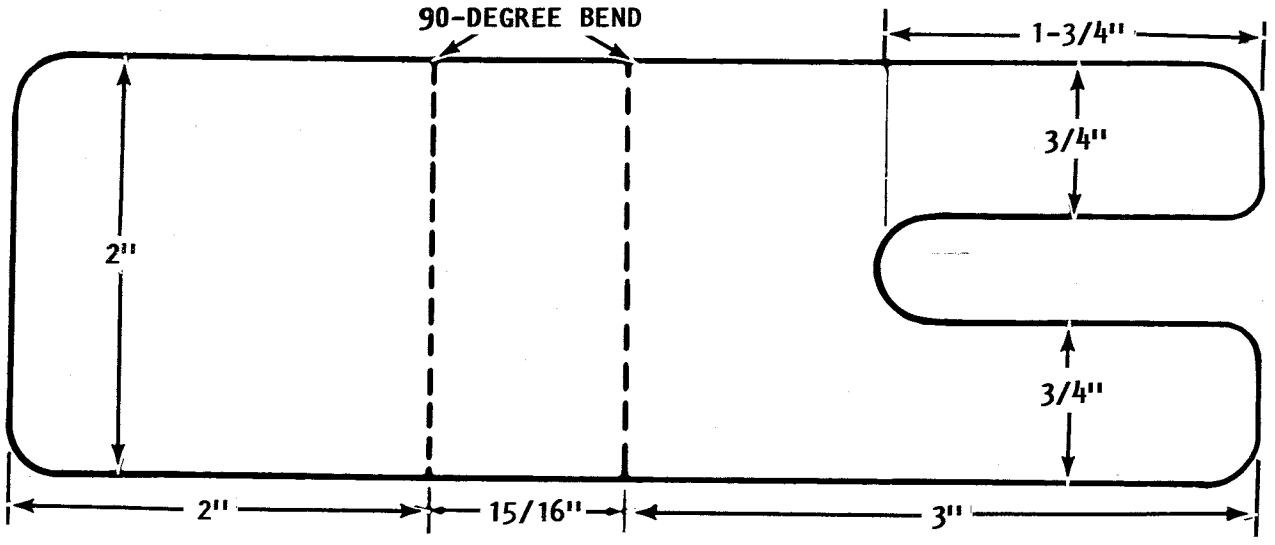
1- Slide the brush springs into the brush holders, and then install the positive and negative leads. Position the special tool over the cap and brushes to hold the brushes in place.

2- Clamp the drive gear in a vise equipped with soft jaws and with the drive gear down. Lower the frame assembly over the armature. Align the marks on the frame assembly with the marks on the upper end cap.

3- Position the lower end cap onto the frame assembly. Lower the cap as far as it will go, and then remove the special tool. Now, align the mark on the cap with the mark on the frame, and then install the thru-bolts and tighten them securely.



Special tool required to install the end cap on a Bosch starter motor. If this tool is not available, special instructions and an illustration are included later in this section.



Working diagram for making a special tool to hold the brushes in place during installation of a Bosch end cap.

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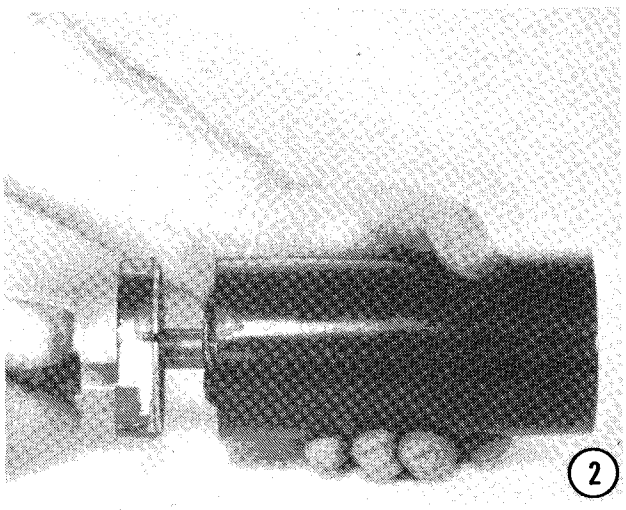
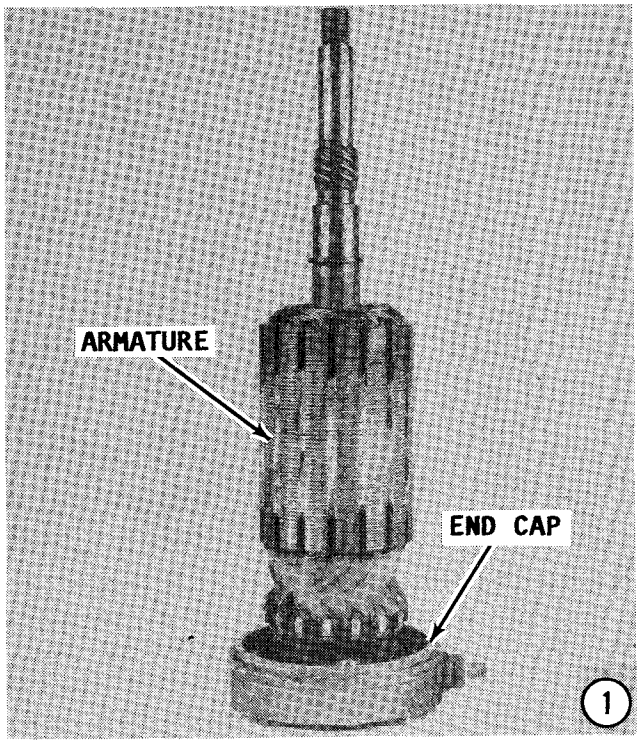
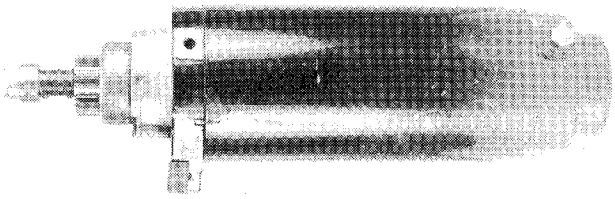


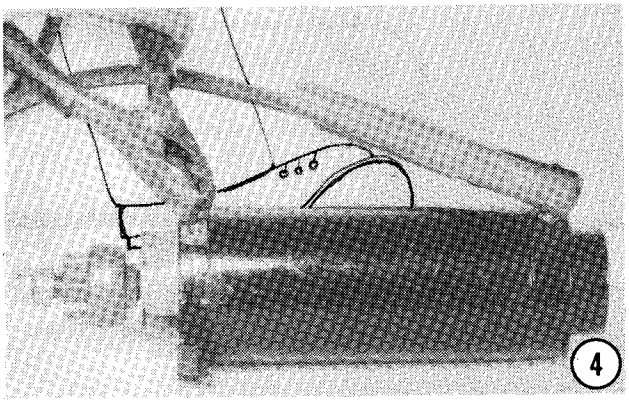
4- Place the cranking motor on the floor. To test operation of the motor, first connect one lead from a set of jumper cables to the positive terminal of a battery. Connect the other end of the same lead to the positive terminal of the motor. Connect one end of the second lead of the jumper cables to the negative terminal of the battery.

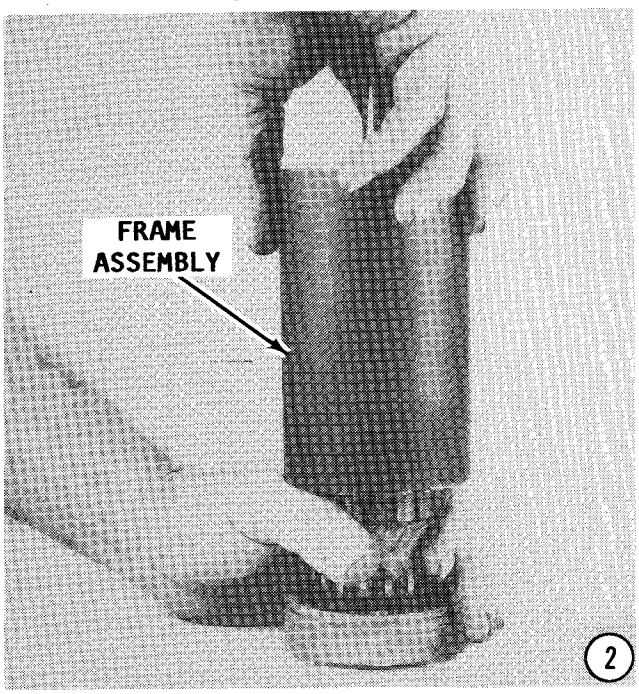
Now, hold the motor firmly on the floor with one foot, as shown, and at the same time, momentarily make contact with the other end of the second jumper lead to the cranking motor case. The pinion gear should spin rapidly.



Slide the rubber collars and spacer onto the starter, if they are used. Install the cranking motor onto the engine and secure it in place with the clamps and mounting bolts. Check to be sure the Black ground cable is attached with the lower mounting bolt. Connect the Black ground cable to the negative (-) cranking motor terminal and the Yellow cable to the positive (+) terminal.







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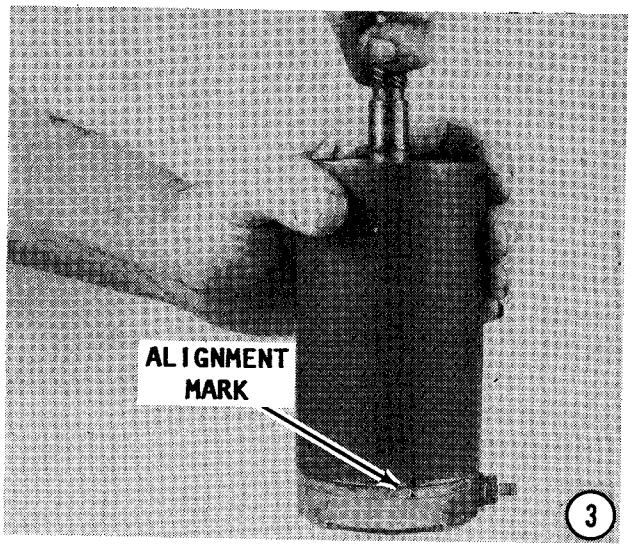
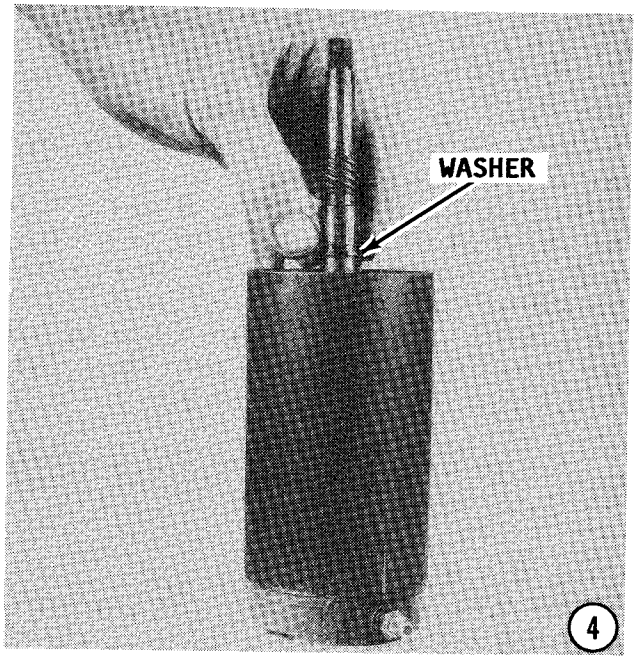
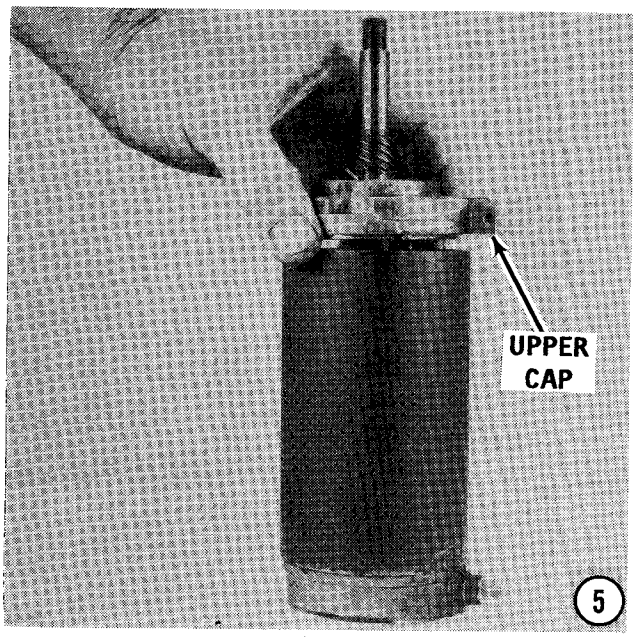


Install the front cowl cover and the wrap-around cowl, if one is used. Connect the positive (+) lead to the battery terminal.

Assembling Bosch Cranking Motor Without Special Tool

1- Install the brush springs into the brush holder, and then place each brush on top of the springs. Lay the end cap on the bench with the brushes facing up. Pickup the armature and place the commutator on top of the brushes. Lower the armature and at the same time, work each brush into its holder. Continue to lower the armature until the full weight of the armature is on the brushes.





2- Now, very **CAREFULLY** lower the frame assembly down over the armature. **TAKE CARE** because the magnets in the frame assembly will tend to pull against the armature.

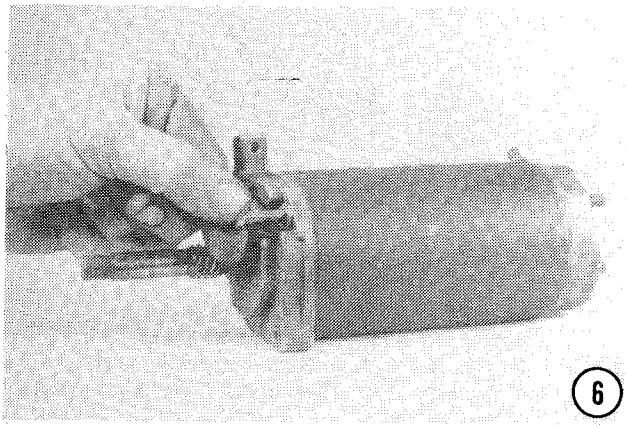
3- When the frame makes contact with the lower cap, align the marks on the cap and the frame.

4- Slide the upper cap washer onto the shaft.

5- Install the upper cap with the mark on the cap aligned with the mark on the frame.

6- Install the thru-bolts and tighten them securely. Install the pinion gear and secure it in place with a new locknut.

7- Place the cranking motor on the floor. To test operation of the motor, first connect one lead from a set of jumper cables to the positive terminal of a battery. Connect the other end of the same lead to the positive terminal of the motor. Connect



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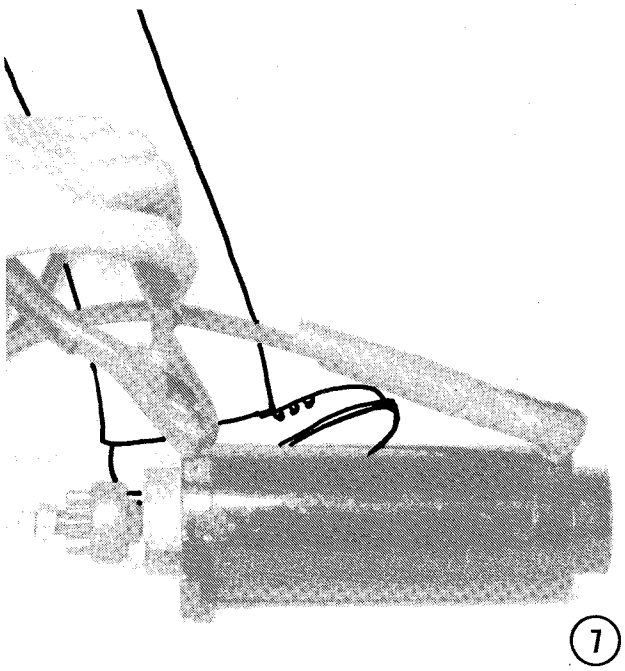
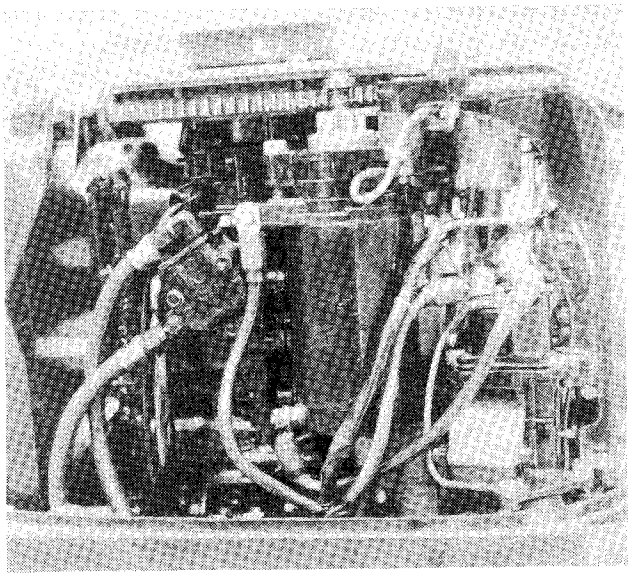


7

one end of the second lead of the jumper cables to the negative terminal of the battery.

Now, hold the motor firmly on the floor with one foot, as shown, and at the same time, momentarily make contact with the other end of the second jumper lead to the case. The pinion gear should spin rapidly.

Slide the rubber collars and spacer onto the starter, if they are used. Install the cranking motor onto the powerhead and secure it in place with the clamps and mounting bolts. Check to be sure the Black ground cable is attached with the lower mounting bolt. Connect the Black ground cable to the negative (-) cranking motor terminal and the Yellow cable to the positive (+) terminal. Install the front cowl cover and the wrap-around cowl, if one is used. Connect the positive (+) lead to the battery terminal.



A rebuilt cranking motor installed on the powerhead. If the work has been properly executed, as described in the text, the motor will give years of trouble-free service.

ASSEMBLING A PRESTOLITE CRANKING MOTOR

1- Check to be sure the brush leads are properly connected. The positive brushes have insulated jackets and the negative brush leads do not. The positive leads are soldered to the field windings, and the negative leads are soldered to the plate assembly.

GOOD WORDS

Detailed instructions for installation of the brushes are included in the brush replacement kit.

Assemble the various parts of the stud in the sequence as indicated in the exploded drawing on Page 9-47. After the stud parts have been assembled, check to be sure the stud is properly insulated from the cranking motor housing. Insulation may be verified with an Ohmmeter. Make contact with one lead of the ohmmeter to the stud and the other lead to an unpainted surface of the housing. The meter should indicate **NO** continuity.

2- Insert the brush plate assembly into the cranking motor housing. Feed the brushes through the proper opening with each spring snaped against the back of the brush. Check to be sure the wiring is routed as shown in the accompanying illustration and the insulated leads of the positive brushes protect the lead from making contact with any part of the frame or the negative leads. Connect the shunt field Green wire to the brush plate.

Secure the plate with the three attaching screws and lockwashers.

CRITICAL WORDS

Do not overlubricate the items mentioned in the next step.

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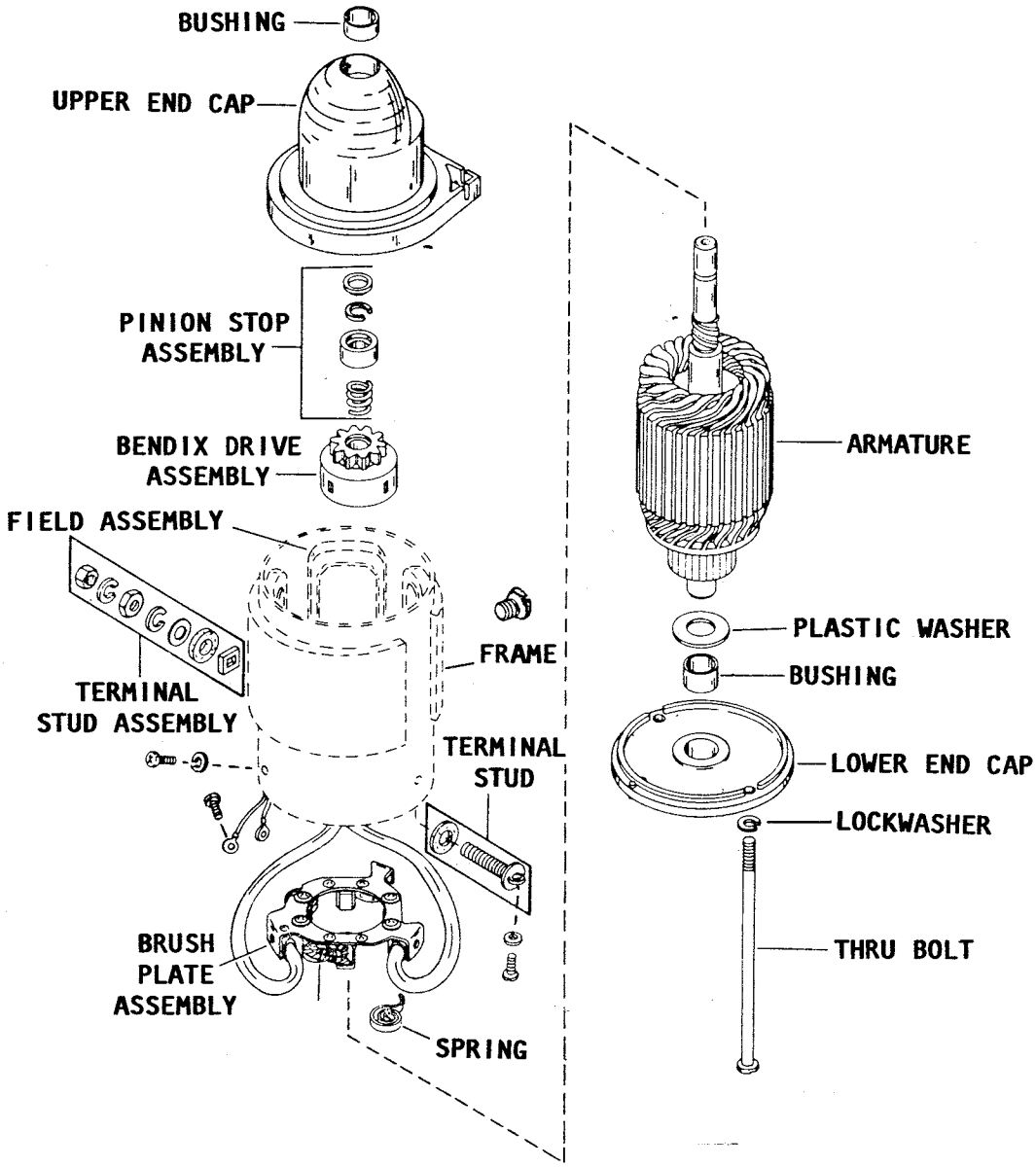

Exploded drawing of a heavy duty Prestolite cranking motor, used on the larger horsepower powerheads covered in this manual. Major parts are identified.

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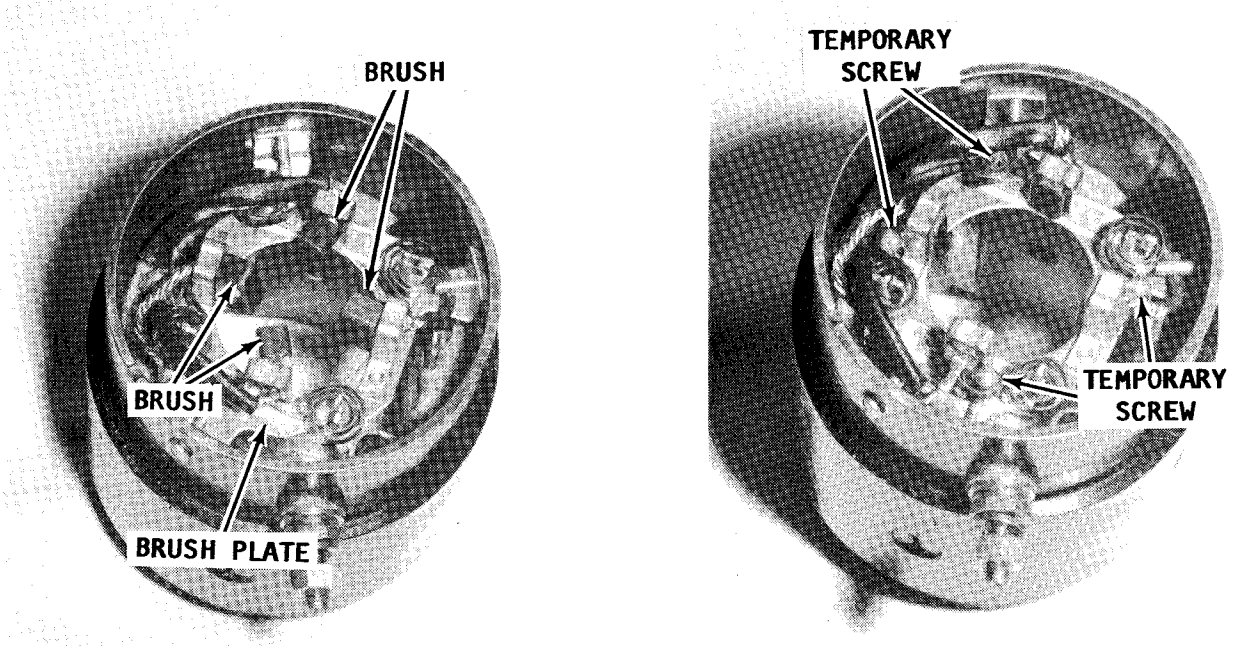
3- Lubricate the bushing in each end cap with just a **DROP** of SAE 10W oil or equivalent. Apply just a **DROP** of oil onto the helical threads of the armature shaft.

4- Assemble the bendix drive assembly and the pinion stop assembly onto the armature shaft in the sequence shown in the exploded drawing on Page 9-47. Check to be sure the shoulder washer is installed with the shoulder facing **TOWARDS** the motor.

5- Obtain four small screws of convenient size. Push the each brush back flush with its holder, and then insert one screw in front of the spring and behind the plate. The screw will hold the brush in the retracted position while the armature is being installed. **DO NOT** forget to remove the four screws after the armature is in place. Insert the armature through the housing with the shaft extending up through the brush plate assembly. **REMOVE** the four screws holding the brushes in the retracted position.

6- Slide the plastic washer onto the shaft. Install the upper and lower end caps. Slip a lockwasher onto each thru-bolt, and then feed the thru-bolts through the lower end cap, the housing, and into the upper end cap. Tighten the thru-bolts securely.



The cranking motor installed on the larger horsepower powerheads is a much heavier duty unit than those installed on intermediate size powerheads covered in this manual. Service procedures are almost identical to the other cranking motors covered in this chapter with the exception of the brush plate (left), and the method of holding the brushes back while the armature is installed (right). Push each brush back and hold it in the retracted position by slipping a small screw, as shown, between the plate and the brush. Do not forget to remove the screws after the armature is in place.

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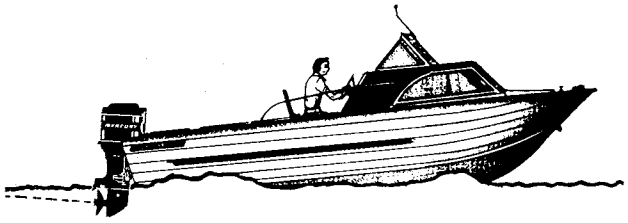
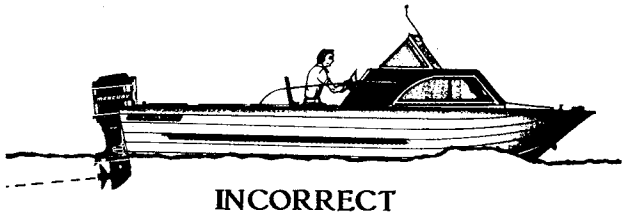
10
TRIM/TILT

10-1 INTRODUCTION

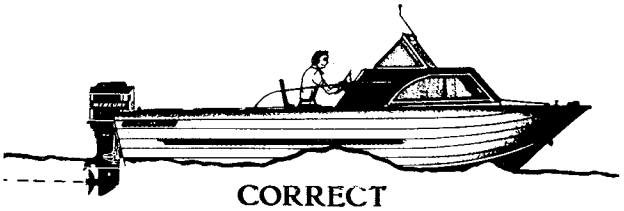
All outboard engine installations are equipped with some means of raising or lowering the lower unit for efficient operation under various load, boat design, and water conditions. The most simple form is a mechanical tilt adjustment consisting of a series of holes in the transom mounting bracket through which an adjustment pin passes through to secure the engine at the desired angle. A second and more modern method, especially for the larger units, is a hydraulically operated system controlled from the helmsperson's position.



INCORRECT
Bow too high -- trim engine down.



INCORRECT
Bow too low -- trim engine up.



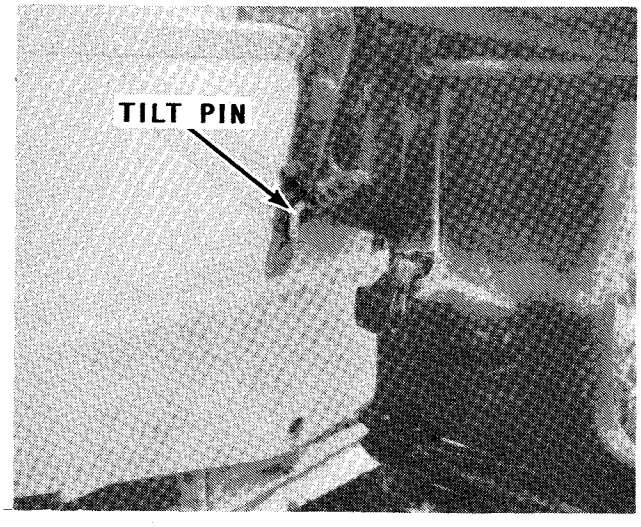
CORRECT
Boat and engine properly trimmed.

The trim position of the outboard unit directly affects the bow position and thus the boat performance.

Early model units, to about 1979, utilized two small trim/tilt cylinders. The cylinders extended very slowly through the trim degree range, and then accelerated to move the outboard to the tilt position for trailering or shallow water operation. This system is designated System **"A"** in this chapter.

From about 1980 through 1984 the trim/tilt system consisted of a single cylinder. This cylinder moved the outboard unit upward slowly through the trim range, and then accelerated the movement to the tilt position. The pump and electric motor unit was installed in the boat with hoses leading to and from the cylinder installed between the transom brackets. This single cylinder system is designated System **"C"** in this chapter.

Since about 1985, the trim/tilt units have incorporated two small trim cylinders and one large tilt cylinder. As with the earlier model units, the trim cylinders move the outboard upward or downward very



The tilt position is adjusted by inserting the tilt pin through one of a series of holes in the transom bracket.

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slowly. Once the maximum trim angle has been reached, approximately 20°, the tilt cylinder continues to move the outboard upward or downward at a much faster rate. The three cylinder unit is designated System **"B"** in this chapter.

CHAPTER ORGANIZATION

SYSTEM "A"

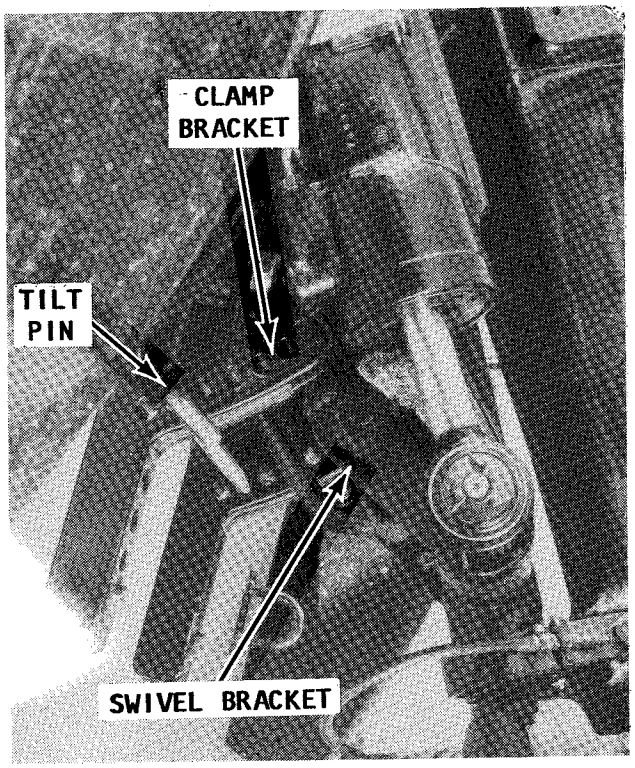
As explained in the Introduction, for purposes of identification, the early model system with two cylinders has been designated as System **"A"**. Service procedures are covered in the first part of this chapter from Section 10-2 thru 10-9.

SYSTEM "B"

The most recent system with two trim cylinders and one large cylinder has been designated as System **"B"**. Service procedures are presented in the second part of this chapter from Section 10-10 thru 10-15.

SYSTEM "C"

The single cylinder system has been designated System **"C"**. The one cylinder serves both for trim and tilt. Service procedures are outlined in the third portion of this chapter from Section 10-16 thru 10-19.



When the outboard is at the full trim out position, the swivel bracket should still be engaged with the clamp bracket flanges by 1/2" (1.75 cm) or more.

10-2 MECHANICAL TILT PIN ALL UNITS

The mechanical tilt arrangement is found on most outboard units. A change in the tilt angle of the engine is accomplished by inserting the tilt adjustment pin through one of a series of holes in the transom mounting bracket. These holes allow the operator to obtain the desired boat trim under various speeds and loading conditions.

The tilt angle of a lower unit is properly set when the anti-cavitation plate is approximately parallel with the bottom of the boat. The boat trim is corrected by stopping the boat, removing the adjustment pin tilting the engine upward or downward, as desired, and then installing the pin through the new hole exposed in the transom mounting bracket.

To raise the bow of the boat, the engine is raised one hole at-a-time until the operator is satisfied with the boat's performance. If the bow is to be lowered, the lower unit is lowered one hole at-a-time.

Performance will generally be improved if the bow is lowered during operation in rough water. The boat should **NEVER** be operated with the lower unit set at an excessive raised position. Such a tilt angle will cause the boat to "porpoise", which is very dangerous in rough water. Under such conditions the helmsperson does not have complete control at all times.

Instead of making extreme changes in the lower unit angle, it is far better to shift passengers and/or the load to obtain proper performance.

In order to obtain maximum efficiency and safety from the boat and engine, the tilt pin must be installed in the proper position. The wide range of boat designs with their various transom angles, requires a determination be made for each engine installation.

Actually, the tilt pin is only required if the boat handles improperly in the full trimmed "in" position at wide open throttle (WOT). Usually this occurs when the transom "angle" is too large.

This section provides detailed procedures to properly install the tilt pin and also the necessary instructions to adjust the tilt limit switch for units with the System **"A"** Trim/Tilt arrangement.

Tilt Pin Installation

Refer to the accompanying illustration

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while performing the following installation steps.

1- Operate the Power Trim to move the engine inward or outward until the anti-cavitation plate is parallel to the boat bottom. With the engine in this position, notice the position of the swivel bracket in relation to the clamp bracket tilt pin holes. Now, install the tilt pin into the first full pin hole closer to the transom .

2- Install the washer and cotter pin into the tilt pin and open the pin end to secure it in place.

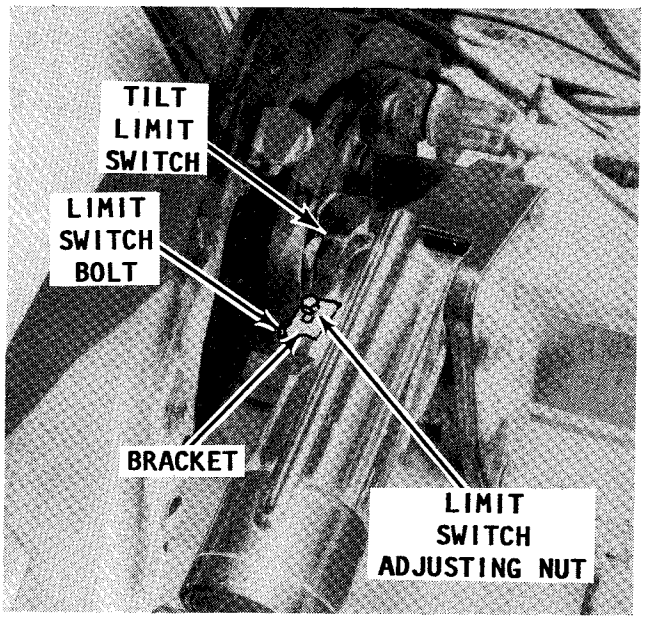
Tilt Limit Switch Adjustment
Units with System "A" Only

SAFETY WORDS: The tilt trim limit switch **MUST** be properly adjusted to prevent the swivel bracket from being trimmed outward beyond the clamp bracket tilt pin flanges. Proper tilt limit switch adjustment will also ensure continuous side support for the swivel bracket.

Refer to the two accompanying illustrations while performing the following six steps to adjust the tilt limit switch.

1- Depress the **IN** button and hold it depressed until the engine has reached the bottom of its travel.

2- Depress the **UP/OUT** button and hold it depressed until the pump motor stops. With the engine in this position, the swivel bracket should still be engaged with the clamp bracket flanges by 1/2" (12.7 mm) or more.



Adjusting the trim limit switch on the starboard side of the outboard.

3- Pull out on the lower unit to remove any slack in the hydraulic cylinders while the trim limit tilt position is checked.

GOOD WORDS: If the piston rods retract into the hydraulic cylinders more than 1/8" (3.17 mm) while the lower unit was being pulled out, the hydraulic system **MUST** bled of air. See Section 10-5.

4- If the engine swivel bracket tilts out further than the limit given in Step 2, the trim limit switch needs adjustment. To adjust the switch, loosen the limit switch bolt on the side of the wrap around bracket. If the engine tilts out too far, turn the limit switch adjustment nut on top of the bracket **COUNTERCLOCKWISE.** If the engine fails to tilt out far enough, turn the adjustment nut **CLOCKWISE.**

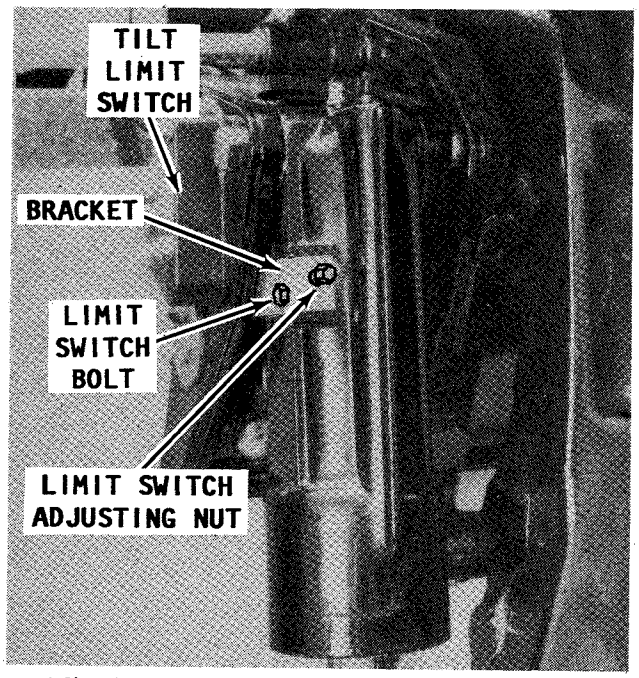
5- Repeat Steps 1 thru 4, as necessary until the proper trim limit switch adjustment is attained.

6- Tighten the limit switch bolt securely to lock in the adjustment.

10-3 SYSTEM "A" MODELS WITH TWO TRIM/TILT CYLINDERS

DESCRIPTION AND OPERATION

The hydraulically powered tilt system permits changing the tilt angle of the engine from the helmsperson's position. Controls and indicators for the system are located on the control panel.



Adjusting the trim limit switch on the port side of the outboard.

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The angle of the lower unit is properly set when the boat is operating to give maximum performance, including comfort and safety.

The powered tilt system consists of a hydraulic pump, two trim/tilt cylinders, a reverse lock valve, trim indicator sender, controls, an indicator gauge, and associated hoses and fittings.

The hydraulic pump includes a valve body-and-gear assembly, control valve, pump motor, and a reservoir. The controls consist of an **UP** button, an **UP/OUT** button, and an **IN** button. The indicator gauge is installed on the control panel next to the control buttons.

OPERATION

When the **UP** trim switch is operated, the **UP** pump solenoid is actuated and the electric motor circuit is closed. The electric motor drives the oil pump and oil is forced into the **UP** side of the trim cylinders. The engine is trimmed upward until the trim switch is released, or until the trim limit cutout switch opens the circuit and stops the engine swivel bracket within the limits of the clamp bracket supporting flanges.

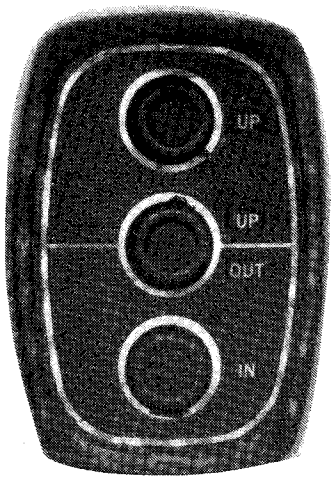
When the **DOWN** trim switch is operated, the **DOWN** solenoid is actuated and the electric motor circuit is closed, but the motor will run in the opposite direction. Again, the motor drives the oil pump and oil is forced into the **DOWN** side of the trim cylinders and the engine is trimmed down to the desired position.

When the **TRAILERING** switch is operated, the **UP** pump solenoid is actuated and the pump motor circuit is closed. The pump motor will drive the oil pump and force oil into the **UP** side of the trim cylinders. The trailering circuit bypasses the trim limit switch, enabling the engine to be tilted upward for trailering, docking or shallow water operation.

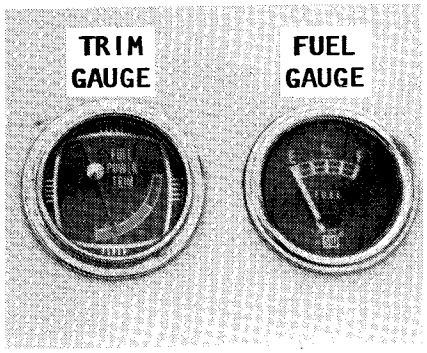
TRAILERING OR LAUNCHING

Two control buttons on the control panel must be pushed at the same time to raise the stern drive to the full up position for trailering or launching the boat -- the normal **UP** button and the middle **UP/OUT** button. By pushing the middle **UP/OUT** button, current is passed to the top **UP** switch. The current passing through the **UP** switch while the button is depressed, will by-pass the trim limit switch so the **UP** circuit will be able to raise the lower unit to the full up position. If the middle **UP/OUT** button is depressed during normal boat operation, a trim limit switch will keep the drive unit from moving out beyond the transom mounting bracket.

When the hydraulic cylinders reach their full extent of travel, the pump motor will labor if the control buttons are not released. Therefore, to prevent damage to the system, a bimetal switch will open the circuit



*Three buttons are used to control the trim/tilt adjustment. One button is used to raise the engine for trim, another to lower the unit, and the third is used simultaneously with the **UP** button to position the outboard for trailering or during launch.*



The trim gauge advised the helmsperson of the relative position of the outboard at all times.

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to stop the pump motor and prevent the motor from overheating. The switch contacts will close automatically after the motor has cooled and the motor can again be operated.

ONE MORE WORD

Whenever the boat is being trailered, a trailer bracket should **ALWAYS** be used to mechanically lock the lower unit in the up position. Such a bracket may be purchased at modest cost from the local marine store and will give "peace of mind" to the owner as he moves the boat from place to place.

SAFETY WORDS

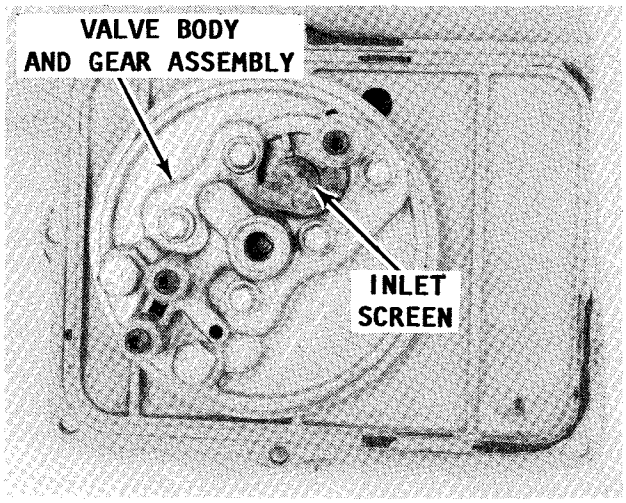
Two precautions **MUST** be followed if the engine is to be operated in shallow water with the engine trimmed beyond the trim limit cut-out:

1- NEVER operate the engine above idle rpm. When the engine is trimmed beyond trim limit cut-out, the swivel bracket does not have support.

2- Check to be sure the water intake ports remain submerged. If the intake ports should rise above the water surface, even for a very short time, severe damage could be caused to the water pump or to other expensive parts from overheating.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

ALWAYS release the **DOWN** or **TRAILER** switch as soon as the engine reaches the end of its travel. If the switch is not released, an overload cut-out switch will open and the pump motor will stop. If the cut-out switch should open, **DO NOT** depress either switch for approximately one minute. During this time, the cut-out switch will reset itself, the switch closes, and the pump may be operated again.



The gear assembly secured in the valve body cannot be serviced. If defective, it must be replaced as a unit.

10-4 SPECIAL INSTRUCTIONS SYSTEM "A"

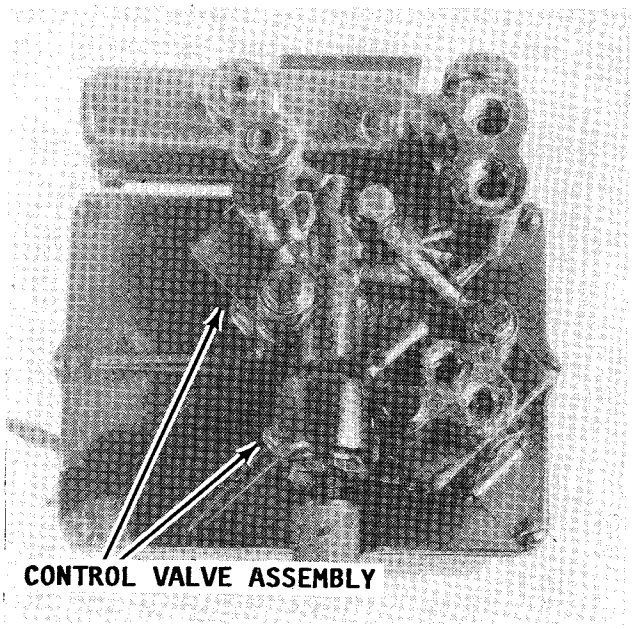
1- Use clean **MS, SD, SE, SF 20W,** or **5W-30,** or **10W-40** or equivalent oil to fill the hydraulic reservoir. Use one of these oils to flush the system.

2- REMEMBER to remove the vent seal when filling the pump reservoir to prevent overfilling. **TOO MUCH** fluid in the system can cause pump body failure or motor failure. **DO NOT** close the vent screw because air in the reservoir **MUST** be able to escape.

3- The engine unit **MUST** be in the **FULL UP** position with the hydraulic cylinders extended when the reservoir is filled. The correct fluid level is **EVEN** with the bottom of the oil filler hole.

4- If the pump stops during long use, allow the pump motor to cool at least one minute before starting it again. An internal thermal circuit breaker protects the pump motor. If the pump will not operate, the circuit breaker may be tripped in the off-position.

5- Keep the work area **CLEAN** when servicing disassembled parts. The smallest



The control valves cannot be serviced. If they are found to be defective, the entire unit must be replaced.

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amount of dirt or lint can cause failure of the pump to operate.

6- The valve body-and-gear cage assembly, or the control valve assembly **MUST** be replaced as a unit because of the precision fitting of the valves and gears.

7- The can over the inlet screen of the valve body-and-gear assembly **MUST** be installed securely or the oil will foam out the vent.

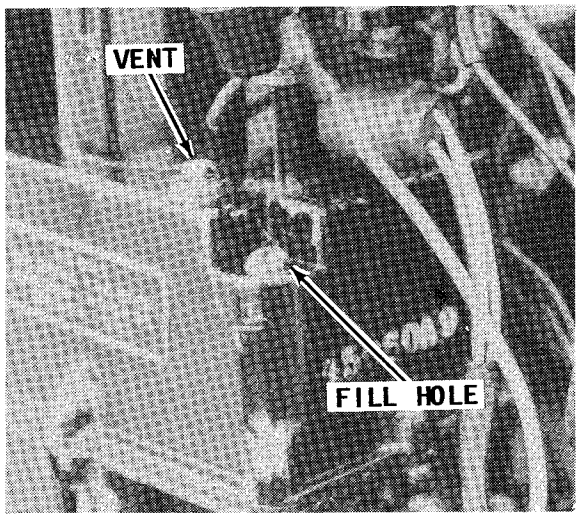
8- TAKE CARE not to allow Liquid Neoprene to get into the valve body-and-gear assembly. Use the neoprene sparingly.

9- The hydraulic pump motor must be moisture-proof. To moisture-proof a motor after service, apply Liquid Neoprene around the pump motor commutator plate edges, around the motor frame where it contacts the reservoir, and in the area where the wire leads enter the motor. Any sign of oil in the pump motor indicates either the reservoir seal is damaged or the vent screw was closed. If the vent was closed, air could not escape and oil was forced into the pump motor.

10- DO NOT allow the trim cylinders to hang by their hydraulic hoses. Such practice may cause damage to the hoses. Use **CARE** when handling trim cylinders during removal/installation of the engine. Rough treatment of the hoses could result in a weakened hose, partial separation at the fitting, or bending of the metal tubing. Such damage could certainly restrict the flow of oil to the trim cylinders.

11- ALWAYS hold the metal ferrule on the hose with pliers when tightening the fitting. The indicator line on the hose **MUST** follow the hose bend without a twist. A twisted hose will cause severe loads resulting in over-stress on the hose and the tubing will be bent.

12- Following service on the system, move the engine from hard-over to hard-over, port and starboard, and from the full **DOWN** to the full **UP** position. During engine movement, check for possible kinks, twists, or severe bends in the hoses or at the fitting ends.



Hydraulic pump reservoir installation for the power trim/tilt system. The vent screw should remain open.

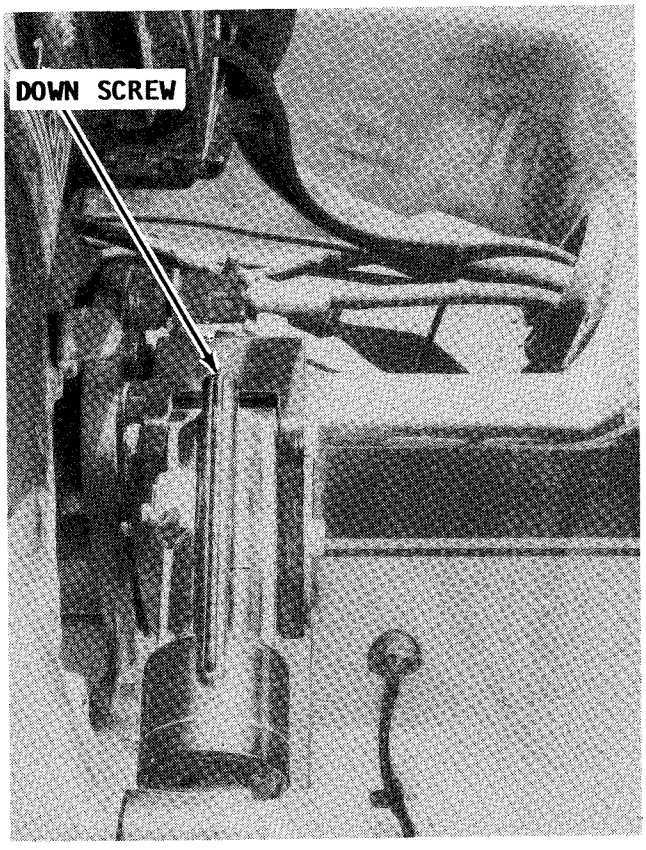
10-5 HYDRAULIC BLEEDING SYSTEM "A"

Air in the system, even a small amount, can lead to poor performance or to a malfunction. Any time the system is opened for service, the following bleeding procedures should be closely followed.

1- Move the engine to the full **UP** position and engage the tilt lock lever.

2- Remove the **FILL** screw and fill the pump with fluid.

3- Operate the trim system completely through the tilt range several times to bleed



*Bleed screw location for the **DOWN** side of the cylinder.*

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air from the system. Check the fluid level in the pump when the engine is in the full **UP** position. Thread the **FILL** screw into place and tighten it securely.

10-6 TROUBLESHOOTING SYSTEM "A"

Always attempt to proceed with the troubleshooting in an orderly manner. The "shot-in-the-dark" approach will only result in wasted time, incorrect diagnosis, replacement of unnecessary parts, and frustration.

To be successful, the troubleshooting process must begin with an accurate determination of the problem, followed by a logical reasoning of what caused the problem, and finally intelligently concluding the required corrective action to be taken. The final phase, of course, is the work involved in returning the unit to satisfactory performance.

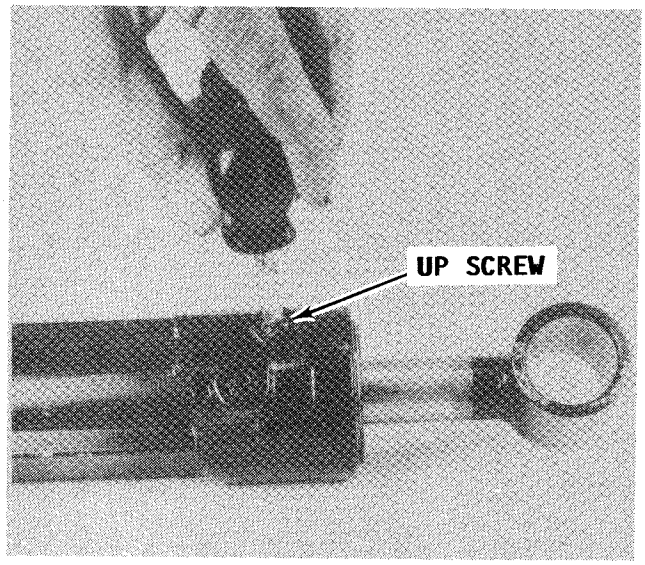
Any problem with the Power Trim system must first be classified as a malfunction in the electrical system or in the hydraulic system.

The following troubleshooting table is designed to provide a logical approach and sequence of work necessary to arrive at the proper solution.

TESTING TRIM SWITCHES EARLY AND LATE MODELS

Test Panel Control Switch

a- Disconnect the power trim harness from the trim pump.



*Bleed screw location for the **UP** side of the cylinder.*

b- Connect a continuity meter or a test lamp between the switch terminals on the back of the switch. The meter should indicate **NO** continuity or the test lamp should not light with the button in the free position. Depress the button. The meter should indicate continuity or the test lamp should light.

Early Model Trim Switches Externally Mounted On Trim Cylinder Bracket Trim Switch Removal

c- Disconnect the power trim harness from the trim pump.

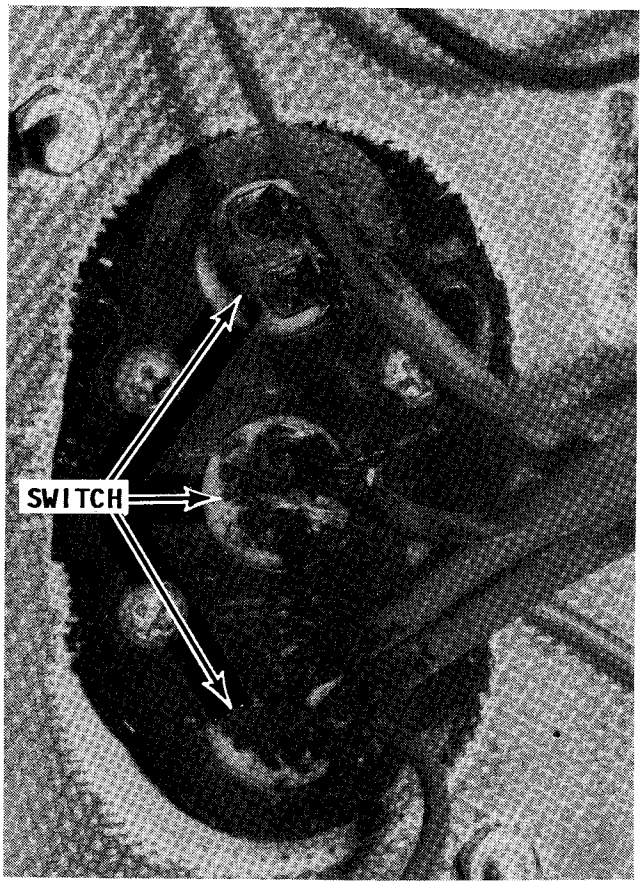
d- Remove the switch control panel from the mounting hole.

e- Remove the four attaching screws, and then remove the switch retainer.

f- Release the soldered connections from the switch.

Trim Switch Installation

g- Solder the wires on the new switch to the terminals. After soldering, coat the terminals with Liquid Neoprene.



*The control switch, as viewed from the **BACK** side, is accessible for service.*

TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSES	CORRECTIVE ACTION
Engine fails to trim up or down	Release valve control knob not completely closed.	Turn valve fully clockwise.
	Oil level low or air in system.	Fill reservoir and bleed system. Check for leaks.
	Determine if hydraulic pump motor operates when trim button is depressed.	If motor operates, service the hydraulic system. If motor fails to operate, refer to electrical system troubleshooting.
Engine trims up, but will not trim down.	Determine if hydraulic pump motor operates when UP trim button is depressed.	If motor operates, service hydraulic system. If motor fails to operate, refer to electrical system troubleshooting.
Engine trims down, but will not trim up.	Determine if hydraulic pump motor operates when UP trim button is depressed.	If motor operates, perform hydraulic system UP pressure test. If motor does not operate, refer to elctrical troubleshooting.
Engine will not return completely to DOWN position, or returns part way with jerky motion.	Air in the system.	Fill reservoir and bleed system. Check for leaks.
	Internal cylinder/s leaks.	Service the hydraulic system.
Engine thumps when shifted.	Air in the system.	Fill reservoir and bleed system. Check for leaks.
	Internal cylinder leaks.	Service the hydraulic system.
	Control valve assembly leaks.	Service the hydraulic system.
Engine trails out when backing off throttle at high speed.	Air in the system.	Fill reservoir and bleed system. Check for leaks.
	Defective control valve assembly.	Install new control valve assembly.
	Internal cylinder leaks.	Service the hydraulic system.
Engine fails to hold a trimmed position or will not remain tilted for extended period.	External leak -- fittings or parts.	Tighten fittings, or replace defective parts.
	Internal leaks.	Service hydraulic system.
	Pump check valve leak, high pressure.	Clean check valve by operating system up and down several times to flush system. If problem not corrected, replace pump valve body assembly.
Engine fails to hold in reverse.	Defective reverse lock valve solenoid.	Refer to electrical troubleshooting.
	Internal cylinder leaks.	Service the hydraulic system.
	Worn reverse lock valve seat.	Service the hydraulic system.

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h- Insert the switch into the panel and secure it in place with the switch retainer and the four attaching screws.

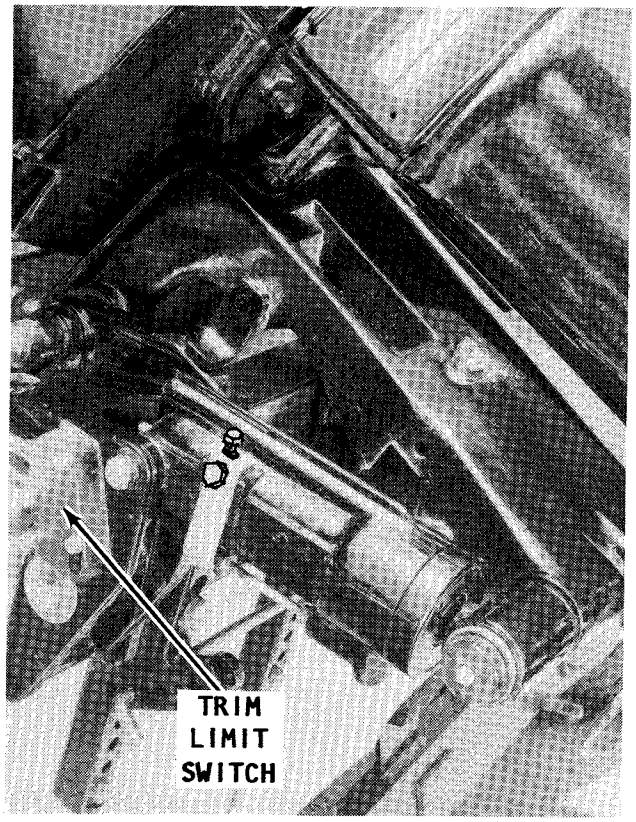
i- Install the switch control panel into the mounting hole.

j- Connect the power trim harness to the trim pump.

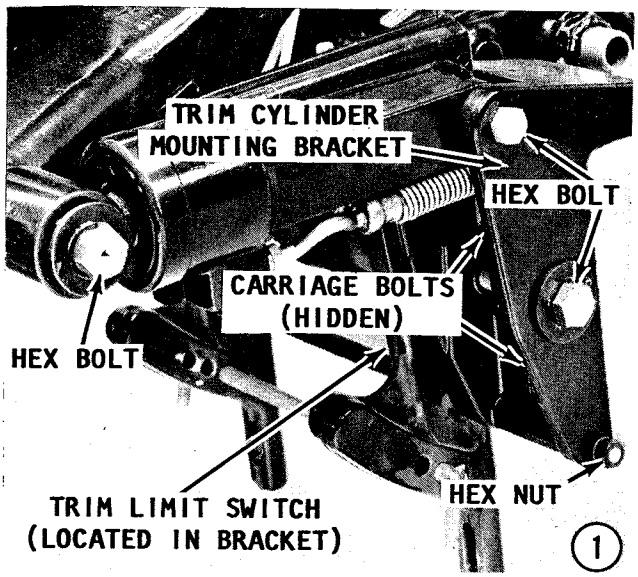
Late Model Trim Switch Mounted On Inside Of Starboard Trim Cylinder Mounting Bracket

1- Remove the two bolts securing the starboard trim cylinder mounting bracket to the transom. Remove the hex bolt and nut securing the trim cylinder mounting bracket to the outboard. Back-out the bolt securing the lower end of the trim cylinder to the outboard. Lift off the trim cylinder and mounting bracket free of the outboard.

2- Remove the five screws, and then lift off the cover and gasket from the mounting bracket. Lift out and **SAVE** the spring from the actuating plunger. Remove the two screws securing the trim limit switch to the mounting bracket. Lift out the trim limit switch and pull the wires free from the mounting bracket. Verify the actuating plunger operates freely without binding.



Two trim limit switches are externally mounted, one on either side of the trim cylinder bracket.

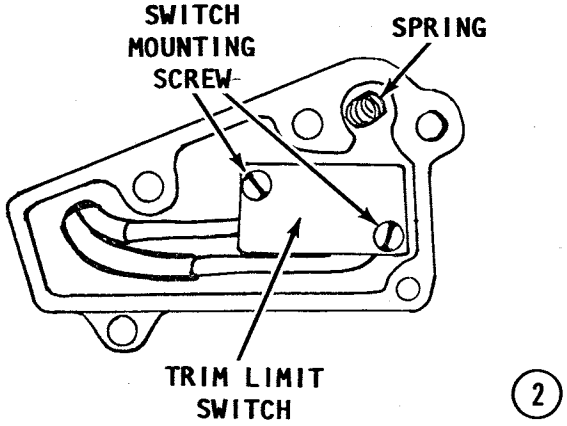


CLEANING AND INSPECTING

Clean the plunger and check the spring to be sure it is not distorted. If trouble-shooting indicates the switch is defective, it must be replaced. Individual parts are not available to "rebuild" the switch.

INSTALLATION

1- Install the actuating plunger. Position the trim limit switch into the mounting bracket. Route the wire harness over the hydraulic hoses and through the hole in the bracket. Coat the trim limit switch and wires with Anti-Corrosion Lubricant or a Silicone Compound. If corrosion was a problem, fill the entire switch cavity with lubricant or the Silicone Compound. Slide the spring into the actuating plunger. Place the gasket and cover onto the mounting bracket with the spring extending through the hole in the gasket. Secure the cover in place



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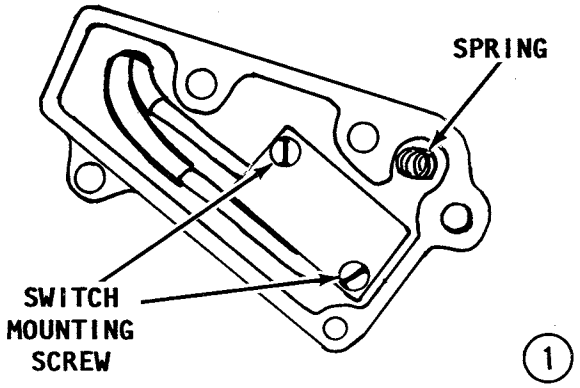


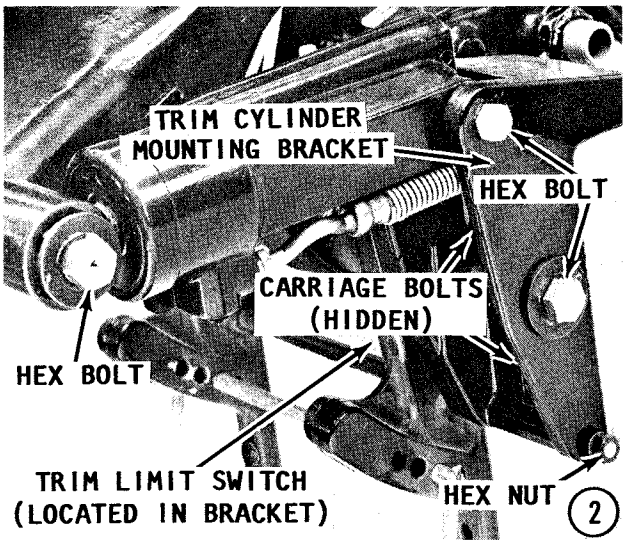
with the five screws. Check the switch by depressing the plunger. The plunger should operate without binding and an audible "click" sound should be heard as the switch turns on and off.

2- Place the trim cylinder and mounting bracket into position on the outboard unit. Install the bolt securing the lower end of the trim cylinder to the outboard. Secure the trim cylinder mounting bracket to the outboard unit with the hex bolt and nut. Coat the shank, not the threads, of the two bolts securing the starboard trim cylinder mounting bracket to the transom with sealing compound. The compound will ensure a watertight installation. Install the bolts and tighten the nuts securely.

SOLENOID TESTING SYSTEM "A"

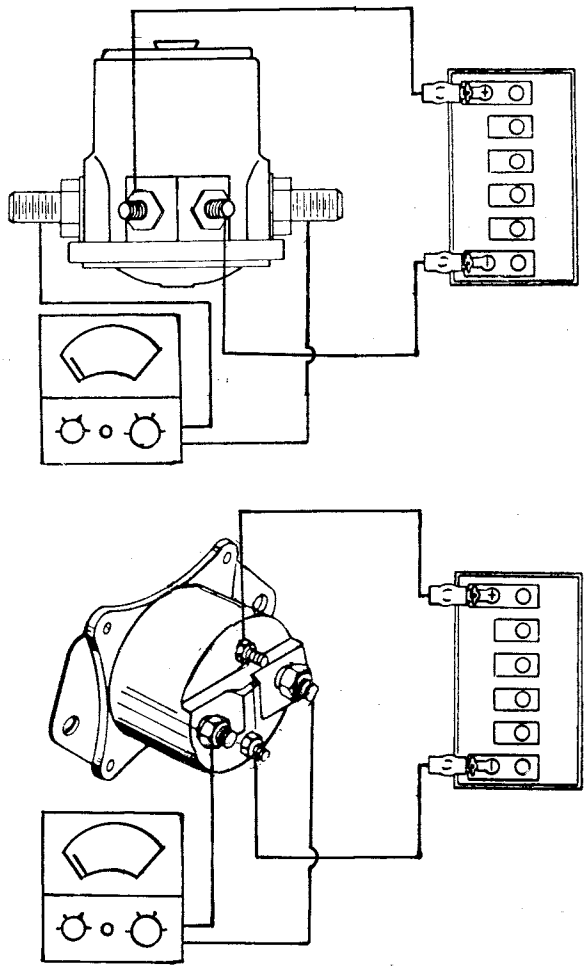
FIRST, THESE WORDS

Some units covered in this manual have and **UP** solenoid and a **DOWN** solenoid. Other units have only one solenoid.



In addition to this fact, two different styles of solenoids were used on the System **"A"** power trim/tilt units. The accompanying illustration shows how each solenoid may be bench tested.

Disconnect all leads from the solenoid terminals. Use the RX1 scale on an ohmmeter. Connect each meter lead to the large solenoid terminals. Connect the positive lead of a 12-volt battery to one of the solenoid small terminals. Connect one end of a piece of wire to the other small solenoid terminal. Now, for just a split-second, make contact with the other end of the wire to the ground terminal of the battery. A loud click sound should be heard from the solenoid and the meter reading should indicate zero ohms. If a audible "click" is not heard and the meter indicates a reading other than zero ohms, the solenoid is defective and must be replaced.



Early model solenoid (above), and late model solenoid (below), hooked up for testing. An audible "click" should be heard from the solenoid and the ohmmeter should indicate zero ohms.

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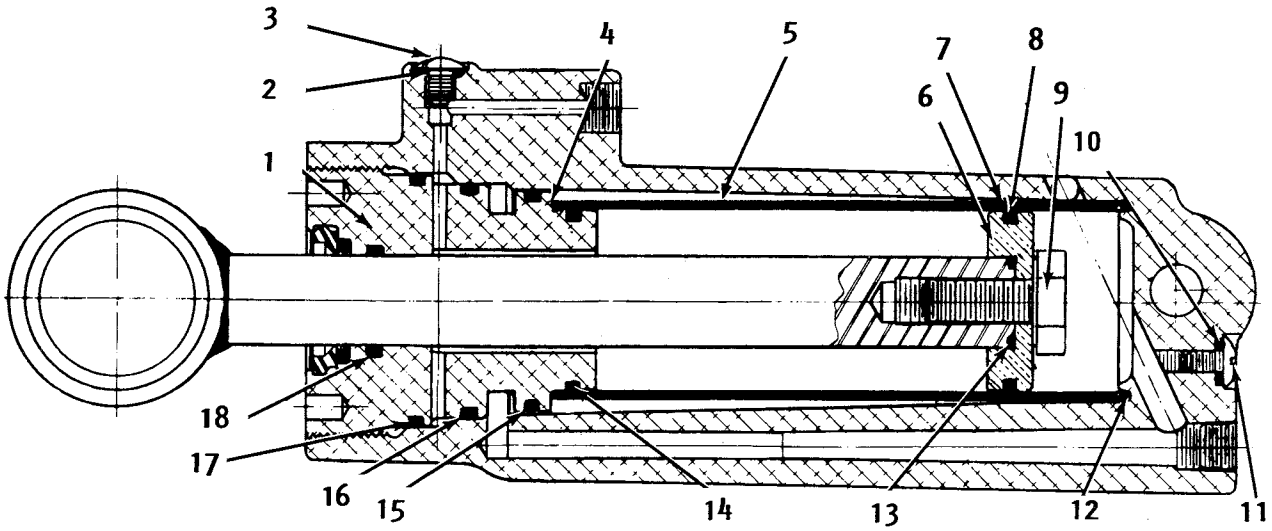
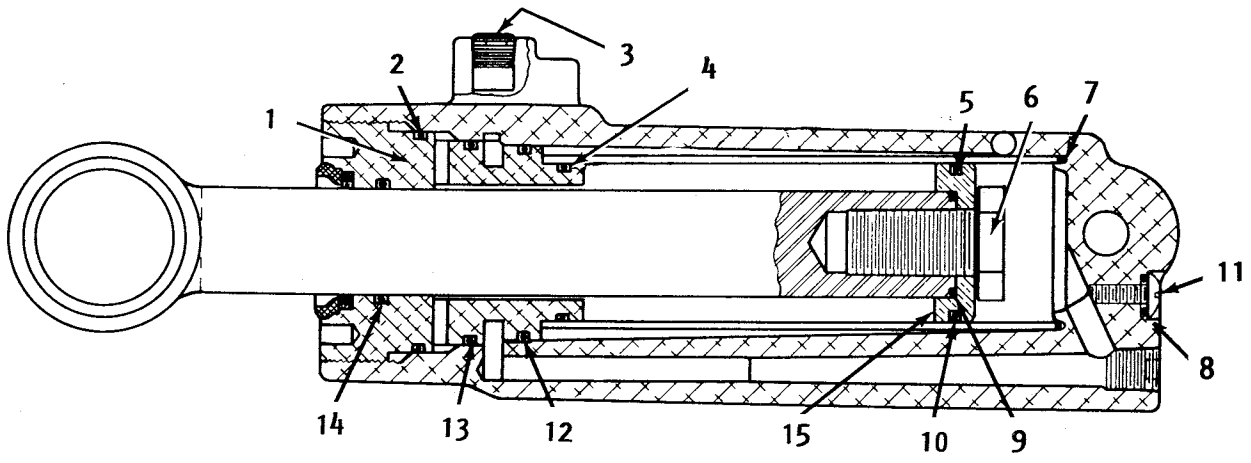


1- RETAINER
2- O-RING - 7/32x11/32x1/16
3- UP BLEED SCREW
4- CHAMFERED END
5- CYLINDER LINER
6- PISTON
7- SLIPPER SEAL
8- O-RING - 1-1/4x1-11/32x3/32
9- BOLT
10- O-RING - 7/32x11/32x1/16
11- DOWN BLEED SCREW
12- O-RING - 1-1/2x1-5/8x1/16
13- O-RING - 5/8x3/4x1/16
14- O-RING - 1-5/16x1-1/2x3/32
15- O-RING - 1-5/8x1-13/16x3/32
16- O-RING - 1-3/4x1-15/16x3/32
17- O-RING - 1-7/8x2-1/16x3/32
18- O-RING - 3/4x27/32x3/32

Cross-section of a 3/4" diameter piston rod cylinder with the bleed screw and O-ring sizes identified.



1- RETAINER
2- O-RING - 1-7/8x2-1/16x3/32
3- UP BLEED SCREW
4- O-RING - 1-5/16x1-1/2x3/32
5- O-RING - 1-1/4x1-7/16x3/32
6- BOLT
7- O-RING - 1-1/2x1-5/8x1/16
8- O-RING - 1-5/16x1-1/2x3/32
9- O-RING - 7/8x1x1/16
10- SLIPPER SEAL
11- DOWN BLEED SCREW
12- O-RING - 1-5/8x1-13/16x3/32
13- O-RING - 1-3/4x1-15/16x3/32
14- O-RING - 1x1-3/16x3/32
15- PISTON

Cross-section of a 1" diameter piston rod cylinder with the bleed screw and O-ring sizes identified.

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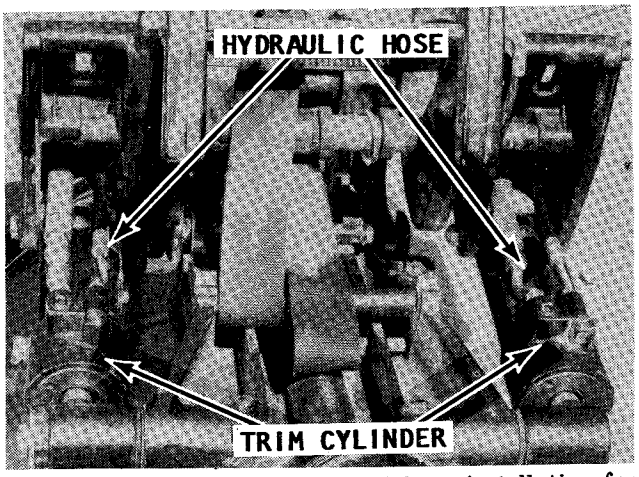


Typical trim/tilt cylinder and hose installation for the trim/tilt system covered in this manual.

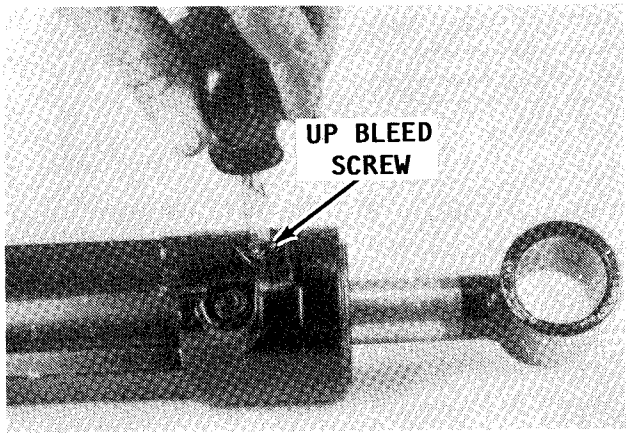
10-7 HYDRAULIC TRIM SERVICE SYSTEM "A"

Trim Cylinder Removal

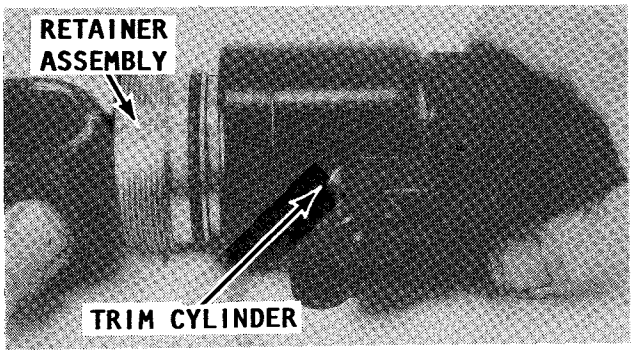
WARNING: Exercise care when working with the trim cylinders. Take extra precautions to prevent the engine from falling, or moving down rapidly. Such action could cause **BODILY INJURY.**

Disconnect the two trim hoses from the cylinder to be removed. Cap the hoses and plug the holes in the cylinders as a precaution against contamination, including air, from entering the system. The caps and plugs will also prevent an unnecessary loss of oil. Remove the mounting bolts at each end of the cylinder, and then remove the cylinder.

ALWAYS keep the work area clean to prevent contamination. The smallest amount of foreign material can lead to a malfunction in the system.



*Removing the bleed screws from the cylinder. The UP screw is at the bottom of the cylinder and the **DOWN** screw is at the top.*



Removing the retainer assembly and liner from the cylinder housing.

Trim Cylinder Disassembling

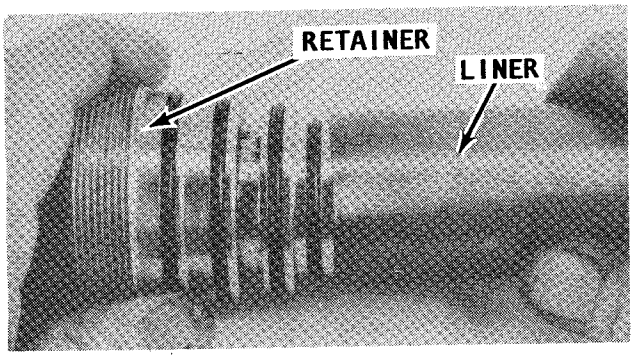
Remove the **UP** and **DOWN** bleed screws, identified as **3** and **11** in the illustration, previous page. Use a 1-3/4" spanner wrench and unscrew the retainer assembly from the cylinder assembly. After the retainer assembly is loose, pull the rod and piston assembly, retainer assembly, and the cylinder liner from the cylinder housing.

Use a long wire pick to dislodge the **O**-ring from the cylinder housing, and then remove the ring. Clamp the rod assembly in a vise equipped with soft jaws, and then slide the cylinder liner off the retainer and piston, using a twisting motion. Remove the bolt and piston from the piston rod. Remove the four **O**-rings from the outside retainer and one **O**-ring from inside the retainer behind the seal and scraper. **DO NOT** remove or damage the seal or scraper.

CLEANING AND INSPECTING

Make an effort to keep the work area clean, because any contamination in the system could lead to a malfunction.

Inspect the cylinder liner and piston for wear. Check to be sure the piston is not bent or distorted.



Removing the retainer assembly from the liner.

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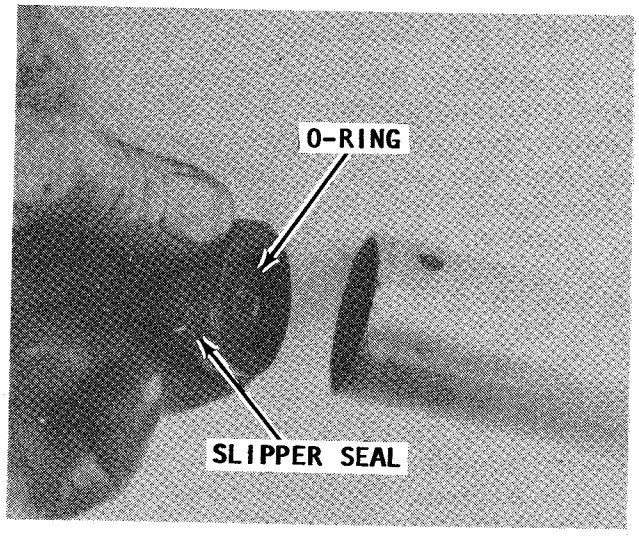


Removing the O-ring and slipper seal from the liner.

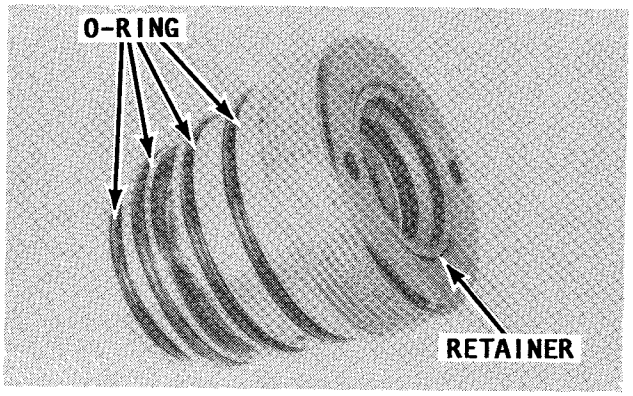
Remove all seals and O-rings.

Clean all parts in a solvent, and then blow them dry with compressed air.

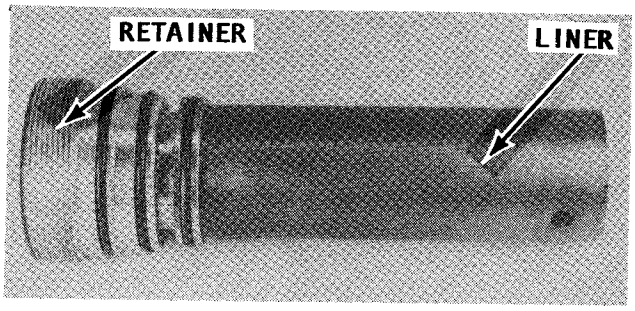
Trim Cylinder Assembling

Lubricate all O-rings and O-ring contact surfaces with Multipurpose Lubricant, as protection against damaging the ring during installation. Install the proper **O**-ring into the cylinder housing. Use Multipurpose Lubricant to hold the **O**-ring in the recessed groove. Press the O-ring firmly into the bottom of the groove, using the cylinder liner as a tool.

Install the **O**-ring into the groove of the new brass piston. **CAREFULLY** stretch the slipper seal over the **O**-ring. **USE CARE** when stretching the slipper seal. If the slipper is overstretched, installation of the piston into the liner will be more difficult. Position the proper **O**-ring into the recessed end of the piston.



*The retainer should be carefully inspected to ensure the threads have not been damaged and the **O**-ring seats are clean.*



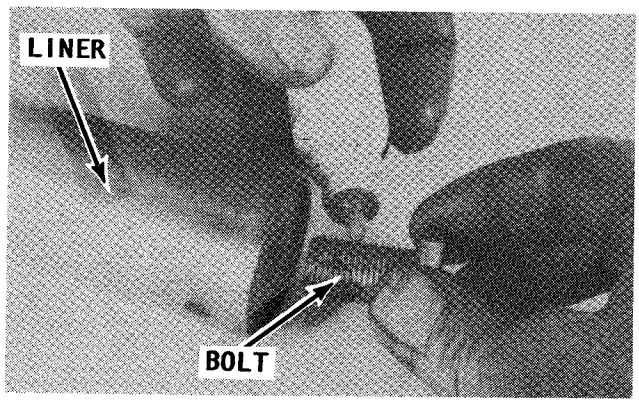
Installing the liner onto the piston.

Install the proper size O-ring into the grooves on the retainer. **CAREFULLY** insert the O-ring into the groove inside the retainer, without damaging the seal or the scraper. Slide the retainer assembly onto the piston rod. Coat the internal surface of the cylinder liner, piston, slipper seal assembly and Installation Tool C-91-69626 with Multipurpose Lubricant. Clamp the rod eye in a vise, as shown.

Position the cylinder liner onto the retainer with the chamfered side **TOWARD** the retainer. Now, position installation tool C-91-69626 on the cylinder liner and place the piston, with the slipper seal installed, into the tool, with the **O**-ring **TOWARD** the end of the rod.

Push the slipper seal into the tool by hand until the retainer bolt can be started. Remove the retainer bolt and apply a small amount of Blue Loctite to the threads. Install the bolt and use the bolt to draw the piston into the liner. Tighten the bolt to a torque value of 35 ft lbs. (47.6 Nm) on 3/4" diameter rods or to 60 ft lbs. (81.6 Nm) on 1" diameter rods.

Apply Multipurpose Lubricant to the end of the liner which seats against the **O**-ring in the housing.



Apply Loctite to the threads of the bolt securing the slipper seal to the end of the cylinder shaft.

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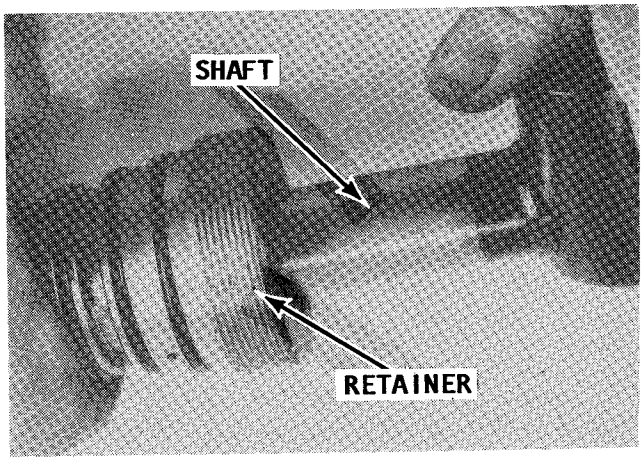


Working the cylinder shaft through the retainer. After the shaft is in place, it should move smoothly through the retainer.

Insert the complete piston, piston rod, cylinder liner, and retainer assemblies into the cylinder housing.

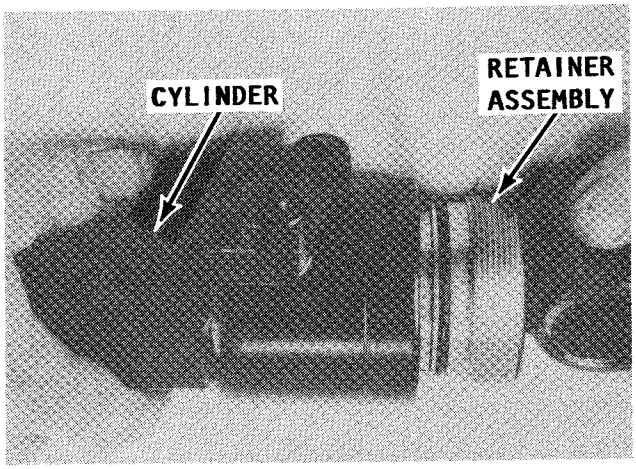
Coat the threads of the retainer with Perfect Seal, or equivalent. Thread the retainer assembly into the cylinder housing and tighten it to a torque value of 35-40 ft-lbs. (47.6-54.4 Nm).

Check the cylinder movement by moving the piston rod completely in and out of the cylinder several times. The movement should be free with no feel of binding.

Install the bleed screws into the cylinder housing. Check to be sure the O-rings under the bleed screws remain in place.

As a protection against corrosion, touch-up any scratches, nicks, etc., by sanding and painting.

Fill and bleed the cylinders according to the procedures outlined in Section 10-5.



Installing the piston and liner into the pump housing.

Trim Cylinder Installation

WARNING: Exercise care when working with the trim cylinders. Take extra precautions to prevent the engine from falling, or moving down rapidly. Such action could cause **BODILY INJURY.**

Position the trim cylinder in place, as shown. Install the top mounting bolt and tighten it to a torque value of 50 ft lbs. (67.8 Nm).

The starboard cylinder has a washer installed between the outer side of the cylinder and the mounting bracket. Install the lower mounting bolts, with a spacer and rubber bushing. Tighten the bolt to a torque value of 50 ft lbs. (67.8 Nm).

Remove the caps from the hoses and the plugs from the cylinders. Connect the hoses to the cylinders. **TAKE CARE** not to cross-thread the hoses in the cylinders. Tighten the hoses securely.

Operate the trim system and check for leaks. See Section 10-5 to bleed any air that may have entered the system during the service work.

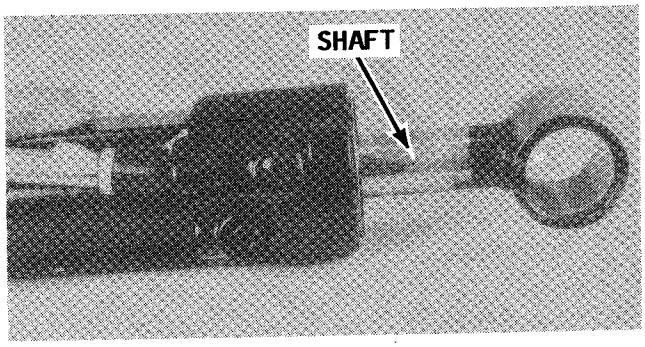
10-8 HYDRAULIC PUMP SERVICE
SYSTEM "A"
TESTING

Trim Pump Motor Test

This simple procedure will determine if the trim pump motor requires service.

a- Disconnect the black and blue motor wires from the solenoid terminals.

b- Connect a 12-volt supply between the motor terminals where the black and blue wires were disconnected. The motor should run. If the motor fails to operate, it requires service or replacement, see Section 10-9.



The cylinder can be checked prior to installation by using compressed air at each pressure port. The piston should move smoothly in each direction. Exercise care because the piston will move rapidly and with force.

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PUMP REMOVAL

Disconnect the large red and black battery wires at the battery to eliminate the possibility of sparks. Tag the wires and terminals at the pump and solenoid, and then disconnect the wires. Remove the mounting nuts, and then remove the pump-and-mounting bracket assembly. If the pump is to be replaced, **TAKE CARE** to prevent loss of hydraulic fluid, and then disconnect the hoses.

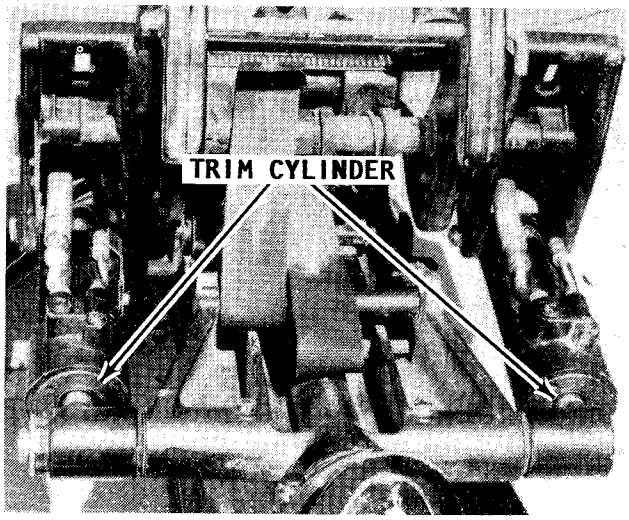
DISASSEMBLING

Clean the outside of the pump with solvent, and then blow it dry with compressed air. The pump **MUST** be thoroughly cleaned before the disassembly work begins to prevent contamination entering the system. Even the smallest amount of foreign material could lead to a malfunction. Keep the work area as clean as possible for the same reason.

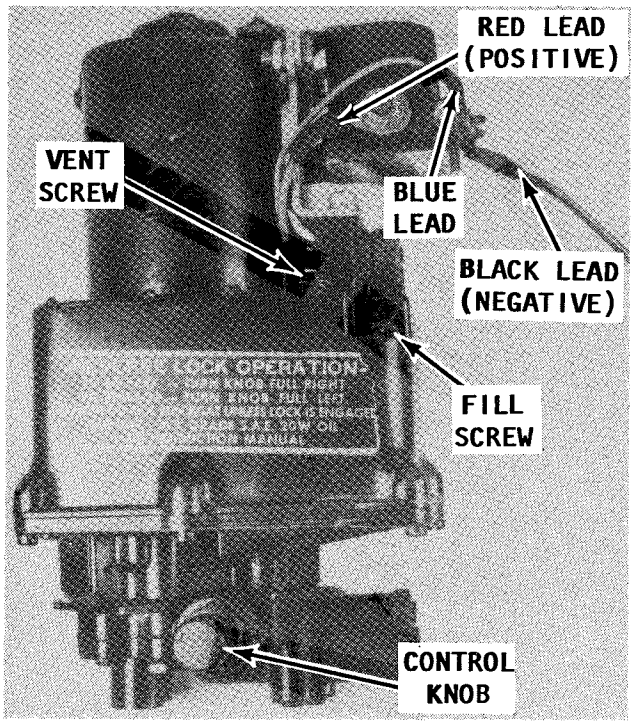
Remove the reservoir fill screw, and then drain the oil. Remove the four 7/16" hex-head screws from the control valve and the eight screws from the valve body and gear assembly. Separate the reservoir from the valve body and **DISCARD** the seal.

CLEANING AND INSPECTING

If the pump is damaged or shows signs of wear, the entire body and gear assembly must be replaced as a unit because the valves and gears have such a precision matched fit.



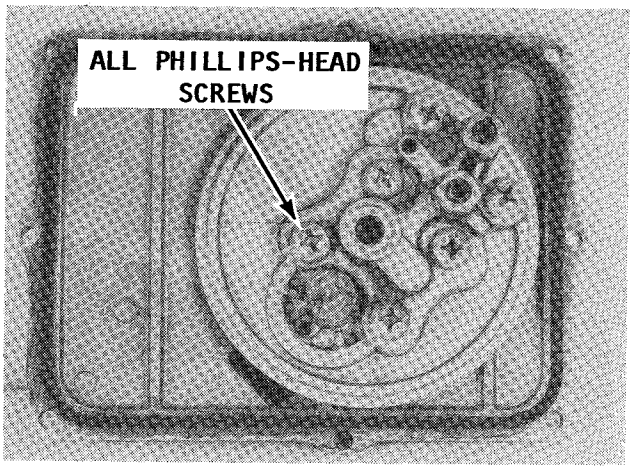
General view of the trim/tilt installed on the outboard, connected, and ready for operation.



Hydraulic pump for the trim/tilt system with associated parts and wiring prior to removal. Tag the wires as an aid during installation.

ASSEMBLING
TRIM/TILT PUMP

Place a **SMALL** amount of Liquid Neoprene C-92-25711-1 in the seal groove of the valve body to hold the seal in place during assembly. **TAKE CARE** with the Liquid Neoprene because any excess amount may enter the valve body and plug the ports. Result: Failure of the pump. Install the seal on the valve body, and then install the



The gear assembly secured in the valve body with Phillips head screws. The assembly is identical to the two at the top of Page 10-17.

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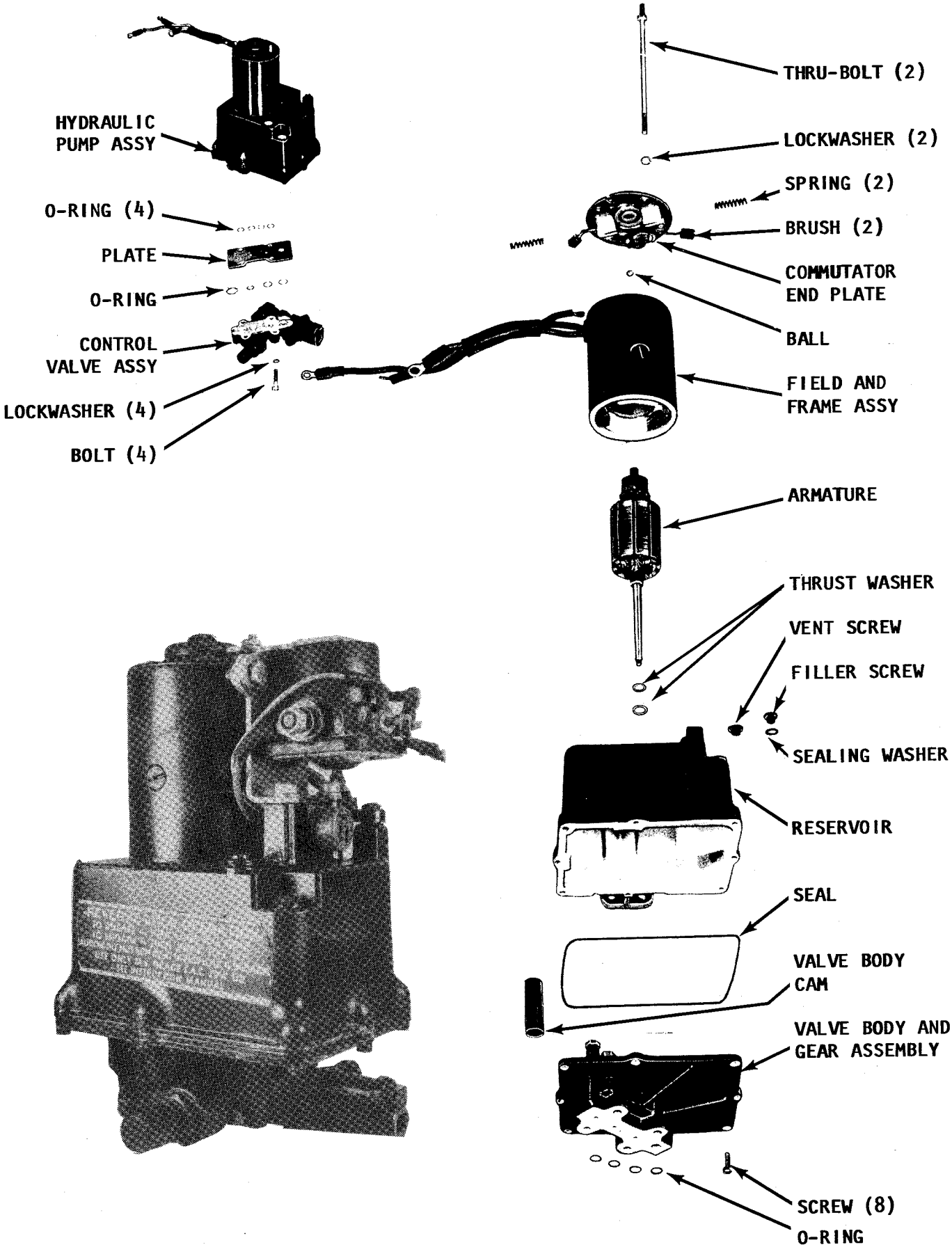

Exploded view of the hydraulic pump and control valve with major parts identified.

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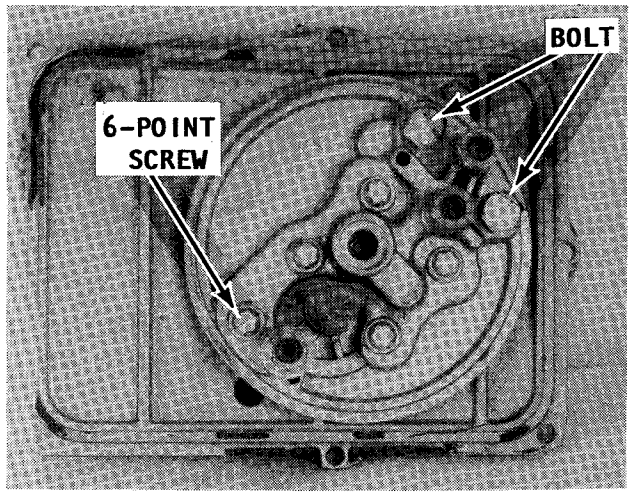


The gear assembly secured in the valve body with 6-point screws and two bolts. The assembly is identical to the one on Page 10-15 and top of next column.

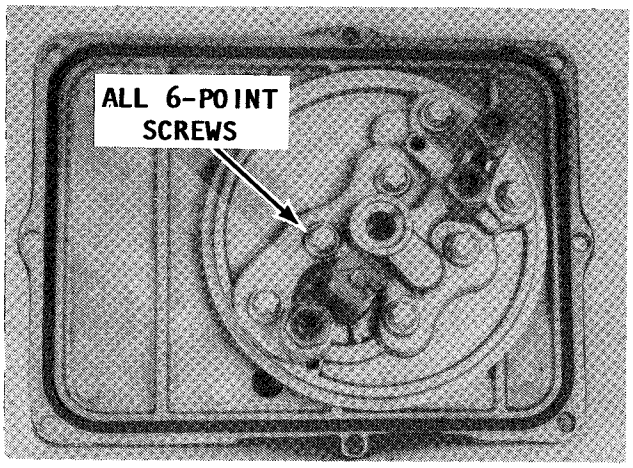
valve body and gear cage assembly onto the reservoir. Secure the parts together with the eight attaching screws. Tighten the opposite screws evenly and securely. Now, apply a coating of Liquid Neoprene, or equivalent, around the edges of the housings to ensure a good seal. After the neoprene has thoroughly dried, paint the parts.

Because the vent screw is left open, the pump is vented, therefore, it is self-bleeding.

INSTALLATION SYSTEM "A" PUMP

Attach the pump and mounting bracket assembly to the transom with the mounting nuts. The pump **MUST** be installed vertically.

Connect the hoses to the pump and tighten the fittings securely. Insert the harness adaptor into the receptacle of the hydraulic pump. Connect the wires from the opposite end of the adaptor. **TAKE CARE** to match the color code or the tags made during removal. The wiring diagrams in the Appendix will be helpful if the color code is not apparent or tags were not used during removal. Slide the rubber sleeves over the connections. Place the rubber boot over the large red battery cable, and then connect the wire to the solenoid. Connect the opposite end of the red wire to the positive (+) battery terminal and the large black wire to the solenoid. Connect the opposite end of the black wire to the negative (-) battery terminal.



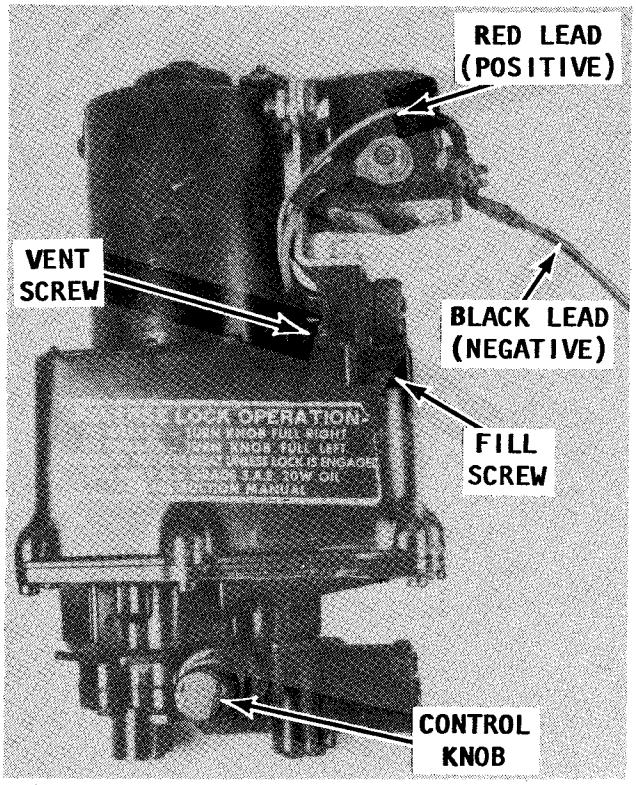
The gear assembly secured in the valve body using 6-point screws. The only difference between this unit, and the one in the left column, and at the bottom of Page 10-15, is the method of attachment to the valve body.

A GOOD WORD: Because the vent screw is left open, the pump is vented, therefore, it is self-bleeding.

10-9 ELECTRIC MOTOR SERVICE SYSTEM "A"

TROUBLESHOOTING

Before going directly to the electric motor as a source of trouble, check the



Typical hydraulic pump with major parts and wiring identified.

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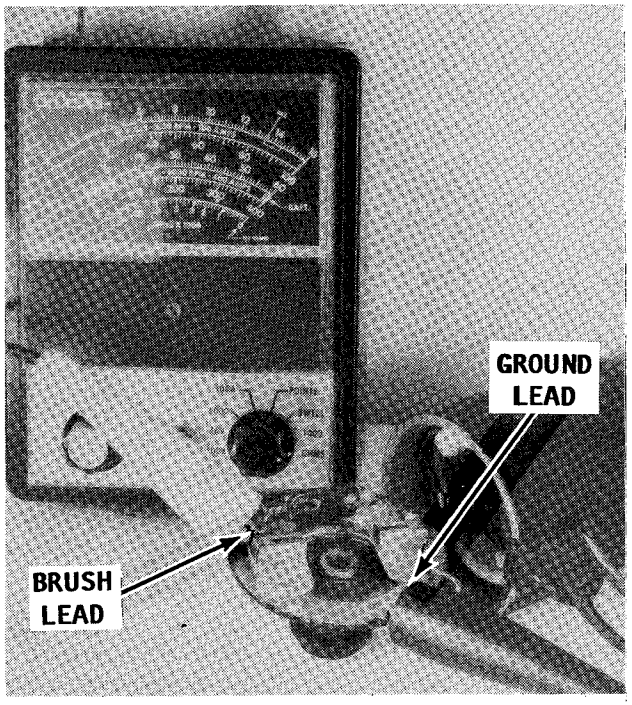
battery to be sure it is up to a full charge; inspect the wiring for loose connections, corrosion and the like; and take a good look at the control switches and connections for evidence of trouble.

The control switches may be eliminated as a source of trouble by connecting the pump directly to the battery for testing purposes. This can be accomplished by disconnecting the black and the blue wires from the solenoid, and then connecting the black wire to the negative (-) battery terminal and the blue wire to the positive (+) terminal.

If the pump motor does not run with this direct connection, either the pump motor or the pump and valve assembly is defective. If the pump motor does operate, the problem is in the wiring or the panel switches.

DISASSEMBLING

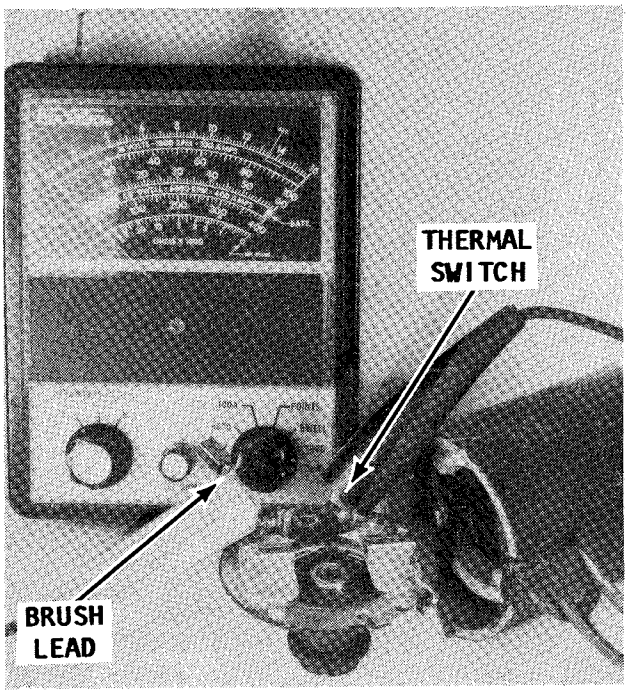
Remove the two screws from the top of the motor and reservoir assembly. Scribe a mark on the reservoir and a matching mark on the motor housing as an aid to assembling. Separate the reservoir from the motor. **TAKE CARE** not to lose the spacers from the armature. Pull the armature out of the frame. Disconnect the ground wire from the upper end cap. Remove the end cap from the frame and field assembly.



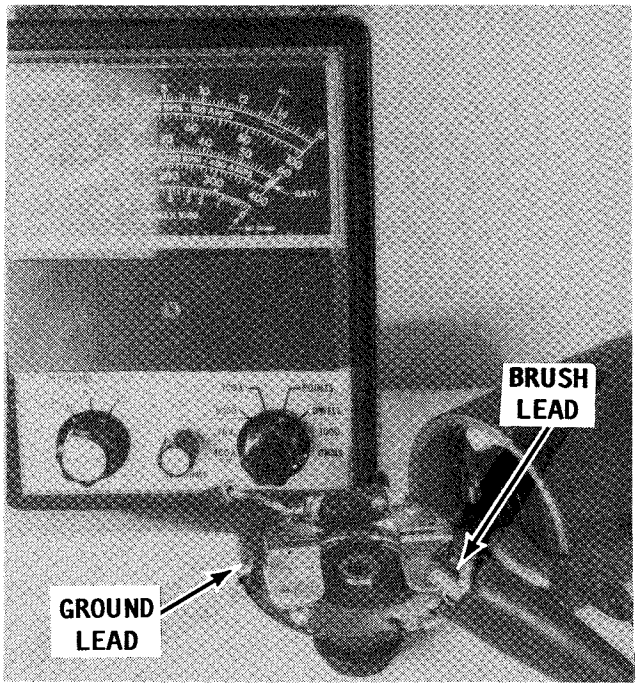
Hookup to check the continuity between the brush holders and the end cap. The meter should read infinity, indicating a lack of continuity.

CLEANING AND TESTING

Any sign of oil in the pump motor indicates either the reservoir seal is damaged or the vent screw was closed. If the vent was closed, air could not escape and oil was forced into the pump motor.



Hookup to check the resistance of the thermal switch. The meter is set on the Rx1 scale.



Testing for a short between a brush pigtail and the end cap.

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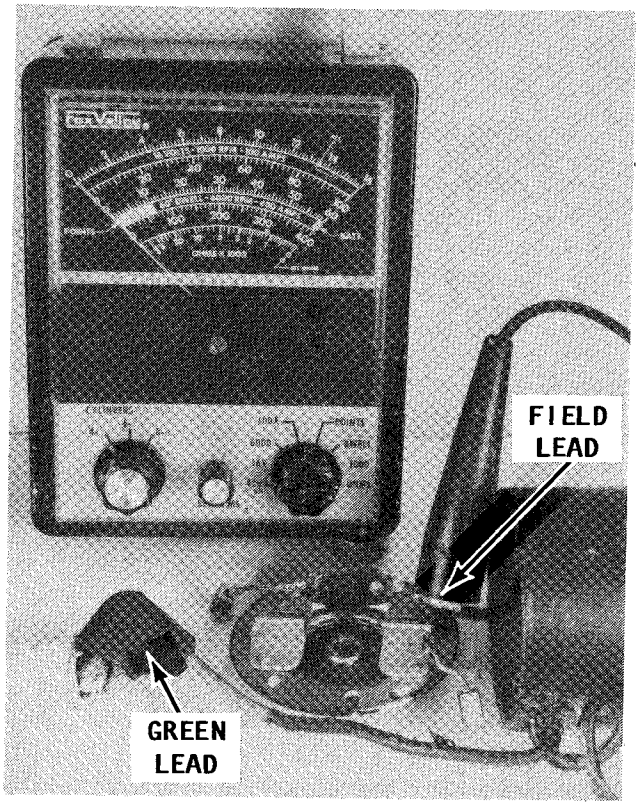
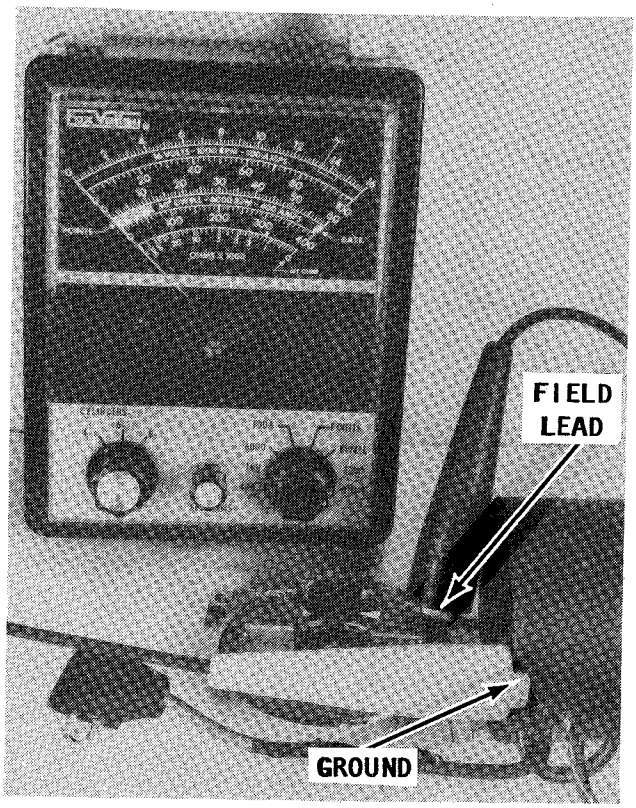
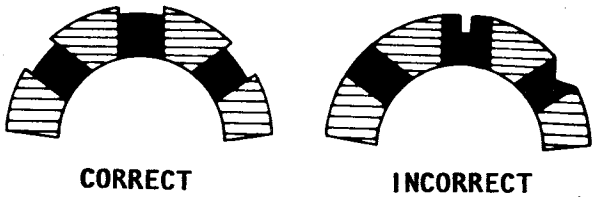


Checking the field coils for a short.



Testing the field coil for continuity. The meter should read infinity, indicating no continuity.



Armature segments properly cleaned (left), and improperly cleaned (right).

Check the amount of wear to the brushes. If they are worn to half their original length, they should be replaced. If the commutator is worn, true it on a lathe, and undercut the mica.

Check the armature on a growler for shorts, open windings, or shorted windings.

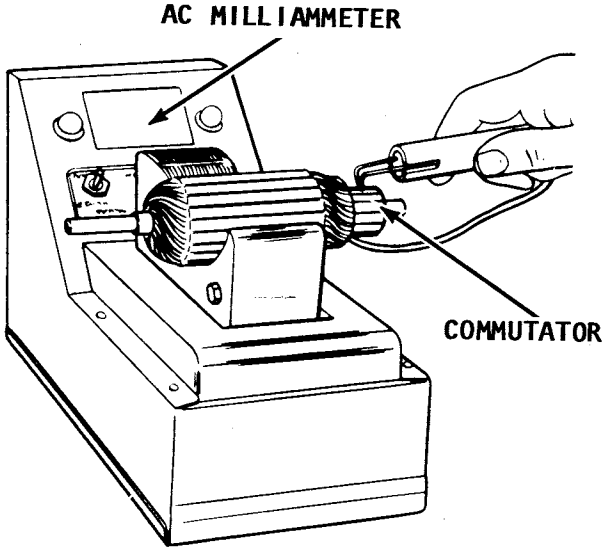
Check the resistance of the thermal switch. If the switch has no continuity or has high resistance, it **MUST** be replaced.

Check between each brush holder and the end cap for a short. There must be no continuity.

GOOD WORDS

If there is any measurable high resistance in any of the tests in this step, the frame and field assembly **MUST** be replaced. Check the field coils for a short, ground, or excessive resistance in the windings. With the tester on Rx1, check for resistance between the green wire and the black jumper wire. Check for resistance between the blue wire and the black jumper wire. Check the black ground wire for resistance.

With the tester still on the Rx1 scale, check for a short between the black jumper



Checking between the commutator segments. Continuity must exist.

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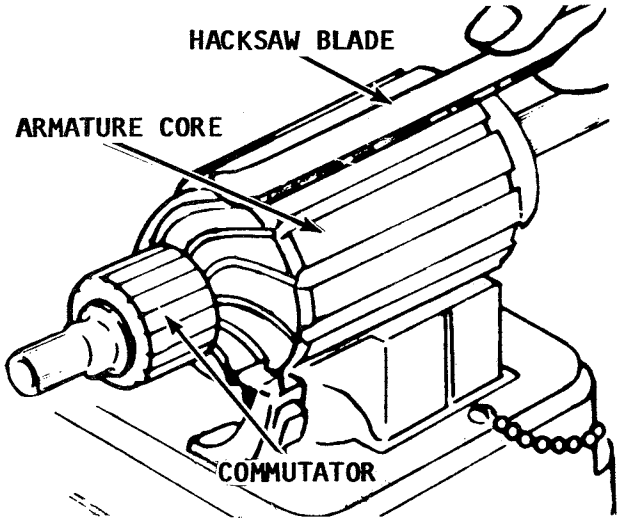
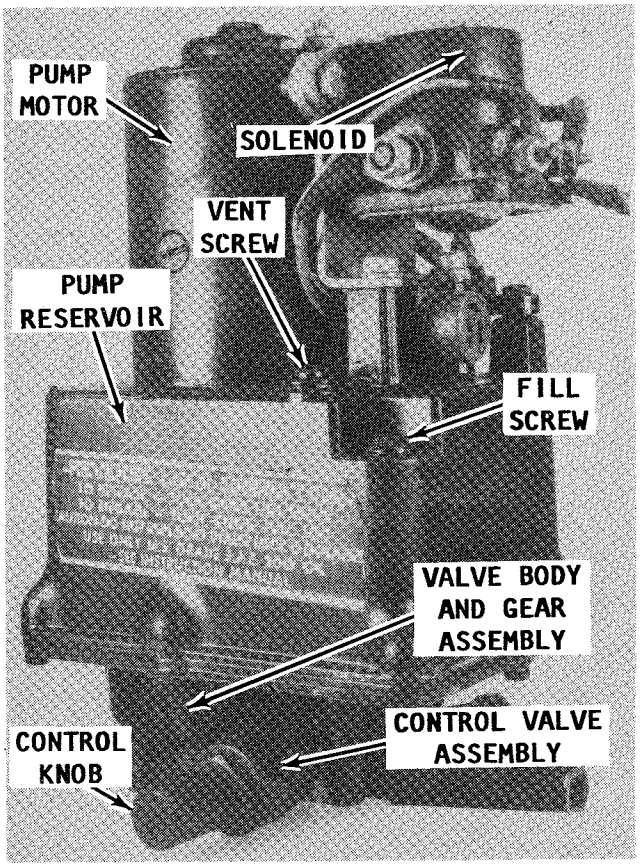


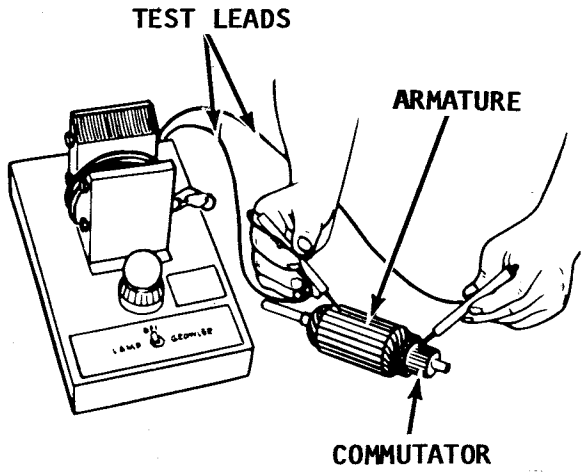
Method of testing the armature for a short circuit using a growler and a hacksaw blade. If the blade vibrates, the mica must be cleaned out or the armature replaced.

wire and ground. A short is indicated if the needle moves to the right. The assembly **MUST** be replaced.

Install the armature into the frame and field assembly. Place the ball bearing on top of the armature shaft, if such a bearing

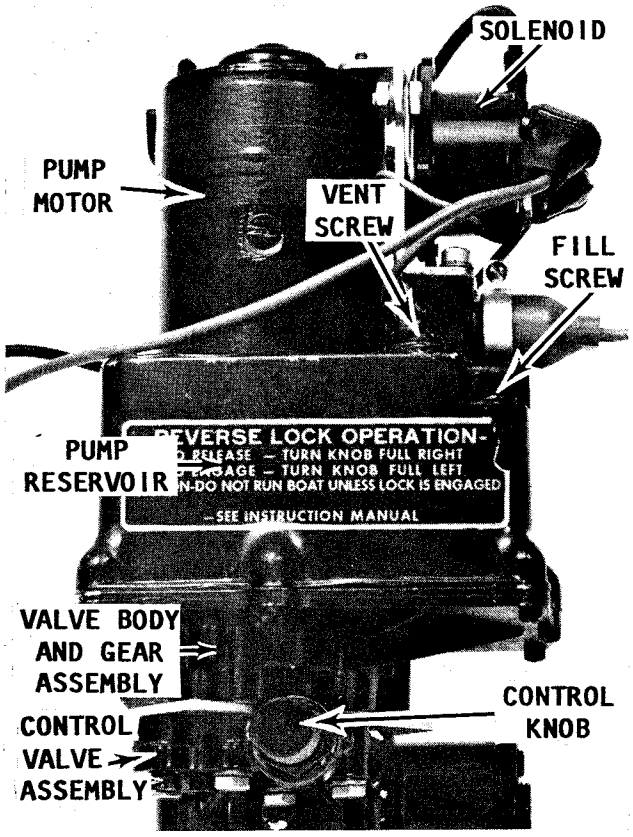


Hydraulic pump with early model solenoid. Other major parts are identified.



Armature check for a short: One test light lead on each commutator segment alternately, and the other lead on the armature core. No continuity.

is used. Depress the brushes into place, and slide them over the commutator bars. **TAKE CARE** not to mar the brushes. Position the assembly onto the reservoir housing and work the shaft into the pump. Install the screws into the cap. Be sure to install the ground wire onto one of the screws securing the cap. Tighten the two bolts to the reservoir housing.



Hydraulic pump identical to the one in the left column except with later model solenoid.

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10-10 SYSTEM "B" MODELS WITH TWO TRIM CYLINDERS AND ONE TILT CYLINDER

DESCRIPTION AND OPERATION

This new updated tilt and trim system is similar to the older model with several engineering design changes. The system consists of an electric motor, pump, pressurized fluid reservoir, two small trim cylinders, and one large tilt cylinder.

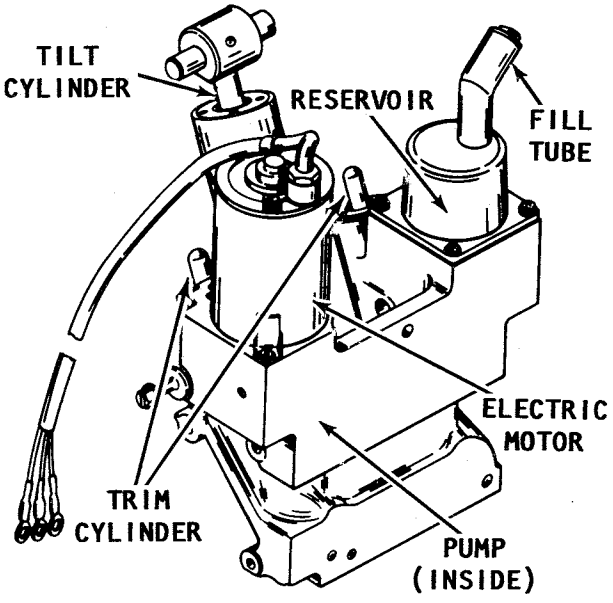
As with the earlier system the remote control panel is provided with an **UP** button and a **DOWN** button. The third button **"TRAILER"** is not needed because there is no trim limit switch to by-pass. The by-pass is done with the hydraulic system.

An electrical trim position sender (optional equipment) is installed in the electrical circuit. This sender consists of a variable resistor to monitor the current sent to the gauge (if installed) to register the position of the powerhead.

Trimming Outboard Unit UP

Depressing the **UP** button will actuate the "up" solenoid and close the circuit to the electric motor. The electric motor will drive the pump forcing fluid into the "up" side of the two trim cylinders.

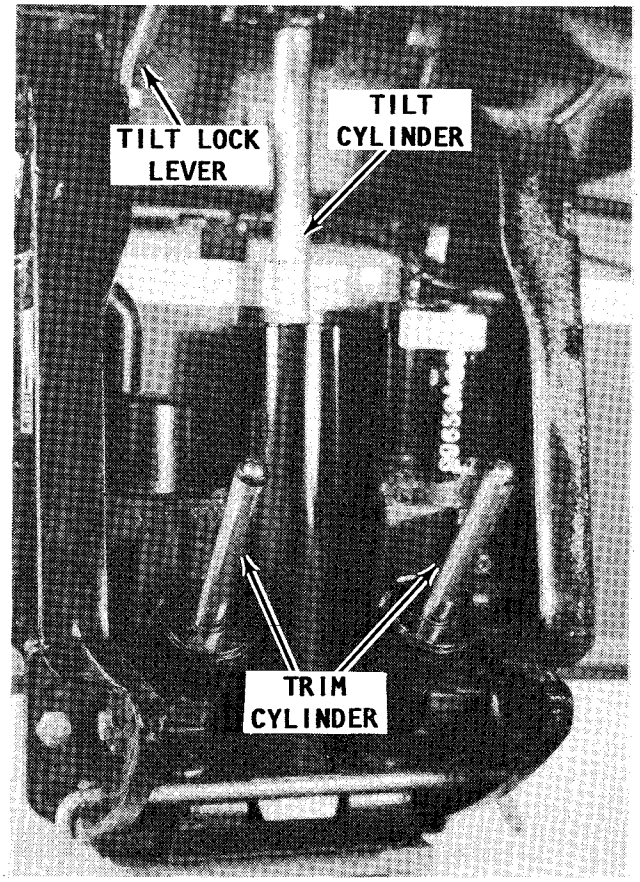
As the trim cylinders extend, the outboard unit may be raised to the desired angle. The system is designed to prevent the unit from being raised above 20° if the powerhead is operating above approximately 2000 rpm.



Line drawing showing the back side of the System "B" Power Trim/Tilt with major parts identified.

When the port side trim cylinder is fully extended, a check valve opens allowing the system to be regulated at 425 psi. If the propeller exceeds 2000 rpm, the propeller thrust is sufficient to build up pressure above 425 psi on the **UP** side of the system. At this point excess fluid is returned to the reservoir through the check valve, lowering pressure in the system. When the pressure is reduced, the outboard unit will be lowered to the trim limit position. In this manner, the check valve is operating as a tilt limit switch preventing the outboard unit to be operated at a greater angle than the 20° trim limit, **IF** propeller rpm exceeds 2000 rpm.

If the powerhead is cut back below 2000 rpm, the maximum angle may be increased above the 20° limit. However, if the powerhead accelerates beyond 2000 rpm, the thrust created by the propeller (provided the propeller is deep enough in the water) will cause the trim system to automatically lower the unit back to the 20° maximum trim angle.



The outboard unit raised to the full up position by the larger center tilt cylinder. The tilt lock lever has been engaged to take the weight from the cylinder.

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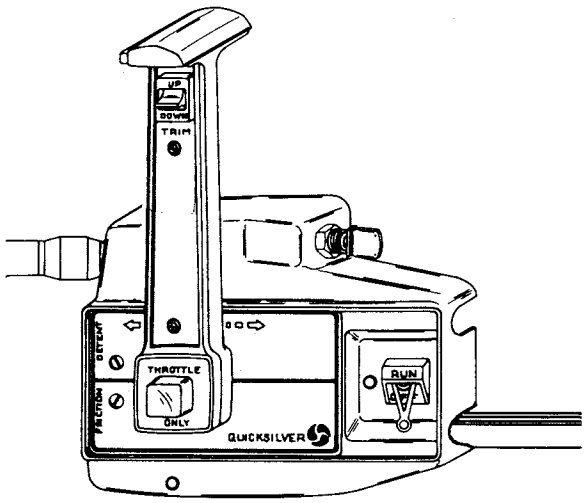


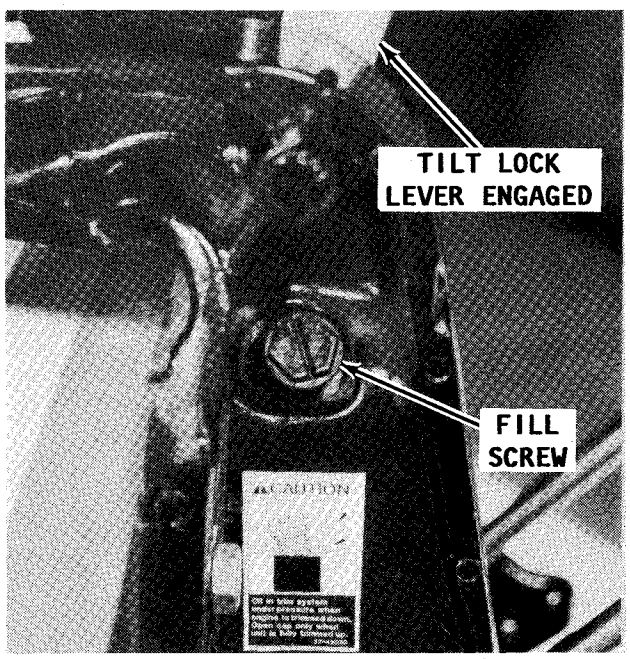
Controls for the System "B" Power Trim/Tilt does not have a "Trailering" button. Holding the ***UP*** *button depressed will activate the center trim cylinder to raise the outboard.*

Trimming Outboard Unit DOWN

Depressing the **DOWN** button will close the "down" circuit and actuate the "down" solenoid. The electric motor will operate in the opposite direction (from the "up" direction), forcing hydraulic fluid into the "down" side of the tilt cylinder. This action will move the outboard unit downward. When the desired angle of trim is obtained the button is released and movement ceases.

Trailering

Depress the **UP** button. This action will close the **UP** circuit and activate the **UP** solenoid. The two trim cylinders will extend slowly to the full trim up position. Hold the **UP** button depressed and the tilt cylinder will continue to move the outboard unit upward to the full up position for trailering.



The System "B" is pressurized! Therefore, heed the warning decal just below the fill screw and ***NEVER*** *back off the screw unless the outboard unit is in the full* ***UP*** *position.*

SAFETY WORDS

As a safety measure to prevent accidental movement of the outboard while trailering to and from the water, it is **STRONGLY** recommended a trailer bracket **ALWAYS** be used to mechanically lock the outboard unit in the up position. Such a bracket may be purchased at modest cost from the local marine store. With the bracket in place, the unit may be trailered in confidence over rough roads without fear of the outboard being jarred suddenly to the "down" position.

10-11 HYDRAULIC BLEEDING SYSTEM "B"

This trim/tilt unit with two small trim cylinders and one large tilt cylinder is almost a "self-bleeding" system. Actually, the "bleed" operation is accomplished through the fill screw.

To check for air in the system, first activate the **UP** circuit and raise the outboard slightly with the trim cylinders. Next, exert a heavy, steady, downward force on the lower unit.

If the trim rods retract into the trim cylinders more than 1/8" (3.2 mm) there is air in the system.

WARNING

TRIM SYSTEM IS PRESSURIZED! DO NOT REMOVE FILL SCREW UNLESS OUTBOARD UNIT IS IN CORRECT POSITION.

If the trim/tilt pump and motor are installed in the boat, the outboard unit MUST be in the full **DOWN** position.

If the trim/tilt pump and motor are installed between the clamp brackets, the outboard unit **MUST** be in the full **UP** position.

TIGHTEN FILL SCREW SECURELY BEFORE MOVING OUTBOARD.

Raise the outboard unit to the full **UP** position. All three pistons will be fully extended. Once the unit is in the full up position, release the button and engage the tilt lock lever. Now, momentarily depress the **UP** button just a couple times. Depressing the **UP** button, for a second or two, will send current through the **UP** solenoid to

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the electric motor; the motor will drive the pump; air in the pump will cause it to "squeal"; the pump will draw fluid from the reservoir; the pump will attempt to send fluid to the tilt cylinder; the piston cannot move because it is already extended; the pressure will increase to 425 psi (2930 kPa); the port side pressure relief valve will automatically open; the excess fluid will be returned to the reservoir, purging the system of air. Actually, the air is returned to the reservoir.

At this time, **SLOWLY** remove the fill screw and the trapped air will escape. Add fluid, if necessary.

Understand, a small amount of air will remain on top of the reservoir under the cap. This is caused by the design of the cap and reservoir and as a "cushion" for the system.

Remove the tilt lock lever; depress the **DOWN** button; lower the outboard unit to the full down position. Now, momentarily depress the **DOWN** button for just a second or two, a couple of times. Depressing the **DOWN** buttom for a second or two will again activate the system; air in the pump will cause it to "squeal"; the pump will draw fluid from the reservoir; the pump will attempt to send fluid to the "down" side of the tilt cylinder; the cylinder cannot move because it is already retracted; the pressure will increase to 425 psi (2930 kPa); the pressure relief valve in the port side trim piston will automatically open; the excess fluid will be returned to the reservoir, purging the system of air. Actually, the air is returned to the reservoir.

Raise the outboard to the full up position again. Engage the tilt lock lever. **SLOWLY** remove the fill screw again and the trapped air will escape. Add fluid, if necessary.

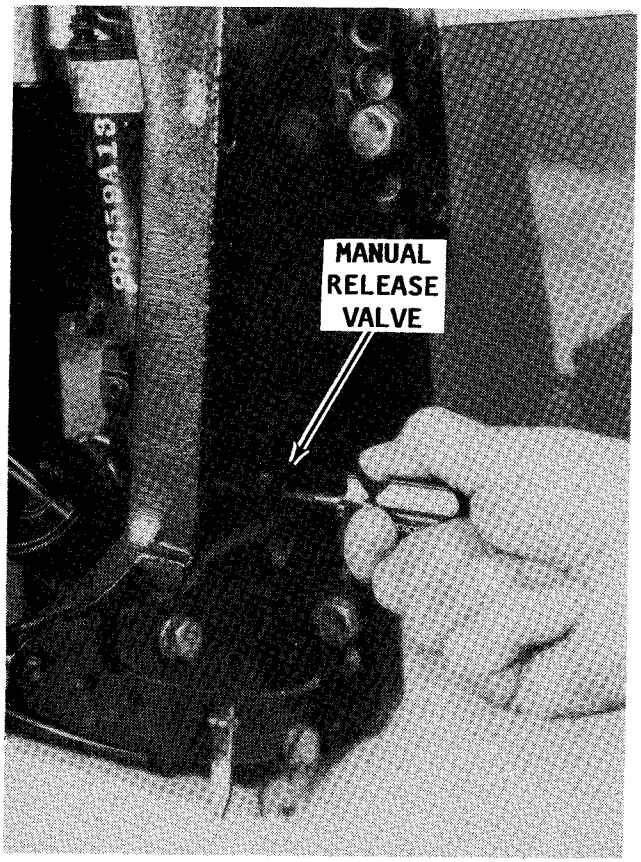
Repeat the above procedure two or three times and any and all excess air will be bled from the system. After the air leaves the system, a noticeable change in the sound of the pump motor laboring with the outboard unit in the full up or down position will be heard.

As a further check, make the initial test for air again by first raising the outboard with the trim cylinders just a few degrees, and then exerting a steady downward pressure on the lower unit. If the trim rods do not retract into the cylinders more than about 1/8" (3.2 mm), all excess air has been bled from the system.

10-12 HYDRAULIC FLUSHING SYSTEM "B"

Only Automatic Transmission Fluid should be used in the power trim system. However, in remote areas or in an emergency, a substitute can be used. SAE 10W-30 or 10W-40 oil rated SE was recommended in the past by the manufacturer for earlier model systems. Therefore, these oils should be a workable substitute until the automatic transmission fluid can be obtained. Once the transmission fluid is available, the system **MUST** be flushed of the oil before putting the system into service. This can be accomplished by simply draining all the oil from the system.

First, raise the outboard unit to the full up position and engage the tilt lock lever. Place a suitable container under the starboard side trim cylinder. Next, **SLOWLY** remove the fill screw and bleed the pressure from the system. Back off the manual release valve about two full turns **COUNTERCLOCKWISE** to release any remaining pressure in the system.



*The manual release valve is used to release pressure in the system to permit raising the outboard manually. Always release the valve **SLOWLY**.*

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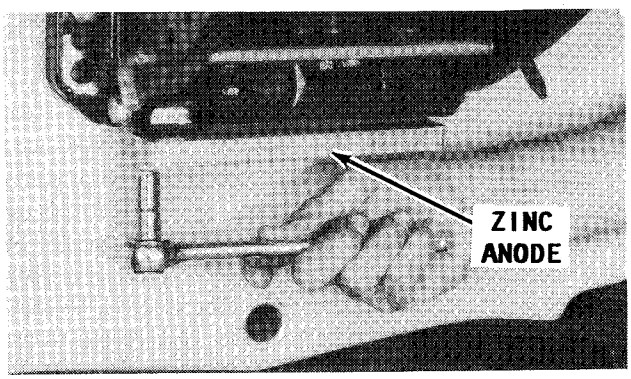


The zinc anode must be removed to gain access to the Allen screw for draining the system.

Next, remove the two bolts securing the zinc anode to the underneath side of the transom bracket, and then remove the anode.

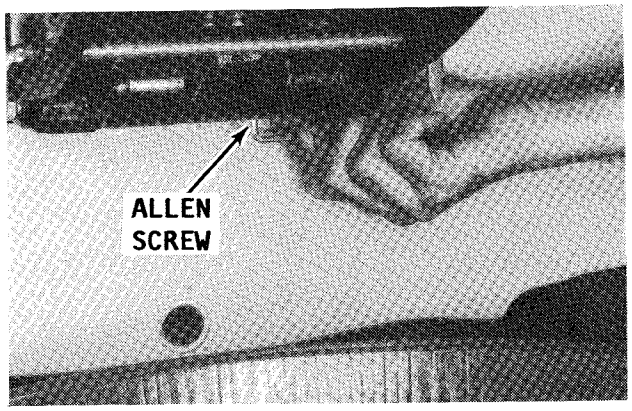
Now, remove the Allen plug from the underneath side of the starboard trim cylinder and drain the oil from the system.

After all the oil has been drained from the system, install the Allen plug, tighten the manual relief valve fully **CLOCKWISE,** and then add Automatic Transmission Fluid to the system.

Bleed air from the system according to the procedures outlined in Section 10-11.

Operate the system several times through the complete cycle from the full down position to the full up position.

Drain this first quantity of flushing transmission fluid according to the foregoing procedures. As the fluid is being drained, take special note of the fluid color. If the fluid has a decided crimson tone, the oil has been flushed from the system. However, if the fluid color has a slight brownish tinge, there is still oil in the system. Repeat the flushing procedure until the brownish tinge has disappeared. The system is now thoroughly flushed and ready for service.



Replacing the Allen screw after the system has been drained of fluid.

10-13 TROUBLESHOOTING SYSTEM "B"

SPECIAL WORDS

When moving through the listed troubleshooting procedures, **ALWAYS** stop and check the system after each task. The problem may have been corrected, intentionally or not.

PRELIMINARY CHECKS

1- Check to be sure the manual release valve, located on the starboard transom bracket, is fully tightened, **CLOCKWISE.**

2- Verify the hydraulic reservoir is filled with fluid. Fluid should be visible when the fill cap is removed. Replenish as required.

WARNING

TRIM SYSTEM IS PRESSURIZED! DO NOT REMOVE FILL SCREW UNLESS OUTBOARD UNIT IS IN CORRECT POSITION.

If the trim/tilt pump and motor are installed in the boat, the outboard unit **MUST** be in the full **DOWN** position.

If the trim/tilt pump and motor are installed between the clamp brackets, the outboard unit **MUST** be in the full **UP** position.

TIGHTEN FILL SCREW SECURELY BEFORE MOVING OUTBOARD.

3- Inspect the hydraulic system, hoses and fittings, for leaks. If an external leak is discovered, correct the condition.

4- Check for air in the system and bleed-off if air is suspected.

To check for air in the system, first activate the **UP** circuit and raise the outboard slightly with the trim cylinders. Now, exert a heavy, steady, downward force on the lower unit.

If the trim rods retract into the trim cylinders more than 1/8" (3.2 mm) there is air in the system.

Raise the outboard unit to the full **UP** position three or four times. Each time the unit is in the full **UP** position, engage the tilt lock lever, and then **SLOWLY** remove the fill screw. Add fluid, if necessary.

In this manner any air in the system is forced out through the fill screw opening.

5- If the system fails to hold the outboard unit in the full tilted (trailering) position, service the port side trim rod from the

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cylinder. See Section 10-15 for detailed procedures to remove, service, and install the trim cylinder.

CRITICAL WORDS

DO NOT remove the check valve from the port side trim rod. (The starboard rod does not have a check valve.) This check valve has been preset at the factory to operate at a specific pressure. Therefore, removal and installation of the check valve could result in improper operating pressure and possible damage to the system.

After the rod has been removed, inspect the check valve for any foreign material and clean as required. If check valve cannot be cleaned satisfactorily, the trim rod and check valve **MUST** be replaced as a unit.

While the rod is out of the cylinder, inspect the **O**-ring and replace it with a new one if there is any sign of damage.

6- Inspect the manual release valve **O**-ring and the valve for damage. See Section 10-15 for detailed procedures to remove, service, and install the manual release valve.

7- If the tilt cylinder fails to raise the outboard unit to the full **UP** position or fails to move the unit downward properly, the tilt cylinder requires attention. See Section 10-15 for detailed instructions to remove, service, and install the tilt cylinder.

8- If the pump "whines" during operation, there is probably air in the system. Bleed the system according to the procedures in Section 10-11.

9- If the motor makes "strange" sounds or seems to be "laboring", the electric motor may require service, see Section 10-15.

SPECIAL WORDS

If a problem is encountered with the tilt/trim system, it is important to determine, if possible, whether the malfunction is in the hydraulic system or in an electrical circuit.

SYMPTOMS OF HYDRAULIC PROBLEM

The most common problem in the hydraulic system is failure of an **O**-ring to hold pressure. Therefore, if any of the following problems are encountered, see the appropriate service instruction in Section 10-14.

a- Outboard will not trim up or down. Fluid level low; manual release valve not fully closed; pump failure; **O**-rings in trim cylinders or in tilt cylinder damaged.

b- Outboard trims up, but will not trim down. Tilt cylinder requires service.

c- Outboard trims down, but will not trim up. Trim cylinders require service.

d- Outboard "shudders" when shifted from one gear to another. Air in the system; internal cylinder leaks -- **O**-rings failure to hold pressure.

e- Outboard fails to hold set trim position or will not hold tilted position. **O**-rings in trim and tilt cylinder fail to hold pressure; internal check valve on port cylinder requires cleaning; external leak --fitting or part.

f- Outboard begins to trail out (starts to rise slightly) when throttle is backed-off from high speed. Manual release valve not fully closed; air in the system; **O**-ring/s in tilt cylinder fail to hold pressure.

g- Outboard fails to hold trim position when unit is operating in reverse gear. Manual release valve not fully closed; **O**-rings in trim cylinders fail to hold pressure.

h- Outboard fails to return to complete down position or returns partially with jerky motion; air in the system; internal leaks in the cylinders.

SYMPTOMS OF ELECTRICAL PROBLEM

If any of the following problems are encountered, troubleshoot the electrical system as outlined in this section.

a- Outboard trims up and down, but the electrical motor "grinds".

b- Outboard will not trim up or down.

c- Outboard trims up, but will not trim down.

d- Outboard trims down, but will not trim up.

Manual Operation

If the battery is dead, or sufficient power cannot be supplied to the electric motor to drive the hydraulic pump for any number of reasons, the outboard unit may be raised manually.

WARNING

IF OUTBOARD UNIT IS IN THE UP POSITION WHEN THE MANUAL RELEASE VALVE IS OPENED, THE OUTBOARD WILL DROP TO THE FULL DOWN POSITION RAPIDLY. THEREFORE, ENSURE ALL PERSONS STAND CLEAR.

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Rotate the manual release valve three to four complete turns **COUNTERCLOCKWISE.**

If the outboard unit is in the down position, it may be raised manually for trim or for trailering. If the unit is in the up position, the unit will drop **RAPIDLY** to the full down position.

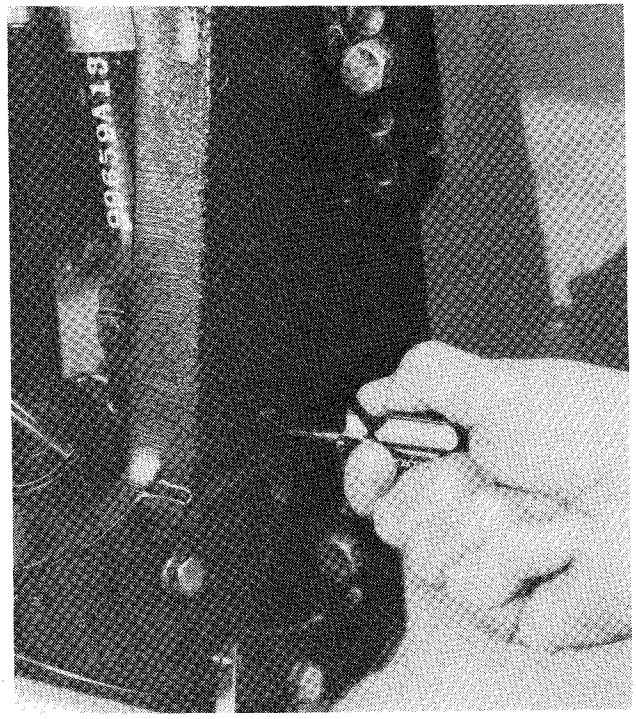
PUMP MOTOR TEST SYSTEM "B"

This simple procedure will determine if the pump motor requires service.

a- Disconnect the **Blue** motor wire from the **UP** solenoid. Disconnect the **Green** motor wire from the **DOWN** solenoid. Disconnect the **Black** motor ground wire.

b- Connect a test lead from the positive terminal of a 12-volt battery to the **Blue** wire just removed from the solenoid. Connect a test lead from the negative (-) terminal of the battery to the **Black** ground wire disconnected. The motor should run. Leave the ground wire connected, and change the positive (+) battery lead to the **Green** wire removed from the **DOWN** solenoid. The motor should run. If the motor fails either one or both of these tests, it requires service or replacement.

To remove and install a System **"B"** motor or pump, see Section 10-15. The System **"B"** pump **CANNOT** be serviced. Therefore, if troubleshooting indicates the pump has failed, it **MUST** be replaced.



*Releasing pressure by backing out the manual release valve **SLOWLY** three or four complete turns.*

ELECTRICAL SYSTEM TROUBLESHOOTING SYSTEM "B"

SPECIAL WORDS

When moving through the listed electrical troubleshooting procedures, **ALWAYS** stop and check the system after each task before proceeding with further troubleshooting. The problem may have been corrected, intentionally or not.

"TRAILER" CIRCUIT INOPERATIVE "UP" CIRCUIT OK

1- With an ohmmeter on the Rx1 scale, check for continuity between the "small" terminal on the lower solenoid (the terminal with the **Blue/White** wire connected), and the **TRAILER** button terminal with the **Blue/White** wire connected. If continuity is not indicated, the wire is open.

2- If the wire checked OK in Step 1, disconnect all battery leads from the battery. Check for continuity across trailer button terminals with trailer button depressed. If continuity is **NOT** indicated, the trailer button is at fault and must be replaced.

"UP" AND "TRAILER" CIRCUITS BOTH INOPERATIVE "DOWN" CIRCUIT OK

BEFORE spending time with a voltmeter and making other tests, check **ALL** connections on the **UP** solenoid and all other wiring for loose or corroded connections, frayed insulation, or a break in a wire.

1- Connect the **Red** voltmeter lead to "small" terminal of the lower solenoid (terminal with the **Blue/White** wire connected). Connect the **Black** voltmeter lead to the ground terminal of the bottom solenoid (the terminal with the **Black** lead connected). Depress the **TRAILER** button.

If **NO** voltage is indicated, there is an open circuit in the **Blue/White** wire and **Purple/White** (or **Purple**) wires between the "UP" solenoid and the trim buttons.

If voltage **IS** indicated, proceed with Step 2.

2- Leave the **Black** voltmeter lead con-

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nected to ground as in Step 1. Connect the **Red** voltmeter lead to the large terminal with two **Red** leads connected on the lower solenoid.

If **NO** voltage is indicated, check for loose or corroded connection at the "large" terminal with the two **RED** leads connected on the lower solenoid.

Also check for loose connection or corrosion at the same terminal on the upper solenoid. Check the condition of the **RED** lead connecting these two terminals of each solenoid together.

If voltage **IS** indicated, proceed with Step 3.

3- Leave the **Black** voltmeter lead connected to ground as in Steps 1 and 2. Connect the **RED** voltmeter lead to the "small" terminal of the lower solenoid (the terminal with the **Black** wire connected).

Depress the **TRAILER** button. If **NO** voltage is indicated, the lower solenoid (the **UP** solenoid) is defective and must be replaced.

If voltage **IS** indicated proceed with Step 4.

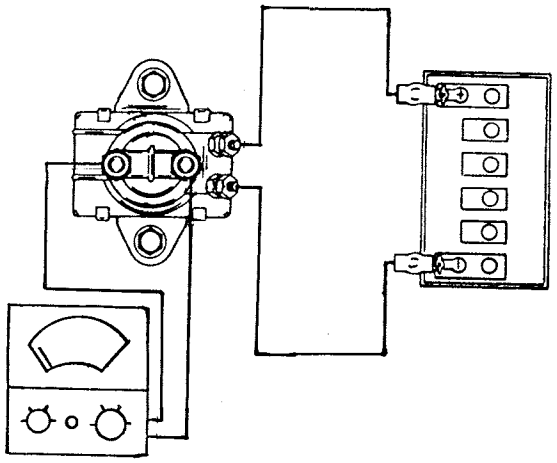
4- Inspect the lower solenoid (the **UP** solenoid), for loose or corroded connections. Remove the lower mounting bolt on the lower solenoid and check for paint, grease, dirt, corrosion, and the like preventing the connecting wire from making a good ground. Install the bolt.

If the **UP** and **TRAILER** circuits still do not function, disconnect the battery leads at the battery. Label the wires leading to the lower solenoid, or draw a quick sketch before disconnecting any of the leads. Remove all connections leading to the solenoid and remove the two attaching bolts. Bench test the solenoid according to the following procedures

Solenoid Bench Tests

a- Connect a 12-volt battery across the two smaller terminals. The ohmmeter should register 0-ohms (zero) indicating continuity and an audible "click" should be heard. The "click" will verify the plunger in the solenoid is being drawn up making contact with the inside terminal to close the circuit.

b- If the ohmmeter indicates a resistance in the solenoid and/or a "click" is not heard, the solenoid is defective and must be replaced.

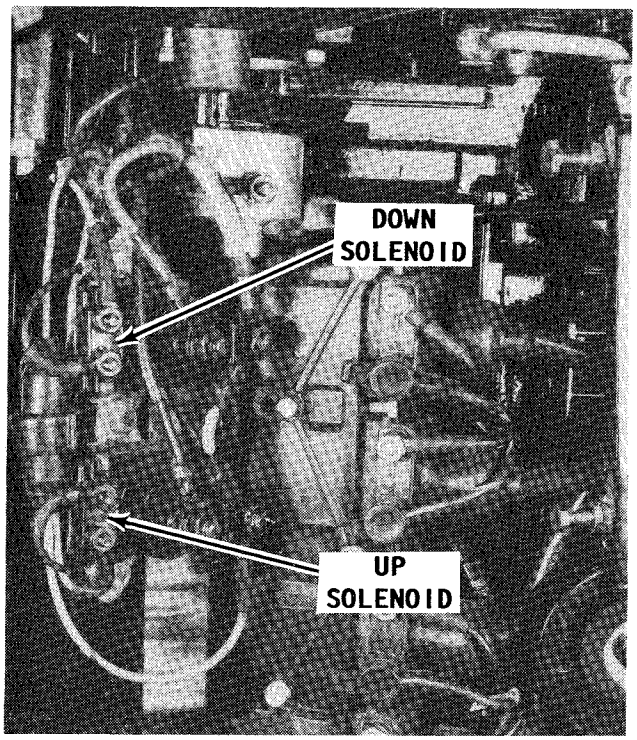


Schematic drawing to show the hookup using a 12-volt battery supply and ohmmeter to test the solenoid, as described in the text.

If the solenoid checked OK, test the charge condition of the battery and inspect all cables and leads.

UP CIRCUIT INOPERATIVE TRAILER CIRCUIT OK

BEFORE spending time with a voltmeter and making other tests, check **ALL** connections on the **UP** solenoid and all other wiring for loose or corroded connections, frayed insulation, or a break in a wire.



*Solenoid installation on the powerhead. The top solenoid controls the **DOWN** movement and the lower solenoid controls the **UP** movement.*

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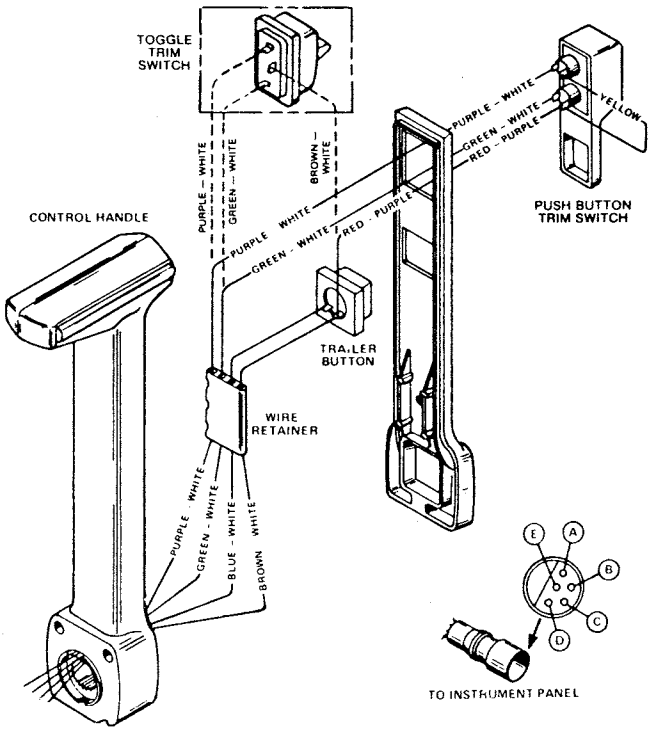
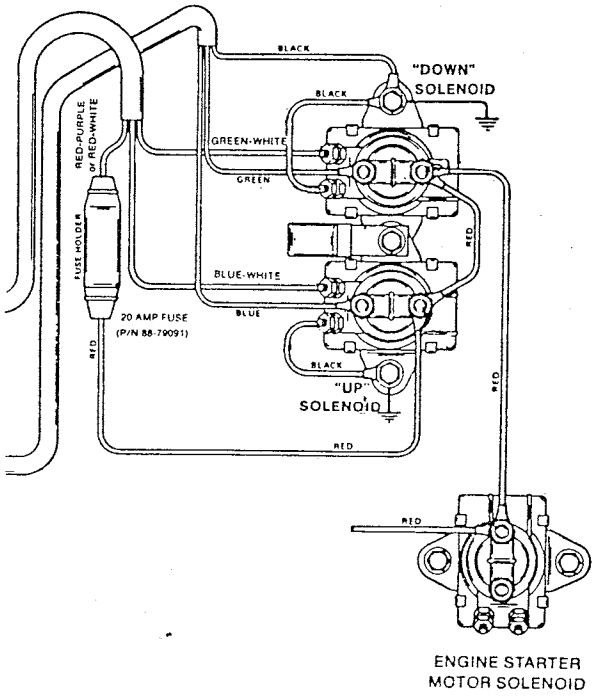


Exploded drawing of the control handle. This illustration and the wiring diagram in the next column will be helpful during the troubleshooting work.



Functional diagram of the System "B". This drawing and the one in the left column will be helpful during the troubleshooting work.

1- With an ohmmeter on the Rx1 scale, check for continuity between the "small" terminal on the lower solenoid (the terminal with the **Blue/White** wire connected). If continuity is **NOT** indicated, there is an open wire in the circuit between these two connections.

If continuity **IS** indicated, proceed with Step 2.

2- If a push button type switch is being tested connect the **RED** voltmeter lead to the **UP** button on the trim switch (the terminal with the **YELLOW** wire connected). If a toggle switch is being tested, connect the **RED** voltmeter lead to the center terminal (the terminal with the **Brown/White** or **Red/Purple** wire connected).

Connect the **Black** voltmeter lead to a good ground such as the mounting bolt of the lower solenoid.

Depress the **UP** trim button. If **NO** voltage is indicated, the trim switch is defective and must be replaced.

If voltage **IS** indicated, proceed to Step 3.

3- Check for poor or corroded connections at the **UP** button or toggle switch.

If the **UP** circuit is still inoperative, replace the **UP** button or switch.

DOWN, UP, AND TRAILER CIRCUITS INOPERATIVE

BEFORE spending time with a voltmeter and making other tests, check **ALL** connections on both solenoids and all other wiring for loose or corroded connections, frayed insulation, or a break in a wire.

1- Check the two 20 amp in-line fuses, as shown in the two accompanying illustrations.

Replace the defective fuse and again test the **UP, DOWN,** and **TRAILER** operation of the trim/tilt system. If the fuses were not "blown", proceed with Step 2.

2- Connect the **RED** lead of a voltmeter to the "large" terminal of the lower solenoid (the terminal with the two **Red** wires connected). Connect the **Black** lead of the voltmeter to the "small" terminal of the lower solenoid (the terminal with the **Black** wire connected).

The voltmeter should indicate close to 12-volts.

If **NO** voltage is indicated, check the battery leads and the **Red** leads between the starter motor and the "large" terminal on the upper solenoid (the terminal with 2 **Red** wires connected) and the same terminal on

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the lower solenoid (the terminal with the two **Red** wires connected). Check for poor connections, corrosion or an open circuit.

If battery voltage **IS** indicated, proceed to Step 3.

3- Leave the **Black** voltmeter lead connected to ground as in Step 2. Connect the **Red** voltmeter lead to the "small" terminal on the lower solenoid (the terminal with the **Blue/White** wire connected.

Depress the **TRAILER** button and check for close to 12-volts. If battery voltage is indicated, check the **Black** ground wires at the solenoids (the upper and lower mounting bolts with **Black** wires attached.), **PARTICULARLY** the **Black** motor lead from the harness, grounded at the top mounting bolt.

If this wire is properly grounded, and circuits are still inoperative, the pump motor may be faulty. Refer to Chapter 9 for troubleshooting electric motors.

If **NO** voltage is indicated, proceed to Step 4.

4- Leave the **Black** voltmeter lead connected to ground as in Step 2 and 3. Connect the **Red** voltmeter lead to the **TRAILER** button (the terminal with the **Brown/White** and **Red/Purple** wires connected).

If battery voltage **IS** indicated, there is an open circuit in each wire. **(Green/White, Blue/White,** and **Purple/White),** between the trim buttons (or toggle switch), and the trim motor. Check for pinched or severed wires and inspect all trim harness connectors for loose or corroded connections.

If **NO** voltage is indicated, proceed with Step 5.

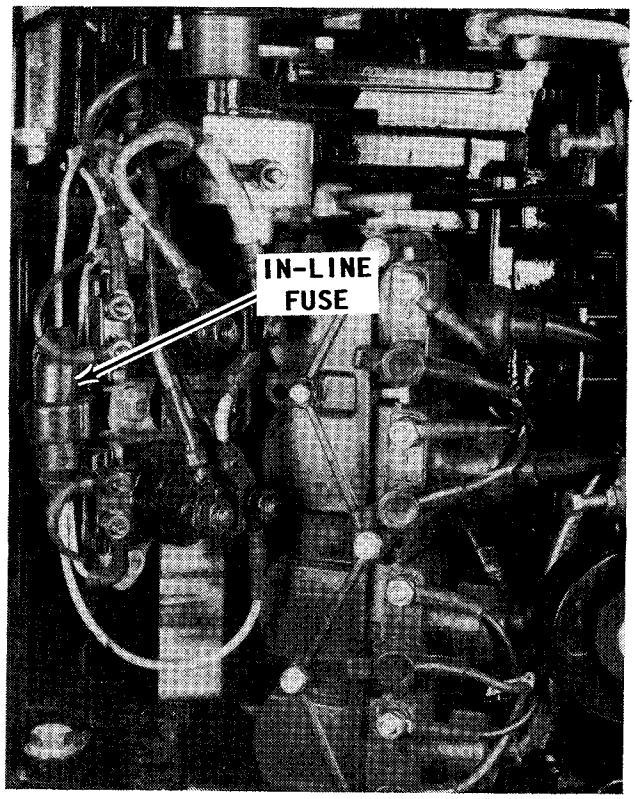
5- Verify voltage is being supplied to the controls by performing the following checks:

a- DO NOT start the engine, but turn the ignition switch to the **RUN** position. Use a voltmeter and check for voltage at any instrument.

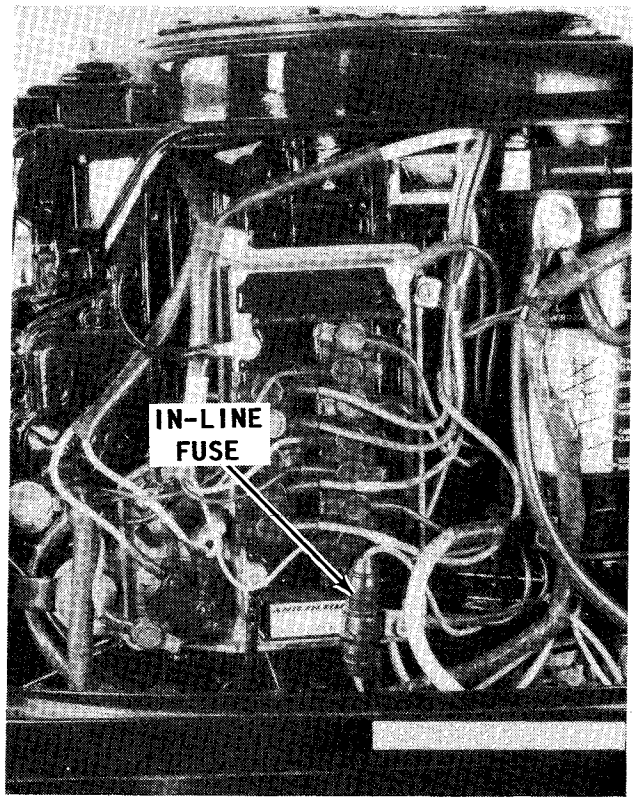
b- If close to 12-volts **IS** indicated, there is an open circuit in the wire between the **TRAILER** button (the terminal with the **Brown/White** and **Red/Purple** wires connected), and the "B" terminal on the back of the ignition switch (the terminal with the **Grey** wire connected), as shown in the accompanying illustration.

c- If **NO** voltage is indicated, proceed to Step 6.

6- Check for continuity between the "large" terminal on the starter solenoid (the terminal with the **Red** wire connected), and the **"B"** terminal on the back of the ignition switch. Check for open wires, loose or corroded connections.



Location of one of two in-line fuses on powerheads equipped with the System "B" Power Trim/Tilt unit.



Location of the other in-line fuse on powerheads equipped with the System "B" Power Trim/Tilt unit.

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DOWN CIRCUIT INOPERATIVE UP CIRCUIT OK

BEFORE spending time with a voltmeter and making other tests, check **ALL** connections on the **DOWN** solenoid and all other wiring for loose or corroded connections, frayed insulation, or a break in the wire.

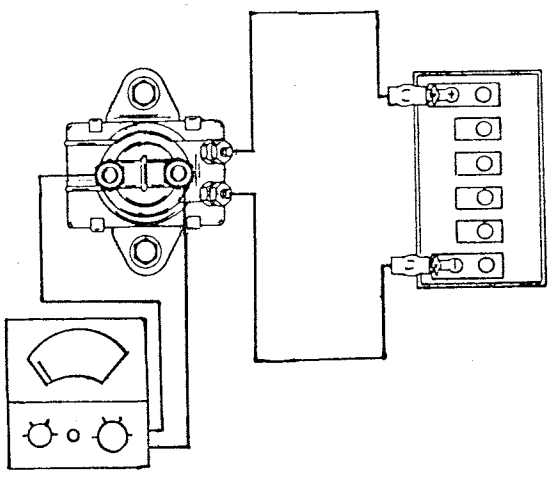
1- Connect the **Red** voltmeter lead to the "small" terminal of the upper solenoid (the terminal with the **Green/White** wire connected). Connect the **Black** voltmeter lead to the top mounting bolt of the upper solenoid (the ground terminal with the **Black** wire connected).

Depress the **DOWN** trim button or toggle switch.

If **NO** voltage is indicated, leave the **Black** voltmeter lead in place and connect the **Red** voltmeter lead to the **DOWN** button (the terminal with the **Green/White** wire connected). Again, depress the **DOWN** button. If close to 12-volts **IS** indicated, there is an open wire between the **DOWN** push button (or toggle switch), and the "small" terminal on the upper solenoid (the terminal with the **Green/White** wire connected).

If **NO** voltage is indicated, proceed with Step 2.

2- Leave the **Black** voltmeter lead connected as in Step 1. Connect the **Red** voltmeter lead to the **DOWN** terminal of the push button (the terminal with the **Red/-Purple** wire connected. If testing a toggle switch, connect the **Red** voltmeter lead to the center terminal (the terminal with the **Brown/White** or **Red/Purple** wire connected).



Functional diagram depicting a battery hooked up directly to one of the solenoids for testing.

If close to 12-volts **IS** indicated, the trim switch is faulty and must be replaced.

If **NO** voltage is indicated, check for loose or corroded connections at the testing points in this step. Test the **DOWN** circuit for operation.

If still inoperative, proceed with Step 3.

3- Leave the **Black** voltmeter lead in place as in Step 1 and 2. Connect the **Red** voltmeter lead to the "large" terminal on the upper solenoid (the terminal with the two **Red** wires connected).

If **NO** voltage is indicated, there is an open circuit between this terminal and the positive battery terminal. Check the entire length of the wires for damage to insulation, evidence of sparking, loose or corroded connections.

If close to 12-volts **IS** indicated, proceed with Step 4.

4- Leave the **Black** voltmeter lead connected as in Step 3. Connect the **Red** voltmeter lead to the "small" terminal on the upper solenoid (the terminal with the **Green/White** wire connected). Depress the **DOWN** trim button or toggle switch.

If **NO** voltage is indicated the **DOWN** solenoid is defective and must be replaced. If close to 12-volts **IS** indicated, proceed with Step 5.

5- Tag the wires or make a quick sketch, and then remove the **DOWN** solenoid. Test the solenoid according to the following procedures.

Solenoid Bench Tests

6- The following simple quick test can be performed to check the integrity of the solenoid:

a- Connect a 12-volt volt battery across the two smaller terminals. The ohmmeter should register 0-ohms (zero) indicating continuity and an audible "click" should be heard. The "click" will verify the plunger in the solenoid is being drawn up making contact with the inside terminal to close the circuit.

b- If the ohmmeter indicates a resistance in the solenoid and/or a "click" is not heard, the solenoid is defective and must be replaced.

If the solenoid checked OK, test the charge condition of the battery and inspect all cables and leads.

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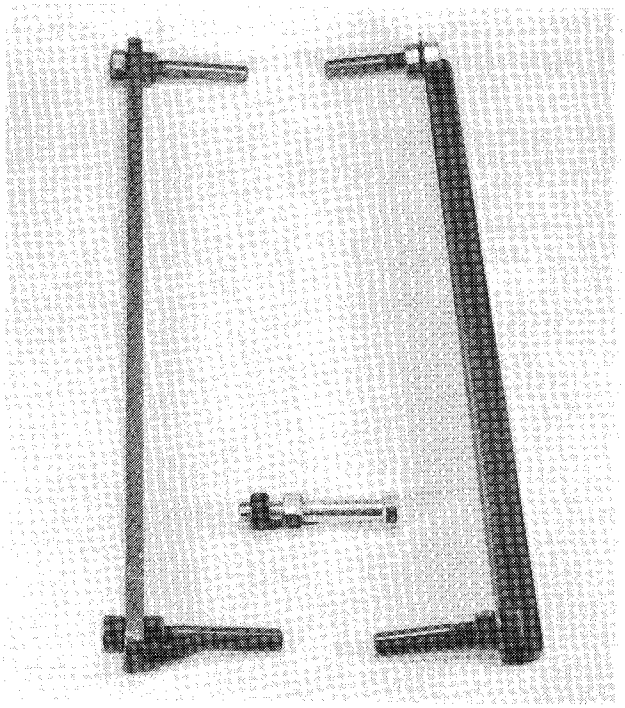
10-14 TRIM/TILT SYSTEM SERVICE SYSTEM "B"

The following procedures provide detailed instructions to remove, service, and install various parts of the System **"B"** Hydraulic Trim/Tilt system. Each small section has a heading to identify the part being serviced.

The hydraulic pump in the System **"B"** cannot be serviced. Therefore, if troubleshooting leads to a faulty pump, without question, then the unit must be replaced. Other parts, such as the trim cylinders, tilt cylinder, reservoir screen, and electric motor, may be serviced. Some may be removed and/or serviced without disturbing other parts. The trim cylinders, and the large tilt cylinder may be serviced without removing the complete system from the clamp bracket. The pump and electric motor may be removed after the starboard clamp bracket is moved clear.

SAFETY WORDS

As a safety measure to prevent accidental movement of the outboard while work is being performed, it is **STRONGLY** recommended a few minutes be used to make a safety support tool as shown in the accompanying illustration. The tool may be made from any metal bar stock or small channel iron of suitable size, with a 3/8" (9.53 mm) hole drilled through at each end and 14" (35.6 cm) apart, as shown. Cut-off the head of a 3/8" bolt about 2-1/2" (6.4 cm) long. Drill a hole through each bolt for a cotter pin. Secure the bolts through the holes made in the bar stock with two nuts, one on each side of the bar. The tool is now ready for installation, one end through the clamp bracket and the other end through the tilt stop bracket. Secure each end of the tool in place with a washer and cotter pin. The trim/tilt system may now be serviced or other work performed with confidence and in safety.



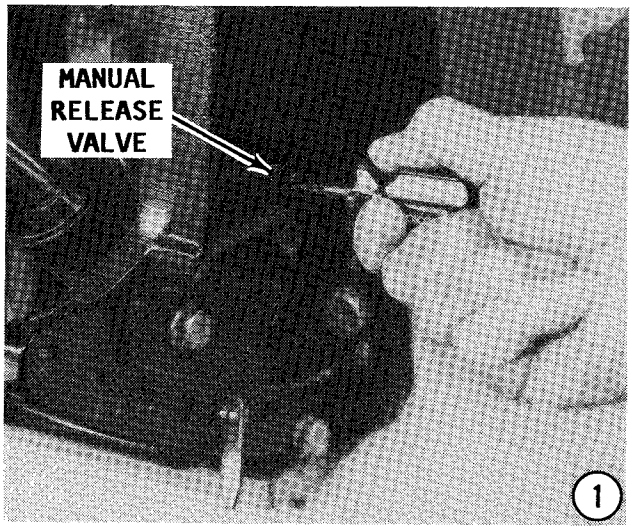
"Home made" safety support tool to hold the outboard in the full up position while performing work on the Power Trim/Tilt unit. The tool can be made from a piece of strap material (left), or a small channel (right), as described in the text.

The following procedures outline detailed instructions for removal of the complete trim/tilt system from the outboard unit, disassembling as far as practical of each major part, cleaning and inspecting, assembling, and installation back on the boat. If the damaged part is discovered, the disassembling work may be stopped, a replacement installed, the unit assembled, and installed between the clamp brackets.

10-15 TRIM/TILT SYSTEM REMOVAL

PRELIMINARY TASKS

1- Raise the outboard unit to the full up position. If the hydraulic system is inoperative, first rotate the manual release valve **COUNTERCLOCKWISE** about three complete turns, and then manually lift the unit to the full up position.



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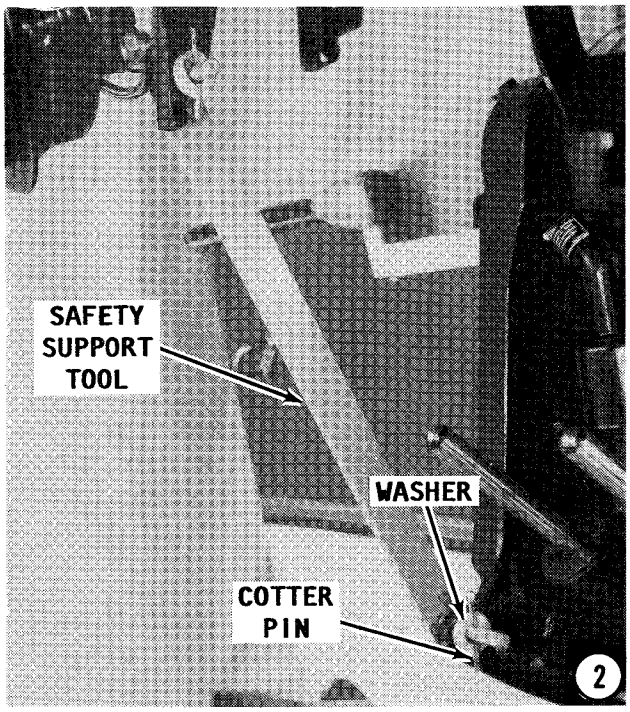
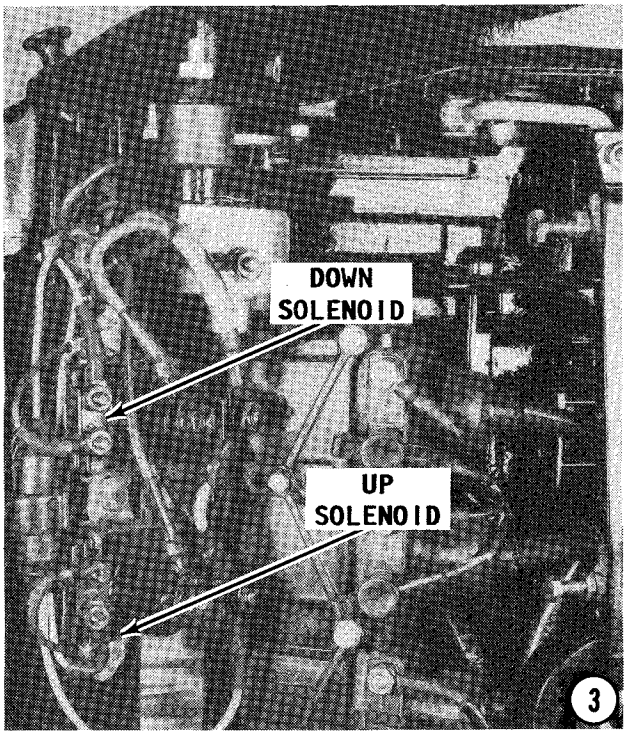
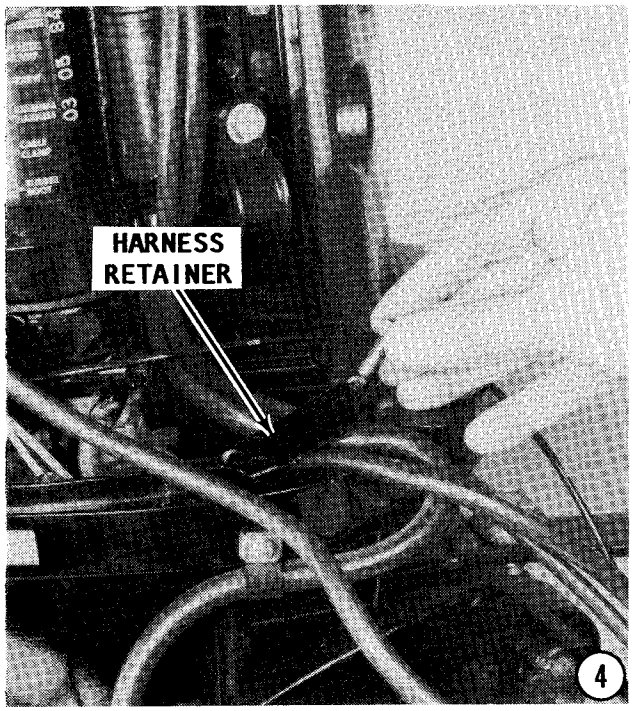


2- Set the tilt lock lever in place. Install the safety support tool as described under "Safety Words" at the beginning of this section. Secure one end of the tool to the clamp bracket with a washer and cotter pin. Secure the other end to the tilt stop bracket in a similar manner, as shown.

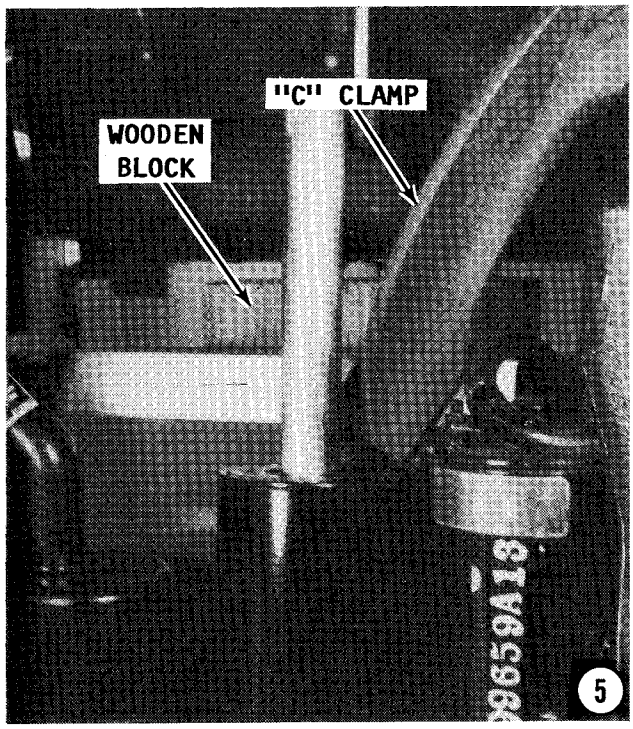
3- Disconnect the electrical leads at both battery terminals. Tag, and then disconnect the wiring at the upper and lower solenoids under the powerhead cowl.





4- Remove the harness retainer and any other clamps securing wiring running to the electric motor.

5- Obtain a large C-clamp and a block of wood, approximately 4" to 6" (10.2 x 21.2 cm) square and about 2" (5.1 cm) thick. Support the outboard unit by clamping the block of wood on the inside of the transom up hard against the swivel bracket tube with the large C-clamp, as shown.



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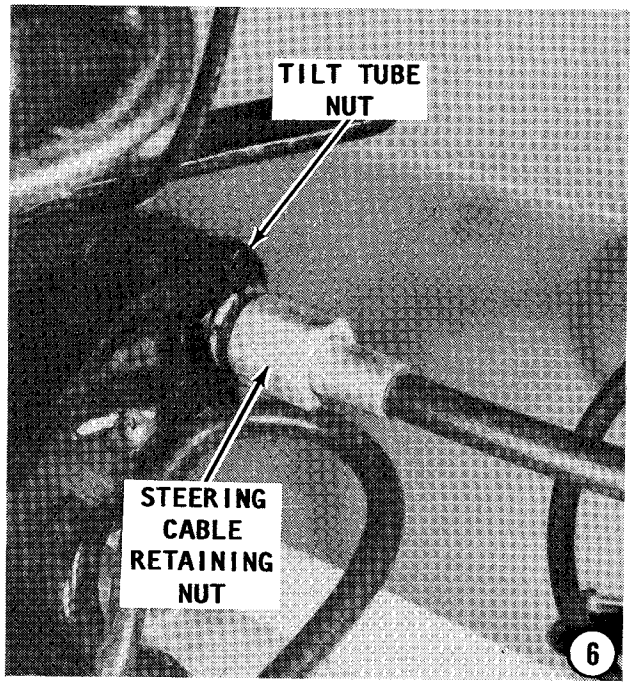
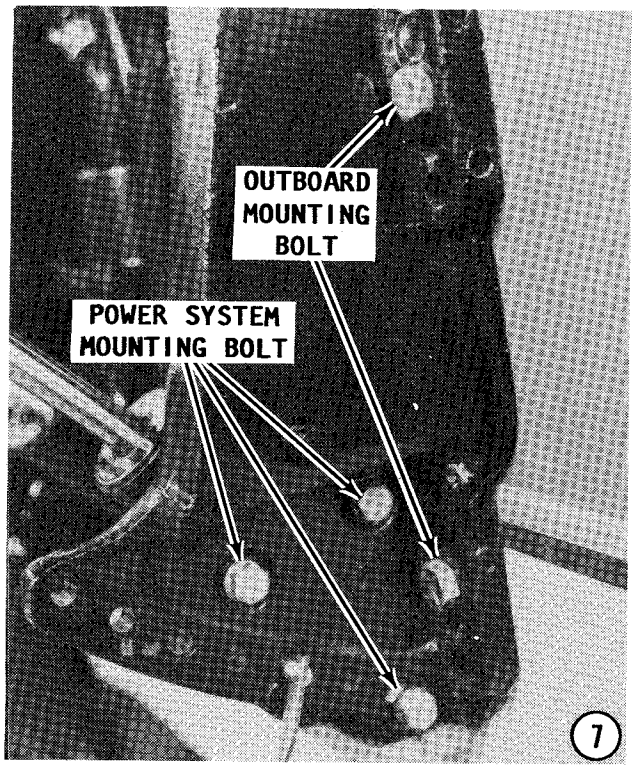
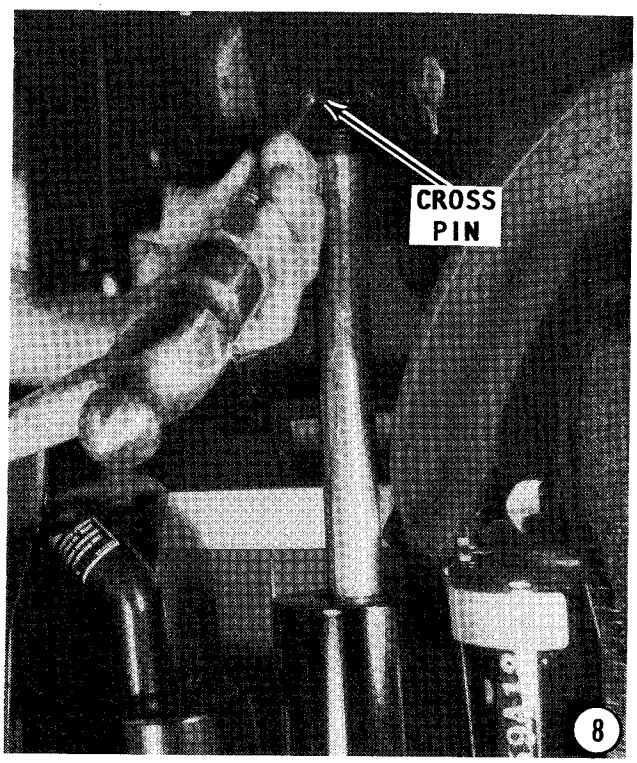


6- If the unit being serviced is equipped with thru-the-tilt tube steering, remove the steering cable retaining nut from the end of the tilt tube. Remove the tilt tube nut.

7- Remove the two outboard mounting bolts and the three bolts securing the trim/-tilt assembly to the starboard bracket. Carefully move the starboard transom bracket away far enough for the manual release valve to clear when the trim/tilt system is removed.

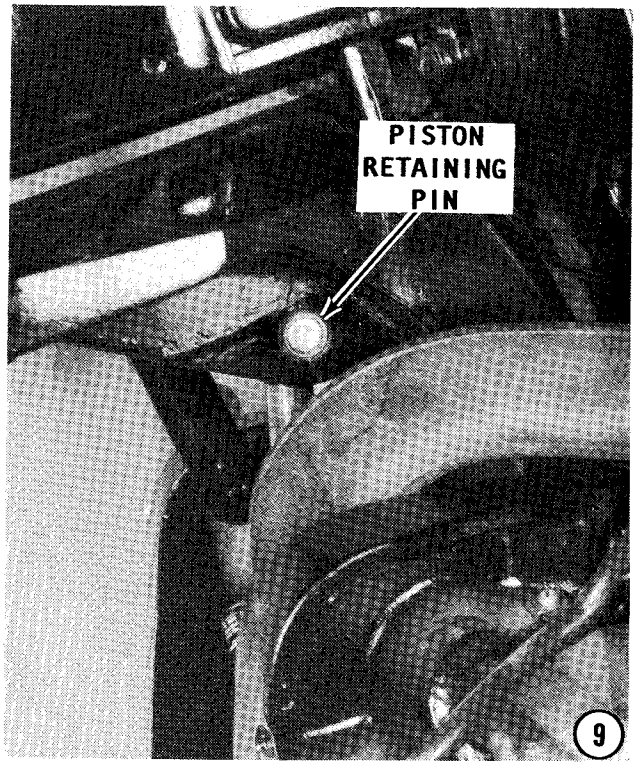




REMOVAL

8- Drive out the cross pin securing the retaining pin for the tilt piston at the upper end.

9- After the cross pin is free, push out the piston retaining pin. **DO NOT** allow the cylinder to fall.



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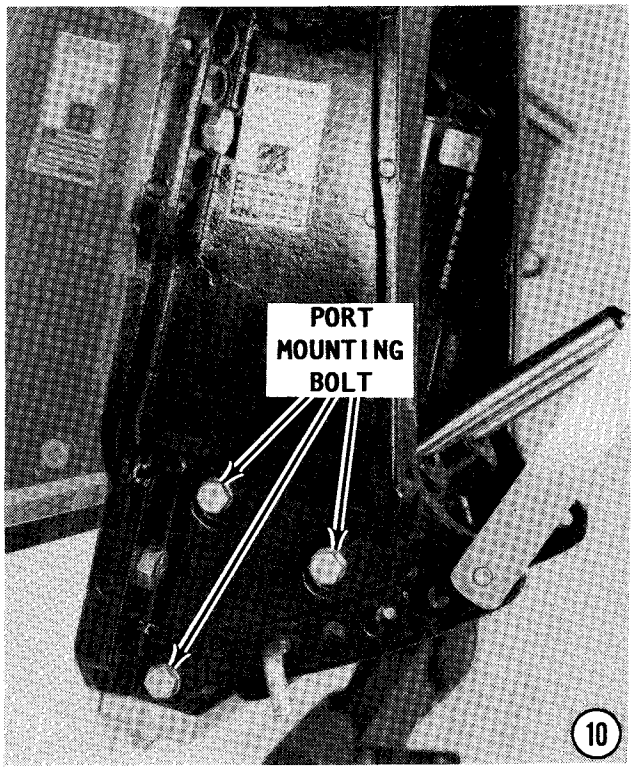
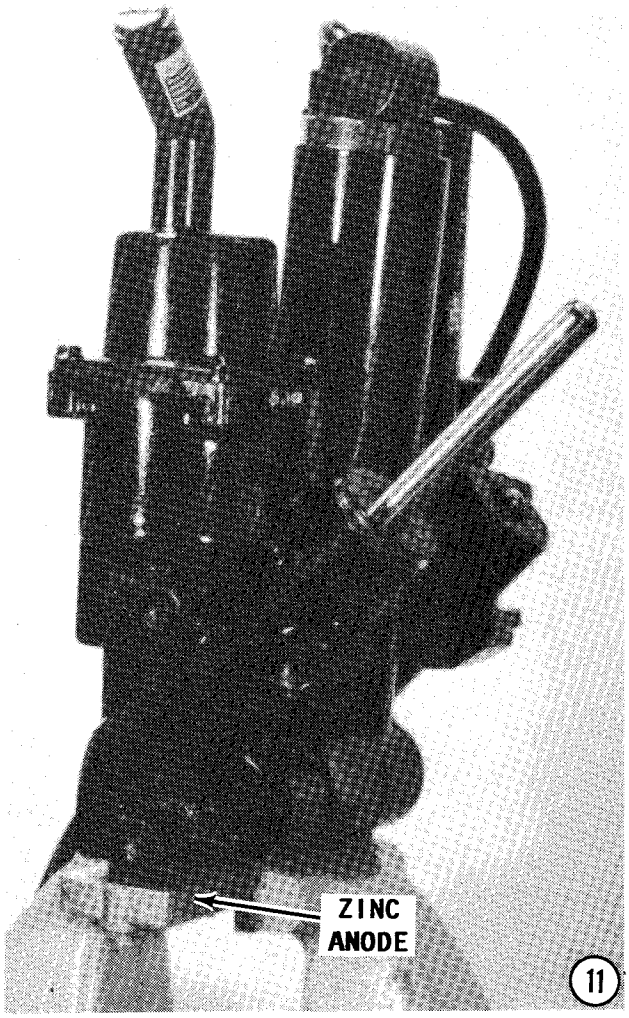




10- Support the trim/tilt system. Remove the three mounting bolts securing the system to the port side clamp bracket. Lower the system from the outboard unit. Pull the wires out with the system.

11- Clamp the trim/tilt system in a vise with the jaws gripping on the anode installed on the underneath side of the system.

GOOD WORDS

The system is now ready for any and all work necessary to restore the trim/tilt unit to satisfactory performance.

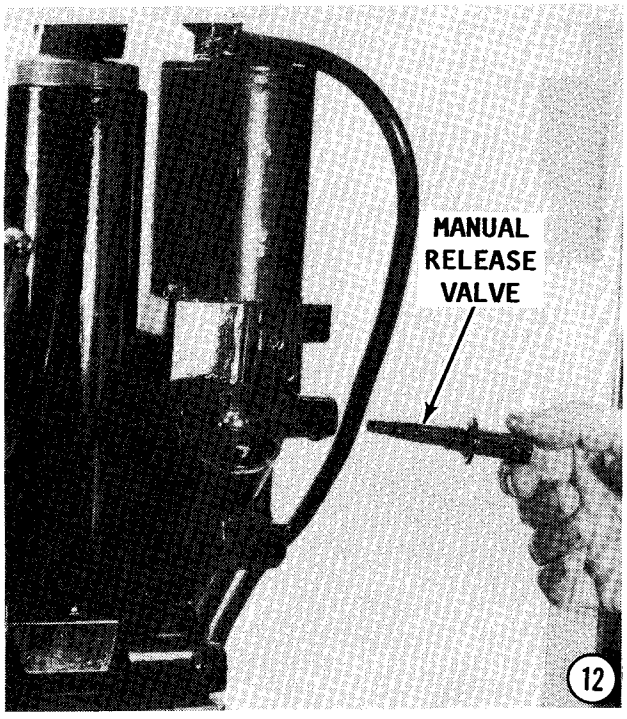
MANUAL RELEASE VALVE

FIRST, THESE WORDS

Only on rare occasion, would the manual release valve need to be removed and serviced. The most probable cause might be the attack of varnish in the hydraulic fluid on the O-rings. Any moisture in the fluid would also be harmful to the O-rings. There is a remote possibility the passageway of the valve may require cleaning.

FIRST, perform PRELIMINARY Steps 1 thru 7 of this section.

12- After the starboard clamp bracket is clear or the complete system removed, then back out the manual release valve by rotating it **COUNTERCLOCKWISE** until it is free and can be withdrawn.



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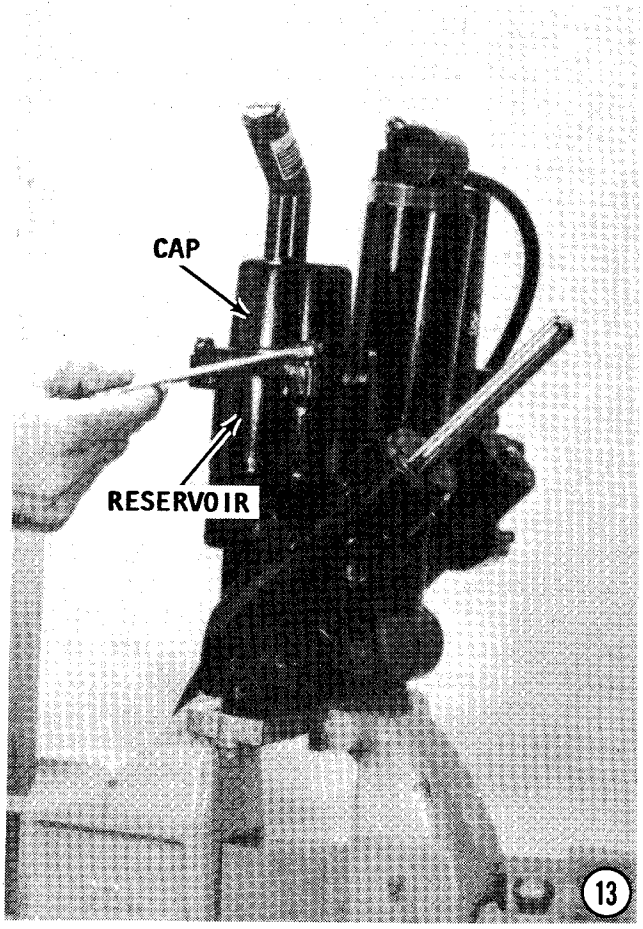
OIL RESERVOIR COVER

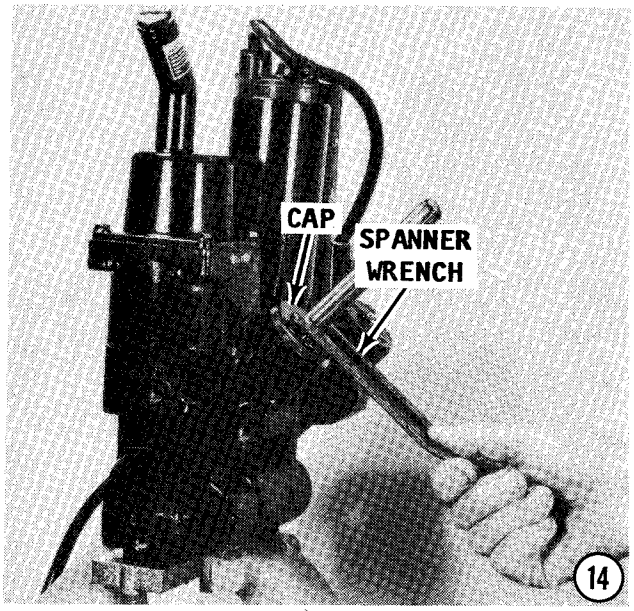
The reservoir cover would only be removed if there is evidence the O-ring is leaking (fluid weeping from around the cover), or a suspicion exists the fluid is contaminated. The cover may be removed with the system still installed on the clamp brackets.

An air gap exists in the reservoir cover as a "cushion" for the system. Therefore, very little fluid will be spilled when the cover is removed.

13- If the system has not been removed from the clamp brackets, perform PRELIMINARY Steps 1 thru 7 of this section. After all pressure has been released, remove the bolts securing the cap to the reservoir. (The accompanying illustration was taken with the system removed from the clamp bracket.) Use the proper size socket with an extension to reach the bolts on the back side.

Lift the cap free of the reservoir. The filler tube and the cover are a one piece unit. Therefore, rotate the filler tube in the clamp bracket hole, and then withdraw the tube from the bracket.





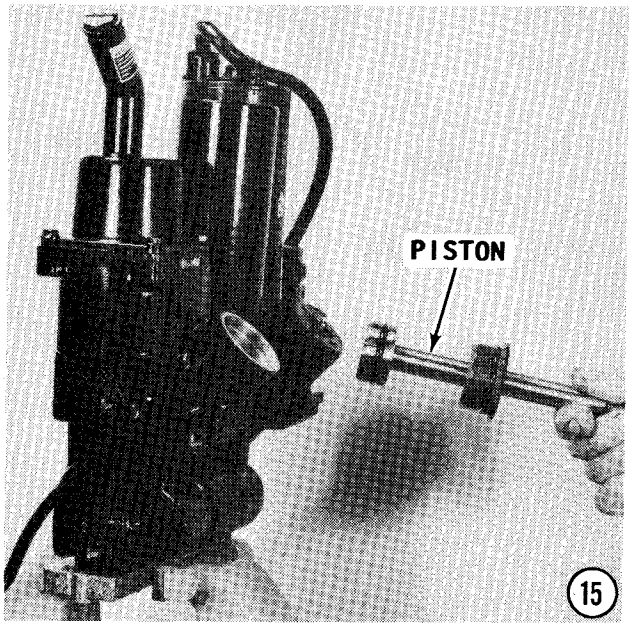
TRIM CYLINDER SERVICE PORT OR STARBOARD

SPECIAL WORDS

If either or both of the trim cylinders are to be serviced without removing the system from the clamp brackets, perform PRELIMINARY Steps 1 and 2 of this section.

14- Using a spanner wrench with the two tips indexed into the two recesses in the cylinder end cap, remove the end cap by rotating the cap in a counterclockwise direction until it is free.

15- After the end cap is free, carefully withdraw the piston straight up and out of the cylinder.



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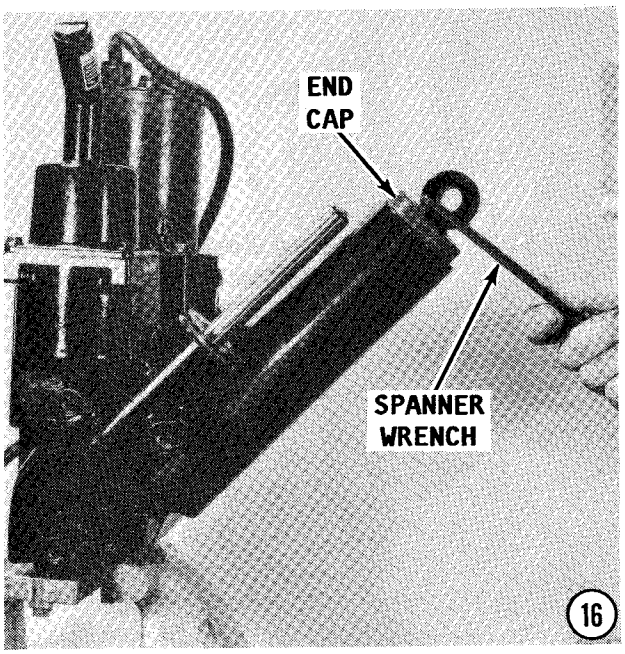


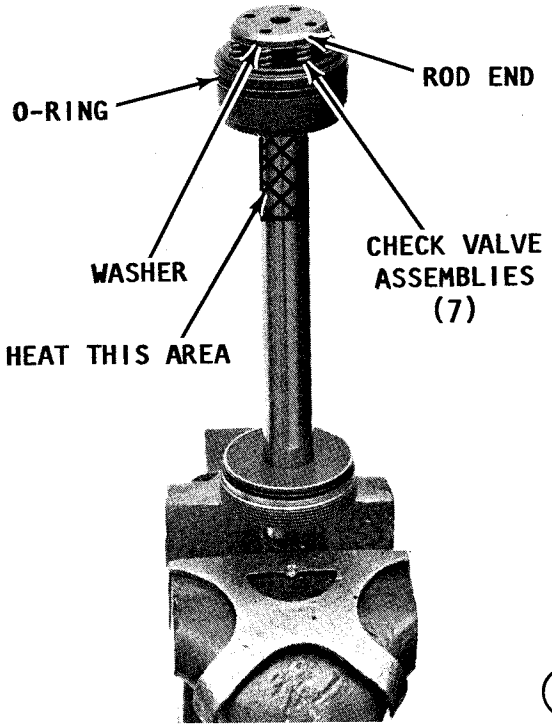
16

TILT CYLINDER SERVICE

SPECIAL WORDS

If the tilt cylinder is to be serviced without removing the system from the clamp brackets, perform PRELIMINARY Steps 1 and 2 of this section.

16- Remove the end cap using a spanner wrench with the points indexed into the recesses of the end cap. Rotate the end cap **COUNTERCLOCKWISE** until it is free of the cylinder.



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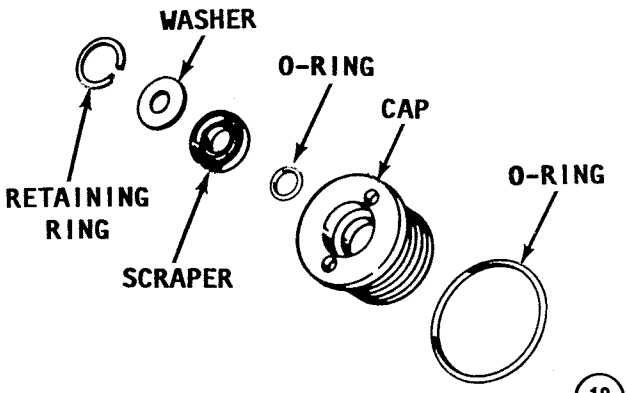

18

Carefully pull the piston and rod assembly straight out of the cylinder, with the end cap on the piston rod.

17- Clamp the rod in a vise equipped with soft jaws with the jaws gripping the upper end. Tighten the vise **JUST** good and snug to prevent any possible damage to the piston end. Remove the rod end using a spanner wrench and rotating the rod end **COUNTERCLOCKWISE** until it is free. If the rod end refuses to loosen, heat may have to be applied to the upper end of the rod **UNDER** the piston.

CRITICAL WORDS

Do not let the check valve assemblies fall when removing the rod end, or the washer.

Lift the rod end straight up and out of the piston. Carefully remove the washer, and then the check valve assemblies. Slide the piston free of the rod. If necessary, slide the end cap off the rod.

18- Disassemble the end cap by first removing the retaining ring, then the washer. The scraper/seal can now be popped out with a small screwdriver. Remove the O-ring.

19- The check valves on the back side of the piston may be removed, if there is evidence the springs do not function properly. Removal is accomplished by first driving the roll pin out using a fine punch or nail and hammer, and then removing the check valve including the spring and ball.

ELECTRIC MOTOR SERVICE AND HYDRAULIC PUMP REMOVAL

The electric motor would be removed if troubleshooting leads to the motor as the source of the problem. The pump will be

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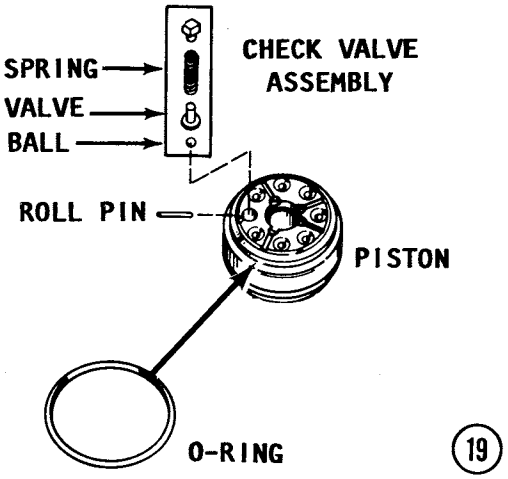


19

removed with the motor and the two will be separated after removal.

The pump **CANNOT** be serviced. Therefore, if troubleshooting indicates the pump has failed, it **MUST** be replaced.

SPECIAL WORDS

The electric motor and the pump may be removed from the trim/tilt assembly without removing the complete unit from the clamp bracket. To remove the motor and pump without disturbing other parts, perform the PRELIMINARY tasks to move the starboard clamp bracket clear as outlined in Steps 1 thru 7 of this section. After the clamp bracket is clear, proceed with Step 20.

20- Remove the two bolts securing the pump to the trim/tilt assembly. Lift the electric motor, with the pump attached, upward and free of the trim/tilt assembly base.

STOP

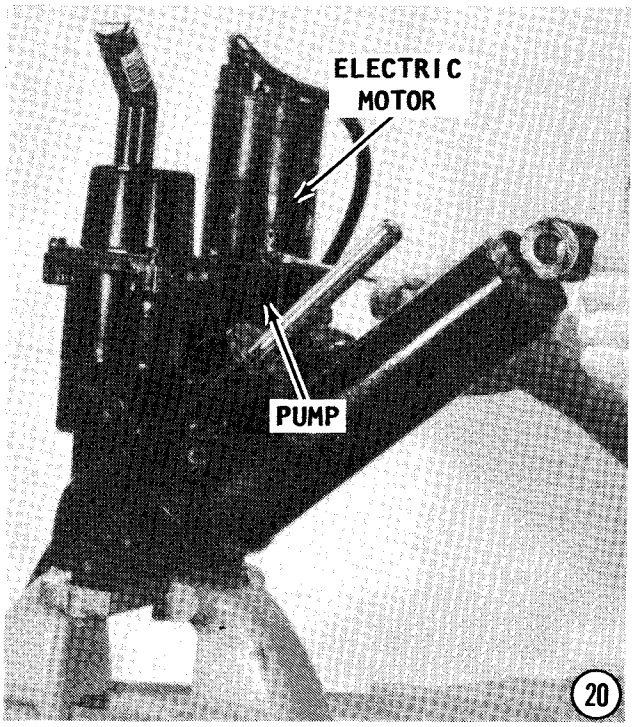
Before separating the electric motor from the pump, scribe a mark on the motor end cap and a matching mark on the motor case as an aid to assembling.

21- Remove the wire clamp from one of the thru-bolts. Remove the two thru-bolts passing through the electric motor into the pump, and then separate the electric motor from the pump. As the electric motor case is being lifted, exercise **CARE** not to drop and damage the armature.

CLEANING AND INSPECTING TRIM/TILT SYSTEM

GENERAL PRACTICE

Check all **O**-rings for any damage. Actually, good shop practice would dictate new



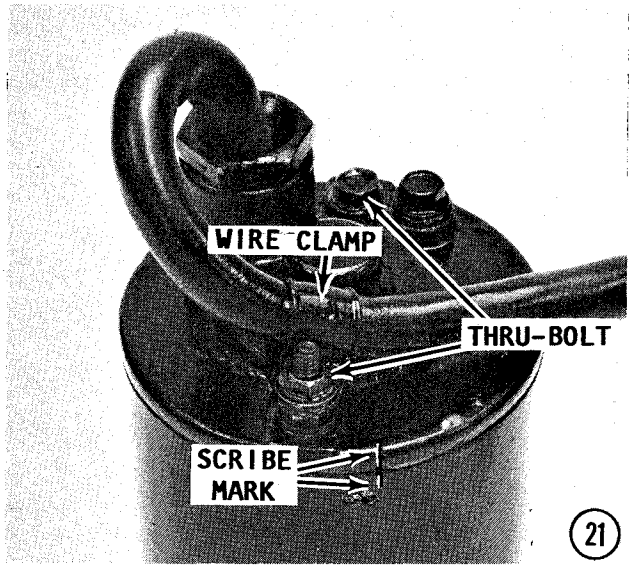
20

O-rings be installed anytime a part is disassembled exposing an **O**-ring.

Pump and Motor

The pump **CANNOT** be serviced. Therefore, if troubleshooting indicates the pump has failed, it **MUST** be replaced.

The electric motor is very similar to other electric motors used on the outboard unit. Brush replacement, armature testing, and field tests may be made in the same manner. Therefore, the motor can be checked, tested, and serviced following the procedures outlined in Chapter 9 for other motors.



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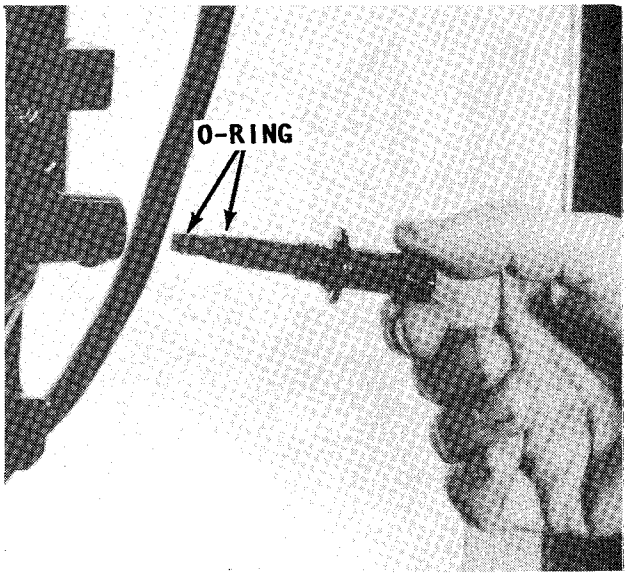


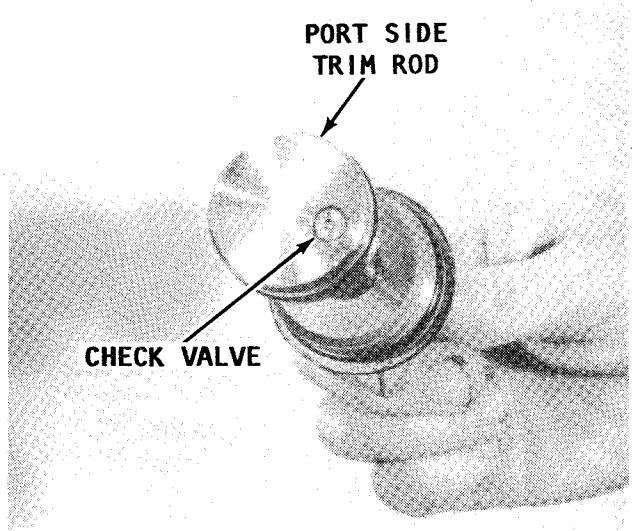
*Manual release valve ready for installation. One style valve has two O-rings and the other has three. The valves are **NOT** interchangeable.*

Check the mating surfaces of the motor and pump to ensure they are clean and undamaged.

A "Pump Seal Kit" is available at the local marine store. This kit includes three O-rings and a flat ring for the hydraulic pump.

Manual Release Valve

One style manual release valve has three O-rings and the other style has only two. The valves are **NOT** interchangeable. Therefore, be sure to replace the valve with the same style as the one removed.



*The check valve in the end of the port trim cylinder **MUST** not be removed. The valve is preset at the factory.*

Trim Cylinder

DO NOT remove the check valve from the port side trim rod. (The starboard rod does not have a check valve.) This check valve has been preset at the factory to operate at a specific pressure. Therefore, removal and installation of the check valve could result in improper operating pressure and possible damage to the system.

If the check valve cannot be cleaned satisfactorily, the trim piston and check valve **MUST** be replaced as a unit. A new piston will have a plastic screen over the top of the check valve. This screen prevents foreign material from entering the check valve. However, if the old piston does not have this plastic screen, then remove the plastic screen from the new replacement piston and install it into the cylinder **WITHOUT** the screen. If the old piston has the screen, then install the new piston with the plastic screen over the check valve.

Inspect the interior of the cylinder for any sign of scoring or roughness. Inspect the seal located in the recess of the end cap. If the seal is damaged or fails to keep the trim piston rod clean, replace the seal. This is accomplished by first prying the old seal from the top of the cap with a screwdriver, and then pushing the new seal into place with the seal lip facing **UP.**

Tilt Cylinder

A "Tilt Cylinder O-ring Kit" is available at modest cost. In addition to the five O-rings needed for complete replacement on the tilt cylinder, the kit also includes a new scraper/seal and a washer used next to one of the O-rings.

Inspect the balls and the springs underneath the rod end for foreign material.

Inspect the interior of the cylinder for any sign of scoring or roughness.

Examine the check valves and clean them thoroughly of any foreign material.

Clean all parts with solvent, and then blow them dry with compressed air.

ASSEMBLING/INSTALLATION SYSTEM "B" TRIM/TILT

FIRST, THESE WORDS

The work area **MUST** be clean. All parts **MUST** be absolutely clean and dirt free prior

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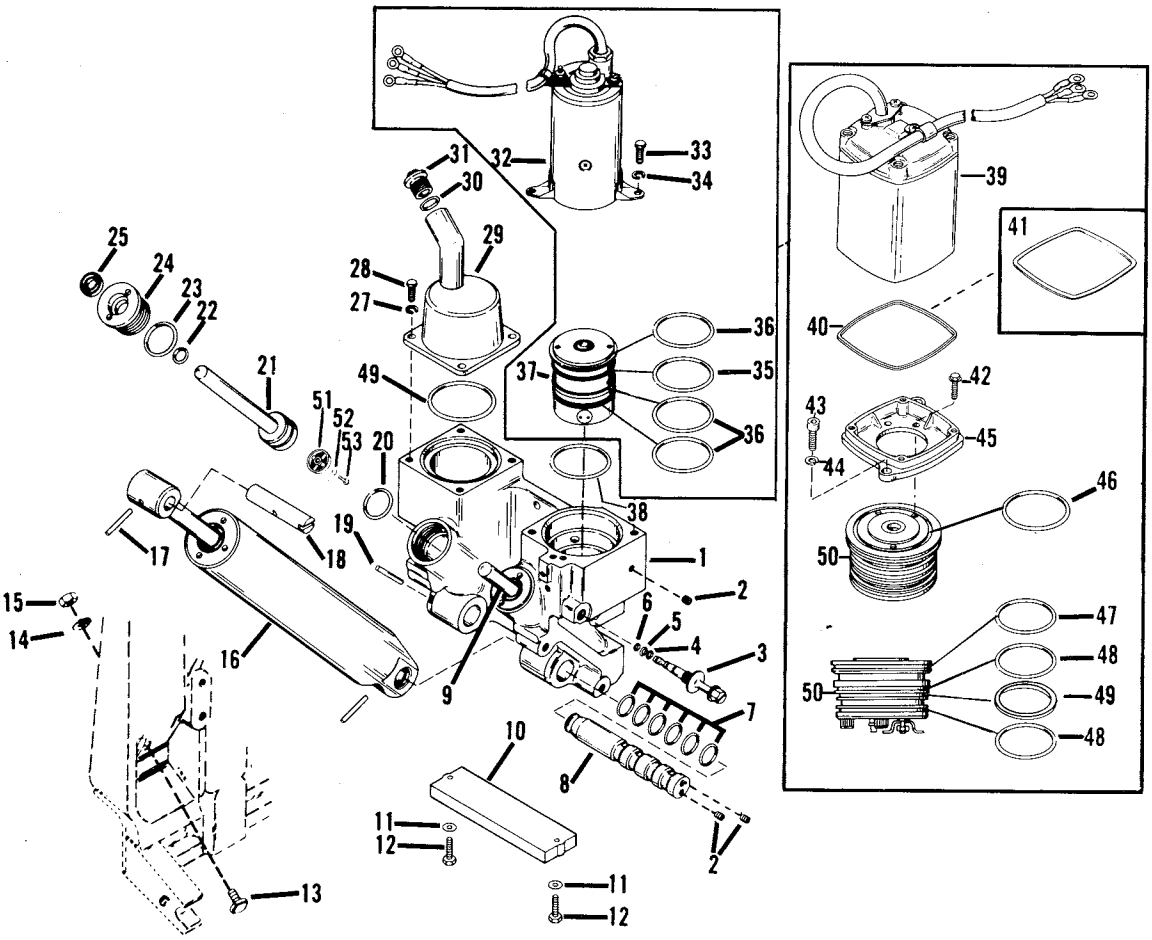

1 HOUSING
2 ALLEN PLUG
3 MANUAL RELEASE VALVE
4 O-RING .239" (6.07 mm) ID
5 O-RING .208" (5.28 mm) ID
6 O-RING .114" (2.90 mm) ID
7 O-RING .989" (25.12 mm) ID
8 SHAFT
9 TRIM ROD ASSEMBLY (STARBOARD)
10 ANODE PLATE
11 WASHER
12 BOLT
13 STRIKER PLATE
14 LOCKWASHER
15 NUT
16 TILT CYLINDER ASSEMBLY
17 CROSS PIN
18 RETAINING PIN
19 PIN
20 O-RING 1.248" 31.70 mm) ID
21 TRIM ROD ASSEMBLY (PORT)
(With check valve.)
22 O-RING .612" (15.54 mm) ID
23 O-RING 1.475" (37.47 mm) ID
24 CAP
25 SEAL
26 O-RING 2.864" (72.75 mm) ID
27 WASHER
28 BOLT
29 RESERVOIR COVER
30 O-RING .583" (14.81 mm) ID
31 FILL SCREW
32 ROUND MOTOR ASSEMBLY
33 BOLT
34 LOCKWASHER
35 O-RING 2.739" (69.57 mm) ID
36 O-RING 2.614" (66.40 mm) ID
37 PUMP ASSEMBLY
38 O-RING 2.739" (69.57 mm) ID
(Not used on some units.)
39 SQUARE MOTOR ASSEMBLY
40 SQUARE RING
(Used when end frame cap has groove.)
41 GASKET
(Used when NO groove in end frame cap.)
42 BOLT
43 ALLEN BOLT
44 LOCKWASHER
45 END FRAME CAP
46 O-RING or FLAT RING
47 O-RING 2.739" (69.57 mm) ID
48 O-RING 2.614 (66.40 mm) ID
49 FLAT RING
50 PUMP ASSEMBLY
51 SCREEN (If used)
52 WASHER (If screen is used.)
53 SCREW (If screen is used.)

Exploded drawing of the System "B" Power Trim/Tilt with major parts identified.

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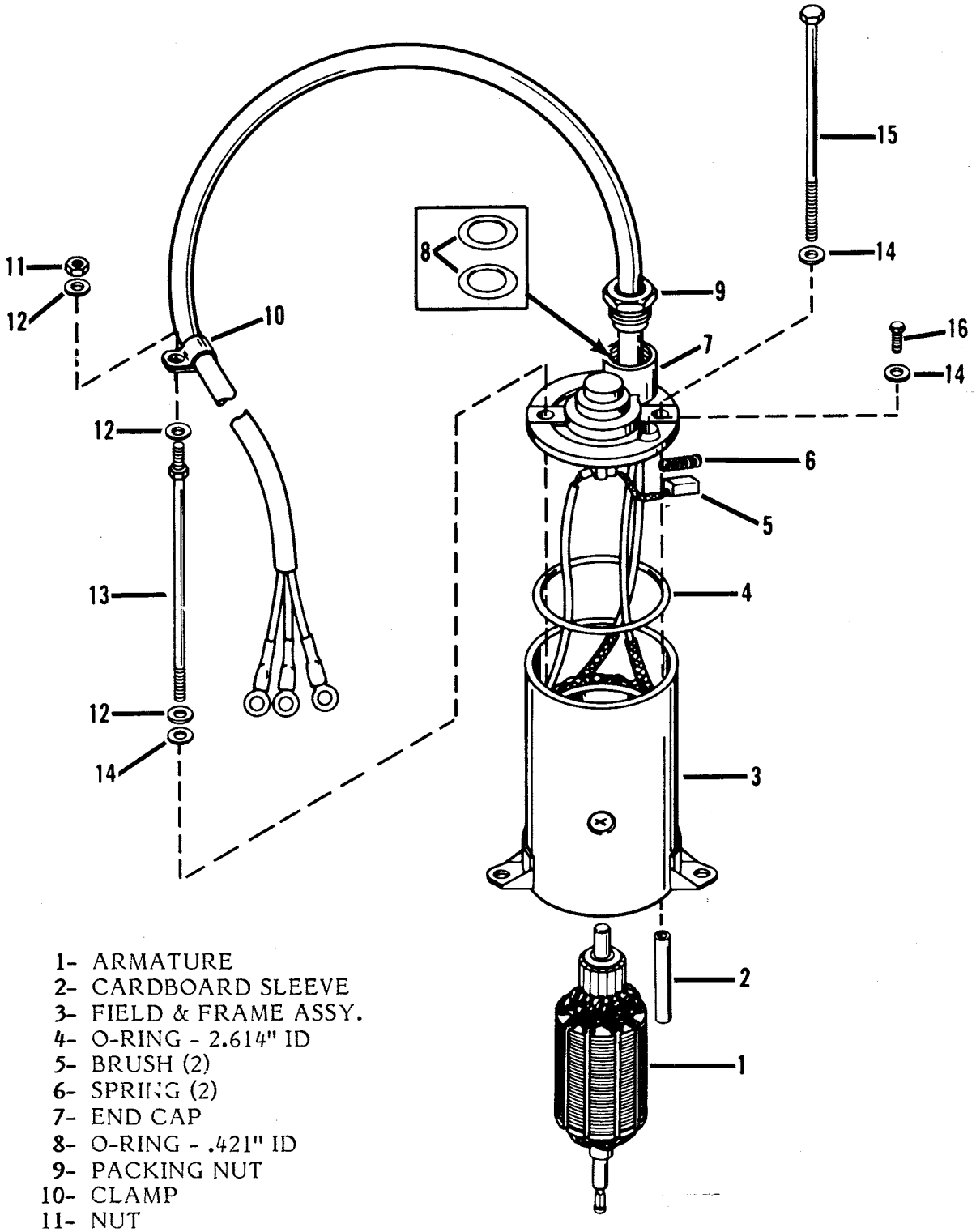

1- ARMATURE
2- CARDBOARD SLEEVE
3- FIELD & FRAME ASSY.
4- O-RING - 2.614" ID
5- BRUSH (2)
6- SPRING (2)
7- END CAP
8- O-RING - .421" ID
9- PACKING NUT
10- CLAMP
11- NUT
12- WASHER
13- THRU-BOLT
14- SEALING WASHER
15- THRU-BOLT
16- BOLT

Exploded drawing of a "round" electric motor used with the System "B" Power Trim/Tilt.

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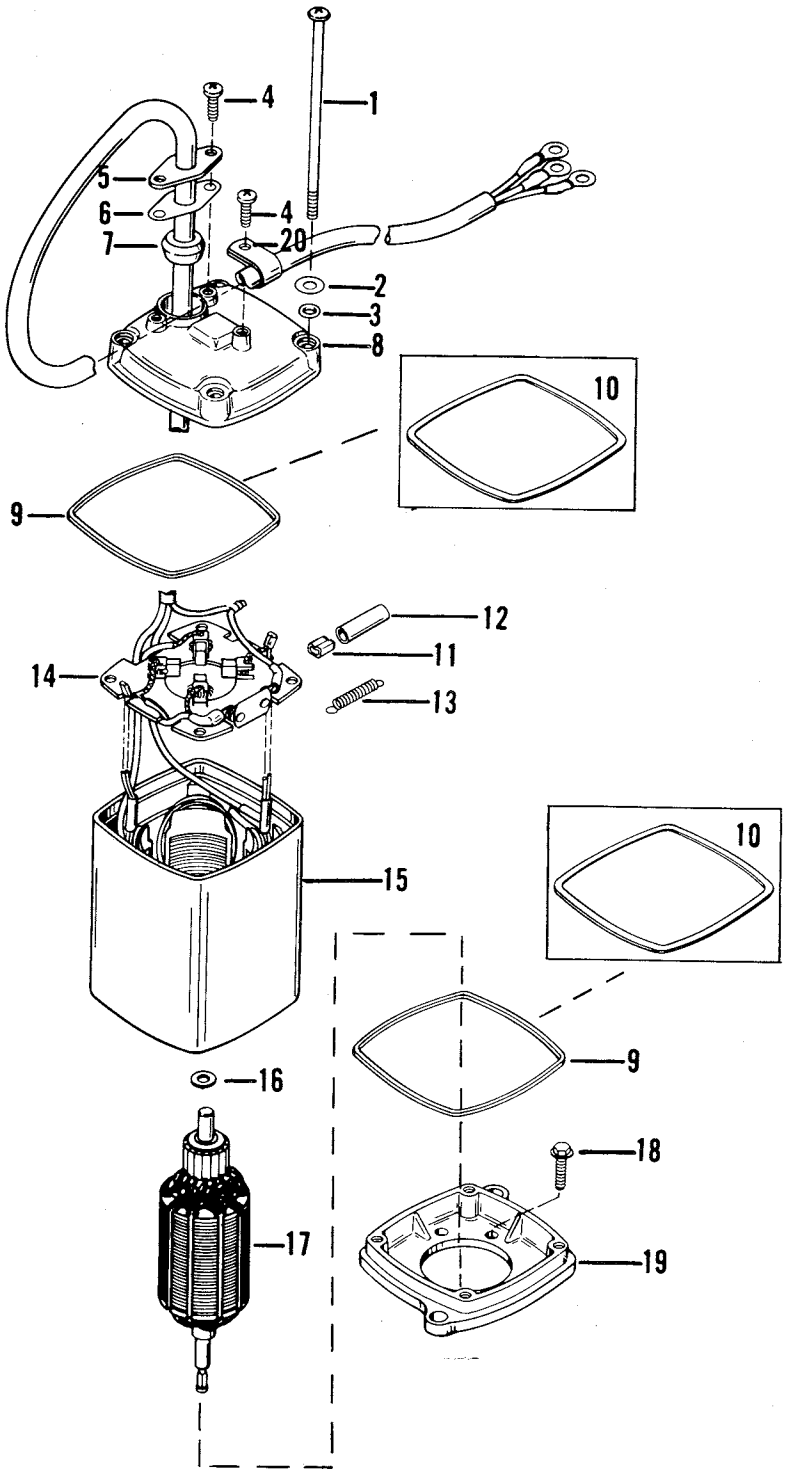

1- THRU-BOLT (4)
2- NYLON WASHER (4)
(If Equipped)
3- O-RING (4)
4- SELF-TAPPING SCREW (3)
5- RETAINER
6- NYLON INSULATOR
(If equipped)
7- RUBBER SEAL
8- UPPER END CAP
9- SQUARE RING (2)
(When end cap has groove)
10- GASKET (2)
(When no groove in end cap)
11- CONNECTOR (3)
12- SLEEVE (2)
13- BRUSH SPRING (4)
14- BRUSH CARD
15- FIELD & FRAME ASSY.
16- THRUST WASHER
17- ARMATURE
18- BOLT (2 or 3)
19- LOWER END CAP
20- CLAMP

Exploded drawing of a "square" electric motor used with the System "B" Power Trim/Tilt.

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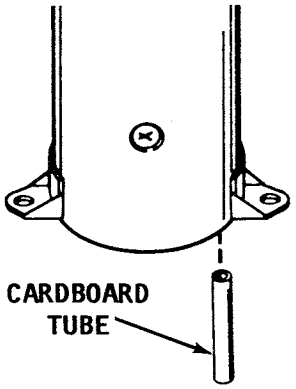


1

to installation. The slightest bit of foregin material could cause the system to malfunction.

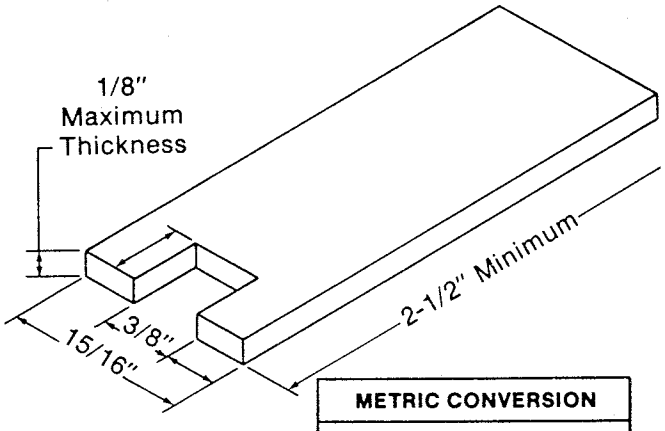
All O-rings and seals must be coated with automatic transmission fluid just before they are installed.

Check with the exploded diagrams to ensure the correct O-ring is being installed in the proper place. An incorrect O-ring installation could cause the system to malfunction.

PUMP AND MOTOR

The following procedures pickup the work after a new pump has been obtained, and/or the electric motor has been rebuilt and is ready to be assembled and mated with the hydraulic pump.

The accompanying exploded drawings of the "Round" motor, the "Square" motor, and the power trim/tilt assembly, with the O-ring sizes given, will be an aid to installing the proper ring into the correct groove.



METRIC CONVERSION
1/8" = 3.2mm
3/8" = 9.5mm
15/16" = 23.8mm
2-1/2" = 63.5mm

"Home made" tool to assist in holding the brushes clear when the armature is inserted into the case.

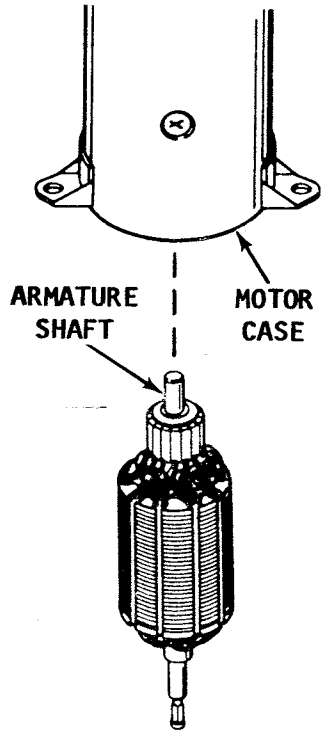
1- Slide the cardboard tube into the case, as shown in the accompanying illustration. Place a **NEW** O-ring into place on the end cap. Set the cap aside, ready for installation.

SPECIAL WORDS

As an aid to holding the brushes clear when the armature is inserted into the case, a special tool may be made as shown in the accompanying illustration.

2- Apply a light coating of SAE 10W motor oil to the upper end of the armature shaft. Place the tool mentioned in the previous paragraph in place to hold the brushes apart when the armature is installed. Push the armature up into the motor case until the upper end of the armature makes contact with the brush holder tool. Exert just a little upward pressure on the armature and at the same time, slide the brush holder out. The armature will move just a little further into the case and the brushes will bear against the armature in a proper manner.

3- Place the end cap onto the case with the mark on the cap aligned with the mark on the case. (These are the marks made just prior to disassembly, as instructed in Step 20.)



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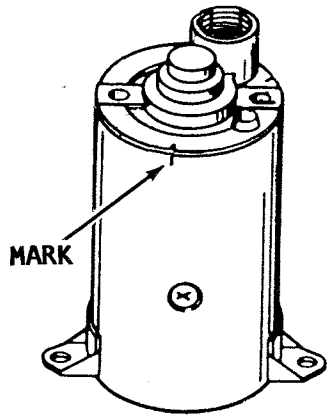


3

4- Install **NEW** O-rings onto the pump. If the square motor pump is used, install the flat ring into the groove, as shown in the accompanying exploded drawing. Install a **NEW** seal into the recess of the upper end of the pump surface. The armature shaft passes through this seal. Coat the O-rings and the seal with Automatic Transmission Fluid.

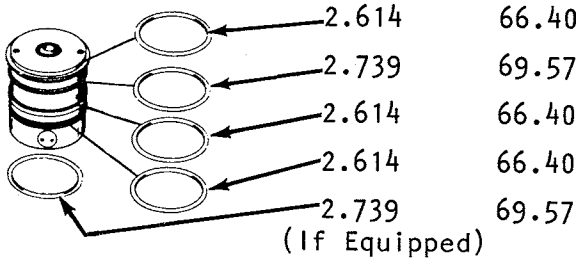
5- Grasp the motor case with the thumb and forefinger holding the end cap in place, and position it over the pump. Push down on the motor case with the lower end of the armature passing through the pump seal. The chamfered part of the pump **MUST** be on the same side as the bolt hole opposite the electrical fitting, as shown. Hold the electric motor and end cap with one hand and with the other hand rotate the pump ever so slightly until the hex end of the armature shaft indexes with the recess in the pump. When this occurs, the end surface of the motor case will be firm against the surface of the pump.

6- Slide the sealing washer onto the thru-bolt with the head. The rubber surface of the washer **MUST** face down to bear against the surface of the end cap. Start to thread the bolt into the pump, but **DO NOT** tighten it at this time. Slide a regular washer on the other thru-bolt, and then the sealing washer with the rubber surface facing **DOWN** to bear against the surface of the end cap. Start to thread the second bolt into the pump. A slight shifting of the motor case or the pump may be necessary. Tighten thru-bolts securely.

7- Secure the electrical lead to the thru-bolt without the head, using first a washer, then the wire clamp, another washer, and finally the nut. Tighten the nut securely. Apply a coating of Quicksilver Liquid Neoprene around the thru-bolts, around the electrical connection, and at the seam between the electric motor and the pump, as a waterproof measure.

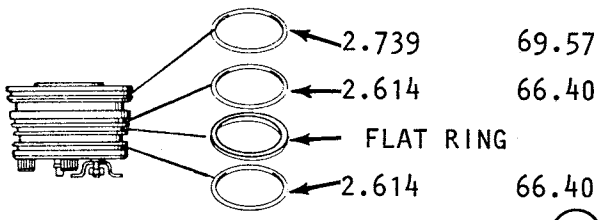
ID Dimension of O-Rings

ROUND PUMP MOTOR



IN.	MM
2.614	66.40
2.739	69.57
2.614	66.40
2.614	66.40
2.739 (If Equipped)	69.57

SQUARE PUMP MOTOR



2.739	69.57
2.614	66.40
FLAT RING	
2.614	66.40

4



5

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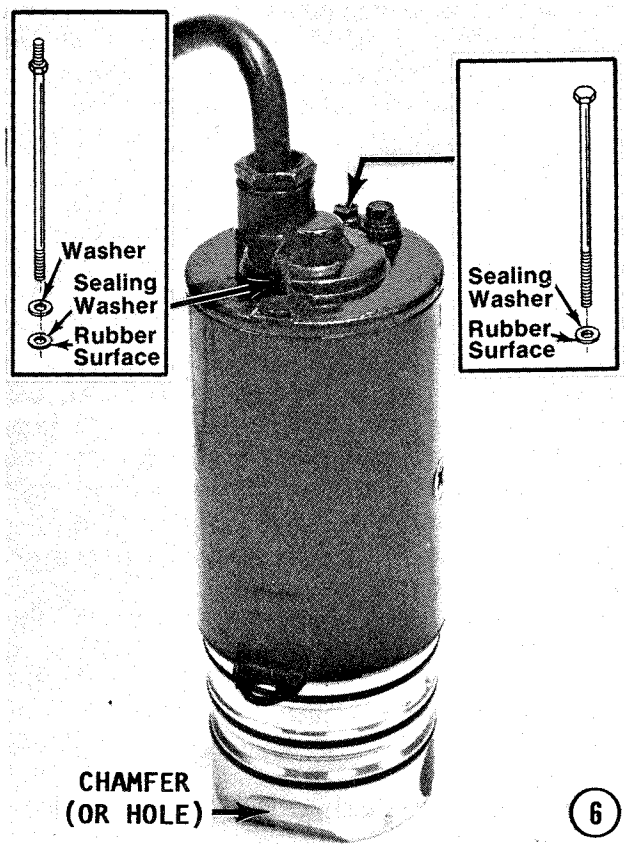
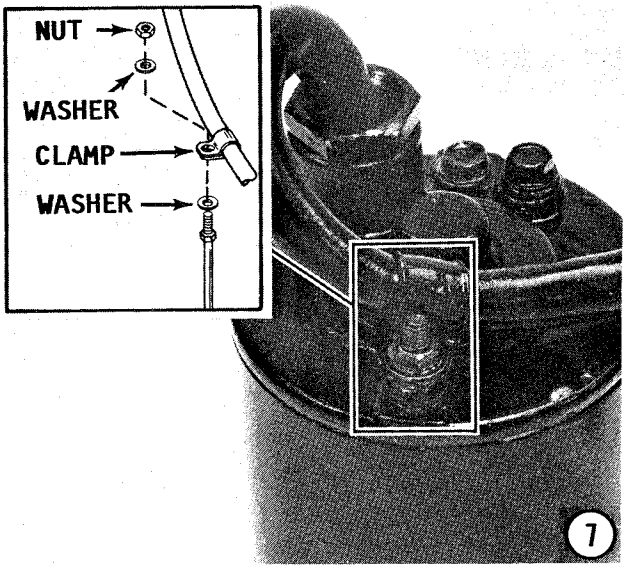


SPECIAL WORDS

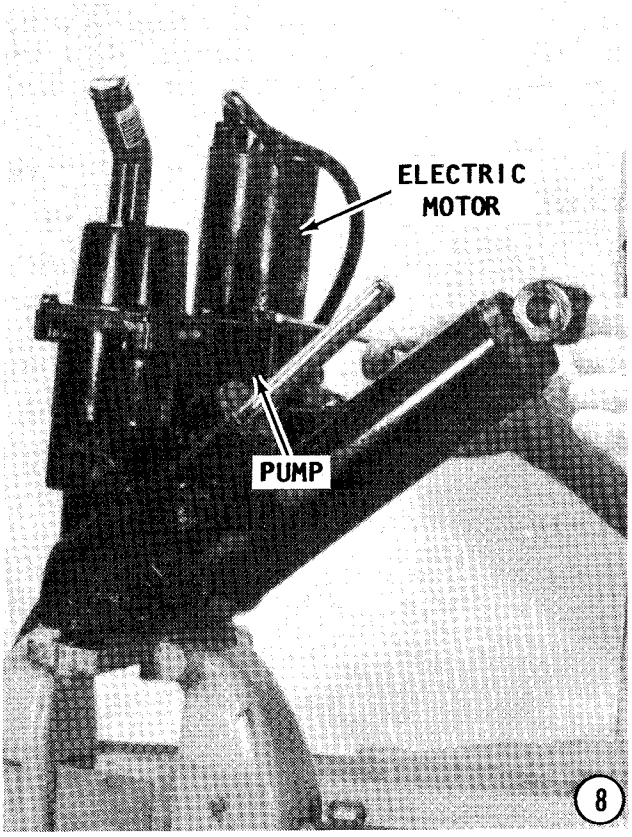
If the pump and motor were removed after the trim/tilt system was removed, continue with the assembling work, and then install the system according to the procedures outlined in Steps 25 thru 30.

If the pump and motor were removed with the trim/tilt system remaining in place between the clamp brackets, perform Steps 8 thru 11.



8- Feed the electrical wire up through the outboard clamp bracket, if the motor and pump were removed with the trim/tilt assembly remaining on the clamp brackets. Move the assembled pump and motor into position on the trim/tilt assembly. Carefully insert the pump into the power trim assembly housing, with the chamfer (or hole) on the lower end of the pump facing **TOWARD** the tilt cylinder. Apply a light coating of Quicksilver Perfect Seal (or equivalent) to the threads of the attaching bolts. Slide a lockwasher onto each bolt. Secure the pump on the housing with the attaching hardware. Tighten the bolts securely. Apply a coating of Quicksilver Liquid Neoprene on the seam between the pump and the housing as a waterproof measure.

9- If the trim/tilt assembly was not removed from the brackets, carefully move the starboard transom bracket into place with the manual release valve passing through the opening in the bracket. Apply a light coating of Loctite Grade "A" on the threads of five bolts. Secure the bracket in place with the two outboard mounting bolts, and the three bolts through bracket into the power trim assembly. Tighten the bolts to a torque value of 30 ft lbs. (40.7 Nm).



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10- Remove the large C-clamp and block of wood.

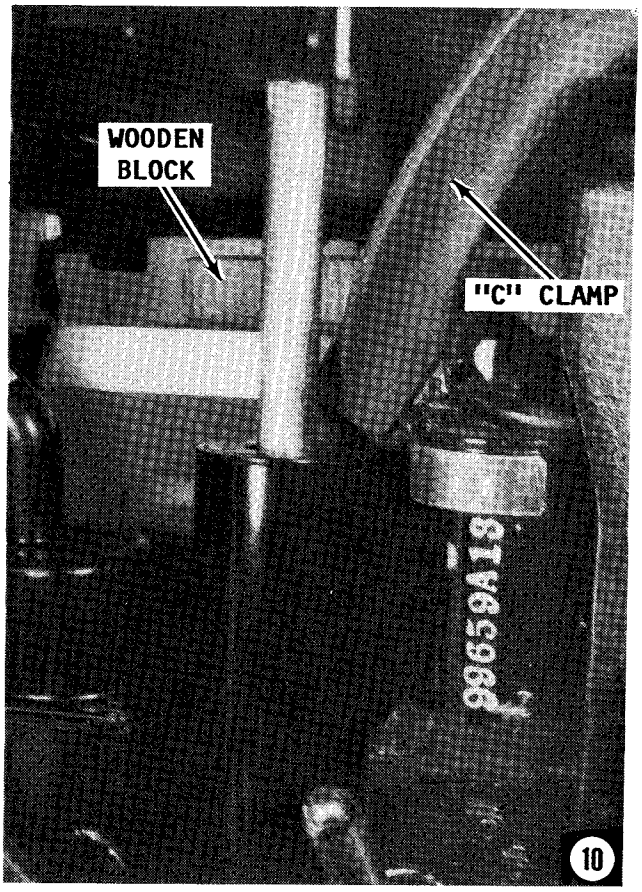
11- Remove the fill screw from the port side bracket and replenish the reservoir with Automatic Transmission Fluid (ATF) Type A or AF (as used in Ford manufactured automobiles), until the fluid is visible through the opening. Bleed the system of air. See Section 10-11.

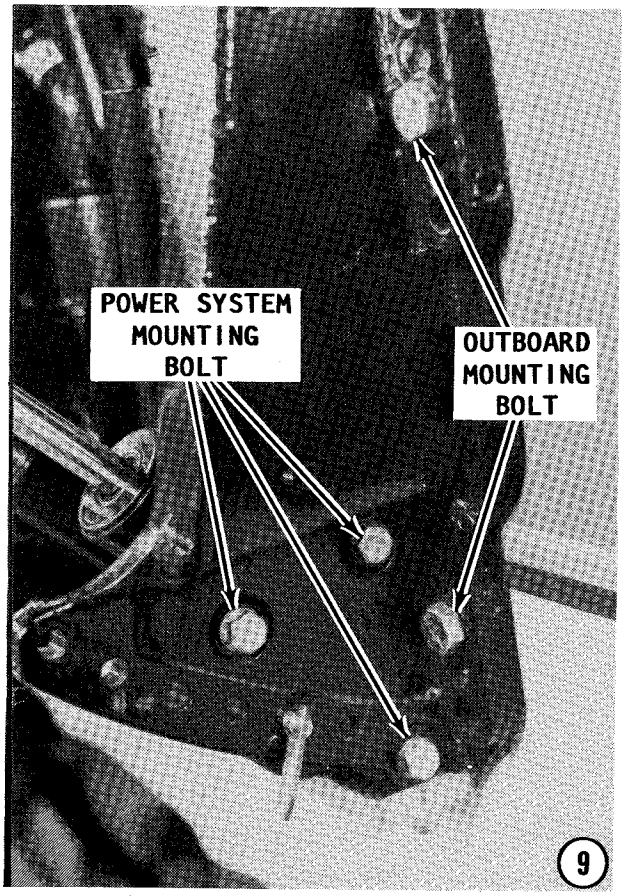
SPECIAL WORDS

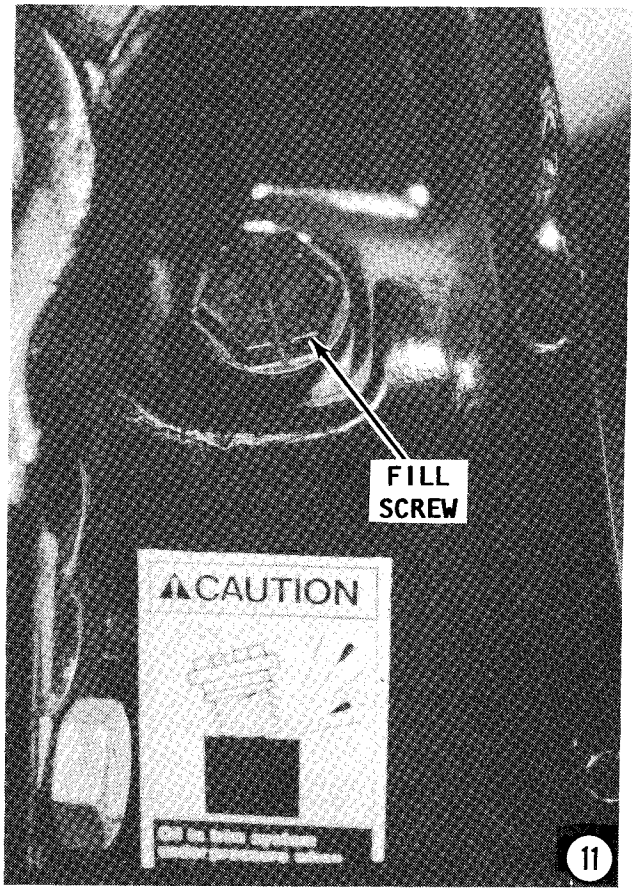
Only Automatic Transmission Fluid should be used in the power trim system. However, in remote areas or in an emergency, a substitute can be used. SAE 10W-30 or 10W-40 oil rated SE was recommended in the past by the manufacturer for earlier model systems. Therefore, these oils should be a workable substitute until the automatic transmission fluid can be obtained. Once the transmission fluid is available, the system **MUST** be flushed of the oil. See Section 10-12 to flush the system.

TILT CYLINDER

12- Assemble the end cap by first working a **NEW O**-ring over the outside of the cap and up under the lip. Next, install a







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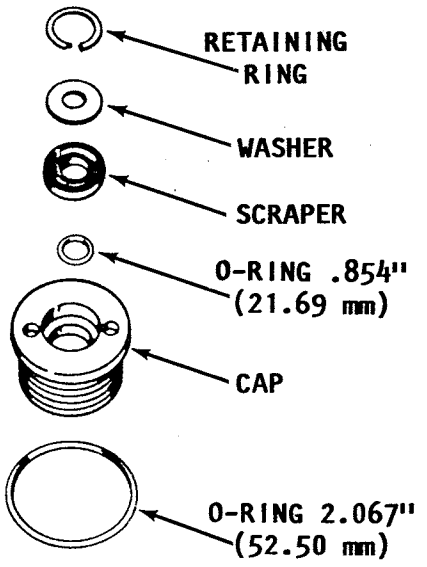


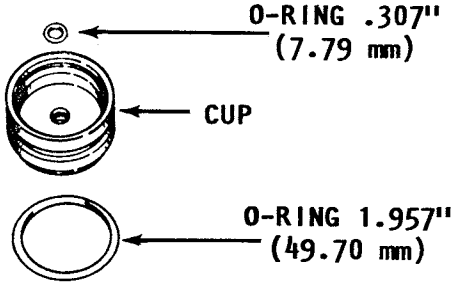
12

NEW O-ring into the recess of the upper side. Insert the scraper/seal into the recess, followed by the washer. Secure them in place with the retaining ring. Clamp the upper end of the rod in a vise equipped with soft jaws. Tighten the vise **JUST** good and snug to prevent damage to the rod. Coat the rod with automatic transmission fluid, and then slide the end cap onto the rod.

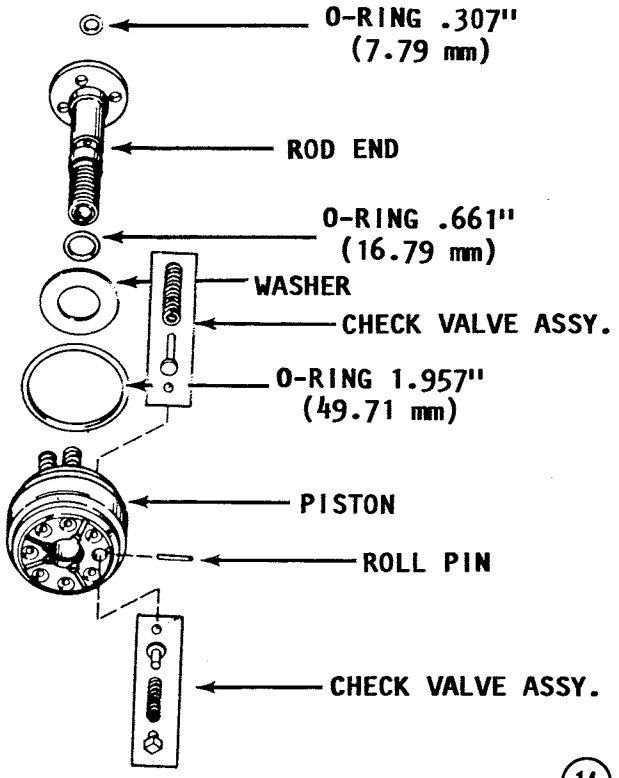
13- If the cup was removed from the cylinder, install the large O-ring over the outside of the cup and a small one in the center from the inside. Slide the cup into the cylinder with the flat surface going in first.

14- If the valves on the back side of the piston were removed, install the parts as shown in the accompanying illustration. Secure each valve assembly in place by driving in a roll pin.

15- Position the cylinder onto the end of the rod. Assemble the seven check valves in place on the end of the piston with each ball going into the recess first, followed by the valve, and then the spring. After they are all in position, **CAREFULLY** lay the washer

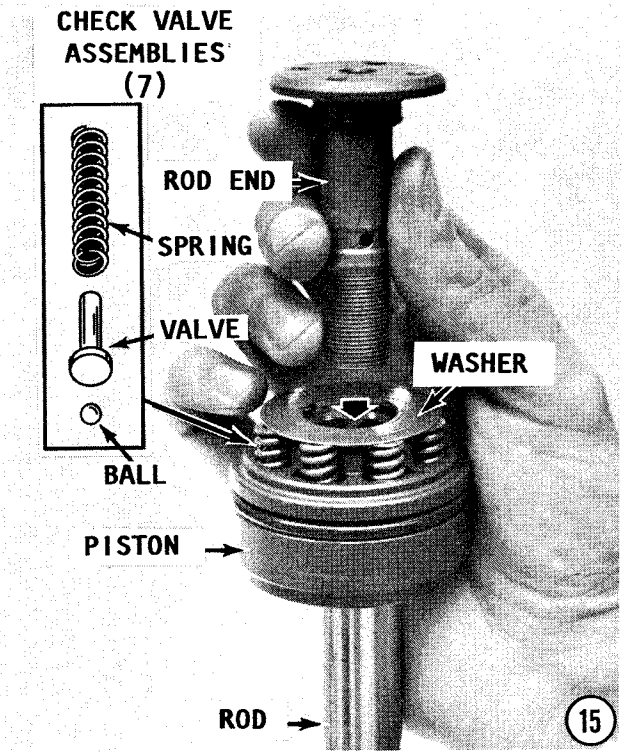


13



14

on top of the springs. Now, slowly slide the rod end, with NEW O-rings in place, down through the center of the washer without disturbing the valve assemblies. Thread the rod end into the end of the rod. Tighten the rod end securely with the spanner wrench.



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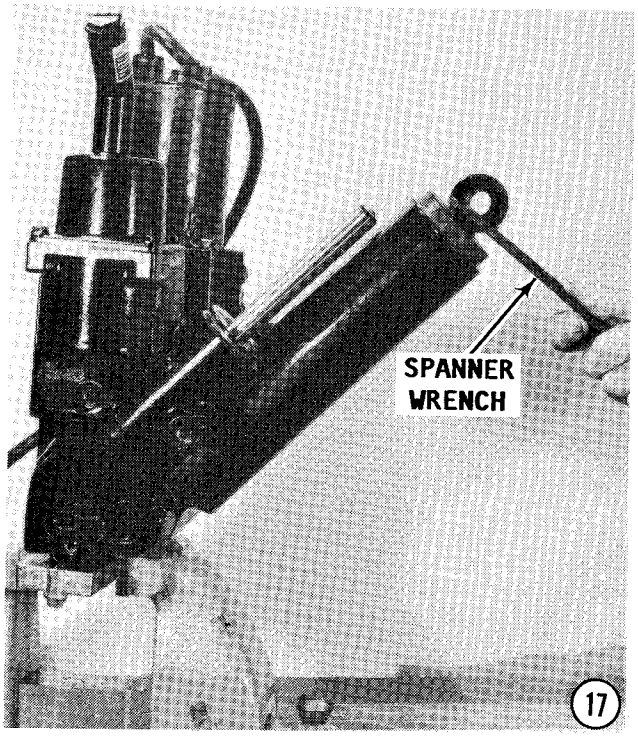
16- After **NEW** O-rings have been installed and all parts coated with Automatic Transmission Fluid, slide the piston and rod assembly into the cylinder.

17- Secure the piston and rod assembly in the cylinder by tightening the end cap with a spanner wrench.



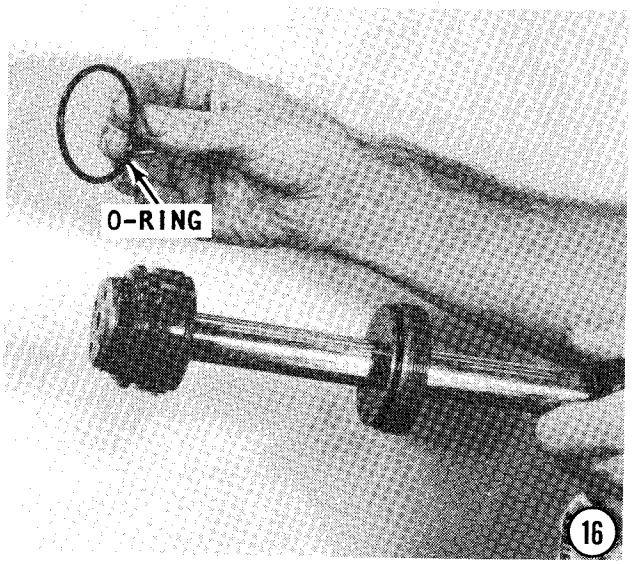
17

SPECIAL WORDS

If the tilt cylinder was serviced without removing the trim/tilt system from the clamp brackets, perform Steps 18 and 19.

If the tilt cylinder was serviced after the tilt/trim system was removed, continue with the assembling work, and then install the system according to the procedures outlined in Steps 25 thru 30.

18- Connect the electrical leads to a 12-volt battery. Depress the **UP** button to extend the piston to the full up position. Start the retaining pin into the port transom with the non-slotted end going in first. Now, observe how the hole for the cross pin is aligned with the slot in the end of the retaining pin. Also note how the cross pin hole on one side of the retaining is chamfered and the other is not. Align the slot approximately with the hole in the end of the tilt piston, and then push the retaining through the port bracket, then the end of the tilt piston, and finally through the starboard bracket. Once the retaining pin is installed, rotate the pin very **SLOWLY** with a screwdriver until the hole in the retaining pin is aligned with the hole in the end of the tilt piston. Once the hole is close to alignment, a small punch may be used through the hole in the piston end to rotate the retaining pin. After the hole is aligned, drive the cross pin into place with the smooth end of the cross pin going in first. Continue to drive the pin with a hammer and punch until the pin is flush with the surface of the piston end.



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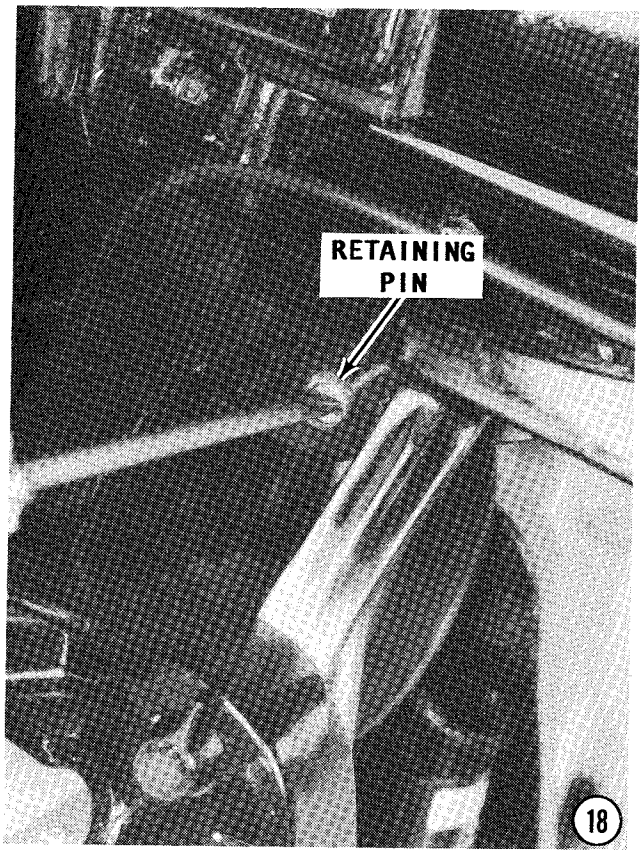

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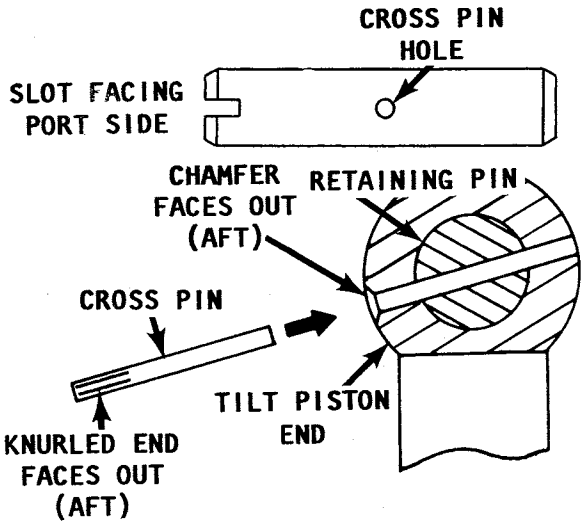
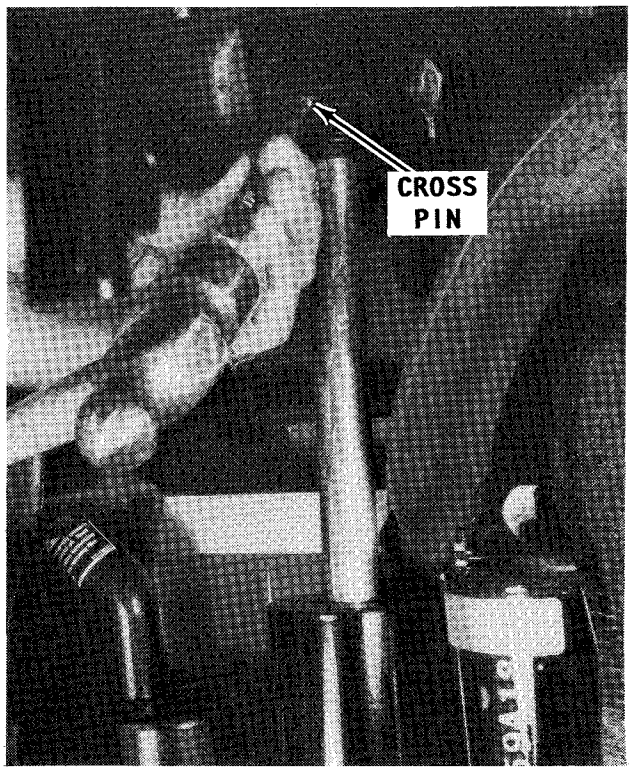
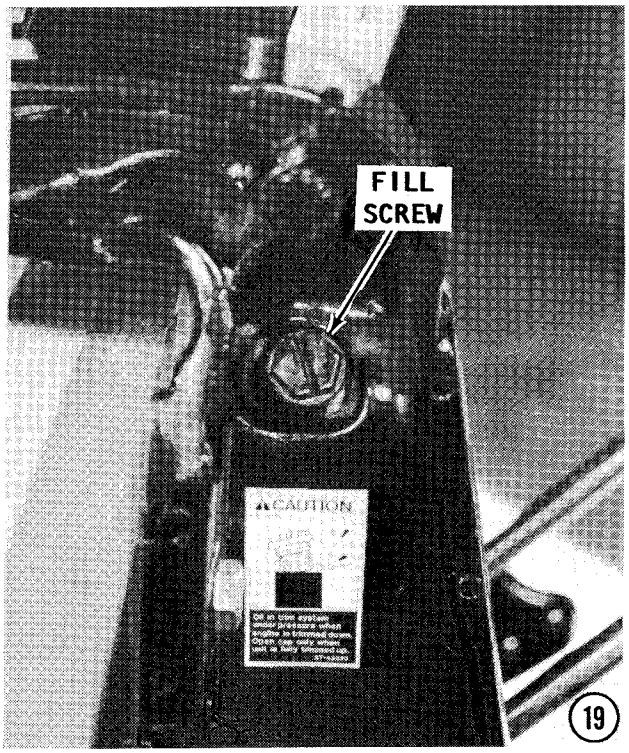


The retaining pin can be rotated with a large screwdriver until the hole in the pin is aligned with the hole in the end of the tilt piston. The chamfered hole in the end of the piston must face ***OUTWARD.*** *If it does not, remove the retaining pin and rotate the piston in the cylinder 1/2 turn.*

19- Remove the fill screw from the port side bracket and replenish the reservoir with Automatic Transmission Fluid (ATF) Type A or AF (as used in Ford manufactured automobiles), until the fluid is visible through the opening. Bleed the system of air. See Section 10-11.



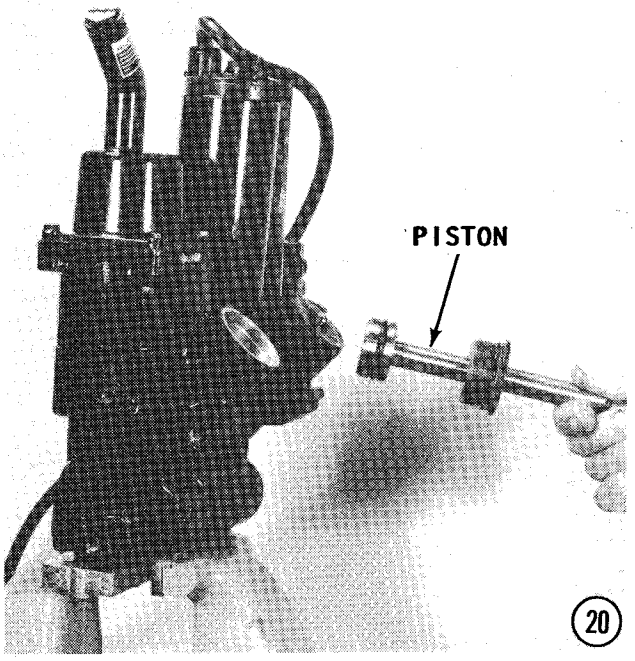
Using a small punch and hammer to drive the cross pin into place, ***AFTER*** *the hole has been aligned as shown in the line drawing on this page.*



TRIM CYLINDERS

20- After **NEW** O-rings have been installed, coat the surface of the piston, the O-rings, and the seal lip with Automatic Transmission Fluid. Carefully slide the piston into the cylinder.

21- Thread the end cap onto the end of the cylinder and then tighten the cap securely with a spanner wrench. Lubricate the piston rod with Anti-Corrosion Grease.



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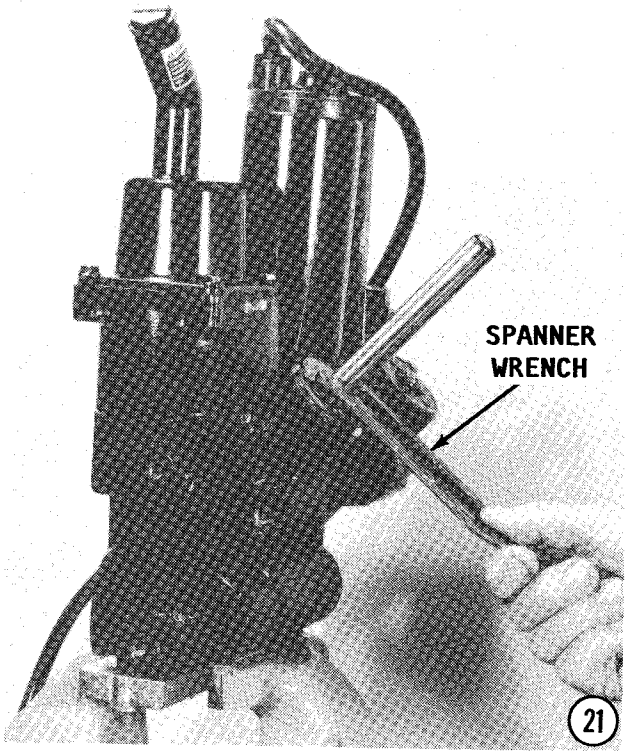
If the tilt/trim system was not removed from the clamp brackets, remove the support safety tool by removing the cotter pins and pulling it free. Release the tilt lock lever, and then operate the system through several full cycles from full up to full down. Check the fluid level through the fill screw opening and add fluid as required.

If the trim/tilt system was removed from the brackets continue with the assembly work and then install the assembly according to Steps 25 thru 30.

FLUID RESERVOIR COVER

22- After a **NEW** O-ring has been installed, position the cap in place on the reservoir. If the trim/tilt system was not removed from the clamp brackets, position the upper end of the fill tube in the clamp bracket hole, and then rotate the cover into position. Secure the cover with the attaching hardware. Use the proper size socket with an extension to install the bolts on the back side. Fill the system with fluid. Install and tighten the fill screw securely.

Remove the support safety tool by removing the cotter pins and pulling it free. Release the tilt lock lever, and then operate the sytem through several full cycles from full up to full down. Check the fluid level through the fill screw opening and add fluid as required.



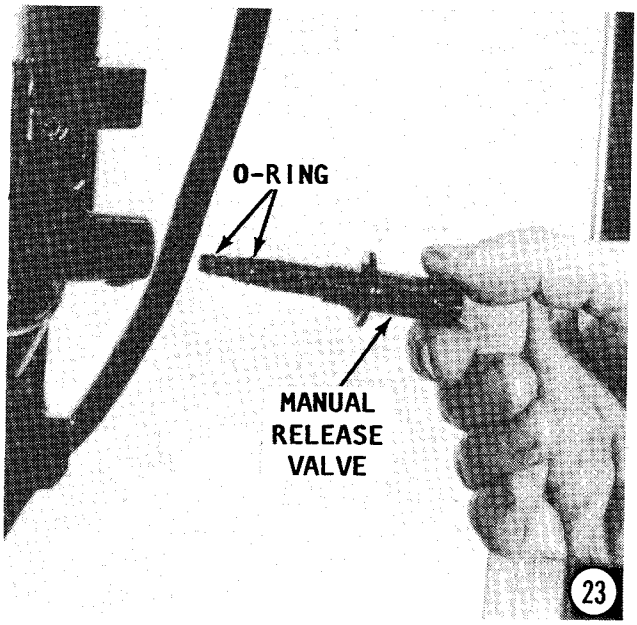


Bleed the system. See Section 10-11.

If the trim/tilt system was removed from the brackets, continue with the assembly work and then install the unit according to Steps 25 thru 30.

MANUAL RELEASE VALVE INSTALLATION

23- Slide new O-rings into place on the manual release valve.



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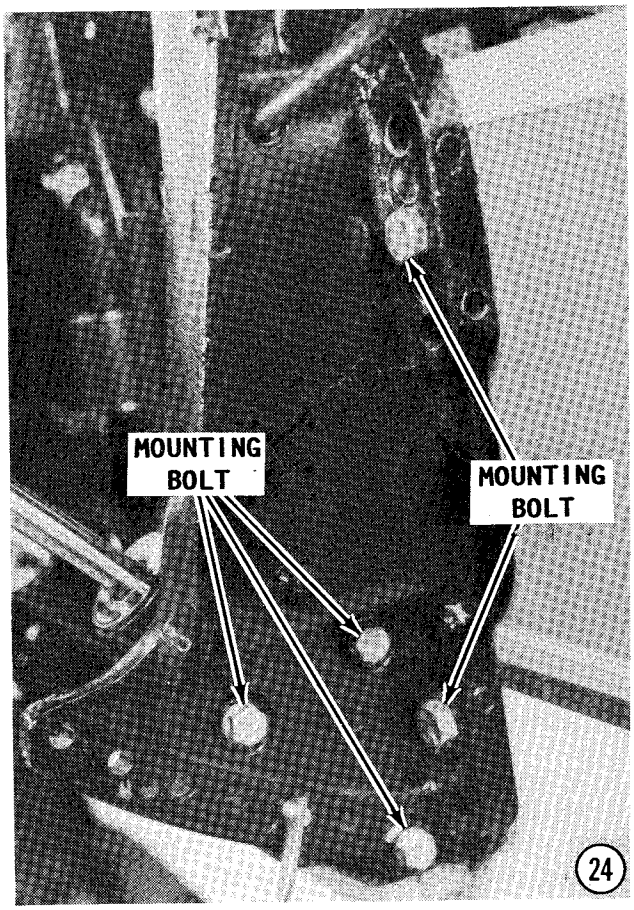
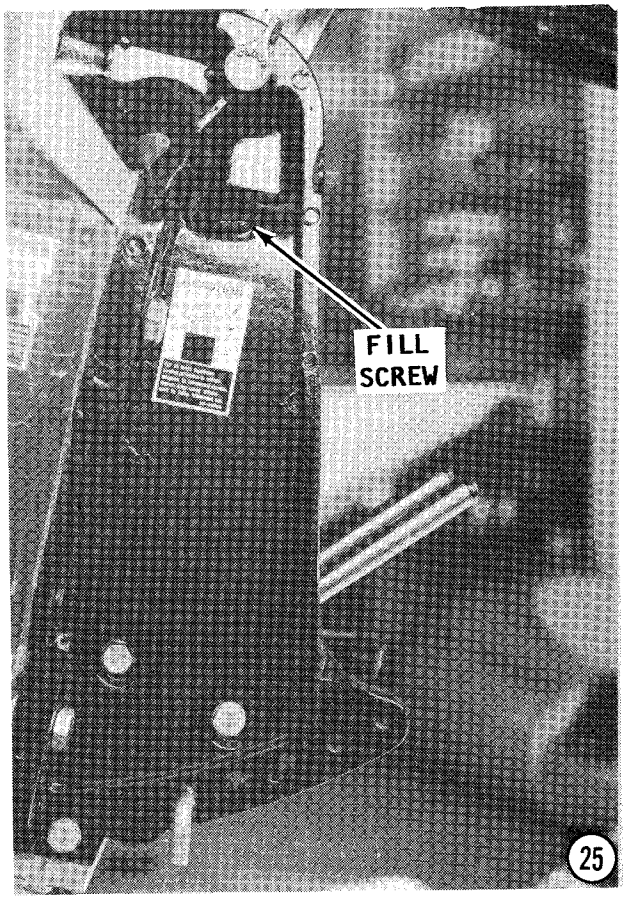




SPECIAL WORDS

One style manual release valve has three O-rings and the other style has only two. Because the valves are **NOT** interchangeable, be sure to replace the valve with the same style as the one removed.

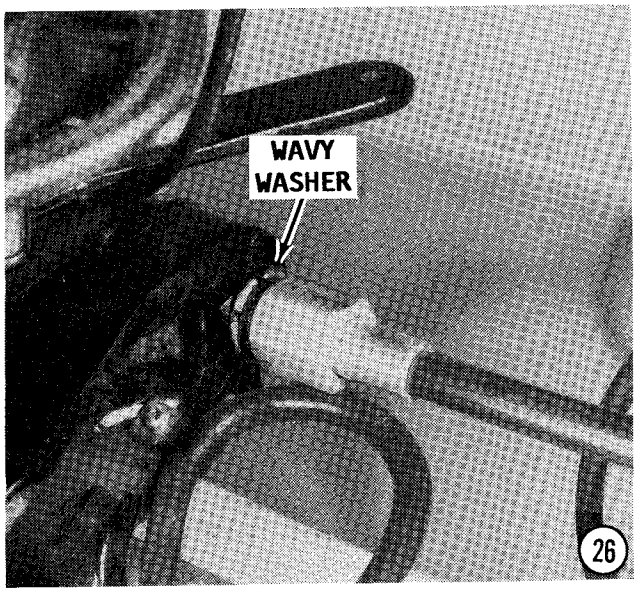
Carefully thread the valve into the pump housing shoulder. Tighten the valve securely.

24- If the valve was removed with the trim/tilt system remaining in the clamp brackets, carefully move the starboard transom bracket into place with the manual release valve passing through the opening in the bracket. Apply a light coating of Loctite Grade "A" on the threads of the five bolts. Secure the bracket in place with the two outboard mounting bolts, and the three bolts through the bracket into the power trim assembly. Tighten the bolts to a torque value of 30 ft lbs. (40.7 Nm).

If the manual release valve was removed after the tilt/trim assembly was removed from the clamp brackets, continue with the assembly work. Install the assembly according to Steps 25 thru 30.

INSTALLATION
TRIM/TILT SYSTEM "B"

25- Apply a coating of Loctite Grade "A" to the threads of all mounting bolts. Lift the assembly into position between the clamp brackets, with the fill tube indexed in the port clamp bracket hole. Install the three bolts securing the system to the port side bracket. **DO NOT** tighten the bolts at this time.



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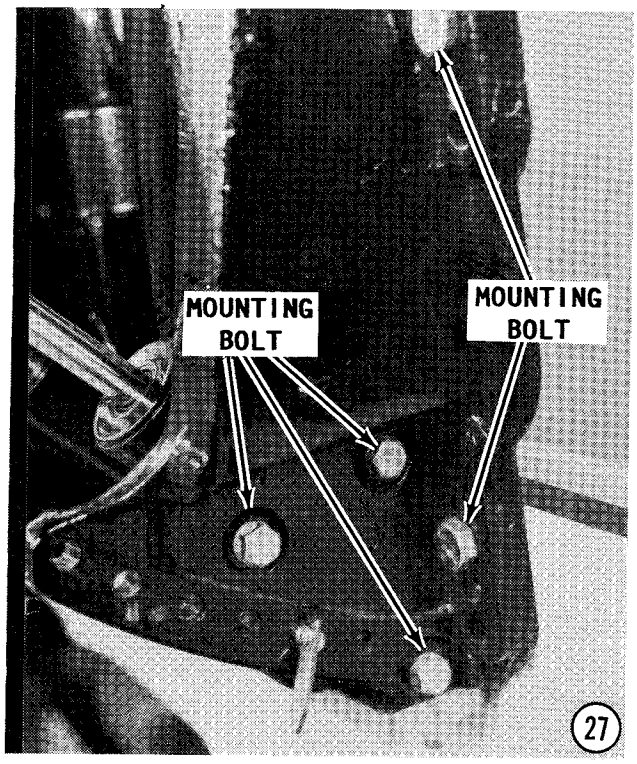
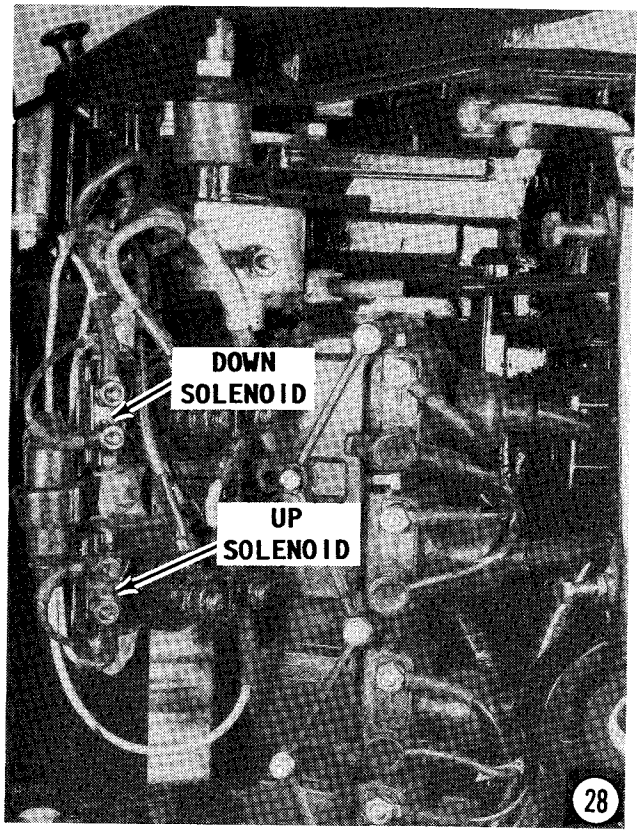
26- Route the wiring through the starboard side clamp bracket. Install the wavy washer onto the tilt tube. Thread the tilt tube nut onto the tube. Tighten the nut securely. Install and tighten the steering cable retaining nut onto the end of the tilt tube.

27- Carefully move the starboard clamp bracket into place with the manual release valve passing through the opening in the bracket. Start the three bolts securing the trim/tilt system to the starboard clamp bracket. Apply marine sealer to the shanks of the bolts securing the clamp bracket to the transom. The sealer is necessary to ensure a watertight installation. Install the bolts, lockwashers, and locknuts. Tighten the nuts securely. **NOW**, tighten the six trim/tilt system mounting bolts, three port and three starboard, to a torque value of 30 ft. lbs. (40.7 Nm).

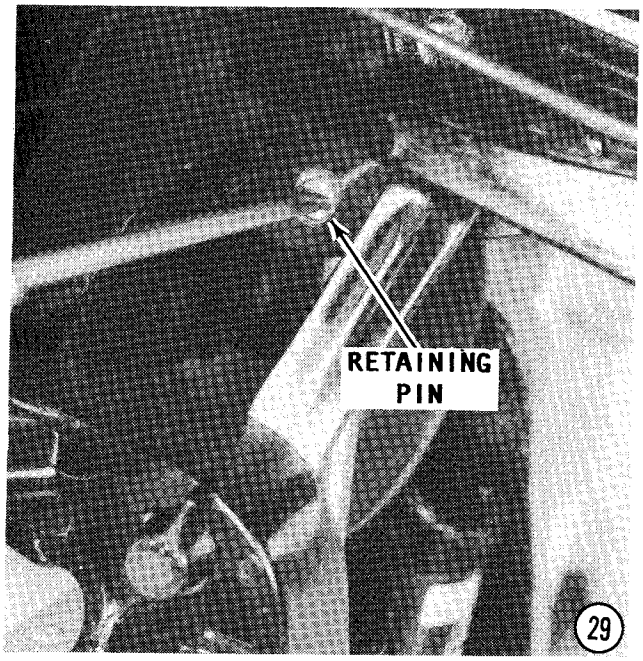
28- Connect the electrical leads to the **UP** and **DOWN** solenoids according to the tags affixed to the wires at the beginning of the disassembling procedures. If the tags were not affixed, refer to the electrical diagram in the Appendix. Connect the electrical leads to a 12-volt battery. Depress the **UP** button to extend the piston to the full up position.

29- Start the retaining pin into the port transom with the non-slotted end going in first.





Now, observe how the hole for the cross pin is aligned with the slot in the end of the retaining pin. Also note how the cross pin hole on one side of the retaining pin is chamfered and the other is not. Align the slot approximately with the hole in the end of the tilt piston, and then push the retaining pin through the port bracket, then the end of the tilt piston, and finally through



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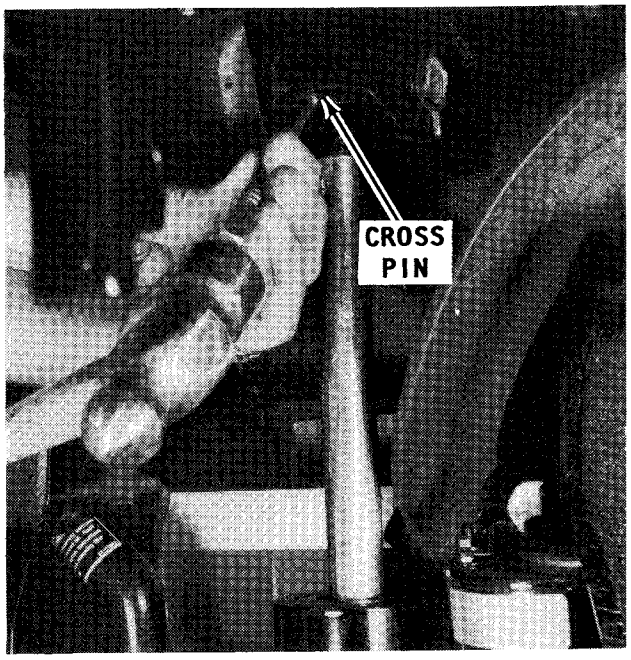
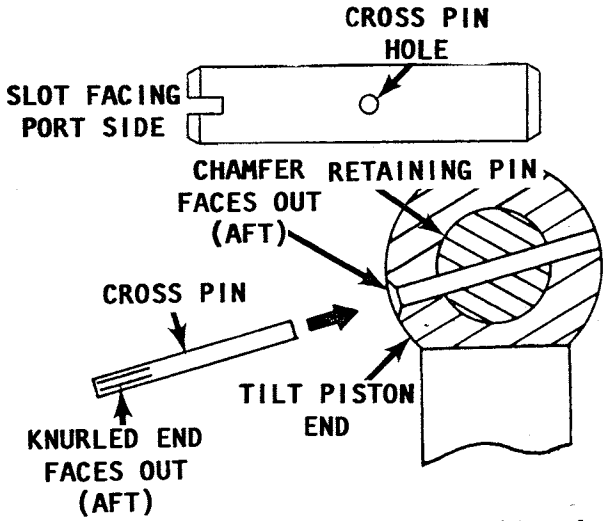


*Using a small punch and hammer to drive the cross pin into place, **AFTER** the hole has been aligned as shown in the line drawing on this page.*

the starboard bracket. Once the retaining pin is installed, rotate the pin very **SLOWLY** with a screwdriver until the hole in the retaining pin is aligned with the hole in the end of the tilt piston.

Once the hole is close to alignment, a small punch may be used through the hole in the piston end to rotate the retaining pin. After the hole is aligned, drive the cross pin into place with the smooth end of the cross pin going in first. Continue to drive the pin with a hammer and punch until the pin is flush with the surface of the piston end.

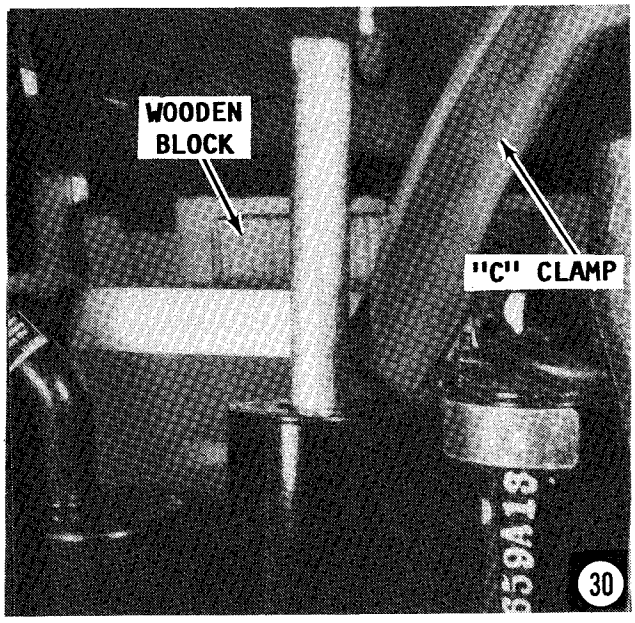


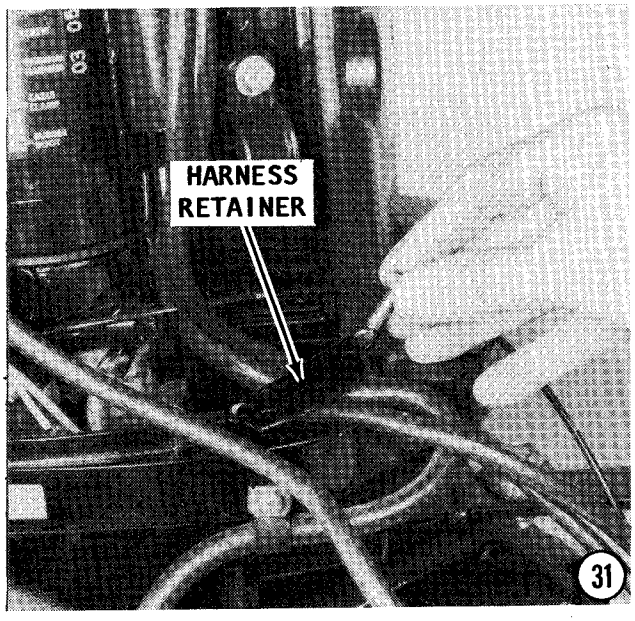
*The retaining pin can be rotated with a large screwdriver until the hole in the pin is aligned with the hole in the end of the tilt piston. The chamfered hole in the end of the piston must face **OUTWARD**. If it does not, remove the retaining pin and rotate the piston in the cylinder 1/2 turn.*

30- Remove the large **C**-clamp and block of wood. Remove the support safety tool by removing the cotter pins and pulling it free. Release the tilt lock lever, and then operate the system through several full cycles from full up to full down. Check the fluid level through the fill screw opening and add fluid as required. Bleed the system of air. See Section 10-11.

31- Install the harness retainer and secure it with the attaching bolts. If any other wire clamps were removed, install and tighten them securely.

Apply Quicksilver Liquid Neoprene, or equivalent, on all electrical connections as a waterproof measure.





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10-16 SYSTEM "C" MODELS WITH ONE CYLINDER TRIM AND TILT

DESCRIPTION AND OPERATION

As the heading suggests, this system consists of a single cylinder mounted between the two transom brackets, a pump mounted in the boat which includes an electric motor for drive and an oil reservoir. The pump is connected to the cylinder with conventional hydraulic hoses and fittings.

The system is controlled by a set of switches, one for **UP**, one for **DOWN** and a trailer switch used only to tilt the outboard unit up for trailering to and from the water or for shallow water operation at idle speed.

When the **UP** switch is depressed, the **UP** pump solenoid is actuated and the circuit to the electric motor is closed. The motor will drive the oil pump forcing hydraulic fluid into the **UP** side of the cylinder and trimming the outboard unit upward until the button is released or until the trim limit cutout switch opens the circuit and stops the outboard unit swivel bracket within the limits of the clamp bracket supporting flanges.

When the **DOWN** switch is depressed, the **DOWN** solenoid is actuated and the circuit to the pump motor is closed. The pump motor will operate in the opposite direction forcing hydraulic fluid into the **DOWN** side of the cylinder to trim the outboard unit down to the desired position.

When the **TRAILER** button is depressed, the **UP** solenoid is actuated and the circuit to the pump motor is closed. The pump motor drives the pump forcing hydraulic fluid into the **UP** side of the cylinder. The trailering circuit bypasses the trim limit switch enabling the outboard unit to be tilted up for trailering or shallow water operation.

SAFETY WORDS

The powerhead should **NEVER** be operated above idle rpm when the outboard unit is tilted beyond the trim limit cutout point because the swivel bracket will not have side support and may break.

ALSO excessive outboard unit trim angle will starve the water pump of sufficient water causing water pump failure and/or overheating of the powerhead. Check to be sure the water level is above the gear housing water intake holes whenever the powerhead is operating.

Thermal Overload Switch

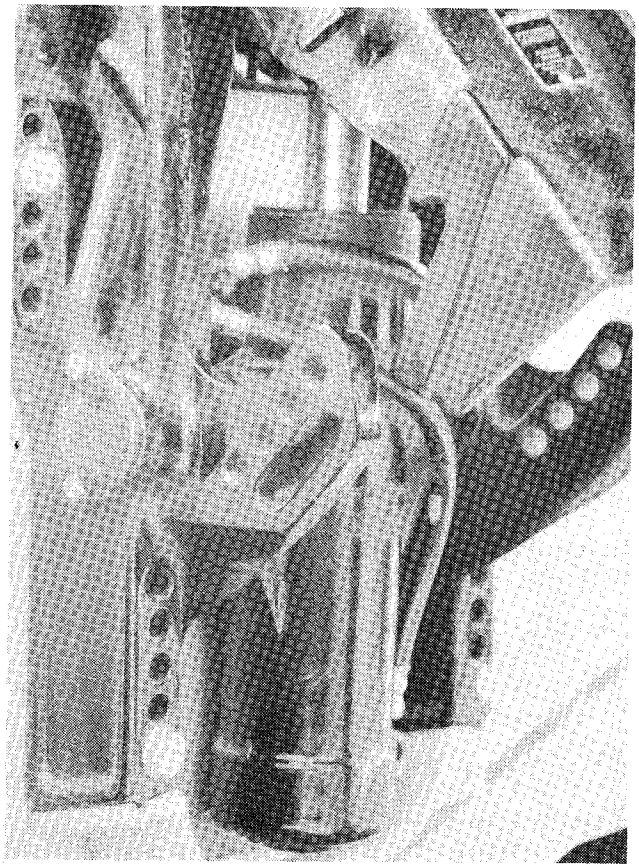
If the **DOWN** or **TRAILER** switch is kept depressed after the outboard unit reaches its end of travel, a thermal overload switch will open to prevent the pump motor from overheating and the pump will stop. The manufacturer strongly recommends the switch be released as soon as the outboard unit reaches the end of its travel.

If the cutout switch should open, **DO NOT** depress the switch for approximately one minute to allow the overload switch to cool. After about a minute the overload switch will close and the pump may again be operated.

Manual Operation

The outboard unit may be raised or lowered manually by first turning the manual release valve control knob to the full **LEFT** position **(COUNTERCLOCKWISE)**, and then lifting the outboard. If lowering the unit, be sure all persons stand clear. As soon as the release valve is opened, the unit will drop to the full down position rapidly.

The valve must be closed (fully **CLOCKWISE**) before the system can be operated by power again.



System "C" single cylinder installation. The pump and associated parts are installed inside the boat.

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10-17 HYDRAULIC BLEEDING SYSTEM "C"

Activate the **UP** circuit and raise the outboard unit to the trim limit position. Push down on the lower unit. The piston should retract into the cylinder no more than 1/8" (3.2mm). If the piston retracts more than this amount, the system contains air which **MUST** be "bled" for efficient operation.

First, check to be sure the manual release valve knob is turned full right (clockwise) and the **FILL/VENT** screw is backed out 1-1/2 turns.

Next, activate the **TRAILER** circuit and raise the outboard unit to full **UP** position. If the unit stops part way, refill the pump to the **ADD** line on the dipstick, not the **FULL** line. Continue raising and filling the pump with hydraulic fluid until the outboard unit raises to the full **UP** position.

Now, activate the **DOWN** circuit and lower the outboard unit to the full **DOWN** position. If the pump sounds as if it is running free and the outboard does not move down, fill the pump with fluid to the **ADD** line on the dipstick.

At this point, "bleed" any remaining air from the system by moving the outboard unit several times through the entire trailering range. Each time the unit is raised to the full **UP** (cylinder fully extended) position, fill the pump with fluid to the **FULL** line on the dipstick.

Finally, tighten the **FILL/VENT** screw, and then back it out 1-1/2 turns to vent the pump reservoir.

10-18 TROUBLESHOOTING SYSTEM "C"

If a problem is encountered with the trim/tilt system, make an attempt to determine if the problem is in the electrical system or in the hydraulic system. The following symptoms and quick checks will be helpful.

Electrical System

Outboard unit fails to trim up or down.

Outboard unit fails to trim down.

Outboard unit trims down, fails to trim up.

Determine if the pump motor operates when the proper switch is activated.

If motor fails to operate, problem is electrical.

If motor operates, problem is hydraulic.

Hydraulic System

Outboard unit fails to move to full **DOWN** position or move part way with jerky motion.

Outboard unit thumps when shifted.

Outboard unit trails out when backing off throttle at high speed.

Outboard unit fails to hold trimmed position or fails to hold tilted position for long period.

Outboard unit fails to hold trim position when in reverse.

For any of the above hydraulic symptoms perform the following checks:

a- Check to be sure manual release valve is fully tightened (clockwise).

b- Check the pump oil level and fill if necessary.

c- Make a visual inspection of the system for external leaks. Tighten the fitting or replace the defective part if a leak is discovered.

d- Check for air in system and "bleed", if necessary. See Section 10-17, this page.

e- Remove the manual release valve and inspect the O-rings for damage. If the O-rings are damaged, the release valve **MUST** be replaced.

WARNING

IF OUTBOARD UNIT IS IN THE UP POSITION WHEN THE MANUAL RELEASE VALVE IS OPENED, THE OUTBOARD WILL DROP TO THE FULL DOWN POSITION RAPIDLY. THEREFORE, ENSURE ALL PERSONS STAND CLEAR.

SPECIAL WORDS

Two different type manual release valves have been used with the System **"C"** pump. One type has two O-rings and the other has three O-rings. These valves are **NOT** interchangeable. Therefore, be **SURE** the same type valve is purchased for replacement.

f- Check the condition of the O-rings on the piston in the cylinder.

g- Remove and clean the two filters on top of the pump.

h- If the outboard unit fails to hold a trimmed position or will not remain tilted for an extended period of time, and the above seven checks are all satisfactory, the trim pump adaptor must be replaced. The adaptor may be purchased in "Kit" form. Detailed instructions for installation are provided with the package.

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10-19 SERVICE SYSTEM "C"

Pump Removal From Boat

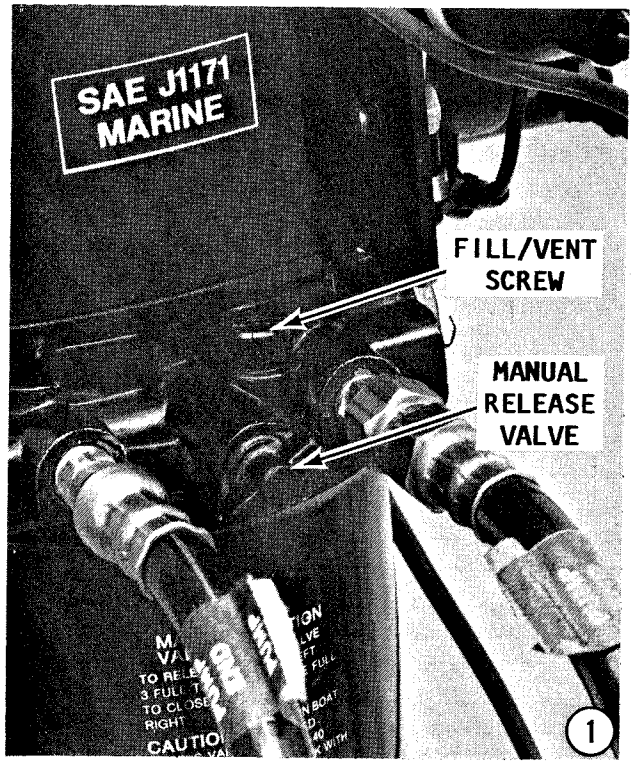
1- Disconnect the pump leads from the battery, negative lead first. Disconnect the 3-pronged connector from the pump. Check to be sure the manual release valve knob is fully tight (clockwise). Remove the trim hoses from the pump and plug the open end of the hoses to prevent contamination. Remove the bolt and lockwasher and lift the pump free of the mounting bracket.

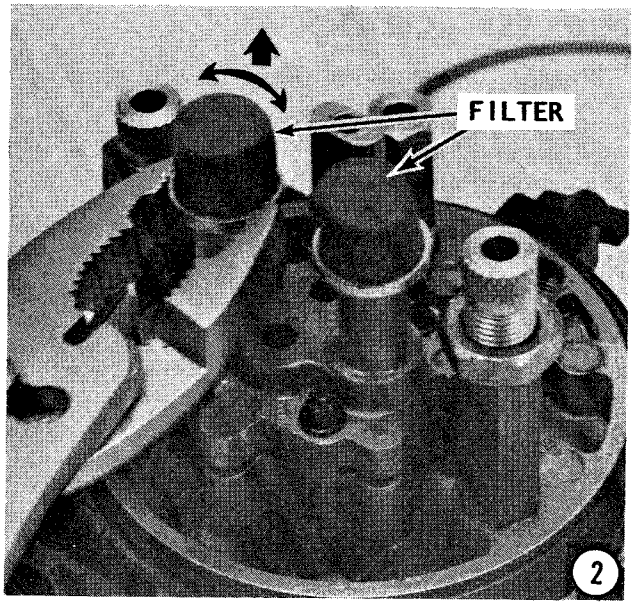
Servicing Pump Filters

2- Remove the oil reservoir from the pump adaptor. Work the filters free by pulling upward and rotating them right and left with a pair of pliers. To install the filters, push them onto the inlet tubes and then tap them into place using the proper size socket and a hammer. Install the oil reservoir O-ring, and then the reservoir. Install the pump into the boat. Finally, fill the reservoir and "bleed" the system.

Pump Installation In Boat

3- Slide the pump into the mounting bracket and secure it in place with the bolt and lockwasher. Connect the hydraulic hoses to the pump. **TAKE CARE** not to crossthread or overtighten the fittings. Connect the 3-pronged connector to the pump. Connect the pump leads to the battery, positive lead first. Turn the manual release valve knob to the fully tightened position (clockwise). Check the oil level and add fluid, if necessary. "Bleed" the system of any air. Check the system for leaks.



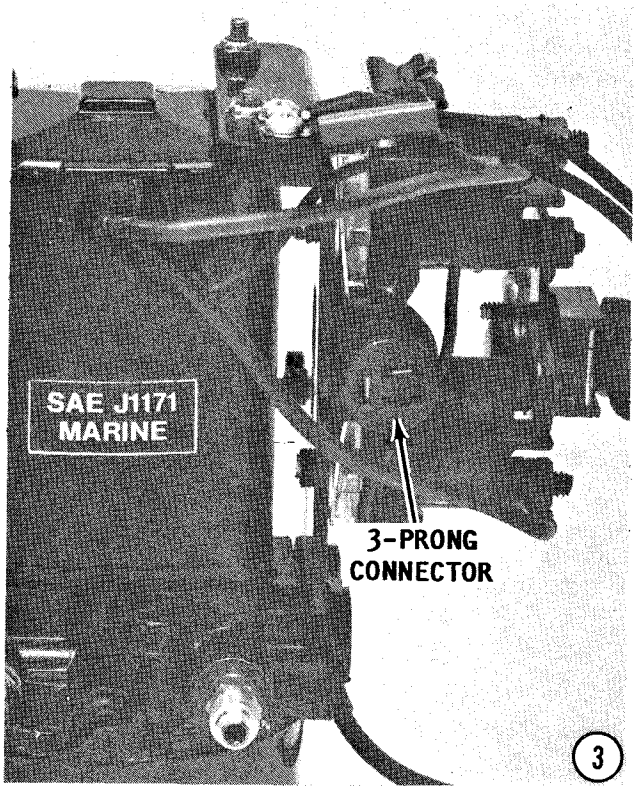


Cylinder Removal

4- Raise the outboard unit, manually, to the full upright position.

SAFETY WORDS

As a safety measure to prevent accidental movement of the outboard while work is



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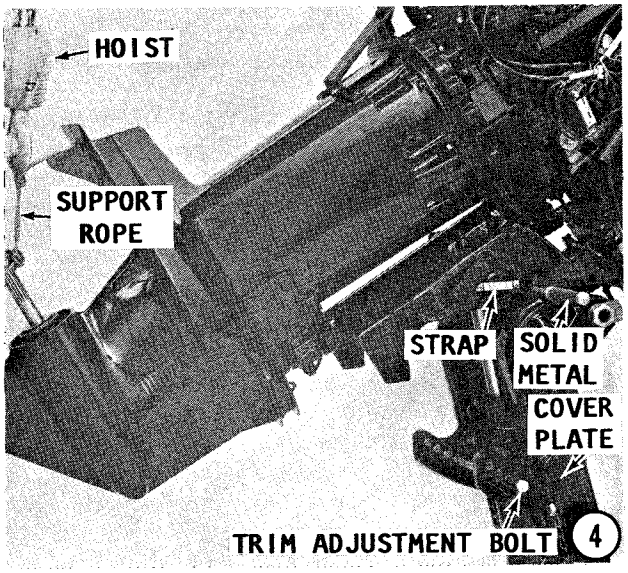
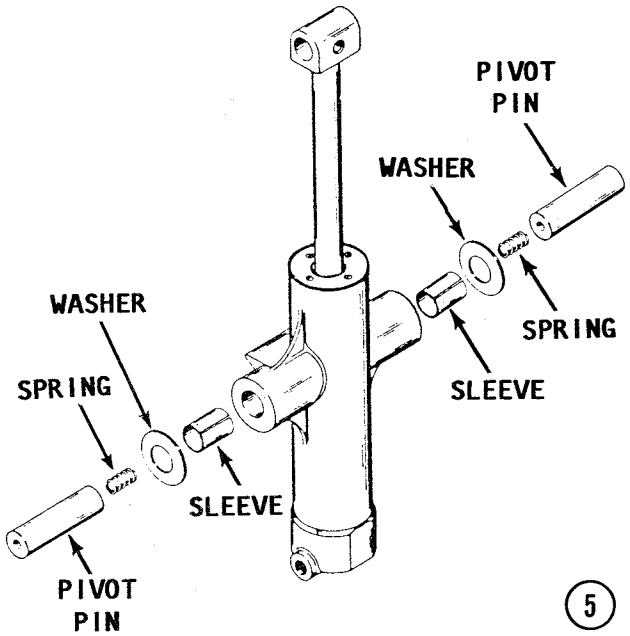
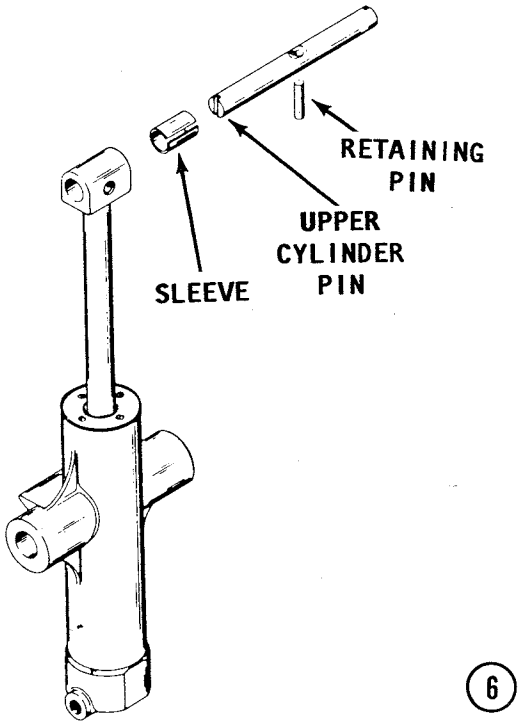


being performed on the trim/tilt system, the unit **MUST** be safely secured in the fully raised position. This can be accomplished by either attaching a hoist to the lower unit and taking a strain to prevent the outboard unit from falling **OR** by sliding a solid metal piece of bar stock or rod stock between the mid section and the transom clamp brackets, **OR** both as shown in the accompanying illustration.

Remove the trim adjustment bolt from the transom clamp bracket.

5- Disconnect the hydraulic hoses from the cylinder and plug the open ends to prevent contamination. Remove the cover plate from each side of the outboard unit

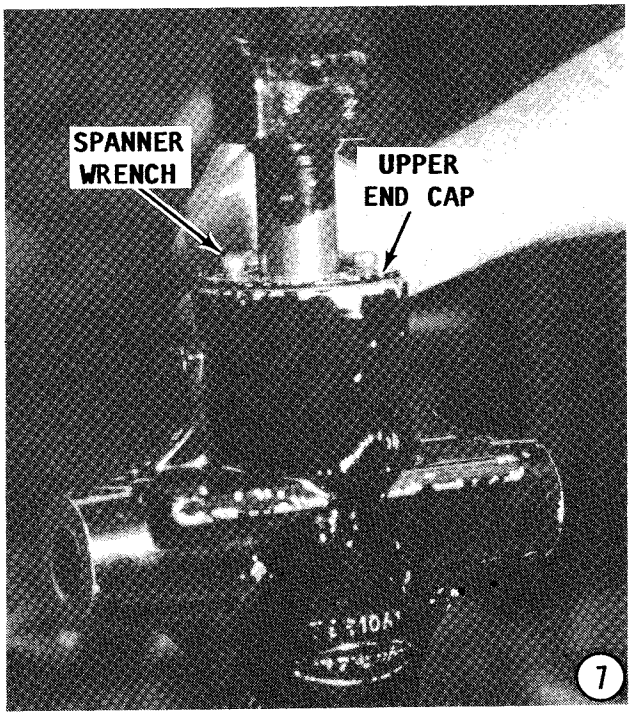




clamp bracket. Thread a 5/16x18 bolt into the pivot pin, one on each side, as an aid in removing the pivot pins. Pull on each bolt and remove both pivot pins.

Remove the straps which secure the trim sender and the trim out limit switch. Remove the switches from the swivel bracket.

6- Support the cylinder because it will be free once this step is completed. Use a blunt punch and hammer and drive the small retaining pin free of the upper cylinder pin.



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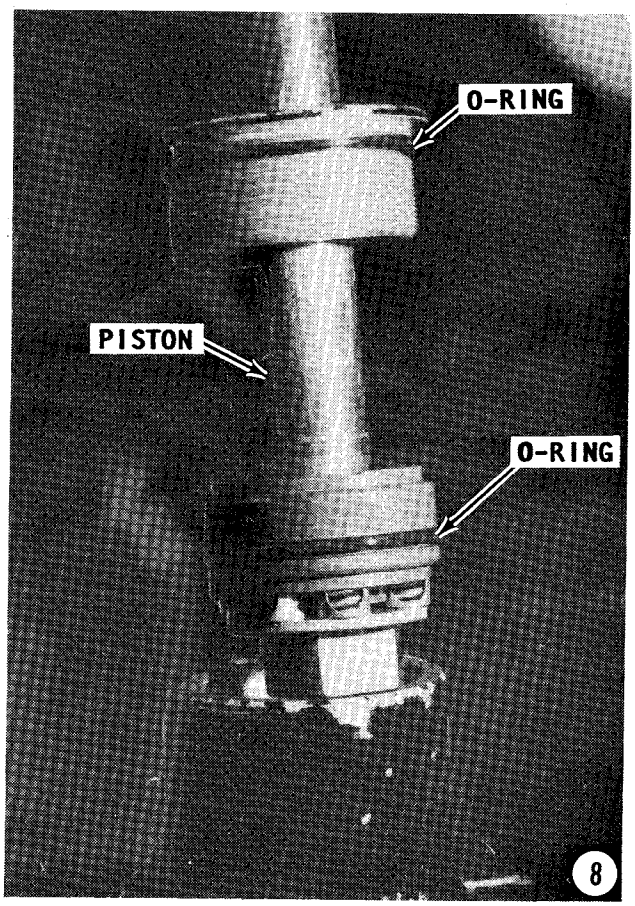


After the retaining pin is free, drive the upper cylinder pin out of the swivel bracket. **TAKE CARE** not to damage the slotted ends of the upper cylinder pin. Remove the sleeve from the upper end of the piston rod.

7- Clamp the cylinder in a vise equipped with soft jaws. Use a spanner wrench and rotate the upper end cap **COUNTER-CLOCKWISE** until it is free of the cylinder.

8- Pull the piston straight up and out of the cylinder.

CLEANING AND INSPECTING GENERAL PRACTICE

Check all **O**-rings for any damage. Actually, good shop practice would dictate new **O**-rings be installed anytime a part is disassembled exposing an **O**-ring.

Pump and Motor

The pump **CANNOT** be serviced. Therefore, if troubleshooting indicates the pump has failed, it **MUST** be replaced.

However, the adaptor between the pump and the motor may be replaced. A kit is available with full installation instructions included.

The electric motor is very similar to other electric motors used on the outboard unit. Brush replacement, armature testing, and field tests may be made in the same manner. Therefore, the motor can be checked, tested, and serviced following the procedures outlined in Chapter 9 for other motors.

Check the mating surfaces of the motor and pump to ensure they are clean and undamaged.

Manual Release Valve

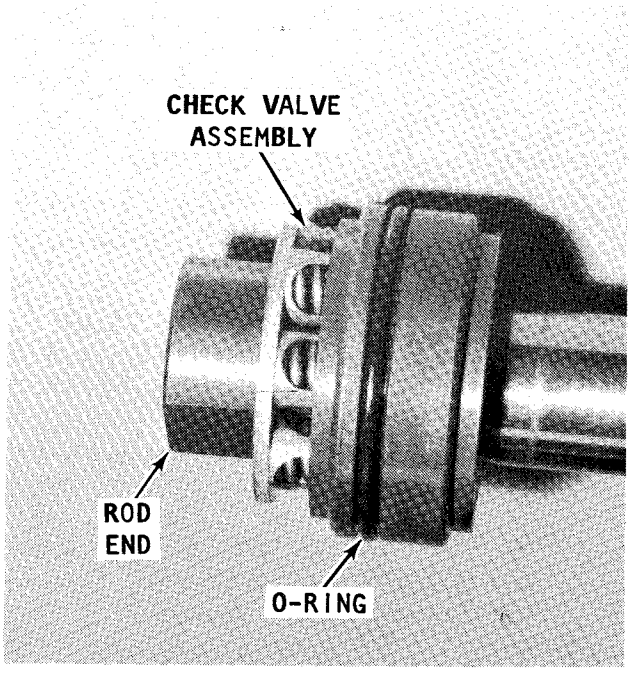
One style manual release valve has three **O**-rings and the other style has only two. The valves are **NOT** interchangeable. Therefore, be sure to replace the valve with the same style as the one removed.

Cylinder

Inspect the interior of the cylinder for any sign of scoring or roughness. Inspect the seal located in the recess of the end cap. If the seal is damaged or fails to keep the trim piston rod clean, replace the seal. This is accomplished by first prying the old seal from the top of the cap with a screwdriver, and then pushing the new seal into place with the seal lip facing **UP.**

Examine the check valves and clean them thoroughly of any foreign material.

Clean all parts with solvent, and then blow them dry with compressed air.



Lower end of the piston with the O-ring, check valve springs, and rod end identified.

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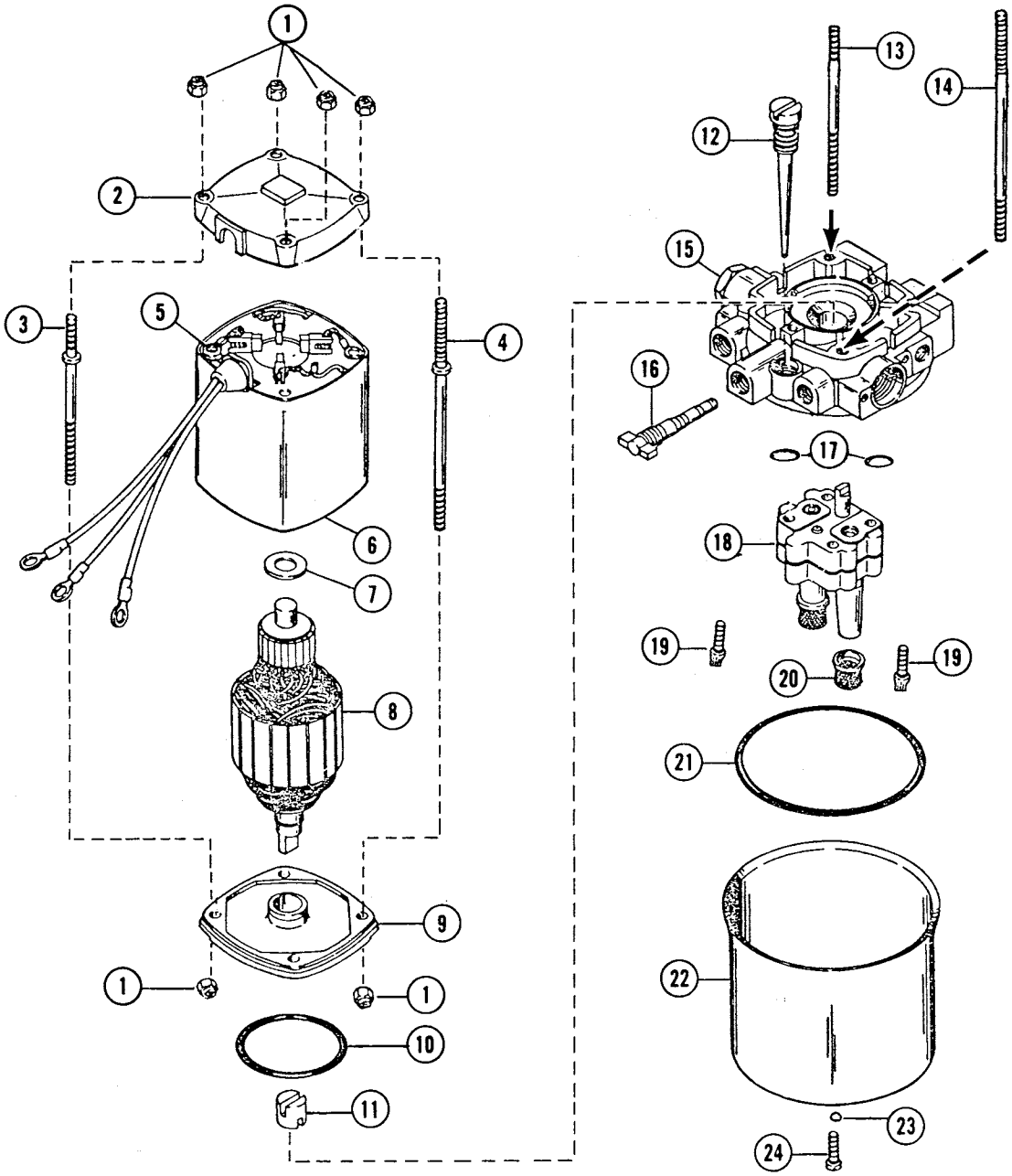

1- LOCKNUT
2- UPPER END CAP
3- THRU STUD 4-1/4" (10.79cm)
4- THRU STUD 4-9/16" (11.58cm)
5- BRUSH CARD
6- FIELD AND FRAME
7- THRUST WASHER
8- ARMATURE
9- LOWER END CAP
10- O-RING 1-15/16" (4.90cm) O.D.
11- COUPLING
12- FILL/VENT SCREW
13- THRU STUD 4-1/2" (11.43cm)
14- THRU STUD 4-13/16" (12.21cm)
15- ADAPTOR
16- MANUAL RELEASE VALVE
17- O-RING 11/32" (8.6mm) O.D.
18- PUMP
19- SCREW
20- FILTER
21- O-RING 3-11/16" (93.4mm) O.D.
22- RESERVOIR
23- O-RING 1/4" (6.4mm) O.D.
24- SCREW

Exploded drawing of the single cylinder trim/tilt pump and electric motor, identified as System "C". The pump and motor are installed in the boat and the cylinder is mounted between the transom brackets. Standard hydraulic lines and fittings connect the pump to the cylinder.

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CYLINDER ASSEMBLING AND INSTALLATION

1- Coat **NEW** O-rings with SAE 10W-30 or 10W-40 motor oil. In tropical areas, SAE 30W oil may be used. Apply oil to the inside surface of the cylinder. Install the **NEW** O-rings onto the piston.

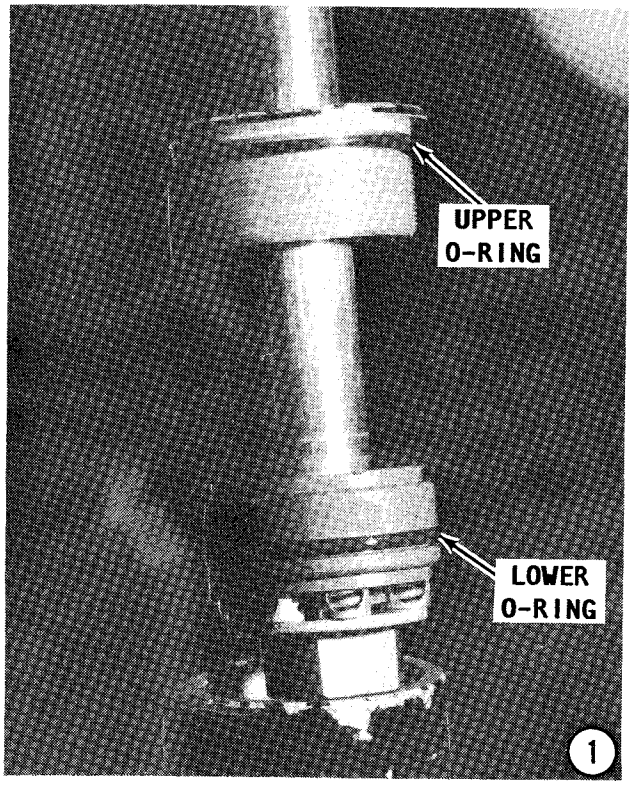
Slide the piston into the cylinder, and then thread the end cap into the cylinder.

2- Tighten the end cap with a spanner wrench.

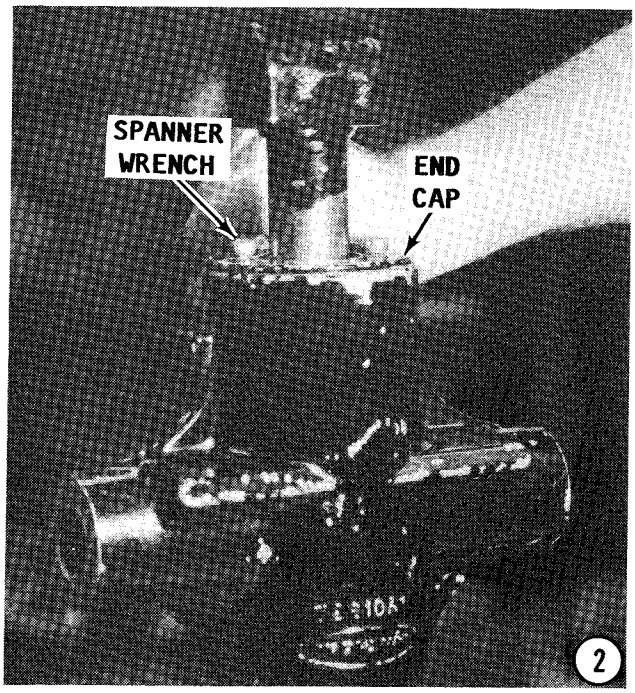
3- Insert the sleeve into the piston rod end. Rotate the sleeve until the slot in the sleeve is aligned with the hole through the rod end. This alignment is necessary to permit the retaining pin to pass through. Now, insert the retaining pin into its hole and just barely through the slot in the sleeve. The pin will hold the sleeve in position. Position the assembled cylinder in place between the transom clamp brackets. Next, coat the upper cylinder pin with Multipurpose lubricant. Roughly align the hole in the cylinder pin with the hole in the rod end, and then slide the pin through the clamp bracket, rod end, and other clamp bracket.

SPECIAL GOOD WORDS

Both ends of the cylinder pin have a slot. Guess why? To provide a means of rotating the pin with a screwdriver to align the hole in the pin with the retaining pin and thus enable the retaining pin to be driven through. The pin is a snug fit to secure the cylinder pin in place.

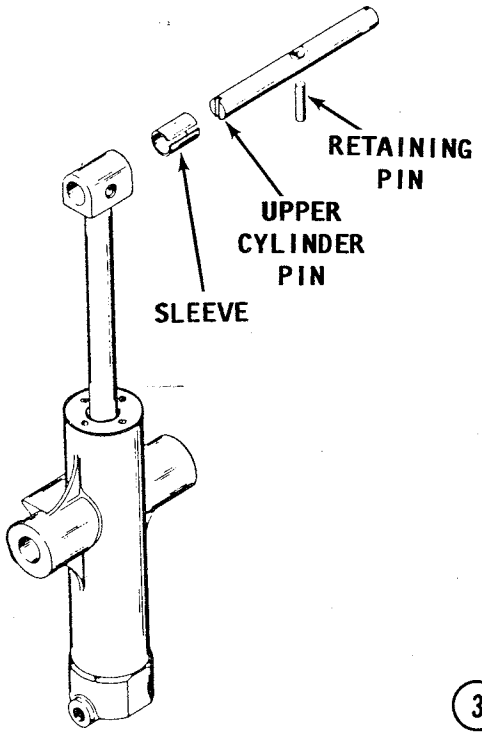


1



2

4- Coat the pivot pin with Multipurpose lubricant. Assemble the pivot pin and associated parts as shown in the accompanying illustration. Install the cover plates to secure the pivot pin in place.



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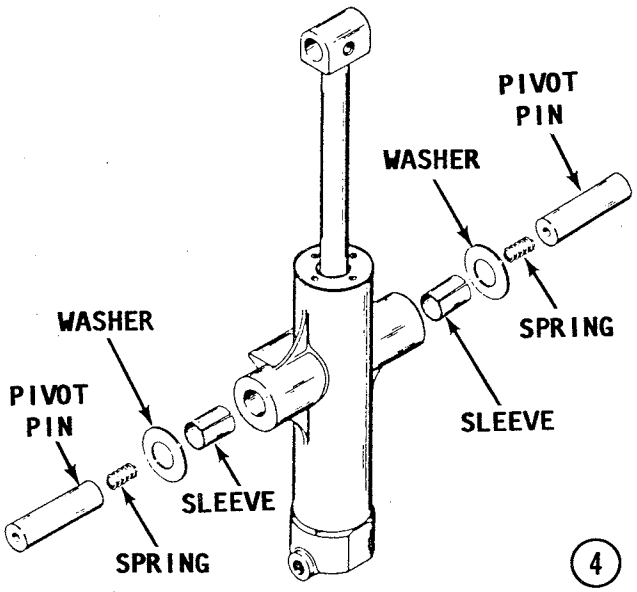
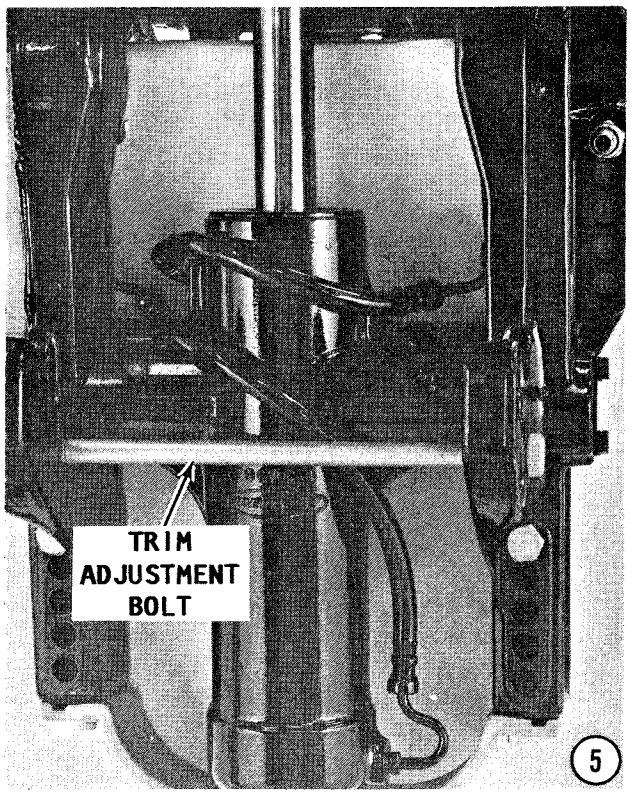


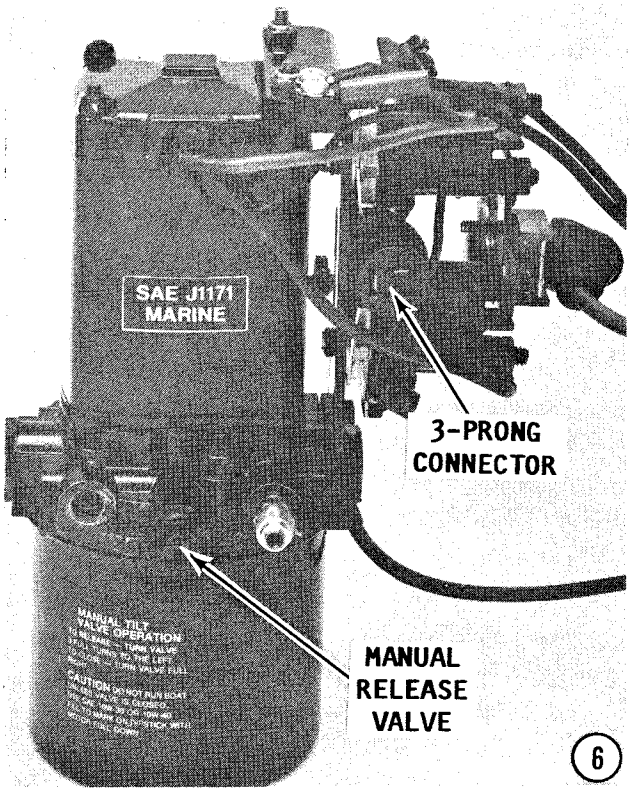
5- Remove the plugs and connect the hydraulic hoses to the cylinder. Install the trim sender and trim out switches to the swivel bracket. Install the trim adjustment bolt into the clamp bracket and secure it in place with a locknut. **DO NOT** overtighten the locknut. Tighten the nut only enough to remove any "play".

Obtain the help of an assistant. Remove the supporting equipment, the solid metal bar or rod and the hoist, if one was used. Lower the outboard unit.

6- Connect the 3-prong connector to the pump. Check to be sure the manual release valve is fully seated (clockwise). Fill the pump reservoir with fluid, and then "bleed" air from the system. See Section 10-17.

Check the completed work for proper operation and no leaks.





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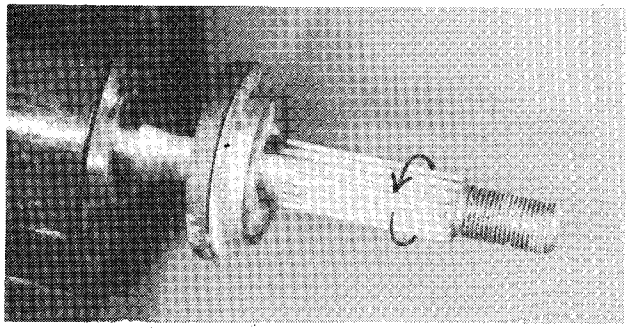
11
LOWER UNIT

11-1 DESCRIPTION

The lower unit is considered as that part of the outboard below the exhaust housing. The unit contains the propeller shaft, the driven and pinion gears, the drive shaft from the powerhead and the water pump. The shifting capabilites, including the forward and reverse gears together with the clutch, shift assembly, and related linkage, are all housed within the lower unit.

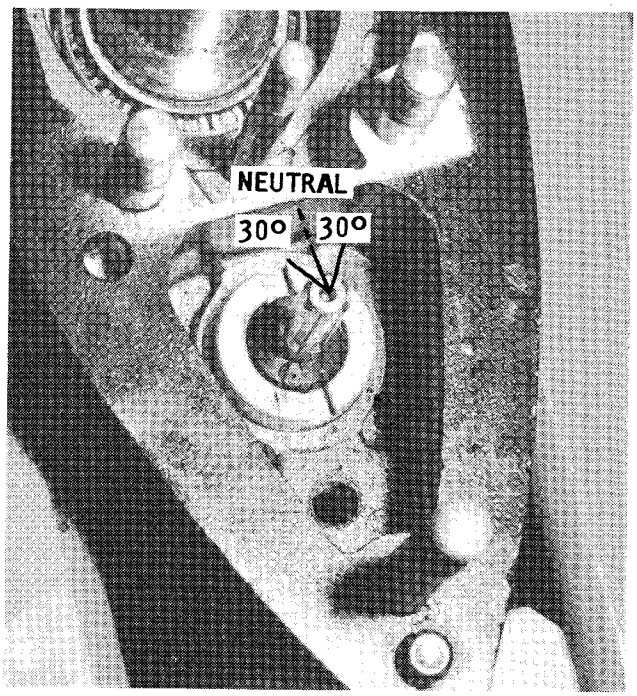
The lower unit may be removed and serviced without disturbing the remainder of the outboard unit.



*With the lower unit still attached to the powerhead, and with the unit in **REVERSE** gear, rotate the propeller shaft **COUNTERCLOCKWISE.** If the shaft does not ratchet, the unit has a Cam-Shift. If the propeller shaft "rachets" when turned counterclockwise, the lower unit has the E-Z Shift.*

CHAPTER COVERAGE

Two different water pumps, two different shift mechanisms, and three different driveshaft arrangements are covered in this chapter. A brief description of each pump, each shift, and each driveshaft arrangement is presented in the following paragraphs.



*With the lower unit separated from the powerhead, and with the unit in **NEUTRAL** gear, rotate the shift shaft clockwise and counterclockwise. If the shift shaft will rotate a full 360°, the unit has the Cam-Shift. If the shift shaft will only rotate about 30° in either direction, the unit has the E-Z Shift.*

Water Pump

Two quite different design water pumps are used on the units covered in this manual. A high pressure water is used on most early lower units and lower units matched with large horsepower powerheads.

A high volume water pump is used on later lower units and units matched with smaller horsepower powerheads.

Actually the components of both designs remain essentially the same -- pump cover, impeller, gasket, inner plate, another gasket, and the water pump base. The shape and the size of these individual parts have been changed to meet the demand for increased volume.

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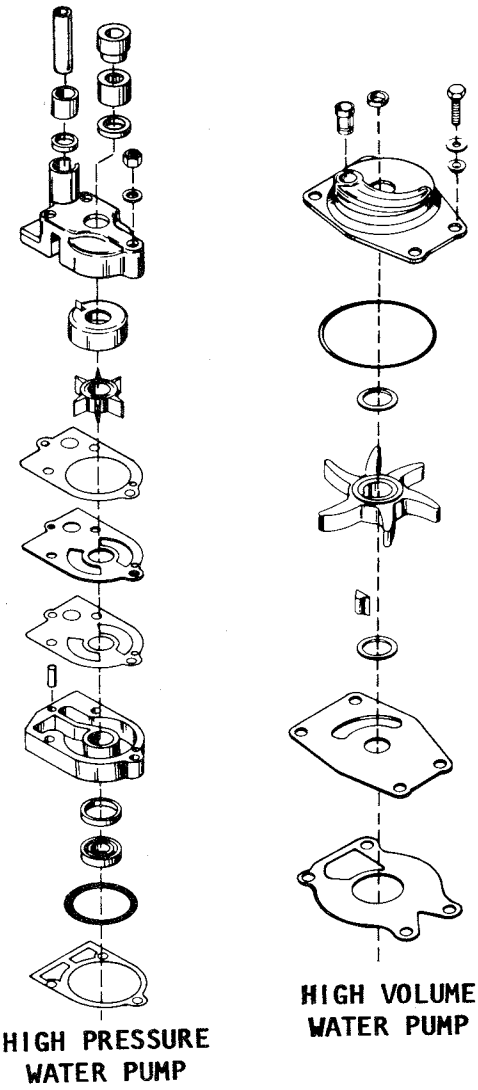
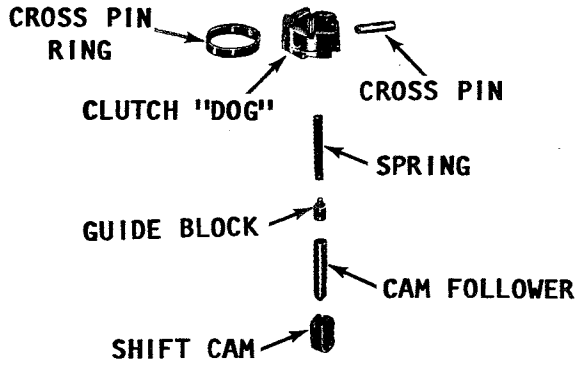


Exploded drawing of a high pressure water pump (left), and a high volume water pump (right). Major parts are identified. The high volume pump is used on newer lower units matched with intermediate size powerheads covered in this manual.

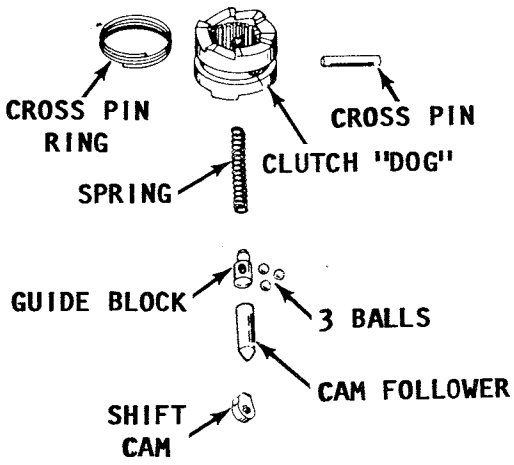
Cam Shift Lower Unit

A cam shift system and an improved method labeled "E-Z" shift by the manufacturer are covered in this chapter. The cam shift system has two distinctly different designs. One has been identified as Cam Shift I and the other as Cam Shift II to permit presentation of separate procedures for each. The differences between these two cam shift arrangements cannot be determined until the lower unit has been disassembled and the shifting components have been exposed. However, a cam shift lower unit can be easily and quickly identified from the E-Z shift lower unit, as explained in this section.

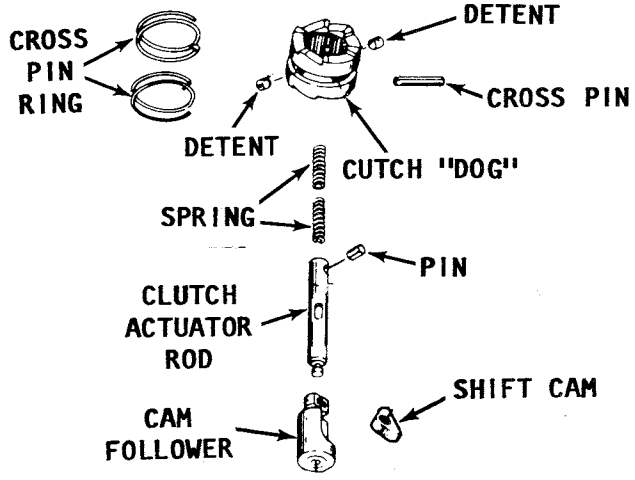
The Cam Shift Type I was installed on lower units matched with V6 powerheads



Shifting components of the Cam-Shift Type I mechanism.



Shifting components of the Cam-Shift Type II mechanism.



Shifting components of the E-Z shift mechanism.

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prior to 1979 and on all lower units matched with early L6, 3-cylinder, and 4-cylinder powerheads. Cam Shift Type I lower units are equipped with the high pressure water pump and the bearing carrier is secured with a large cover nut.

The Cam Shift Type II has been used on lower units matched with late model 3-cylinder, 4-cylinder, and L6 powerheads. The Cam Shift Type II is equipped with a high volume water pump and the bearing carrier is secured to the lower unit by two externally mounted "ears". The two accompanying illustrations will help in identifying a Cam Shift Type II lower unit.

E-Z Shift Lower Unit

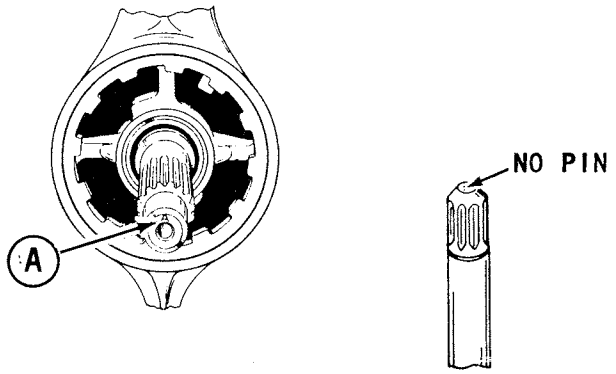
The "E-Z" shift has been used in lower units matched with V6 powerheads since 1979.

The major difference between the Cam Shift and E-Z shift mechanisms is the clutch actuating rod and associated parts, as shown in the two accompanying illustrations.

Identifying Shift Design

A quick and easy test can and should be made to determine if the unit being serviced has the Cam-Shift or the E-Z shift. This test should be done before any service work is begun. With the powerhead still attached to the lower unit, simply shift the unit into **REVERSE** gear.

Now, attempt to rotate the propeller shaft **COUNTERCLOCKWISE.** If the lower unit has the "Cam-Shift" gear housing, the propeller shaft will not ratchet as it is rotated counterclockwise with the unit in reverse gear. If the gear housing has the "E-Z" shift, the propeller shaft will ratchet when turned counterclockwise.



The letter "A" was embossed on the end of the propeller shaft for the first production year of the Alpha drive.

Driveshaft Arrangements

The three types of driveshafts are:

"Old" driveshaft with a pre-load pin at the upper end.

"Old" driveshaft **WITHOUT** a preload pin.

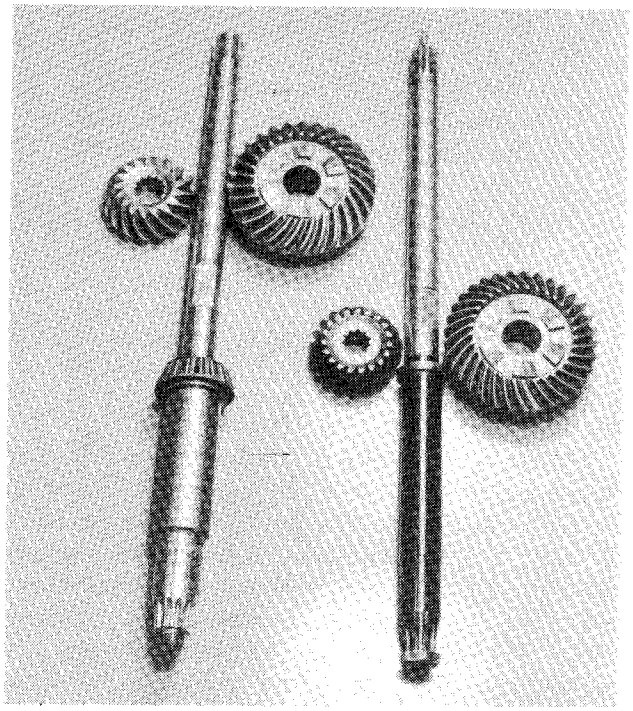
New "Alpha", also known as "MR" driveshaft without a pre-load pin on the upper end and a new cut to the gears.

Briefly the differences are as follows:

Old style WITH a pre-load pin placed a load on the driveshaft in the downward direction. The driveshaft had a "one-piece" ball bearing set **OR** a "two-piece" tapered roller bearing set.

Old style driveshaft **WITHOUT** the pre-load pin uses a "two-piece" tapered roller bearing set and a new bevel cut for the pinion gear in a counterclockwise direction. The new gear arrangement placed a load on the driveshaft in the upward direction and held it. Therefore, the pin was no longer required.

The **Alpha** driveshaft has the new bevel cut on the pinion gear and both the forward and reverse gears, the same as for the old style without the pre-load pin, as shown in the accompanying illustration. The new shaft and gear set is shown on the left and the old one on the right. Notice the absence of the pre-load pin on the new driveshaft and the opposite direction of the gears. The



A new driveshaft, pinion gear, and driven gear, for the Alpha drive (left), alongside the old driveshaft and gears. Differences are explained in the text.

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new gear direction places an **UPWARD** load on the driveshaft. Therefore, the pre-load pin at the upper end is no longer needed.

Increased strength has also been built into the Alpha driveshaft as indicated by the diameter of the lower portion.

The first year the Alpha driveshaft was introduced an "A" was embossed on the end of the propeller shaft to identify the lower unit as having the new driveshaft. After the first year the letter "A" was discontinued. Therefore, the only way to determine if the unit has an Alpha driveshaft is during disassembling. If the upper end of the driveshaft does **NOT** have a pre-load pin **AND** if there is a retainer nut around the driveshaft under the water pump, the unit being serviced has the Alpha drive.

PROCEDURES

Detailed instructions are presented for:
Troubleshooting -- Section 11-2.
Lower unit removal -- 11-3.
Disassembling water pump -- 11-4.
Servicing Cam-Shift Type I units, including disassembling, exploded drawings, assembling, and adjustments -- 11-5.
Servicing Cam-Shift Type II units, including disassembling, exploded drawings, assembling, and adjustments -- 11-6.
Servicing E-Z shift units, including disassembling, exploded drawings, assembling, and adjustments -- 11-7.
Water pump installation all units -- 11-8.
Cleaning and Inspecting all units -- 11-9
Lower unit installation to intermediate housing, all units -- 11-10.

Because so many procedures are common to the different lower units, except in specified areas, all service tasks for the particular unit being serviced are presented in one section. Therefore, the work moves along smoothly and when differences are encountered the steps to be followed are clearly indicated. By the same token, when the steps involve all units covered in the section, this fact is also boldly brought to the reader's attention.

ILLUSTRATIONS

Because this chapter covers such a wide range of models over an extended period of time, the illustrations included with the procedural steps are those of the most popular lower units. In some cases, the unit being serviced may not appear to be absolutely identical with the unit illustrated. However, the step-by-step work sequence will be valid in all cases. If there is a special procedure for a unique lower unit, the differences will be clearly indicated in the step.

SPECIAL WORDS BEFORE BEGINNING WORK

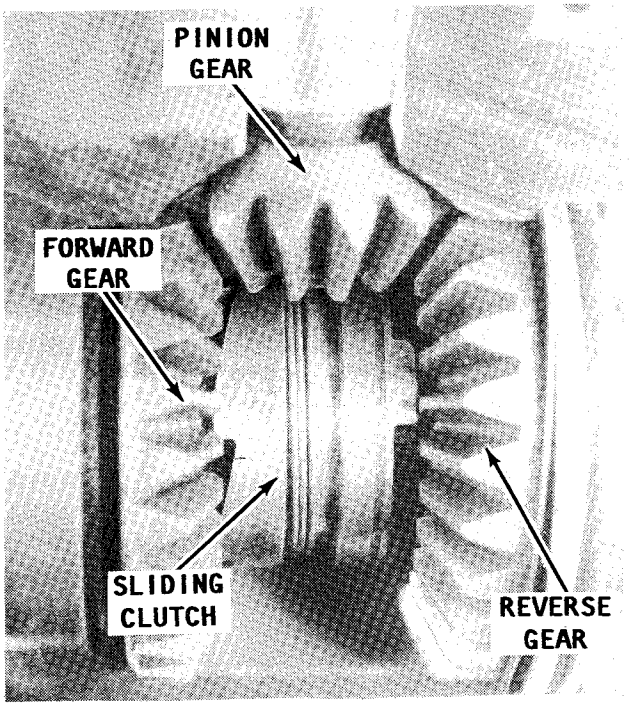
All threaded parts are **RIGHT-HAND** unless otherwise indicated.

If any water in the lower unit or metal particles are discovered in the gear lubricant, the lower unit should be completely disassembled, cleaned, and inspected.

Use "soft jaws" in a vise to prevent damage to expensive parts.

Take time to obtain a suitable mandrel which will contact only the bearing race, when it is necessary to press or drive bearings into place.

Keep a record of shim material removed, as an aid during installation.



*Cutaway view of the lower unit in **NEUTRAL**. The sliding clutch engages either the forward or reverse gear with the pinion gear on the end of the driveshaft.*

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Maintain patience when adjusting gear depth and backlash to prevent noisy operation and possible premature gear failure. Adjustments **CANNOT** be rushed.

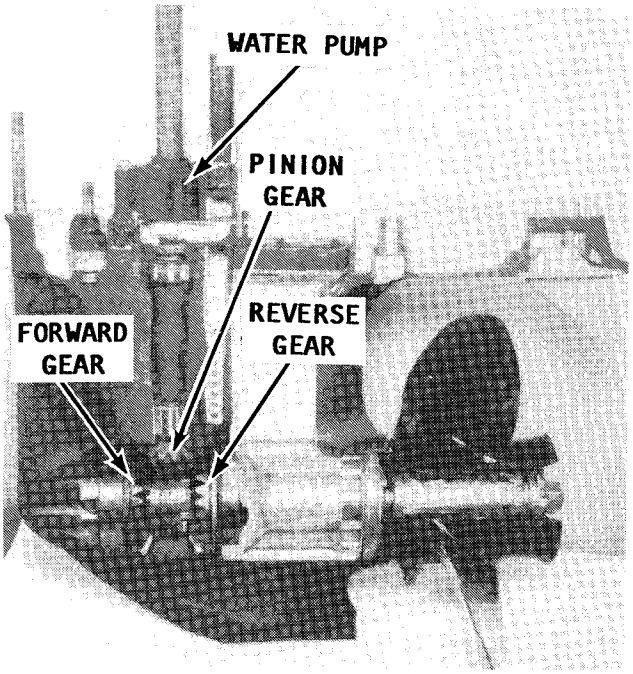
Oil seals and O-rings should always be replaced regardless of their appearance. Use Water Resistant Multipurpose lubricant on the seals and O-rings as an aid to installation.

11-2 TROUBLESHOOTING

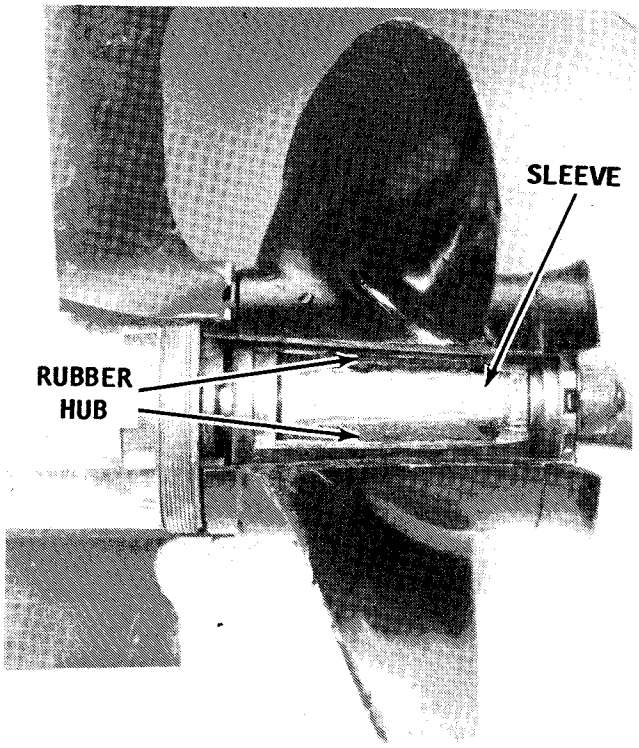
Troubleshooting **MUST** be done **BEFORE** the unit is removed from the powerhead to permit isolating the problem to one area. Always attempt to proceed with troubleshooting in an orderly manner. The "shot in the dark" approach will only result in wasted time, incorrect diagnosis, replacment of unneccessary parts, and frustration.

The following procedures are presented in a logical sequence with the most prevalent, easiest, and less costly items to be checked listed first.

1- Check the propeller and the rubber hub. See if the hub is shredded. If the propeller has been subjected to many strikes against underwater objects, it could slip on its hub. If the hub appears to be damaged, replace it with a **NEW** hub. Replacement of the hub **MUST** be done by a propeller repair building shop equipped with the proper tools and experience for such work.

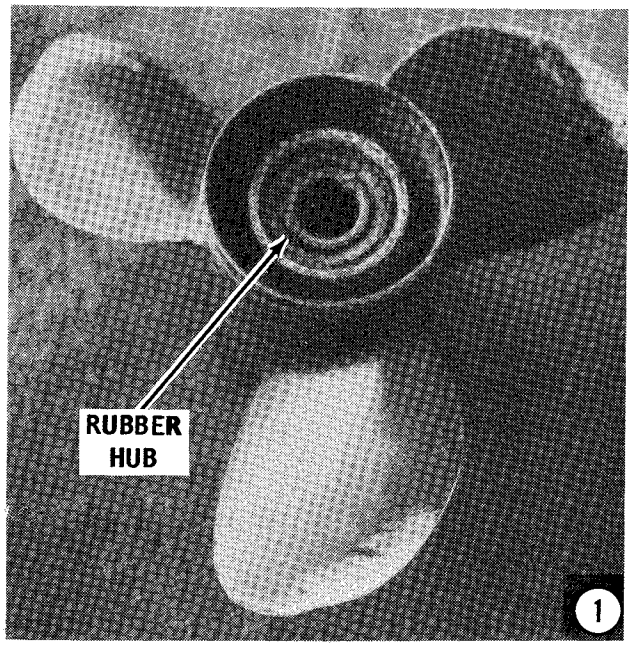


Classroom type cutaway view of a lower unit with major parts, including the propeller and water pump, installed. Notice how the forward, reverse and pinion gears all are "bevel cut".



*Cutaway view showing the rubber hub and sleeve. The rubber hub protects the lower unit if the propeller should strike an underwater object. If the rubber hub loses its holding power with the inner hub of the propeller, the propeller hub **MUST** be replaced.*

2- Shift mechanism check: Verify the ignition switch is **OFF**, to prevent possible personal injury, should the powerhead start. Shift the unit into **REVERSE** gear and at the same time have an assistant turn the propeller shaft to ensure the clutch is fully engag-



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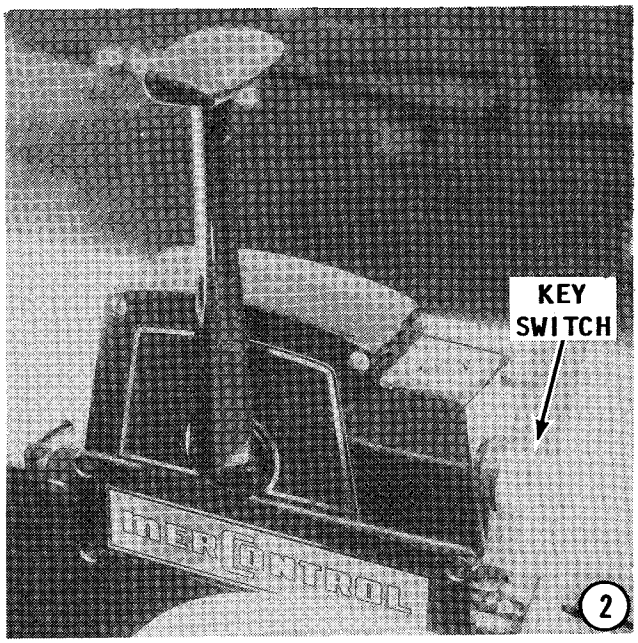


ed. If the shift handle is hard to move, the trouble may be in the lower unit unit, remote control cable, or the shift box.

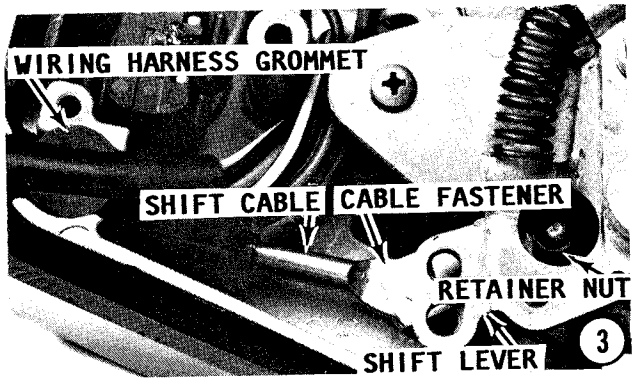
3- Isolate the problem: Disconnect the remote-control cable at the engine and then lift off the remote-control shift cable. Operate the shift lever. If shifting is still hard, the problem is in the shift cable or control box, see Chapter 12. If the shifting feels normal with the remote-control cable disconnected, the problem must be in the lower unit. To verify the problem is in the lower unit, have an assistant turn the propeller and at the same time move the shift cable back-and-forth. Determine if the clutch engages properly.

11-3 LOWER UNIT REMOVAL ALL UNITS

ADVICE

Before beginning work on the lower unit, take time to **READ** and **UNDERSTAND** the information presented in Section 11-1. Verifying which lower unit is to be serviced will ensure the proper procedures are being followed after the lower unit is separated from the driveshaft housing and the water pump has been removed.

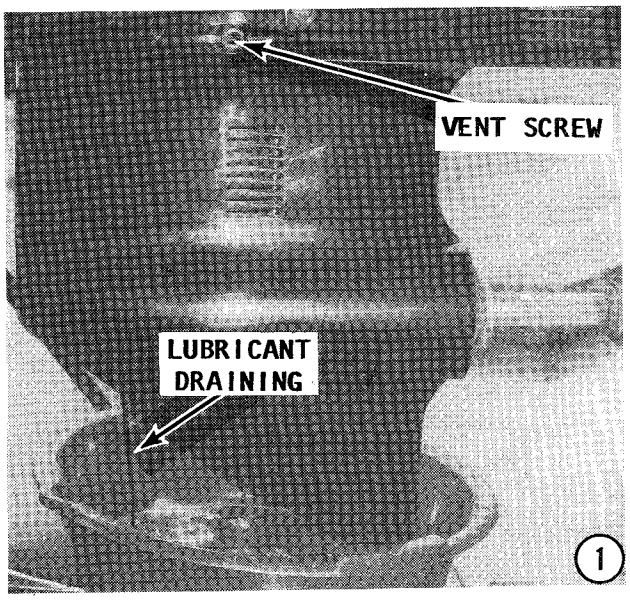
Disconnect the high tension spark plug leads, remove the spark plugs, and disconnect the leads at the battery terminals, before working on the lower unit.



1- Position a suitable container under the lower unit, and then remove the **FILL** screw and the **VENT** screw. Allow the gear lubricant to drain into the container. As the lubricant drains, catch some with your fingers from time-to-time, and rub it between your thumb and finger to determine if any metal particles are present. If metal is detected in the lubricant, the unit must be completely disassembled, inspected, and the damaged parts replaced. Check the color of the lubricant as it drains. A whitish or creamy color indicates the presence of water in the lubricant. Check the drain pan for signs of water separation from the lubricant. The presence of any water in the gear lubricant is bad news. The unit must be completely disassembled, inspected, the cause of the problem determined, and then corrected.

2- Models with Cam-Shift Type I and Type II: shift the lower unit into **FORWARD** gear. Models with E-Z shift: shift the lower unit into **NEUTRAL** gear.

Raise the lower unit upward until the tilt lever can be actuated, and then engage the tilt stop.



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SAFETY WORDS

As a safety measure to prevent accidental movement of the outboard while work is being performed, it is **STRONGLY** recommended a few minutes be used to make a safety support tool as shown in the accompanying illustration. The tool may be made from any metal bar stock or small channel iron of suitable size, with a 3/8" (9.53 mm) hole drilled through at each end and 14" (35.6 cm) apart, as shown. Cut-off the head of a 3/8" bolt about 2-1/2" (6.4 cm) long.

Drill a hole through each bolt for a cotter pin. Secure the bolts through the holes made in the bar stock with two nuts, one on each side of the bar. The tool is now ready for installation, one end through the clamp bracket and the other end through the tilt stop bracket. Secure each end of the tool in place with a washer and cotter pin. The lower unit may now be serviced or other work performed with confidence and in safety.

Propeller Removal

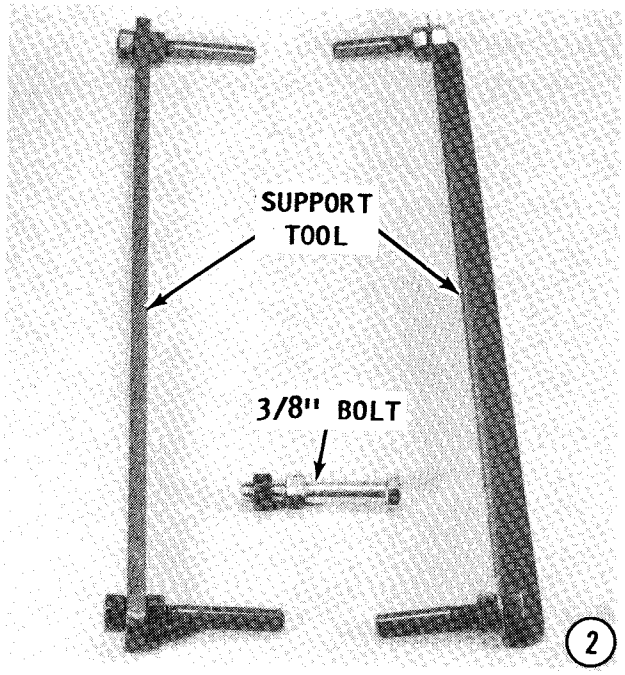
SAFETY WORDS — ALL MODELS

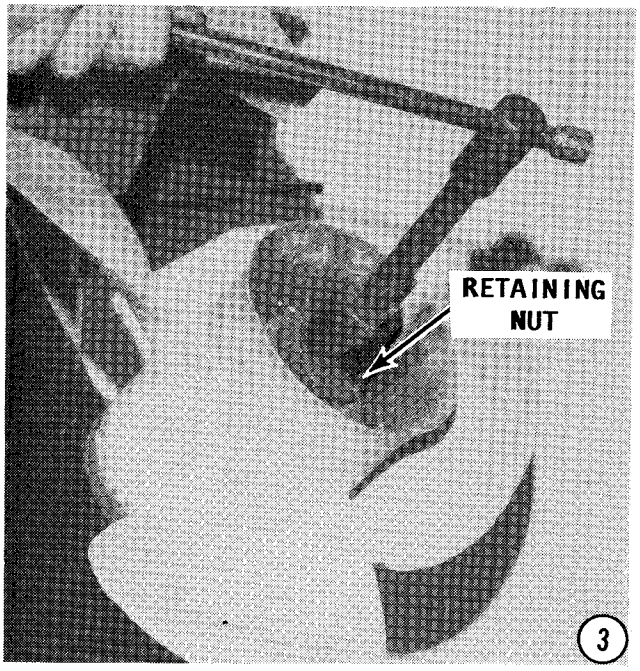
An outboard engine may start very easily. Therefore, anytime the propeller is to be removed or installed, check to be sure:

a- Key switch is in **OFF** position.

b- Spark plug wires are disconnected.

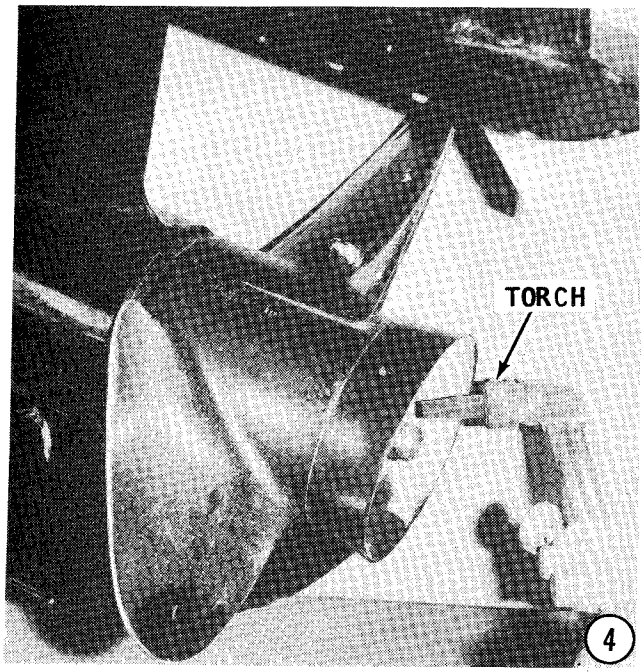
c- Electrical leads disconnected at the battery terminals.





3- Bend the locking tabs forward out of the locking washer. Some lower units have a locknut installed instead of a lockwasher. Never pry on the edge of the propeller. Any small distortion will affect propeller performance.

Remove the propeller nut by first placing a block of wood between one of the propeller blades and the anticavitation plate to prevent the propeller from turning, and then remove the nut. Remove the splined washer. Remove the outer thrust hub from the propeller shaft. If the thrust hub is stubborn and refuses to budge, use two



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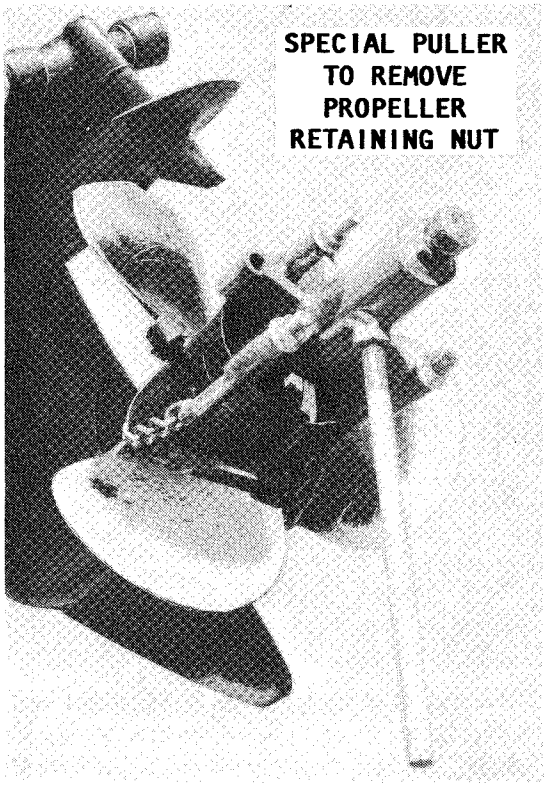
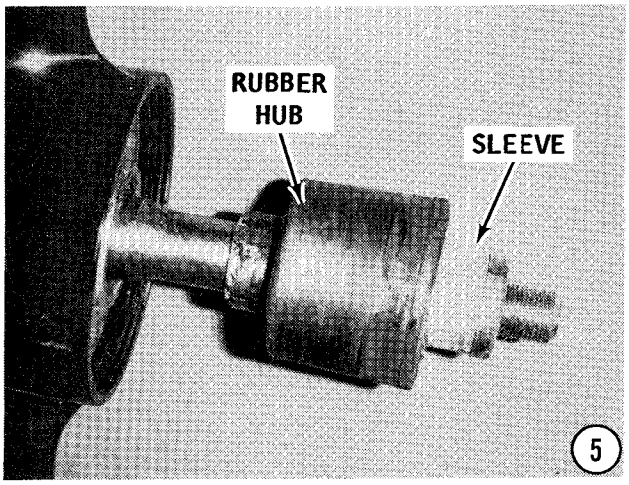


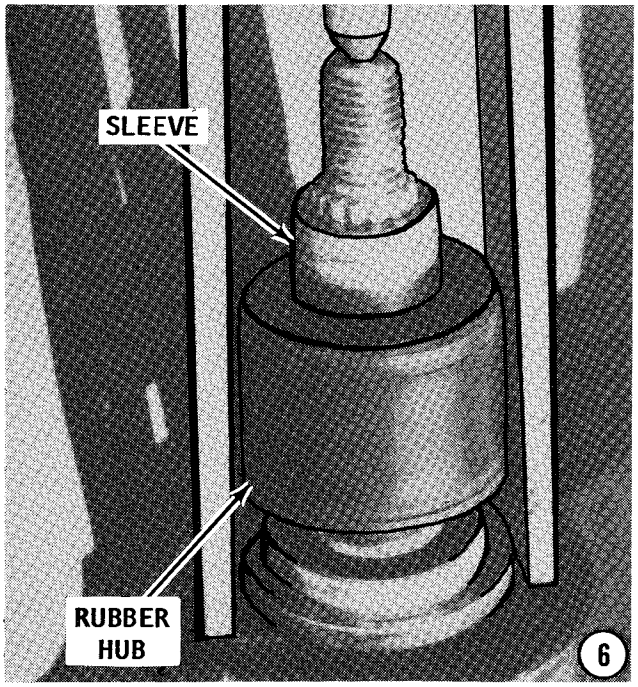
Special puller installed in preparation to removing the propeller retaining nut.

PADDED pry bars on opposite sides of the hub and work the hub loose. **TAKE CARE** not to damage the lower unit. Remove the propeller. If the propeller is "frozen" to the shaft, perform the following procedures to break it loose.

"Frozen" Propeller

4- If the propeller is frozen to the shaft, heat must be applied to the shaft to melt out the rubber inside the hub. Using heat will destroy the hub, but there is no other way. As heat is applied, the rubber will expand and the propeller will actually be blown from the shaft. Therefore, **STAND CLEAR** to avoid personal injury.



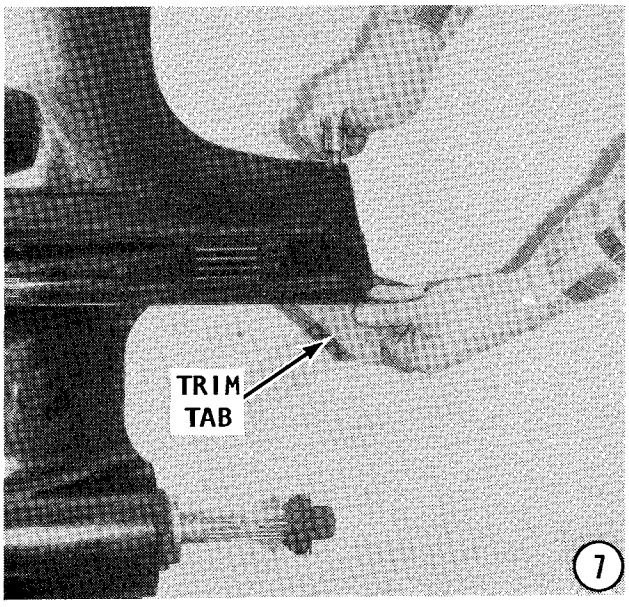


5- Use a knife and cut the hub free of the inner sleeve.

6- The sleeve can be removed by cutting it with a hacksaw, or it can be removed with a puller. Again, if the sleeve is frozen, it may be necessary to apply heat. Remove the thrust hub from the propeller shaft.

Procedures for propeller installation are given at the end of this chapter, after the lower unit has been installed.

Remove the inner thrust hub. If this hub is also stubborn, use padded pry bars and work the hub loose. Again, **TAKE CARE** not to damage the lower unit.



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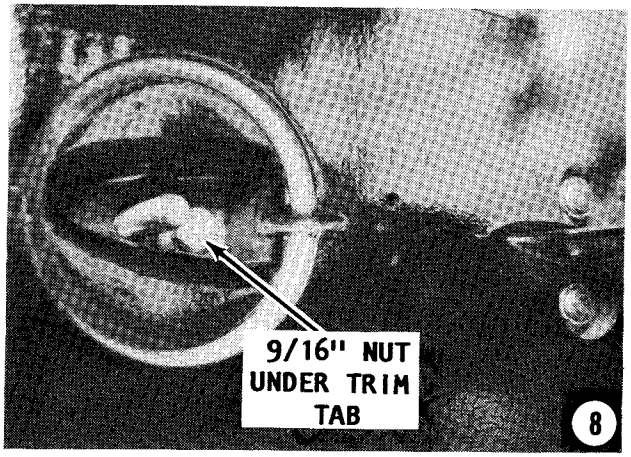
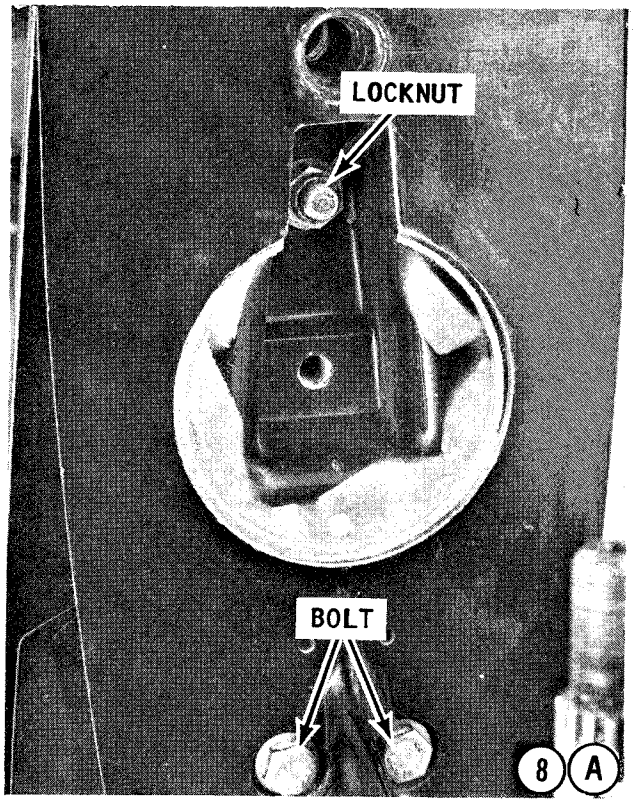
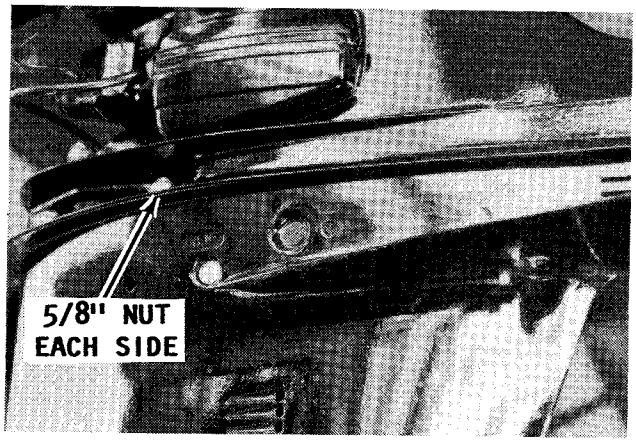


7- Models with Cam-Shift Type I and Type II: check to be sure the lower unit is in **FORWARD** gear. Models with E-Z shift: check to be sure the lower unit is in **NEUTRAL** gear. Scribe a trim tab reference mark on the anti-cavitation plate. This mark will ensure the trim tab will be installed back at the same angle. Remove the plastic cap from the rear edge of the exhaust housing. Insert the proper size wrench into the hole and remove the trim tab adjusting bolt, and then the trim tab.

8- Remove the 9/16" nut from the recess where the trim tab was mounted. Remove the 5/8" nut from the bottom middle of the anti-cavitation plate. Loosen the 5/8" nut located on each side of the exhaust





One nut on each side of the exhaust housing must be loosened, but not removed, until the lower unit is supported, as explained in the text.

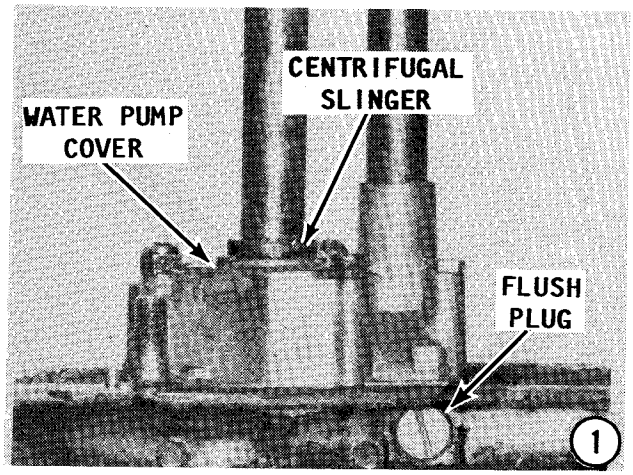
housing. **DO NOT** attempt to remove these two nuts at this time. Separate the lower unit from the exhaust housing as far as the nuts and studs will permit. Hold the lower unit from falling and at the same time remove the two nuts. Remove the lower unit from the intermediate housing.

11-4 WATER PUMP SERVICE

HIGH PRESSURE PUMP REMOVAL AND DISASSEMBLING

1- Remove the centrifugal slinger from the top of the water pump. Remove the three retaining nuts and washers securing the pump cover to the pump base. Some model units may have three nuts and one bolt. Use two pry bars, one on each side, and pry the pump cover off the studs. If the cover is "frozen" to the pump, it may be necessary to use a chisel to break the cover loose from the studs.

The seal is very difficult to remove. If the seal or insert is unfit for further ser-



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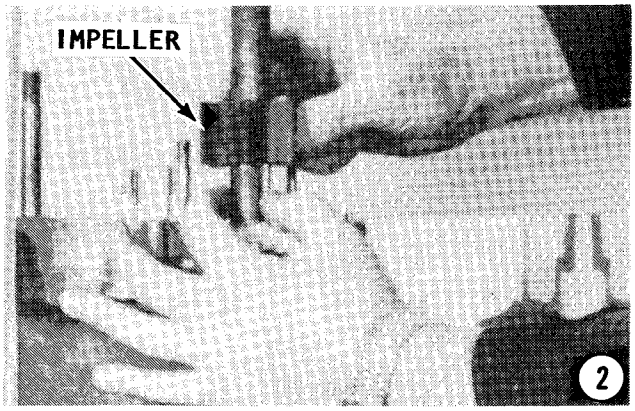
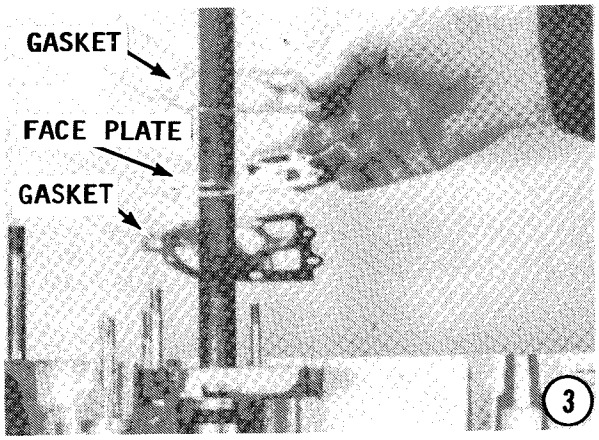


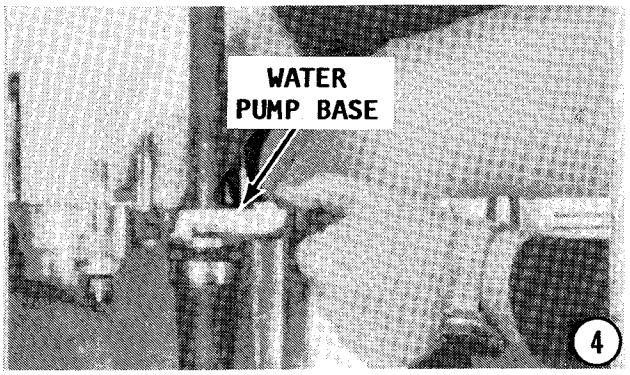
vice, the recommendation is to replace the pump cover. A kit is available from the local dealer and will include a new seal -- installed, and a new insert. The new insert will slip right into place. If the cover kit is not available, proceed to remove the seal and insert as follows: Use a punch and hammer and drive the pump insert out of the pump cover. Drive the pump cover seal out of the cover from the insert side.

2- Remove the impeller from the driveshaft. If the impeller is stubborn, it may be necessary to use a punch and hammer to drive the impeller upward and off the driveshaft. If a punch and hammer will not move the impeller, the only answer is to use a chisel and split the impeller. A new impeller should **ALWAYS** be installed when the lower unit is opened. Remove and **SAVE** the impeller drive pin from the flat area of the driveshaft.

3- Lift upward on the face plate and remove it and the gasket from the mounting studs. Clean any gasket material from the face plate and from the pump base.

4- Remove the water pump base by first removing the flushing screw, seal, and gasket. This flushing screw has not been used for many years. If the word "Flush" is





embossed on the side of the gear case, then the unit has the flushing screw. Late model lower units have a threaded hole provided in the water pump base. However, If such a hole is present, install a 10-24 screw into the hole and continue to turn the screw until the pump base is lifted from the mating surface of the lower unit. Remove the **O**-ring and oil seal from the base plate as sembly.

Watch for and **SAVE** any shim material installed under the base assembly. Cam-Shift Type I units with old style driveshaft **WITHOUT** the preload pin will have this shim material under the water pump base assembly. All other units will **NOT** have shim material under the water pump base assembly. They will have shim material under the driveshaft tapered roller bearing race.

Cam-Shift Type I units **WITHOUT** the preload pin will have shim material in **BOTH** places. Detailed procedures using a micrometer or a feeler gauge to properly shim the water pump for this model lower unit are presented in Section 11-8, Water Pump Installation and apply only to Cam-Shift Type I units **WITHOUT** the preload pin.

If the oil seals are unfit for further service, the manufacturer recommends the pump base be replaced. The base is available in kit form and will include new seals. If the kit is not available, proceed to remove the seals as follows: remove the oil seals from the pump base by prying or driving them away from the impeller side of the pump base. Remove the **O**-ring from the groove in the pump base. Clean any gasket material from the upper and lower surfaces of the pump base.

HIGH VOLUME PUMP REMOVAL AND DISASSEMBLING

1- Slide the sealing ring from the top of the water pump. Remove the four bolts,

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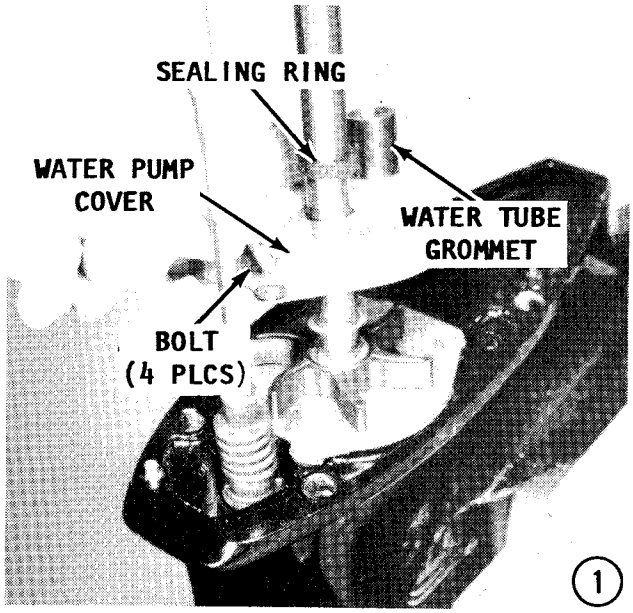

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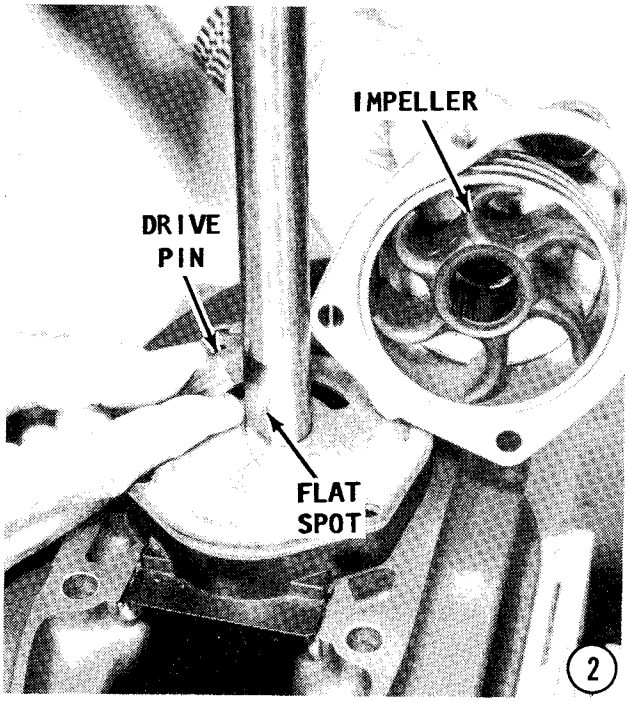
washers, and isolators securing the pump cover to the pump base. If necessary, use two screwdrivers, one on each side, and pry the pump up and free of the outer plate. Remove and discard the gasket. The water tube grommet, if still in servicable condition may remain in place on the water pump cover. The impeller may remain on the driveshaft or may stick in the pump cover.

2- If the impeller remained on the driveshaft, slide the impeller up and free of the driveshaft. If the impeller is stubborn, it may be necessary to use a punch and hammer to drive the impeller upward and off the driveshaft. If a punch and hammer



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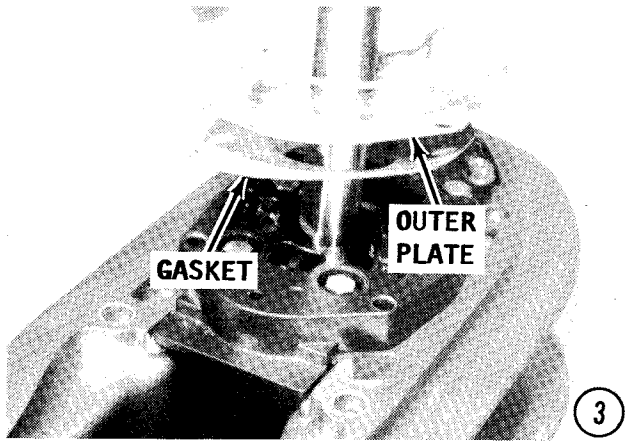

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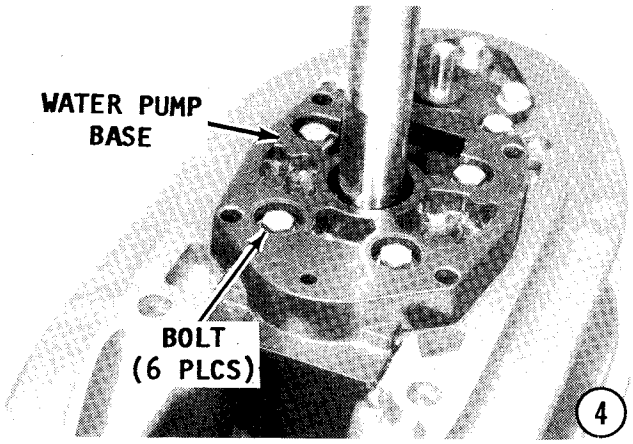
will not move the impeller, the only answer is to use a chisel and split the impeller. A new impeller should **ALWAYS** be installed when the lower unit is opened. Remove and **SAVE** the impeller drive pin from the flat area of the driveshaft.

3- Lift the outer plate and gasket up and free of the pump base. Clean all old gasket material from the plate and the pump base.

4- Remove the six bolts and washers securing the water pump base to the lower unit.



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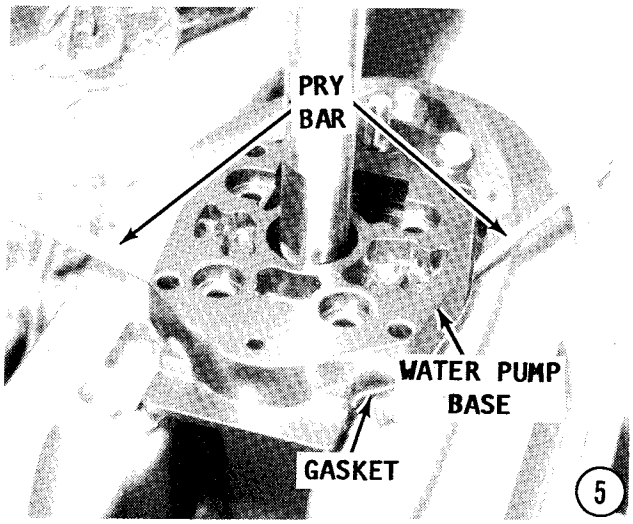

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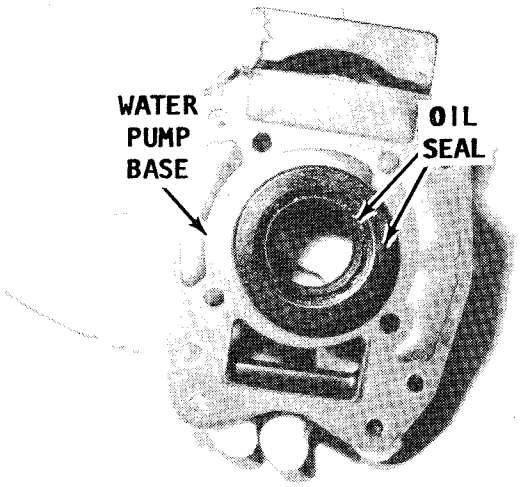

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5- Use two screwdrivers and pry the water pump base from the lower unit. Remove and discard the gasket under the base.

6- Inspect the condition of the two oil seals housed in the water pump base. Check the oil seals for correct installation. On this type water pump, the seals **MUST** be installed back to back. If either seal is no longer fit for service, pry both seals out with a screwdriver, one at a time.

VERY SPECIAL GOOD WORDS

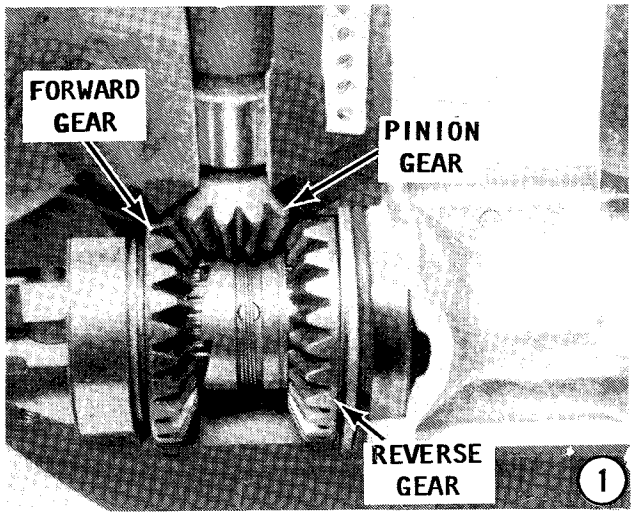
If the only work to be performed on the lower unit is servicing the water pump, proceed directly to Section 11-8, Water Pump Installation, beginning on Page 11-81.

If further work is be done, and the unit has the Cam-Shift Type I, continue with the next section, 11-5. Procedures for servicing Cam-Shift II are outlined in Section 11-6, beginning on Page 11-35.

If further work is be done, and the unit has the E-Z shift, proceed directly to Section 11-7, beginning on Page 11-53.

11-5 SERVICING CAM-SHIFT TYPE I UNITS EARLY 3-, 4- CYLINDER, L6 AND V6 TO ABOUT 1979

1- The reverse gear-to-pinion gear backlash and the forward gear-to-pinion gear backlash should be checked **PRIOR** to disassembly. The reverse gear backlash can be checked only at a point of propeller shaft rotation where it is not possible to shift from neutral gear into reverse, as outlined in the following procedure.



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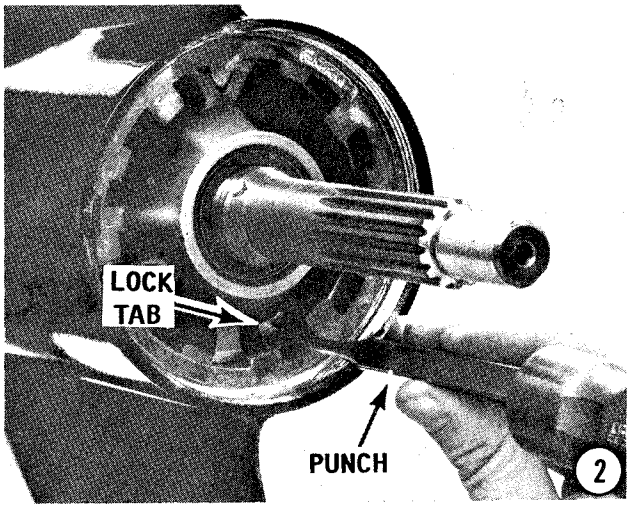
FIRST, observe the upper end of the driveshaft and determine if there is a pre-load pin installed in the center of the shaft. Presence of the pin is most important.

Three hands are necessary for the backlash check, therefore, obtain the help of an assistant.

Slowly rotate the propeller shaft and at the same time attempt to shift into the reverse gear position. Once this position is reached:

- **a-** Push down on the driveshaft, if the driveshaft has a pre-load pin. Pull up on the driveshaft if no pre-load pin.
- **b-** Pull outward on the propeller shaft.
- **c-** Hold pressure on the lower shift shaft toward reverse.
- **d-** Lightly rotate the propeller shaft clockwise and counterclockwise.

The amount of free play felt is the reverse gear-to-pinion gear backlash. For the correct amount of backlash allowable on the unit being serviced, check the Specifica-



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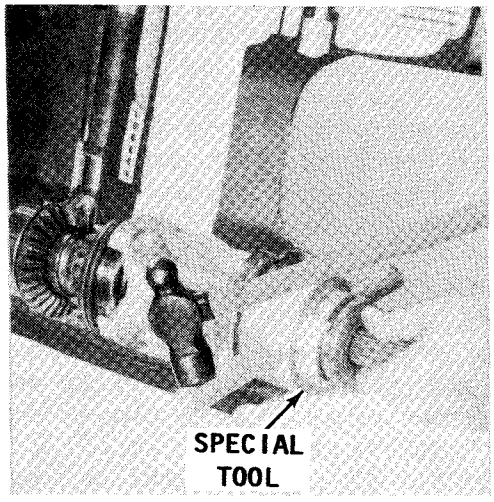

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tions in the Appendix. Record the amount of backlash felt because it may affect shimming of the reverse gear during assembly.

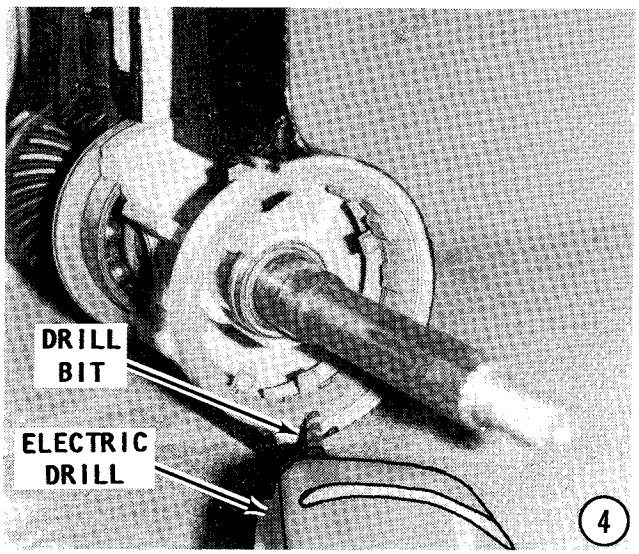
Repeat Step 1 to check the backlash of the forward gear, except push in on the propeller shaft.

Bearing Carrier and Propeller Shaft Removal

2- Bend the lock tab away from the cover nut recess with a punch. Some models may not have the lock tab.

3- Place the smaller diameter end of Gear Housing Cover Tool C-91-53126 into the cover nut. Slide the thrust hub over the end of the propeller shaft and down into the cover tool. The thrust hub will tend to keep the cover tool square against the cover nut. Strike the handle of the cover tool sharp blows with a mallet to turn the cover nut **COUNTERCLOCKWISE.**

As the cover nut loosens, continue to remove it with the cover nut tool. If the cover nut refuses to budge, it may be necessary to carefully apply heat to the lower unit around the outside of the nut.



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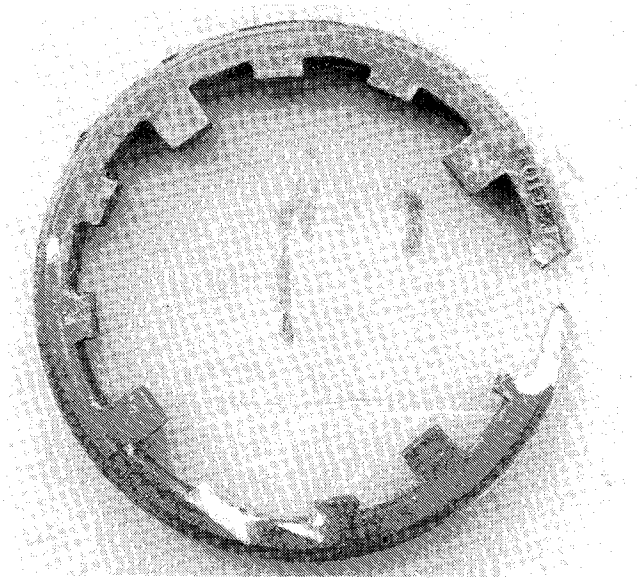


"Frozen" bearing carrier nut after being sacrificed and drilled out, thus saving more expensive parts.

4- If the nut still refuses to loosen, a last resort is to drill the nut, as shown.

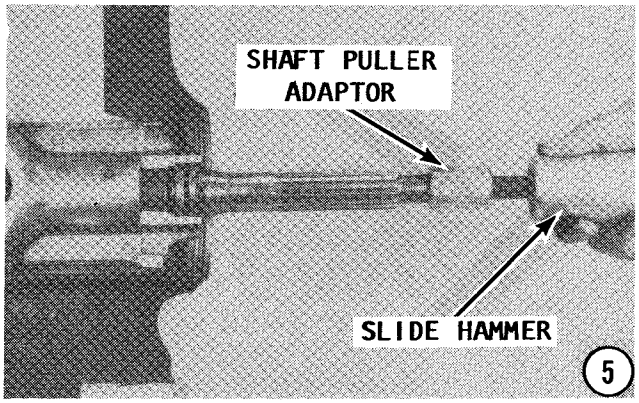
NOW, THESE WORDS

Three methods are available to remove the bearing carrier from a Cam-Shift Type I lower unit. The first and safest method is to use a simple adaptor with a slide hammer. This procedure is explained in Step 5.

The second method involves the use of a slide hammer and long puller jaws to remove the carrier from the lower unit and is explained in Step 5A.

The third and least desireable method is to use a mallet to actually drive the lower unit off the carrier. The procedures involved in this method are outlined in Step 5B.

In all three methods, heat **CAREFULLY** applied to the outside of the lower unit, will assist in removing the bearing carrier.



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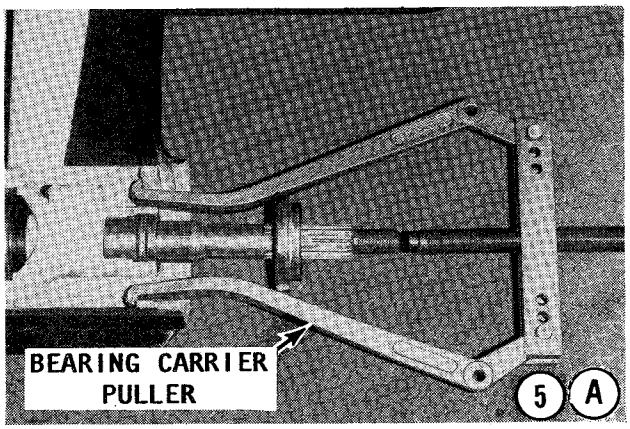
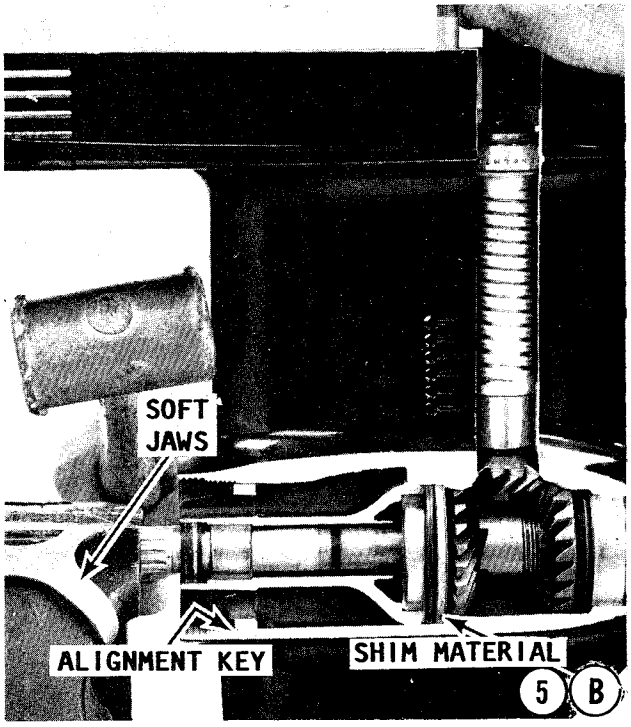


5- The first method of removing the bearing carrier is to use a shaft puller adaptor and a slide hammer, as shown in the accompanying illustration. Thread the adaptor onto the propeller shaft as far as possible. Next thread the slide hammer into the adapter and the shaft, clutch dog, reverse gear, and bearing carrier are ready to be removed as a unit. Operate the slide hammer to pull the parts mentioned.

5A- As explained, this step is an alternate method of removing the bearing carrier from the lower unit. Obtain Slide Hammer C-91-34569A1 with long Puller Jaws C-91-46086A1. Use the propeller thrust hub to maintain an outward pressure on the puller jaws. Save the bearing carrier alignment key. Remove the propeller shaft from the lower unit. Set the unit aside for disassembly later.

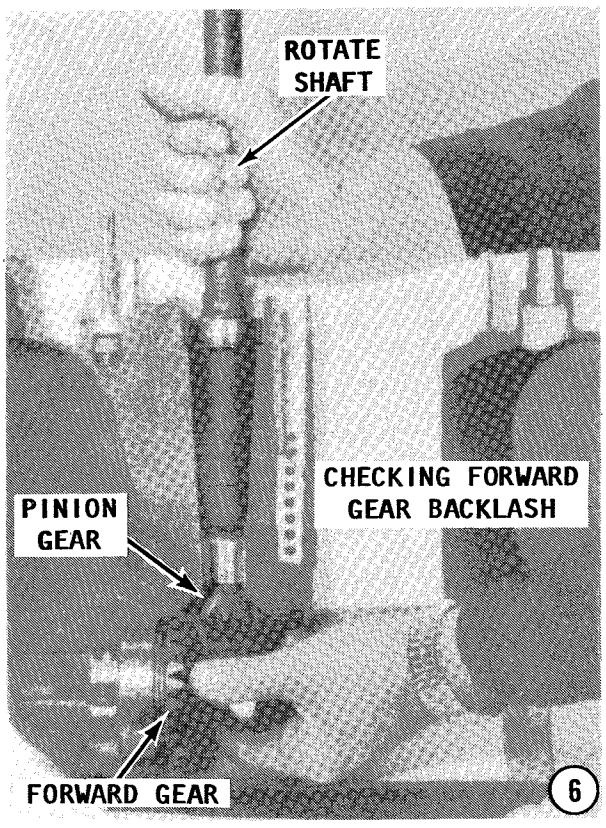


5B- The third and least desirable method is as follows: Clamp the propeller shaft in a vise equipped with soft jaws in a horizontal position. Use a mallet and strike the lower unit with quick sharp blows midway between the anti-cavitation plate and the propeller shaft. This action will drive the lower unit off the bearing carrier. **TAKE CARE** not to drop the lower unit or loose the alignment key when the unit finally comes free of the carrier. Now, if the lower unit refuses to move, it may be necessary to carefully apply heat to the lower unit in the area of the carrier and at the same time attempt to move it off the carrrier.

Remove the propeller shaft and bearing carrier from the vise. Slide the propeller shaft out of the bearing carrier from the rear to the front. Set the assembly aside for disassembly later.

Driveshaft and Bearing Removal

6- Clamp the lower unit in a vise equipped with soft jaws in the upright position. Again, check and record the forward gear backlash. **BEFORE** disassembling the unit check the forward gear to pinion gear backlash. This is accomplished by pushing down on the driveshaft with one hand and at the same time rocking the forward gear back-



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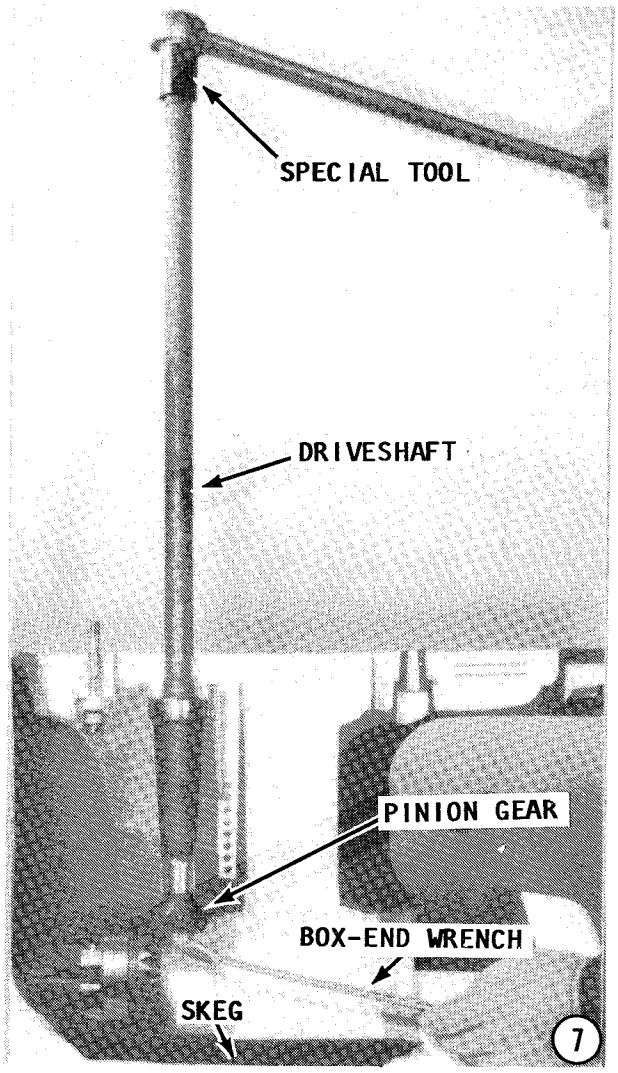
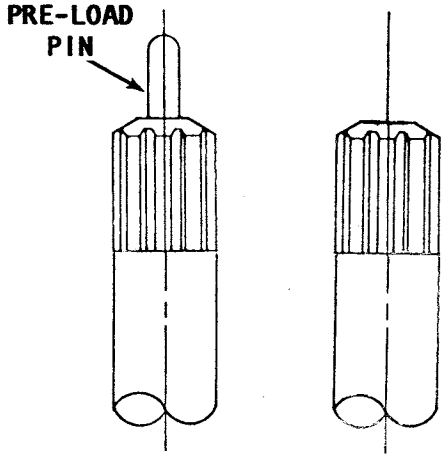
and-forth with the other hand. The amount of movement felt is the backlash. Check the Specifications in the Appendix for the unit being serviced.

7- Clamp the skeg in a vice equipped with soft jaws or between two pieces soft wood. Obtain special tool C-91-34377A1. Use a box end wrench through the bearing carrier cavity on the pinion gear nut and the special tool on the end of the driveshaft with a breaker bar. Now, hold the pinion nut with the box end wrench, as shown and turn the driveshaft counterclockwise until the nut is released from the driveshaft.

STOP AND OBSERVE

Look down into the lower unit and observe the type of upper driveshaft bearing installed. Two types of bearings are used in Cam-Shift Type I lower units covered in this section. One type uses a regular "one piece" ball bearing and race arrangement. This type of bearing cannot be disassembled. If this type bearing is used, perform Step 8 and then skip to Step 11.



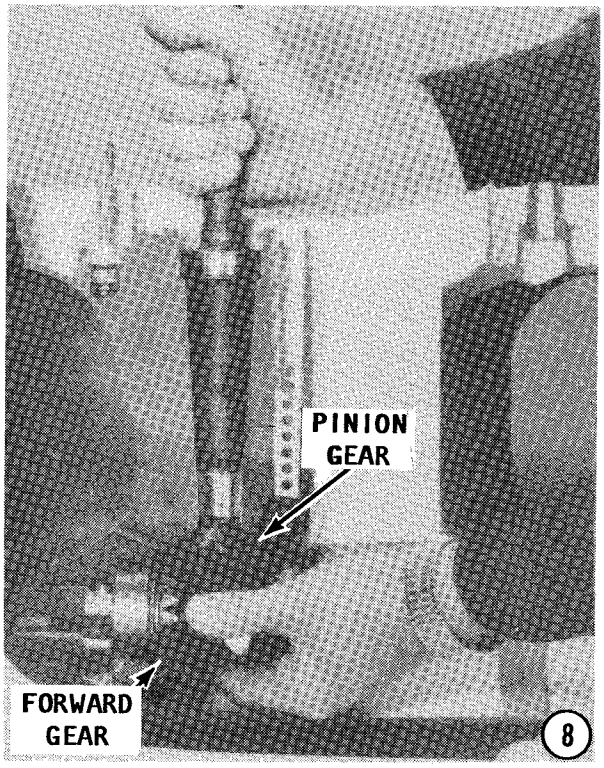


Upper end of the driveshaft with a pre-load pin (left), and without the pin (right).

The other type of upper driveshaft bearing is a "two piece" tapered roller design. Both the bearing and the race **MUST** be replaced as a set. If this type of bearing is installed, perform Steps 8 and all subsequent steps.

Units WITH Driveshaft Preload Pin

The driveshaft has a preload pin in the upper end. On this unit, push **DOWN** on the driveshaft with one hand and at the same time rock the forward gear back-and-forth with the other hand. The amount of move-



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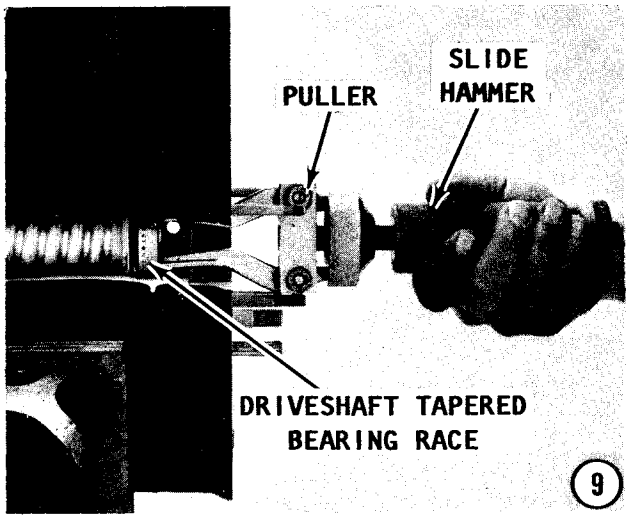
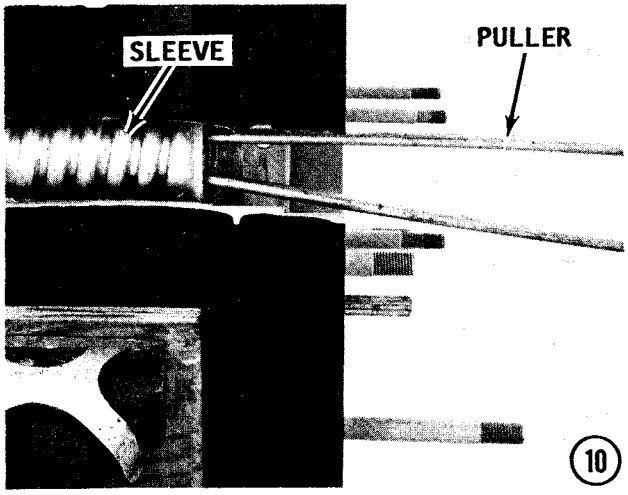


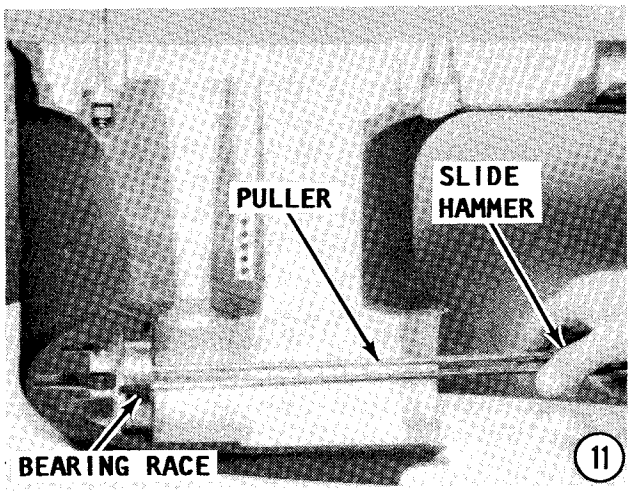
ment felt is the backlash. Check the Specifications in the Appendix for the unit being serviced.

Units WITHOUT Driveshaft Preload Pin

The lower units matched with these powerheads do not have the preload pin at the upper end. On these units, pull **UP** on the driveshaft with one hand and at the same time rock the forward gear back-and-forth with the other hand. The amount of movement felt is the backlash. Check the Specifications in the Appendix for the unit being serviced.

8- Use a block of wood to protect the lower unit and drive the unit off the driveshaft. **TAKE CARE** to prevent the lower unit from falling when it finally comes free of the driveshaft. Reach in and remove the shim material that was used under the bearing. Save the shim material because the same amount will probably be used during assembling. Remove the driveshaft from the vise. Remove the pinion gear from the lower unit.



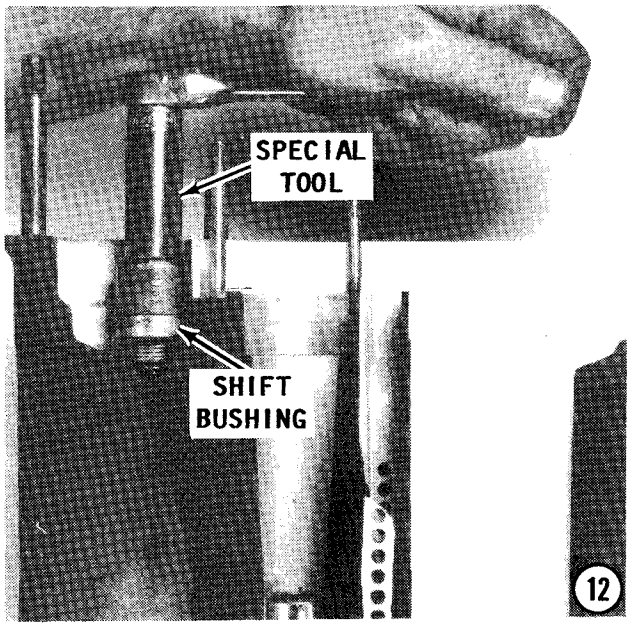


9- Clamp the lower unit in a vise equipped with soft jaws. Use a slide hammer and remove the driveshaft tappered bearing race. Save the shims from under the tapered bearing race. The same amount of shim material will probably be used during assembly.

10- Obtain Water Pump Cartridge Puller C-91-27780. Use the puller to remove the lubrication sleeve from the lower unit. Some units may not have this sleeve installed. Set the driveshaft aside for disassembly later.

Forward Gear and Bearing Removal

11- After the pinion gear is removed, the forward gear and bearing can be lifted out of the lower unit. The tapered bearing race will remain within the lower unit. Re-



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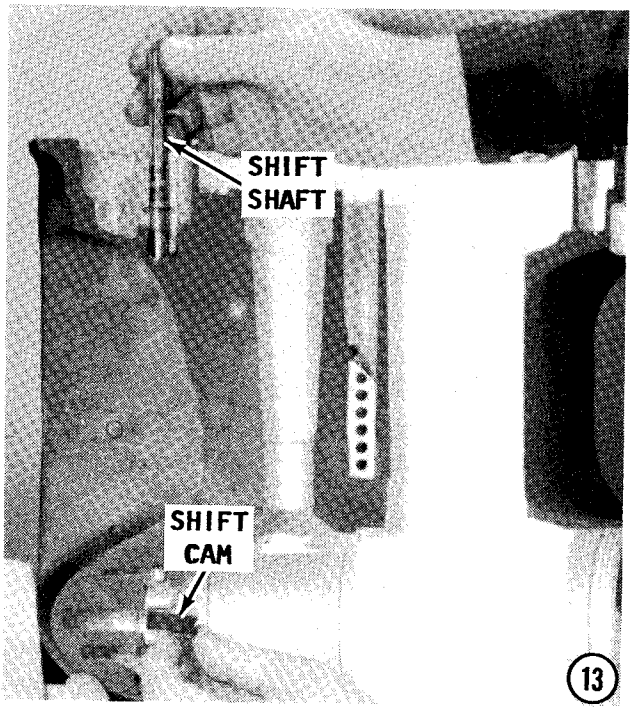
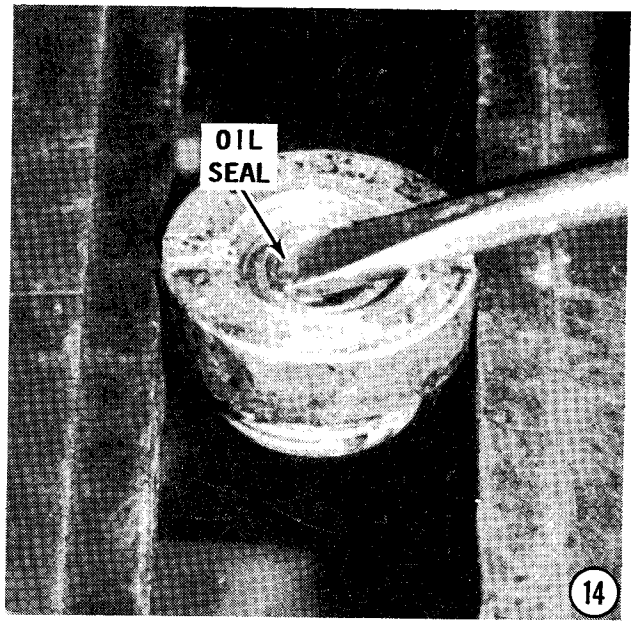


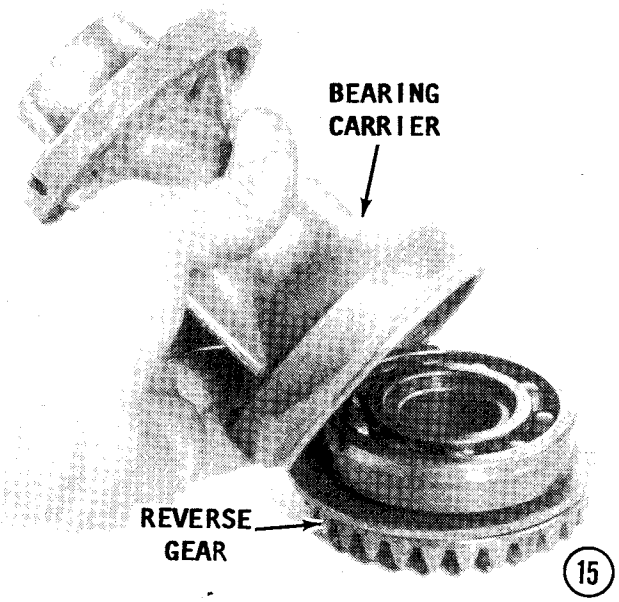
move the forward bearing race and shim material using a slide hammer.

12- Clamp the lower unit in the upright position in a vise equipped with soft jaws. Obtain Shift Shaft Bushing Tool C-91-23033. Slide the tool over the shift shaft and engage the tangs on the tool with the slots in the bushing. Turn the tool **COUNTER-CLOCKWISE** and remove the bushing.

13- Lift the shift shaft out of the lower unit. The shift cam is now free to be removed.

14- Remove the **O**-ring from the shift shaft bushing. The oil seals can be removed



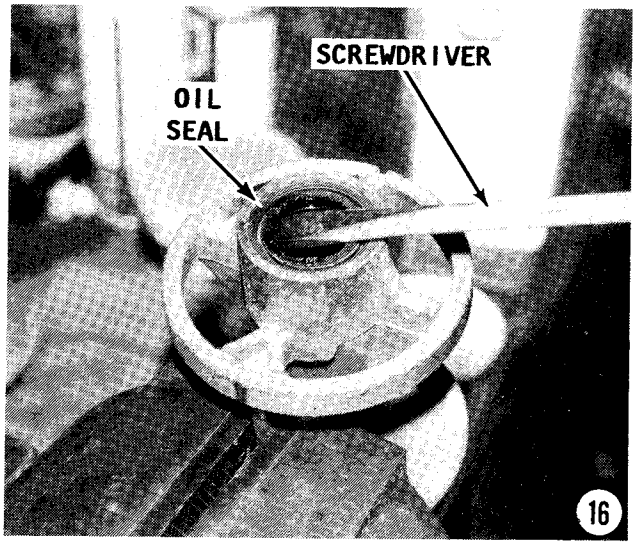


by driving them out with a punch from the lower unit side of the shift shaft bushing. This bushing is sold as an assembly with the seals installed. Set the assembly aside for disassembly later.

Bearing Carrier Disassembling

15- Clamp the bearing carrier in a vise equipped with soft jaws. Remove and **DISCARD** the **O**-ring from between the bearing carrier and the thrust washer. Use a slide hammer and remove the reverse gear. If the reverse gear ball bearing remained in the bearing carrier, remove the bearing using a slide hammer.

16- Remove the seal by prying or driving it toward the rear. On some late model units, two seals are used. Set the assembly aside ready for cleaning and inspecting.



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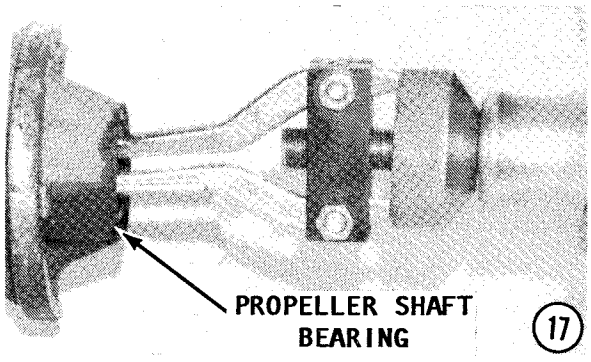
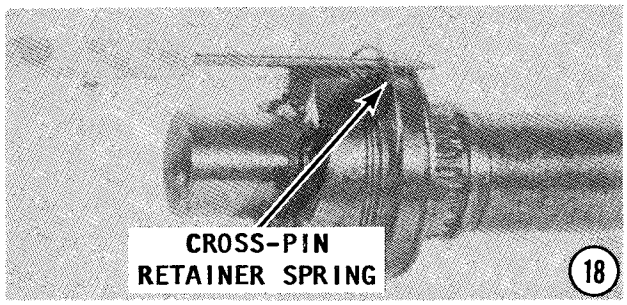
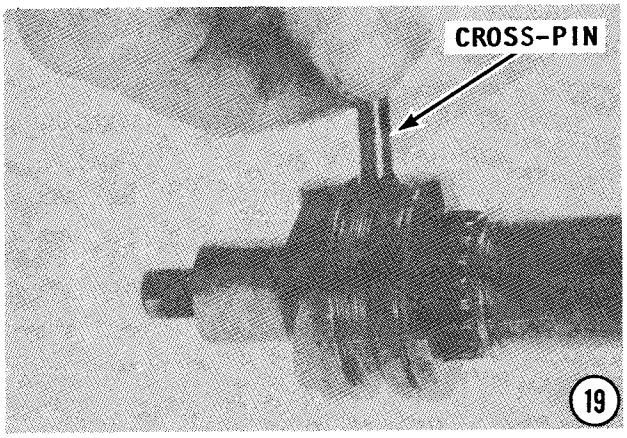


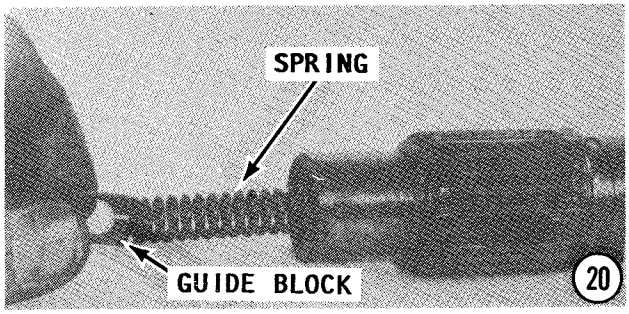


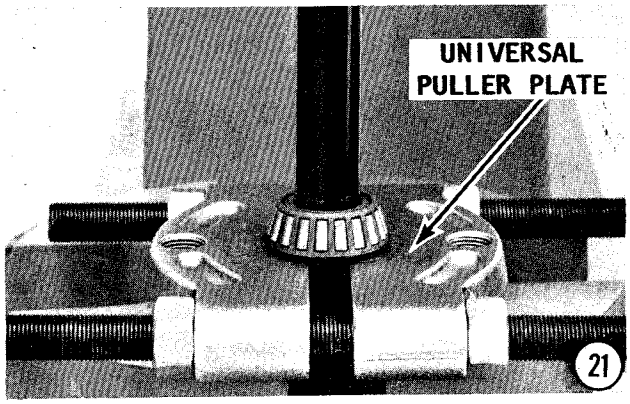
17- **DO NOT** remove the propeller shaft bearing unless it is unfit for further service. Condition of the bearing may be determined by inspecting the roller bearing surface of the propeller shaft. To remove the bearing, use a slide hammer and puller jaws.

Propeller Shaft Disassembling

18- Position the propeller shaft cam follower against a solid object. Insert a thin blade screwdriver or an awl under the first coil of the cross-pin retainer spring and rotate the propeller shaft to unwind the spring from the sliding clutch. **TAKE CARE** not to overstretch the spring.







19- Push against the cam follower and at the same time push the cross-pin out of the sliding clutch with a punch.

20- Release the pressure on the cam follower and slide the clutch forward off the propeller shaft. Now, tip the propeller shaft and allow the cam follower, guide block, and spring to slide out of the propeller shaft. Set the unit aside for cleaning and inspecting.

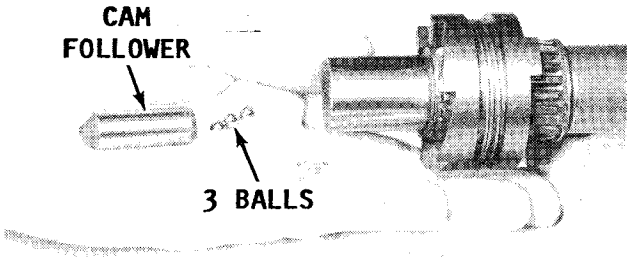
SPECIAL WORDS

Some newer lower units will have three small ball bearings behind the cam follower, as in the Cam-Shift Type II. **HOWEVER,** the remainder of the lower unit components and the water pump will be the same as other Cam-Shift Type I.

Driveshaft Disassembling

FIRST, THESE WORDS

As mentioned earlier after Step 7, two types of bearings are used on the driveshaft of the lower units covered in **THIS** section. One is a tapered bearing. Removal of this type bearing is covered in Step 21. The



The only difference in some late model lower units is in the actual shifting mechanism, making it a Cam-Shift Type II. The remainder of the lower unit is identical with the Cam-Shift Type I.

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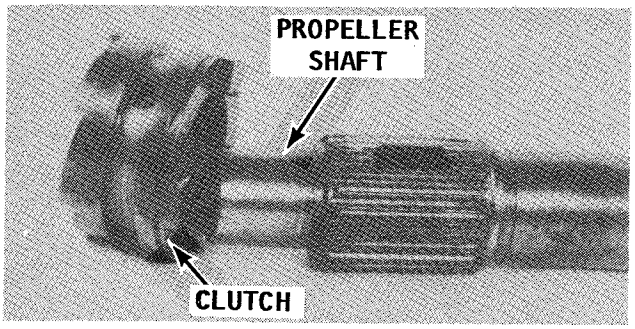


The clutch "dog" and matching splines on the propeller shaft should be closely inspected.

other type is a ball bearing and is covered in Step 22. **DO NOT** remove either type bearing unless the bearing is no longer fit for further service. If the bearing requires replacement, the bearing race **MUST** also be replaced.

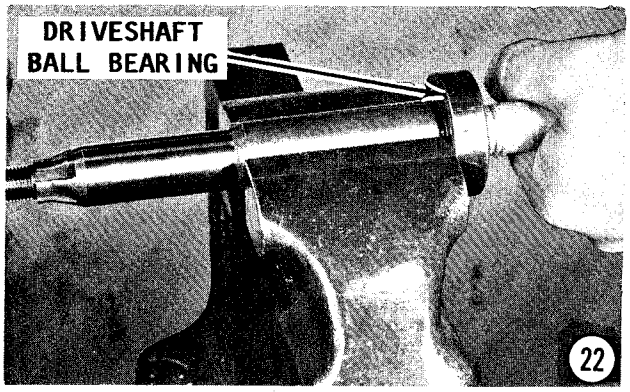
21- Position the driveshaft and Universal Puller Plate C-91-37241 on a press, as shown. Press the driveshaft out of the bearing.

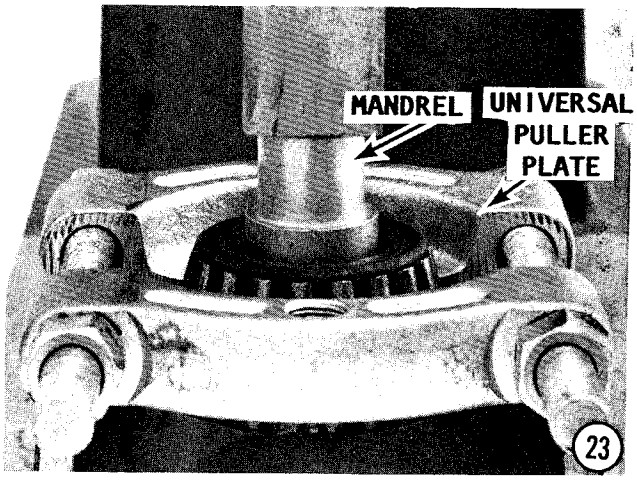
22- Remove the driveshaft ball bearing retainer snap ring. Position the driveshaft in a partially opened vise with the ball bearing above the jaws. **DO NOT** tighten the vise on the shaft. Now, use a mallet and drive the shaft out of the bearing.

Separating Forward Gear From Bearing

The forward gear does **NOT** have to be removed in order to perform an adequate job of cleaning and inspecting. Therefore, it is not necessary to remove the gear unless it is unfit for further service.

23- Position Universal Puller Plate C-91-37241 between the forward gear and the tapered bearing. Place the puller plate and gear on a press with the gear on the bottom. Press the gear out of the bearing with a suitable mandrel. If the bearing cannot be removed, clamp the forward gear in a vise equipped with soft jaws. Use a punch and





hammer to drive the roller bearing out of the forward gear.

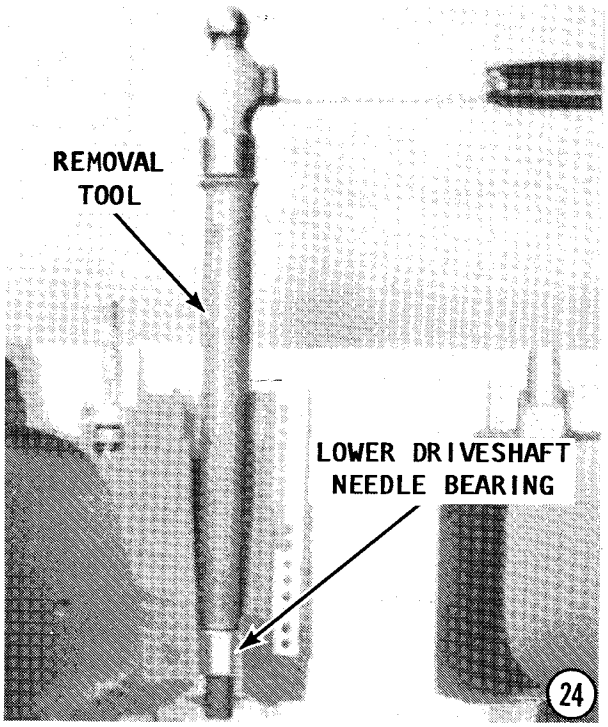
BAD NEWS

Once the bearing has been removed it **CANNOT** be used a second time because the roller cage will be damaged during the removal operation.

24- Use a round piece of raw stock, a wooden dowel will do the job, and drive the lower driveshaft needle bearing out of the housing, as shown.

CLEANING AND INSPECTING

See Section 11-9, beginning on Page 11-86 for detailed comprehensive procedures to clean and inspect the complete lower unit.



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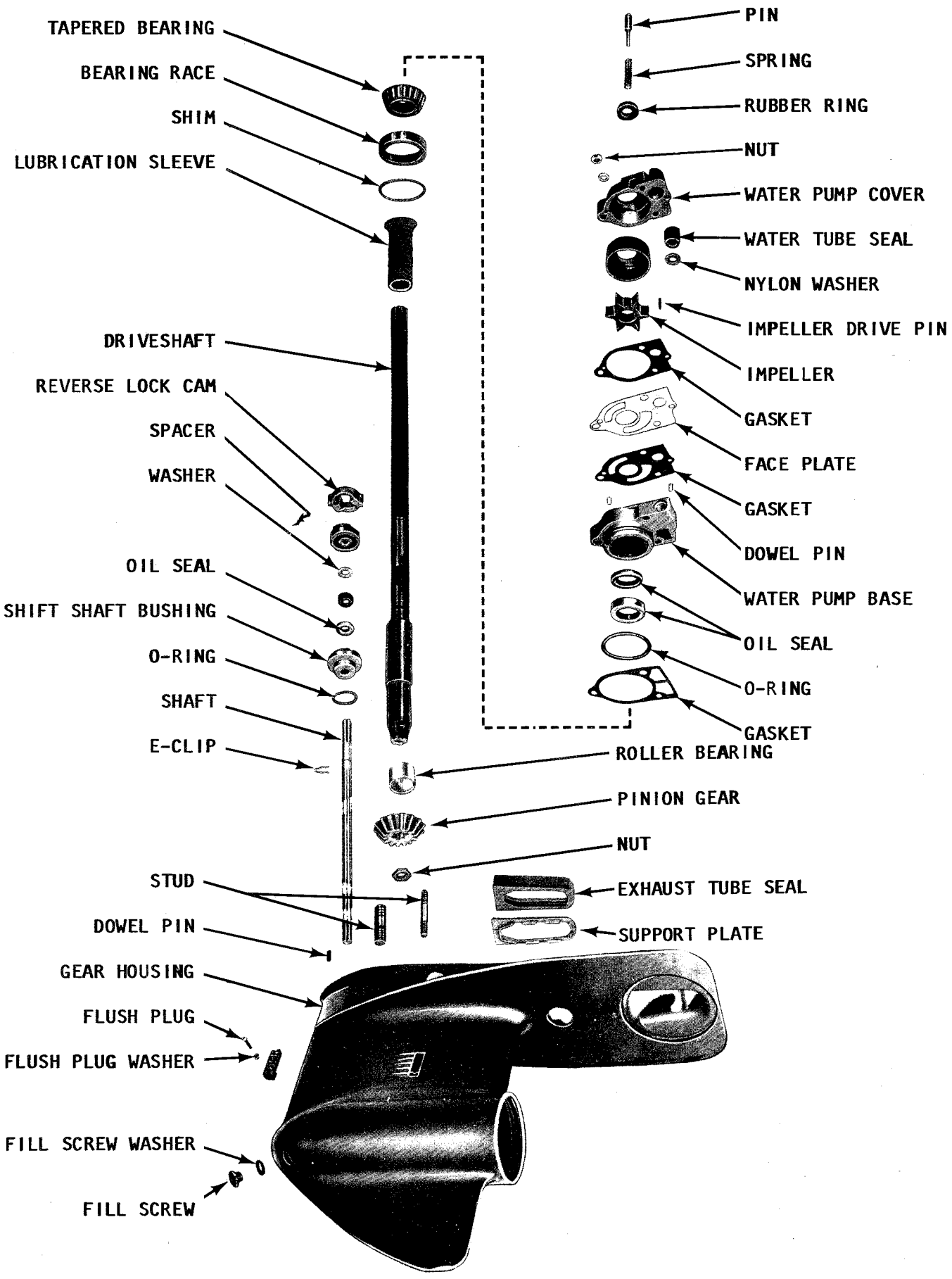

Exploded drawing of a typical old style Cam-Shift Type I driveshaft ***WITHOUT*** *the preload pin at the upper end and with a set of tapered roller bearings at the lower end. Major driveshaft and water pump parts are identified.*

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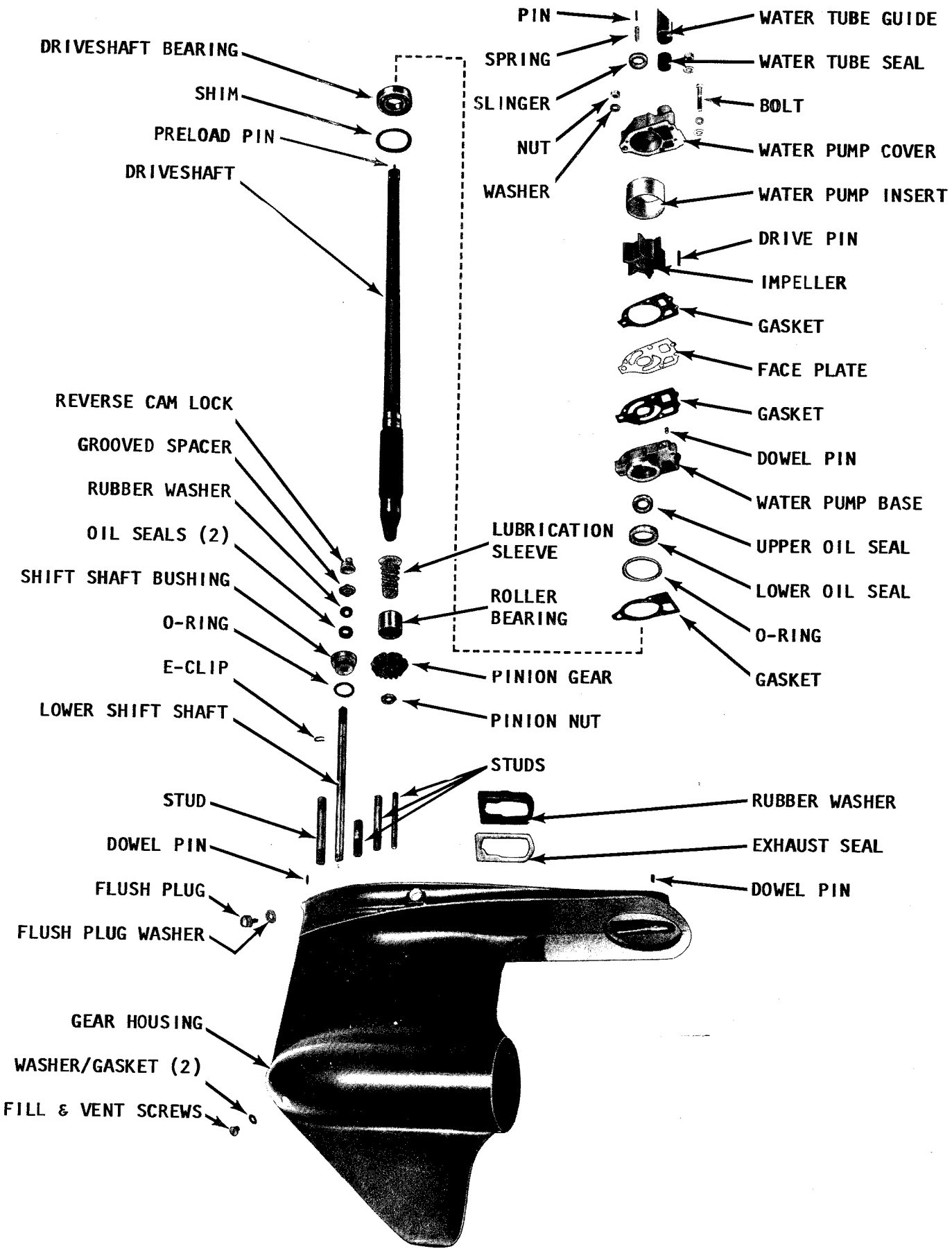

*Exploded drawing of a typical old style Cam-Shift Type I driveshaft **WITH** the preload pin at the upper end a set of roller bearings at the lower end. Major driveshaft and water pump parts are identified.*

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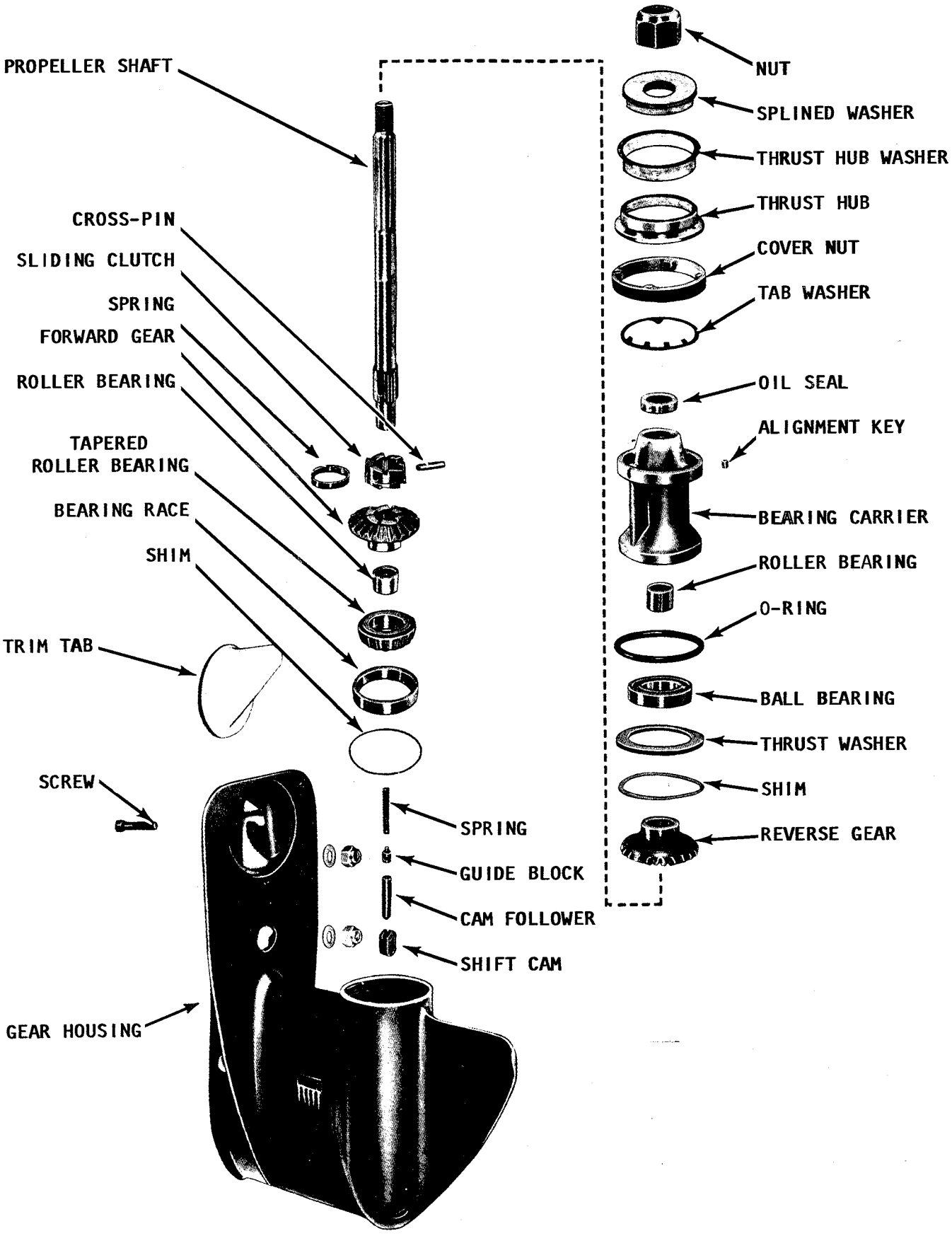

Exploded drawing of a typical Cam-Shift Type I propeller shaft covered in this section. Major parts are identified.

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ASSEMBLING

Lower Driveshaft Bearing

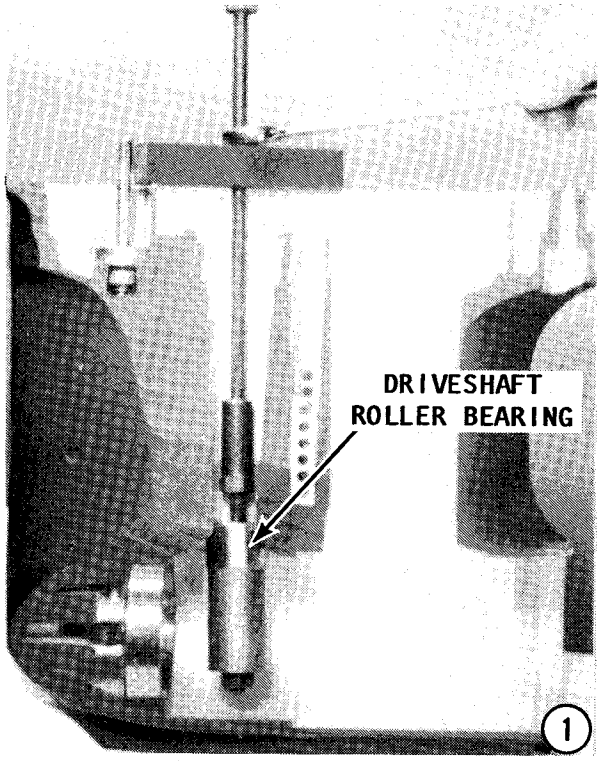
If a new lower unit is being installed, the driveshaft roller bearing will already be in place.

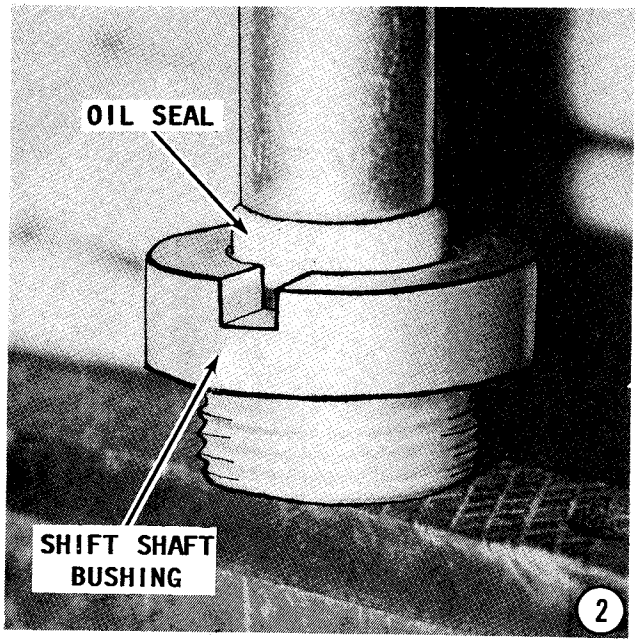
1- Obtain Bearing Removal and Installation Kit C-91-312291. Place the drive shaft roller bearing over the driver head of the installation kit with the numbered side of the bearing **TOWARD** the shoulder of the driver head. Thread the driver rod from the kit into the drive head. Coat the needle bearing area of the driveshaft cavity with Formula 50 oil. Position the rod, driver head and bearing into the lower unit driveshaft cavity. Place a pilot washer from the kit over the driver rod and slide it down into the driveshaft bearing cavity. Use a mallet to drive the roller bearing downward until it is approximately 1/16" (1.6mm) above the bottom end of the driveshaft cavity. Remove the driver rod, head, and pilot washer.

Shift Shaft Assembling

FIRST, THESE WORDS

A new shift shaft bushing is sold as an assembly and will have the oil seals installed.



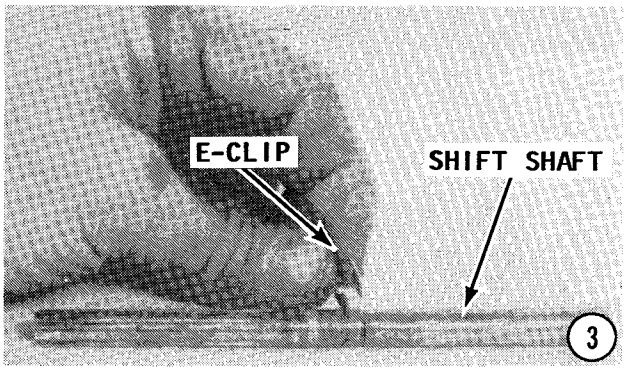


2- Place the shift shaft bushing on a press with the threaded side **DOWN.** Coat the metal surface of both oil seals with Loctite Type "A". Place the smaller diameter oil seal into the shift shaft bushing with the lip of the seal **TOWARD** the outside, the top. Press the seal into place using a suitable size mandrel. Place the larger oil seal into the top of the shift shaft bushing with the lip of the seal **TOWARD** the outside, the top. Press the seal into place using a suitable mandrel. Clean any excess Loctite from the seals and bushing. Install a **NEW O**-ring over the threads and against the shoulder of the bushing. Now, lubricate the seals and the **O**-ring with Multipurpose Lubricant, or equivalent.

3- Snap the **E**-clip into the groove in the shift shaft. The clip must be seated properly to prevent the shift rod from rising out of the shift cam in the lower unit.

Shift Shaft Installation

4- Place the cam into the forward portion of the lower unit between the cast



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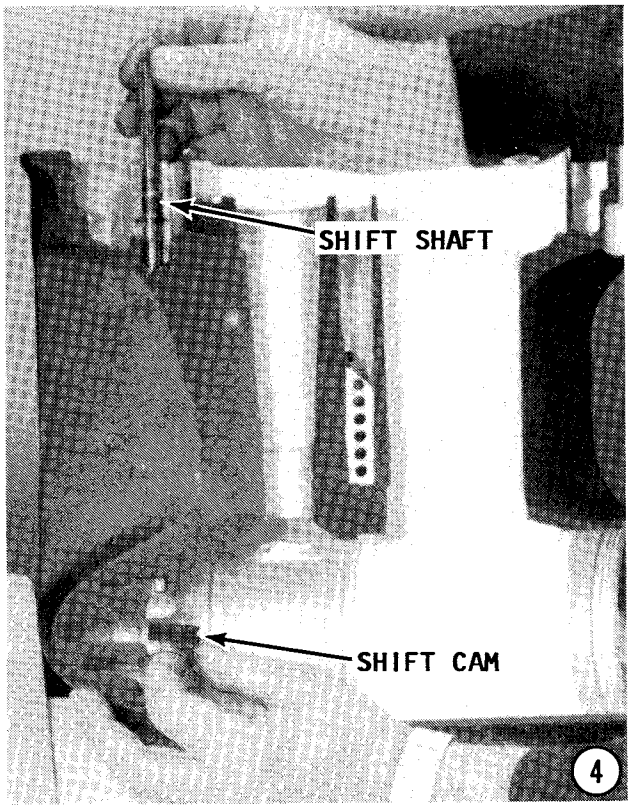
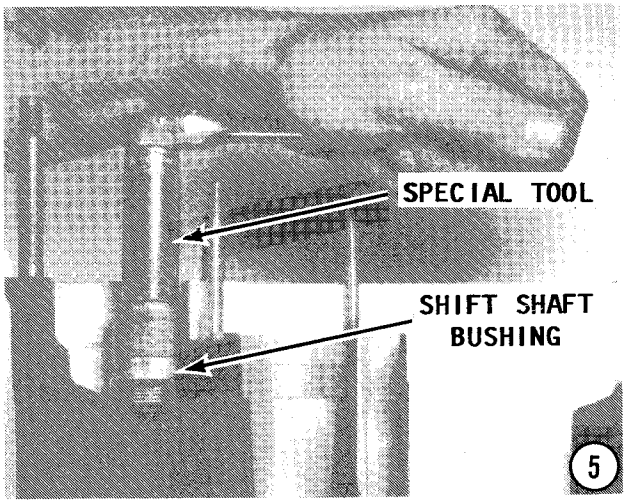
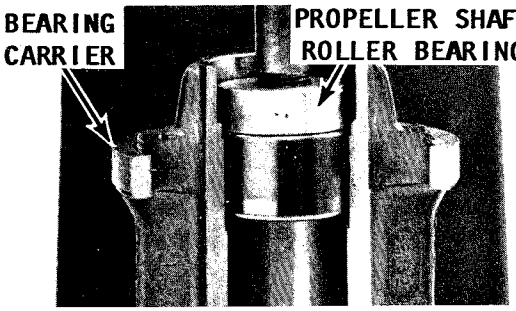


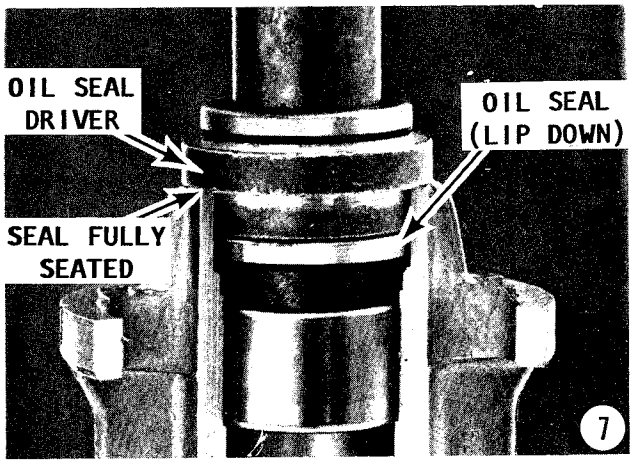
webbing. If the shift cam has numbers embossed on one side, then the side with the numbers **MUST** face **UP** after installation.

The ramps on the shift cam **MUST** be visible from the rear of the lower unit and the longer side, the reverse ramp, **MUST** be toward the left side, the fill screw hole side. Place the lower shift shaft, the short spline end, into the shift shaft cavity. Rotate the shift shaft to engage the splines into the splines of the shift cam.

5- Slide the shift shaft bushing over the shift shaft and start the threads of the bushing into the lower unit. Obtain Shift Shaft Bushing Tool C-91-31107. Use the tool to tighten the shift shaft bushing securely. **DO NOT** attempt to install the reverse lock cam at this time.



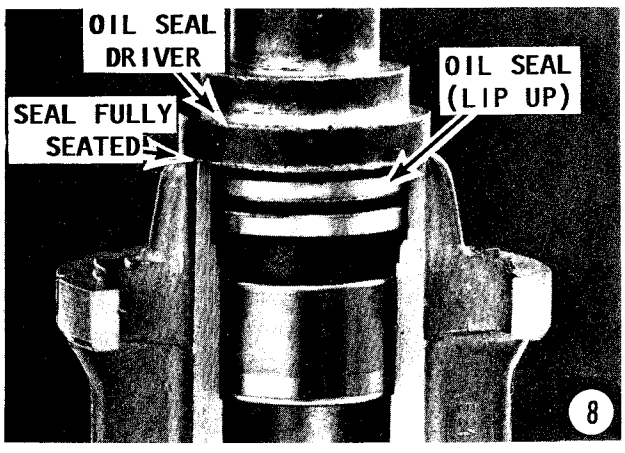




Bearing Carrier Assembling

6- Position the propeller shaft roller bearing into the aft end of the bearing carrier with the numbered side **TOWARD** the aft end. Press the roller bearing into the bearing carrier with a suitable mandrel.

7- Coat the outer diameter of the propeller shaft oil seals with Loctite Type "A". Obtain Oil Seal Driver C-91-31108. Place one seal on the longer shoulder side of the driver tool with the lip of the seal **AWAY** from the shoulder. Press the seal into the



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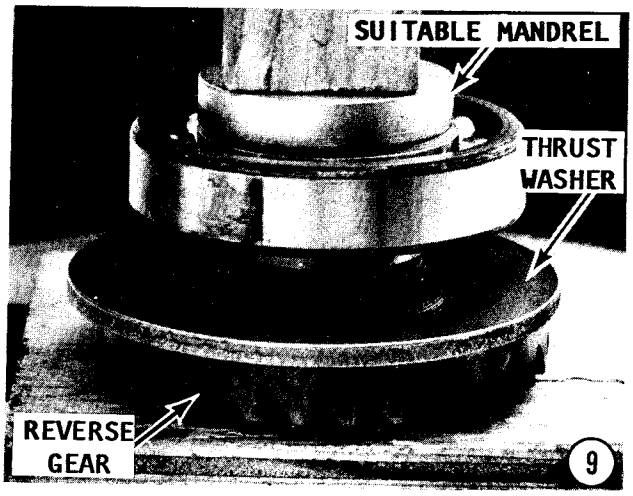
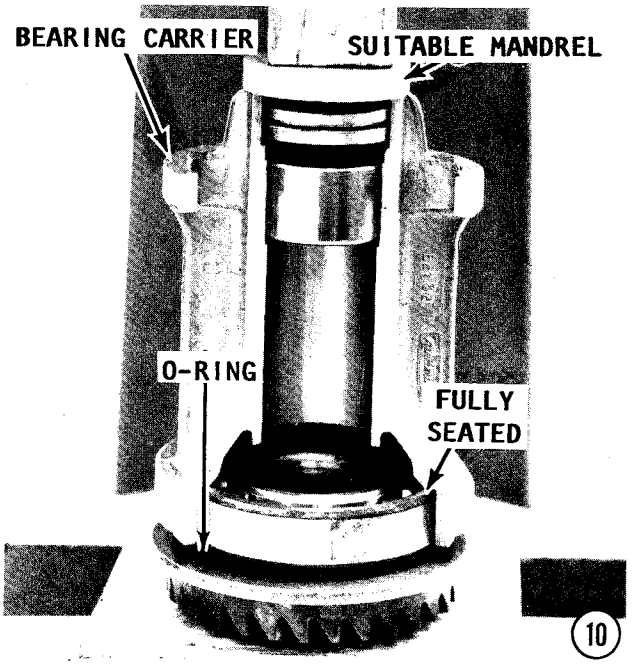


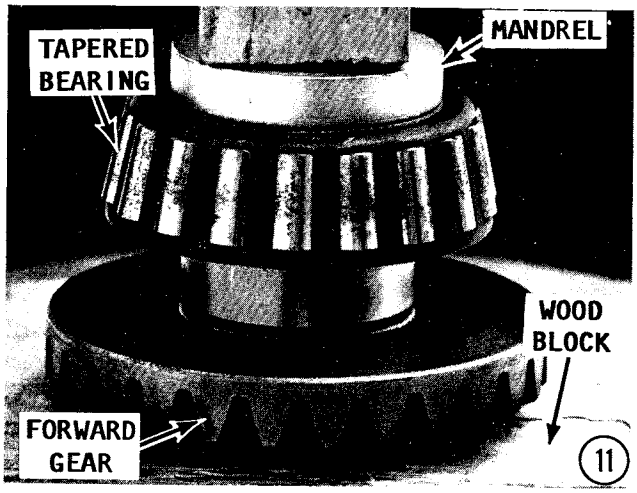
bearing carrier until the seal driver bottoms against the bearing carrier. Place the second seal on the short shoulder side of the seal driver with the lip of the seal **TOWARD** the shoulder.

8- Press the seal into the bearing carrier until the seal driver bottoms against the bearing carrier. Clean excess Loctite from the seals.

9- Position the reverse gear on a press with the gear teeth facing **DOWN.** Place the thrust washer over the gear. Place the ball bearing over the gear with the numbered side **UP.** Now, press the ball bearing onto the gear with a suitable mandrel.

10- Place the bearing carrier over the gear and bearing assembly. Press the bearing carrier onto the bearing. Place a **NEW** O-ring over the bearing carrier and position



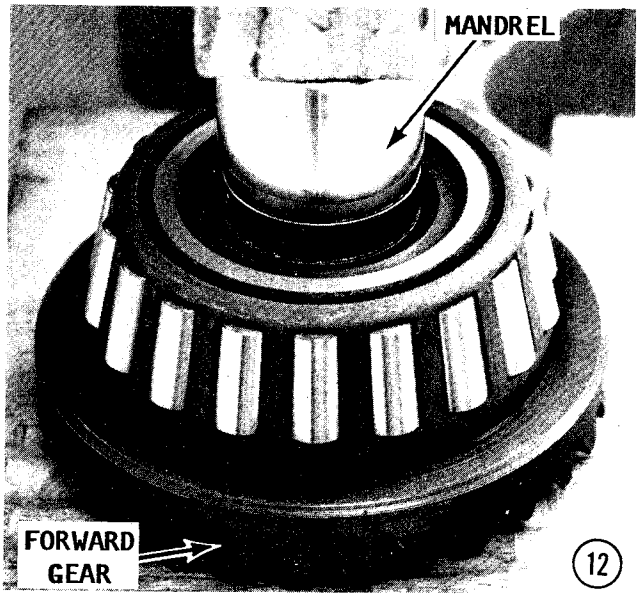


it between the bearing carrier and the thrust washer. Coat the O-ring and oil seals with Multipurpose Lubricant, or equivalent. Set the unit aside for installation later.

Forward Gear Assembling

11- Place the forward gear on a press with the gear teeth **DOWN.** Position the forward gear tapered bearing over the gear. Now, press the bearing onto the gear with a suitable mandrel until the bearing is firmly seated. Check for clearance (gap) between the inner bearing race and the shoulder of the gear. There should be **NO** clearance.

12- Position the roller bearing over the center bore of the forward gear with the numbered side of the bearing facing **UP.** Use a suitable mandrel and press the roller bearing into the gear until the bearing is seated against the shoulder.



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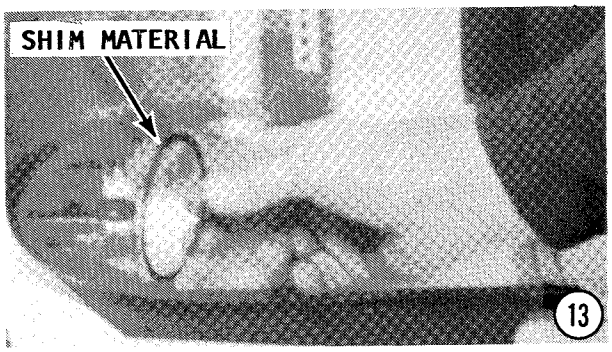


CRITICAL WORDS

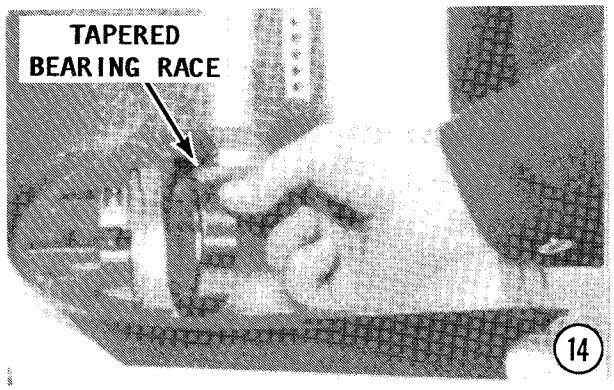
The bearing carrier is used as a pilot while installing the forward gear bearing cup in the next step. Therefore, the bearing carrier must have been assembled to include at least the propeller shaft roller bearing as outlined in Step 6.

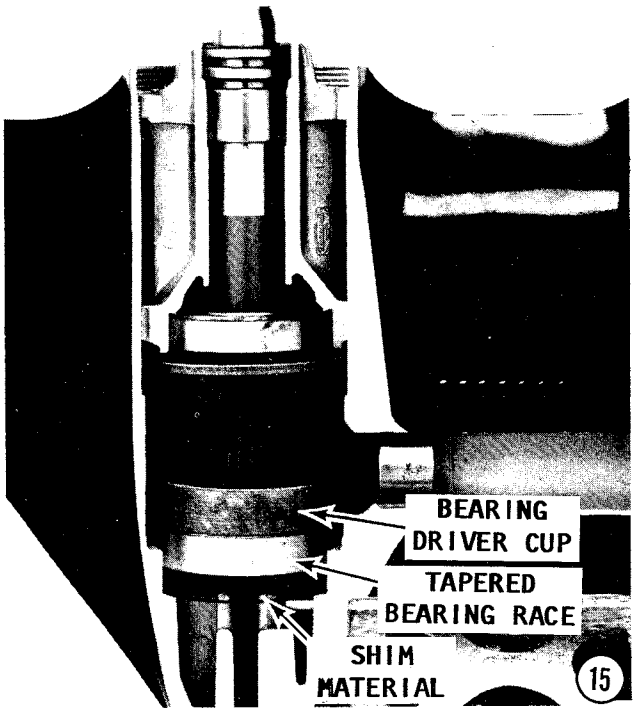
Forward Bearing Race Installation

13- Place the same amount of shim material saved during disassembly into the lower unit. If the shim material was lost, or if a new lower unit is being used, begin with approximately 0.010" (.25mm) material. Coat the forward bearing race bore with Formula 50 oil.

14- Position the tapered bearing race squarely over the bearing bore in the front portion of the lower unit. Obtain Bearing Driver Cup tool C-91-31106. Place the tool over the tapered bearing race.

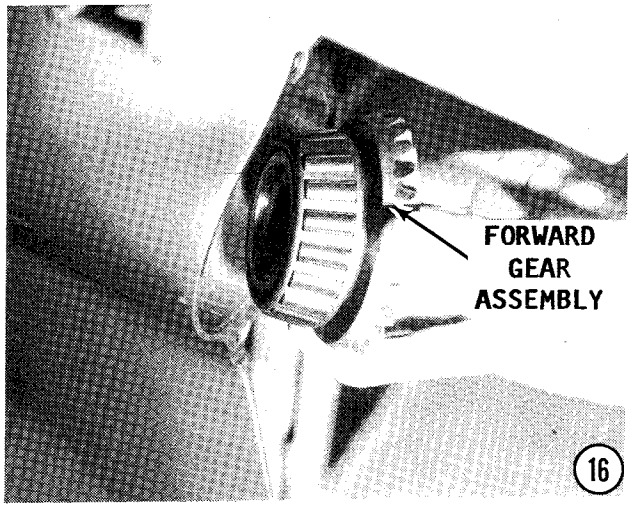
15- Insert the propeller shaft into the hole in the center of the bearing cup. Lower the bearing carrier asembly down over the propeller shaft, and then lower it into the lower unit. The bearing carrier will service as a pilot to ensure proper bearing race alignment. Now, use a mallet and drive the propeller shaft against the bearing driver cup until the tapered bearing race is seated against the shim material. Withdraw the propeller shaft and bearing carrier, then lift out the driver cup.





PLAN AHEAD

Obtain a suitable substance which can be used to indicate a wear pattern on the forward and pinion gears as they mesh. Machine dye may be used and if this material is not available, Desenex Foot Powder (obtainable at the local Drug Store/Pharmacy), or equivalent may be substituted. Desenex is a white powder available in an aerosol container. Before assembling either gear, apply a light film of the dye, Desenex, or equivalent, to the driven side of the gear. After the gears are assembled and rotated several times, they will be disassembled and the wear pattern can be examined. The substance will be removed from the gears prior to final assembly.



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16- Position the forward gear assembly into the forward bearing race.

Driveshaft Assembling

FIRST, THESE WORDS

As mentioned in the disassembling procedure following Step 7, two different type bearings are used on the driveshaft of the various lower unit unit covered in this section. Some units have a "one-piece" ball bearing assembly installed and others use a "two-piece" tapered bearing. Procedures to install the "one-piece" ball bearing type are covered in Step 17 and to install the driveshaft assembly in Step 19 and 20. The "two-piece" tapered bearing type installation instructions are presented in Step 18 and 21.

One-piece ball bearing

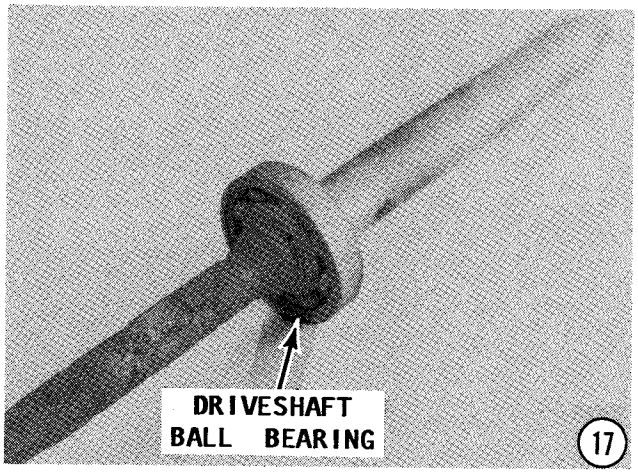
17- Position the driveshaft bearing over the top end of the driveshaft with the groove in the outer bearing race toward the pinion gear end of the driveshaft. Position the driveshaft bearing above the jaws of Universal Puller Plate C-91-37241 and then press the driveshaft into the driveshaft bearing.

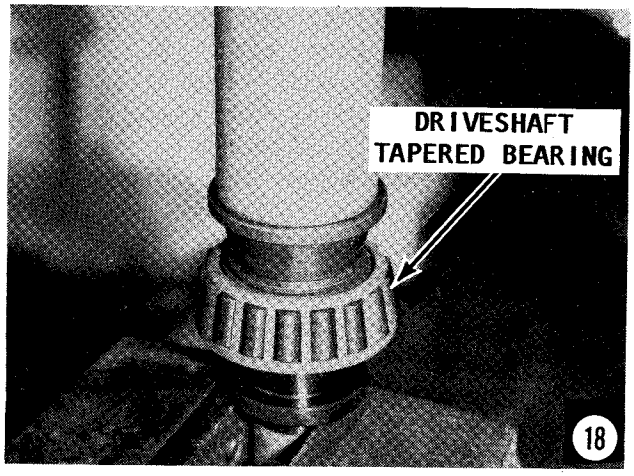
Two-piece tapered bearing

18- Two-piece tapered bearing installation: Position the driveshaft tapered bearing over the pinion gear end of the driveshaft. Use a suitable mandrel and press the bearing flush against the shoulder on the driveshaft.

Driveshaft Installation
One-piece ball bearing

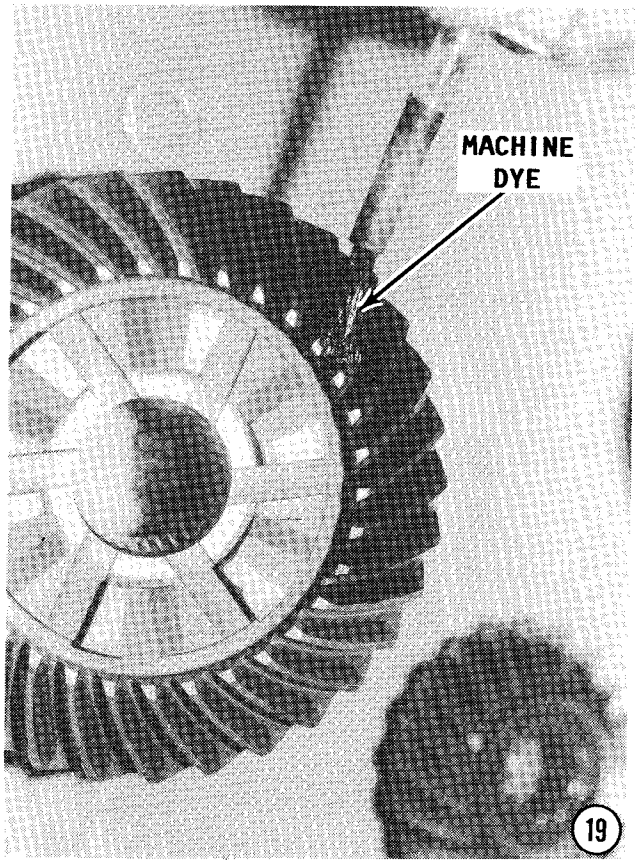
19- Apply a thin coating of substance, as explained in the "Plan Ahead" paragraph prior to Step 16, to the driven side of the





pinion gear, before proceeding. Place the shim material saved during disassembly into the lower unit driveshaft bearing bore. If a new lower unit is being installed, or if the bearing material was lost, begin by using 0.015" (0.38mm) shim material. Use a small amount of Multipurpose Lubricant to hold the shims in place.

Position the pinion gear in the lower unit with the teeth of the pinion gear indexed (meshed) with the teeth of the forward gear. Insert the driveshaft into the lower unit and



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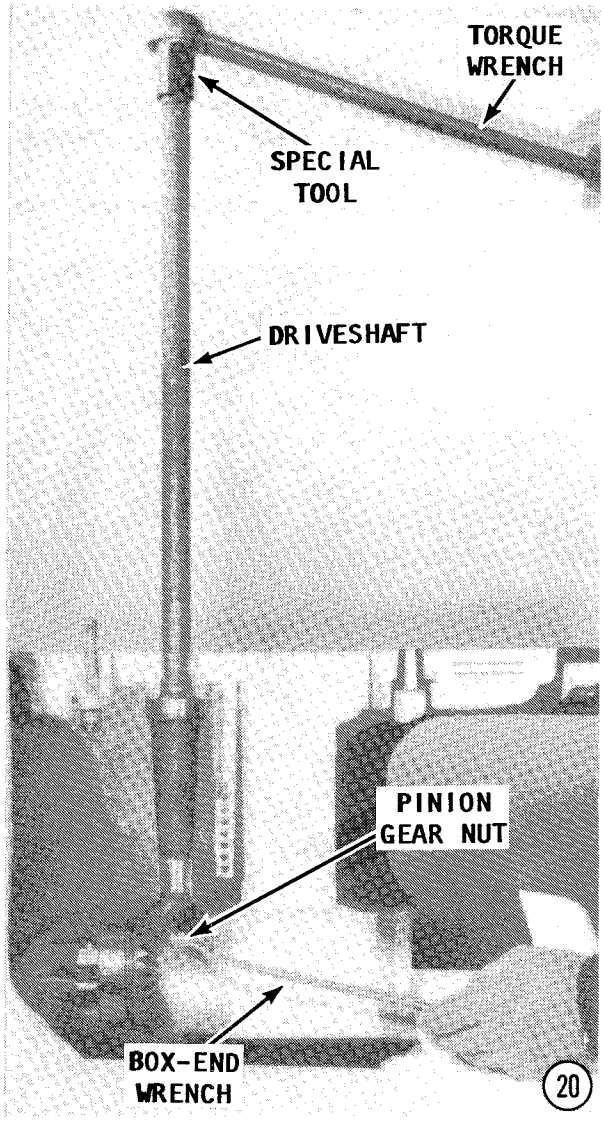
at the same time hold the pinion gear in position with the other hand. Tap on the end of the driveshaft with a mallet to drive the bearing into the lower unit. After **EACH TAP,** rotate the driveshaft and at the same hold the pinion gear toward the driveshaft in an attempt to align and engage the splines. Continue with this tapping and rotating procedure until the driveshaft enters the pinion gear.

20- Hold the pinion gear against the driveshaft splines, while the driveshaft bearing is seated against the shims, by continuing to tap with the mallet against the driveshaft. Install the pinion gear retainer nut onto the driveshaft. Hold the pinion gear retainer nut with a socket wrench. Pad the area where the socket wrench flex handle will contact the lower unit while the pinion nut is being tightened. Obtain Drive Shaft Nut Wrench C-91-56775. Place the wrench over the crankshaft end of the driveshaft. Use a torque wrench and socket to tighten the pinion nut to torque value of 70-80 ft lbs (95-109Nm).



Two-piece tapered bearing

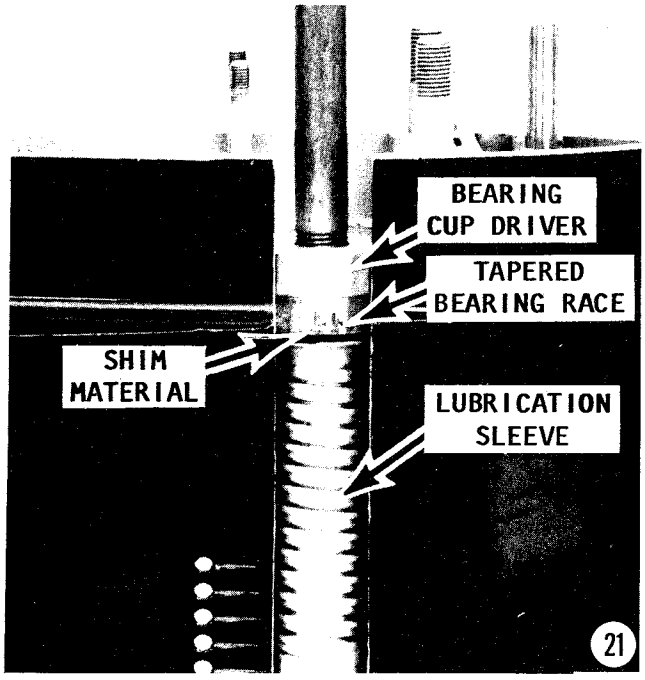
21- Place the lubrication sleeve into the driveshaft cavity. **CHECK** to be sure the sleeve fits down into the cavity far enough to be below the shim surface. **DO NOT** use excessive force because the sleeve could become distorted.

Position the shim material saved during disassembly into the driveshaft cavity. Use a small amount of water resistant Multipurpose Lubricant to hold the shim material in place. Obtain Bearing Driver Cup C-91-34379 and Bearing Removal and Installation Kit C-91-31229A1. Now, using the cup and the bearing kit, drive the tapered bearing race into the lower unit cavity until the race is seated against the shim material.

STOP

Apply a thin coating of substance, as explained in the "Plan Ahead" paragraph prior to Step 16, to the driven side of the pinion gear, before performing Step 22.

22- Position the pinion gear in the lower unit below the driveshaft cavity and with the teeth of the pinion gear indexed (meshed) with the teeth of the forward gear.



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Hold the pinion gear in position and at the same time, insert the driveshaft into the driveshaft cavity. Now, rotate and insert the driveshaft until the driveshaft splines align and engage with the splines of the pinion gear. Continue to insert the driveshaft into the pinion gear until the tapered bearing is against the bearing race.

Start the pinion gear retainer nut. Hold the pinion gear retainer nut with a socket wrench. Pad the area where the socket wrench flex handle will contact the the lower unit while the pinion nut is being tightened. Obtain Drive Shaft Nut Wrench C-91-56775. Place the wrench over the crankshaft end of the driveshaft. Use a torque wrench and socket to tighten the pinion nut to torque value of 70-80 ft lbs (95-109Nm).

PINION GEAR DEPTH

GOOD WORDS

The proper amount of pinion gear depth (pinion gear engagement with the forward gear), is critical for proper operation of the lower unit. Therefore, read and **UNDERSTAND** the procedures involved in Steps 24 thru 28 before attempting any change in the shim material.

The pinion gear depth procedures vary depending on whether the driveshaft has a pre-load pin on the upper end or does not have the pre-load pin. Therefore, two set of instructions are presented in the following steps. Procedures for the driveshaft with the pre-load pin are presented in Step 23. Procedures for the driveshaft without the pre-load pin are given in Step 23A. Detailed instruction to change the shim material are given in Steps 25 thru 28.

Pinion Gear Depth
Driveshaft WITH Preload Pin

23- Seat the driveshaft bearing outer race firmly against the shim material using a punch and hammer. **TAKE CARE** not to damage the bearing with the punch. Grasp the driveshaft, **PUSH DOWN** and at the same time, check the pinion gear tooth engagement with the forward gear teeth to be sure contact is made the full length of the tooth. This can be accomplished by using a flashlight and looking through the gear housing opening. If the pinion gear depth is incorrect, the paragraphs following Step 23A list detailed steps to be followed to correct the condition.

Pinion Gear Depth
Driveshaft WITHOUT Preload Pin

23A- Grasp the driveshaft, **PULL UPWARD** and at the same time, check the pinion gear tooth engagement with the forward gear teeth to be sure contact is made the full length of the tooth. This can be accomplished by using a flashlight and looking through the gear housing opening. If the pinion gear depth is incorrect, the following paragraphs list detailed steps to be followed to correct the condition discovered.

Shim Material and Backlash

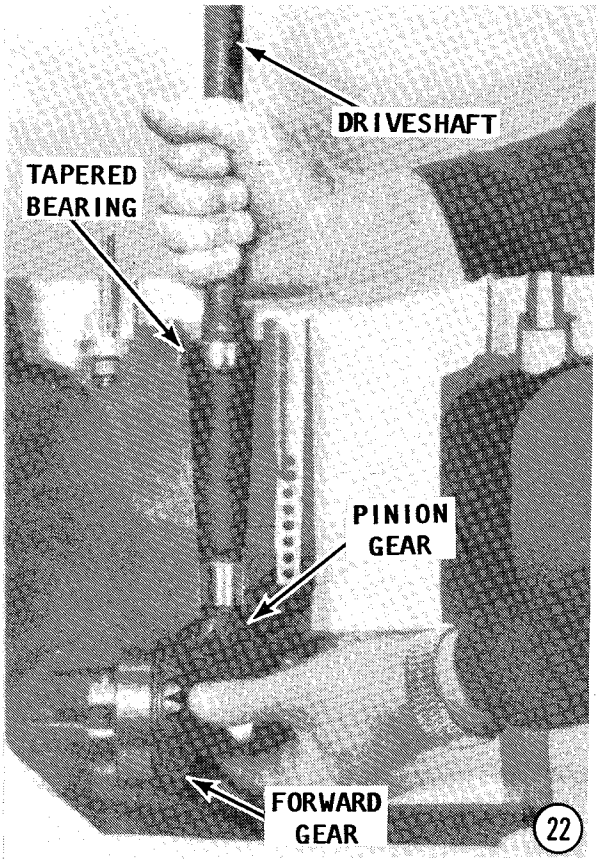
Adding or removing shim material will affect the forward gear and the reverse gear as follows:-

Forward gear -- adding shim material **DECREASES** backlash.

Forward gear -- removing shim material **INCREASES** backlash.

Reverse gear -- adding shim material **INCREASES** backlash.

Reverse gear -- removing shim material **DECREASES** backlash.



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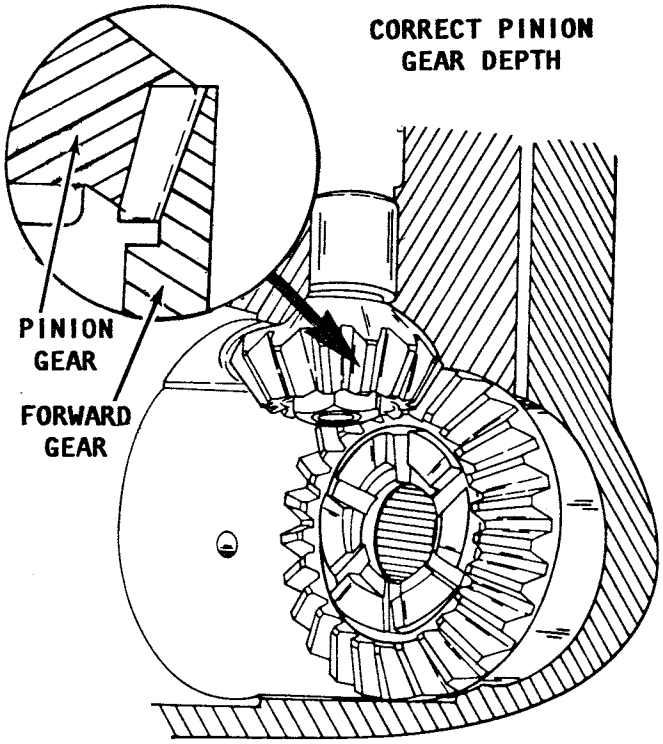
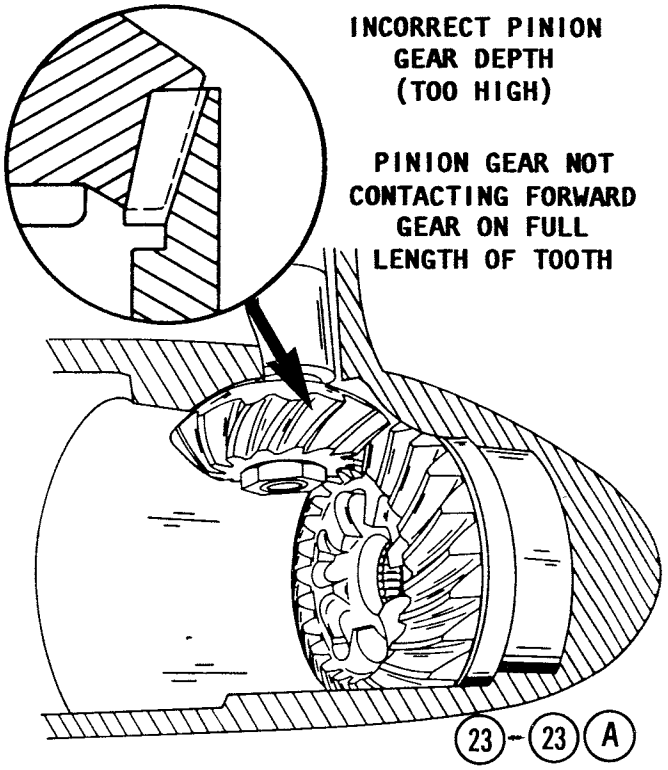


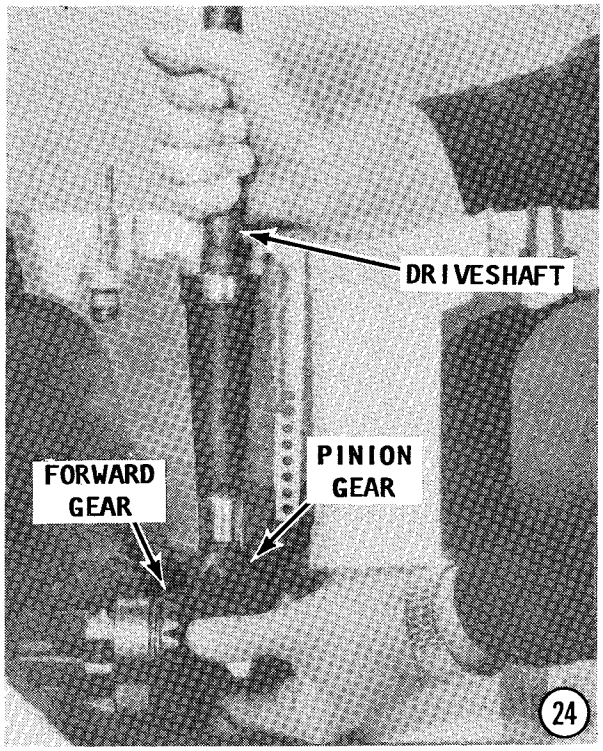


Forward Gear Backlash

24- Push downward on the driveshaft (all models with pre-load pin) or pull upward on the driveshaft (all models without the pre-load pin). Hold the driveshaft in this position and check the pinion gear tooth engagement with the forward gear teeth. In either case, contact should be made the full length of the teeth. Now, place your other hand into the bearing carrier cavity with a couple fingers hooked in the forward gear. Pull on the forward gear and rock it lightly back-and-forth. The amount of free play between the gear teeth is considered the gear backlash. Check the Specifications in the Appendix for the proper backlash allowed for the unit being serviced.

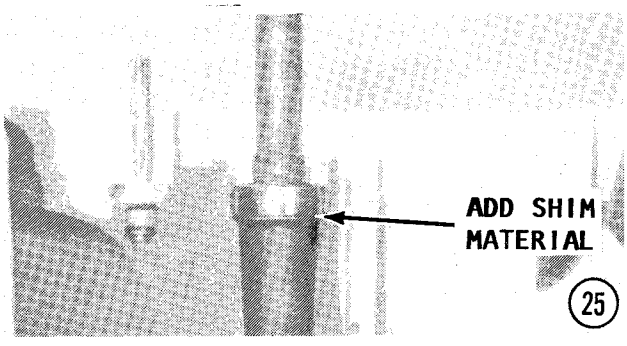
If the backlash appears to be correct, proceed directly to Step 29.

If the backlash is not within the Specification limits, proceed to make changes in the shim material, as follows.



PINION GEAR AND FORWARD GEAR BACKLASH ADJUSTMENT

The following procedures are to be performed for proper pinion gear and backlash adjustments. Because a variety of possibilities may develop as the work progresses,



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step-by-step illustrations would only be confusing. Therefore, captioned illustrations are included with the instructions to provide an overall view of how the adjustments are to be made.

If the pinion gear depth or the forward gear backlash is incorrect, follow the shimming procedures under the heading for the specific condition discovered.

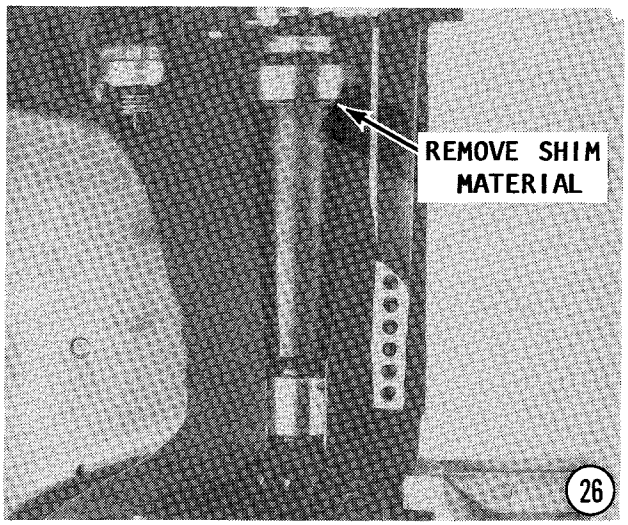
Pinion Gear Depth Too Deep but Backlash LESS than Specifications

25- Remove the driveshaft, tapered bearing race if used, and the pinion gear. Add shim material to obtain the correct pinion gear depth. For each 0.001" (0.025 mm) of shim material added, the forward gear backlash will increase approximately 0.0015" (0.038 mm).

Assemble the parts and again check the pinion depth and forward gear backlash.

Pinion Gear Depth Too Shallow and Backlash LESS than Specifications

26- Remove the driveshaft, tapered bearing race, if one is used, and the pinion gear. Remove shim material to correct the pinion gear depth. Remove the forward gear and the forward gear bearing race. Remove an **EQUAL** amount of shim material from the forward gear, plus an additional amount to increase the forward gear backlash to the amount given in the Specifications. The forward gear backlash will increase approximately 0.0015" (0.038 mm) for each 0.001" (0.025 mm) of shim material removed from in front of the forward gear bearing.



Assemble the parts and again check the pinion gear depth and the backlash.

Pinion Gear Depth Is Correct but Forward Gear Backlash is Excessive

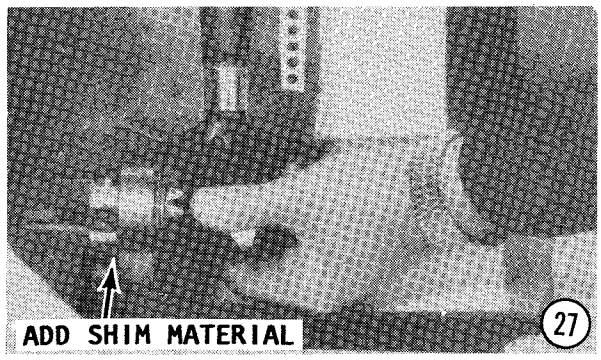
27- Remove the driveshaft and the pinion gear. Remove the forward gear and the forward bearing race. Add shim material to reduce the forward gear backlash. Adding 0.001" (0.025 mm) shim material will decrease the gear backlash by approximately 0.0015" (0.038 mm). Assemble the parts and again check the forward gear backlash.

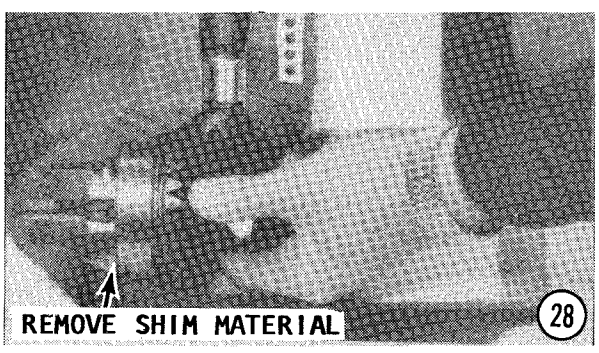
Pinion Gear Depth Is Correct but Backlash Less than Specifications

28- Remove the driveshaft and the pinion gear. Remove the forward gear and forward gear bearing race. Remove shim material to increase the gear backlash to specification. Removal of 0.001" (0.025 mm) shim material will increase the gear backlash approximately 0.0015" (0.038 mm).

Pinion Gear and Backlash Correct

Once the proper amount of backlash and the pinion gear depth is satisfactory, check the gear mesh pattern.





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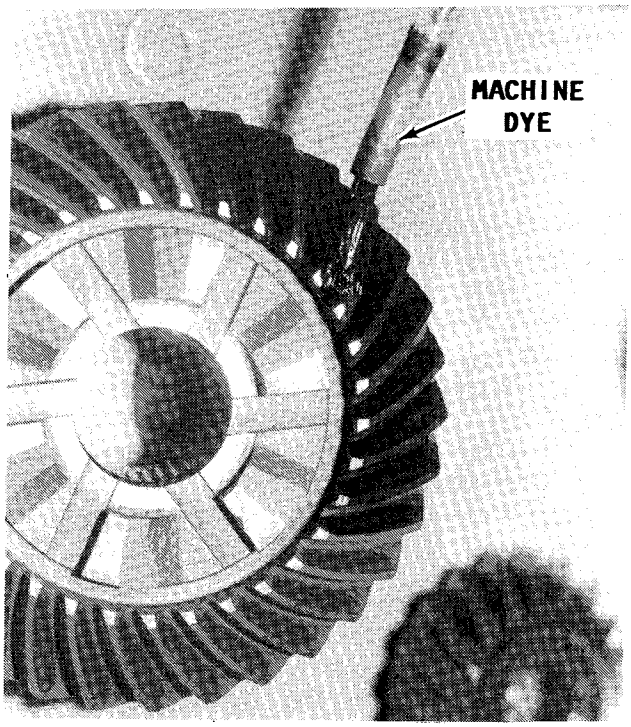


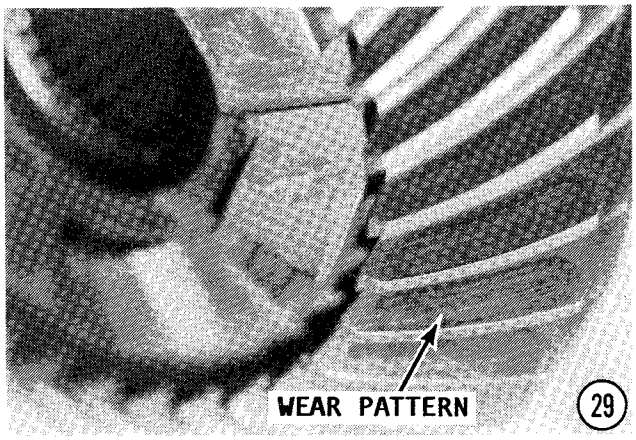
Machine dye being applied to one of the driven gears in preparation to obtaining a gear mesh pattern with the pinion gear, as explained in the "Plan Ahead" paragraph on Page 11-26.

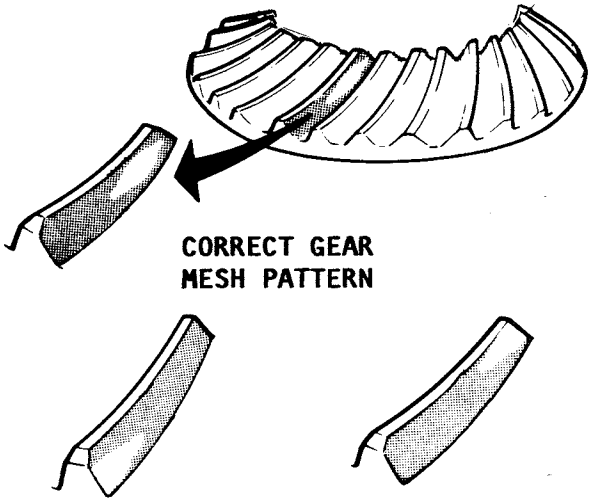
29- With the unit still assembled, rotate the driveshaft **CLOCKWISE** approximately 6 to 8 complete revolutions.

Now, disassemble the unit and compare the pattern made on the gear teeth with the accompanying illustrations. The pattern should almost be oval on the drive side and be positioned about halfway up the gear teeth.

If the pattern appears to be satisfactory, clean the dye or powder from the gear teeth and assemble the unit one final time.

If the pattern does **NOT** appear to be satisfactory, add or remove shim material, as required. Adding or removing shim material will move the gear pattern towards or away from the center of the teeth.





A normal gear wear pattern, as shown in the upper part of the illustration, will be centered on the tooth and will not extend over either end of the tooth.

Propeller Shaft Assembling

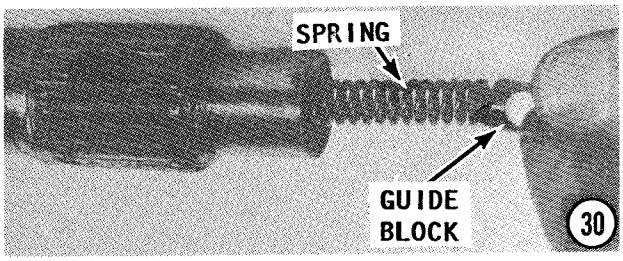
Again, check the forward gear-to-pinion gear backlash. The backlash could decrease slightly if the driveshaft bearing was not seated properly. If necessary, repeat the shimming procedure.

30- Insert the spring into the end of the propeller shaft. Insert the guide block, stepped end, into the front end of the propeller shaft with the cross-pin hole aligned with the cross-pin hole in the sliding clutch. Insert the flat end of the cam follower into the front end of the propeller shaft.

SPECIAL WORDS

If three balls were discovered behind the cam follower in Step 20 of Disassembling, then insert the three balls just prior to inserting the cam follower into the propeller shaft.

31- Slip the sliding clutch over the clutch splines with the cross-pin hole aligned with the cross-pin slot in the propeller shaft. Position the cam follower against a solid object and push against the cam follower to compress the spring. Hold the



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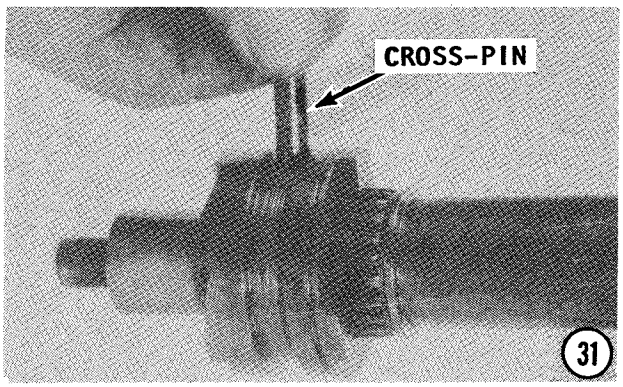


propeller shaft in this position and at the same time, use a punch to align the guide block cross-pin opening with the sliding clutch cross-pin hole. Remove the punch and insert the cross-pin. Release pressure on the spring.

32- Install the cross-pin retainer spring over the sliding clutch. **TAKE CARE** not to over-stretch the spring. Remove the cam follower and insert just a little Multipurpose Lubricant into the end of the propeller shaft. Install the cam follower with the flat end going in first.

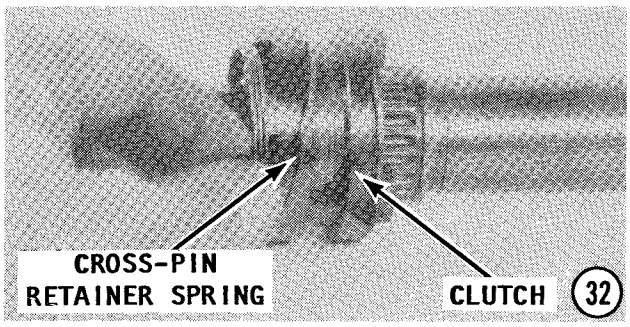
Bearing Carrier Installation

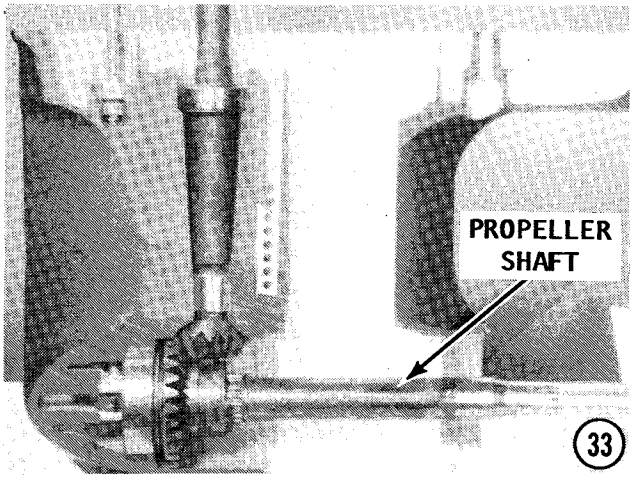
33- Insert the propeller shaft into the center of the forward gear assembly.

34- If the reverse gear backlash was correct before disassembly, as checked in Step 1, install the same amount of shim material retained during disassembly onto the shoulder in the lower unit to the rear of the reverse gear.

GOOD NEWS

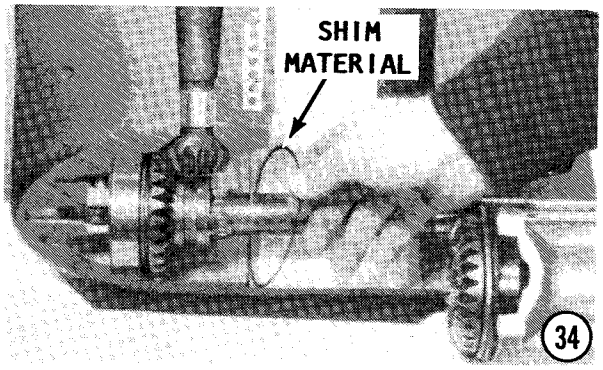
The reverse gear backlash specification for all units with Cam-Shift Type I covered in this manual is 0.040-0.060" (1.016-0.524mm). This is a liberal 0.020" play. If the backlash is not within the 0.020" specification, the unit must be disassembled; shim material added or removed; and the unit assembled again. The backlash will change approximately 0.0015" (0.038 mm) for each

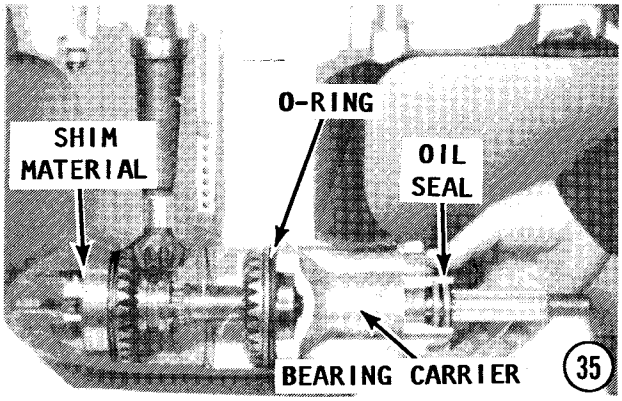




0.001" (0.025mm) of change in shim thickness. Adding shim material will increase the backlash, removing shim material will decrease the backlash.

35- Install a **NEW O**-ring into the groove between the bearing carrier and the thrust washer. Coat the **O**-ring and propeller shaft oil seals with Multipurpose Lubricant. Coat the outside surfaces of the bearing carrier where the carrier contacts the lower unit with Perfect Seal. **PREVENT** the Perfect Seal from entering the bearings. Slide the bearing carrier into the lower unit. **TAKE CARE** not to damage the propeller shaft oil seals. Push the bearing carrier into the





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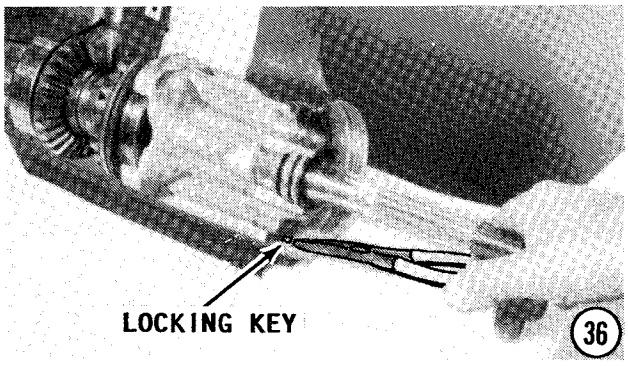


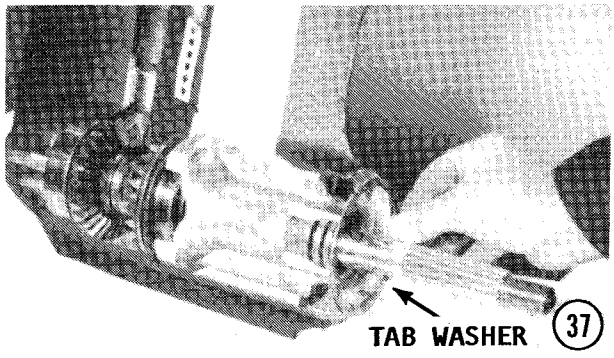
lower unit and at the same time slowly rotate the driveshaft to allow the pinion gear teeth to engage with the reverse gear teeth.

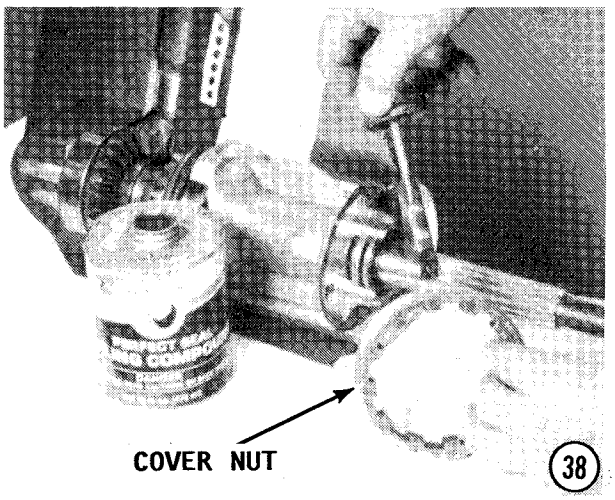
36- Align the keyway in the bearing carrier with the keyway in the lower unit, and then insert the locking key.

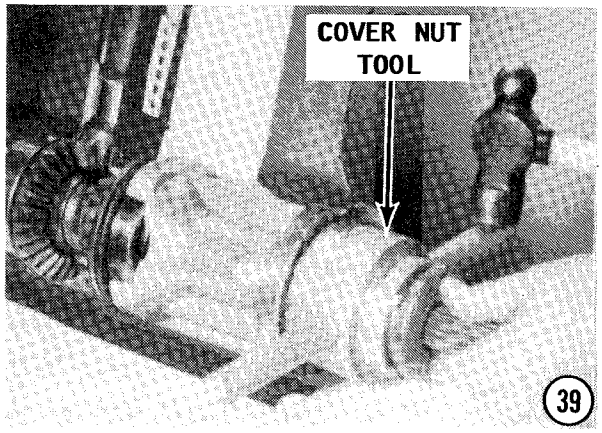
37- Slide a **NEW** tab washer over the bearing carrier with the **"V"** portion opposite the keyway.

38- Coat the threads of the bearing carrier cover nut with Perfect Seal. Insert the cover nut into the bearing carrier with the word **OFF** and the arrow visible.

39- Start the cover nut a few turns **BY HAND** as a precaution against cross-threading. Obtain Gear Housing Cover Tool





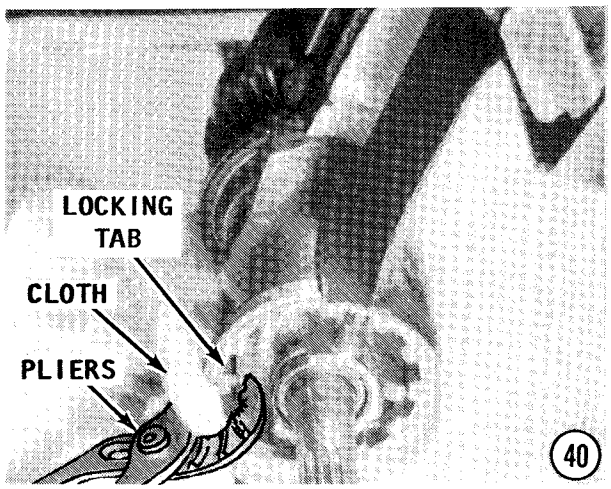


C-91-73688. Tighten the cover nut with the tool to the torque value of 210 ft lbs (285Nm).

40- Use a pair of water pump pliers to perform this step and pad the lower jaw of the pliers to protect the outside finish of the lower unit. Bend one of the locking tabs down into a cutout in the cover nut. The tabs are arranged in such a manner that one, and maybe more, will align with the cutouts in the nut.

Reverse Gear Backlash

41- Shift the lower unit into reverse gear. Rotate the propeller shaft **COUNTERCLOCKWISE** to take-up any free-play between the reverse gear and the clutch dogs. Shift into neutral gear and rotate the propeller shaft only 1/8" (3.17 mm) **COUNTERCLOCKWISE.** Now, attempt to shift into reverse gear. The attempt should **FAIL.** If the attempt is successful and it is possible to shift into reverse gear, repeat this step. Hold pressure on the lower shift shaft toward the reverse gear and at the same time,



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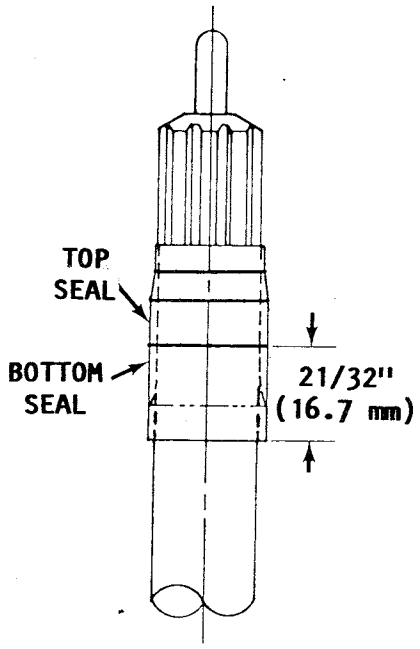
push down on the driveshaft and have an assistant pull outward on the propeller shaft, and at the same time rock the shaft lightly left-and-right.

The amount of free-play felt is the reverse gear backlash. The free-play should be 0.040-0.060" (1.016-1.524mm) for all Cam-Shift Type I units covered in this manual.

If the reverse gear backlash is incorrect, change the amount of shim material behind the reverse gear according to Step 34.

42- Slide the bottom driveshaft seal onto the upper part of the driveshaft with the splined end of the seal facing **UPWARD.** Install the top driveshaft seal onto the driveshaft with the smaller outside diameter of the seal facing **UPWARD.**



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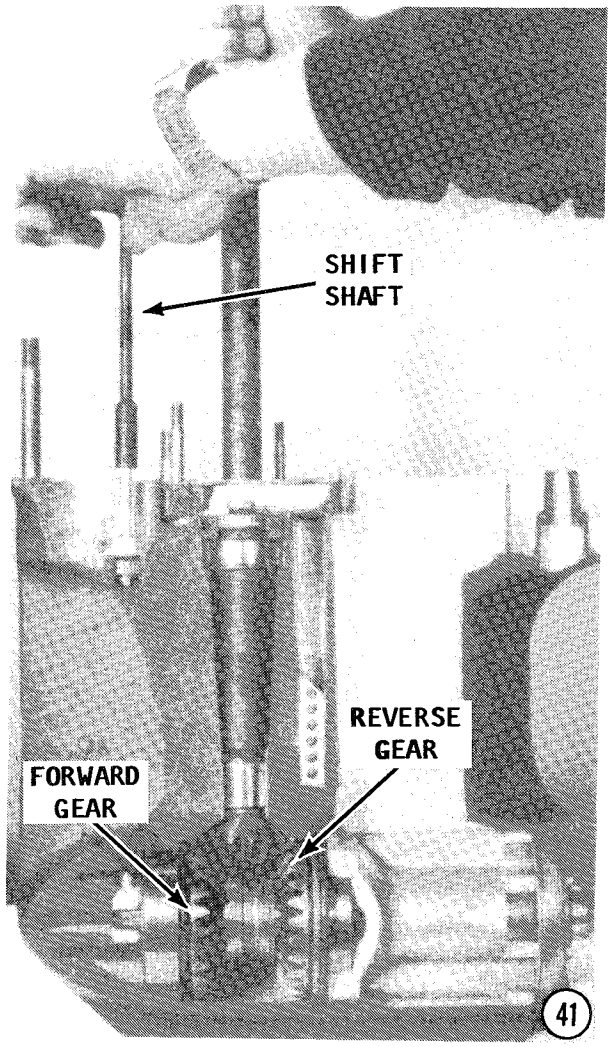
SPECIAL GOOD WORDS

The Cam-Shift Type I lower unit is now ready for installation of the water pump, including the base and shimming, if required.



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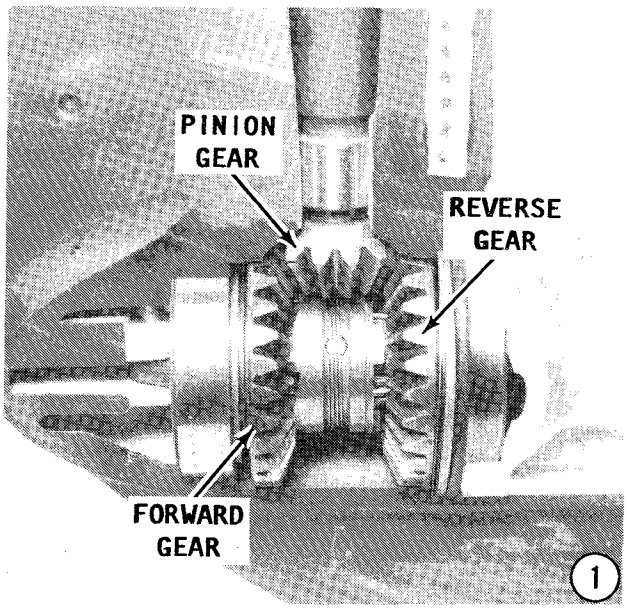
Proceed directly to Section 11-8, beginning on Page 11-81.

11-6 SERVICING CAM-SHIFT TYPE II LOWER UNIT MATCHED WITH 3- AND 4-CYLINDER POWERHEADS AND 6-CYLINDER INLINE POWERHEADS

The following procedures outline complete detailed instructions to remove virtually all parts of the lower unit. If a particular part is found to be in satisfactory condition and does not require removal, simply skip the steps involved and proceed with the required tasks to remove damaged parts.



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1- The reverse gear-to-pinion gear backlash and the forward gear-to-pinion gear backlash should be checked **PRIOR** to disassembly. The reverse gear backlash can be checked only at a point of propeller shaft rotation where it is not possible to shift from neutral gear into reverse, as outlined in the following procedure.

Three hands are necessary for the backlash check, therefore, obtain the help of an assistant.

Slowly rotate the propeller shaft and at the same time attempt to shift into the reverse gear position. Once this position is reached:

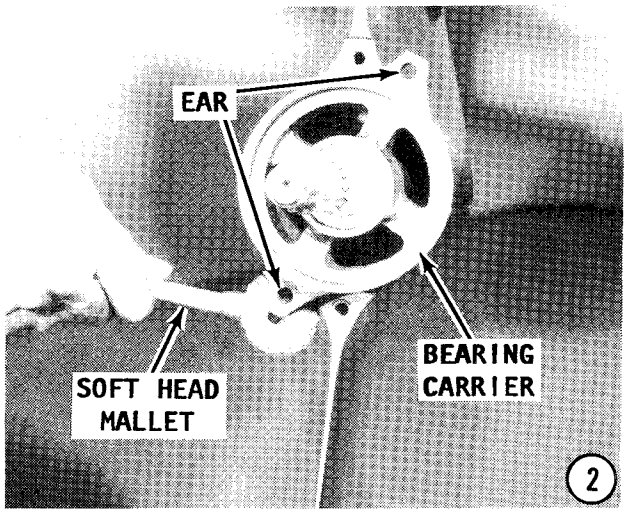
a- Pull up on the driveshaft.
b- Pull outward on the propeller shaft.
c- Hold pressure on the lower shift shaft toward reverse.
d- Lightly rotate the propeller shaft clockwise and counterclockwise.

The amount of free play felt is the reverse gear-to-pinion gear backlash. For all powerheads covered in this manual, the correct amount of backlash allowable is 0.040"-0.060" (1.0-1.5mm). Record the amount of backlash felt because it may affect shimming of the reverse gear during assembly.

Repeat Step 1 to check the backlash of the forward gear, except push in on the propeller shaft. Allowable backlash for the forward gear varies, depending on the model being serviced. Therefore, consult the table in the Appendix.

Bearing Carrier Removal

2- Remove the two bolts and washers securing the bearing carrier in the lower unit. Use a soft head mallet and tap the ears of the bearing carrier to offset the carrier from the housing, as shown in the accompanying illustration. Now, tap opposite "ears" alternately and evenly on the back side to remove the carrier from the lower unit housing.



NOW, THESE WORDS

If the carrier is "frozen" and refuses to budge, one of three methods may prove successful to remove the carrier.

The first and safest method is to use a simple adaptor with a slide hammer. This procedure is explained in Step 2A.

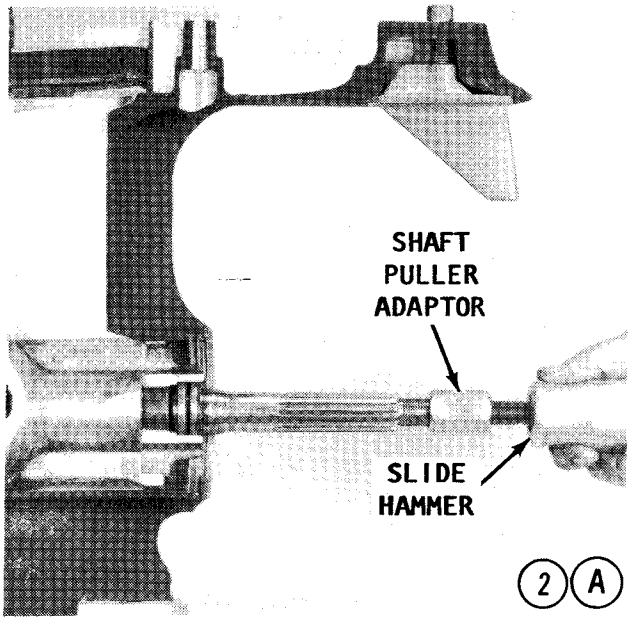
The second method involves the use of a slide hammer and long puller jaws to remove the carrier from the lower unit. This procedure is explained in Step 2B.

The third and least desirable method is to use a mallet to actually drive the lower unit off the carrier. The procedure involved in this method is outlined in Step 2C.

In all three methods, heat **CAREFULLY** applied to the outside of the lower unit, will assist in removing the bearing carrier.

2A- The first method of removing the bearing carrier is to use a shaft puller adaptor and a slide hammer, as shown in the accompanying illustration. Thread the adaptor onto the propeller shaft as far as possible. Next, thread the slide hammer into the adapter and the shaft, clutch dog, reverse gear, and bearing carrier are ready to be removed as a unit. Operate the slide hammer to pull the parts mentioned.

2B- As explained, this step is an alternate method for removing the bearing car-



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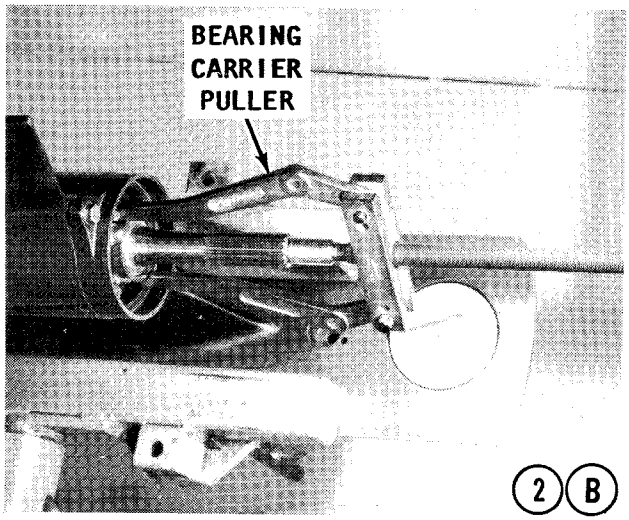
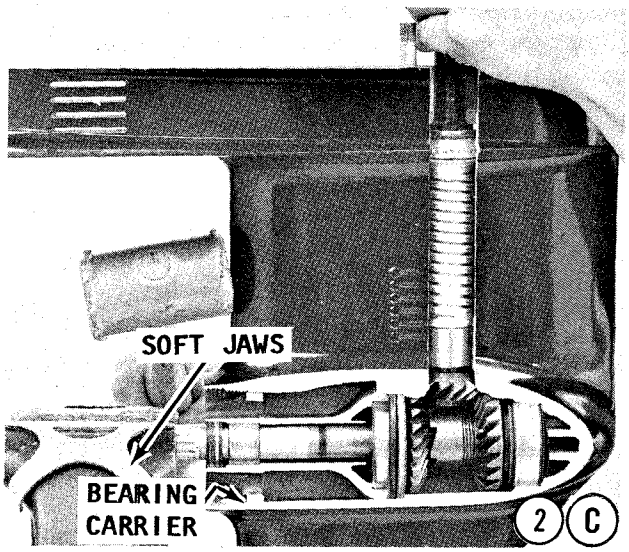


rier from the lower unit. Obtain Slide Hammer C-91-34569A1 with long Puller Jaws C-91-46086A1. Use the propeller thrust hub to maintain an outward pressure on the puller jaws. Remove the propeller shaft from the lower unit. Set the unit aside for disassembly later.

2C- The third and least desirable method is as follows: Clamp the propeller shaft in a vise equipped with soft jaws in a horizontal position. Use a mallet and strike the lower unit with quick sharp blows midway between the anti-cavitation plate and the propeller shaft. This action will drive the lower unit off the bearing carrier. **TAKE CARE** not to drop the lower unit when the unit finally comes free of the carrier.

Now, if the lower unit refuses to move, it may be necessary to carefully apply heat to the lower unit in the area of the carrier and at the same time attempt to move it off the carrier.



Remove the propeller shaft and bearing carrier from the vise. Slide the propeller shaft out of the bearing carrier from the rear to the front. Set the assembly aside for disassembly later.

Bearing Carrier Disassembly

3- Inspect the two seals and the condition of the needle bearing at the rear end of the carrier. If the seals have failed and have allowed water to enter the lower unit, both needle bearings are no longer fit for further service. If the bearing does not roll freely or shows any sign of corrosion, clamp the carrier in a vise equipped with soft jaws. Obtain and use Slide Hammer C-91-34569A-1 to pull the bearing free of the carrier.

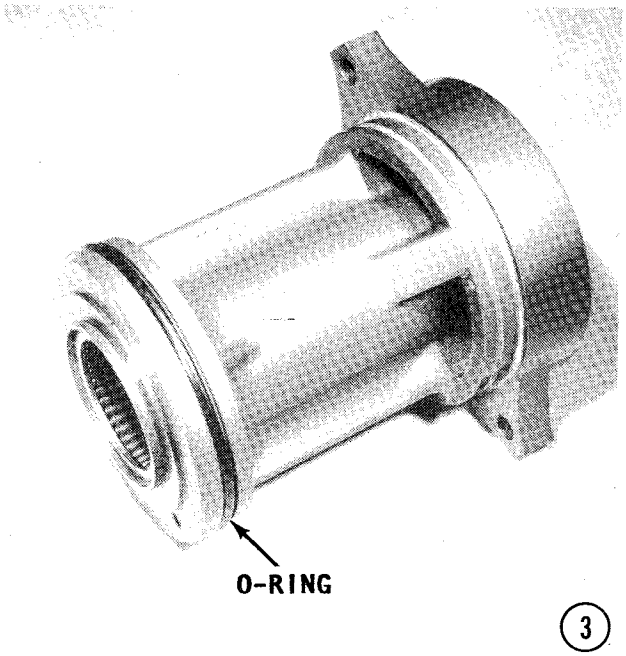
Use a screwdriver and remove both seals. These seals should have been installed back to back. The outer seal prevents water from entering and the other seal prevents oil from escaping.

Obtain Bearing Removal and Installation Kit, C-91-31229A-5. Obtain Mandrel C-91-36569 and Driver Rod C-91-37323, or a suitable substitute mandrel. Insert the removal tools into the forward end of the carrier and press the needle bearing out the rear end of the carrier.

Remove and discard the large O-ring around the carrier.

Propeller Shaft Disassembly

4- Tilt the forward end of the propeller shaft up slightly to prevent loss of the cam



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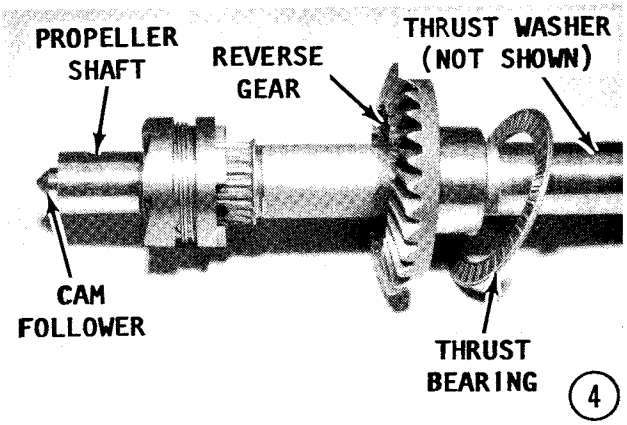

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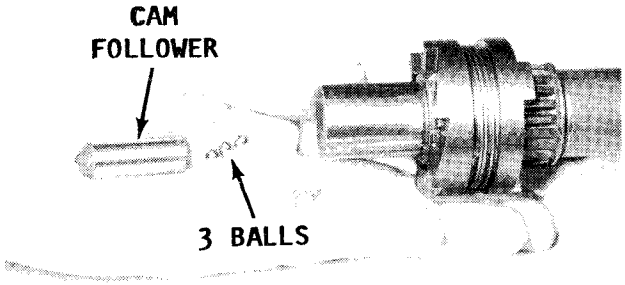
follower and very small parts behind the follower into the depths of the housing. Pull the shaft free of the housing. The reverse gear, a thrust bearing, and a thrust washer will come out with the shaft.

SPECIAL WORDS

Note the absence of any shim material behind the reverse gear. A backlash specification is given by the manufacturer. However, an adjustment is not possible by adding or removing shim material behind the reverse gear.



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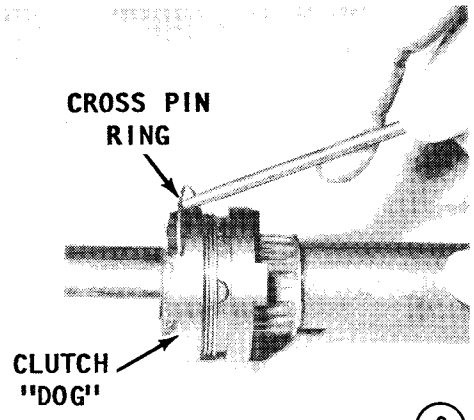

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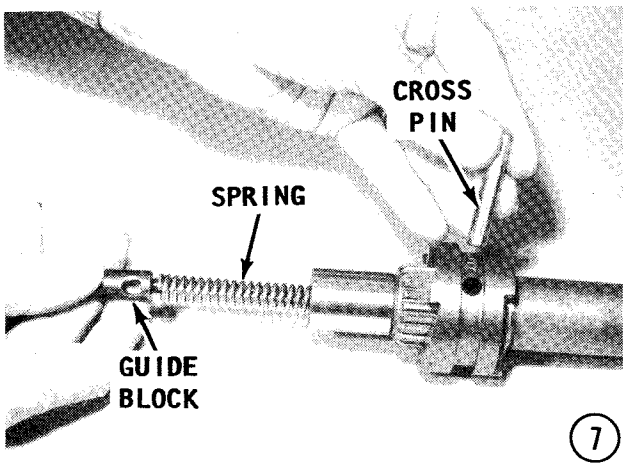

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5- Slide the cam follower, and then the three very small balls from the forward end of the propeller shaft.

6- Insert a thin blade screwdriver or an awl under the first coil of the cross pin ring, and then rotate the propeller shaft to unwind the spring from the sliding clutch. **TAKE CARE** not to overstretch the spring.

7- Push the cross pin clear of the clutch "dog" and the propeller shaft. **BE PREPARED** to catch the guide block and spring when they "fly" free from the end of the propeller shaft.

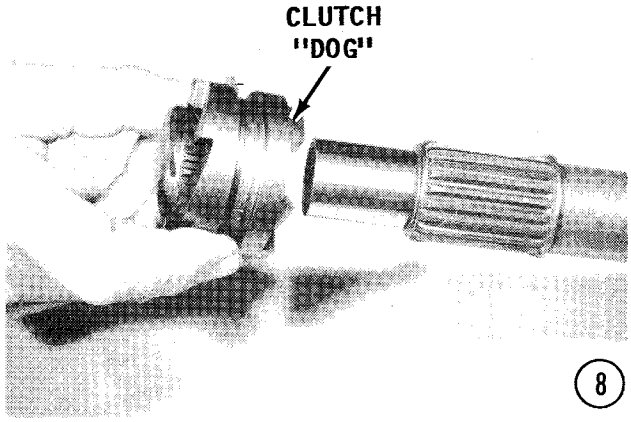
8- Slide the clutch "dog" from the propeller shaft.

Shift Shaft Removal

9- Pull the shift rod boot up and over the shift rod. Pry the circlip off the rod **OR** remove the coupler and nylon spacer, depending on which items are used.

Remove the two attaching bolts and lift the shift rod and shift rod retainer straight up and out of the lower unit. Remove and discard the **O**-ring around the retainer.

If the rod will not come free, leave this task until later, after Step 14 has been ac-



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complished, and there is more access to the shift cam at the lower end of the shift rod.

Pinion Nut and Pinion Gear Removal

10- Select a box end wrench the same size as the pinion nut. This tool will be used to prevent the nut from turning as the driveshaft is rotated. Obtain Driveshaft Holding Tool, C-91-56775.

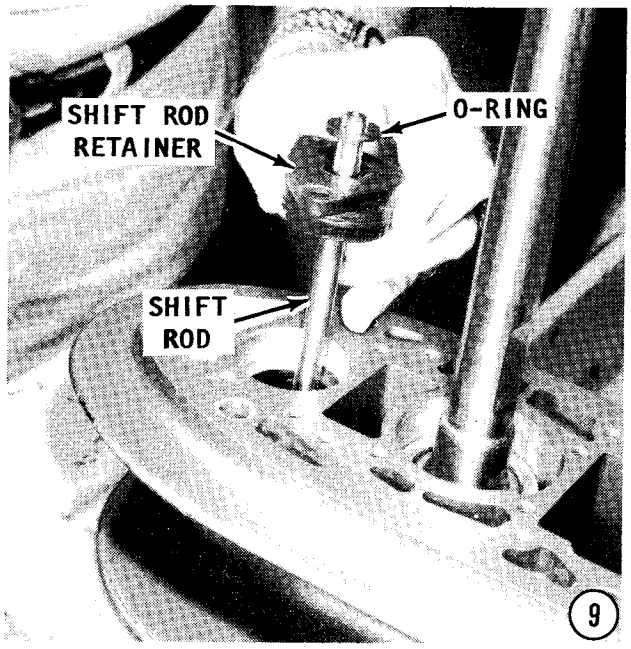
Install the holding tool onto the end of the driveshaft. Now, with the box end wrench on the pinion gear nut, use an appropriate wrench and rotate the tool and driveshaft **COUNTERCLOCKWISE** until the pinion gear nut is free. Remove the nut and the pinion gear assembly.

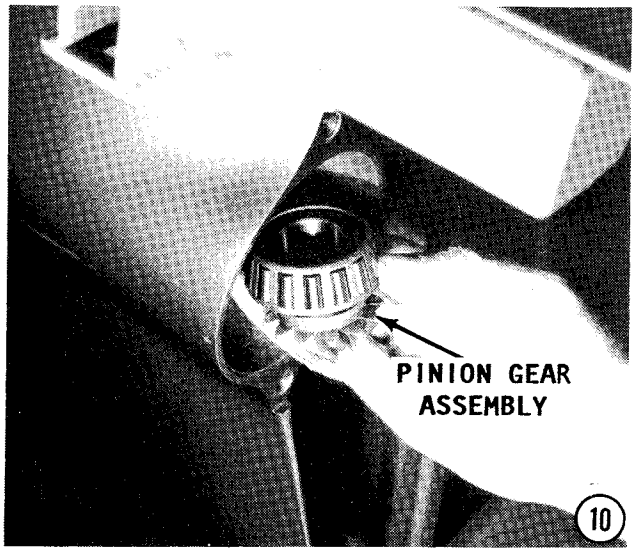
Set aside the old pinion gear nut. The manufacturer recommends the nut **NOT** be used a second time. Once the nut has been removed it loses its designed locking characteristics. The old pinion nut will be temporarily installed on the driveshaft for shimming and backlash calculations, and then removed and discarded.

GOOD WORDS

The driveshaft tapered roller bearing is pressed onto the pinion gear. If the bearing is no longer fit for further service, the bearing can be separated from the gear by performing Step 11. If the bearing is satisfactory, proceed directly to Step 12.

11- Obtain and position Universal Puller Plate, C-91-37241 between the pinion gear and the tapered roller bearing. Place the





puller plate and gear, with the gear on the bottom, in an arbor press. Use a suitable mandrel and press the gear free of the bearing. The mandrel **MUST** contact the gear collar, but clear the bearing cage.

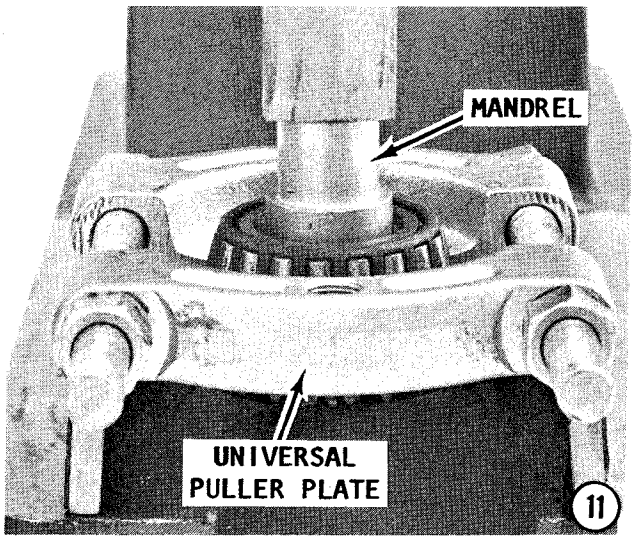
BAD NEWS

Once the bearing has been removed, it **CANNOT** be used a second time. The roller cage will be distorted during the removal process.

Driveshaft Removal

12- Pull the driveshaft up and out of the lower unit housing.

Remove and discard the sealing ring around the driveshaft. Inspect the condition of the wear sleeve at the lower end of the driveshaft. If the sleeve is worn or distorted it will allow water to enter the lower unit. To remove the wear sleeve, support the driveshaft in a universal bearing separa-



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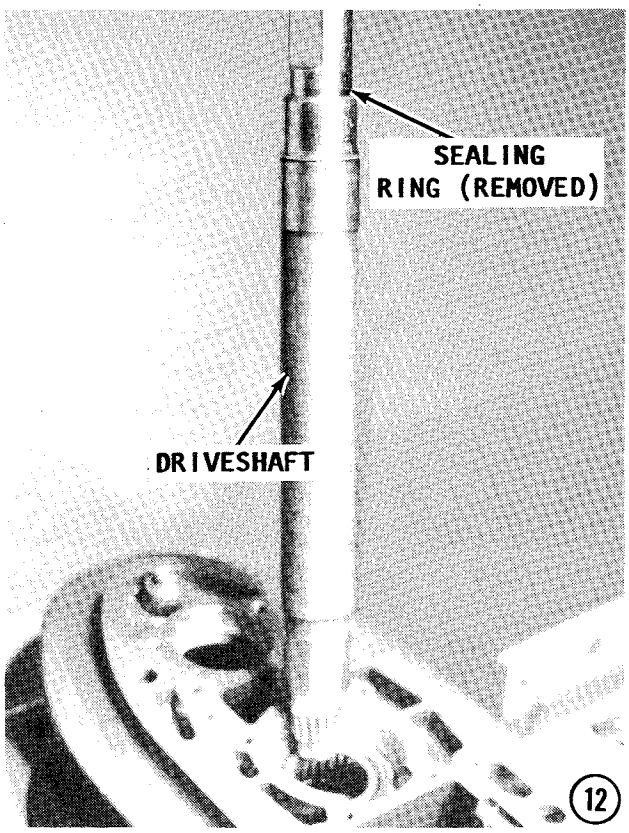
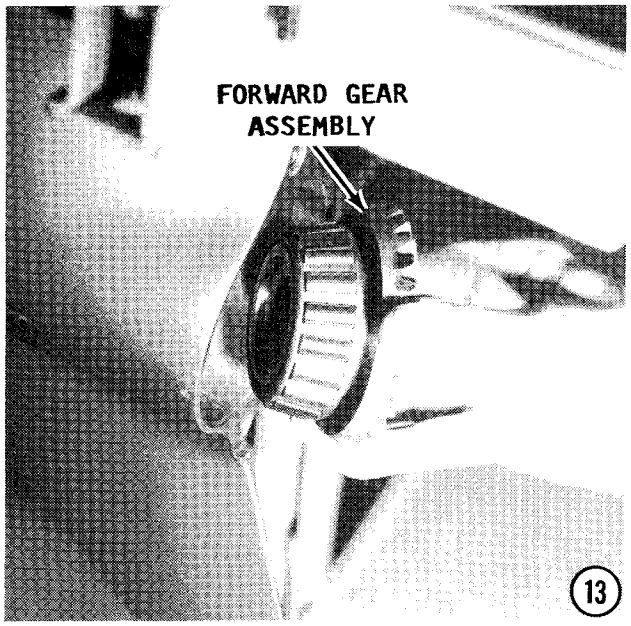
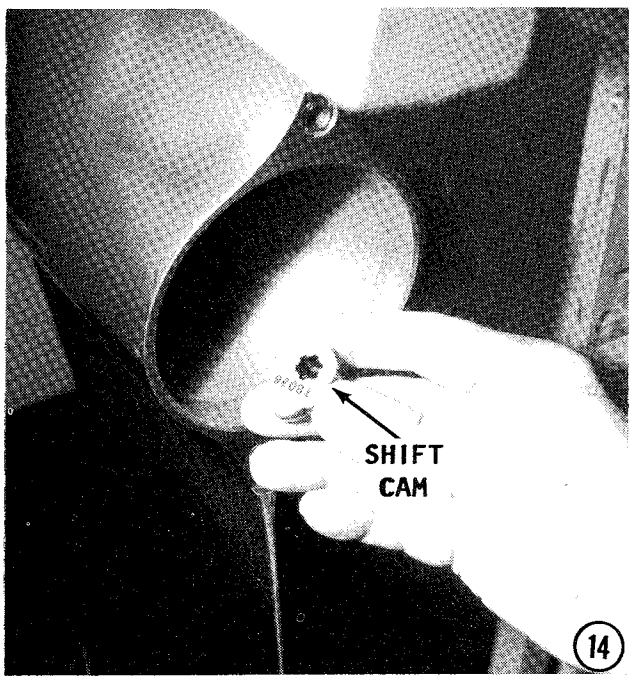


tor tool, resting over an open vice. Carefully, using a soft head mallet, tap the upper splined driveshaft end to force the wear sleeve up and free of the driveshaft.

Forward Gear Needle Bearing Removal

13- After the pinion gear and driveshaft have been removed, the forward gear assembly and associated bearing can be lifted out of the housing.

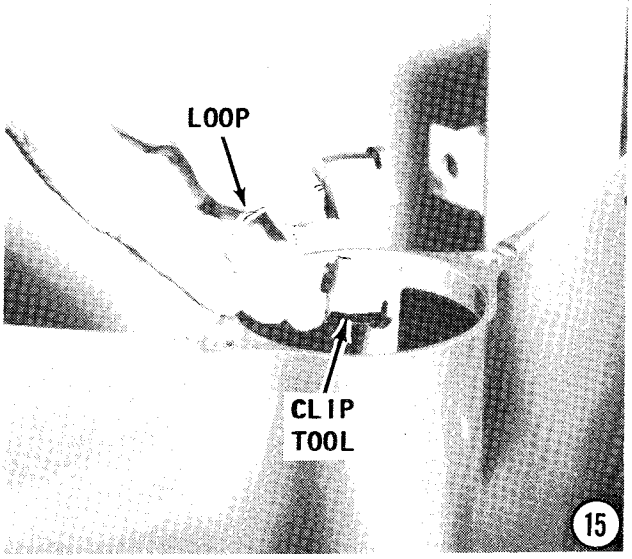




BEARING WORDS

The forward gear tapered roller bearing is pressed onto the short shaft of the gear assembly. A needle bearing is a snug fit in the inner bore of the gear assembly, as indicated in the exploded drawing on Page 11-43.

The needle bearing supports the forward end of the propeller shaft. If the needle bearing is no longer fit for further service, it can be removed by tapping, with a blunt punch and hammer, around the bearing cage from the aft end -- the gear end -- of the bearing. This action will destroy the bearing cage. Therefore, be sure a replacement bearing is on hand, before attempting to remove the defective bearing.



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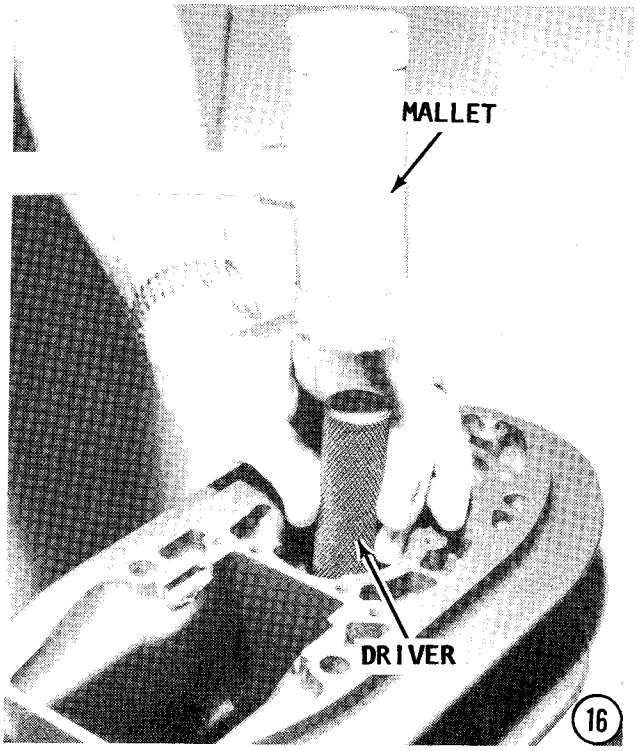


14- Reach into the housing and pull out the shift cam. If the attempt to remove the shift shaft failed in Step 9 of these disassembly procedures, the shaft will still be engaged with the cam. Attempt to "wiggle" the cam free of the shaft. An application of penetrating oil dribbled down the shaft and sprayed into the housing may help the cam come free.

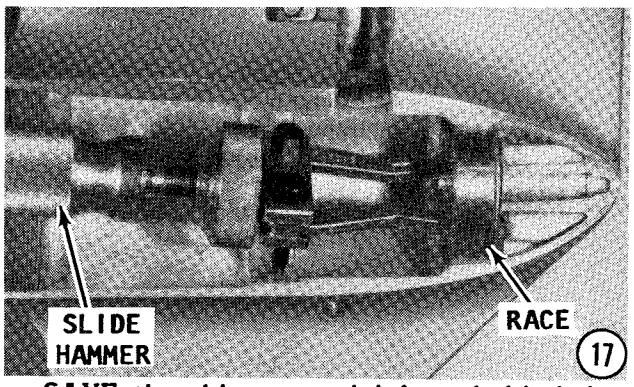
BEARING RACE WORDS

If the forward gear tapered roller bearing or the pinion gear tapered roller bearing was removed, the race of the affected bearing **MUST** also be removed. The bearing and the race must be installed as a set. A wear pattern will have been worn in the race by the old bearing. Therefore, if the race is not replaced, the new bearing will be quickly worn by the old worn race.

Pinion Gear Bearing Race Removal

15- The upper drive shaft bearing and oil sleeve need not be disturbed for this procedure. Obtain Bearing Race Tool C-91-1430A1. Insert the clip tool against the race with the spring loop in the propeller shaft cavity.

16- Place the driver down through the top of the lower unit to index into the clip tool. Tap the driver with a hammer or mallet until the race is driven free of the housing.



SAVE the shim material from behind the race. The same amount of shim material will most likely be required during assembly.

Forward Gear Bearing Race Removal

17- Remove the forward gear tapered roller bearing race using a slide hammer.

SAVE any shim material from behind the race after the race is removed. The same amount of shim material will probably be used during assembly.

Upper Driveshaft Roller Bearing Removal

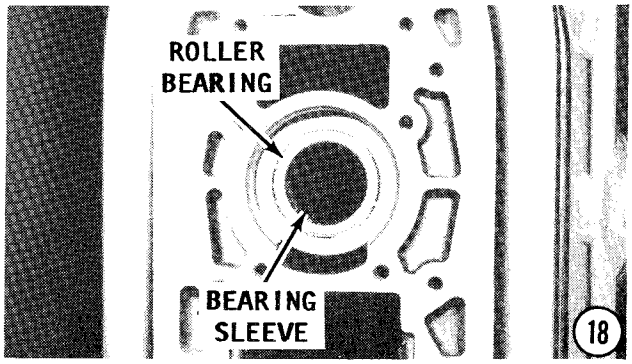
18- Inspect the condition of the upper driveshaft roller bearing -- not the tapered bearing. The bearing is a one piece unit. If defective, it can be removed using a slide hammer with puller jaw attachment.

The roller bearing is pressed into a bearing sleeve, then the sleeve is pressed into the driveshaft bore. To remove the bearing and sleeve, hook the puller jaws first around the roller bearing and pull it from the sleeve. Then hook the jaws under the sleeve and pull the sleeve from the driveshaft.

If necessary, remove the oil sleeve behind the bearing using the same tool.

CLEANING AND INSPECTING

See Section 11-9, beginning on Page 11-86 for detailed comprehensive procedures to clean and inspect all parts of the lower unit.



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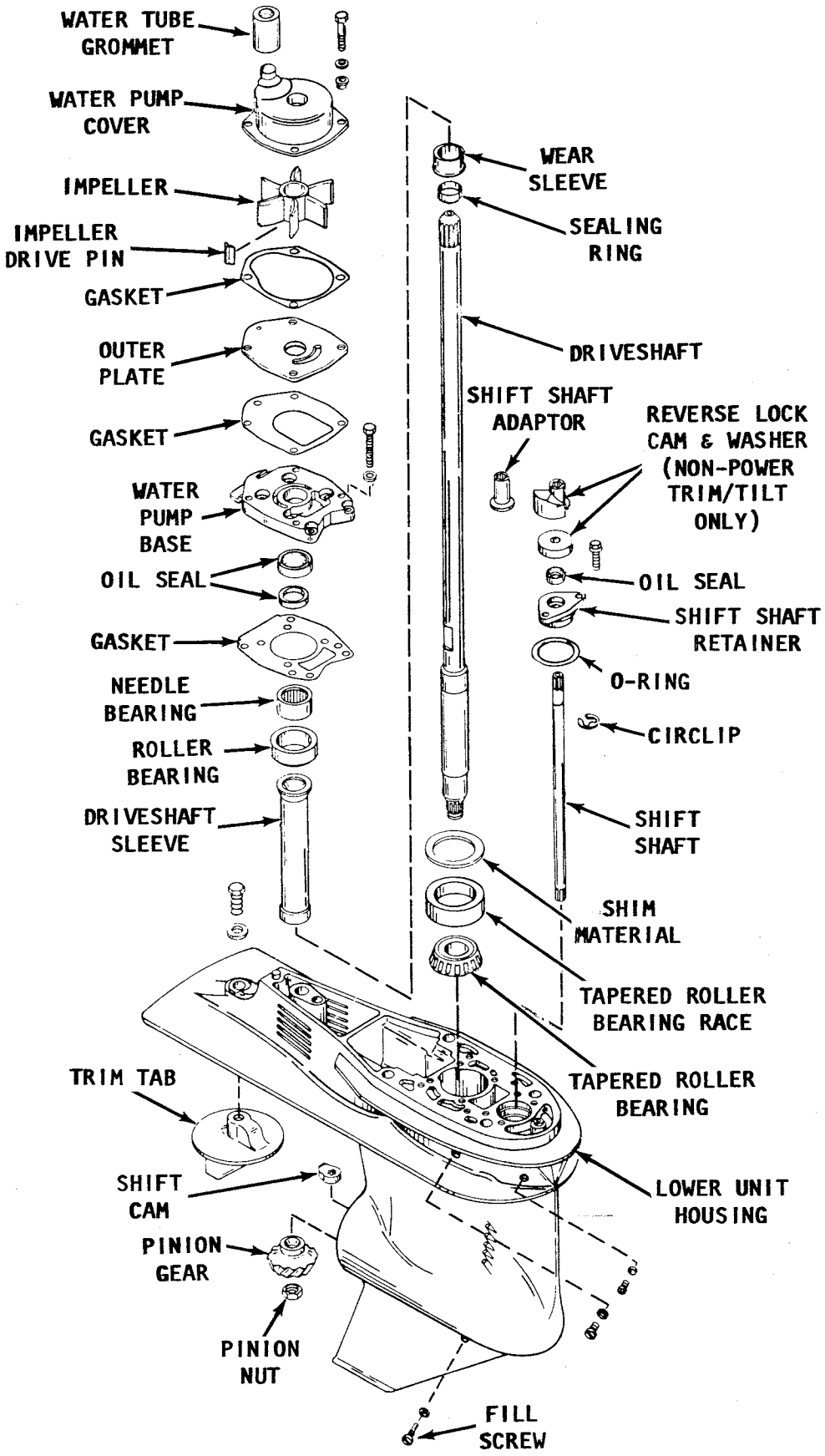

Exploded drawing of the driveshaft and water pump of a Cam-Shift Type II lower unit. Major parts are identified.

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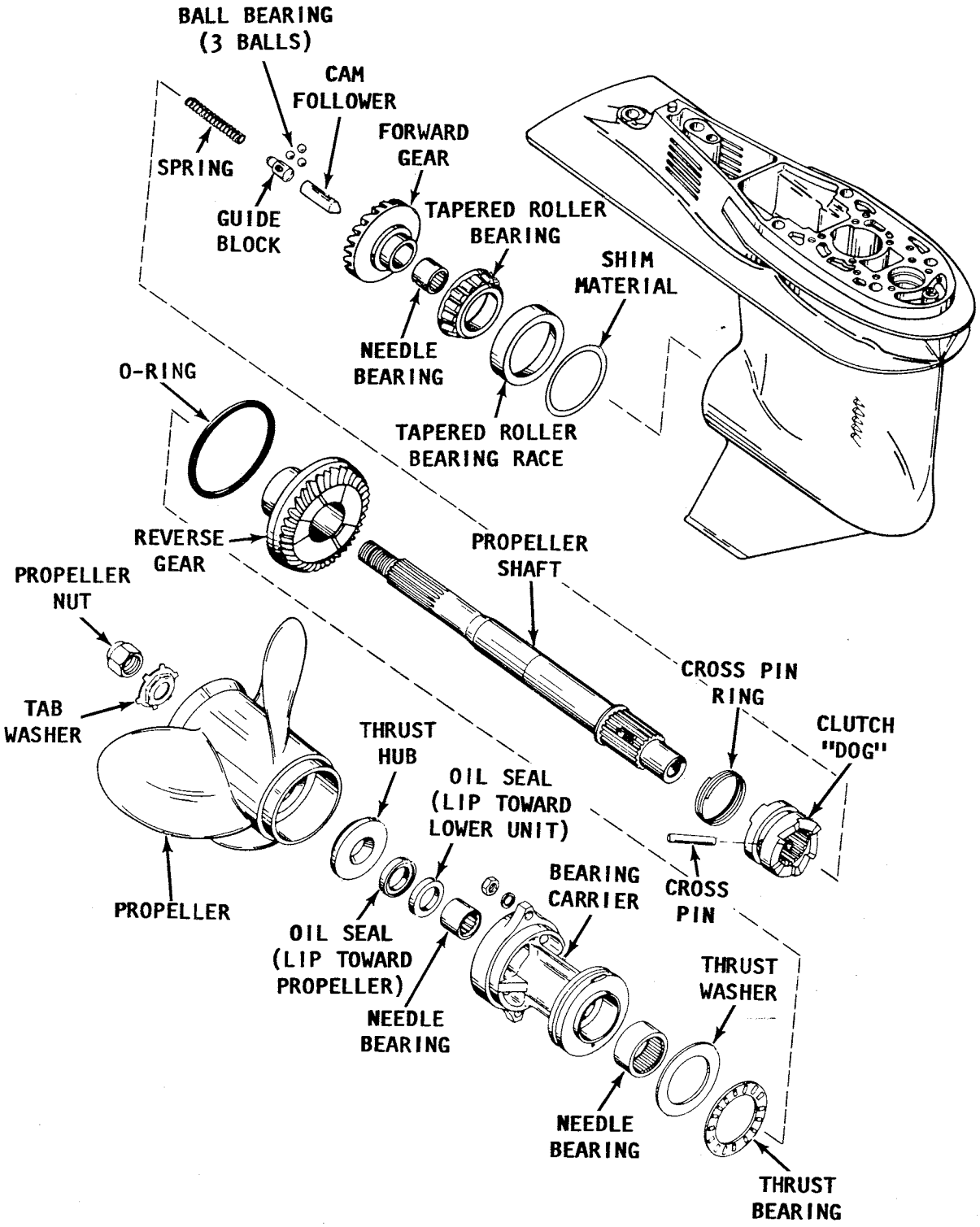

Exploded drawing of the propeller shaft and shifting mechanism of a Cam-Shift Type II. Major parts are identified.

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ASSEMBLING CAM SHIFT TYPE II

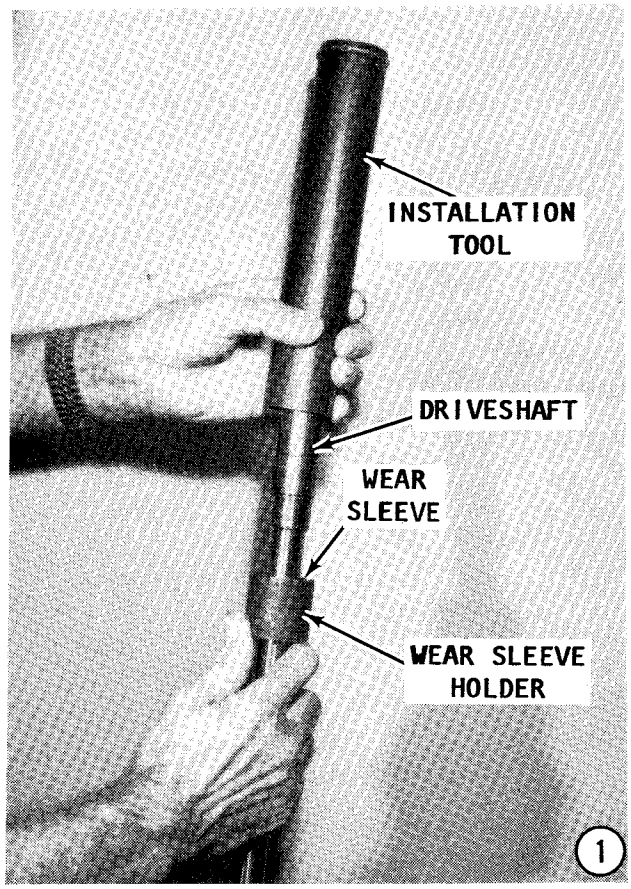
The following procedures outline complete detailed instructions to install virtually all parts of the lower unit. If a particular part was found to be in satisfactory condition and was not removed, simply skip the steps involved and proceed with the required tasks to return the lower unit to efficient operation.

CRITICAL WORDS

Before beginning the installation work, count the number of teeth on the pinion gear and on the reverse gear. Not necessary to count the forward gear. Knowing the number of teeth on the pinion and reverse gear will permit obtaining the correct tool setup for the shimming procedure.

Driveshaft and Wear Sleeve Installation

1- If the wear sleeve was removed in Step 12 of disassembling, obtain Wear Sleeve Installation Tool C-91-14310A1. Insert the new wear sleeve into the sleeve holder. Slide the bottom end of the driveshaft into the sleeve and holder. Slide the long collar portion of the installation tool over the top end of the driveshaft.



Move the assembled tool and driveshaft to an arbor press. Position the base of the sleeve holder onto a suitable support which will allow the bottom end of the driveshaft to pass through. Press on the top surface of the long collar until the bottom surface of the collar seats against the top surface of the sleeve holder.

Install a new sealing ring around the driveshaft, and then apply a light coating of Loctite Grade "A" around the ring.

Set the driveshaft aside for later installation.

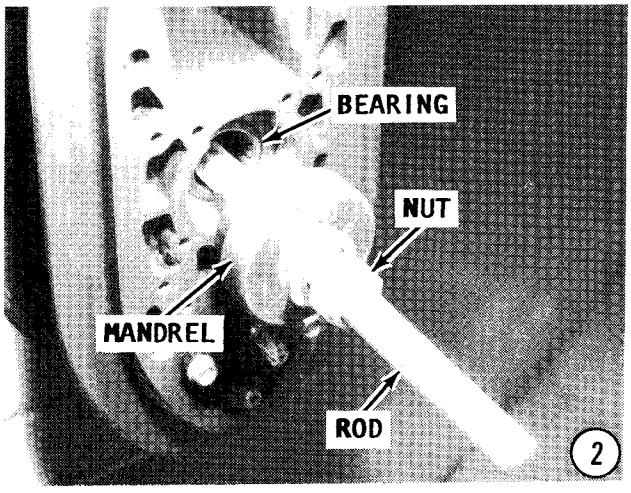
Upper Driveshaft Bearing Installation

2- Apply a light coating of Quicksilver Needle Bearing Lubricant to the inner surface of the bearing sleeve.

Identify the end of the new roller bearing with the embossed numbers. Identify the end of the bearing sleeve with a slight taper. Place the tapered end down on the arbor press support plate. Insert the new roller bearing down into the larger end of the bearing sleeve with the numbered end facing **UPWARD.** Obtain a suitable mandrel and press the bearing in until it is flush with the sleeve.

If the oil sleeve was removed from the driveshaft bore in Step 17 of disassembly, install the sleeve into the bore with the tab on the upper portion of the sleeve facing **AFT.** This sleeve **MUST** be in place **BEFORE** the upper driveshaft bearing is installed.

To install the upper driveshaft bearing, obtain the following special tools: Two mandrels from Bearing Installation Tool Kit C-91-14309A1, a long threaded rod C-91-31229, and a special nut C-11-24156.



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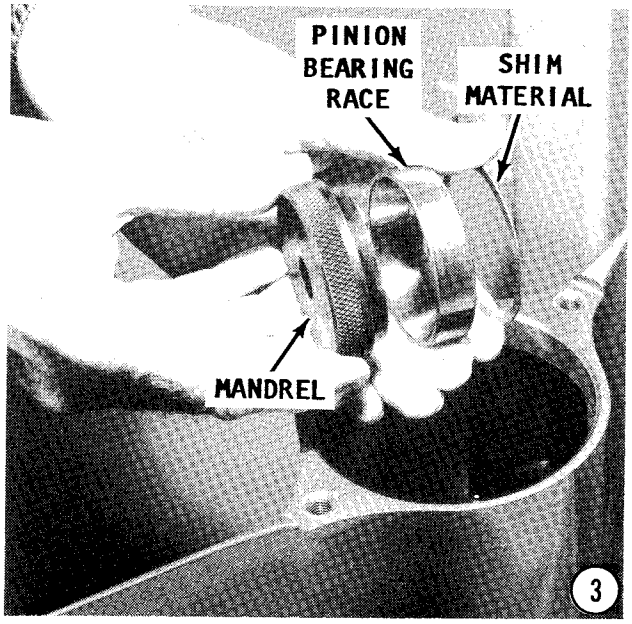
Thread the nut onto the rod until the nut is about 2/3 of the way up. Hold the shorter of the two mandrels inside the lower unit under the driveshaft bore. Insert the threaded rod into the bore and thread the mandrel onto the rod until the mandrel is secure. Place the assembled roller bearing and sleeve over the threaded rod, into the cavity, and with the flush/numbered side facing **UPWARD.** Slide the other mandrel over the threaded rod with the shoulder side **DOWN** to fit inside the sleeve.

Now, thread the nut on the rod down against the upper mandrel until all slack (clearance) is removed from the setup. With the proper size wrench on the top of the rod, prevent the rod from rotating, and at the same time rotate the nut **CLOCKWISE** down against the upper mandrel. As the nut is rotated the two mandrels will come closer together. This action will seat the bearing and sleeve assembly. When the shoulder of the upper mandrel makes contact with the upper face of the lower unit, the bearing/sleeve assembly is correctly positioned in the driveshaft bore.

Remove the special tools.

Pinion Gear Bearing Race Installation

3- Using the same special tool setup employed in the previous step, the pinion gear bearing race can be installed. Set the pinion gear bearing race onto the shorter mandrel with the taper **TOWARD** the mandrel. Place the same amount of shim material, removed in Step 16 of disassembly, on top of the race.



GOOD WORDS

If the shim material was misplaced or not recorded, begin with material totalling 0.025" (0.635mm). Remember, shim material must be measured **INDIVIDUALLY** and the thickness of each added to arrive at the total thickness. Never use a micrometer to measure the total thickness of several pieces of shim material. Such a procedure results in a very inaccurate measurement and will lead to incorrect shimming of the lower unit.

Step 3 continues. Insert the threaded rod thru the shim material, the bearing race, and into the mandrel. Assemble the tool as described in the previous step. The upper driveshaft bearing has already been installed in Step 2. Install the pinion gear bearing race in the same manner.

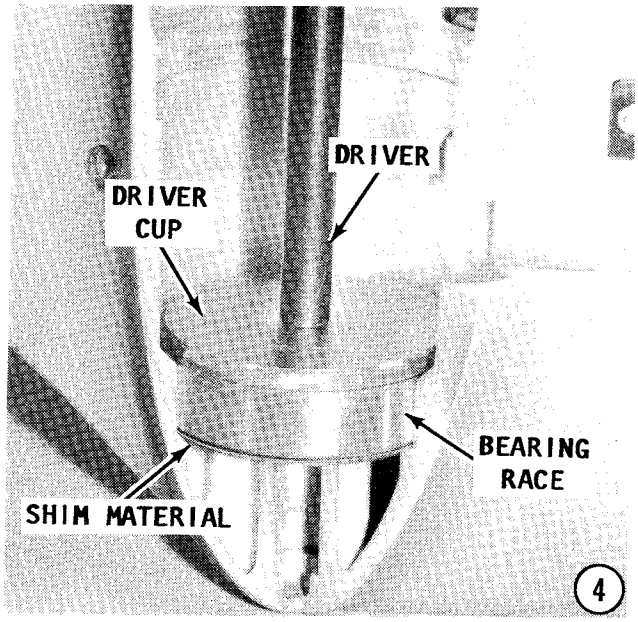
Forward Gear Tapered Roller Bearing Race Installation

CRITICAL WORDS

The bearing carrier is used as a pilot while installing the forward gear bearing race in the next step. Therefore, the bearing carrier must be temporarily assembled to include at least the propeller shaft roller bearing.

Forward Bearing Race Installation

4- Place the same amount of shim material saved during disassembly, Step 17, into the lower unit. If the shim material was



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lost, or if a new lower unit is being used, begin with approximately 0.010" (0.25mm) material. Coat the forward bearing race bore with Quicksilver Formula 50-D lubricant, or equivalent.

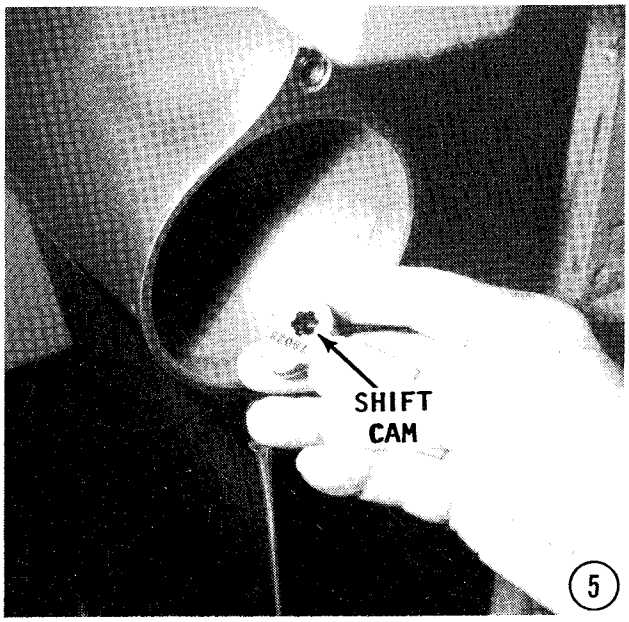
Position the tapered bearing race squarely over the bearing bore in the front portion of the lower unit. Obtain Bearing Driver cup tool C-91-31106. Place the tool over the tapered bearing race.

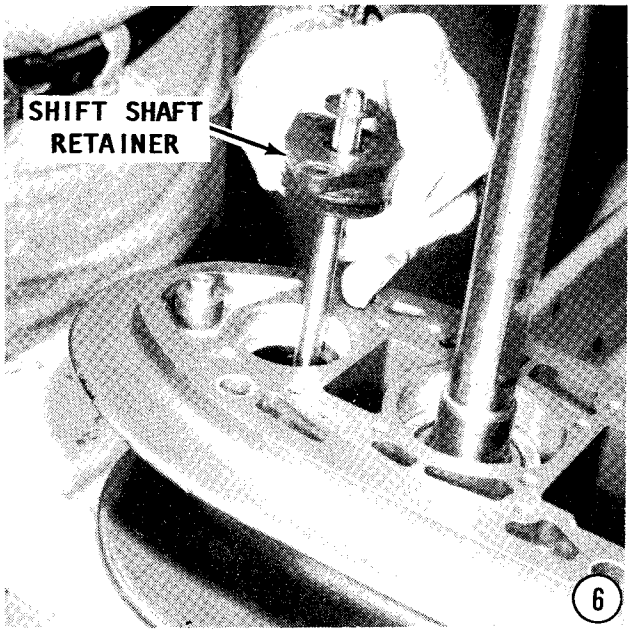
Insert the propeller shaft into the hole in the center of the bearing race. Lower the bearing carrier assembly down over the propeller shaft, and then lower it into the lower unit. The bearing carrier will serve as a pilot to ensure proper bearing race alignment. Now, use a mallet and drive the propeller shaft against the bearing driver cup until the tapered bearing race is seated against the shim material. Withdraw the propeller shaft and bearing carrier, then lift out the driver cup.

Shift Shaft Installation

5- Place the cam into the forward portion of the lower unit between the cast webbing. The ramps on the shift cam **MUST** be visible from the rear of the lower unit and the longer side, the reverse ramp, **MUST** be toward the left side, the fill screw hole side. The numbered face of the shift cam must face **UPWARD.**

6- Install a new O-ring around the shift rod retainer. Place the lower shift shaft, the short spline end, into the shift shaft cavity. Rotate the shift shaft to allow the shaft splines to index with the cam splines.

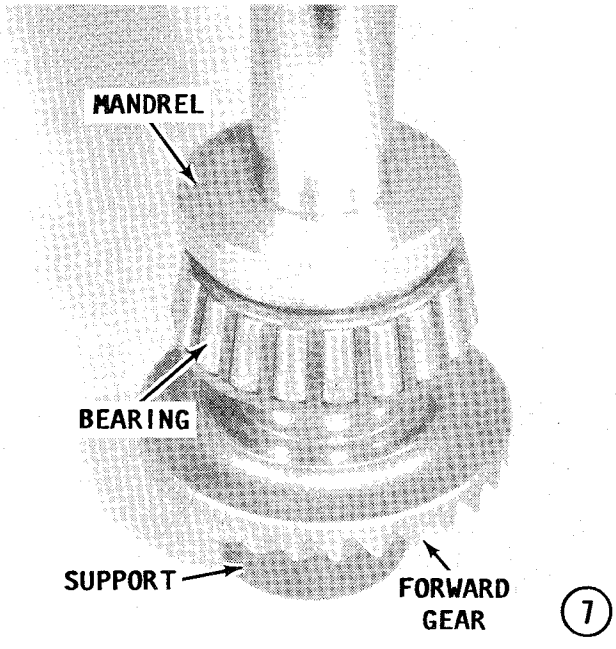




Tap the retainer evenly into the shift shaft cavity. Apply Loctite Grade "A" to the threads of both securing bolts. Install and tighten the bolts to a torque value of 60 in lbs (6.8Nm). Install the coupler and nylon spacer, or boot, depending on the item used.

Forward Gear and Bearing Assembling

7- Place the forward gear on a press with the gear teeth **DOWN.** Position the forward gear tapered bearing over the gear. Now, press the bearing onto the gear with a suitable mandrel until the bearing is firmly seated. Press on the inner bearing race **ONLY.** Pressing on the bearing cage will distort the bearing. Check for clearance



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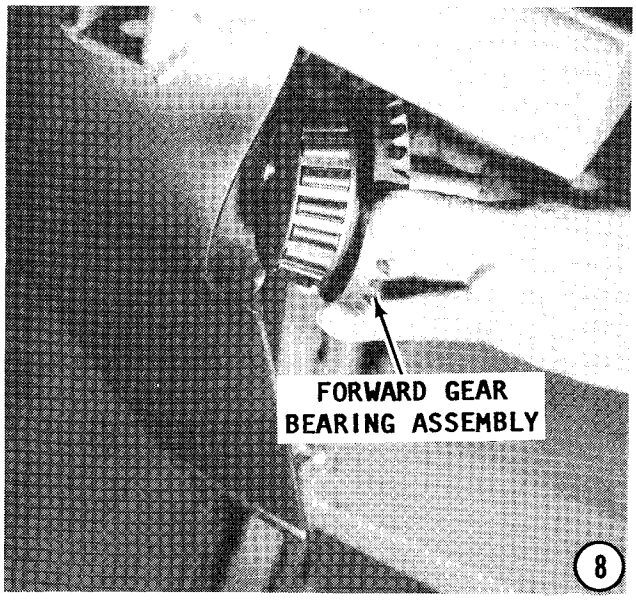
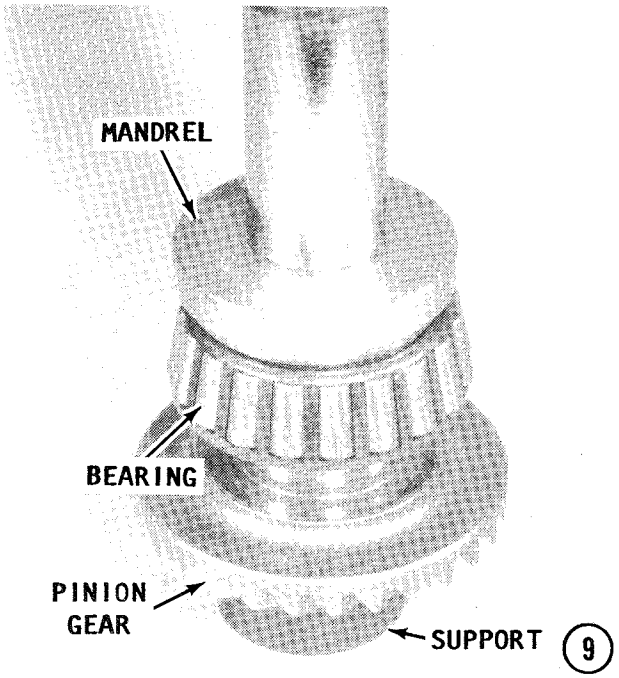


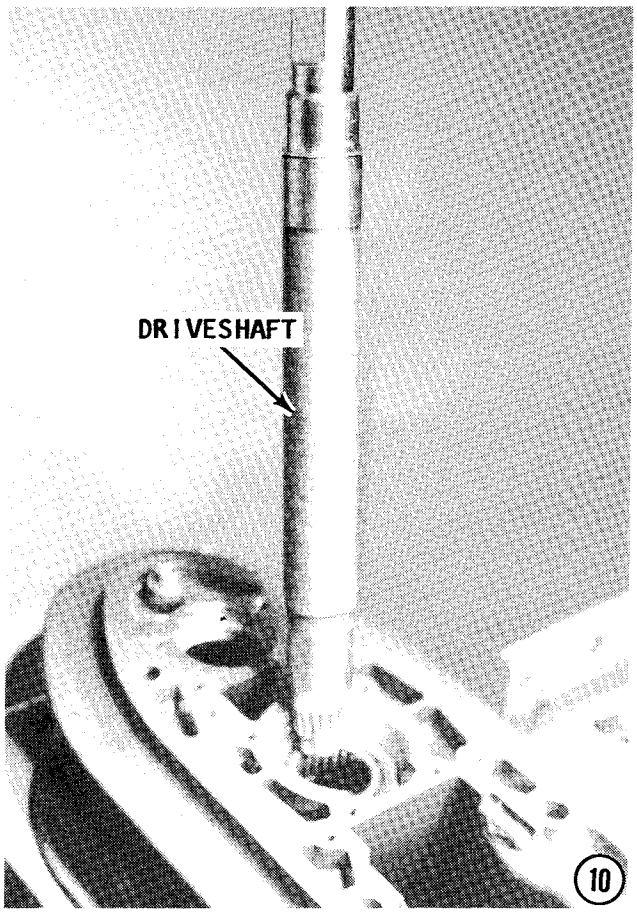
(gap) between the inner bearing race and the shoulder of the gear. There should be **NO** clearance.

Position the roller bearing over the center bore of the forward gear with the numbered side of the bearing facing **UP.** Use a suitable mandrel and press the roller bearing into the gear until the bearing is seated against the shoulder.

8- Insert the forward gear assembly into the forward gear bearing race.

9- Place the pinion gear on a press with the gear teeth **DOWN.** Position the pinion gear tapered bearing over the gear. Now, press the bearing onto the gear with a suitable mandrel until the bearing is firmly seated. Press on the inner bearing race **ONLY.** Pressing on the bearing cage will distort the bearing. Check for clearance (gap) between the inner bearing race and the shoulder of the gear. There should be **NO** clearance.

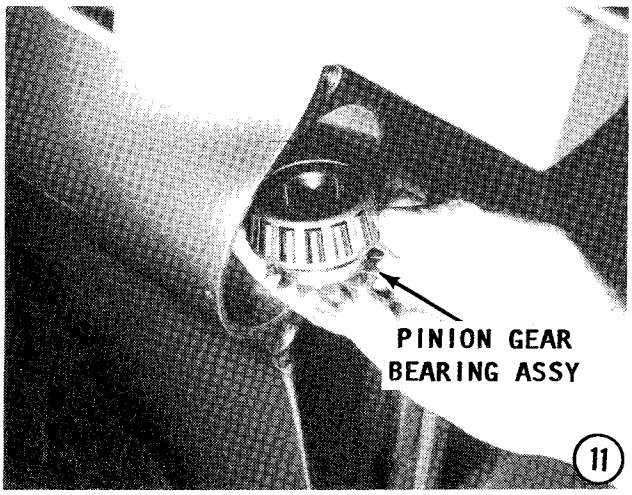




Driveshaft Installation

10- With one hand, lower the driveshaft into the top of the lower unit.

11- With the other hand, hold the pinion gear up in the lower unit below the



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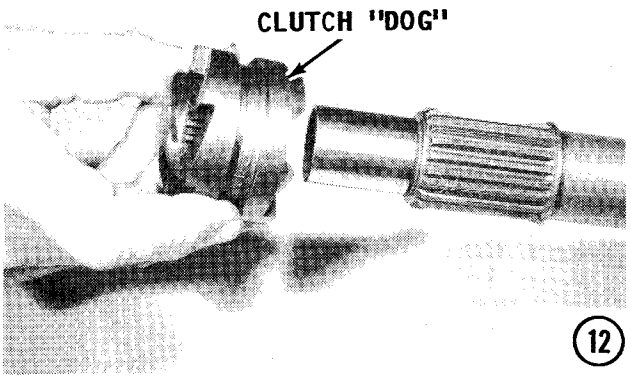

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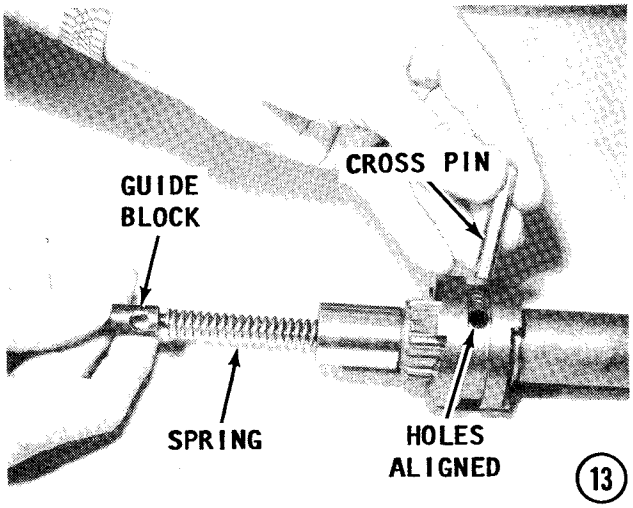

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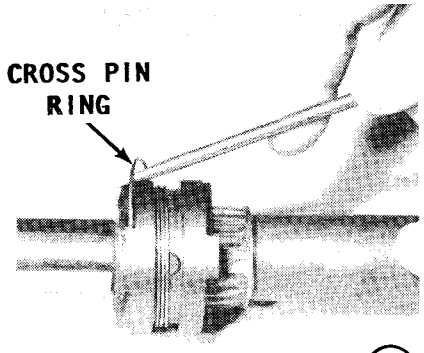

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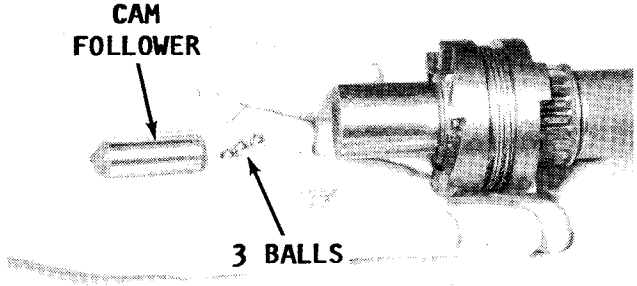

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driveshaft cavity and with the teeth of the gear indexed (meshed) with the teeth of the forward gear.

Now, rotate and insert the driveshaft until the driveshaft splines align and engage with the splines of the pinion gear. Continue to insert the driveshaft into the pinion gear until the tapered bearing is against the bearing race. Use the old pinion nut for this step, because if a new nut is used, it will lose its locking characteristics. Start the nut onto the end of the driveshaft.

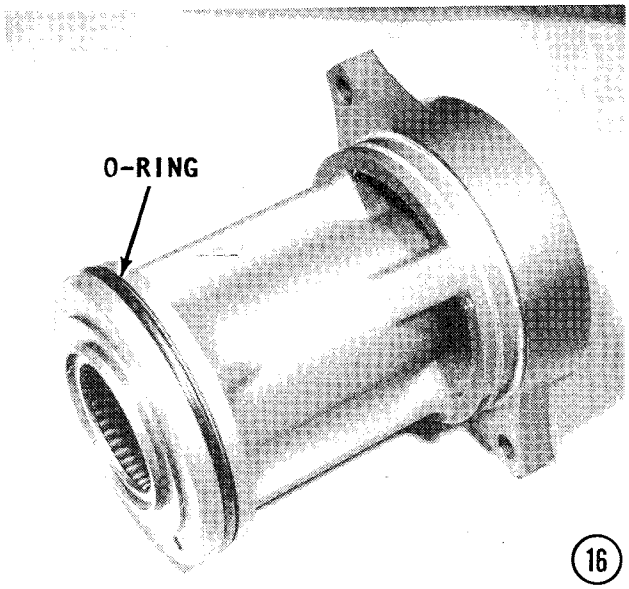
Install the **OLD** pinion gear nut onto the driveshaft. Hold the pinion nut with a socket wrench. Pad the area where the socket wrench flex handle will contact the lower unit while the pinion nut is being tightened. Obtain Drive Shaft Nut Wrench C-91-56775. Place the special wrench over the upper end of the driveshaft. Use a torque wrench and socket to tighten the nut to a torque value of 70 ft lbs (95Nm).

SPECIAL WORDS

After the pinion gear depth and the forward gear backlash have been set, the old nut **MUST** be replaced with a **NEW** pinion gear nut. Once the nut is tightened and removed, the nut looses some of its locking characterics.

Propeller Shaft Assembling

12- Align the hole through the clutch "dog" with the slot in the propeller shaft, and then slide the "dog" onto the clutch with the "square" teeth facing the propeller end of the shaft. The teeth with the "slanted" ramps face **FORWARD.**



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13- Insert the spring into the end of the propeller shaft. Insert the guide block, stepped end, into the front end of the propeller shaft with the cross-pin hole aligned with the cross-pin hole in the sliding clutch.

Temporarily insert the flat end of the cam follower into the front end of the propeller shaft. Position the cam follower against a solid object and push against the cam follower to compress the spring. Hold the propeller shaft in this position and at the same time, use a punch to align the guide block cross-pin opening with the sliding clutch cross-pin hole. Remove the punch and insert the cross-pin. Release pressure on the spring. Remove the cam follower.

14- Install the cross-pin ring over the sliding clutch. **TAKE CARE** not to over stretch the spring.

15- Insert just a little water resistant Multipurpose Lubricant into the end of the propeller shaft. Insert the three very small steel balls. Set the propeller shaft aside ready for later installation.

GOOD WORDS

When handling the assembled propeller shaft, **TAKE CARE** to keep the forward end tilted slightly **UPWARD** to keep the small balls and other parts in place inside the shaft.

MORE GOOD WORDS

The following steps provide detailed instructions to assemble all parts of the bearing carrier. If any parts covered were not disturbed during disassembling, simply skip the steps involving those parts and continue with the necessary tasks.

Bearing Carrier Assembling

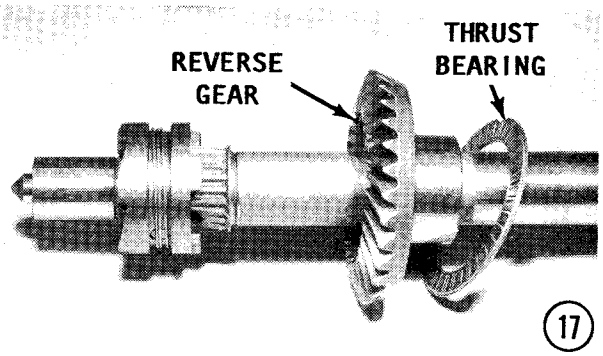
16- Position the smaller propeller shaft roller bearing into the aft end of the bearing carrier with the numbered side **TOWARD** the aft end. Press the needle bearing into the bearing carrier with mandrel C-91-37263 or other suitable mandrel.

Coat the outer diameter of the propeller shaft oil seals with Loctite Type "A". Obtain Oil Seal Driver C-91-31108. Place one seal on the longer shoulder side of the driver tool with the lip of the seal **AWAY** from the shoulder. Press the seal into the bearing carrier until the seal driver bottoms against the bearing carrier. Place the second seal on the short shoulder side of the seal driver with the lip of the seal **TOWARD** the shoulder.

Press the seal into the bearing carrier until the seal driver bottoms against the bearing carrier. Clean excess Loctite from the seals.

Position the larger propeller shaft roller bearing into the forward end of the bearing carrier with the numbered side **TOWARD** the forward end. Press the roller bearing into the bearing carrier using Mandrel C-91-13945 or equivalent substitute. Install a new **O**-ring around the carrier. Apply a coating of Special Lubricant 101 C-92-13872A1 onto the installed **O**-ring.

17- Slide the reverse gear and thrust bearing onto the propeller shaft. Check to



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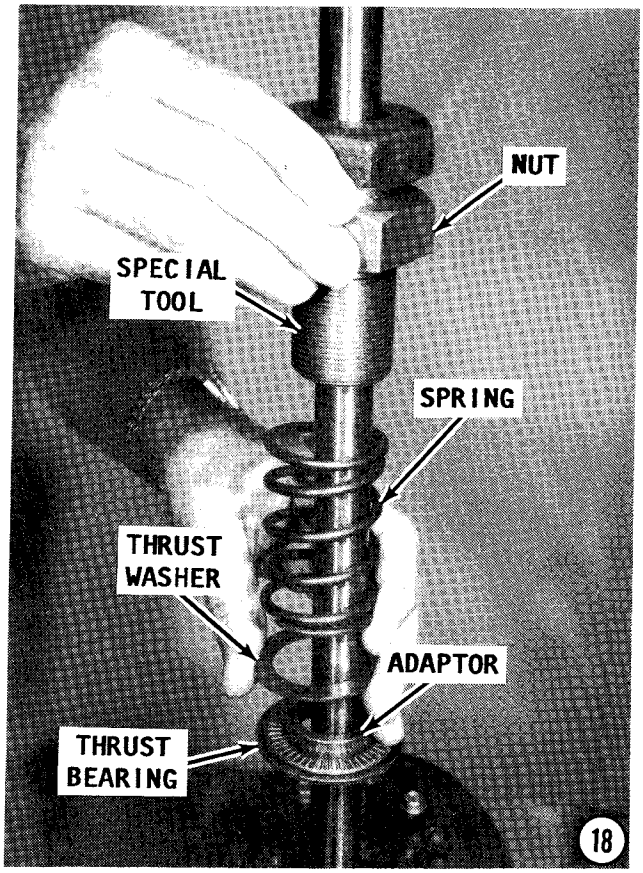

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be sure the cam follower and the three very small steel balls are still in place inside the shaft. Set the bearing carrier aside with the propeller shaft, ready for later installation.

Pinion Gear Depth

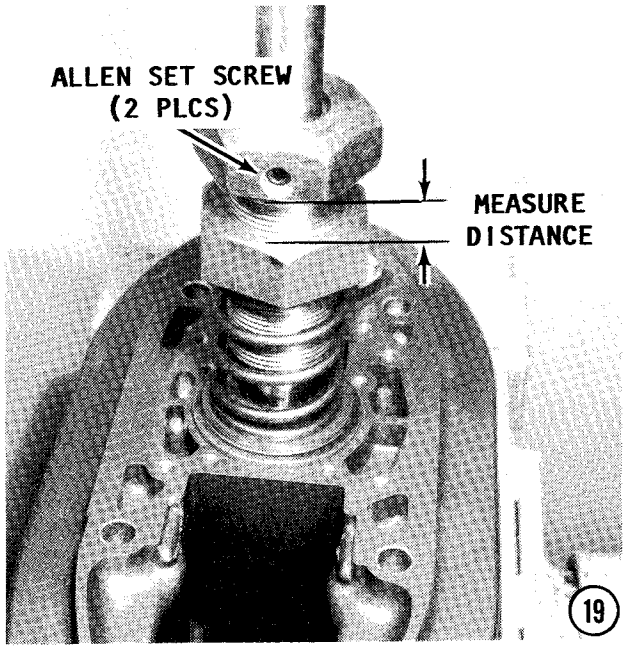
18- Obtain Bearing Preload Tool C-91-14311A1. This tool consists of a spring, which seats aganst the lower unit and is used to simulate the **UPWARD** driving force on the pinion gear bearing. Install the following, one by one, over the driveshaft:

a- Adaptor, with the flat face down against the lower unit
b- Thrust bearing
c- Thrust washer
d- Spring
e- Special large bolt, with the nut on the bolt threaded all the way to the top of the threads.
f- Sleeve, with two holes

19- Align the two holes in the sleeve with the two Allen set screws in the bolt head. These two set screws grip the driveshaft and prevent the tool from slipping on the driveshaft. Tighten the two set screws securely with the Allen key provided with the tool kit.

Measure the distance between the bottom surface of the bolt head and the top surface of the nut. Record this measurement.

Use a wrench to hold the bolt head steady and another wrench to tighten the nut down against the spring. Continue tightening the nut until the distance between the bottom surface of the bolt head and the top surface of the nut equals 1.00" (25.4mm) **plus** the distance recorded when the tool was installed.



The driveshaft has now been forced **UPWARDS** placing an **UPWARD** preload on the pinion gear bearing.

20- Obtain Pinion Gear Locating Tool C-91-12349A2. Insert the tool into the installed forward gear assembly. If positioned correctly, one of the flats on the gauging block should be positioned directly under the pinion gear teeth.

Notice the gauging block has a series of flat sides, identified by the numbers 1 thru 8. The eight different numbered faces are needed for use with different combinations of gear ratios. Only two gear ratios are used on units covered in this manual. At the beginning of this section, the assembler was asked to count and record the number of teeth on the pinion and reverse gears. The reason for the count is as follows:

If the pinion gear has 13 teeth and the reverse gear has 30 teeth, the gear ratio is 13/30. With this gear ratio, face No. 8 is positioned closest to the pinion gear.

If the pinion gear has 14 teeth and the reverse gear has 29 teeth, the gear ratio is 14/29. With this gear ratio, face No. 2 is positioned closest to the pinion gear.

SPECIAL WORDS

No other gear ratio combinations are possible for units covered in this manual. If another "odd-ball" gear ratio is encountered, somewhere, sometime, someone has purposely changed the gear ratio to suit their own requirements, possibly for operation of the outboard at different altitudes. Therefore, factory specifications would no longer apply. Should this occur, consult your local dealer for advice. He will probably advise you to put the lower unit back together as you found it, wait for it to fail and replace the failed parts to meet with a factory specified gear ratio.

Lets' assume everything is as it should be and the appropriate tool face to use is determined. Position this face (either No. 8 or No. 2) under the pinion gear teeth. Install the locating disc over the tool shank with the access hole facing **UPWARD.** Push the disc all the way into the lower unit until

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it rests against a machined shoulder of the bore. This disc supports the tool shank in the lower unit bore.

21- The pinion depth is the distance between the bottom of the pinion gear teeth and the flat surface of the gauging block.

Measure this distance by inserting a long feeler gauge into the access hole and between the pinion gear teeth and gauging block flat face.

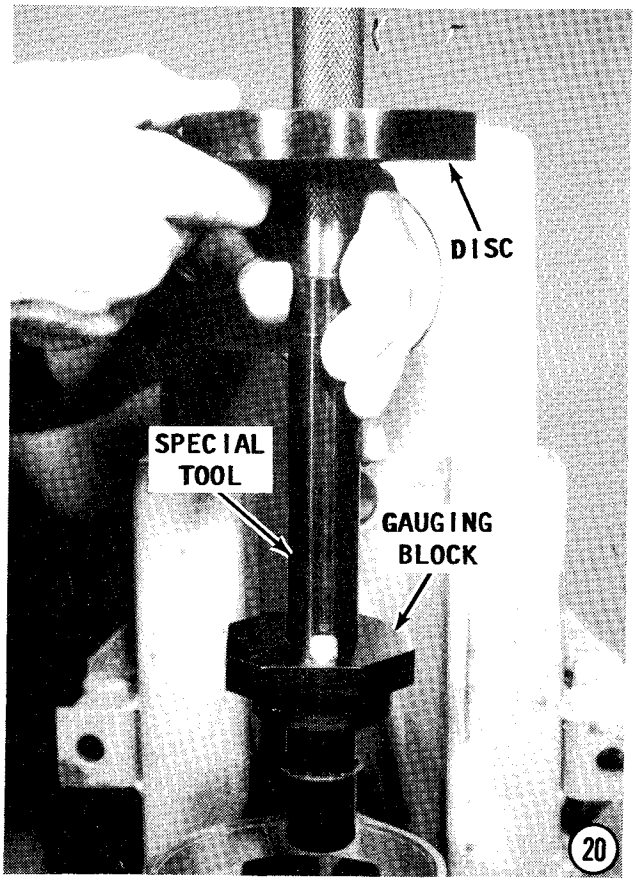
For all units covered in this section, the correct clearance is 0.025" (0.64mm). If the clearance is correct, remove only the Pinion Gear Locating Tools from the inside of the gearcase. Leave the Pinion Gear Bearing Preload Tool in place on the driveshaft for further shimming procedures.

If the clearance is not correct, add or subtract shim material from behind the pinion gear bearing race to lower or raise the gear.

If the pinion gear depth was found to be greater than 0.25" (0.64mm), then shim material must be added to lower the gear.

If the pinion gear depth was found to be less than 0.25" (0.64mm), then shim material must be removed to raise the gear.

The difference between 0.025" (0.64mm) and the **ACTUAL** clearance measured is the amount of shim material needed to correct the pinion gear depth.



Forward Gear Backlash

GOOD WORDS

The propeller shaft is temporarily installed for this procedure.

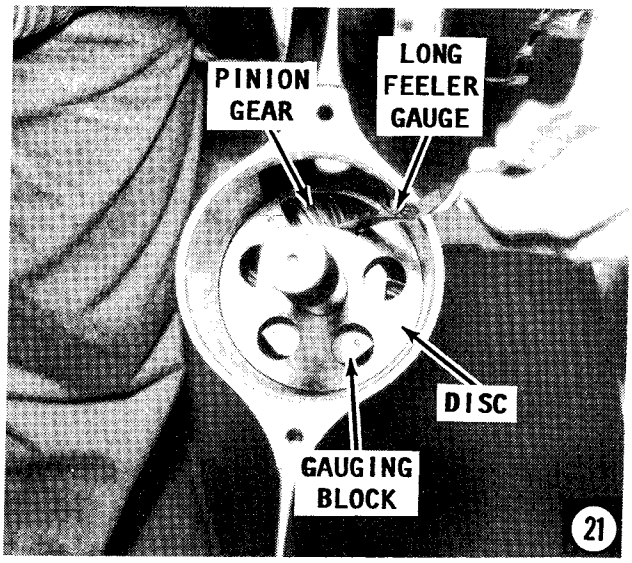
Final installation of the shaft **MUST** be performed later **BECAUSE** an **OLD** pinion gear nut was installed on the driveshaft to determine the pinion gear depth.

SPECIAL WORDS

Obtain a piece of PVC sprinkler pipe, 6" (15.2cm) long by 1 1/4 - 1 1/2" (3.2-3.8cm) diameter and a washer large enough to slide over the propeller shaft threads. Before installing the assembled bearing carrier into the lower unit, install the PVC pipe over the propeller end of the shaft, followed by the large washer and propeller nut to hold it all together. Hand tighten the nut. The pipe will exert a pressure on the bearing carrier, thrust washer and reverse gear and will allow each component to be held in alignment while the shaft is installed. Once the shaft is well seated inside the lower unit, the propeller nut, washer and PVC pipe is removed.

22- Insert the assembled propeller shaft, reverse gear and thrust bearing into the lower unit. Rotate the bearing carrier, if necessary, to position the word **"TOP"** facing **UPWARD** after installation.

Following final installation, coat the threads of the attaching bolts with Loctite Grade "A". Install and tighten the bolts to a torque value of 150 in lb (17Nm). On some



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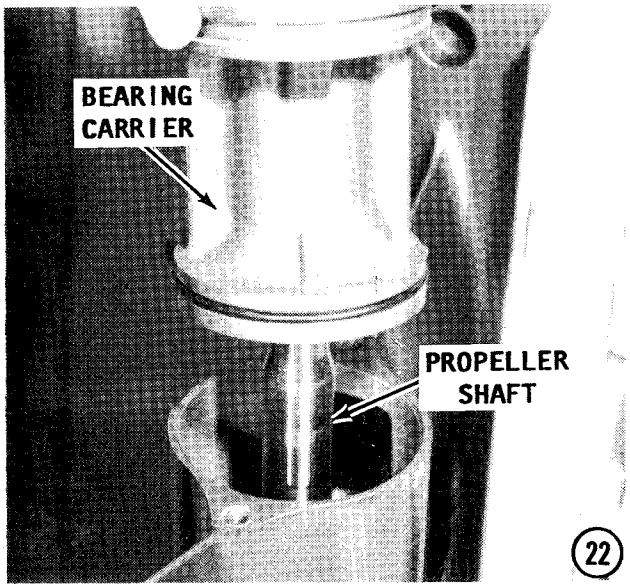
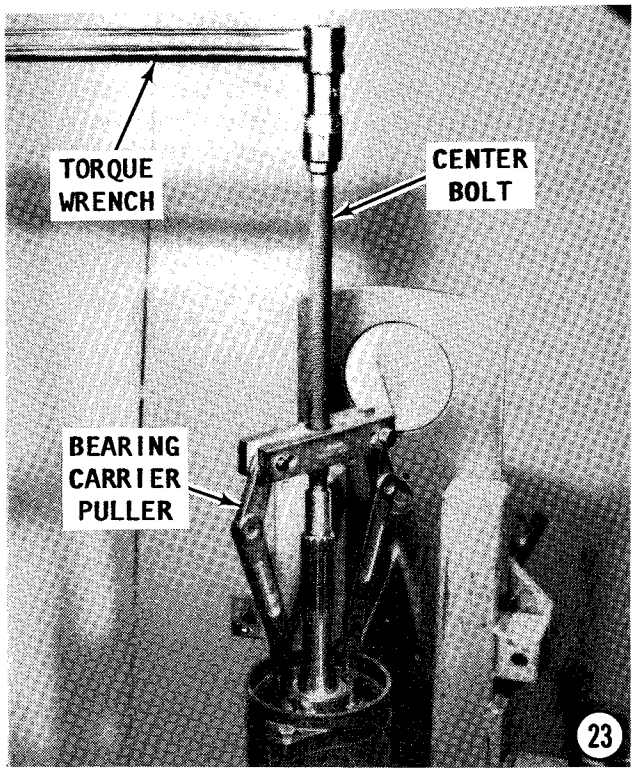


models, nuts on studs are used in place of bolts. Install and tighten the nuts to a torque value of 275 in lb (31.5Nm).

Shimming Forward Gear To Correct Backlash

23- Install a bearing carrier puller with the arms of the puller on the carrier and the center bolt on the end of the propeller shaft. Tighten the puller center bolt to a torque value of 45 in lb (5Nm). This action places a preload on the forward gear, pushing the forward gear into the forward gear bearing. Rotate the driveshaft about ten full revolutions to properly seat the forward gear tapered roller bearing. Then recheck the torque value on the center puller bolt.

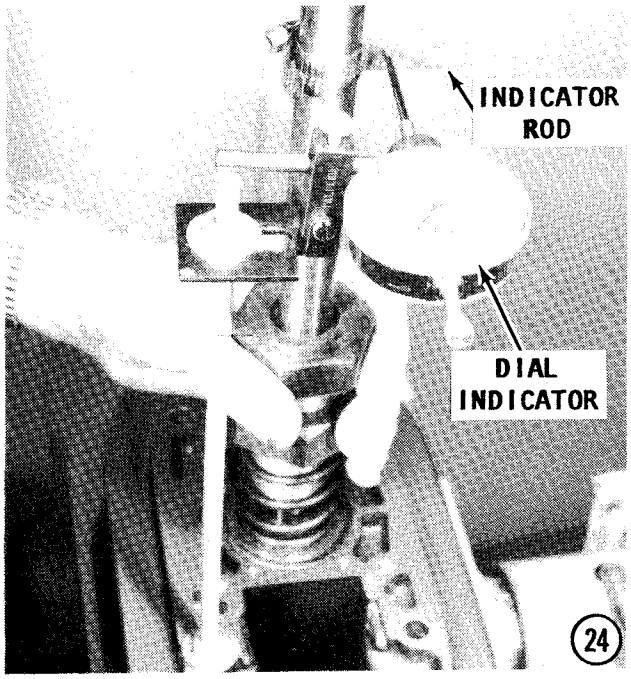


24- Attach the backlash dial indicator rod C-91-78473 to the driveshaft. Position the dial indicator shaft to the line marked **"4"** on the dial indicator rod for a pinion gear to forward gear ratio of 2.30:1 (13 teeth on the pinion gear). Use the line marked **".448"** (11.37mm) on the indicator rod for a pinion gear to forward gear ratio of 2.07:1 (14 teeth on the pinion gear).

Rotate the driveshaft back and forth and observe movement of the dial indicator. Total movement is the forward gear backlash. Check the listings in the Appendix for proper amount of backlash permissible for the unit being serviced. If the backlash is too great, add shim material behind the forward gear-bearing race. If the backlash is too small, remove shim material from behind the forward gear bearing race. For each 0.001" (.025mm) of backlash, add or remove 0.00125" (.032mm) shim material.

Closing Tasks

Remove all special tools. Remove the bearing carrier and propeller shaft. Replace the old pinion nut with a **NEW** nut following the procedures given in Step 11. The new nut is tightened to a torque value of 70 ft lb (95Nm). Reinstall the propeller shaft and bearing carrier following the procedures given in Step 23.



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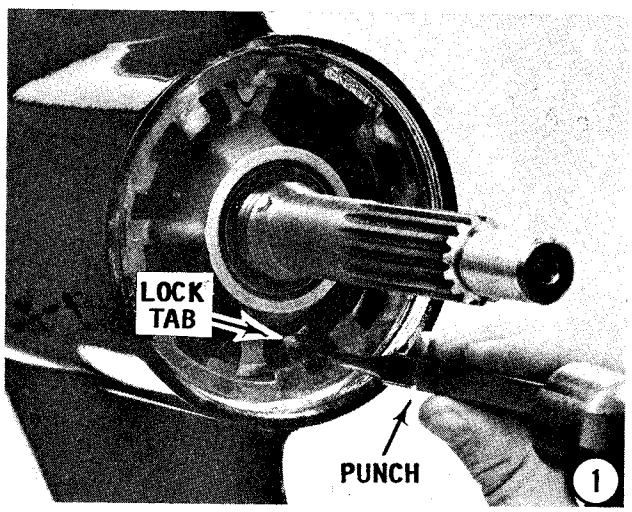


11-7 SERVICING E-Z SHIFT MODELS, SINCE ABOUT 1979

SPECIAL WORDS

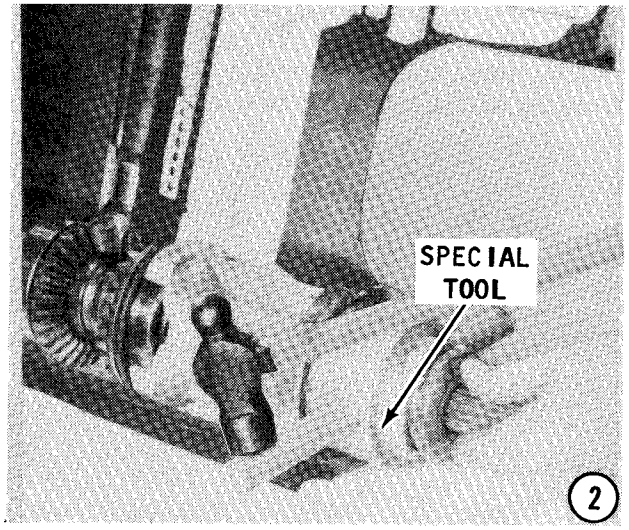
The differences between an E-Z shift and a Cam Shift lower unit are explained in Section 11-1, first page. A simple test is also explained to verify which unit is to be serviced. Check and be sure the correct procedures are being followed.

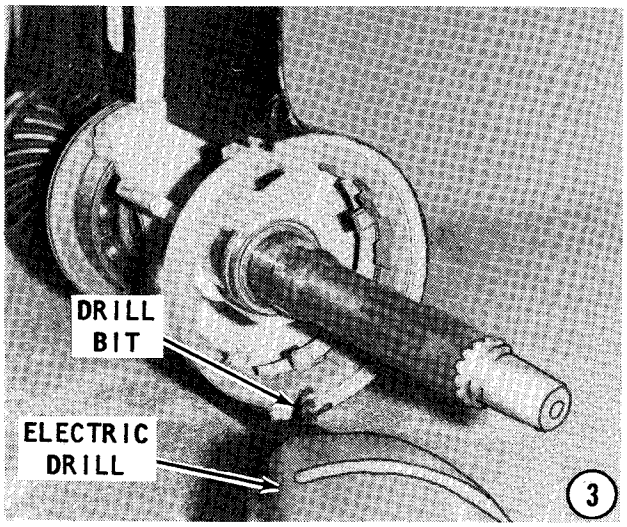
The following procedures pickup the work for an E-Z shift after the lower unit has been separated from the driveshaft housing, as outlined in Section 11-3, and the water pump has been removed per Section 11-4.

Bearing Carrier Removal

1- Bend the lock tab away from the cover nut of the bearing carrier recess with a punch. Some models may not have the lock tab.

2- Place the smaller diameter end of Gear Housing Cover Tool C-91-53126 into the cover nut. Slide the thrust hub over the end of the propeller shaft and down into the cover tool. The thrust hub will tend to keep the cover tool square against the cover nut. Strike the handle of the cover tool sharp blows with a mallet to turn the cover nut **COUNTERCLOCKWISE.**

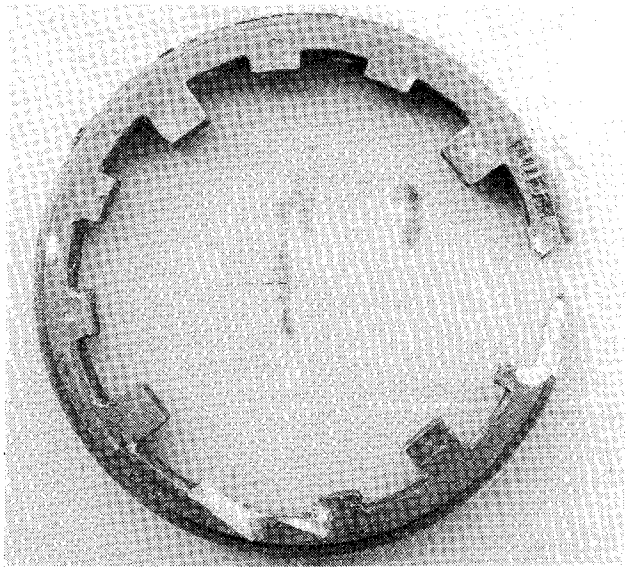




As the cover nut loosens, continue to remove it with the cover nut tool. If the cover nut refuses to budge, it may be necessary to carefully apply heat to the lower unit around the outside of the nut.

3- If the nut still refuses to loosen, a last resort is to drill the nut, as shown.

4- Double check to be sure the E-Z shift is in **NEUTRAL** gear before proceeding. A simple check is to rotate the propeller shaft back-and-forth while observing the driveshaft. The driveshaft should **NOT** rotate in either direction. If the unit needs to be



"Frozen" bearing carrier nut after being sacrificed and drilled out, thus saving more expensive parts.

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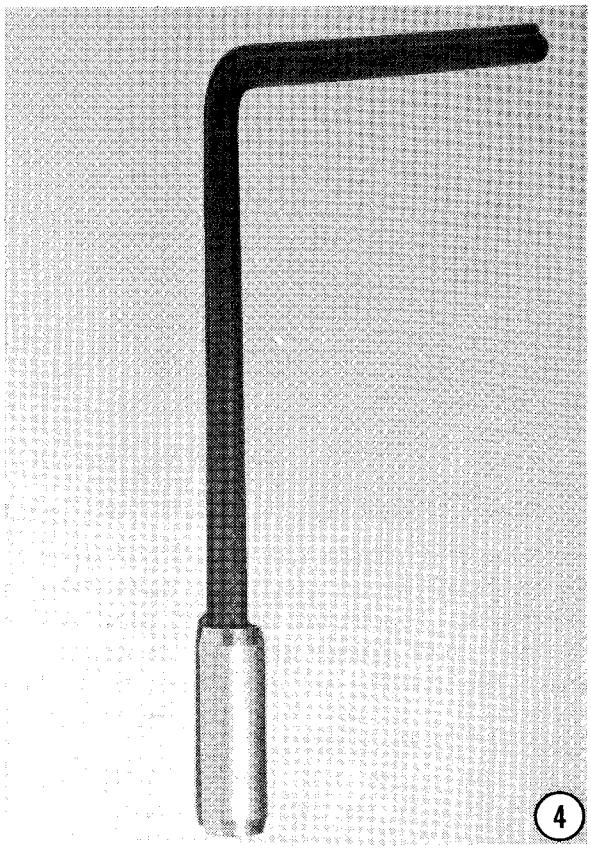
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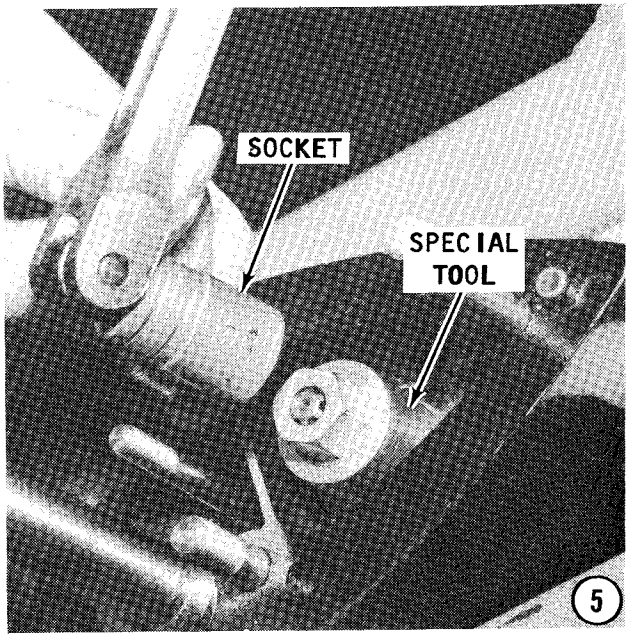
shifted into neutral, take care not to scar the shift shaft while rotating it. A special tool may be made from the upper portion of a shift shaft, bend and cut, as shown. If this tool cannot be made, wrap a piece of soft material around the splines, aluminum will do, and then use a pair of pliers.

If the unit is not in neutral gear, the propeller shaft cannot be withdrawn from



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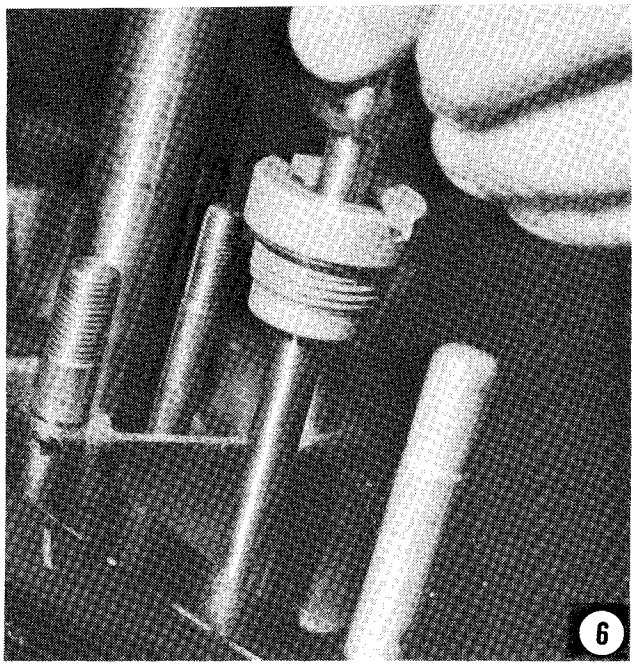
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the lower unit housing until the cam in the pocket is returned to the neutral position. This is not an easy task to do later.

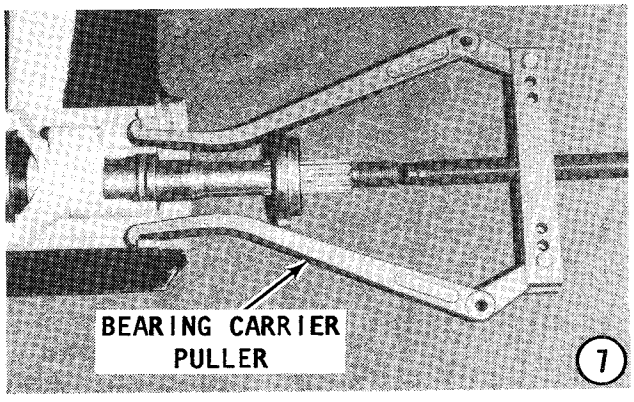
Therefore, let it be said again: the unit must be in **NEUTRAL.**

5- Obtain shift shaft bushing removal tool C-91-31107. Use the special tool and the proper size socket to unthread the bushing. If the special tool is not available, a blunt punch indexed in one of the slots near the outer edge and a hammer may be used to unthread the bushing. Work carefully, using sharp, short, quick blows with the hammer.

DO NOT remove the bushing from the shift shaft, at this time.

CAUTION

Again check to be sure the unit is in **NEUTRAL.** The unit in neutral will save much time and frustration when it comes time to withdraw the propeller shaft.



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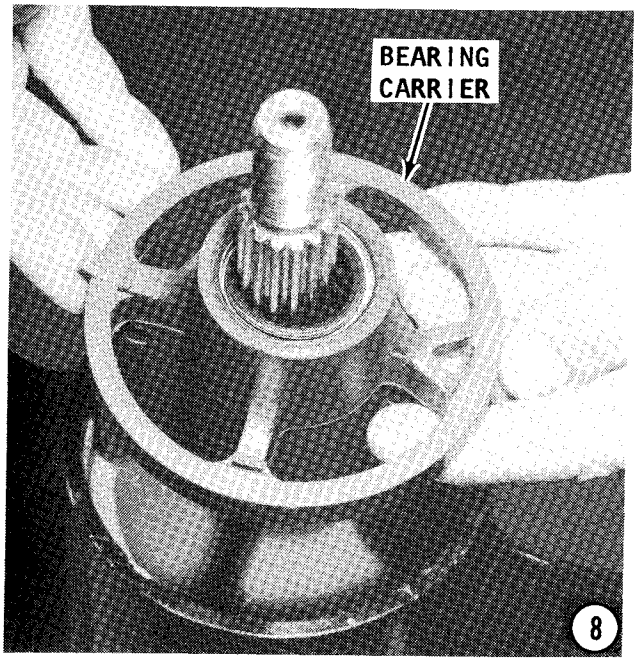
6- After you are positive the unit is in **NEUTRAL,** withdraw the shift shaft and the bushing from the lower unit.

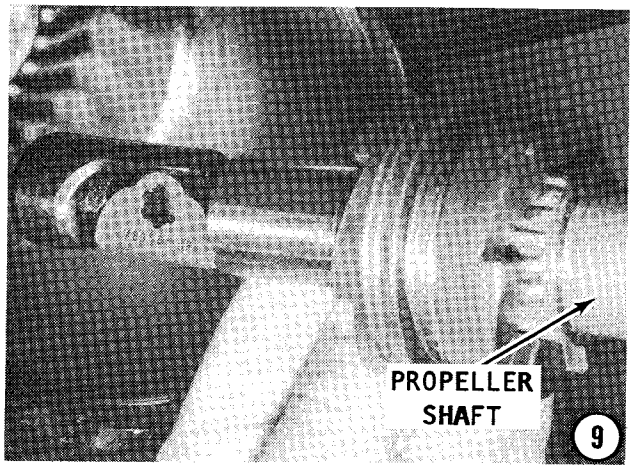
7- Obtain a bearing carrier puller or long jaw puller C-91-46086A1. Hook the jaws of the puller onto the back side of the bearing carrier. Tighten the thru bolt against the outer end of the propeller shaft. As the bolt is tightened, the bearing carrier will begin to move.

8- After the carrier is loose, pull it free of the lower unit housing, but leave the propeller shaft in place, at this time. **TAKE CARE** not to lose the alignment key from the bearing carrier. The reverse gear will come out with the carrier.

9- Grasp the propeller shaft and attempt to withdraw it straight out of the lower unit housing. If the unit has been in neutral, as instructed, the shaft will come free of the lower unit housing. If the unit was not in neutral, the shaft will not come free. **DO NOT** jerk or attempt to force the propeller shaft free. Any forcing will only damage the shift mechanism and the shaft will still not come free.

If the unit was not in neutral, and the propeller shaft will not move outward, push the shaft back into place against the forward gear. Use a flashlight and look down into the lower unit and observe the location of the shift cam. If the splined hole in the shift cam is visible, install the shift shaft back into place. Now, rotate the shift shaft to the **NEUTRAL** position. Carefully, withdraw the propeller shaft.



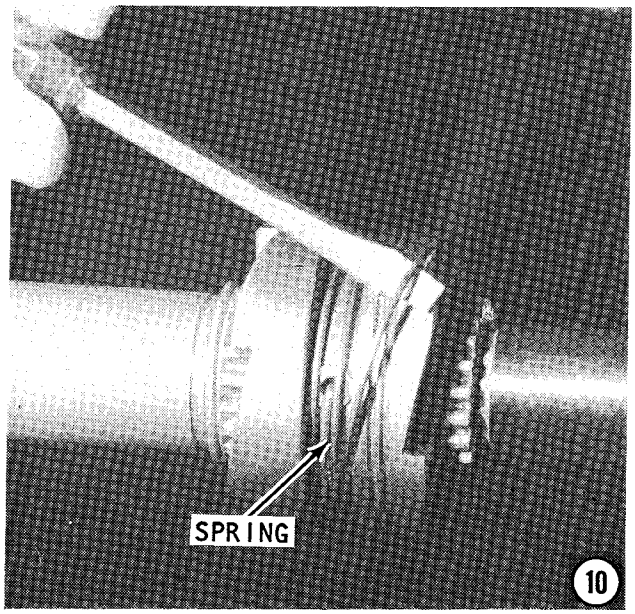


If the splined hole in the shift cam was not visible, as described in the previous paragraph, slide the bearing carrier part way back into place to support the propeller shaft. Place the lower unit housing on the deck with the port side of the housing facing upward. Now, rock the housing on the deck and from time to time attempt to withdraw the propeller shaft. What this maneuver will accomplish is to slide the cam back into the neutral position and thus enable the propeller shaft to be withdrawn.

As the propeller shaft is withdrawn the shift clutch, shift cam, cam follower, actuator rod and associated parts will come out with the shaft. Set these loose parts aside for cleaning.

Propeller Shaft Disassembling

10- Slide a thin screwdriver or awl under the end of one cross pin retainer spring, as shown. Rotate the propeller shaft and the



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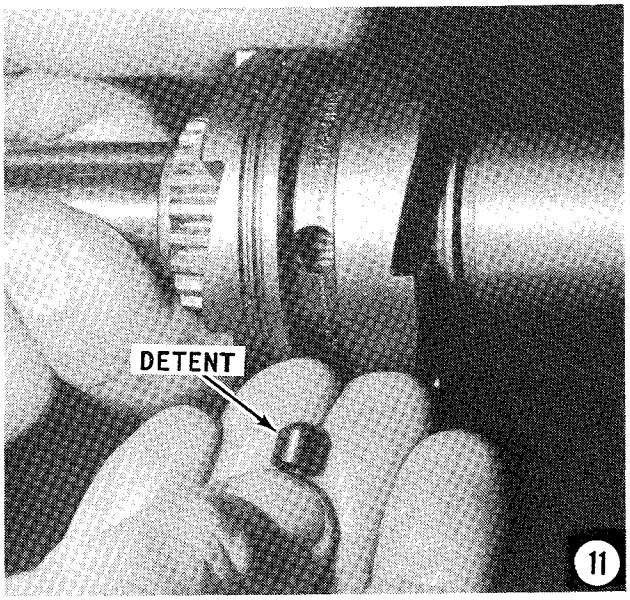
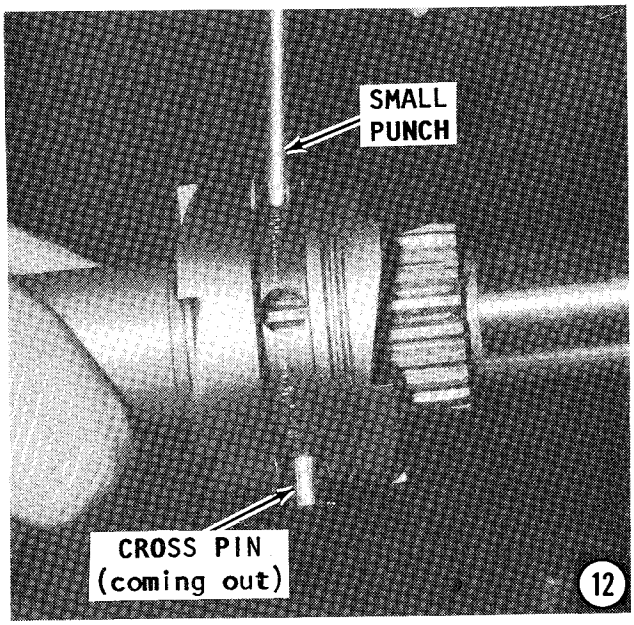


spring will come free of the sliding clutch. The two springs are identical, but installed on the clutch in opposite directions. Therefore, insert the screwdriver or awl under the second spring and rotate the propeller shaft in the opposite direction. The second spring will come free. **TAKE CARE** not to stretch the springs any more than necessary.

11- After the two springs have been removed as described in Step 10, the two detents will fall free.

12- Obtain a suitable small size punch and push the cross pin free of the sliding clutch. A hammer is not necessary because the pin is only a "snug" fit in the clutch. Notice the two flat sides on the pin. These flat sides will be most important during assembling.



13- Pull the cam follower and clutch actuator **STRAIGHT** off the propeller shaft end. Do not force the cam follower up or down or from side to side as follower is removed from the shaft.

14- The parts of the actuator rod assembly, as shown in the accompanying illustration, will all come free. Be sure to **SAVE** the shim washer and note how it was placed on top of which spring, as an aid to assembling.

15- Pull the sliding clutch free of the propeller shaft.

Driveshaft and Bearing Removal

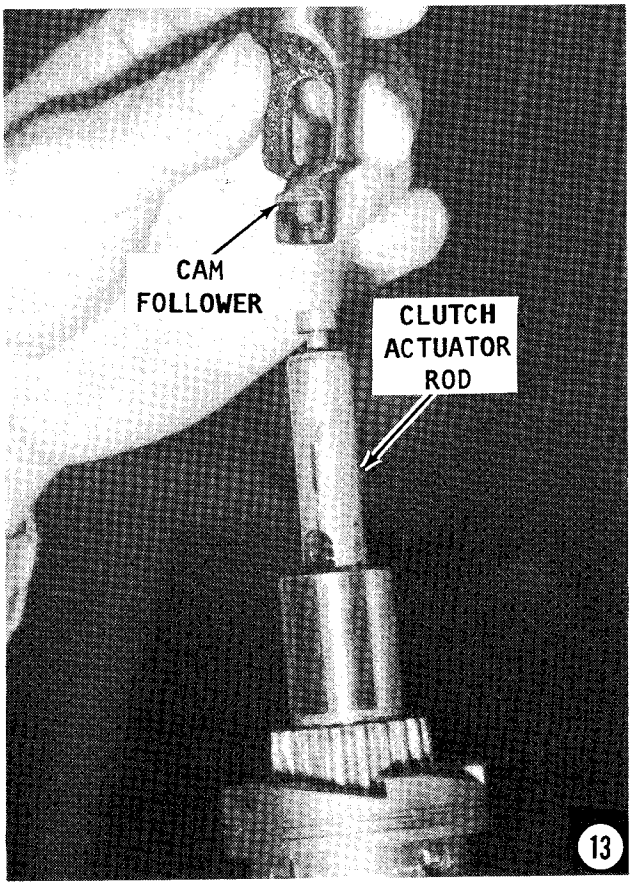
SPECIAL WORDS

The following information was presented in Section 11-1, but is repeated here to ensure the reader is familar with the lower unit being serviced before further disassembling work is performed.

Actually, two different driveshafts may be used on lower units with the E-Z shift covered in this section:

Old style **WITH** a preload pin.

New Alpha driveshaft **WITHOUT** a preload pin, since about 1985.



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Briefly the differences are as follows:

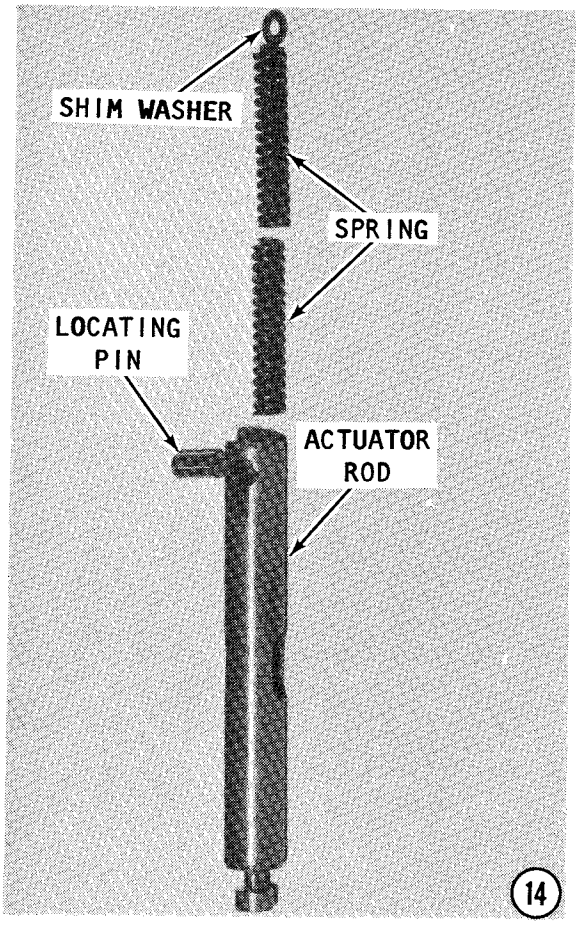
Old style **WITH** a preload pin placing a load on the driveshaft in the downward direction.

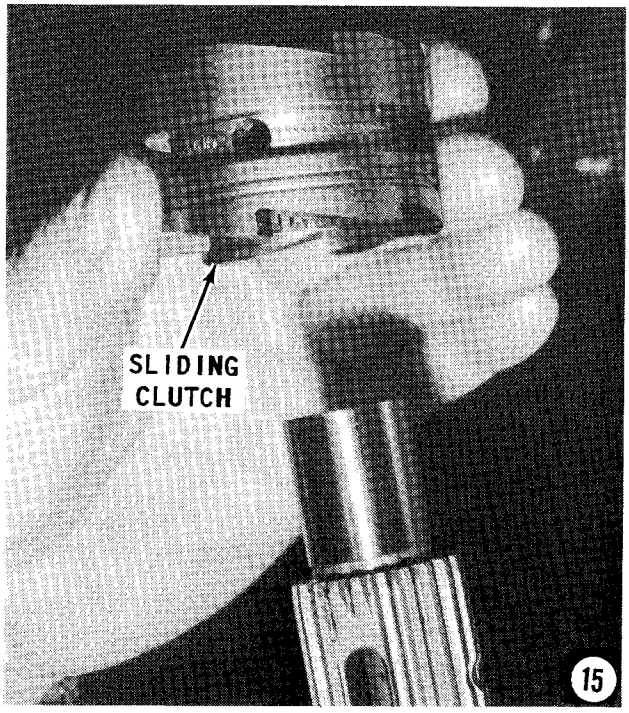
New "Alpha", also known as "MR" driveshaft without a preload pin on the upper end and new cut to the gears.

The new bevel cut on the pinion gear and the driven gears is reversed for the Alpha driveshaft, as shown in the accompanying illustration. The new shaft and gear set is shown on the left and the old one on the right. Notice the absence of the preload pin on the new driveshaft and the opposite direction of the gears. The new gear direction places a **UPWARD** load on the driveshaft. Therefore, the preload pin at the upper end is no longer needed.

16- Clamp the skeg in a vise equipped with soft jaws in the upright position. Again, check and record the forward gear backlash. **BEFORE** disassembling the unit check the forward gear to pinion gear backlash. This is accomplished by one of two methods, depending on the unit being serviced as follows:

First, check the upper end of the driveshaft. Some models have a preload pin and



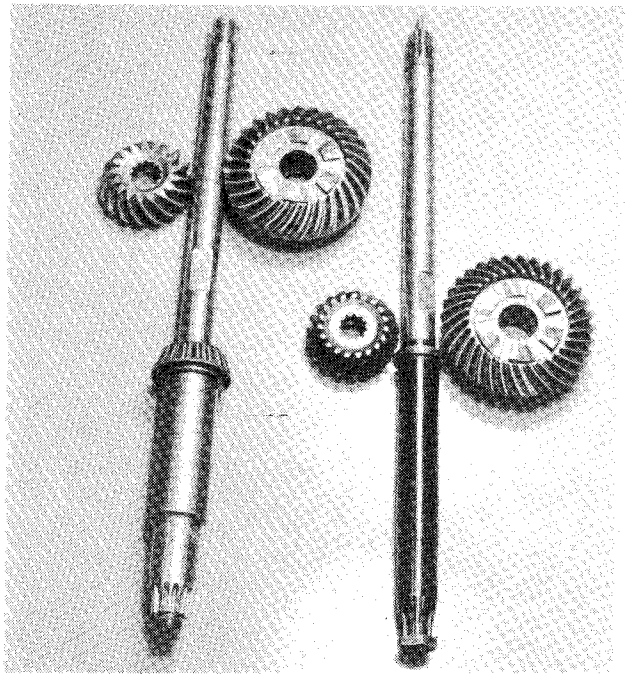


others do not. Various procedures differ greatly depending on whether the shaft has or does not have a preload pin.

The upper driveshaft bearing is a "two-piece" tapered roller design. Both the bearing and the race **MUST** be replaced as a set.

Units WITH Driveshaft Preload Pin

The driveshaft has a preload pin in the upper end. On this unit, push **DOWN** on the



A new driveshaft, pinion gear, and driven gear, for the Alpha drive (left), alongside the old driveshaft and gears. Differences are explained in the text.

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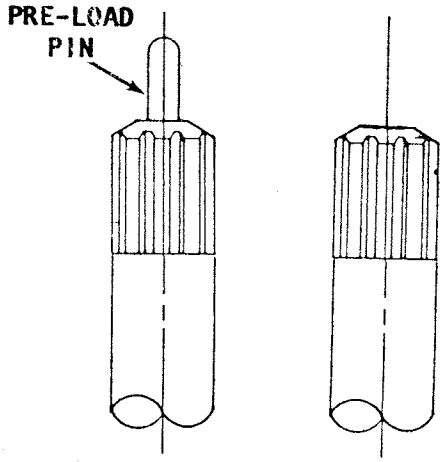
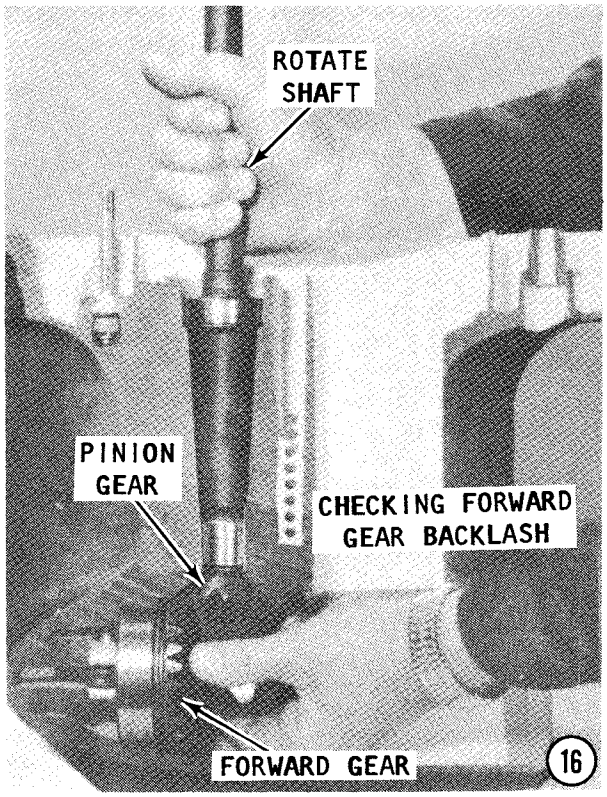


Upper end of the driveshaft with a pre-load pin (left), and without the pin, Alpha drive (right).

driveshaft with one hand and at the same time rock the forward gear back-and-forth with the other hand. The amount of movement felt is the backlash. Check the Specifications in the Appendix for the unit being serviced.

Units WITHOUT Driveshaft Preload Pin

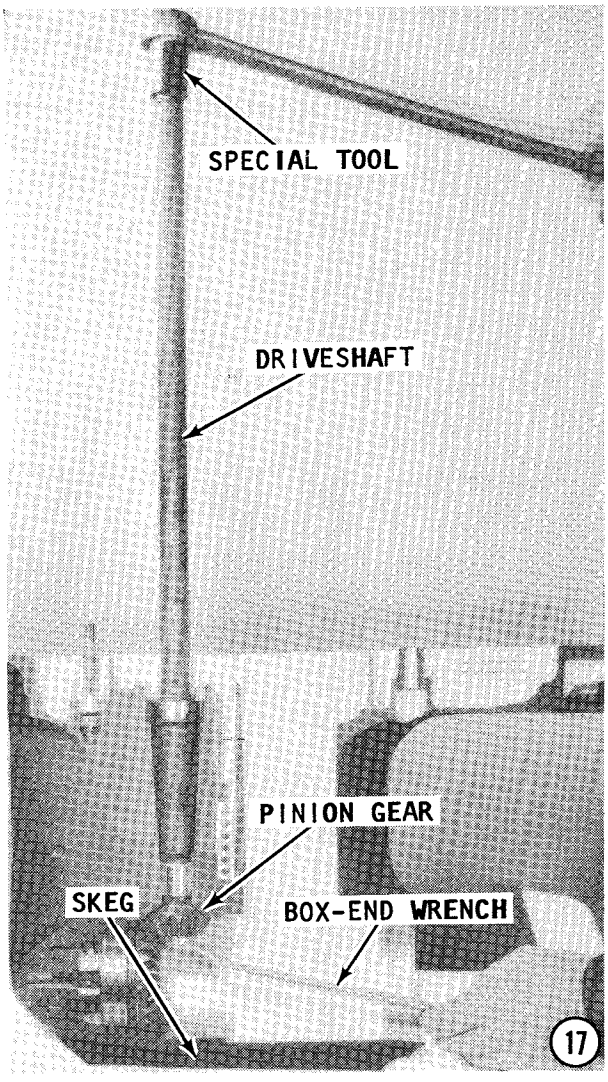
On these units without a preload pin on the upper end of the driveshaft, pull **UP** on the driveshaft with one hand and at the same time rock the forward gear back-and-forth with the other hand. The amount of movement felt is the backlash. Check the Specifications in the Appendix for the unit being serviced.



17- Leave the lower unit clamped in the vise. Obtain special wrench C-91-56775, (or C-91-34377A1 for coarse splines) and a breaker bar to work the driveshaft. Obtain special pinion nut holding tool C-91-61067A1. If the pinion nut holding tool is not available, a substitute can be made from a proper size box-end wrench for the nut. Grind the wrench down on both sides until it will clear the pinion teeth. Hold the nut with the modified box-end wrench, as shown and at the same time, rotate the driveshaft counterclockwise with the special tool and breaker bar until the nut is released from the driveshaft. Remove the pinion gear.

ALPHA DRIVE ONLY

18- Obtain bearing retainer nut special tool C-91-43506. Slide the special tool down the driveshaft until the tool is indexed



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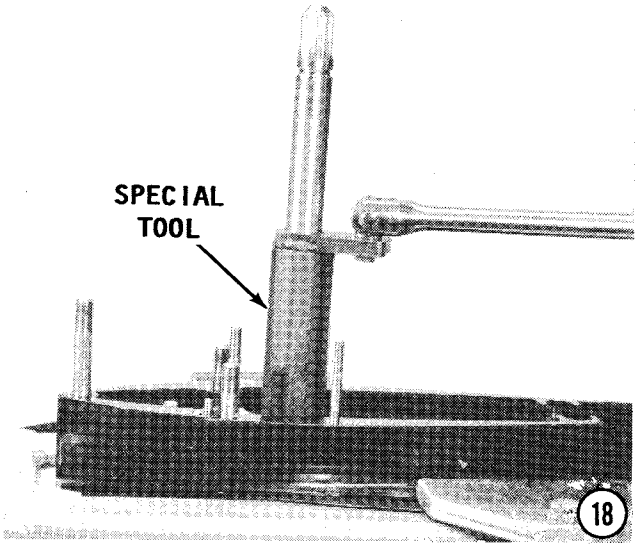
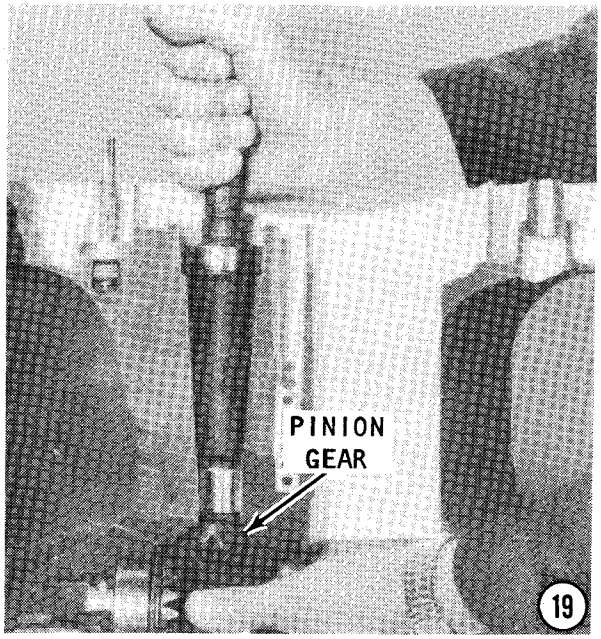


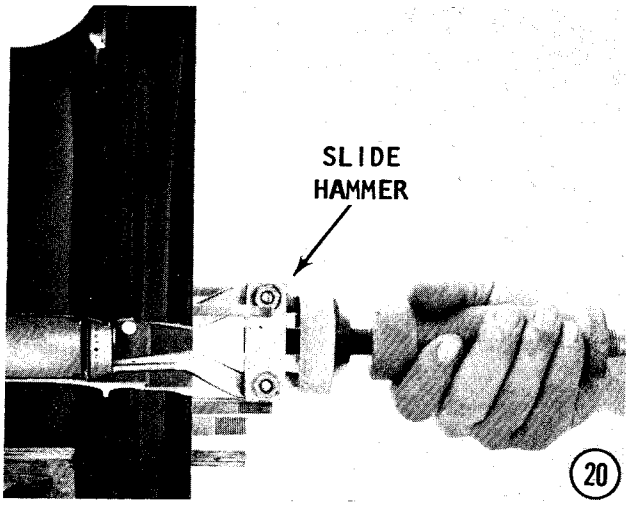
over the nut. Use a breaker bar on the special tool and loosen the nut. Slide the special tool free of the driveshaft, and then back the nut off and clear of the driveshaft.

All UNITS

19- Pull the driveshaft straight up and out of the lower unit. Reach in through the propeller shaft opening and remove the pinion gear.

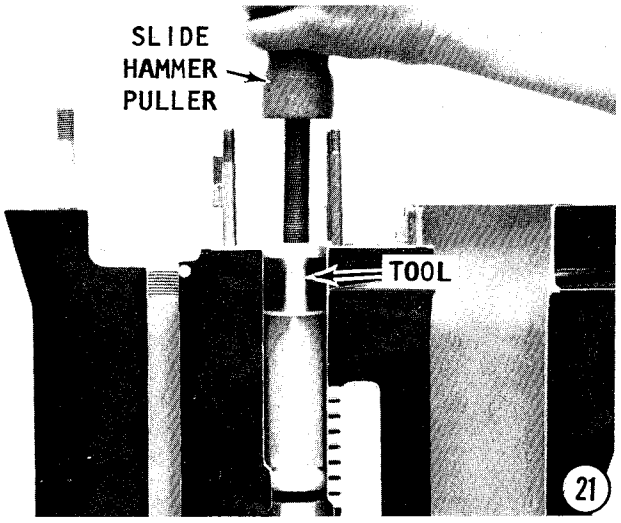
If the driveshaft refuses to come out, an alternate method is to first clamp the driveshaft in a vise equipped with soft jaws. Next, use a block of wood to protect the lower unit and drive the lower unit off the driveshaft. If this method is used, **TAKE CARE** to prevent the lower unit from falling when it finally comes free of the driveshaft.

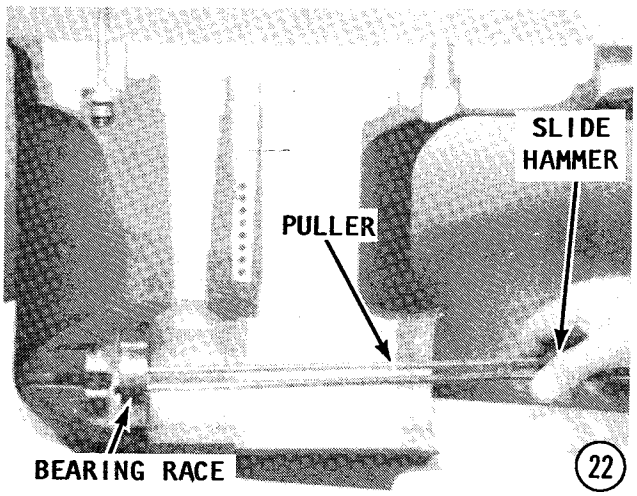




20- Use a slide hammer and remove the driveshaft tapered bearing race. Save the shims from under the tapered bearing race. The same amount of shim material will probably be used during assembling.

21- Obtain Water Pump Cartridge Puller C-91-27780. Use the puller to remove the lubrication sleeve from the lower unit.





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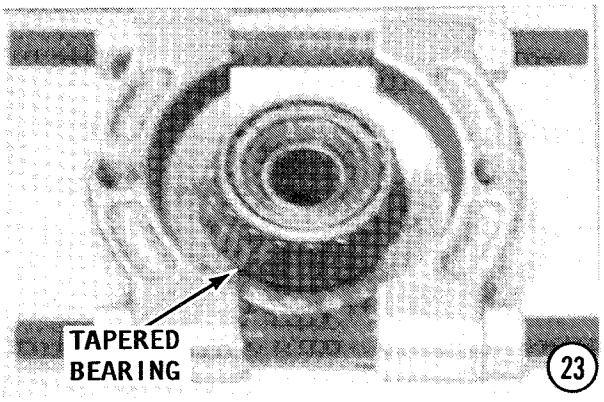


Some units may not have this sleeve installed. Set the driveshaft aside for disassembly later.

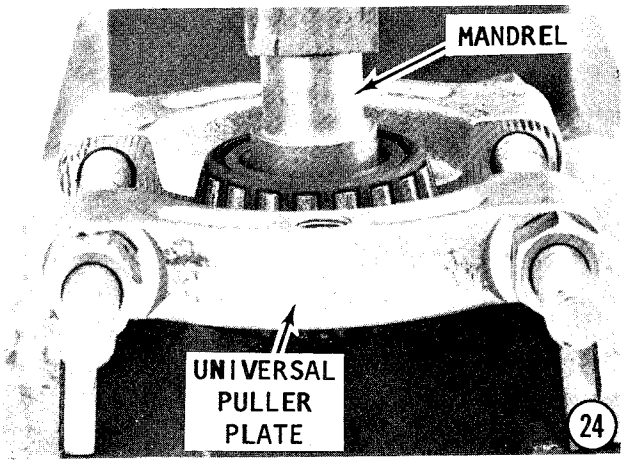
Forward Gear and Bearing Removal

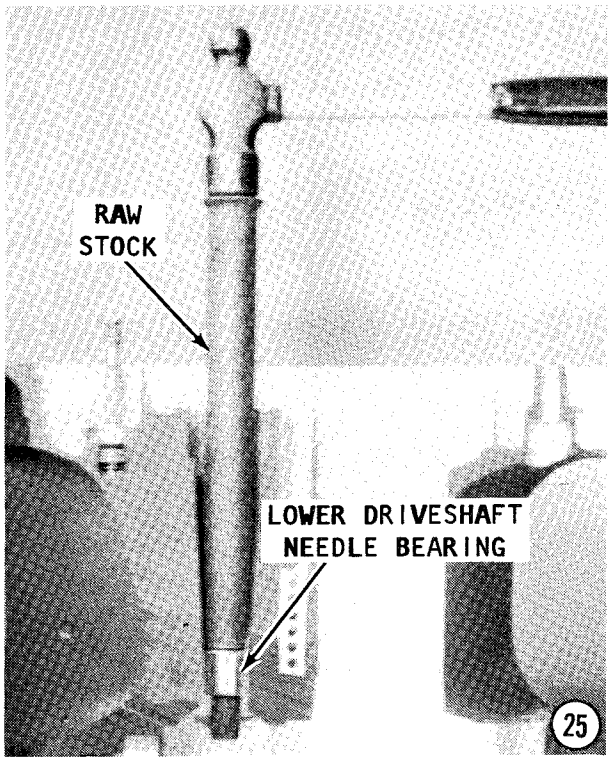
22- After the pinion gear is removed, the forward gear and bearing can be lifted out of the lower unit. The tapered bearing race will remain within the lower unit. **DO NOT** attempt to remove the bearing race unless it is unfit for further service, or the forward gear backlash is far too excessive. Remove the forward bearing race and shim material using a slide hammer.

Separating Forward Gear From Bearing

The forward gear bearing does **NOT** have to be removed to perform an adequate job of cleaning and inspecting. Therefore, it is not necessary to separate the bearing and gear unless either is unfit for further service.

23- Position Universal Puller Plate C-91-37241 between the forward gear and the tapered bearing. Place the puller plate and gear on a press with the gear on the bottom. Press the gear out of the bearing with a suitable mandrel. If the bearing cannot be removed, clamp the forward gear in a vise



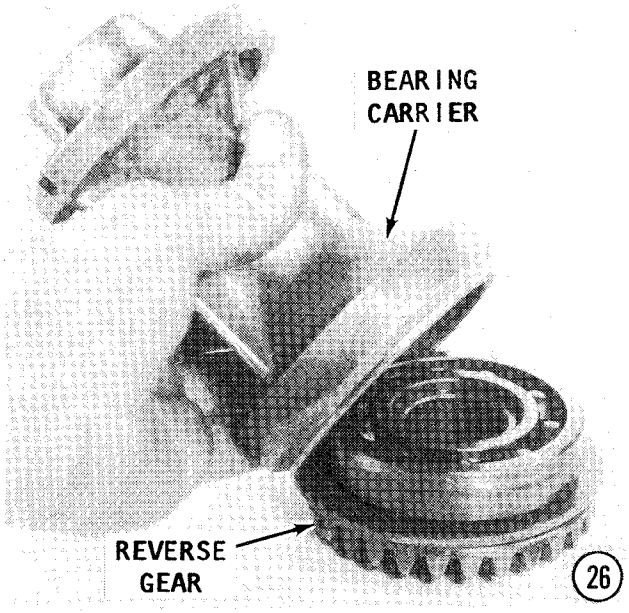


equipped with soft jaws. Use a punch and hammer to drive the roller bearing out of the forward gear.

Driveshaft Disassembling

DO NOT remove the driveshaft bearing unless it is no longer fit for further service. If the tapered bearing requires replacement, the bearing race **MUST** also be replaced.

24- Position the driveshaft and Universal Puller Plate C-91-37241 on a press, as



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shown. Press the driveshaft out of the tapered bearing hub.

BAD NEWS

Once the bearing has been removed it **CANNOT** be used a second time because the roller cage will be damaged during the removal operation. In this case the race will have to be replaced because the bearing and race are a matched set.

25- Use a round piece of raw stock, a wooden dowel will do the job, and drive the lower driveshaft needle bearing out of the housing, as shown.

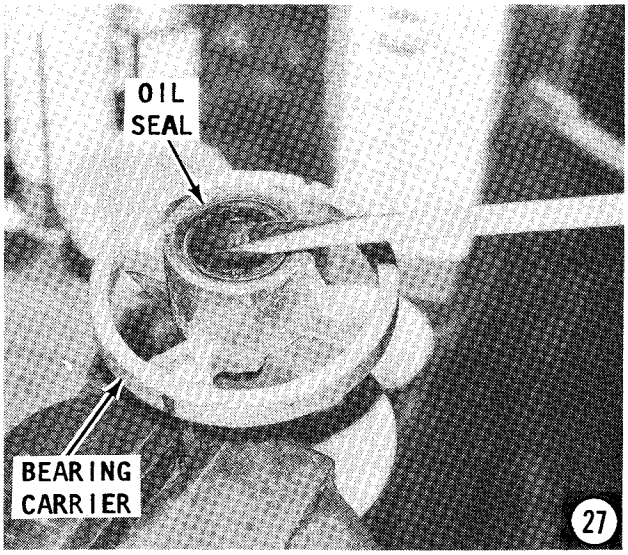
Separating Reverse Gear From Bearing Carrier

26- Clamp the bearing carrier in a vise equipped with soft jaws. Remove and **DISCARD** the **O**-ring from between the bearing carrier and the thrust washer. Use a slide hammer and remove the reverse gear. If the reverse gear ball bearing remained in the bearing carrier, use a slide hammer and remove the bearing. If the bearing remained on the gear, remove the bearing using a Universal Puller Plate, C-91-37241 and a suitable mandrel to press the gear out of the bearing.

27- Remove the seal by prying or driving it toward the rear. On some late model units, two seals are used. Set the assembly aside ready for cleaning and inspecting.

CLEANING AND INSPECTING

See Section 11-9, beginning on Page 11-86 for detailed, comprehensive procedures to clean and inspect the complete lower unit.



ASSEMBLING AND INSTALLATION E-Z SHIFT LOWER UNIT

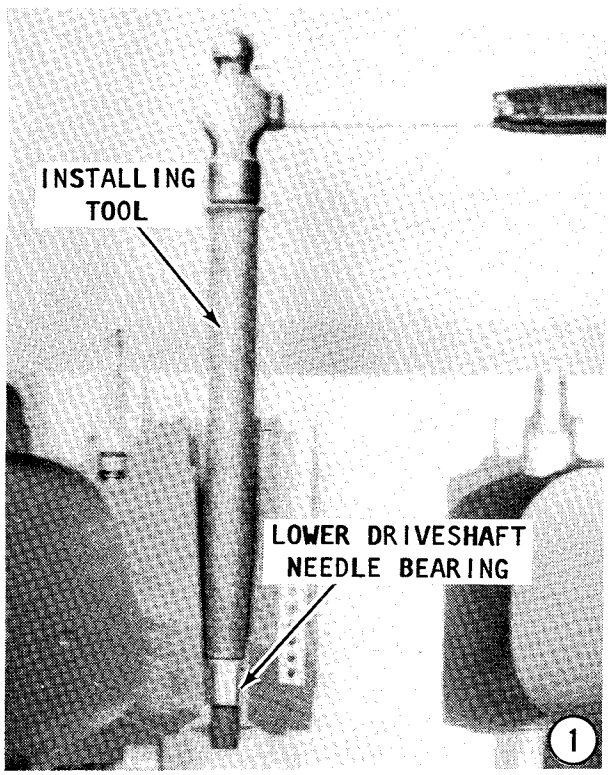
Lower Driveshaft Roller Bearing

If a new lower unit housing is being installed, the lower driveshaft roller bearing will already be in place.

1- Obtain Bearing Removal and Installation Kit C-91-312291. Place the drive shaft roller bearing over the driver head of the installation kit with the numbered side of the bearing **TOWARD** the shoulder of the driver head. Thread the driver rod from the kit into the drive head. Coat the needle bearing area of the driveshaft cavity with Quicksilver Formula 50-D lubricant. Position the rod, driver head and bearing into the lower unit driveshaft cavity. Place a pilot washer from the kit over the driver rod and slide it down into the driveshaft bearing cavity. Use a mallet to drive the roller bearing downward until it is approximately 1/16" (1.59 mm) above the bottom end of the driveshaft cavity. Remove the driver rod, head, and pilot washer.

Bearing Carrier Assembling

2- Position the propeller shaft roller bearing into the aft end of the bearing carrier with the numbered side **TOWARD** the aft end. Press the roller bearing into the bearing carrier with a suitable mandrel.



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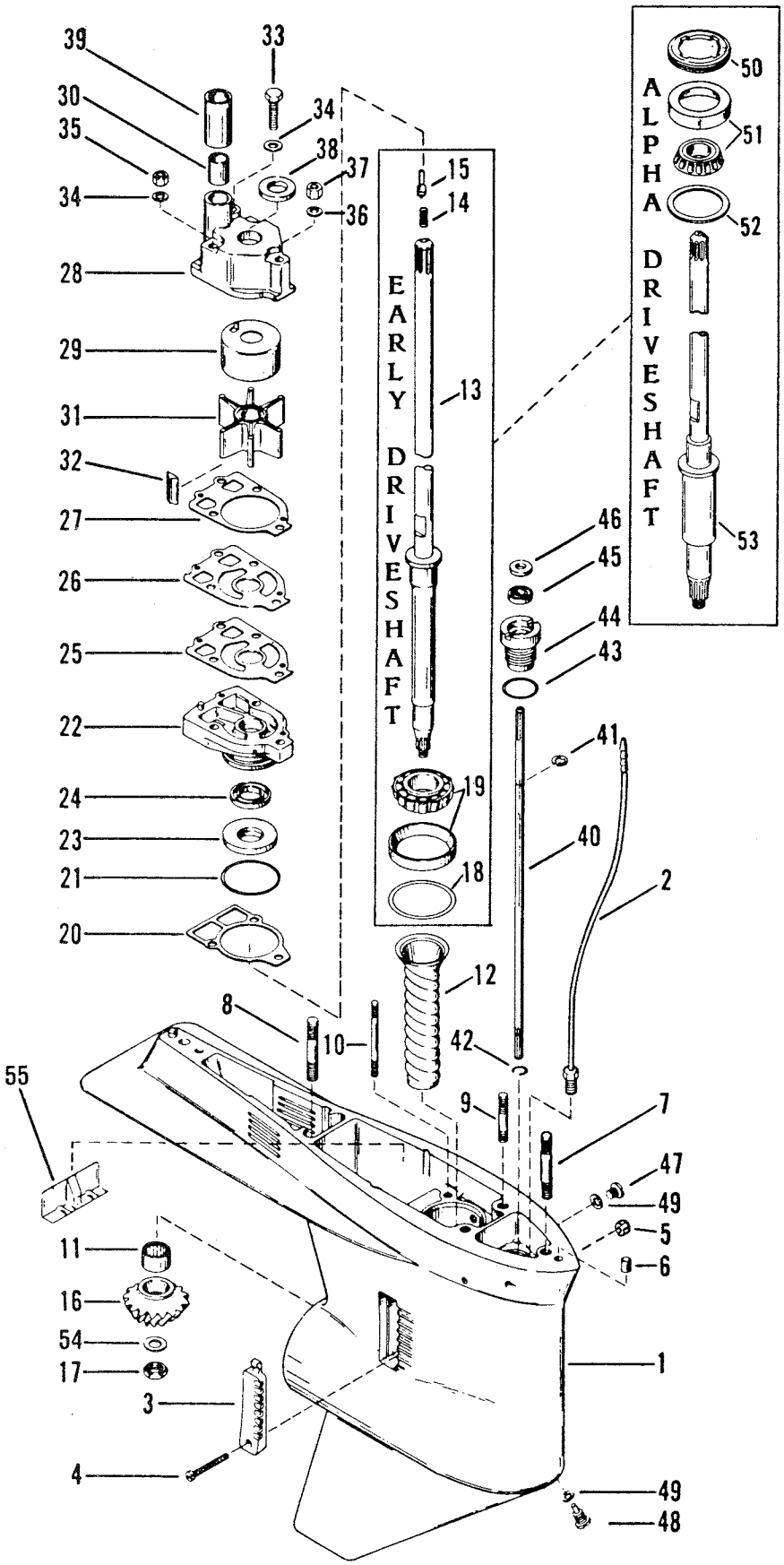

1- LOWER UNIT HOUSING
2- SPEEDOMETER HOSE
3- WATER INLET
4- SCREW
5- HEX NUT
6- DOWEL PIN
7- STUD
8- STUD
9- STUD, WATER PUMP
10- STUD, WATER PUMP
11- NEEDLE BEARING
12- SLEEVE
13- DRIVESHAFT
14- SPRING
15- PIN, DRIVESHAFT
16- PINION GEAR
17- PINION NUT
18- SHIM MATERIAL
19- ROLLER BEARING ASSY.
20- GASKET
21- O-RING
22- WATER PUMP BASE
23- OIL SEAL, LARGE
24- OIL SEAL, SMALL
25- GASKET
26- FACE PLATE
27- GASKET
28- WATER PUMP BODY
29- WATER PUMP INSERT
30- RUBBER SEAL
31- IMPELLER
32- KEY
33- BOLT
34- WASHER (IF USED)
35- NUT
36- WASHER
37- NUT
38- CENTRIFUGAL SLINGER
39- GUIDE SLEEVE
40- LOWER SHIFT SHAFT
41- "E" CLIP
42- RETAINING RING
43- O-RING
44- BUSHING
45- OIL SEAL
46- RUBBER WASHER
47- "VENT" SCREW
48- "FILL" SCREW
49- GASKET
50- BEARING RETAINER
51- ROLLER BEARING ASSY.
52- SHIM MATERIAL
53- DRIVESHAFT
54- WASHER (ALPHA DRIVE)
55- DIVIDER BLOCK

Exploded drawing of an E-Z Shift lower unit, with major parts identified. Parts of the old style driveshaft with the preload pin at the upper end is shown in the main portion of the drawing. The new Alpha driveshaft is shown to the right. Notice how the tapered bearings are reversed and the absence of the preload pin.

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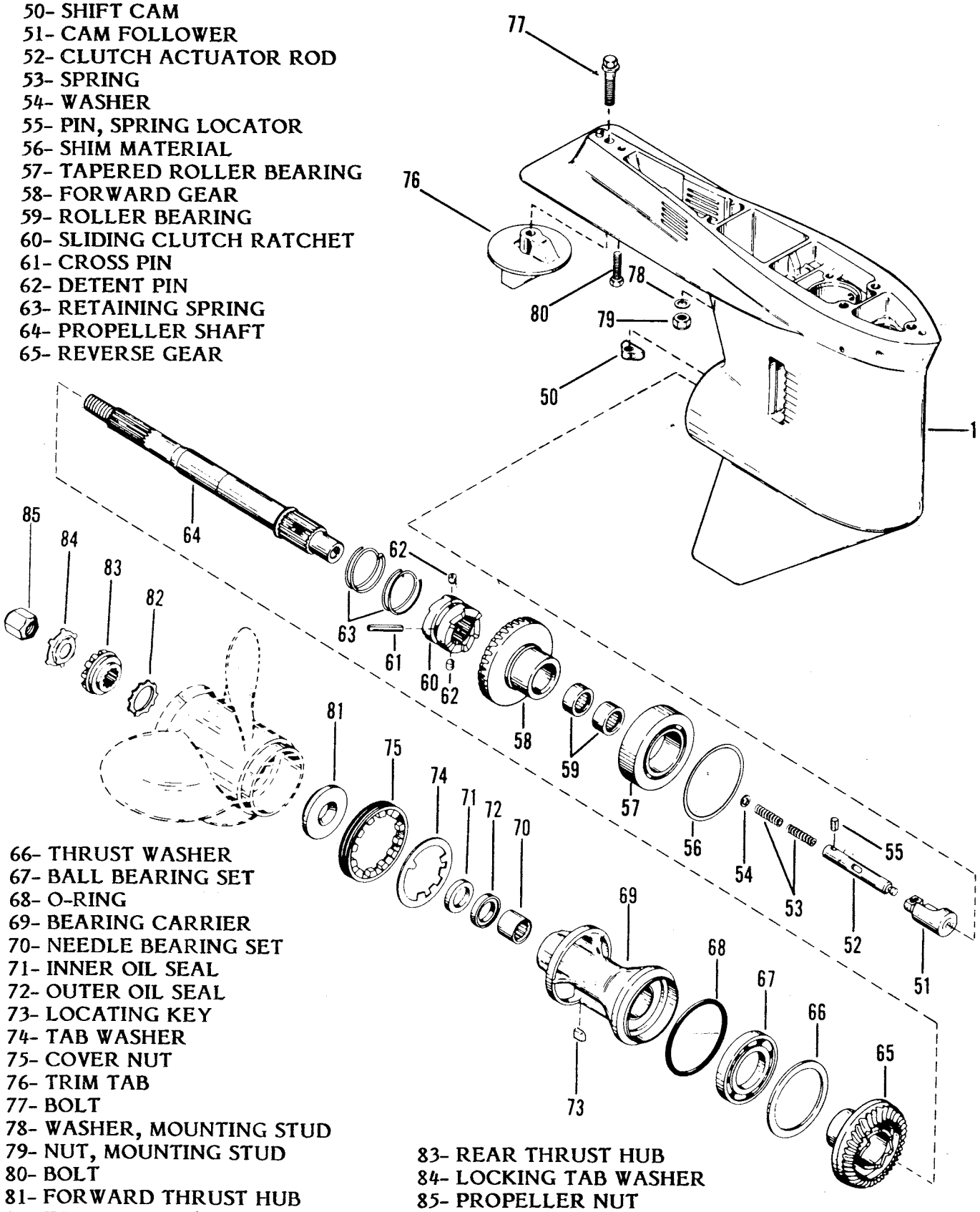
1- LOWER UNIT HOUSING
50- SHIFT CAM
51- CAM FOLLOWER
52- CLUTCH ACTUATOR ROD
53- SPRING
54- WASHER
55- PIN, SPRING LOCATOR
56- SHIM MATERIAL
57- TAPERED ROLLER BEARING
58- FORWARD GEAR
59- ROLLER BEARING
60- SLIDING CLUTCH RATCHET
61- CROSS PIN
62- DETENT PIN
63- RETAINING SPRING
64- PROPELLER SHAFT
65- REVERSE GEAR



66- THRUST WASHER
67- BALL BEARING SET
68- O-RING
69- BEARING CARRIER
70- NEEDLE BEARING SET
71- INNER OIL SEAL
72- OUTER OIL SEAL
73- LOCATING KEY
74- TAB WASHER
75- COVER NUT
76- TRIM TAB
77- BOLT
78- WASHER, MOUNTING STUD
79- NUT, MOUNTING STUD
80- BOLT
81- FORWARD THRUST HUB
82- TAB WASHER (SOME MODELS)
83- REAR THRUST HUB
84- LOCKING TAB WASHER
85- PROPELLER NUT

Exploded drawing of the E-Z Shift propeller shaft, with major parts identified.

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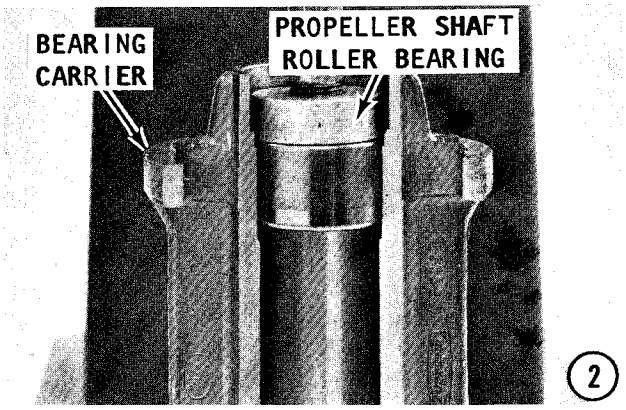
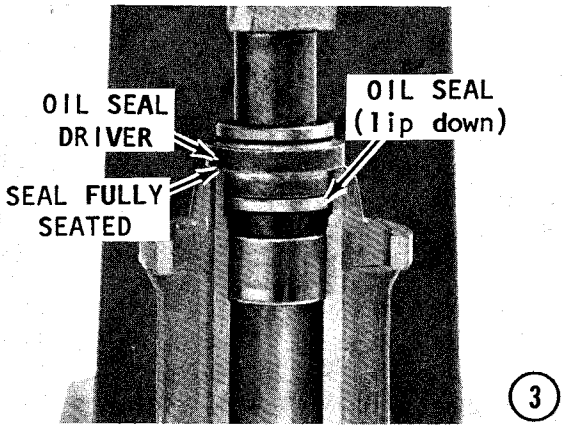
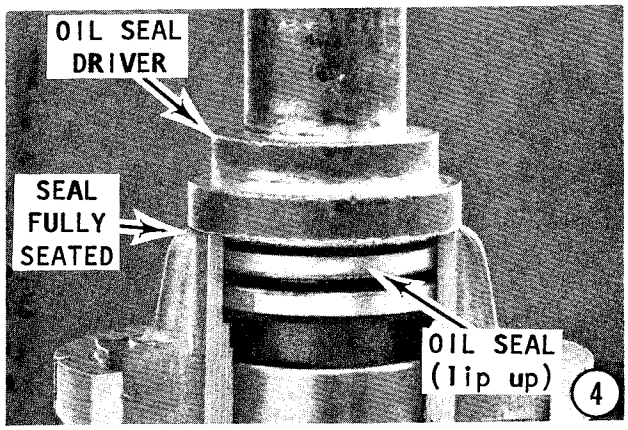
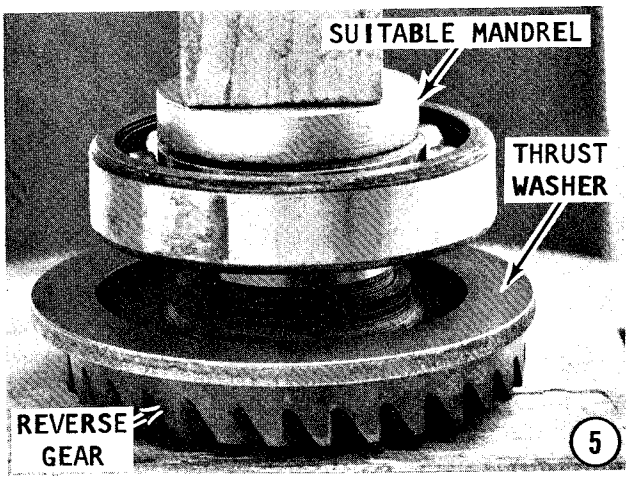








3- Coat the outer diameter of the propeller shaft oil seals with Blue Loctite. Obtain Oil Seal Driver C-91-31108. Place one seal on the longer shoulder side of the driver tool with the lip of the seal **AWAY** from the shoulder. Press the seal into the bearing carrier until the seal driver bottoms against the bearing carrier. Place the second seal on the short shoulder side of the seal driver with the lip of the seal **TOWARD** the shoulder.

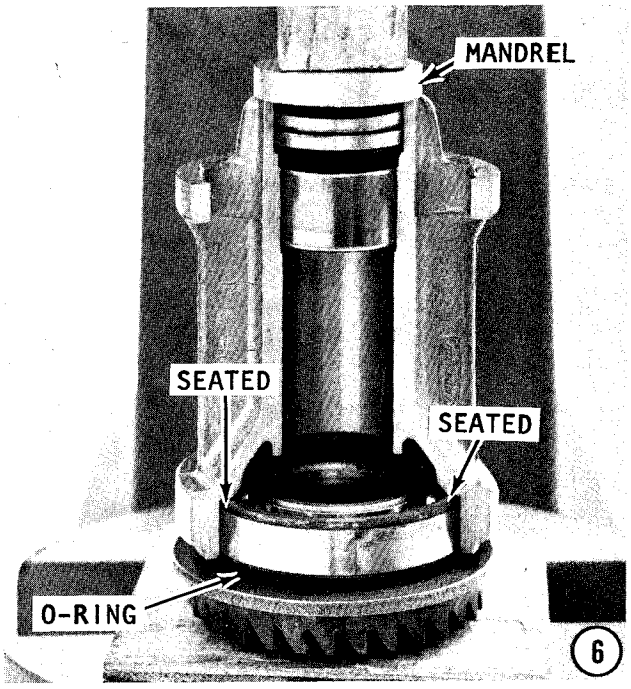
4- Press the seal into the bearing carrier until the seal driver bottoms against the bearing carrier. Clean excess Loctite from the seals.

5- Position the reverse gear on a press with the gear teeth facing **DOWN.** Place the thrust washer over the gear, beveled side **DOWN.** Place the ball bearing over the gear with the numbered side **UP.** Now, press the ball bearing onto the gear with a suitable mandrel.

6- Place the bearing carrier over the gear and bearing assembly. Press the bearing carrier onto the bearing. Place a **NEW** O-ring over the bearing carrier and position it between the bearing carrier and the thrust washer. Coat the O-ring and oil seals with Multipurpose Lubricant, or equivalent. Set the unit aside for installation later.

Forward Gear and Bearing Assembling

7- Place the forward gear on a press with the gear teeth **DOWN.** Position the forward gear tapered bearing over the gear.



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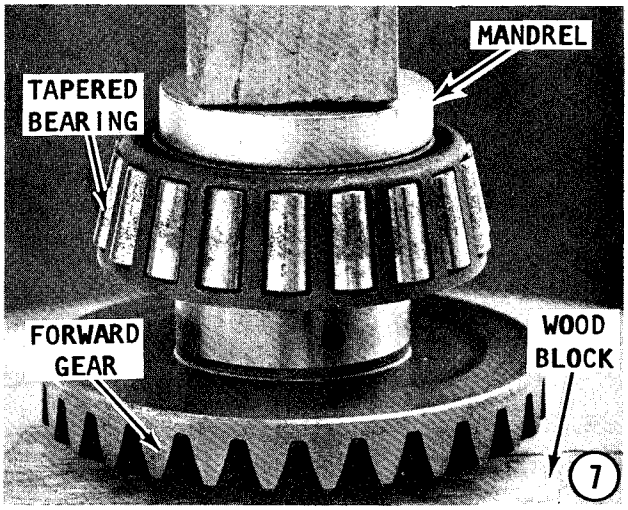
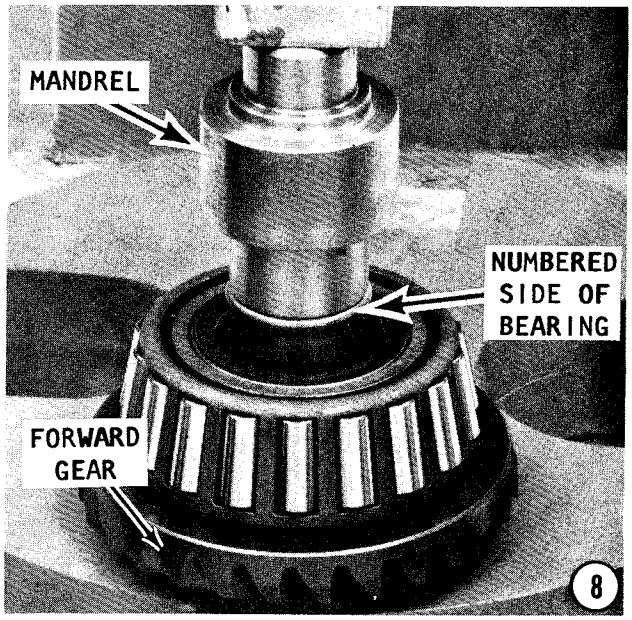


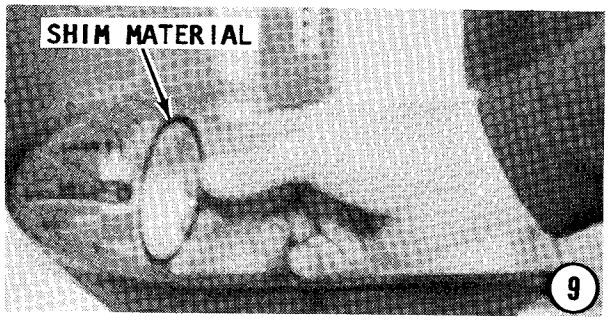
Now, press the bearing onto the gear with a suitable mandrel until the bearing is firmly seated. Check for clearance (gap) between the inner bearing race and the shoulder of the gear. There should be **NO** clearance.

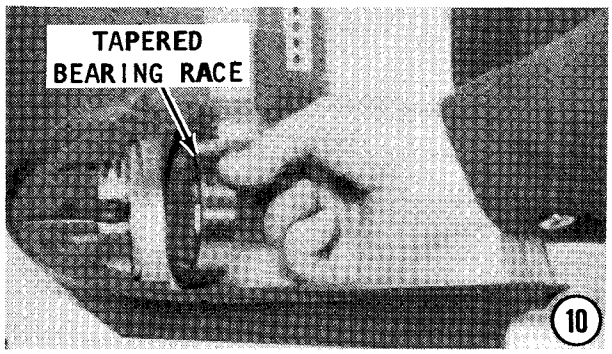
8- Position the roller bearing over the center bore of the forward gear with the numbered side of the bearing facing **UP.** Use a suitable mandrel and press the roller bearing into the gear until the bearing is seated against the shoulder.

CRITICAL WORDS

The bearing carrier is used as a pilot while installing the forward gear bearing cup in the next step. Therefore, the bearing carrier must have been assembled to include at least the propeller shaft roller bearing as outlined in Step 6.



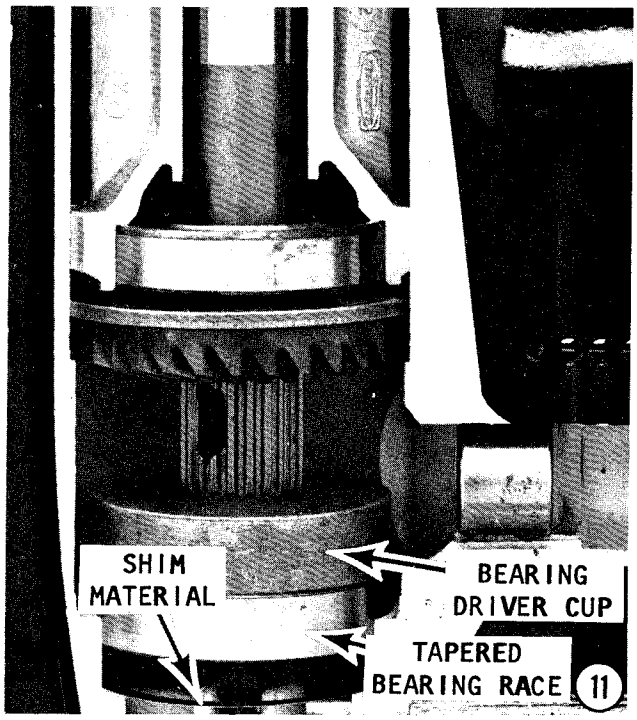




Forward Bearing Race Installation

9- Place the same amount of shim material saved during disassembly into the lower unit. If the shim material was lost, or if a new lower unit is being used, begin with approximately 0.010" (0.25mm) material. Coat the forward bearing race bore with Quicksilver Formula 50-D lubricant, or equivalent.

10- Position the tapered bearing race squarely over the bearing bore in the front portion of the lower unit. Obtain Bearing



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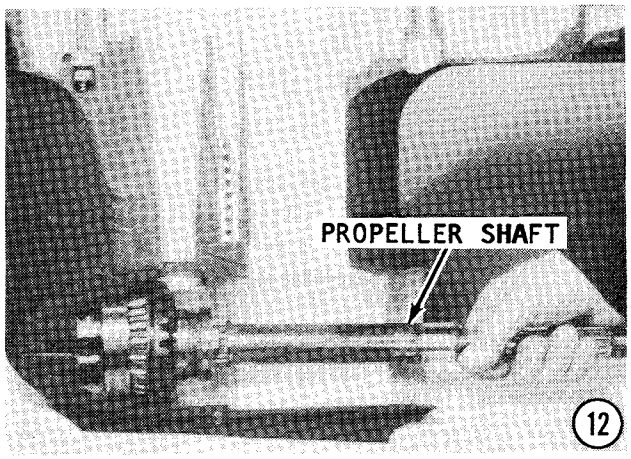
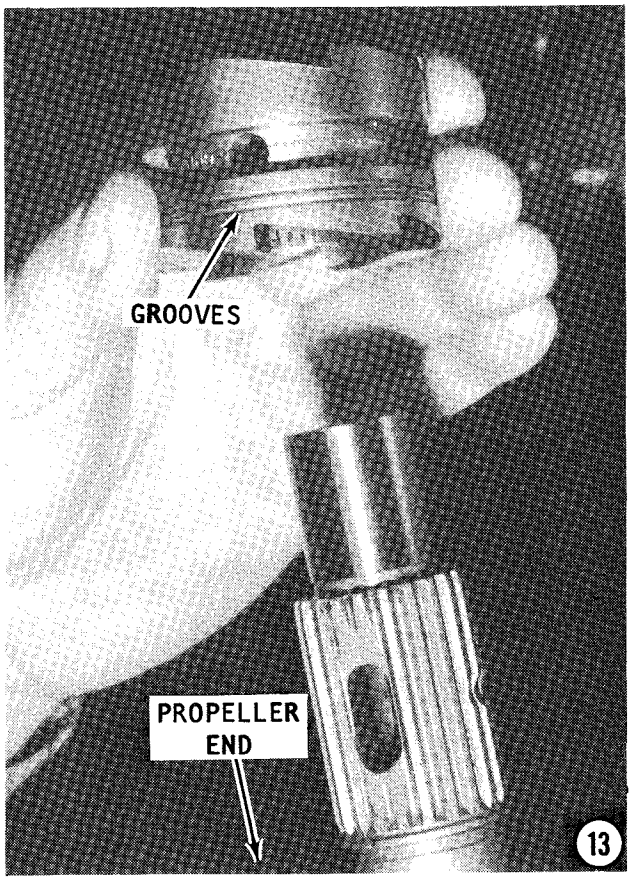


Driver Cup tool C-91-31361. Place the tool over the tapered bearing race.

11- Insert the propeller shaft into the hole in the center of the bearing cup. Lower the bearing carrier assembly down over the propeller shaft, and then lower it into the lower unit. The bearing carrier will serve as a pilot to ensure proper bearing race alignment. Now, use a mallet and drive the propeller shaft against the bearing driver cup until the tapered bearing race is seated against the shim material. Withdraw the propeller shaft and bearing carrier, then lift out the driver cup.



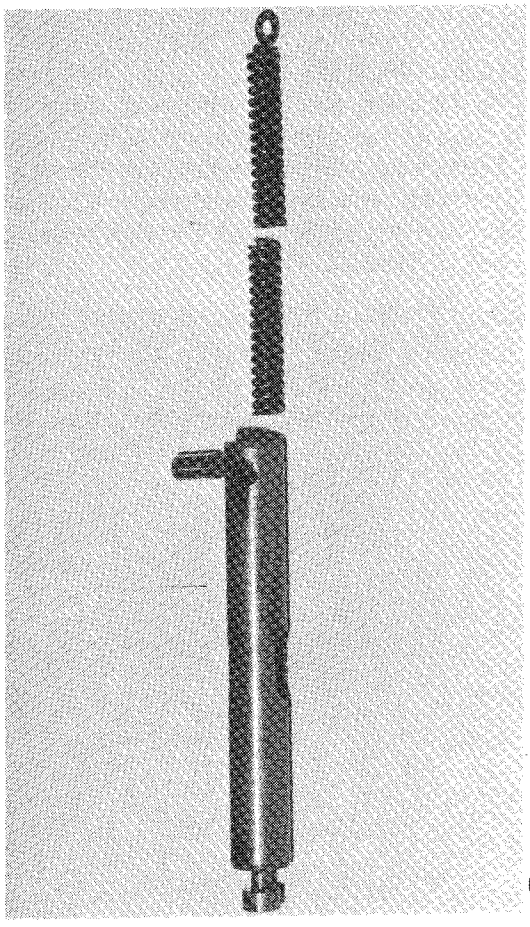
PLAN AHEAD

Obtain a suitable substance which can be used to indicate a wear pattern on the forward and pinion gears as they mesh. Machine dye may be used and if this material is not available, Desenex Foot Powder (obtainable at the local Drug Store/Pharmacy), or equivalent may be substituted. Desenex is a white powder available in an aerosol container. Before assembling either gear, apply a light film of the dye, Desenex, or equivalent, to the driven side of the gear. After the gears are assembled and rotated several times, they will be disassembled and the wear pattern can be examined. The substance will be removed from the gears prior to final assembly.

12- Position the forward gear assembly into the forward bearing race.

Propeller Shaft Assembling

13- Move the sliding clutch onto the propeller shaft with the grooves facing toward the propeller end of the shaft, as shown. As the clutch goes onto the shaft, the internal splines of the clutch will index



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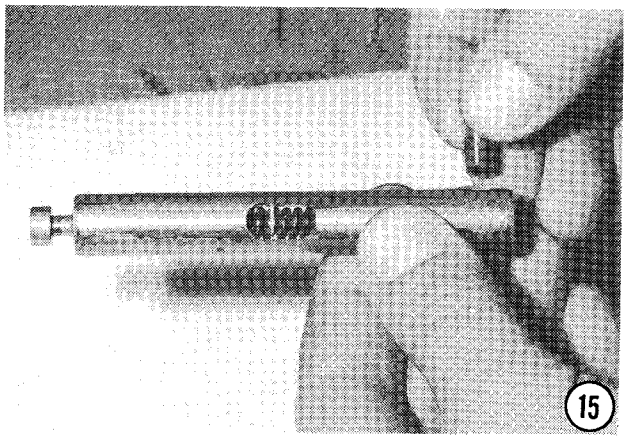
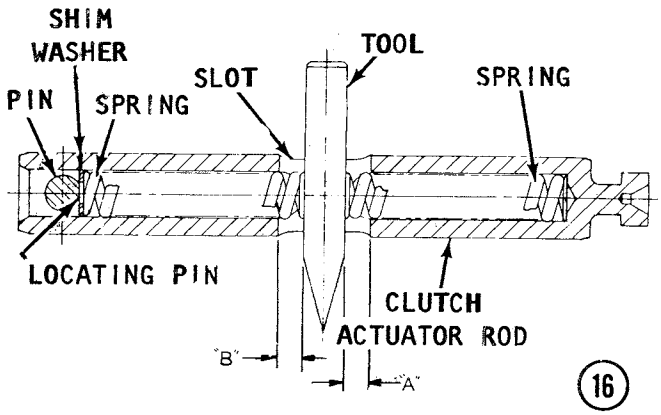
with the splines on the propeller shaft. Check to be sure the hole through the clutch aligns with the slot in the shaft. If it does not, slide the clutch free of the shaft, rotate the clutch one spline, right or left, and then slide it on again. If it is not possible to align the hole with the slot, slide the clutch free, rotate the shaft 90° to a new set of holes and try again. The hole in the clutch and the slot in the shaft will only align in **ONE** position. Naturally, when the correct set of holes through the clutch are aligned with the slot and the proper splines are indexed. The detent holes in the sliding clutch will also align with the notches in the propeller shaft.

14- To assemble the actuator rod, first arrange the parts, as shown. Notice how the locating pin has one flat side. This flat must bear against the end of the last spring to go in.

15- Slide the two springs into the actuator rod. The springs are identical, either one in first, and either end in first. Insert the shim washer into the rod to seat on top of the spring. Coat the locating pin with a small amount of Multipurpose Lubricant. Now, slide the locating pin through the rod with the flat side facing toward the springs. Once in place, the flat of the pin will bear against the shim washer.

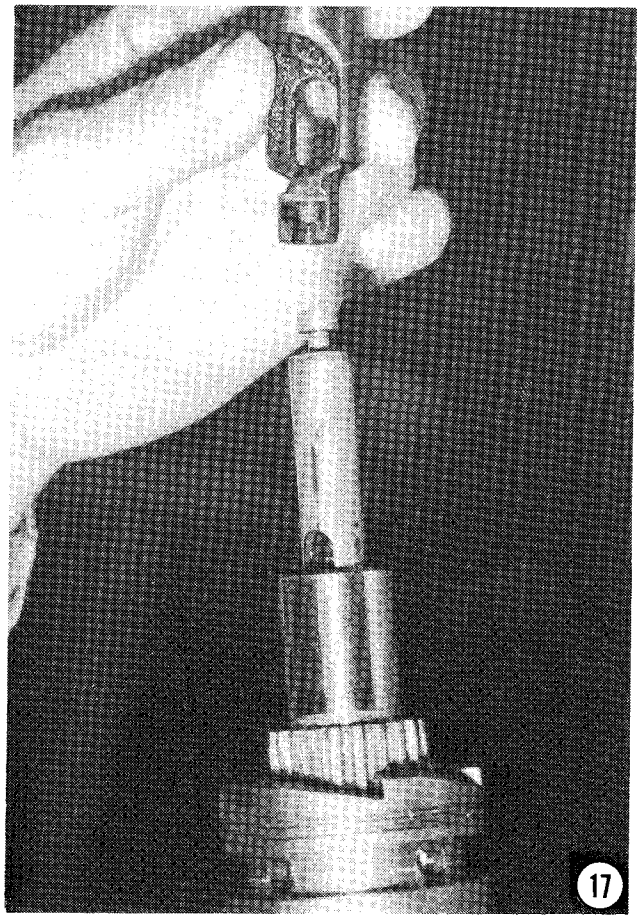
16- Insert an awl through the slot in the actuator rod to separate the two springs. Work the awl from one side and the cross pin from the other side and push the cross through the slot. Measure the distance from each edge of the cross pin to the end of the slot on that side. The measurements must be equal with 1/64" (0.4mm). To shift the pin one way or the other, the rod is disassembled, and an additional shim washer placed in one end or the other to shift the





cross pin in the opposite direction. The illustration shows the use of special cross pin tool No. C-91-86642.

17- Move the clutch back onto the propeller shaft to expose the slot. Insert the actuator rod part way into the propeller shaft. Rotate the rod to roughly align the slot with the hole in the clutch. Install the cam follower onto the end of the actuator rod, and then push the rod further into the propeller shaft. Rotate the actuator rod to align the cross pin slot in the rod with the slot in the propeller shaft, and the hole in the sliding clutch.



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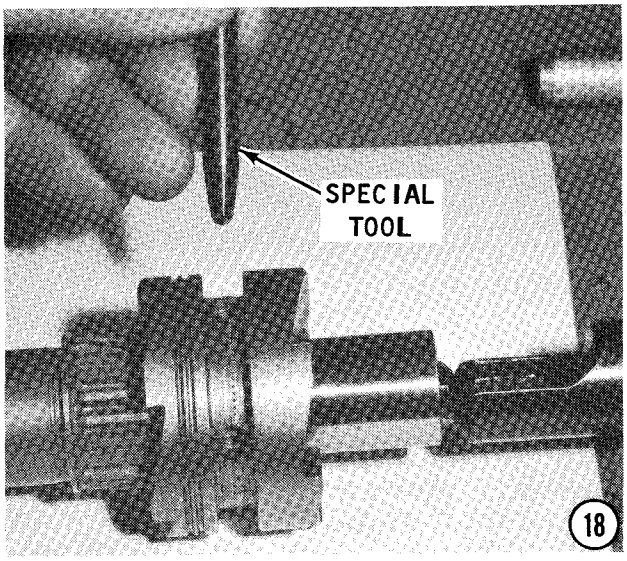
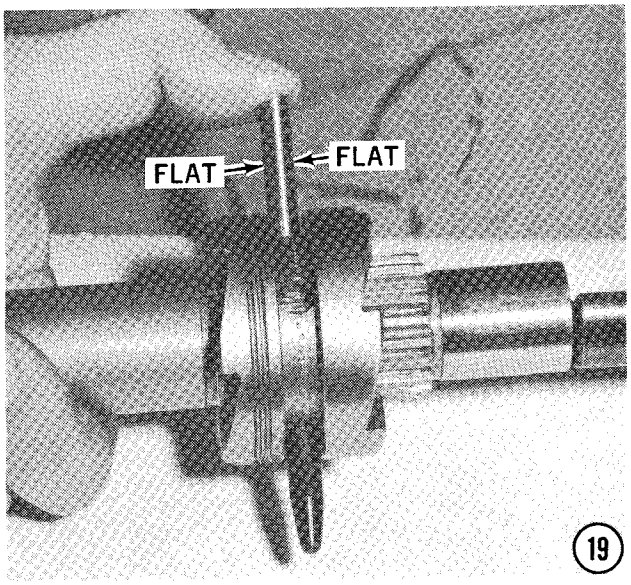
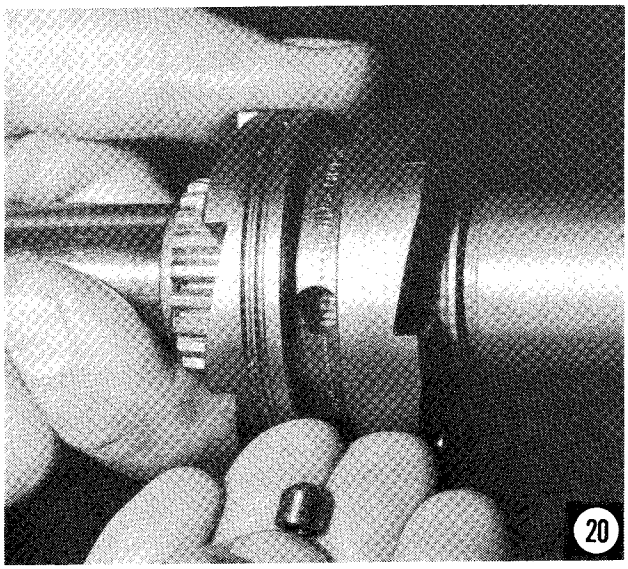


18- Obtain special cross pin tool No. C-91-86642. If this tool is not available obtain some type of pointed pin of sufficient size to spread the springs in the actuator rod apart to allow the cross pin to be inserted. A possible makeshift tool would be to cut off the shank of an appropriate size screwdriver. Insert the special or makeshift tool through the sliding clutch and spread the springs in the actuator rod.

19- Observe how the cross pin has two flat sides opposite one another. These flats must bear against the springs in the actuator rod. Now, start the cross pin with the flats facing to bear against the springs in the actuator rod. Push the cross pin into the hole immediately behind the tool. As the cross pin moves into place the special tool will be forced out. After the tool is free and both ends of the cross pin are flush





with the surface of the sliding clutch, the task is complete.

20- Apply just a dab of Multipurpose Lubricant onto each detent pin. Observe how each pin has a rounded end and a flat end. Insert the two pins into the two detent holes of the sliding clutch with the rounded end going in first, toward the propeller shaft.

21- Observe the two retaining springs. Notice how each has a bent tang on one end. The other end is straight.

SPECIAL WORDS

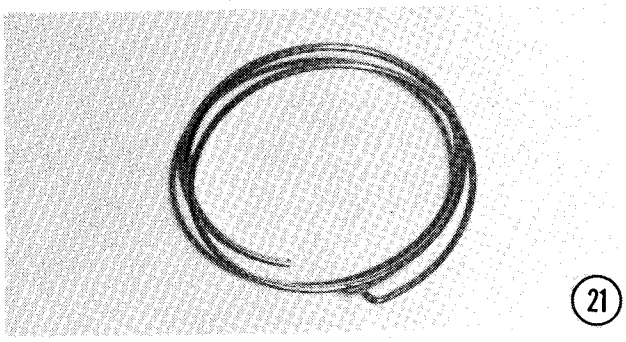
The retaining springs are identical. **HOWEVER,** one spring is wound into place in a clockwise direction and the other in a counterclockwise direction. Once in place, the following conditions **MUST** be met:

a- The springs must be wound in opposite directions.

b- The tang of each spring must be indexed into the detent of one detent pin.

c- The straight end of each spring must lie against the wall of the groove.

d- The spring coils must not overlap each other or the other spring.



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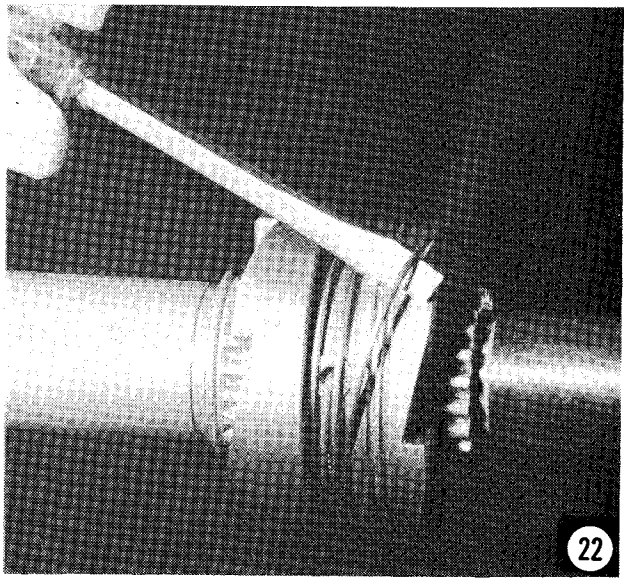
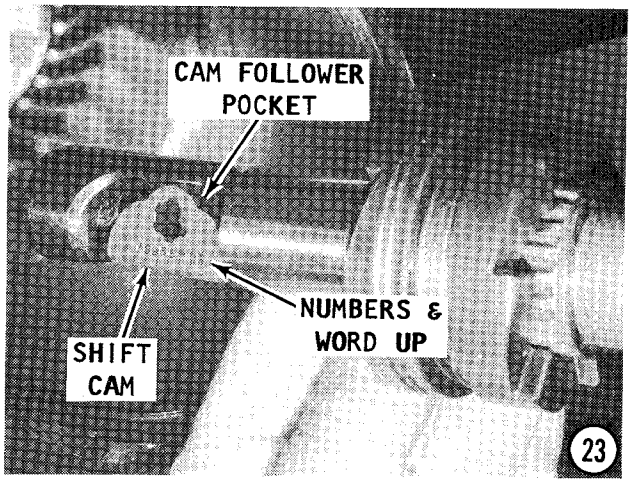


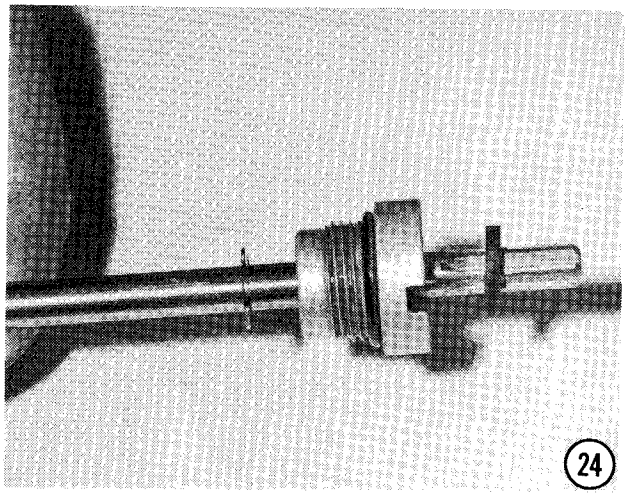
Take care not to over stretch the retaining springs as they are being installed onto the sliding clutch.

22- Slide one spring over the propeller shaft, and then insert the tang end into the detent hole that will permit the straight end of the spring to lie against the groove wall. Insert a screwdriver under the spring and wind it into place by rotating the propeller shaft. These wraps of the spring will also hold the second detent in place during installation.

After the first spring is in place, slide the second spring over the opposite end of the propeller shaft. Index the tang end of the spring into the detent of the second detent pin. Wind the spring into place with the screwdriver and by rotating the propeller shaft in the opposite direction.

Check to be sure one coil of either spring is not overlapped with its own spring or a coil of the other spring. Work the coils

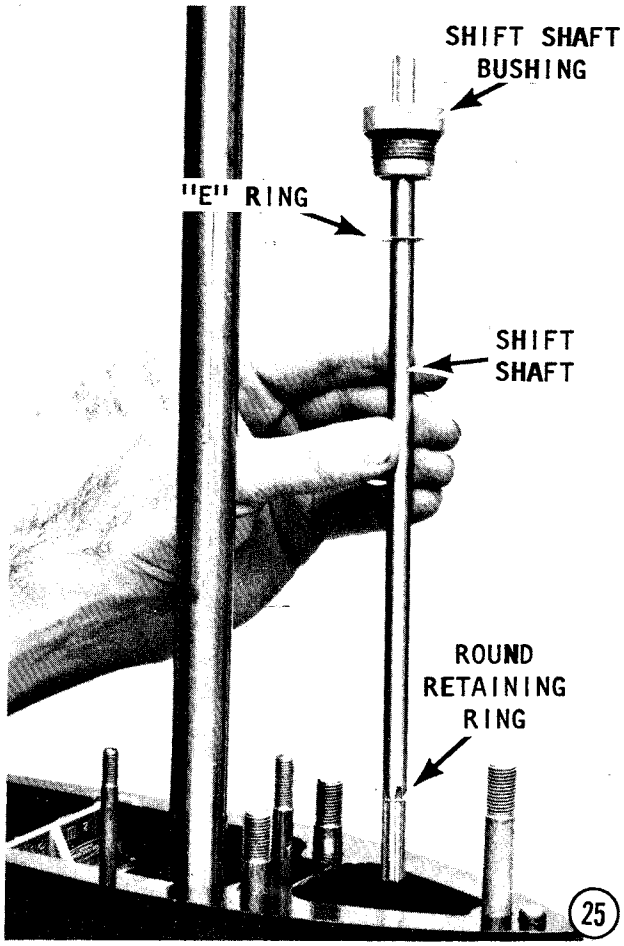




to lay individually in the sliding clutch groove.

To verify the parts have been assembled correctly, push the sliding clutch first in one direction and then in the other. You should be able to feel the detents move into place in each direction for forward and reverse gear engagement.

23- Coat the cam pocket of the cam follower with Multipurpose Lubricant. This lubricant will hold the shift cam in place



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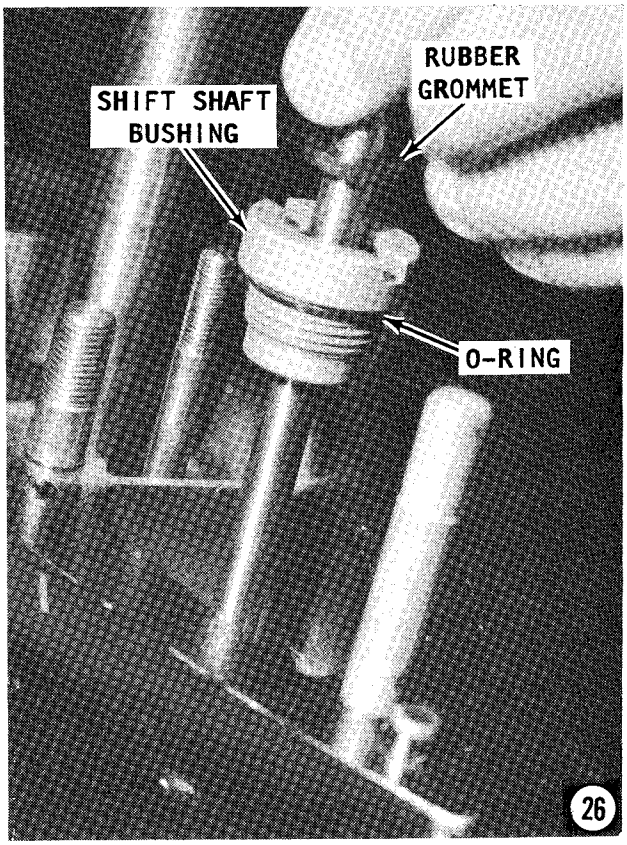
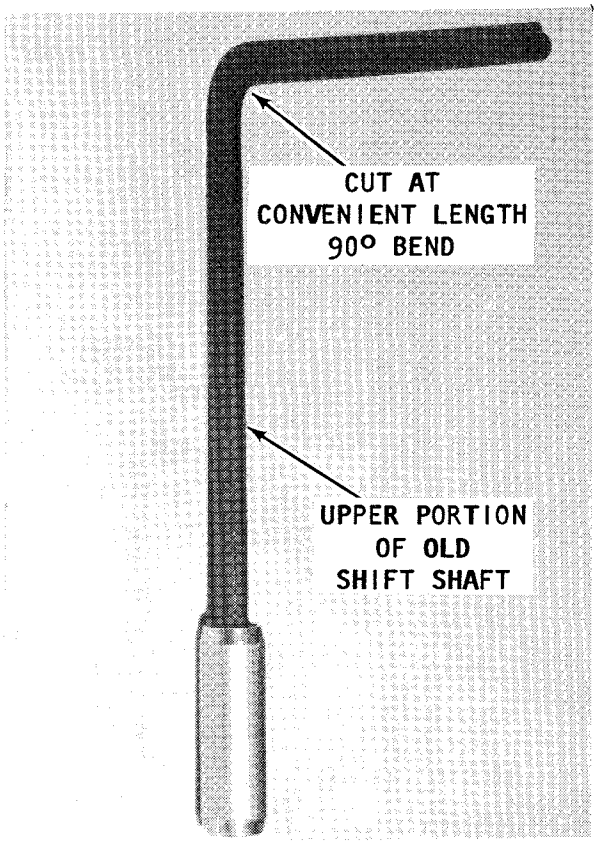




An old shift shaft, cut and bent to form a special tool to rotate the shift shaft without damaging the shift shaft splines. If this tool cannot be made, use a piece of soft metal and pair of pliers.

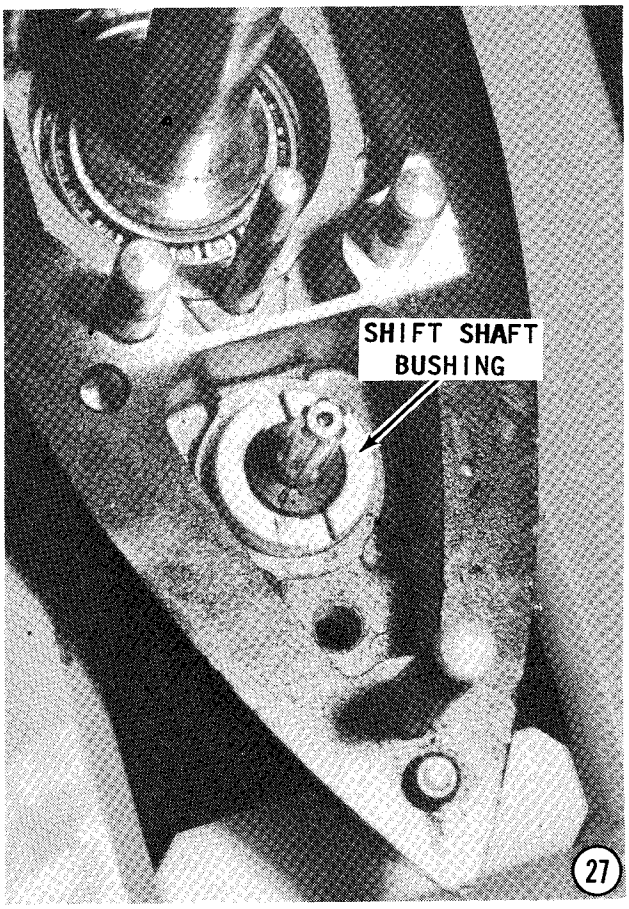
during installation of the propeller shaft into the lower unit housing. Observe the numbers and the word "UP" embossed on one surface of the shift cam. Insert the shift cam into the cam pocket with the numbers and the word "UP" facing up, as shown.

Gently insert the propeller shaft into the lower unit housing with the shift cam in as close to a horizontal position as possible. Continue to move the propeller shaft into place until the forward end of the shaft seats in the bearing.

24- Slide the shift shaft bushing and the rubber grommet onto the shift shaft, if it was removed. Install a **NEW** O-ring onto the shift shaft bushing.

25- Check to be sure the round retaining ring on the lower end of the shift shaft and the E-clip at the upper end are securely in place.

26- Use a flashlight and look down through the opening for the shift shaft and verify the hole in the shift cam in properly positioned to receive the shift shaft when the shaft is installed. If the hole is not aligned, rotate the propeller shaft slightly until the hole is aligned. **SLOWLY** slide the shift shaft down through the lower unit



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opening. Continue moving the shift shaft downward and the splines on the end of the shaft will index with the splines in the shift cam.

SPECIAL WORDS

It may be necessary to rotate the shift shaft ever so slightly to permit the shift shaft splines to index with the shift cam splines.

To ensure the shift shaft is properly indexed with shift cam, use the special tool made during disassembly from the upper portion of an old shift shaft, as shown in the accompanying illustration. If the tool was not made, wrap a piece of soft metal, such as aluminum, around the end of the shaft to protect the splines, and then use a pair of pliers. Rotate the shaft back and forth, with the tool or pliers. As the shift shaft is rotated, observe the propeller shaft move in and out of the lower unit housing slightly. Movement of the propeller shaft ensures correct assembly work.

CRITICAL WORDS

While the propeller shaft is in the lower unit and until the bearing carrier is installed, **TAKE CARE** not to bump or apply any side force on the propeller shaft. A side force on the shaft may break the neck of the clutch actuator rod.

27- Apply a light coating of Perfect Seal to the threads of the shift shaft bushing. **TAKE CARE** to prevent the Perfect Seal from contacting the bushing oil seals or the **O**-ring. Rotate the bushing by hand to prevent cross threading.

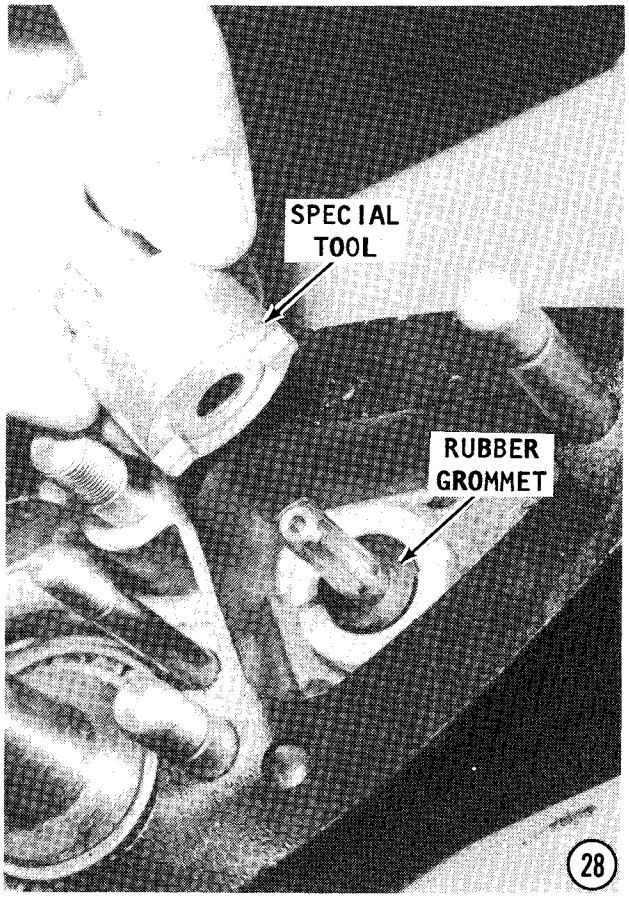
28- Push the rubber grommet down the shift shaft until it seats in the shift shaft bushing. Obtain special tool No. C-91-31107.

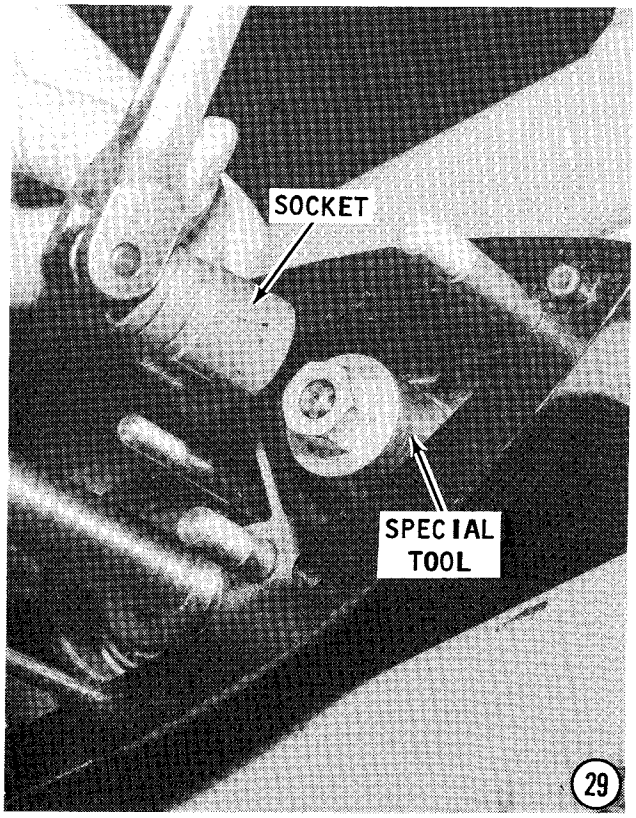
29- Tighten the bushing just snug using the special tool and the proper size socket. If the special tool is not available, use a blunt punch indexed in one of the slots at the outside edge of the bushing, and a hammer. Use quick, sharp, decisive blows to tighten the bushing. **REMEMBER,** tighten the bushing just snug.

Driveshaft Assembling and Installation

30- If the tapered roller bearing was pressed off the driveshaft, install the bearing onto the driveshaft, as follows:

Apply a light coating of bearing lubricant to the inside surface of the driveshaft tapered bearing.





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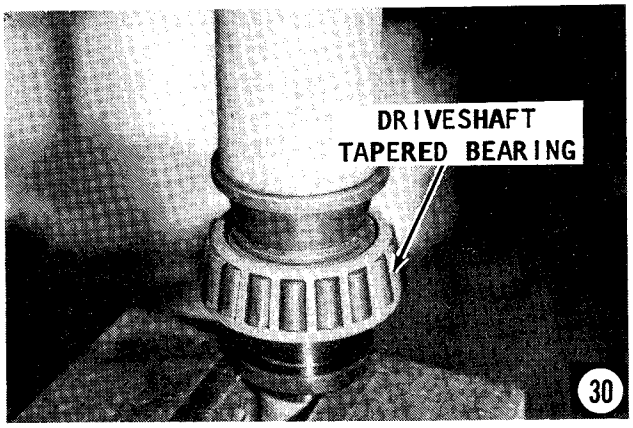


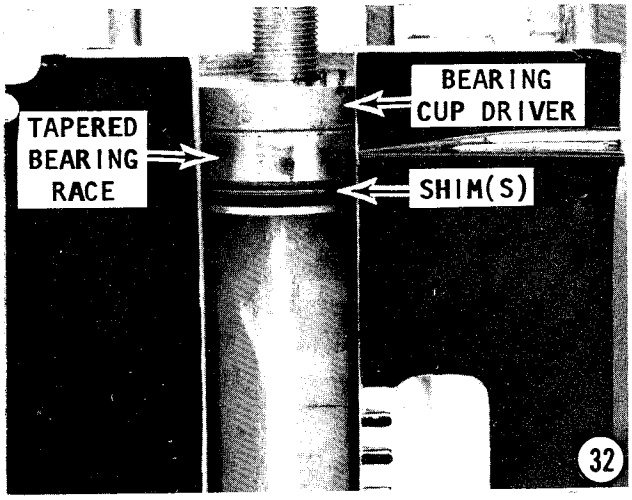
CRITICAL WORDS

When the old style driveshaft, with the preload pin, is installed into the lower unit, the small end of the taper must face **DOWN.**

When the Alpha driveshaft is installed, without the preload pin, the small end of the taper must face **UP.**

Insert the driveshaft into a suitable adapter with one side of the driveshaft shoulder against the adapter. Use a wrench adapter on the upper end of the driveshaft to protect the splines. Use a suitable mandrel and press against the inner bearing race. Continue moving the bearing onto the driveshaft until the bearing is seated against the other surface of the shoulder.

Apply a light coating of bearing lubricant to the inside surface of the driveshaft tapered bearing. Insert the driveshaft into a suitable adapter with one side of the driveshaft shoulder against the adapter. Use a wrench adapter on the upper end of the driveshaft to protect the splines. Use a suitable mandrel and press against the inner bearing race. Continue moving the bearing onto the driveshaft until the bearing is seated against the other surface of the shoulder.



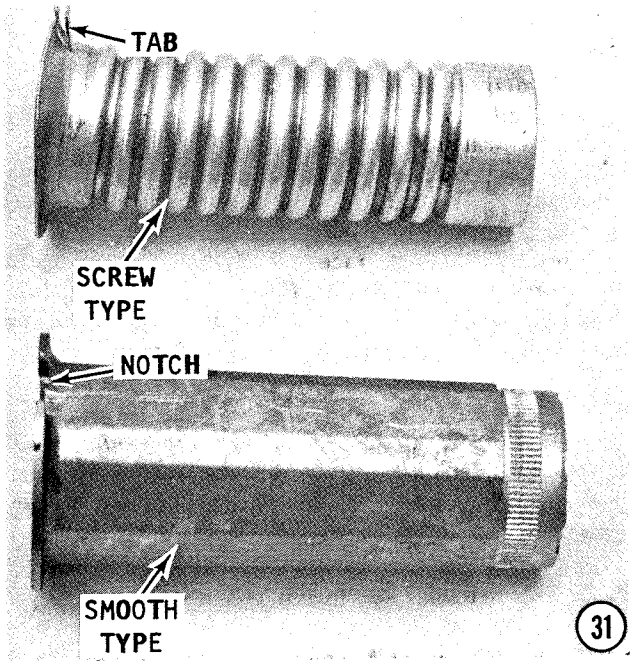
Driveshaft Installation

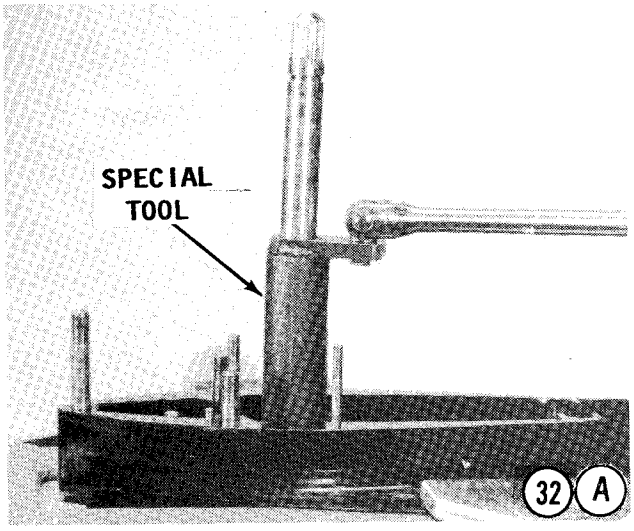
31- Insert the lubrication sleeve into the driveshaft cavity.

TWO TYPE SLEEVES

Two type lubrication sleeves are used. Both type are used on the old style driveshaft with the preload pin. The Alpha drive uses only the second "screw" type.

One type has a smooth outside surface. When installing this smooth sided sleeve, align the "flats" on the sleeve with the "flats" in the bore. Position the sleeve with the notch at the top of the sleeve **TOWARD** the leading edge of the lower unit.





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The other type sleeve has a "screw" pattern on the outside surface. This is the only type used with the Alpha drive. When installing this "screw" patterned sleeve, align the tab on the sleeve with the slot in the driveshaft bore.

CHECK to be sure the sleeve fits down into the cavity far enough to be below the shim material surface. **DO NOT** use excessive force because the sleeve could become distorted.

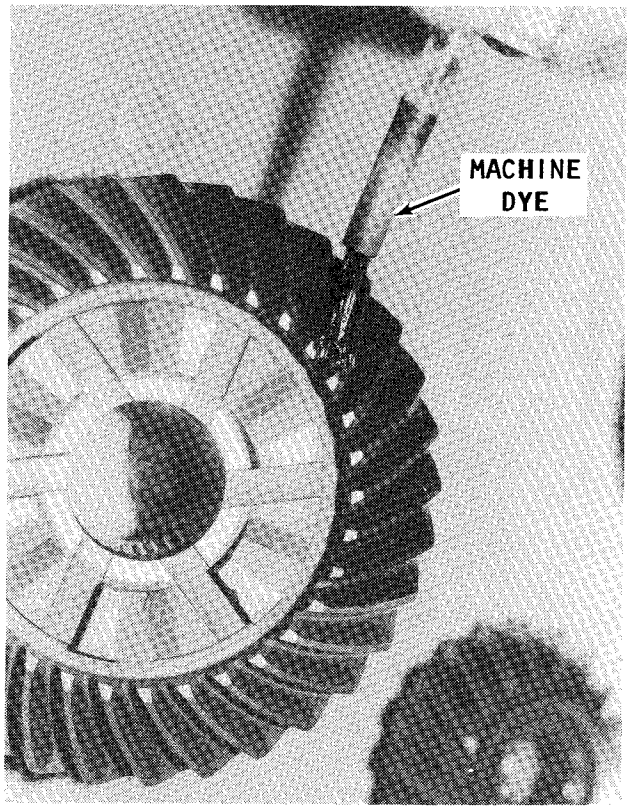
32- Position the shim material saved during disassembly into the driveshaft cavity.

Use a small amount of Multipurpose Lubricant to hold the shim material in place. Obtain Bearing Driver Cup C-91-38918 and Bearing Removal and Installation Kit C-91-31229A1.

CRITICAL WORDS

When installing the bearing race for the old style driveshaft with the preload pin, the small end of the taper must face **DOWN.**

When installing the bearing race for the Alpha drive, the small end of the taper must face **UP.**



Machine dye being applied to one of the driven gears in preparation to obtaining a gear mesh pattern with the pinion gear.

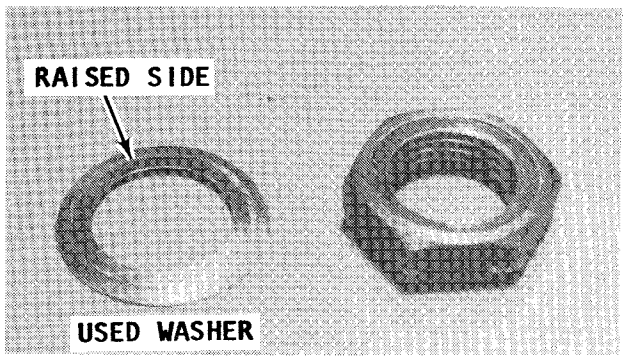
Now, using the cup and the bearing kit, drive the tapered bearing race into the lower unit cavity until the race is seated against the shim material.

Alpha Unit Only

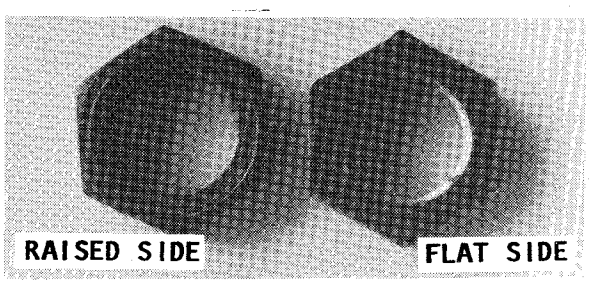
32A- Install the bearing retainer nut with the word **OFF** facing upward. Obtain bearing retainer nut tool C-91-43506. Secure the retaining nut by tightening it with the special tool to a torque value of 100 ft lb (135.6Nm).

STOP

Obtain a suitable substance which can be used to indicate a wear pattern on the forward and pinion gears as they mesh, as explained in the "Plan Ahead" paragraph prior to Step 12. Machine dye may be used and if this material is not available, Desenex (T.M.) Foot Powder (obtainable at the local Drug Store/Pharmacy), or equivalent may be substituted. Desenex is a white powder available in an aerosol container. Apply a light film of the dye, Desenex, or equivalent, to the driven side of the pinion gear. After the gears are assembled and rotated several times, they will be disassembled and the wear pattern can be examined. The substance will be removed from the gears prior to final assembly.



*The Alpha drive uses a flat washer behind the pinion gear nut to distribute the load. If a used washer is to be installed, the raised side **MUST** face the nut.*



*Both sides of a pinion gear nut. The raised portion, shown in the left view, **MUST** face the pinion gear.*

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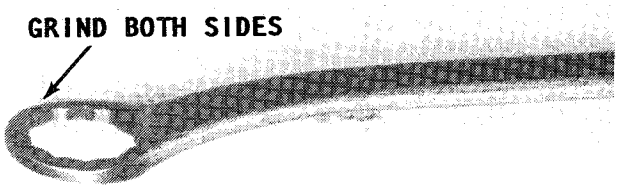
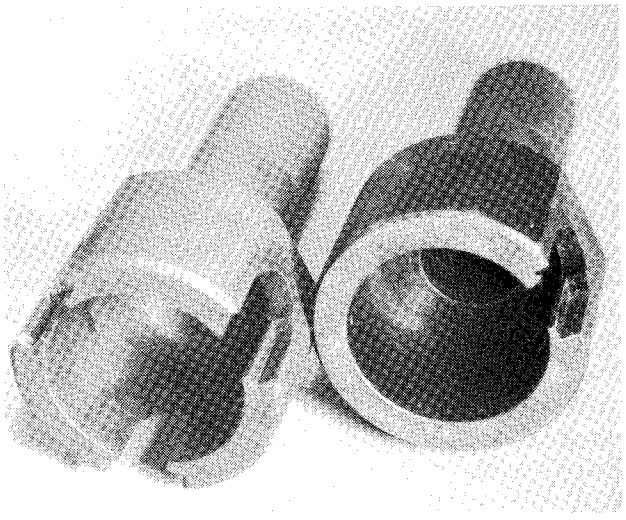
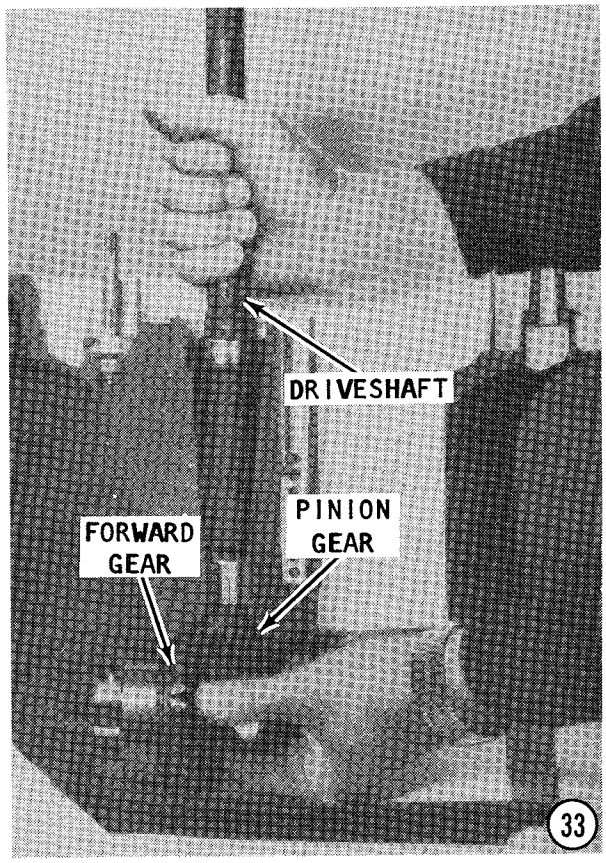


A modified box-end wrench used to remove/install the pinion gear nut, if the special tool shown below is not available.



New pinion nut holding tool (left), alongside an old one (right). The new tool has three cutouts and may be used on all lower unit models. The old one can only be used on models prior to the Alpha drive.

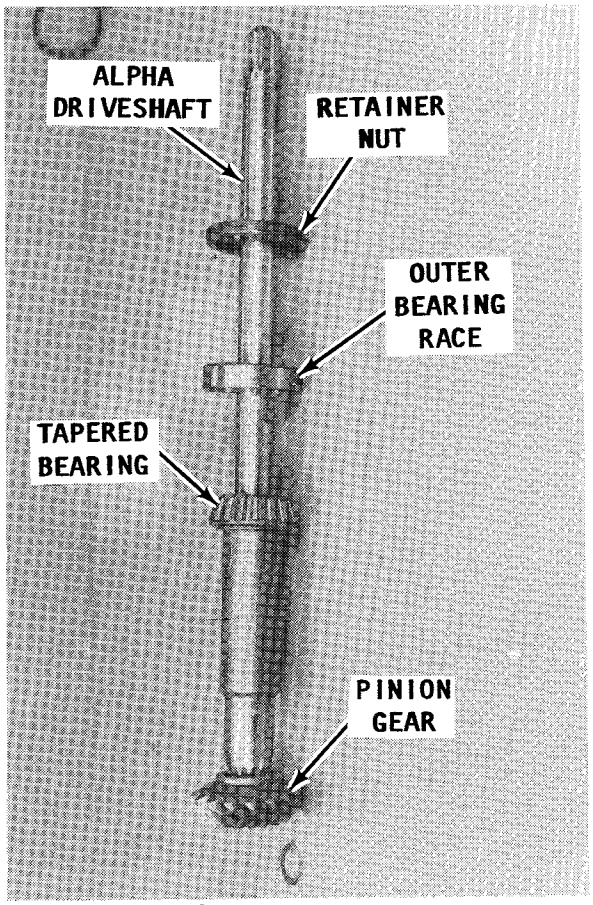


ALL UNITS

33- With one hand, lower the driveshaft into the top of the lower unit; with the other hand, hold the pinion gear up in the in the lower unit below the driveshaft cavity and with the teeth of the gear indexed (meshed) with the teeth of the forward gear. Now, rotate and insert the driveshaft until the driveshaft splines align and engage with the splines of the pinion gear. Continue to insert the driveshaft into the pinion gear until the tapered bearing is against the bearing race. Use an old pinion nut for this step, because if a new nut is used, it will lose its locking ability. Start the nut onto the end of the driveshaft.

WORDS FOR ALPHA DRIVE

On the Alpha drive, a thin washer is used to more evenly distribute the load of the nut against the pinion gear. When the washer is new, both sides are flat. However, after use, one side becomes slightly concave, the other side raised. When installing a used washer, the raised side **MUST** face toward the pinion gear; the concave side facing the nut.



Alpha driveshaft with associated parts arranged in the order of installation.

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ALL UNITS

Slide a driveshaft adaptor onto the end of the driveshaft. Now, turn the driveshaft with a torque wrench on the adaptor, and at the same time, hold the pinion nut with special tool No. C-91-61067A1 or with a modified box-end wrench, as described in the disassembling procedures. Rotate the adaptor with the torque wrench until the nut has been tightened to a torque value of 70 ft lb (95Nm).

Push inward on the propeller shaft and at the same time: for old style driveshaft, push **DOWNWARD** on the driveshaft, for Alpha drive, pull **UPWARD** on the driveshaft. While exerting this pull or push force, rotate the driveshaft clockwise from 25 to 30 turns. This action will establish a forward and pinion gear wear pattern.

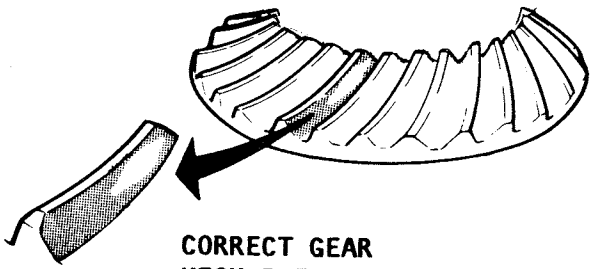
PINION GEAR DEPTH

GOOD WORDS

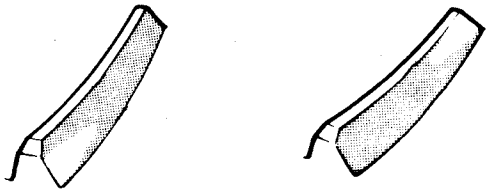
The proper amount of pinion gear depth (pinion gear engagement with the forward gear) is critical for proper operation of the lower unit. Therefore, read and **UNDERSTAND** the procedures involved in Steps 34 thru 38 before attempting any change in the shim material.

STOP AND READ

Two methods are available to properly shim the lower unit. The first method involves shimming and checking the backlash before the unit is assembled. The second method is the factory approved procedure which involves assembling the unit; taking the required clearance measurements; and then disassembling the unit if necessary, in order to change the number of shims installed. This second method requires the use of special tools, while the alternate procedure can be accomplished using standard tools or modified standard tools.



CORRECT GEAR MESH PATTERN



BOTH INCORRECT PATTERNS

A normal gear wear pattern, as shown in the upper part of the illustration, will be centered on the tooth and will not extend over either end of the tooth.

Three tasks are necessary to properly shim the lower unit. First the pinion gear must be shimmed to the correct depth. Secondly, the forward gear must be shimmed to the pinion gear for the proper backlash. And finally, the reverse gear is shimmed to the pinion gear with the correct backlash. The reverse gear on the Alpha drive does not require shimming. A thrust washer is used to absorb backlash.

TWO SETS OF SHIMMING PROCEDURES

Procedures are outlined in the following pages as follows:

a- Shim old style and Alpha drive without the use of special tools, Steps 34 through 41. Differences between the two driveshafts are clearly indicated.

b- Shim new Alpha drive using special factory tools, Steps 42 through 48.

DECIDE how the shimming procedures are to be performed and then move to the appropriate steps.

Pinion Gear Depth
Driveshaft WITH Pre-Load Pin

34- Seat the driveshaft bearing outer race firmly against the shim material using a punch and hammer. **TAKE CARE** not to damage the bearing with the punch. Grasp the driveshaft, **PUSH DOWN** and at the same time check the pinion gear tooth engagement with the forward gear teeth to be sure contact is made the full length of the tooth. This can be accomplished by using a flashlight and looking through the gear housing opening. If the pinion gear depth is incorrect, the following paragraphs list detailed steps to be followed for the correction of the condition discovered.

Pinion Gear Depth
Driveshaft WITHOUT Pre-Load Pin
Alpha Drive

35- Grasp the driveshaft, **PULL UPWARD** and at the same time, check the

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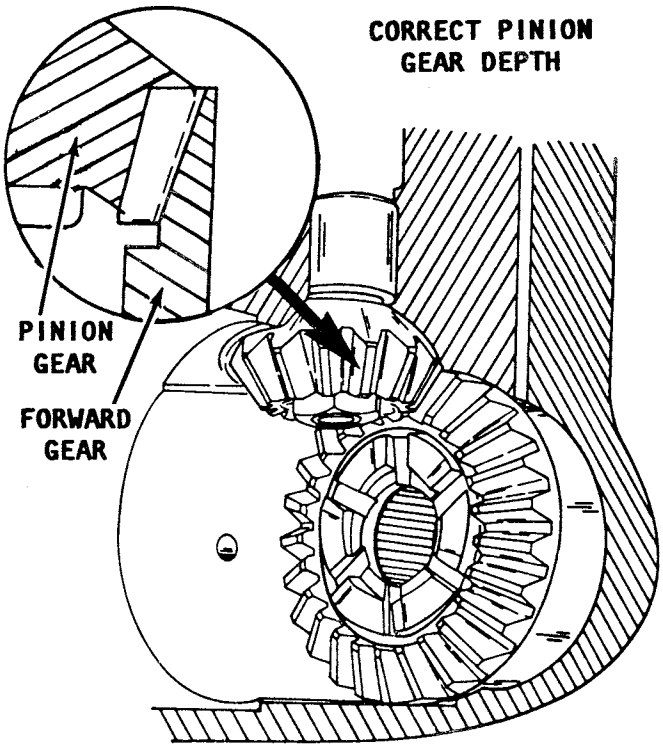
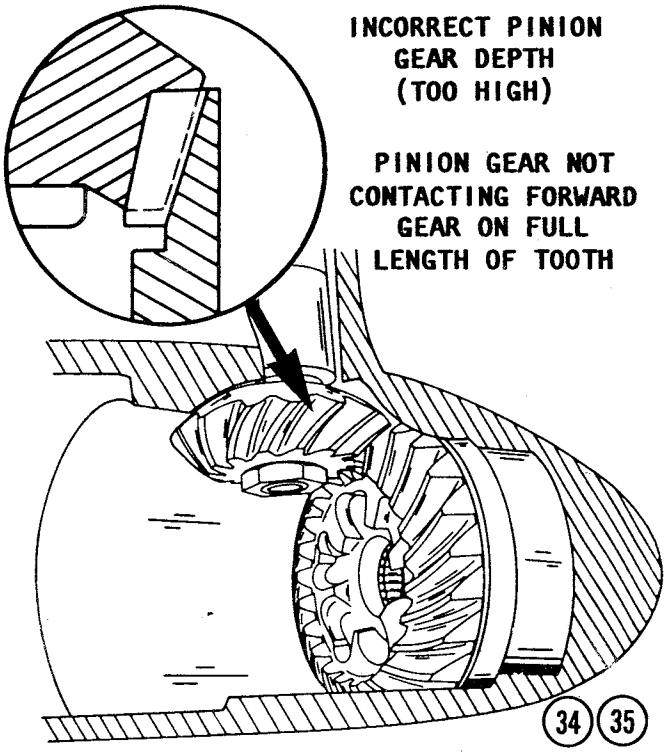




pinion gear tooth engagement with the forward gear teeth to be sure contact is made the full length of the tooth. This can be accomplished by using a flashlight and looking through the gear housing opening. If the pinion gear depth is incorrect, the following paragraphs list detailed steps to be followed for the correction of the condition discovered.

Forward Gear Backlash

36- Push downward on the driveshaft (all models with pre-load pin) or pull upward on the driveshaft (models without the pre-load pin -- Alpha drive), hold it in this position and check the pinion gear tooth engagement with the forward gear teeth. In either case, contact should be made the full length of the teeth. Now, place your other hand into the bearing carrier cavity with a couple fingers hooked in the forward gear. Pull on the forward gear and rock it lightly back-and-forth. The amount of free play between the gear teeth is considered the gear backlash. Check the Specifications in the Appendix for the proper backlash allowed for the unit being serviced.

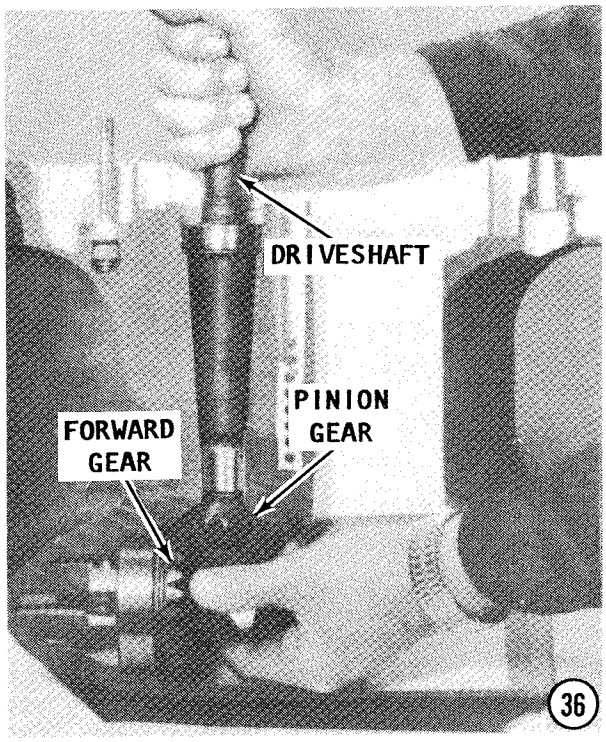
If the backlash appears to be correct, proceed directly to Step 41.

If the backlash is not within the Specification limits, proceed to make changes in the shim material, as follows.

PINION GEAR AND FORWARD GEAR BACKLASH ADJUSTMENT

The following procedures are to be performed for proper pinion gear and backlash adjustments.

If the pinion gear depth or the forward gear backlash is incorrect, follow the shim-



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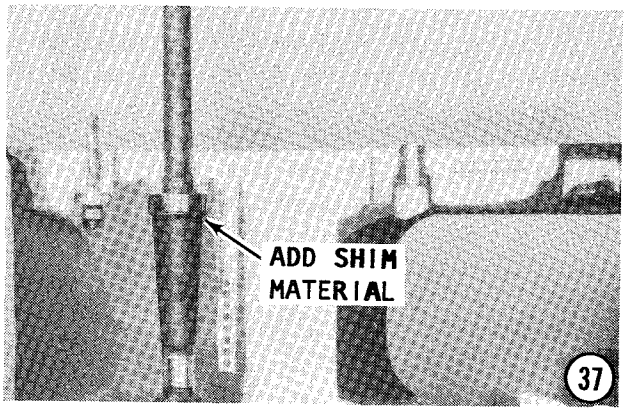


ming procedures under the heading for the specific condition discovered.

Shim Material and Backlash

Adding or removing shim material will affect the forward gear and the reverse gear as follows:

Forward gear -- adding shim material **DECREASES** backlash.

Forward gear -- removing shim material **INCREASES** backlash.

Reverse gear -- adding shim material **INCREASES** backlash.

Reverse gear -- removing shim material **DECREASES** backlash.

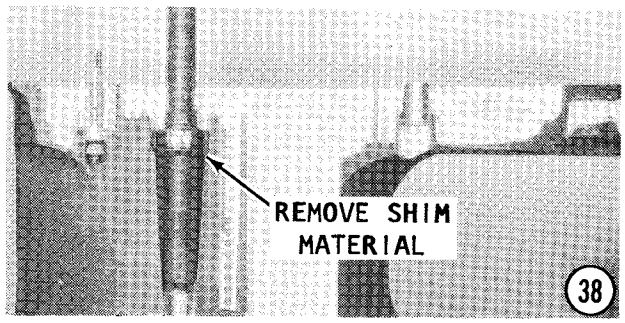
Pinion Gear Depth Too Deep but Backlash LESS than Specifications

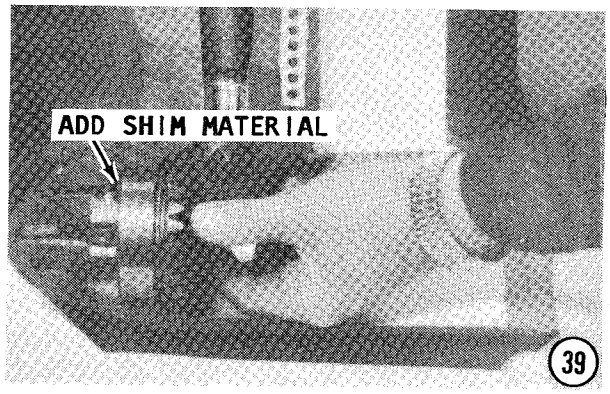
37- Remove the driveshaft, tapered bearing race if used, and the pinion gear. Add shim material to obtain the correct pinion gear depth. For each 0.001" (0.025 mm) of shim material added, the forward gear backlash will increase approximately 0.0015" (0.038 mm).

Assemble the parts and again check the pinion depth and forward gear backlash.

Pinion Gear Depth Too Shallow and Backlash LESS than Specifications

38- Remove the driveshaft, tapered bearing race, if one is used, and the pinion gear. Remove shim material to correct the





pinion gear depth. Remove the forward gear and the forward gear bearing race. Remove an **EQUAL** amount of shim material from the forward gear, plus an additional amount to increase the forwad gear backlash to the amount given in the Specifications. The forward gear backlash will increase approximately 0.0015" (0.038 mm) for each 0.001" (0.025 mm) of shim material removed from in front of the forward gear bearing.

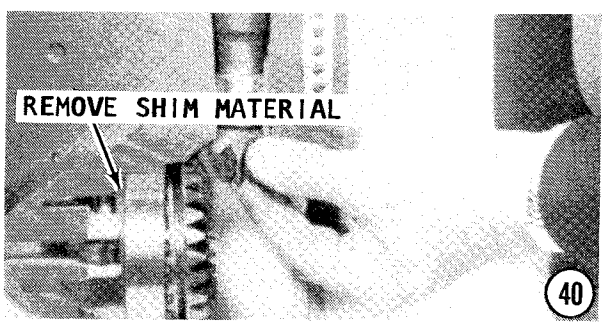
Assemble the parts and again check the pinion gear depth and the backlash.

Pinion Gear Depth Is Correct but Forward Gear Backlash is Excessive

39- Remove the driveshaft and the pinion gear. Remove the forward gear and the forward bearing race. Add shim material to reduce the forward gear backlash. Adding 0.001" (0.025 mm) shim material will decrease the gear backlash by approximately 0.0015" (0.038 mm). Assemble the parts and again check the forward gear backlash.

Pinion Gear Depth Is Correct but Backlash Less than Specifications

40- Remove the driveshaft and the pinion gear. Remove the forward gear and forward gear bearing race. Remove shim material to increase the gear backlash to specification. Removal of 0.001" (0.025 mm) shim material will increase the gear backlash approximately 0.0015" (0.038 mm).



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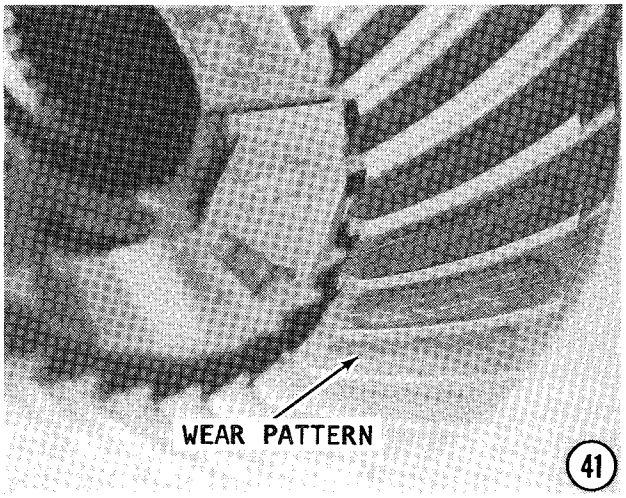
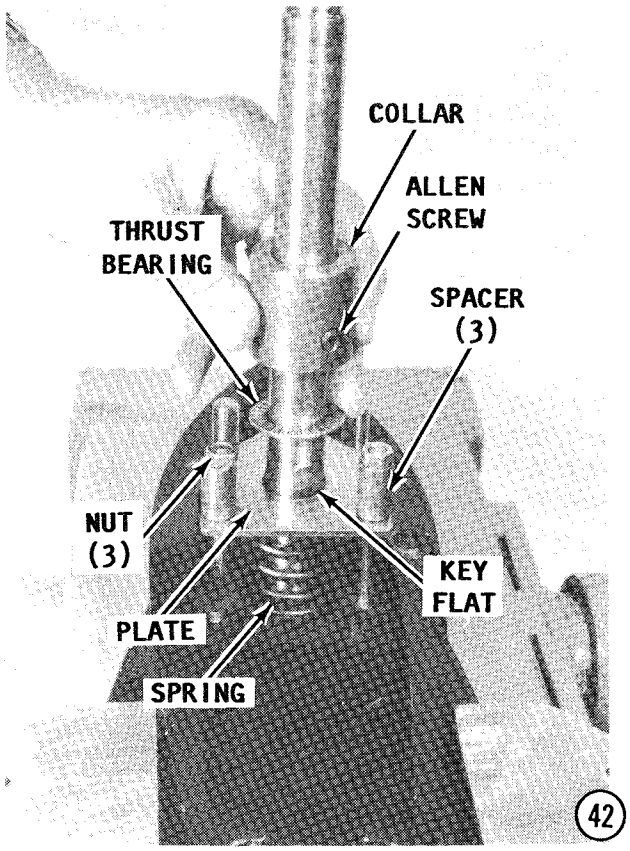


Pinion Gear and Backlash Correct

Once the proper amount of backlash and the pinion gear depth is satisfactory, check the gear mesh pattern.

41- With the unit still assembled, rotate the driveshaft **CLOCKWISE** approximately 6 to 8 complete revolutions.

Now, disassemble the unit and compare the pattern made on the gear teeth with the accompanying illustrations. The pattern should almost be oval on the drive side and be positioned about halfway up the gear teeth.



If the pattern appears to be satisfactory, clean the dye or powder from the gear teeth and assemble the unit one final time.

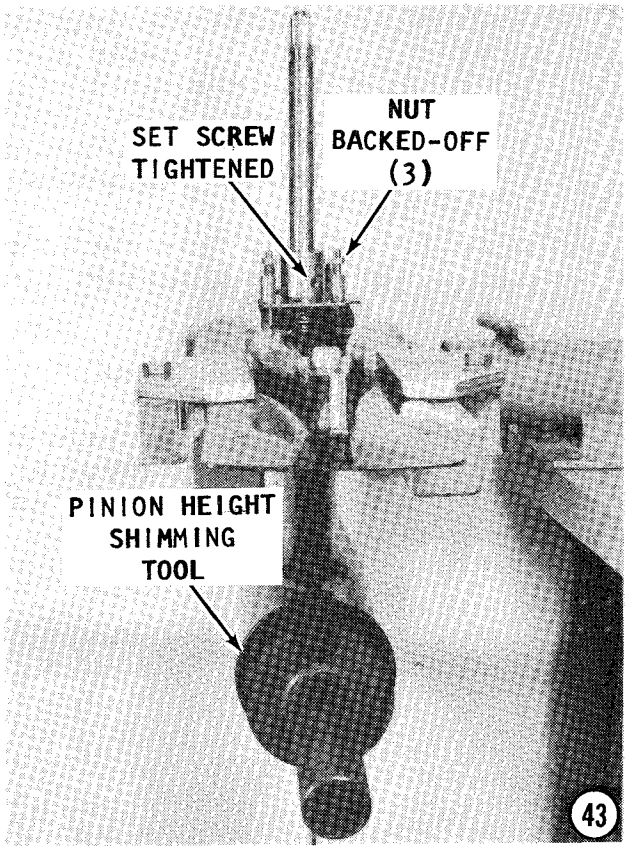
If the pattern does **NOT** appear to be satisfactory, add or remove shim material, as required. Adding or removing shim material will move the gear pattern towards or away from the center of the teeth.

SHIMMING ALPHA DRIVE USING SPECIAL TOOLS

Pinion Gear Shimming

42- Obtain special pre-load tool C-91-44307A1. This tool consists of a spring that will seat on top of the driveshaft retaining nut; a plate that fits over the driveshaft and the three water pump studs; a thrust bearing to ride on top of the plate; a collar with Allen screw that slides down the driveshaft and the screw bears on a flat on the driveshaft; and three nuts for the water pump studs.

Install the spring, plate, spacers, and nuts of the tool as described and shown. One of the nuts takes a 1/2" wrench and the other two a 7/16" wrench. Now, tighten the nuts alternately and evenly --moving the plate down the driveshaft as the spring is compressed. Continue tightening the nuts



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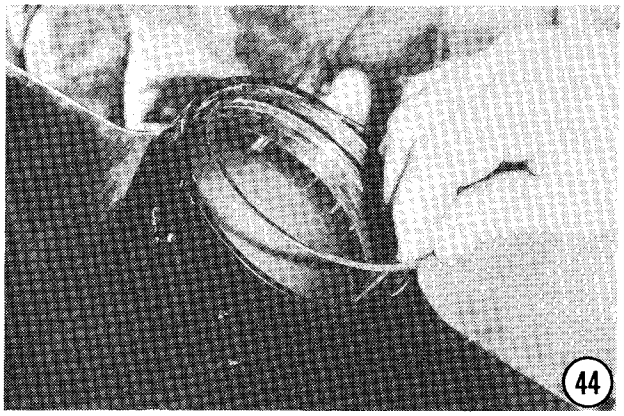
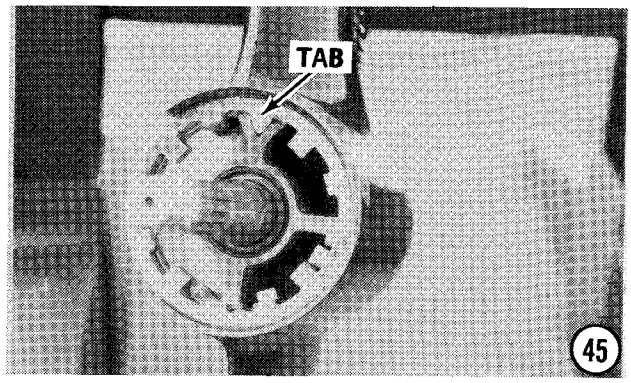
until the 1/2" nut "bottoms out" (all the threads on the stud are used. Check to be sure the plate is fairly level with the surface of the lower unit.

Slide the thrust bearing down the driveshaft and onto the surface of the plate. The thrust bearing may be installed with either side facing down. Check to be sure the Allen set screw in the collar is backed out to allow the collar to slide down the driveshaft. Move the collar down the driveshaft with the Allen screw end going down first, as shown and positioned to allow the Allen set screw to bear onto the water pump impeller key flat.

43- Tighten the Allen set screw securely, and then back-off the three nuts on the water pump studs. The driveshaft has now been forced **UPWARD** placing an **UPWARD** load on the driveshaft bearing.

Insert pinion gear shimming tool, C-91-56048, over the propeller shaft and into the housing. The design of this tool will allow the flat portion of the front of the gauge to clear the pinion gear. After the tool is inserted all the way past the pinion gear, turn the tool until the flat on the tool is **AWAY** from the pinion gear. Now, with the tool held in this position, insert a 0.025" (.64mm) feeler gauge between the bottom face of the pinion gear and the rounded part of the gauge. Most feeler gauges are not long enough to make this measurement properly. However, a suitable gauge can be made by grinding the teeth off a hacksaw blade and then using it to take the clearance measurement. If the clearance is over 0.025" (.64mm), **REMOVE** shims from under the upper bearing cup. If the clearance is under 0.025" (.64mm), **ADD** shims under the bearing cup. Leave the preload shimming tool installed for forward and reverse gear shimming procedures.





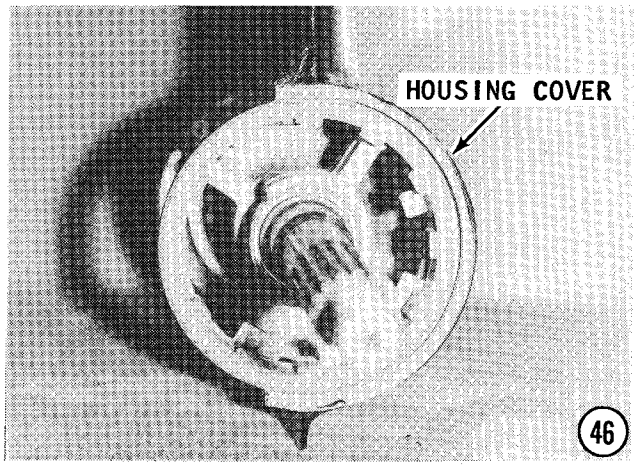
44- Install the carrier shims, which were tagged and wired together during disassembly. Install a **NEW O**-ring seal on the carrier between the thrust washer and the carrier housing. Coat the surfaces of the **O**-ring seal and carrier with anti-corrosion grease. Insert the carrier assembly.

45- Insert the bearing carrier-to-gear housing alignment key. If the housing has two notches, use the top notch. Install the bearing carrier retainer tabbed washer, with the **V**-tab aligned with the **V**-notch on the bearing carrier.

46- Thread the gear housing cover into place **BY HAND** to prevent cross-threading. Tighten it a couple of turns by hand. Use bearing carrier wrench C-91-61069 and tighten the cover to a torque value of 150 ft lb (204Nm), if the locking washer has a locking tab, or to 250 ft lb (340Nm), if the washer does not have a locking tab. **DO NOT** secure the tabbed washer at this time. The tab is not secured until **AFTER** the forward and reverse gear backlash has been adjusted.

Shimming Forward Gear To Correct Backlash

47- Install bearing carrier puller with the arms of the puller on the carrier and the



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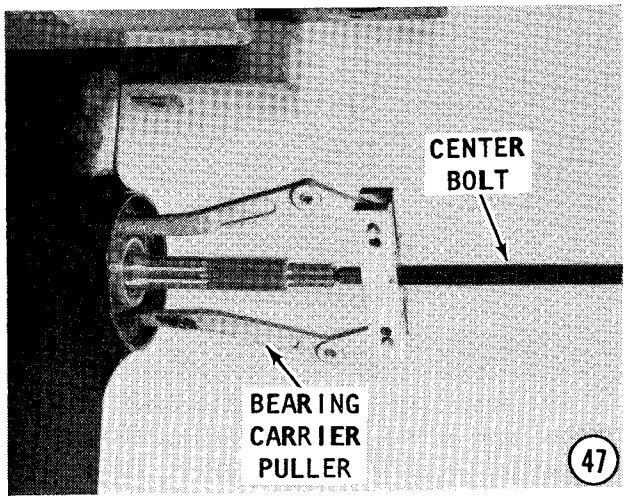
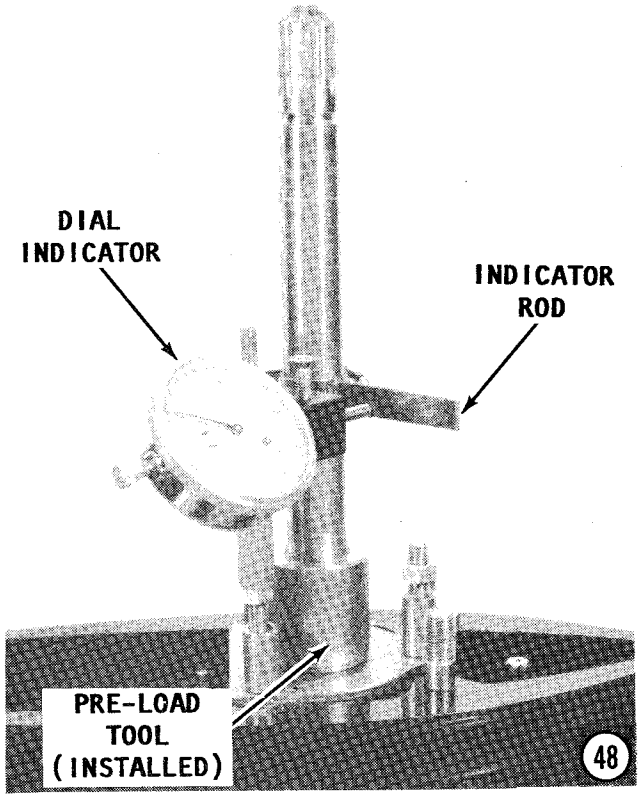


center bolt on the end of the propeller shaft. Tighten the puller center bolt to a torque value of 45 in lb (5Nm). This action places a preload on the forward gear, pushing the forward gear into the forward gear bearing. Rotate the driveshaft about three full revolutions, then recheck the torque value on the center puller bolt.

48- Attach the backlash dial indicator rod C-91-53459 to the driveshaft. Position the dial indicator shaft to the line marked **"I"** on the dial indicator rod for a pinion gear to forward gear ratio of 1.87:1 (15 teeth on the pinion gear). Use the line marked **"II"** on the indicator rod for a pinion gear to forward gear ratio of 2:1 (14 teeth on the pinion gear). Rotate the driveshaft back-and-forth and observe movement of the dial indicator. Total movement is the forward gear backlash. Check the listings in the Appendix for proper amount of backlash permissible for the unit being serviced. If the backlash is too much, add shim material behind the forward gear bearing race. If the backlash is too small, remove shim material from behind the forward gear bearing race. For each 0.003" (.076mm) of backlash, add or remove 0.002" (.051mm) shim material.

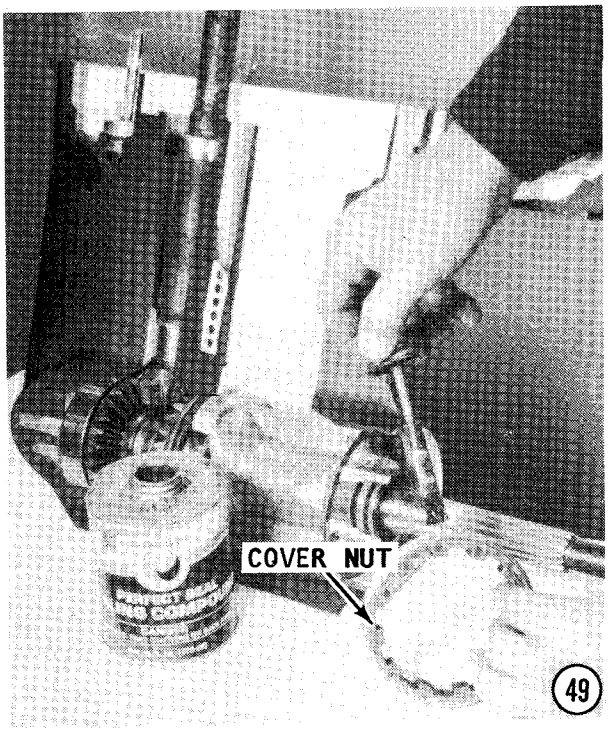


END SHIMMING PROCEDURES

ASSEMBLING CONTINUES

49- After correcting the forward gear backlash, **REMOVE** the bearing carrier assembly and clean it of all lubricant used during assembling. After the assembly is clean, apply a liberal coating of Perfect Seal to the outer diameters of the carrier that contact the gear housing. **DO NOT** allow any sealer to enter the ball bearing or the reverse gear. Coat the threads of the retainer with the sealer, and then thread the retainer on by **HAND,** to prevent any possibility of cross-threading.

50- Tighten the gear housing cover to the required torque value. Bend one of the tabs on the locking washer into one of the slots in the cover.



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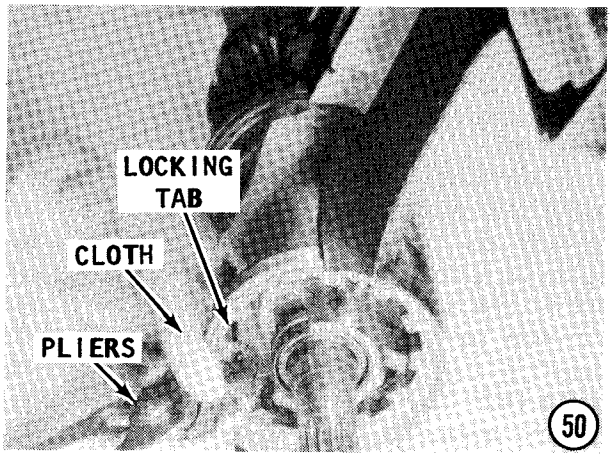


11-8 HIGH PRESSURE WATER PUMP ASSEMBLING AND INSTALLATION

The procedures in this section present detailed instructions to assemble and install the high pressure water pump used on most early lower units and lower units matched with large horsepower powerheads.

Water Pump Base Assembling

1- Position the water pump base on a press. Coat the outer diameter of the oil seals with Blue Loctite. Use a suitable mandrel and press the smaller diameter of the oil seal into the pump base with the lip of the seal **TOWARD** the impeller side. Use a suitable mandrel and press the larger diameter oil seal into the pump base with the lip of the seal **TOWARD** the driveshaft bearing side. Clean any excess Loctite from the oil seals. Install a **NEW** O-ring into the groove in the driveshaft bearing side of the pump base. Lubricate the O-ring and the oil seals with Multipurpose Lubricant, or equivalent.

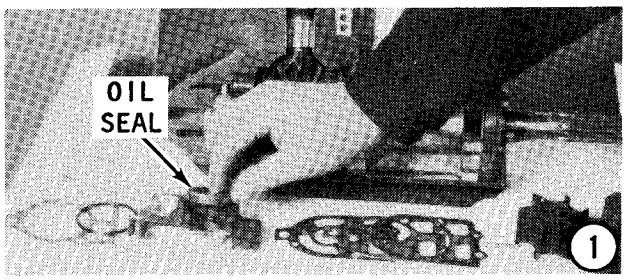
Water Pump Base Shimming
Units Without Driveshaft Preload Pin
Except Alpha Drive — No Pump Shimming

FIRST, THESE WORDS

The lower units covered in this manual without the driveshaft preload pin, (with the exception of the Alpha Drive) **REQUIRE** shim material under the water pump base. Units with the preload pin **AND** the Alpha drive (which does not have the preload pin) **DO NOT** require water pump base shimming.

Proper shimming of the water pump is **CRITICAL** in order to maintain the correct pinion gear depth and forward gear backlash. The correct amount of shim material is installed when there is no clearance between the driveshaft bearing and the pump base but 0.002" (0.051mm) has been allowed for compression of the pump base gasket.

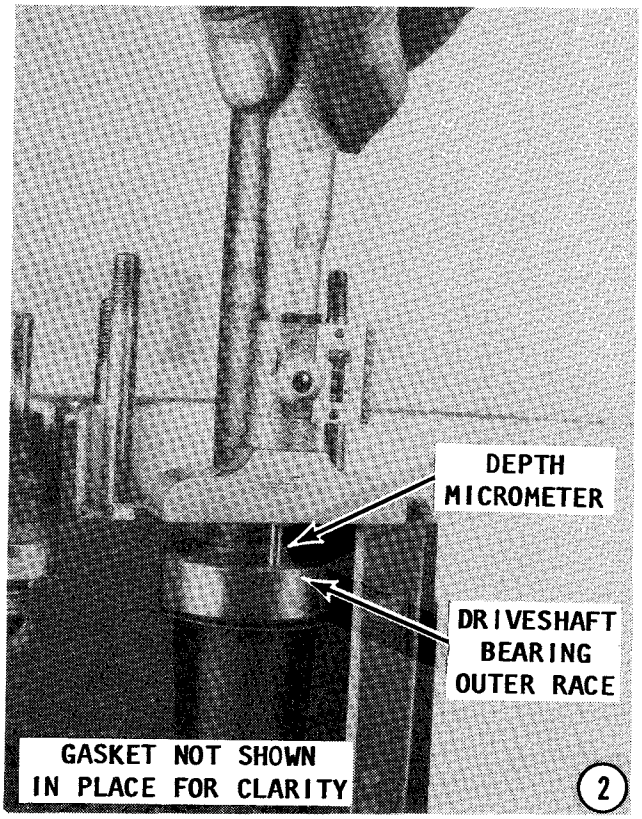
Two methods of shimming are available, one using a depth micrometer and the other a feeler gauge.



Depth Micrometer Method

2- Place a **NEW** gasket in position over the water pump studs and down against the lower unit. Use a depth micrometer and measure the distance between the top side of the gasket and the driveshaft bearing outer race. Consider this first measurement as "A".

3- With the depth indicator, measure the distance from the top of the boss (the area of the pump base that enters the driveshaft bearing cavity) to the surface that will contact the pump base gasket. Consider this second measurement as "B". Subtract



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measurement "B" from measurement "A", and then from the answer, subtract another 0.002" (0.051mm) as an allowance for compression of the water pump base gasket.

EXAMPLE

0.525" Measurement "A"
0.495" Measurement "B"
0.030" Answer to subtraction
0.002" Gasket compression allowance
0.028" Subtraction and shim required

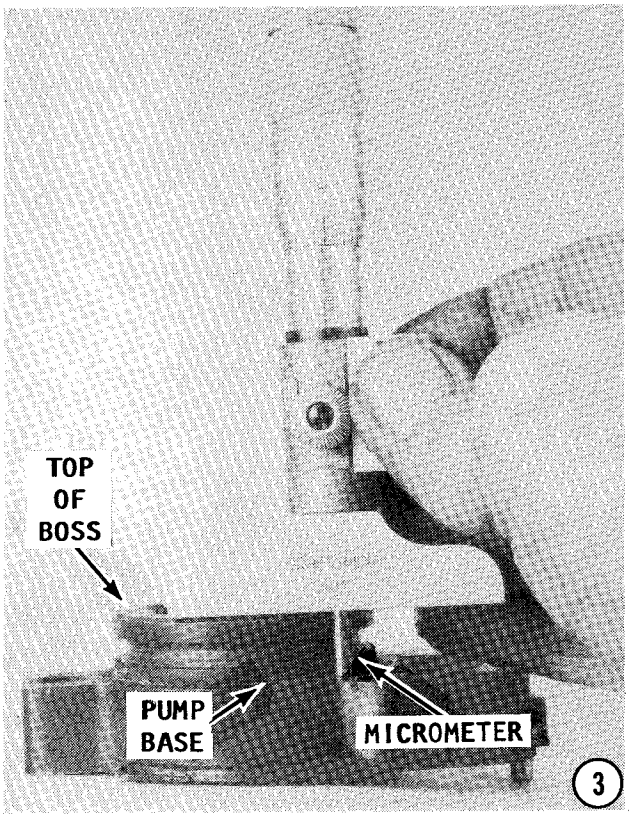
OR

13.335 mm Measurement "A"
12.573 mm Measurement "B"
0.762 mm Answer to subtraction
0.051 mm Gasket compression allowance
0.711 mm Subtraction and shim required

The proper amount of shim material will result in zero clearance between the driveshaft bearing and the water pump base. It will also maintain the proper pinion gear depth and forward gear backlash.

Feeler Gauge Method

4- Position a **NEW** gasket over the water pump studs and down against the lower unit. Remove the **O**-ring from the water pump base to aid installation of the water pump base **ONLY** for measurement purposes. Install the shims saved during disassembly plus an additional 0.020" (0.508mm) of shim material.



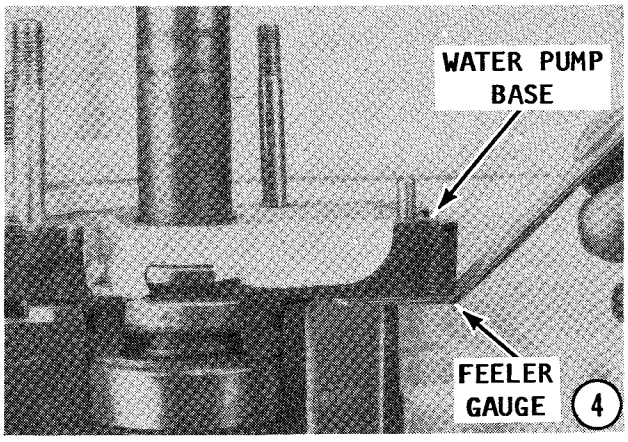
Slide the water pump base down over the driveshaft and water pump studs, and then push it down firmly into the lower unit. Hold the pump base against the lower unit and at the same time, insert a feeler gauge between the pump base and the gasket to measure the gap. The gap measurement, plus 0.002" (0.051mm) is the correct amount of shim material to remove. Removing this amount of shim material will result in zero clearance between the pump base and the driveshaft bearing shim and allows 0.002" (0.051mm) for compression of the pump base gasket.

EXAMPLE

Gap measured is 0.010" (0.254mm). Add 0.002" (0.051mm) and the answer is 0.012" (0.305mm). Therefore, remove 0.012" (0.305mm) of shim material.

5- Coat the pump insert area of the pump cover with Perfect Seal. Install the pump insert into the pump cover with the tab on the insert entering the recess in the pump cover. Clean any excess Perfect Seal from the insert and pump cover. Slide the water tube seal into the water outlet opening in the top of the pump cover with the plastic side of the seal **TOWARD** the bottom. Coat the insert and water tube seal with Multipurpose Lubricant.

Install the amount of shim material determined from Disassembling Step 2, 3, and/or 4. Slide the shim material down over the driveshaft and into position on top of the driveshaft bearing.



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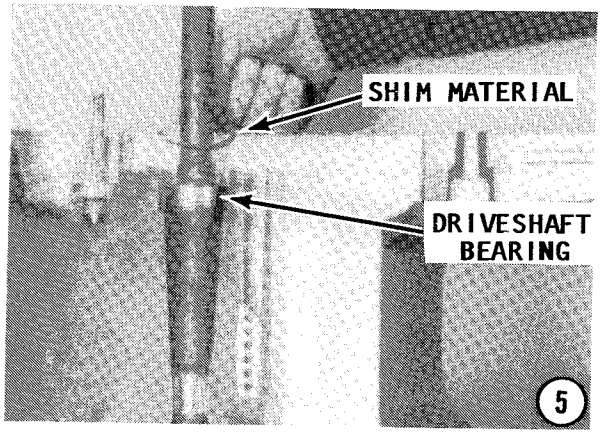


6- Remove the lower unit-to-water pump base gasket from the lower unit. Take care not to damage the gasket. Install this gasket over the water pump base O-ring.

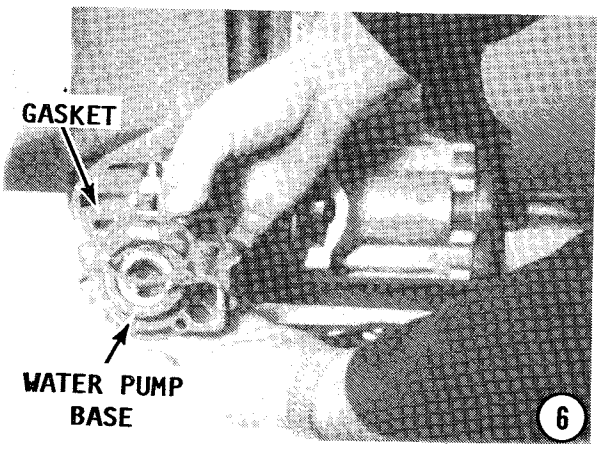
7- Install the pump base into the lower unit. Check to be sure the pump base is seated firmly against the lower unit.

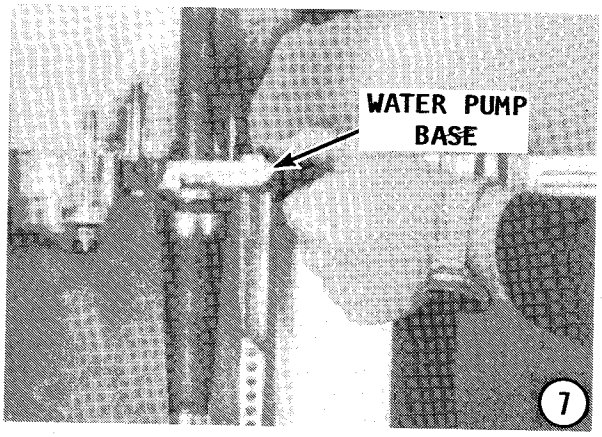
8- Install the following items in the order given: The pump base-to-face plate gasket, the face plate, and then the face plate-to-pump cover gasket. The gaskets and the face plate are indexed by dowel pin location and **MUST** be installed properly.

9- Coat the impeller drive pin area of the driveshaft, the flat area on the shaft just above the face plate, with Multipurpose Lubricant. Position the impeller drive pin on the driveshaft. Slide a **NEW** impeller down over the driveshaft and drive pin.

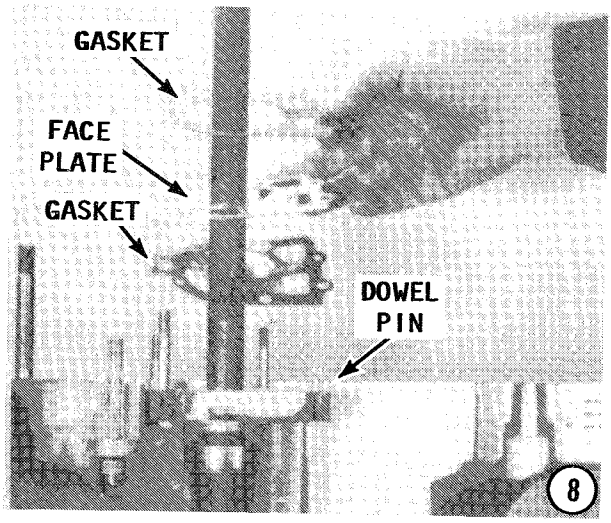
STOP

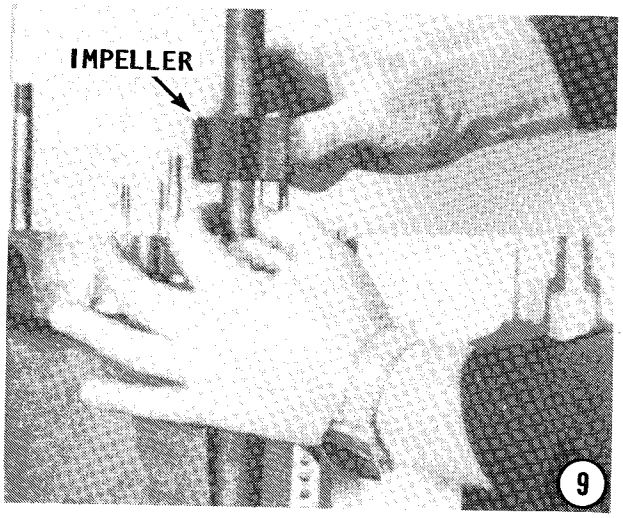
Use a thin blade screwdriver and check to be sure the impeller drive pin has not moved partially off the flat on the driveshaft. If the drive pin moves off the flat, the impeller would be forced against the pump insert after installation and cause premature impeller wear. The drive pin should be free to move upward approximately 1/16" (1.59mm).





10- Apply a thin coating of Multipurpose Lubricant onto the inside diameter of the water pump cover. Slide the assembled water pump cover down over the driveshaft and water pump studs. Rotate the driveshaft **CLOCKWISE** and at the same time push down on the pump cover to ease entry of the impeller into the cover.





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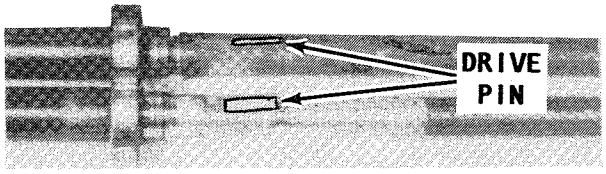
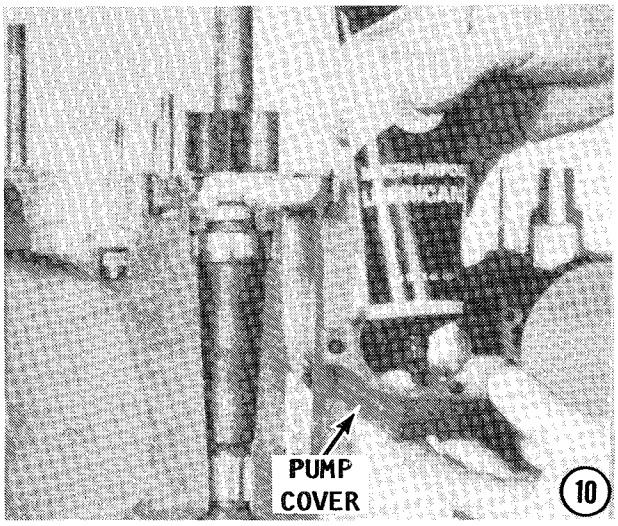
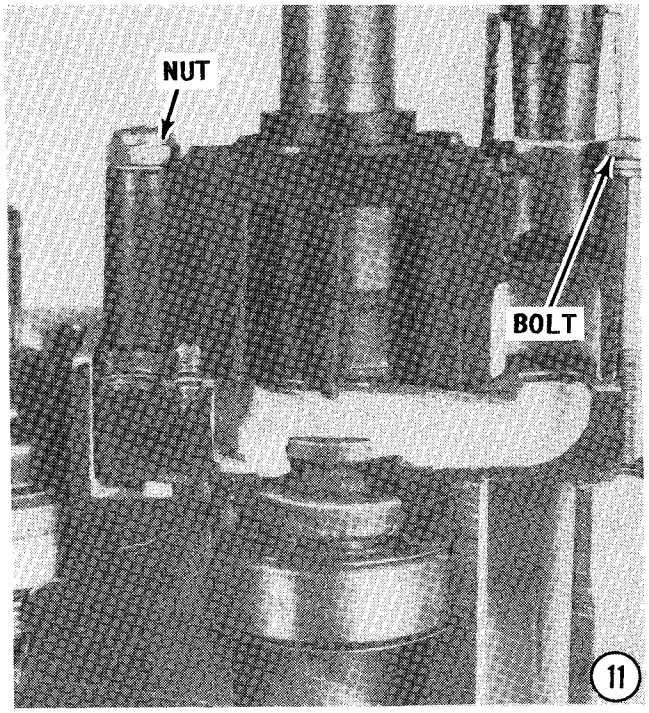


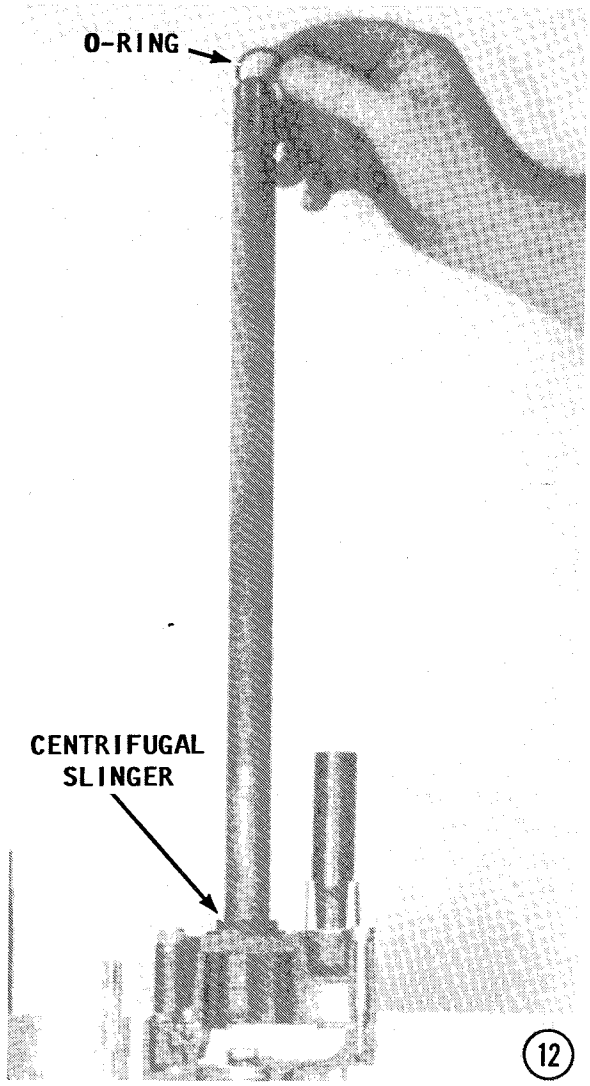
Old style round dowel-type water pump impeller key (top), and the new flat-type pin (lower). The new key should be used when a new impeller is installed.



11- Install the water pump cover retainer washers, nuts, and bolts. Tighten the bolt and nuts evenly to the torque value as follows:

Nuts 1/4-28	30 in lbs (3.4Nm)
Nuts 5/16-24	40 in lbs (4.5Nm)
Bolt 1/4-20	20 in lbs (2.3Nm)

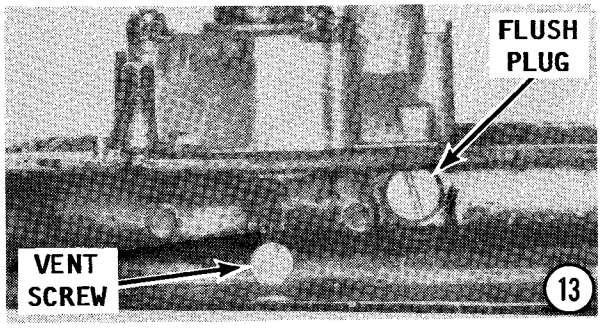




DO NOT overtighten the bolt or nuts on plastic water pump covers. Overtightening could cause the cover to crack during operation.

12- Install the centrifugal slinger over the driveshaft and down against the pump cover.

13- For units equipped with a flush plug: Position the gasket onto the flush plug, and then install the plug into the lower unit.



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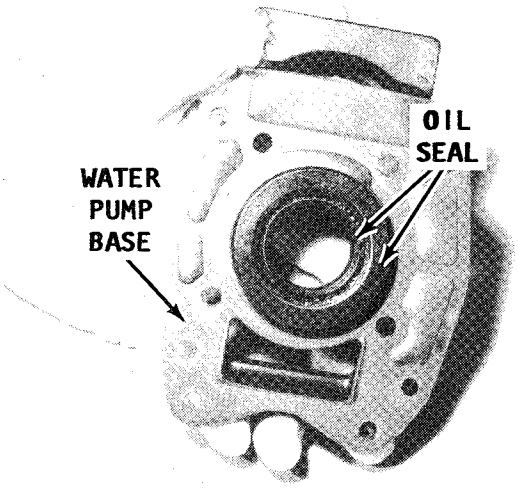
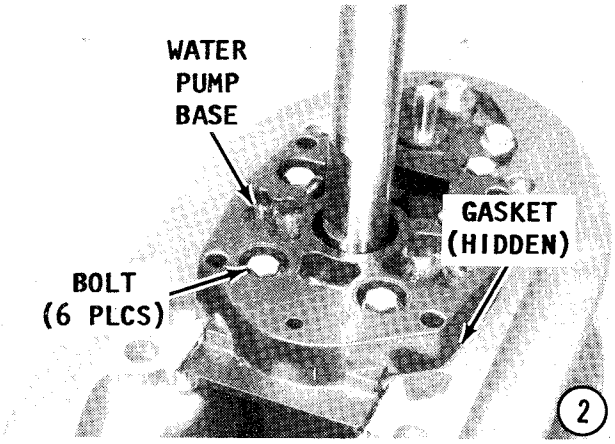


1

HIGH VOLUME WATER PUMP ASSEMBLING AND INSTALLATION

1- If the two oil seals were not removed during disassembly, skip this step and proceed directly to Step 2. If the two oil seals were removed in Step 6 of disassembling, proceed as follows: Obtain Oil Seal Drive C-91-13949, Loctite Grade "A" (271), and Quicksilver Needle Bearing Assembly Lubricant C-92-42649A-1, or appropriate substitutes.

Apply Loctite to the outer circumference and pack the lip of the two oil seals to be installed with lubricant. Slide the first seal, with the seal lip facing away from the tool, onto the longer shoulder side of the installation tool. Support the water pump base on in arbor press and press in the seal until the shoulder of the tool bottoms against the pump base. If working without the special tool, **CAREFULLY** and **SQUARELY** tap in the seal until the seal seats inside the base.



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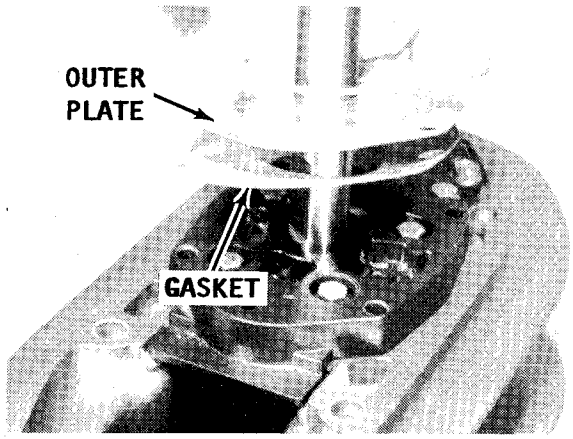


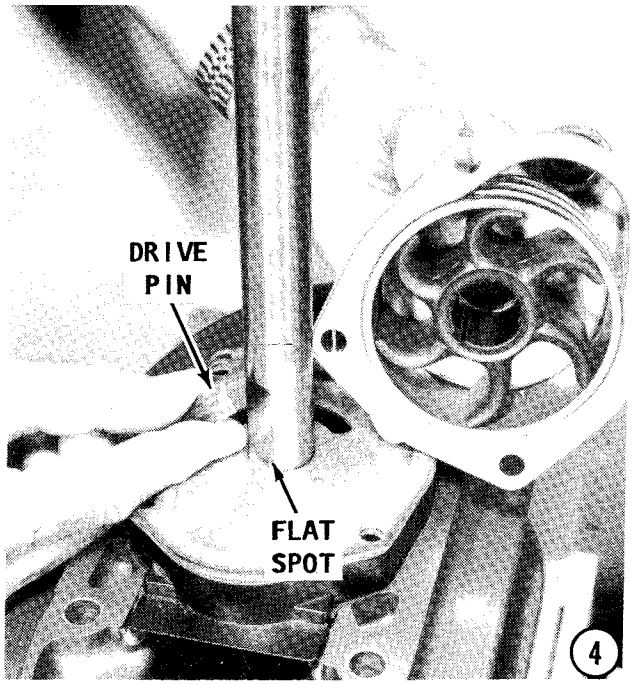
3

Slide the second seal, with the seal lip facing toward the tool, onto the shorter shoulder side of the installation tool. Install this second seal in the same manner as the first.

2- Place a new gasket in place on the lower unit. Slide the water pump base down over the driveshaft. Tap the base down lightly to seat it over the gasket. Apply Loctite to the threads of the six retaining bolts. Install and tighten the bolts and washer to a torque value of 60 in lbs (6.8Nm).

3- Slide the gasket and then the outer plate down the driveshaft.

4- Coat the impeller drive pin area of the driveshaft with Water Resistant Multipurpose lubricant. Position the impeller drive pin on the driveshaft. Slide a **NEW** impeller down the driveshaft to index over the drive pin.



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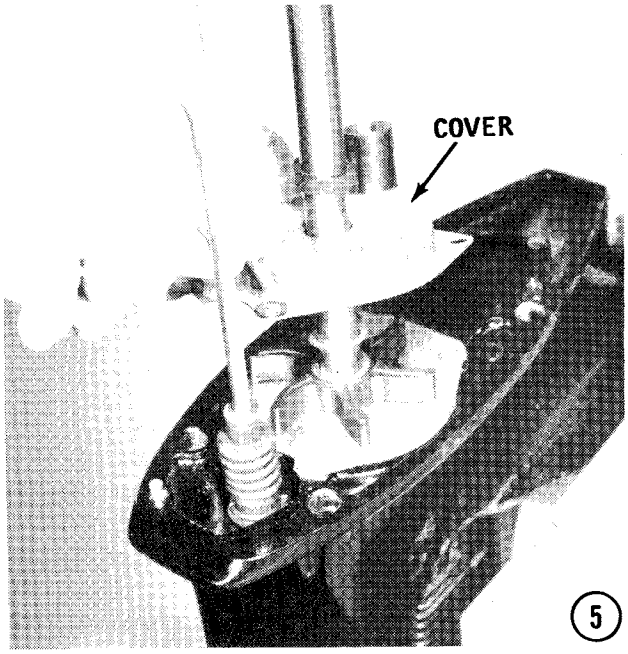


GOOD WORDS

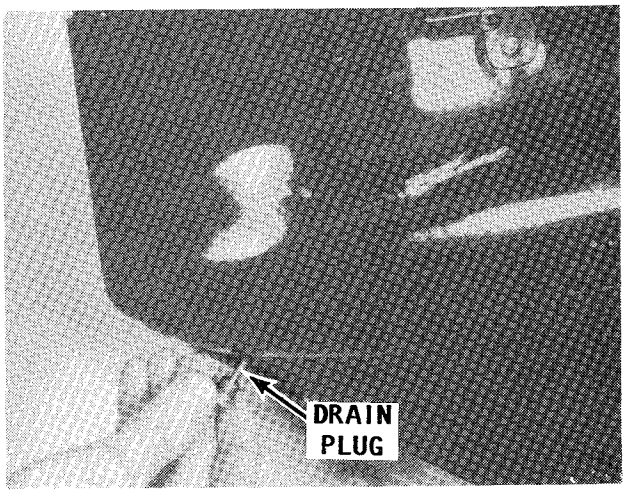
If at all possible, **ALWAYS** install a **NEW** water pump impeller. If the old impeller must be installed, **ALWAYS** install the impeller in the same position to allow the vanes to rotate in the same direction as the original installation. Installing the the impeller in such a manner to cause the vanes to rotate in the opposite direction will only result in premature impeller failure.

5- Apply a thin coating of Water Resistant Multi-purpose lubricant to the inside diameter of the water pump cover. Apply Loctite "A" (271) to the threads of the four securing bolts. Slide the cover down the driveshaft. Rotate the shaft **CLOCKWISE** and at the same time push down on the pump cover to ease entry of the impeller into the cover.

Install the water pump cover retaining bolts, washer, and isolators. Tighten the bolts to a torque valve of 60 in lbs (6.8Nm).

Slide the sealing ring down the driveshaft onto the top of the water pump cover.

Apply a coating of Water Resistant Multipurpose lubricant around the inside diameter of the water tube grommet as an aid in later assembly to the water tube.



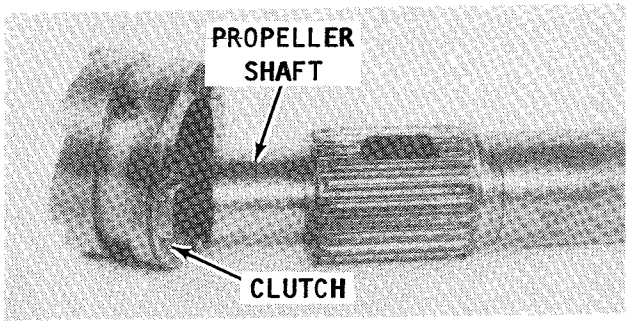
Installing the old style drain plug. New plugs have an integral magnet to catch and hold metal particles in the lubricant. Replace the old with the new as soon as possible.

11-9 CLEANING AND INSPECTING ALL LOWER UNITS

Clean all water pump parts with solvent, and then dry them with compressed air. Inspect the water pump cover and base for cracks and distortion, possibly caused from overheating. Inspect the face plate and water pump insert for grooves and/or rough surfaces. If possible, **ALWAYS** install a new water pump impeller while the lower unit is disassembled. A new impeller will ensure extended satisfactory service and give "peace of mind" to the owner. If the old impeller must be returned to service, **NEVER** install it in reverse to the original direction of rotation. Installation in reverse will cause premature impeller failure.

Inspect the impeller side seal surfaces and the ends of the impeller blades for cracks, tears, and wear. Check for a glazed or melted appearance, caused from operating without sufficient water. If any question exists, and as previously stated, install a new impeller if at all possible.

Clean all bearings with solvent, dry them with compressed air, and inspect them carefully. Be sure there is no water in the air line. Direct the air stream through the bearing. **NEVER** spin a bearing with compressed air. Such action is highly dangerous and may cause the bearing to score from lack of lubrication. After the bearings are clean and dry, lubricate them with Quicksil-



The clutch "dog" and matching splines on the propeller shaft should be closely inspected.

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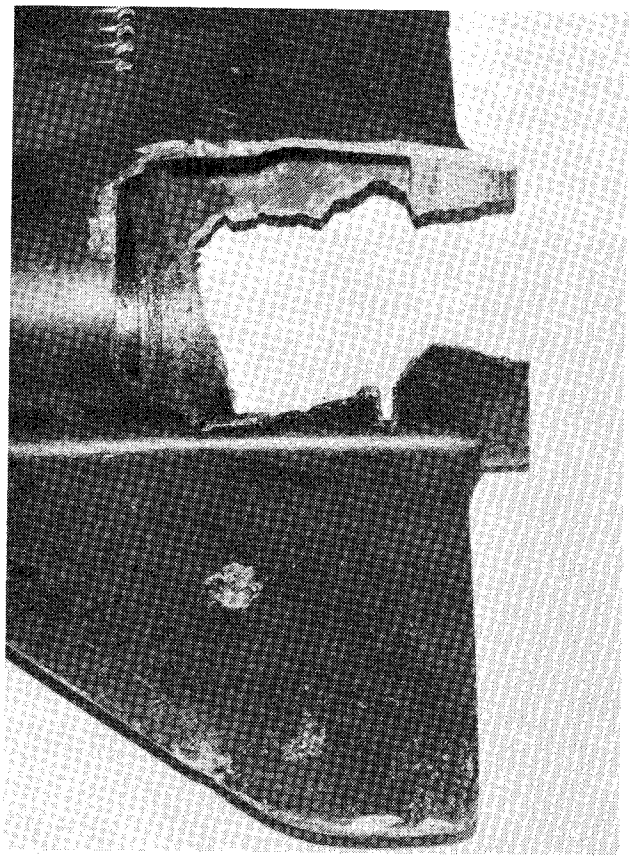
ver Formula 50-D lubricant or equivalent. Do not lubricate tapered bearing cups until after they have been inspected.

Inspect all ball bearings for roughness, catches, and bearing race side wear. Hold the outer race, and work the inner bearing race in-and-out, to check for side wear.

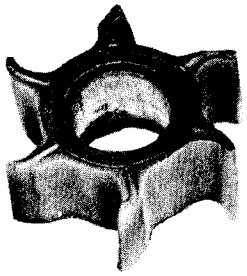
Determine the condition of tapered bearing rollers and inner bearing race, by inspecting the bearing cup for pitting, scoring, grooves, uneven wear, imbedded particles, and discoloration caused from overheating. **ALWAYS** replace tapered roller bearings as a set.

Inspect the bearing surface of the shaft roller bearing support. Check the shaft surface for pitting, scoring, grooving, imbedded particles, uneven wear and discoloration caused from overheating. The shaft and bearing must be replaced as a set if either is unfit for continued service.

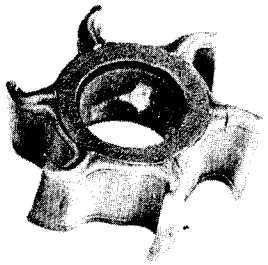
Inspect the sliding clutch of the propeller shaft. Check the reverse gear side clutch "dogs". If the "dogs" are rounded one of three causes may be to blame.



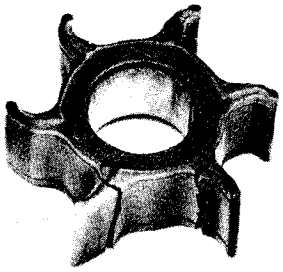
This lower unit housing was destroyed because the bearing carrier was "frozen" so badly drastic action was required. Even so, all working components inside the unit were saved for further service.



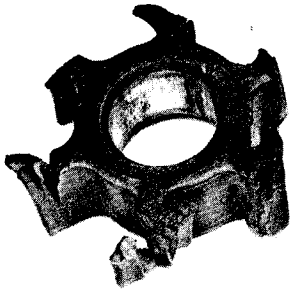
Ater 60 seconds at 1500 rpm



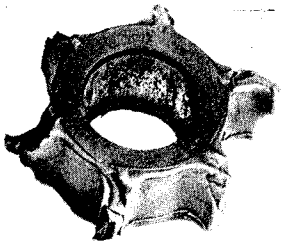
After 90 seconds at 1500 rpm



After 30 seconds at 2000 rpm



After 45 seconds at 2000 rpm



After 60 seconds at 2000 rpm

Water pump impeller damage caused by the powerhead running at various speeds for short periods without water circulating through the pump.

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a- Improper shift cable adjustment.

b- Running engine at too high an rpm while shifting.

c- Shifting from neutral to reverse gear too quickly.

Inspect the cam follower and replace it and the shift cam if there is any evidence of pitting, scoring, or rough surfaces.

Check the straightness of the propeller shaft with a set of **V**-blocks. Rotate the propeller shaft on the blocks and at the same observe the propeller shaft splined area for a bend. Inspect the seal surfaces, the area of the shaft where the bearing carrier oil seals make contact. If any type of groove is discovered in this area the shaft should be replaced. Inspect the propeller shaft spline area for corrosion damage or wear.

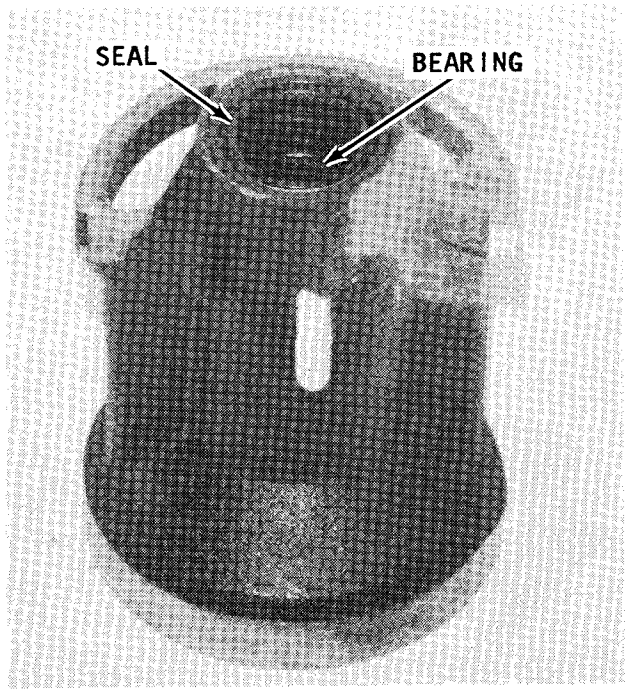
Inspect the propeller shaft roller bearing surfaces for pitting, rust marks, uneven wear, imbedded metal particles or signs of overheating caused by lack of adequate lubrication.

Good shop practice requires installation of new **O**-rings and oil seals **REGARDLESS** of their appearance.

Clean the bearing carrier, pinion gear, drive gear clutch spring, and the propeller shaft with solvent. Dry the cleaned parts with compressed air.

Check the pinion gear and the drive gear for abnormal wear. Apply a coating of light-weight oil to the roller bearing. Rotate the bearing and check for cracks or catches.

Inspect the propeller shaft oil seal surface to be sure it is not pitted, grooved, or scratched. Inspect the roller bearing contact surface on the propeller shaft for pitting, grooves, scoring, uneven wear, imbedded metal particles, and discoloration caused from overheating.



This damaged bearing carrier was "frozen" in the lower unit and destroyed during the removal process.

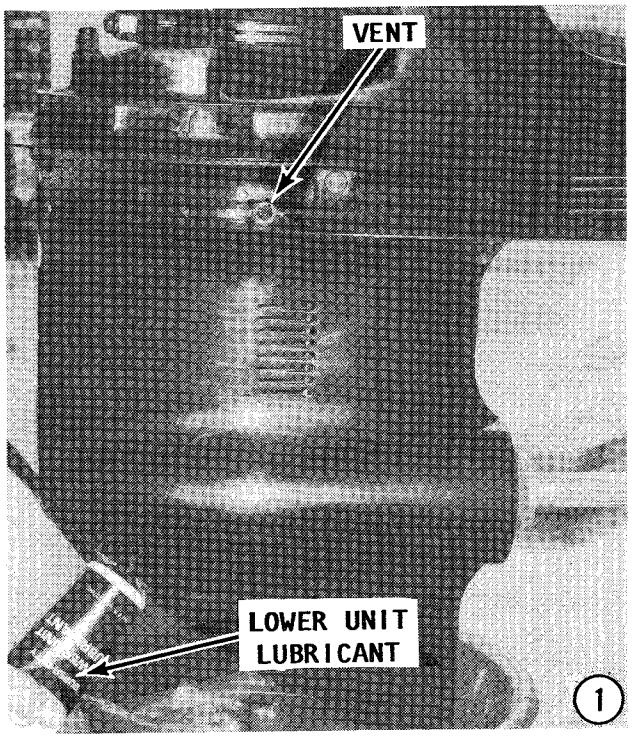
11-10 LOWER UNIT INSTALLATION

Filling the Lower Unit

1- Always fill the lower unit with lubricant and check for leaks **BEFORE** installing the unit to the driveshaft housing.

Take time to remove any old gasket material from the **FILL** and **VENT** recesses and from the screws. Place the lower unit in an upright vertical position. Fill the lower unit with Super-Duty Lubricant, or equivalent, through the **FILL** hole at the bottom of the unit. **NEVER** add lubricant to the lower unit without first removing the **VENT** screws **AND** having the unit in its normal operating position (vertical). Failure to remove the vent screw will result in air becoming trapped within the lower unit. Trapped air will not allow the proper amount of lubricant to be added.

Approximate lower unit capacities are as follows:



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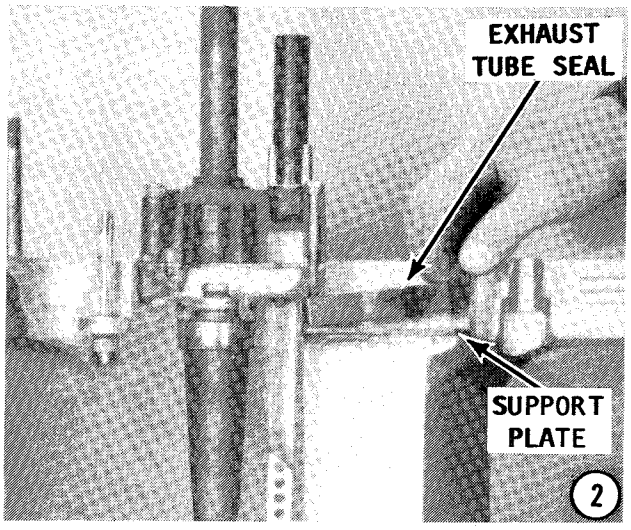


Cam-Shift Type I	21 fl oz (620ml)
Cam-Shift Type II	22.5 fl oz (665ml)
E-Z Shift	24.5 fl oz (718ml)

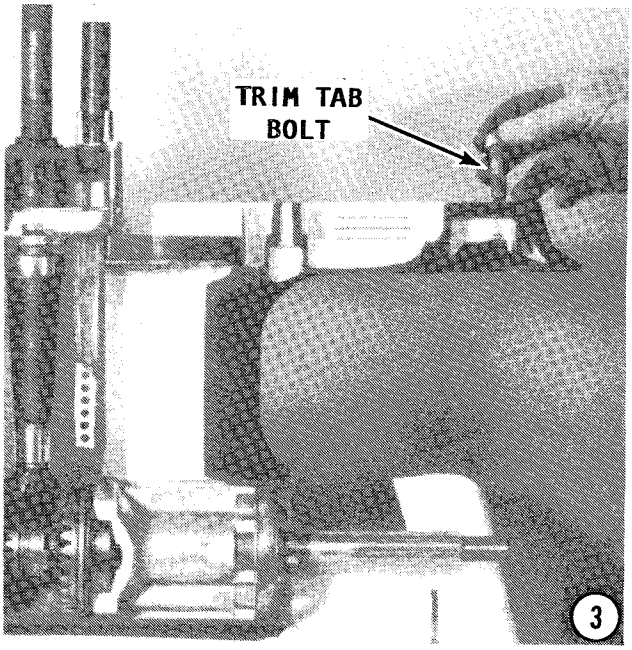
Continue filling **SLOWLY** until the lubricant flows out the **VENT** hole with no air bubbles visible.

Use a **NEW** gasket and install the **VENT** screw. Slide a **NEW** gasket onto the **FILL** screw. Remove the lubricant tube and **QUICKLY** install the **FILL** screw.

Check the lower unit for leaks.

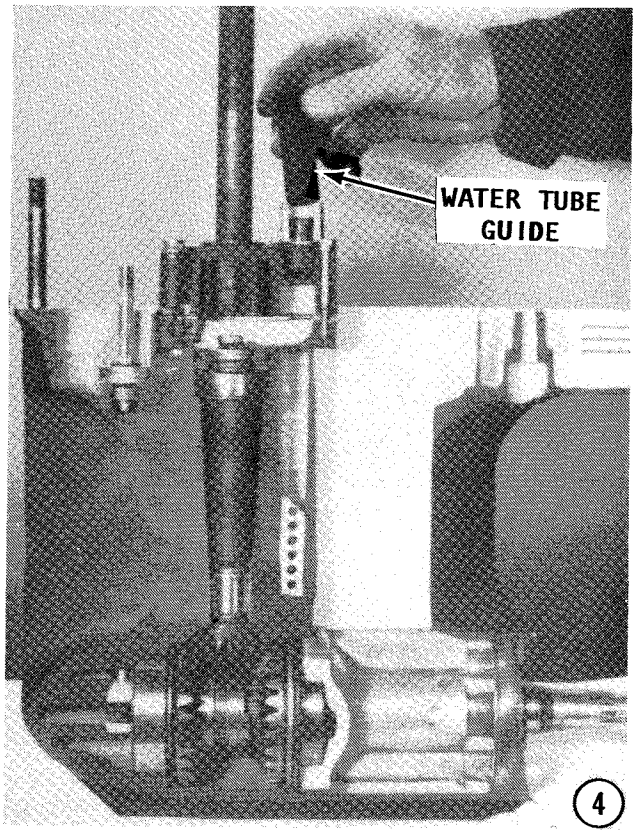
Exhaust Tube Installation

2- Install the support plate into the opening to the rear of the water pump with the flat side **UP.** Position the exhaust tube seal above the support plate, and then work the seal into the opening between the water pump base and the support plate. Coat the exhaust tube seal with Multipurpose Lubricant, or equivalent.



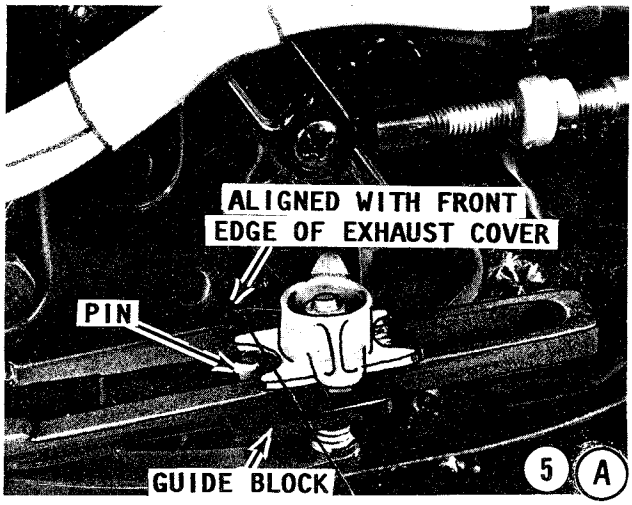
3- Install the trim tab bolt into the rear hole in the rear of the lower unit-to-exhaust housing machined surface.

4- Install the water tube guide into the water pump cover above the water tube seal.



CRITICAL WORDS

Check the lower unit to be sure it is in the proper gear as follows:



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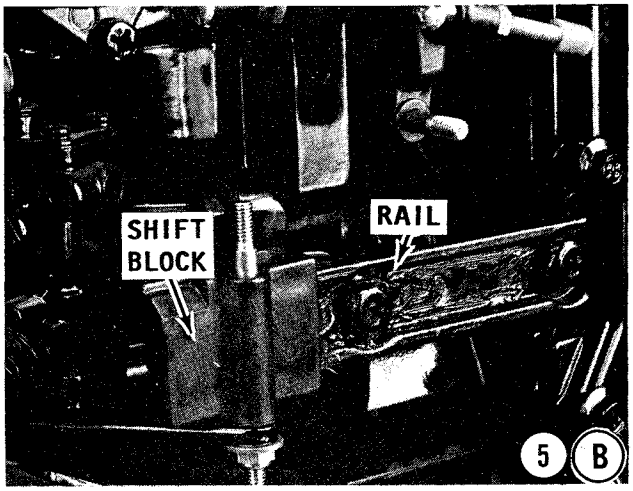


Cam-Shift -- Type I & Type II -- **FORWARD** gear.

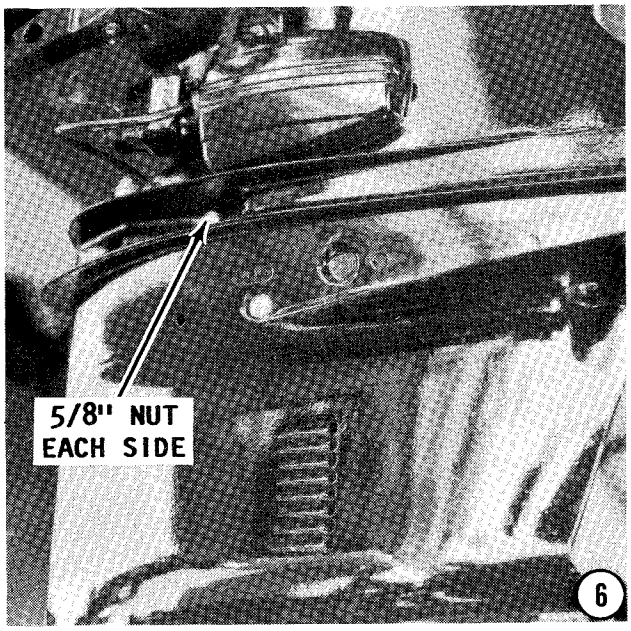
E-Z Shift unit -- **NEUTRAL** gear.

Move the upper shift shaft into the proper gear position also.

5- Align the guide block to position the rear edge of the pin with the front edge of the exhaust cover plate. Some older model units will not have this guide block.

On Cam-Shift Type II units, the forward end of the shift block **MUST** extend 1/8" (3.2mm) past the front of the rail.

6- Tilt the engine outward until it is possible to actuate the tilt lever. Check to be sure the water tube is in position in the exhaust extension plate. Check to be sure the reverse lock push rod and the shift shaft guide block are in the correct position. Apply a light coating of Multipurpose Lubricant to the driveshaft splines and to the shift shaft splines.

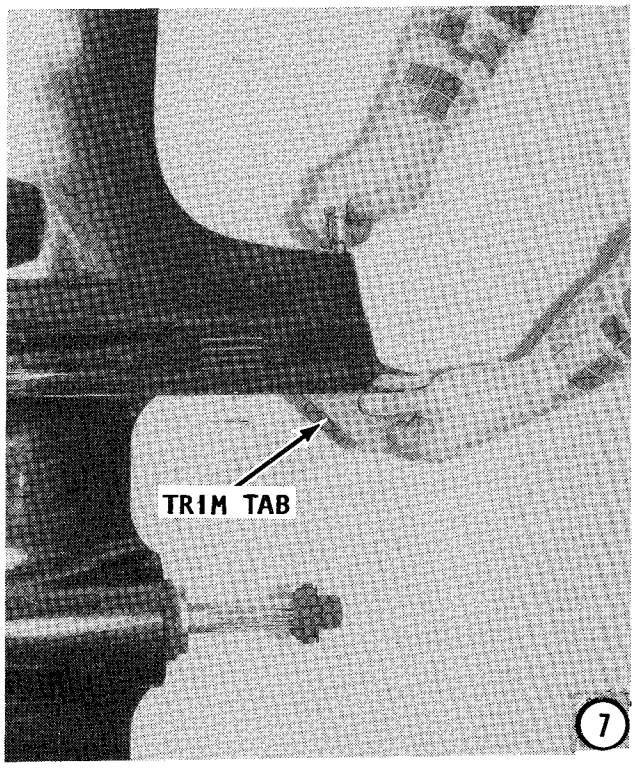


BAD NEWS

An excessive amount of lubricant on top of the driveshaft to crankshaft splines will be trapped in the clearance space. This trapped lubricant will not allow the driveshaft to fully engage with the crankshaft. As a result, when the lower unit nuts are tightened, a load will be placed on the driveshaft/crankshaft and will cause damage to either the powerhead or the lower unit or both. Therefore, any lubricant **MUST** be cleaned from the top of the driveshaft.

Install the driveshaft into the exhaust housing. Start the water tube into the water guide tube with your fingers or with a screwdriver. Route the speedometer hose up through the shift shaft hole. Position the lower unit under the exhaust housing studs with the machined surfaces parallel. Slide the lower unit housing up over the studs as far as possible. Maintain pressure on the lower unit against the exhaust housing and at the same time slowly rotate the engine flywheel **CLOCKWISE** to align the crankshaft splines with the driveshaft splines. When the splines are aligned and index (mate), the two units may be moved closer together.

Slide flat washers onto the studs on both sides of the exhaust housing. Start the nuts onto the studs and bring them up **FINGERTIGHT.** Check the upper shift shaft



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entry into the lower shift shaft by observing the position of the shift shaft at the exhaust extension plate bushing. If the upper and lower shift shafts are not aligned, the upper shift will be pushed upward as the lower unit is tightened against the exhaust housing.

To correct the entry of the upper shift shaft into the lower shift shaft, place a punch against the upper shift shaft, and then strike the punch with a hammer to help align the shaft. **AVOID** excessive force. If necessary, realign the shafts.

After the shift shafts are aligned and the driveshaft splines are mated, close the gap between the lower unit and the exhaust housing until the two machined surfaces make contact. Now, hold the two units in contact with one hand and check the shift operation with the other hand. Shift into forward gear; the propeller shaft should **NOT** rotate counterclockwise. Shift into neutral; the propeller shaft should be free to rotate in either direction. Shift into reverse gear; the propeller shaft should be free to turn in either direction **ONLY** about 1/3 turn.

If the lower unit fails any of the shift tests just described, the upper and lower shift shafts are not aligned properly. Remove the lower unit and repeat this step.

Start the bolt at the rear of the lower unit inside the trim tab recess. **DO NOT** tighten the bolt at this time.

Alternately and evenly tighten the two nuts started earlier in this step. Slide the washers, and then start the nuts onto the studs at the bottom center of the anti-cavitation plate. Install the washer and nut onto the stud at the leading edge of the intermediate housing. Tighten the bolt started in the trim recess.

Tighten the 3/8"-16 nuts securing the lower unit to the intermediate housing to a torque value of 55 ft lb (75Nm).

Tighten the 7/16"-20 nuts or bolts securing the lower unit to the intermediate housing to a torque value of 65 ft lb (88Nm).

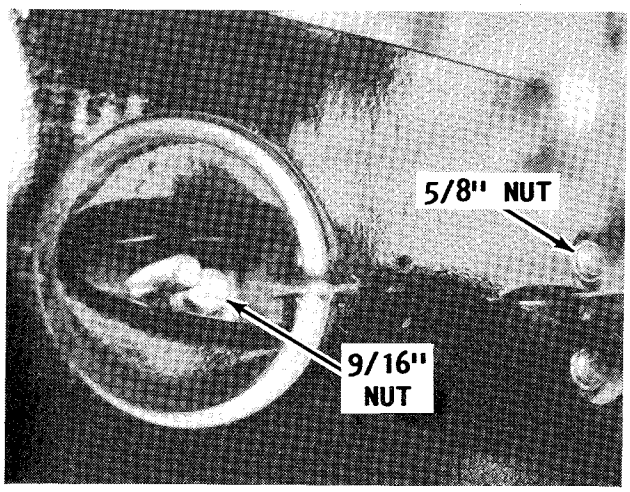
Tighten the trim tab bolt to a torque value 25 ft lb (34Nm).

7- Install the trim tab in the same position from which it was removed. A scribe mark should have been made on the trim tab and a matching mark on the anti-cavitation plate before the trim tab was removed. These marks were to ensure the tab would be installed at the same angle, as mentioned in Step 1 of the removal procedures.

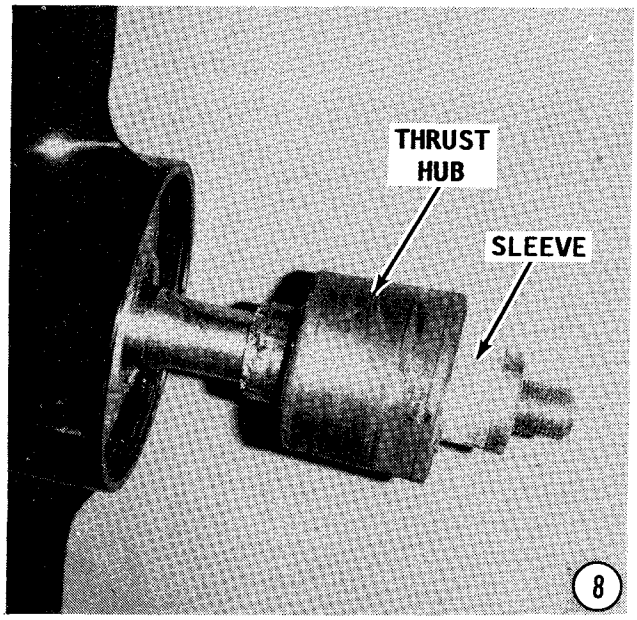
GOOD WORDS

The trim tab should be positioned to enable the helmsperson to handle the boat with equal ease to starboard and port at normal cruising speed. If the boat seems to turn more easily to starboard, loosen the socket head screw and move the trim tab trailing edge to the right. Move the trailing edge of the trim tab to the left if the boat tends to turn more easily to port.

Snap the plastic cap into the trim tab bolt opening at the rear edge of the lower unit. Shift the engine into **FORWARD** gear, release the tilt lock lever and lower the engine to the normal operating position.



The 9/16" nut in the recess is covered by the trim tab. A reference mark enscribed on the trim tab and on the anti-cavitation plate will allow the trim tab to be installed back at the same angle from which it was removed.



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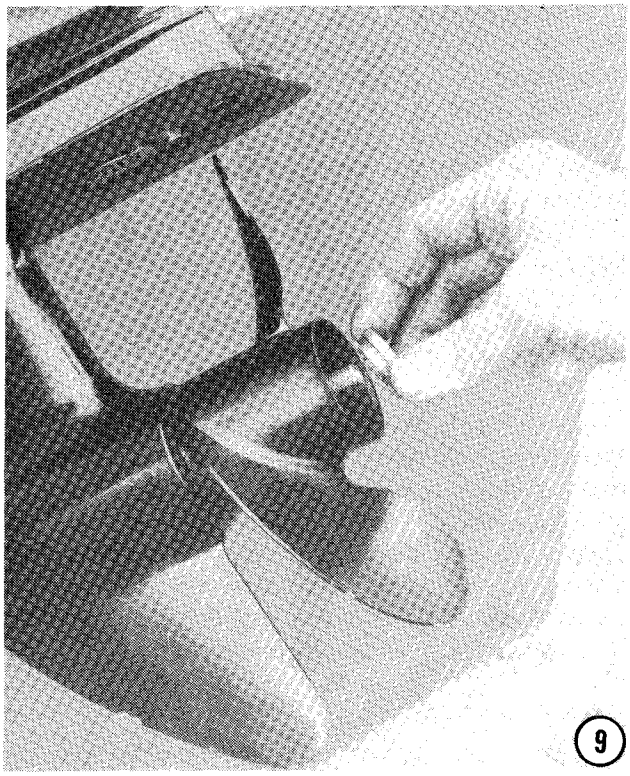


Propeller Installation

SAFETY WORDS: An outboard engine may start very easily. Therefore, anytime the propeller is to be removed or installed, check to be sure:

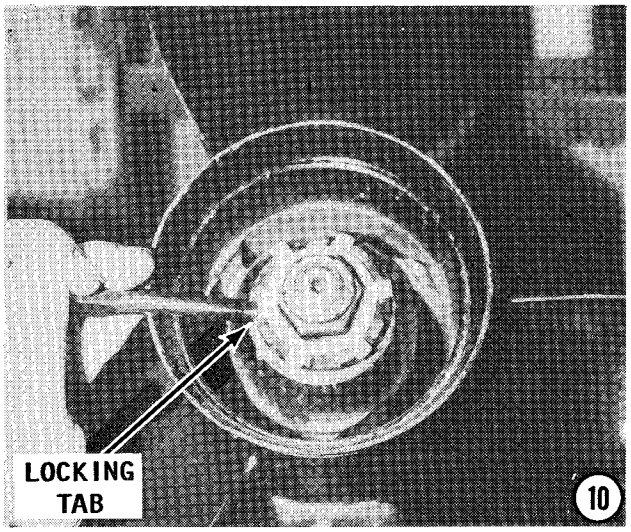
a- Key switch is in **OFF** position.

b- Spark plug wires are disconnected.

c- Electrical leads disconnected at the battery terminals.

8- Position the thrust hub over the propeller with the shoulder side entered into the propeller.

As an aid to removing the propeller the next time, apply a liberal coating of Perfect Seal to the propeller shaft splines.



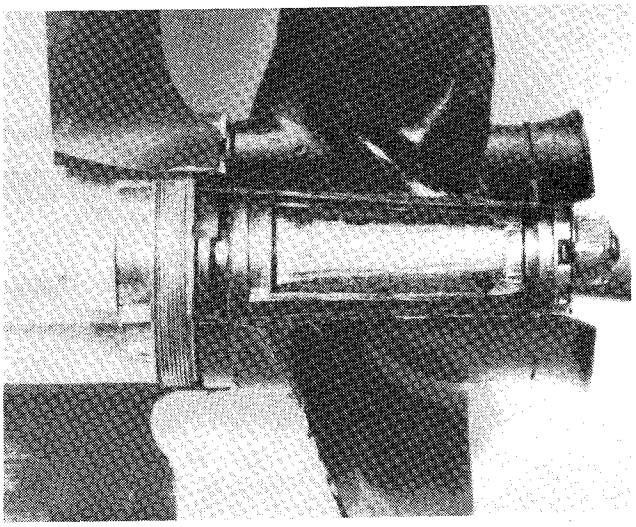
9- Position the propeller on the propeller shaft, and then slide it up against the thrust hub taper. Slide a second splined washer onto the propeller shaft and engage the splines in the washer with the splines of the propeller shaft. Slide the tab washer onto the propeller shaft with the nut recess **TOWARD** the splined washer. Start the propeller nut onto the propeller shaft threads.

Align the tabs on the tab washer with the recessed areas of the splined washer. Place a block of wood between a propeller blade and the anti-cavitation plate to prevent the propeller shaft from rotating while the nut is being tightened. Tighten the propeller nut to the torque value of 55 ft lbs (75Nm).

10- Use a punch and hammer to bend the tabs of the tab washer into the recess of the splined washer. Remove the block of wood. Connect the spark plug wires to the spark plugs. Connect the electrical lead to the battery terminal. Mount the engine in a test tank or body of water.

CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Start the engine and check the completed work for satisfactory operation and no leaks.



*A cutaway view of a modern propeller showing the rubber hub and sleeve. The rubber hub protects the lower unit if the propeller should strike an underwater object. If the rubber hub loses its holding power with the inner hub of the propeller, the propeller hub **MUST** be replaced.*

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12
REMOTE CONTROLS

12-1 INTRODUCTION

Remote controls are seldom obtained from the original outboard manufacturer. Shift boxes and steering arrangements may be added by the boat manufacturer. Because of the wide assortment, styles, and price ranges of remote controls, the boat manufacturer, or customer, has a wide selection from which to draw, when outfitting the boat.

Therefore, the procedures and suggestions in this chapter are for the "Commander" shift controls widely used with the outboard units covered in this manual. The procedures are specific and in enough detail to allow troubleshooting, repair, and adjustment of the "Commander" shift unit for maximum comfort, performance and safety.

WOULD YOU BELIEVE

Probably 90% of steering cable problems are directly caused by the system not being operated, just sitting idle during the off-season. Without movement, all steering cables have a tendency to "freeze". **Would you also believe:** Service shops report almost 50% of the boat cables replaced every year are due to lack of movement. Therefore, during off-season when the boat is laid up in a yard, or on a trailer alongside the house, take time to go aboard and operate the steering wheel from hard-over to hard-over several times.

These sections provide step-by-step detailed instructions for the complete disassembly, cleaning and inspection, and assembly of the "Commander" shift box. Disassembly may be stopped at any point desired and the assembly process begun at that point. However, for best results and maximum performance, the entire system should be serviced if any one part is disassembled for repair.

An exploded drawing of the "Commander" shift box is presented between the assembling and disassembling procedures. This diagram will be most helpful in gaining an appreciation of how the shift box functions and the relationship of individual parts to one another.

If at all possible, keep the parts in order as they are removed. Make an effort to keep the work area clean and keep disassembled parts covered with a shop cloth to prevent contamination.

GOOD WORDS

If the control cable has a "Zerk" fitting at the engine end, the cable **MUST** be retracted, then the fitting lubricated with Quicksilver Multi-Purpose lubricant or Quicksilver 2-4C Lubricant.

STEERING CHECKS

The steering system may be checked by performing a few very simple tests. First, move the steering wheel from hard-over to hard-over, port and starboard several times. The outboard unit should move without any sign of stiffness. If binding or stiffness is encountered, the cause may be a defect in the swivel bearing.

Next, remove the steering bolt at the outboard unit, and again turn the steering wheel back-and-forth from hard-over to hard-over, port and starboard several times. If there is any sign of stiffness, it is proof the problem is with the cables. They may be corroded or there may be a defect in the steering mechanism.

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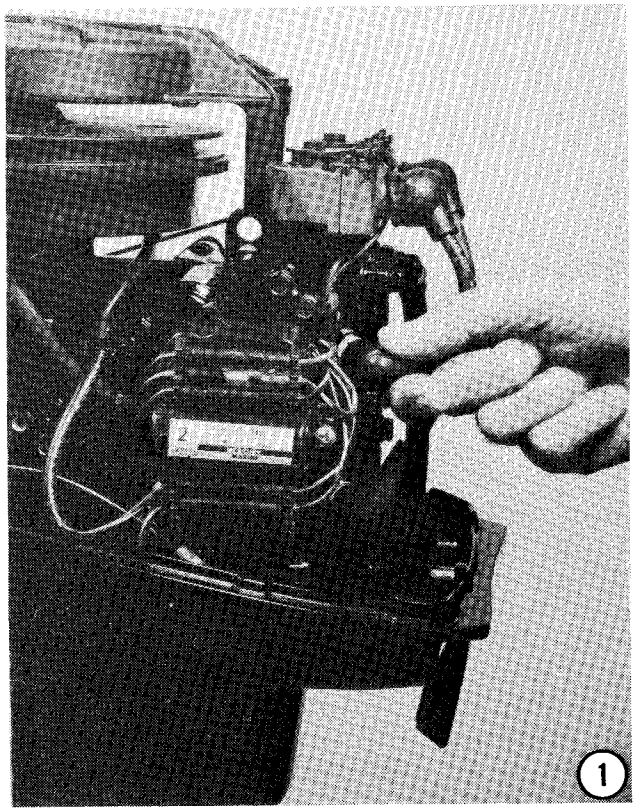

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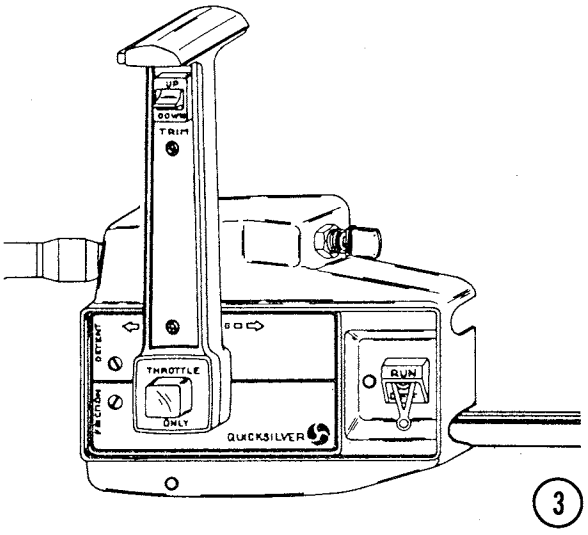
12-2 COMMANDER CONTROL SHIFT BOX

REMOVAL AND DISASSEMBLING

The following detailed instructions cover removal and disassembly of the "Commander" control shift box from the mounting panel in the boat.

1- Turn the ignition key to the **OFF** position. Disconnect the high tension leads from the spark plugs, with a twisting motion.



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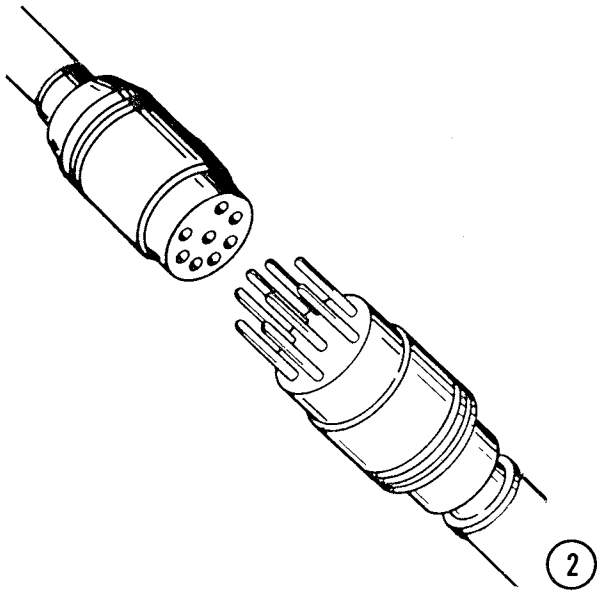
2- Disconnect the remote control wiring harness plug from the outboard trim/tilt motor and pump assembly.

3- Disconnect the tachometer wiring plug from the forward end of the control housing.

4- Remove the three locknuts, flat washers, and bolts securing the control housing to the mounting panel. One is located next to the **RUN** button (the ignition safety stop switch), and the second is beneath the control handle on the lower portion of the plastic case. The third is located behind the control handle when the handle is in the **NEUTRAL** position. Shift the handle into **FORWARD** or **REVERSE** position to remove the bolt, then shift it back into the **NEUTRAL** position for the following steps.



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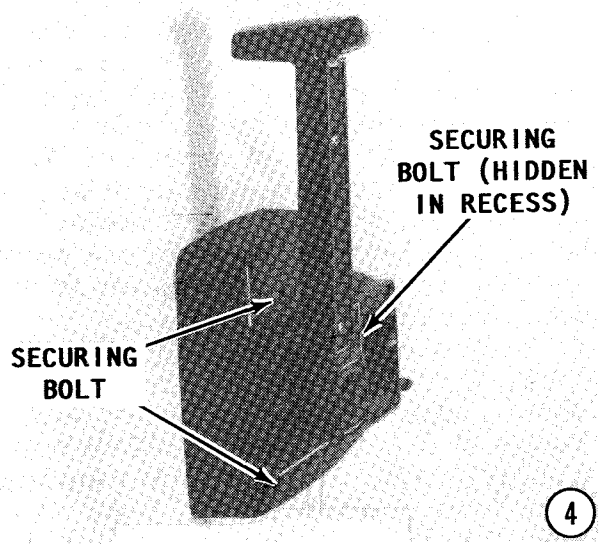

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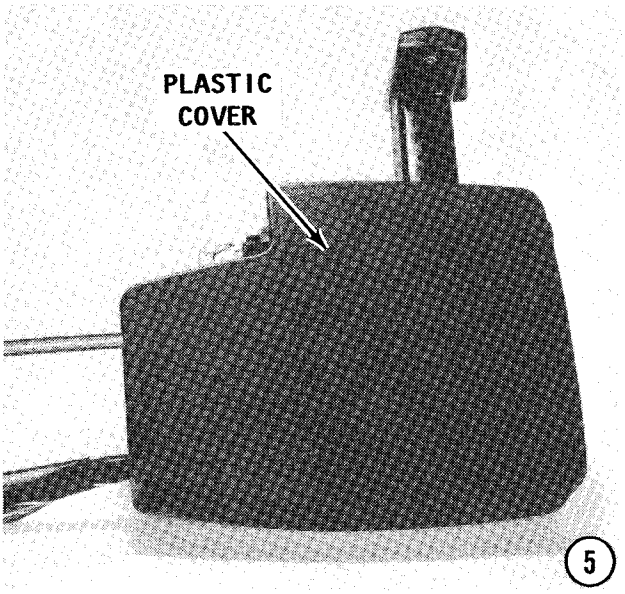


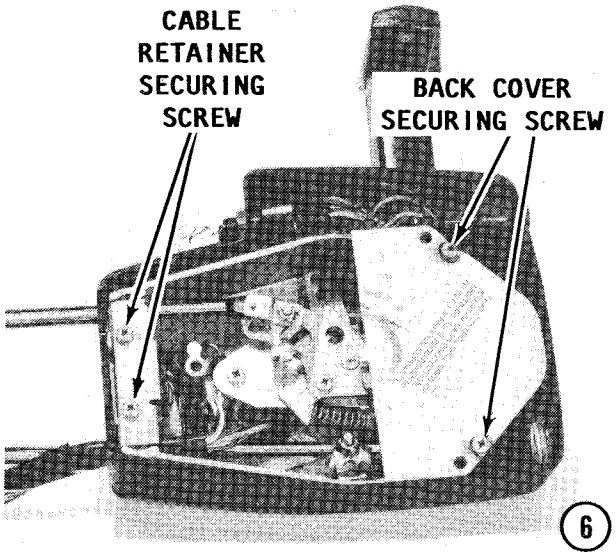
5- Pull the remote control housing away and free of the mounting panel. Remove the plastic cover from the back of the housing. Lift off the access cover from the housing. (Some "Commander" remote control units do not have an access cover.)

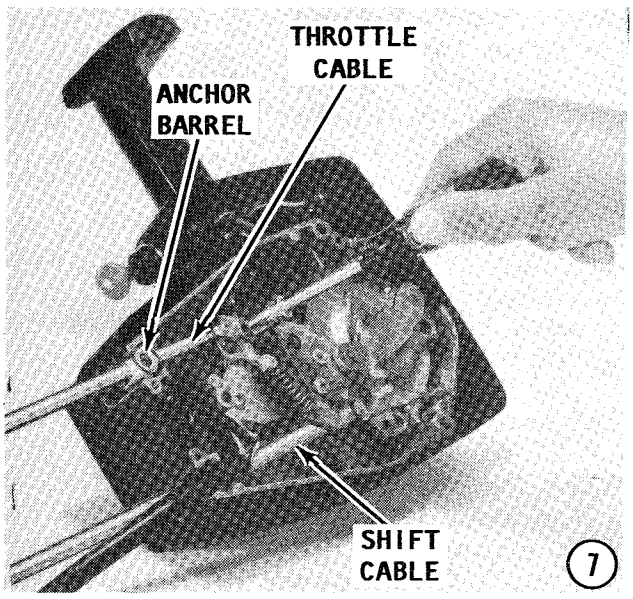
6- Remove the two screws securing the cable retainer over the throttle cable, wiring harness, and shift cable. Unscrew the two Phillips-head screws securing the back cover to the control module, and then lift off the cover.

Throttle Cable Removal

7- Loosen the cable retaining nut and raise the cable fastener enough to free the throttle cable from the pin. Lift the cable from the anchor barrel recess.

8- Remove the grommet.



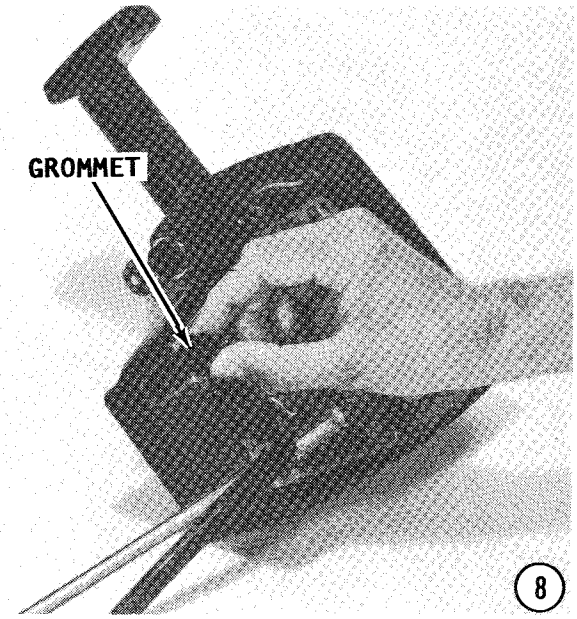


Shift Cable Removal

9- Shift the outboard unit into **REVERSE** gear by depressing the neutral lock bar on the control handle and moving the control handle into the **REVERSE** position. **LOOSEN,** but do not remove, the shift cable retainer nut with a 3/8" deep socket as far as it will go without removing it. Raise the shift cable fastener enough to free the shift cable from the pin.

DO NOT attempt to shift into **REVERSE** while the cable fastener is loose. An attempt to shift may cause the cable fastener to strike the neutral safety microswitch and cause it damage.

Lift the wiring harness out of the cable anchor barrel recess and remove the shift cable from the control housing.



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Control Handle Removal For Power Trim/Tilt With Toggle Trim Switch Or Push-Button Trim Switch

GOOD WORDS

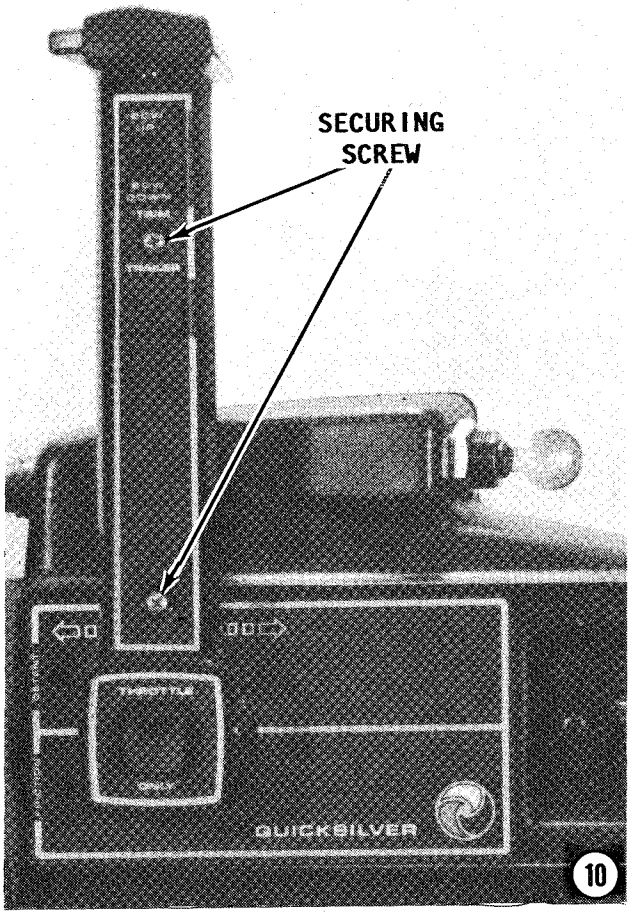
For non-power trim/tilt units, it is not necessary to remove the cover of the control handle. If servicing one of these units, proceed directly to Step 13. All others perform Steps 11 and 12.

10- Depress the **NEUTRAL** lock bar on the control handle and shift the control handle back to the **NEUTRAL** position. Remove the two Phillips head screws which secure the cover to the handle, and then lift off the cover. The push button trim switch will come free with the cover, the toggle trim switch will stay in the handle body.

Unsnap and then remove the wire retainer. Carefully unplug the trim wires and straighten them out from the control panel hub for ease of removal later.

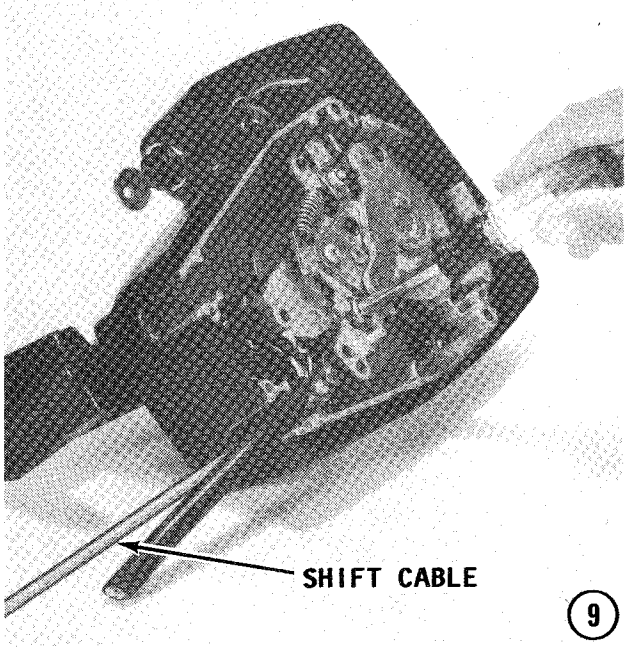
11- Back-off the set screw at the base of the control handle to allow the handle to be removed from the splined control shaft.

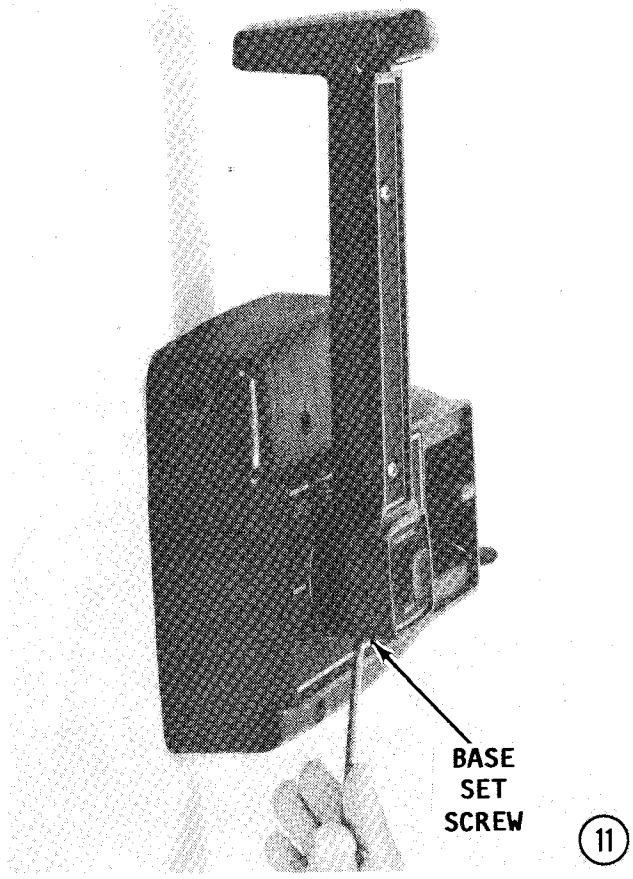
12- Grasp the "throttle only" button and pull it off the shaft.



SPECIAL WORDS

Take care not to damage the trim wires when removing the control handle, on power trim models.





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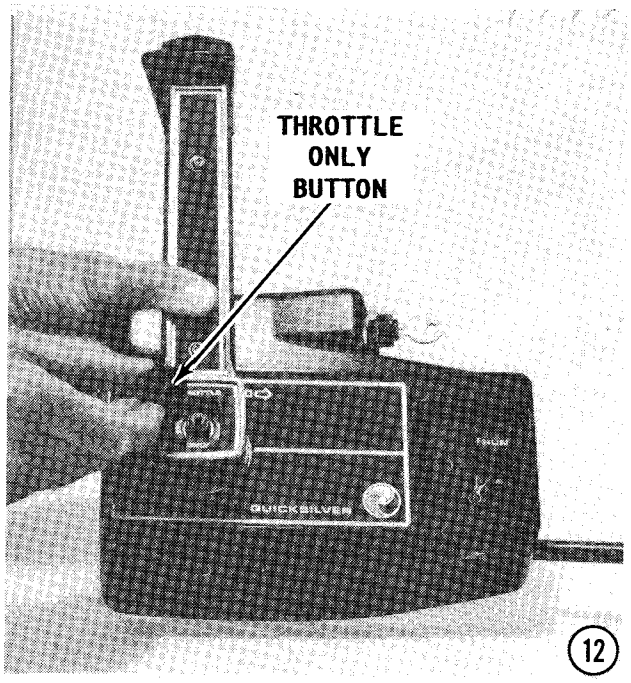

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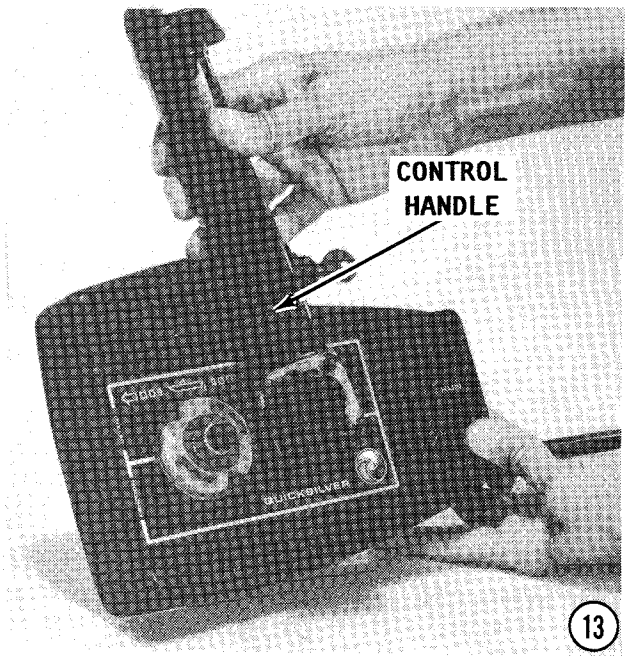
13- Remove the control handle.

14- Lift the neutral lockring from the control housing.

TAKE CARE to support the weight of the control housing to avoid placing any unnecessary stress on the control shaft during the following disassembling steps.

15- Remove the three Phillips-head screws securing the control module to the plastic case. Two are located on either side of the bearing plate and one is in the recess where the throttle cable enters the control housing.



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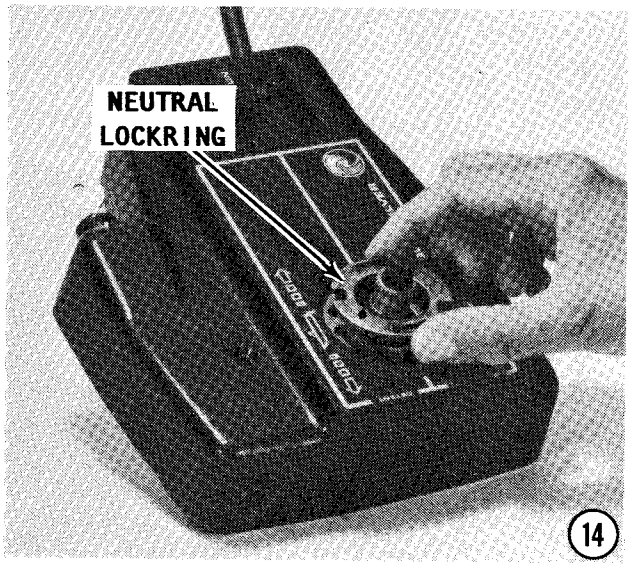


14

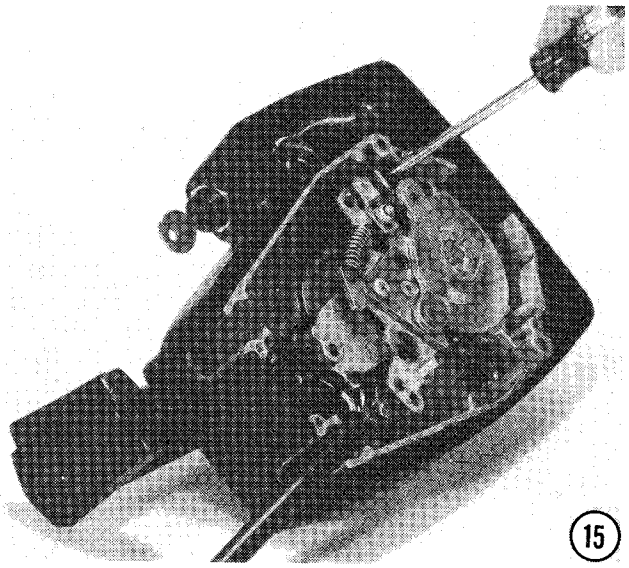
16- Back-out the detent adjustment screw and the control handle friction screw until their heads are flush with the control module casing. This action will reduce the pre-load from the two springs on the detent ball for later removal.

GOOD WORDS

As this next step is performed, count the number of turns for each screw as they are backed-out and record the figure somewhere. This will be a tremendous aid during assembling.

17- Remove the two locknuts securing the neutral safety switch to the plate assembly and lift out the micro-switch from the recess in the assembly.

18- Remove the Phillips-head screw securing the retaining clip to the control module.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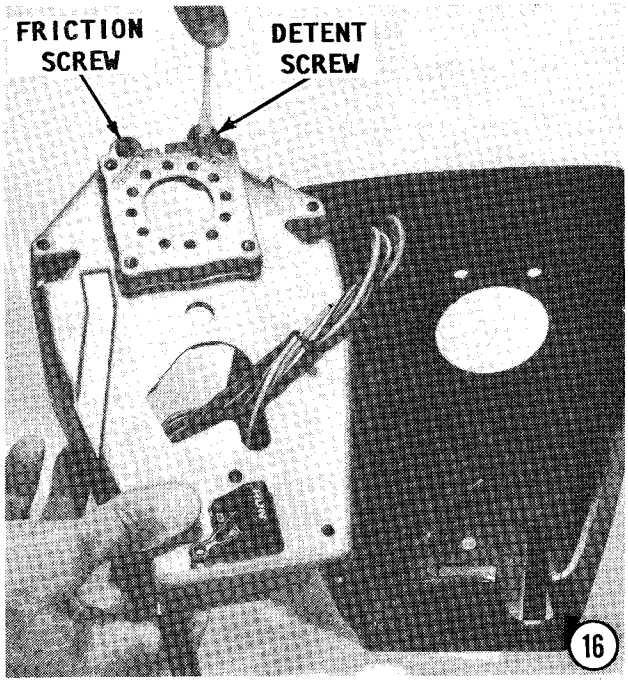
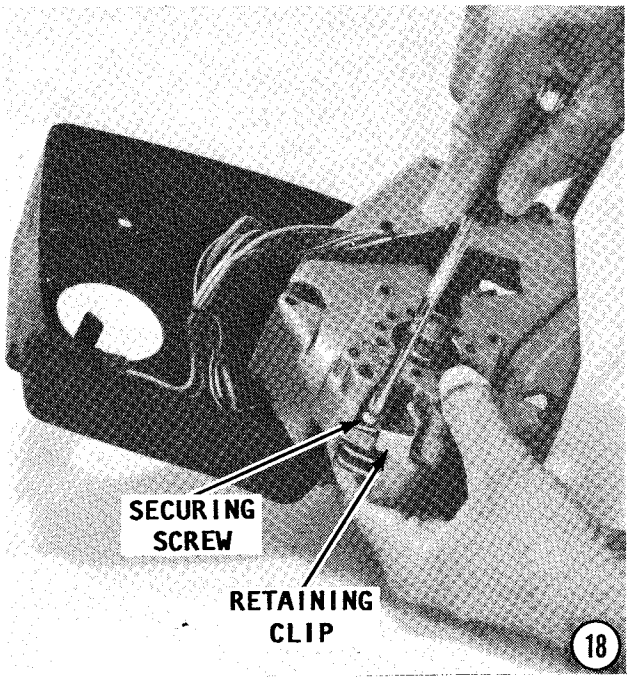
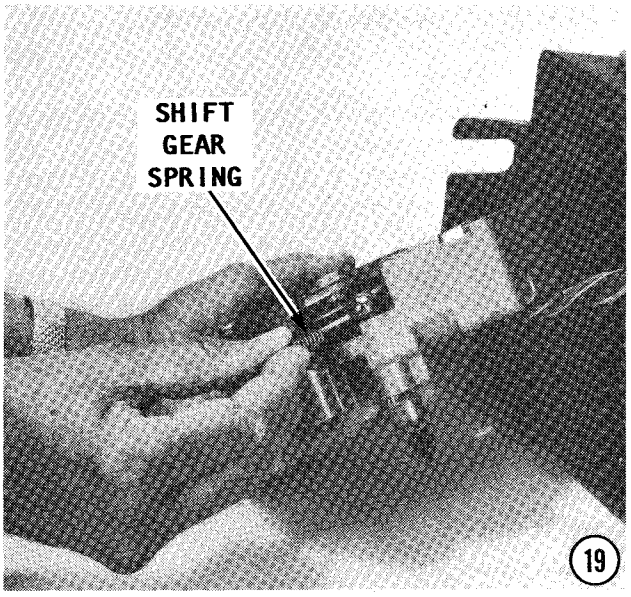
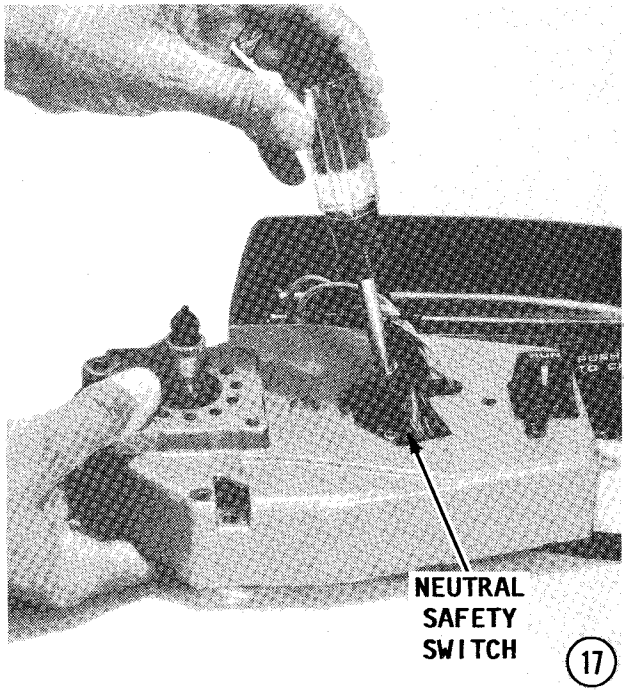
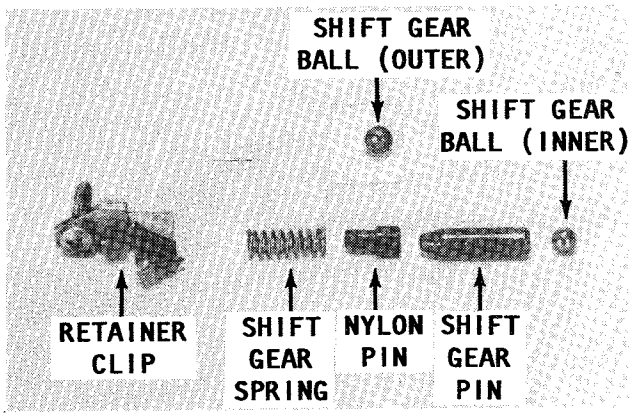




19- Support the module in your hand and tilt it until the shift gear spring, shift nylon pin (earlier models have a ball), shift gear pin, another ball the shift gear ball (inner), fall out from their recess. If the parts do not fall out into your hand, attach the control handle and ensure the unit is in the **NEUTRAL** position. The parts should come free when the handle is in the **NEUTRAL** position.







Arrangement of parts from the control module recess. As the parts are removed and cleaned, keep them in order, ready for installation.

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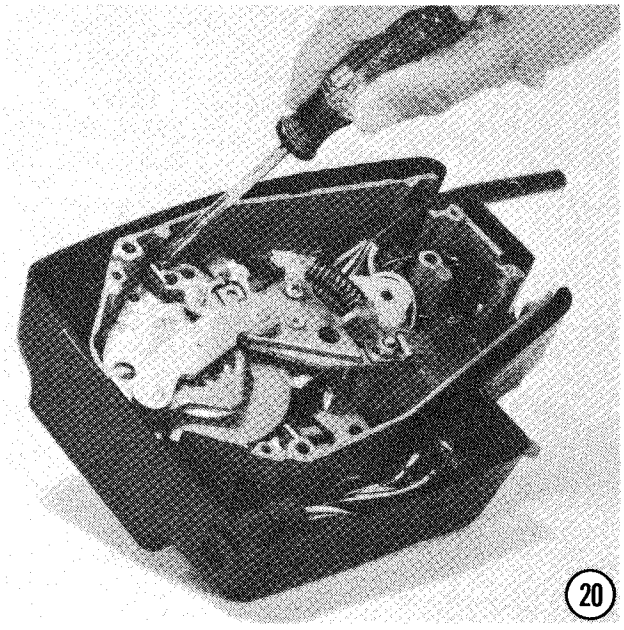


20- Remove the three Phillips-head screws securing the bearing plate assembly to the control module housing.

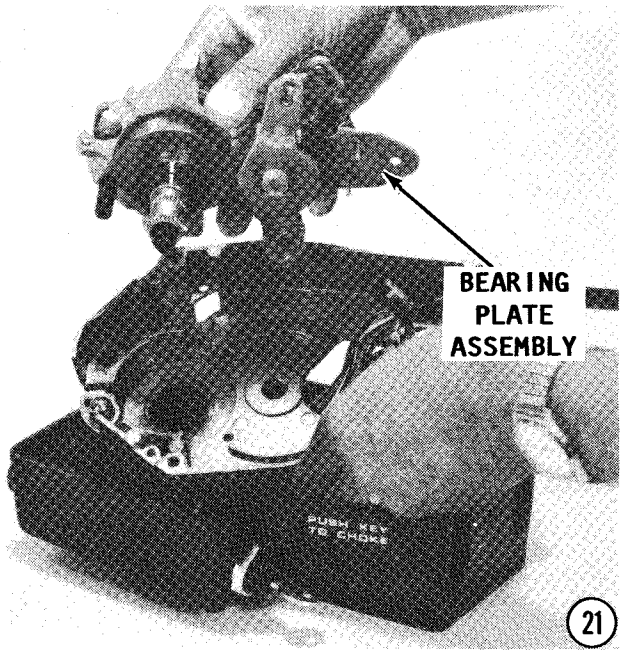
21- Lift out the bearing plate assembly from the control module housing.

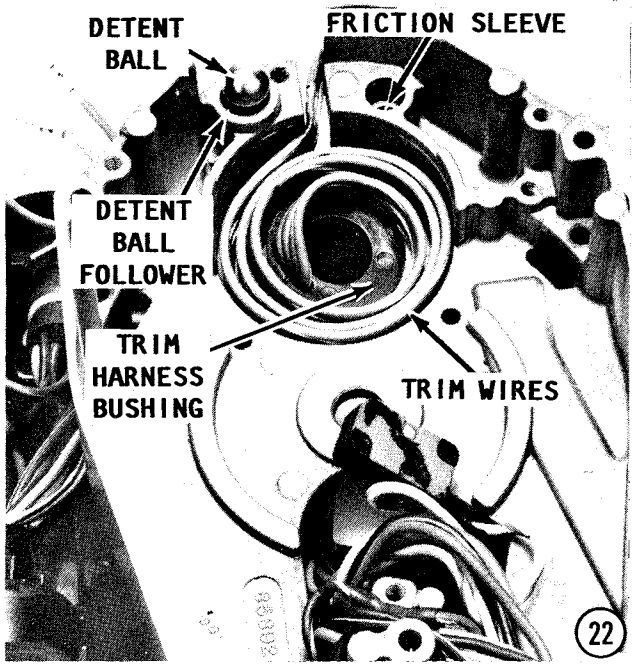
Power Trim/Tilt Units Only

22- Uncoil the trim wires from the recess in the remote control module housing and lift them away with the trim harness bushing attached.

All Units

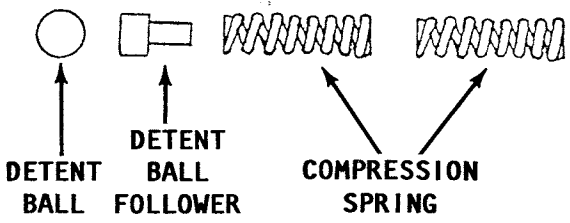
23- Remove the detent ball, the detent ball follower, and the two compression springs (located under the follower), from their recess in the control module housing.

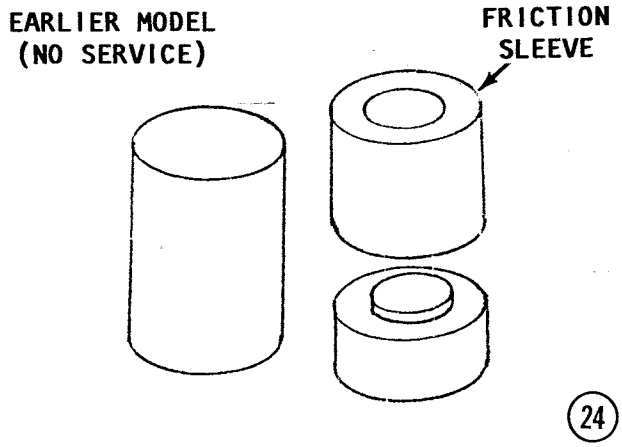




24- If it is not part of the friction pad, remove the control handle friction sleeve from the recess in the control module housing.

25- Pull the throttle link assembly from the module. Remove the compression spring from the throttle lever. It is not necessary to remove this spring unless there is cause to replace it. At this point, there is the





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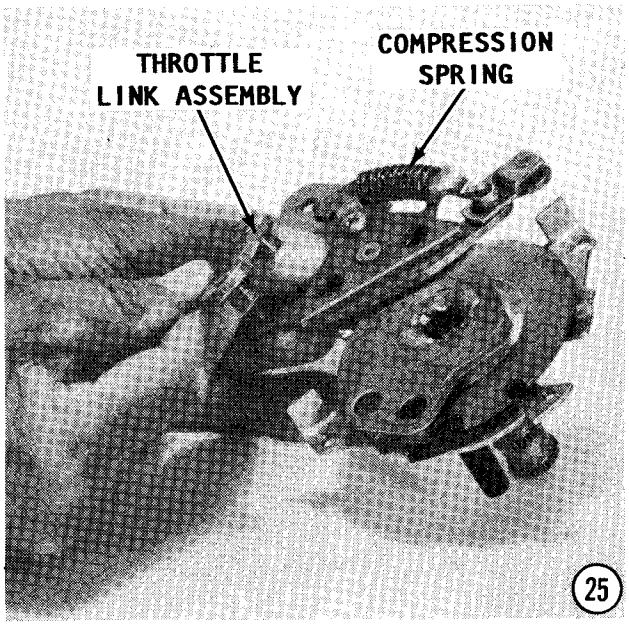
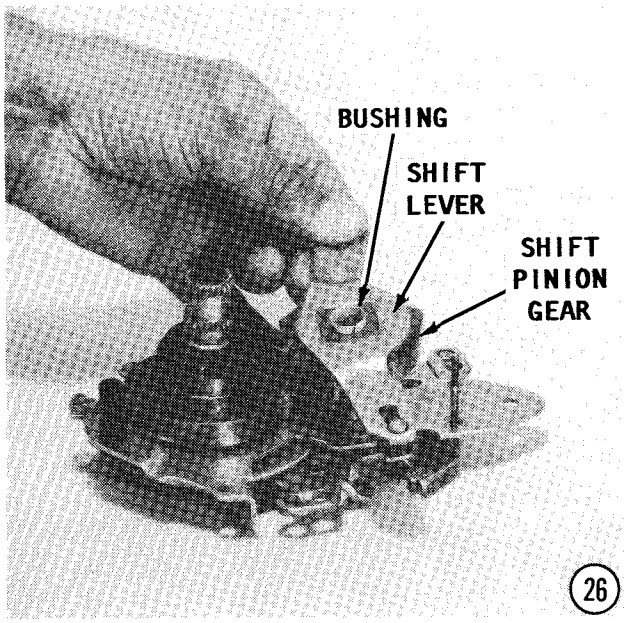


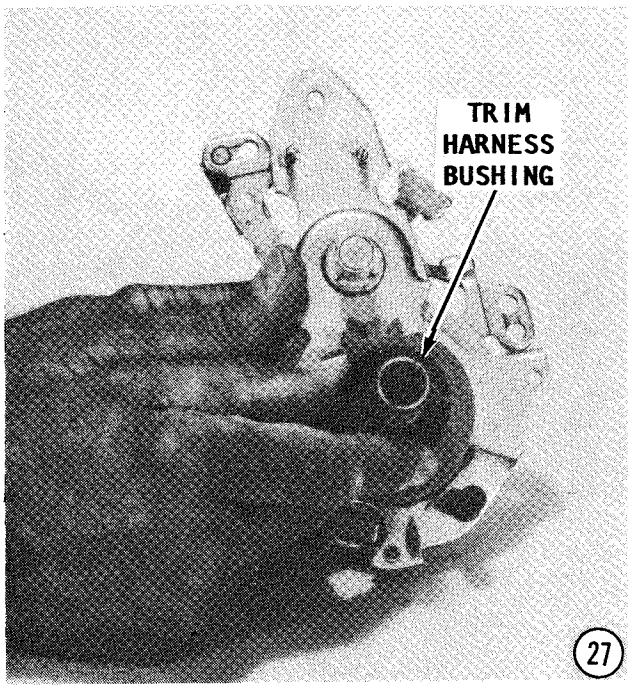
least amount of tension on the compression spring, therefore, now would be the time to replace it, if required.

26- Lift the shift pinion gear (with attached shift lever), off the pin on the bearing plate. The nylon bushing may come away with the shift lever or stay on the pin. Remove the shift lever and shift pinion gear as an assembly. **DO NOT** attempt to separate them. Both are replaced if one is worn.

Non-Power Trim/Tilt Units Only

27- Remove the trim harness bushing and wiring harness retainer from the control shaft. (On non-power trim/tilt units these two items act as spacers.)



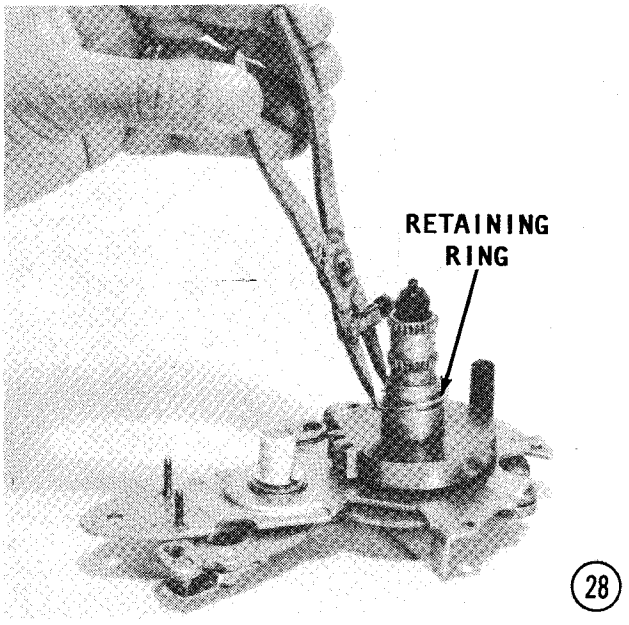


All Units

28- Remove the shift gear retaining ring from its groove with a pair of Circlip pliers.

SPECIAL WORDS

If the Circlip slipped out of its groove, this would allow the shift gear to ride up on the shaft and cause damage to the small parts contained in its recess. The shift gear ball (inner), the shift gear pin, the shift gear ball (outer), or the nylon pin and **PARTICULARLY** the shift gear spring **MUST** be inspected closely.



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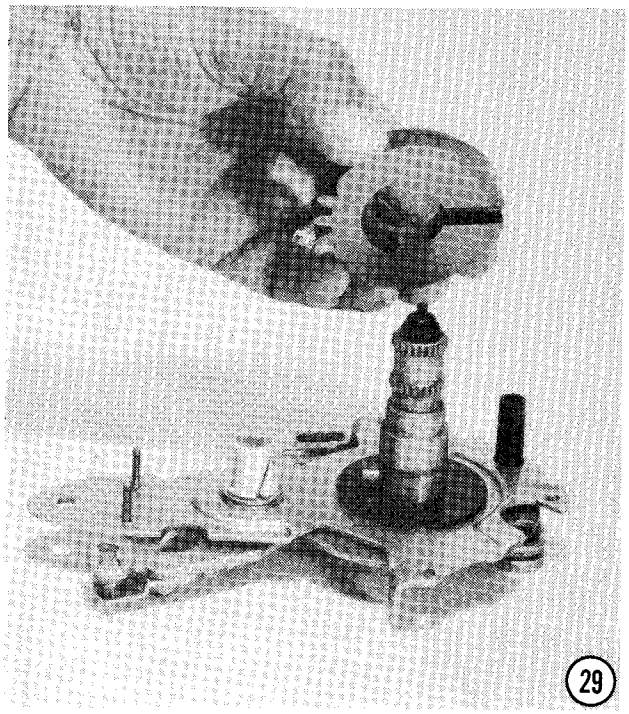


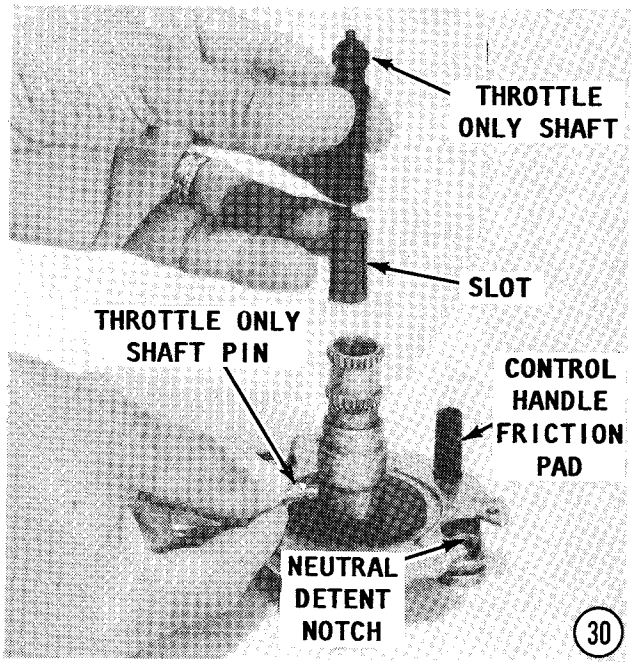
29- Lift the gear from the control shaft.

30- Remove the "throttle only" shaft pin and "throttle only" shaft from the control shaft.

31- Remove the step washer from the base of the bearing plate.

CLEANING AND INSPECTING

Clean all metal parts with solvent, and then blow them dry with compressed air.



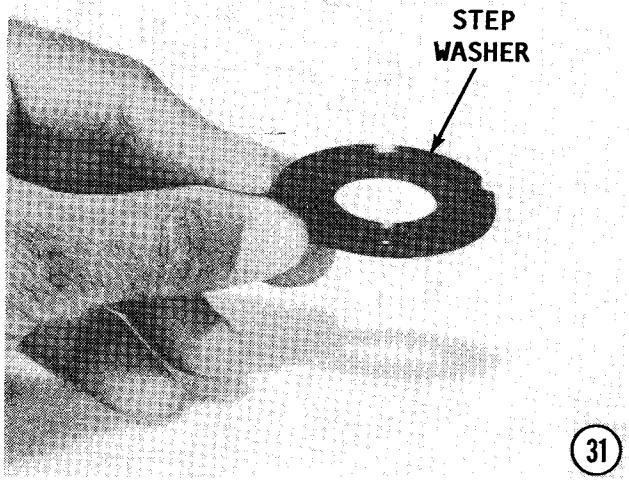
NEVER allow nylon bushings, plastic washers, nylon pins, wiring harness retainers, and the like, to remain submerged in solvent more than just a few moments. The solvent will cause these type parts to expand slightly. They are already considered a "tight fit" and even the slightest amount of expansion would make them very difficult to install. If force is used, the part is most likely to be distorted.

Inspect the control housing plastic case for cracks or other damage allowing moisture to enter and cause problems with the mechanism.

Carefully check the teeth on the shift gear and shift lever for signs of wear. Inspect all ball bearings for nicks or grooves which would CAUSE them to bind and fail to move freely.

Closely inspect the condition of all wires and their protective insulation. Look for exposed wires caused by the insulation rubbing on a moving part, cuts and nicks in the insulation and severe kinking which could cause internal breakage of the wires.

Inspect the surface area above the groove in which the Circlip is positioned for signs of the Circlip rising out of the groove. This would occur if the clip had lost its "spring" or worn away the top surface of the groove as mentioned previously in Step 29. If the Circlip slipped out of its groove, this would allow the shift gear to ride up on the shaft and cause damage to the small parts contained in its recess. The shift gear ball (inner), the shift gear pin, the shift gear ball (outer), or the nylon pin and **PARTICULARLY** the shift gear spring **MUST** be inspected closely.



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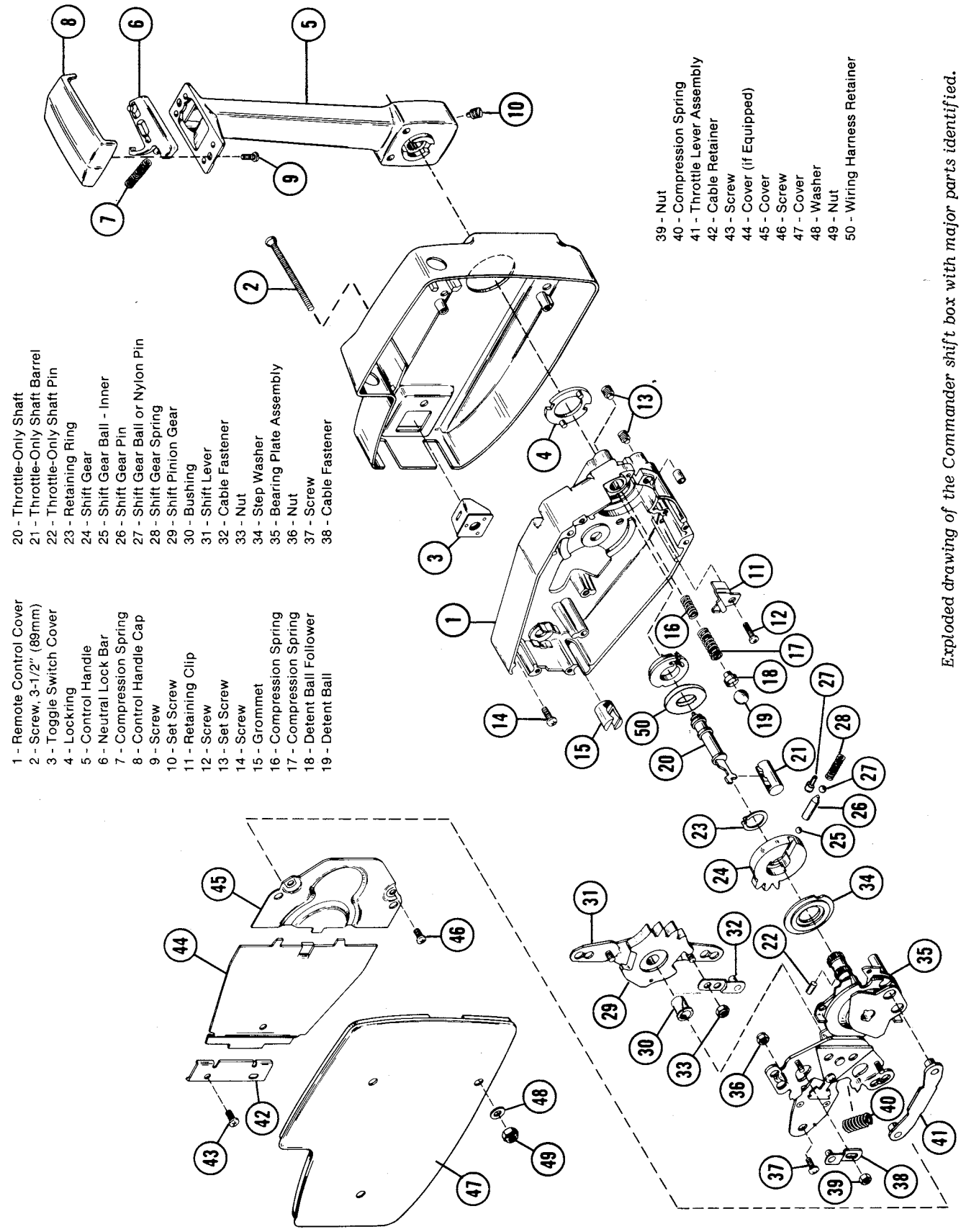

Exploded drawing of the Commander shift box with major parts identified.

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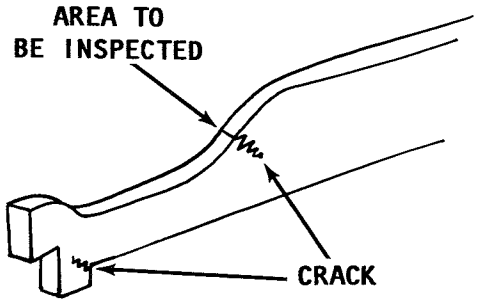


The throttle-only shaft should be inspected for wear along the ramp, as indicated.

Inspect the "throttle only" shaft for wear along the ramp. In early model units, this shaft was made of plastic. Later models have a shaft of stainless steel. Check for excessive wear or cracks on the ramp portion of the shaft, as indicated in the accompanying illustration. Also check the lower "stop" tab to be sure it has not broken away.

SPECIAL WORDS

Good shop practice dictates a thin coat of Multipurpose Lubricant be applied to all moving parts as a precaution against the "enemy" moisture. Of course the lubricant will help to ensure continued satisfactory operation of the mechanism.

ASSEMBLING AND INSTALLATION COMMANDER CONTROL SHIFT BOX

FIRST, THESE WORDS

The Commander control shift box, like others, has a number of small parts that **MUST** be assembled in only one order -- the proper order. Therefore, the work should not be "rushed" or attempted if the person assembling the unit is "under pressure". Work slowly, exercise patience, read ahead before performing the task, and follow the steps closely.

1- Place the step washer over the control shaft and ensure the steps of the washer seat onto the base of the bearing plate.

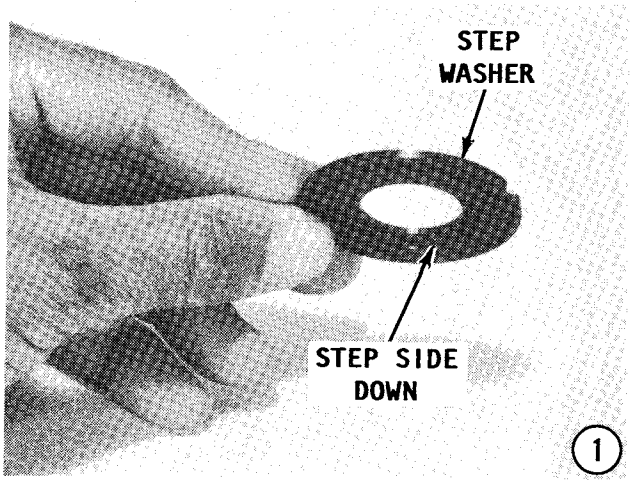
2- Rotate the control shaft until the "throttle only" shaft pin hole is aligned centrally between the neutral detent notch and the control handle friction pad. Lower the "throttle only" shaft into the barrel of the control shaft with the wide slot in the "throttle only" shaft aligned with the line drawn on the accompanying illustration. Secure the shaft in this position with the "throttle only" shaft pin.

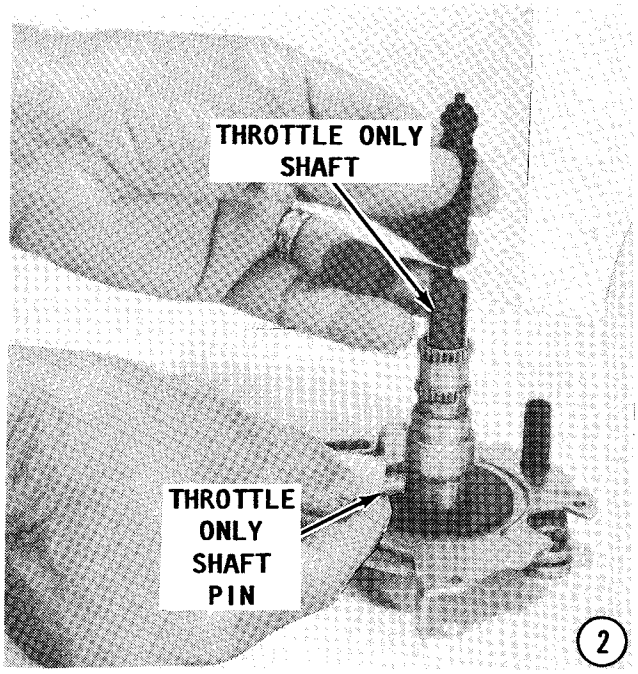
SPECIAL WORDS

When the pin is properly installed, it should protrude slightly in line with the plastic bushing, as shown in the accompanying illustration.

Make an attempt to gently pull the "throttle only" shaft out of the control shaft. The attempt should fail, if the shaft and pin are properly installed.

3- Place the shift gear over the control shaft, and check to be sure the "throttle only" shaft pin clears the gear.





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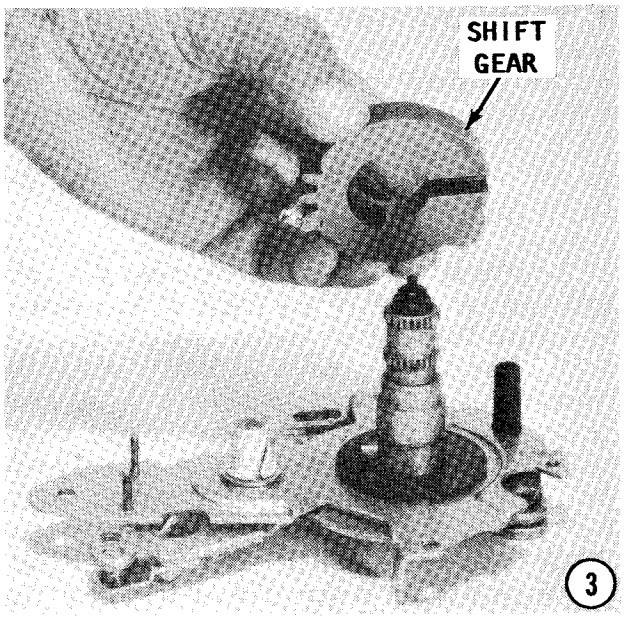


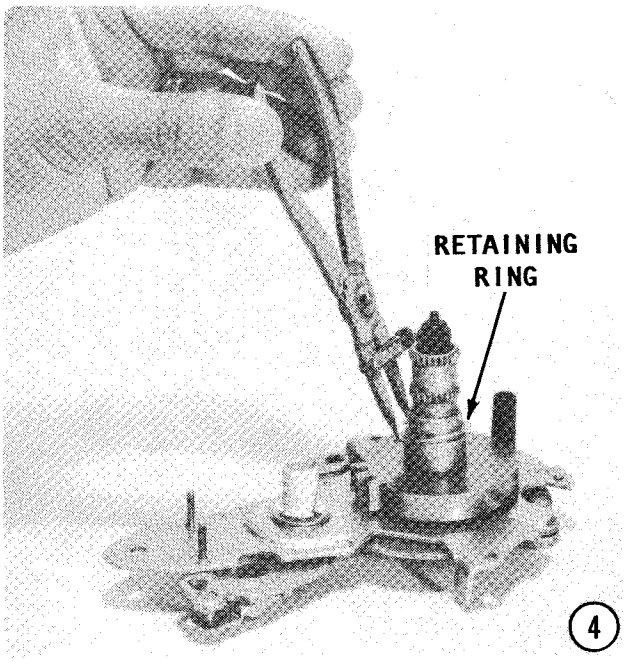
4- Install the retaining ring over the control shaft with a pair of Circlip pliers. Check to be sure the ring snaps into place within the groove.

Non-Power Trim/Tilt Units Only

5- Slide the wiring harness retainer and the trim harness bushing over the control shaft. The trim harness bushing is placed "stepped side" **UP** and the notched side toward the forward side of the control housing.

Power Trim/Tilt Units Only

6- Insert the trim harness bushing into the recess of the remote control housing and



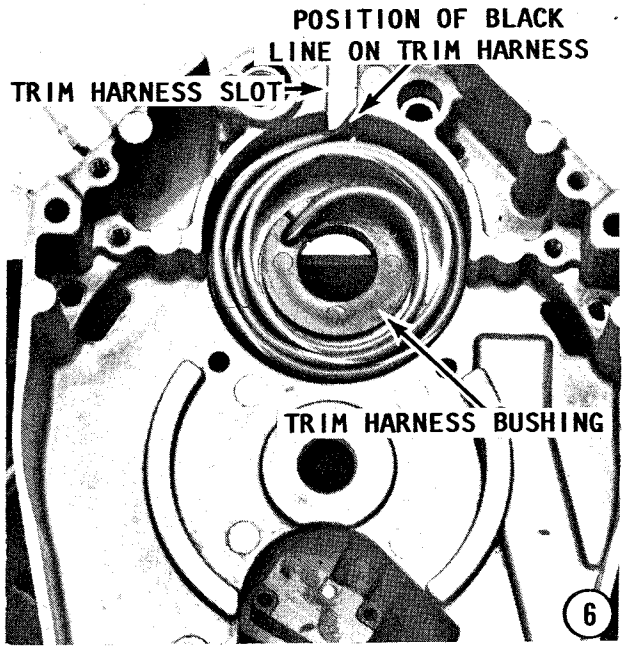


carefully coil the wires, as shown in the accompanying illustration. Ensure the black line on the trim harness is positioned at the exact point shown for correct installation. The purpose of the coil is to allow slack in the wiring harness when the control handle is shifted through a full cycle. The bushing and wires move with the handle.

All Units

7- Position the bushing, shift pinion gear and shift lever onto the pin on the bearing plate, with the shift gear indexing with the shift pinion gear.

8- Install the two compression springs,



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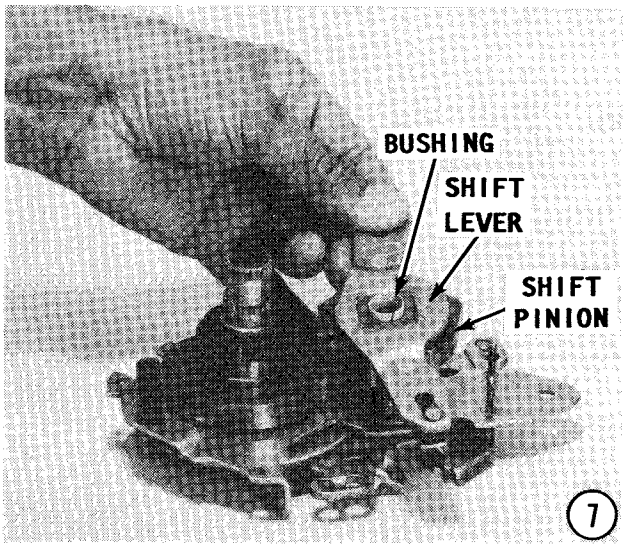
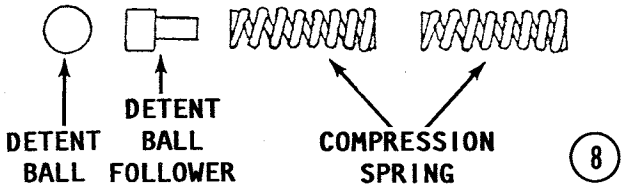


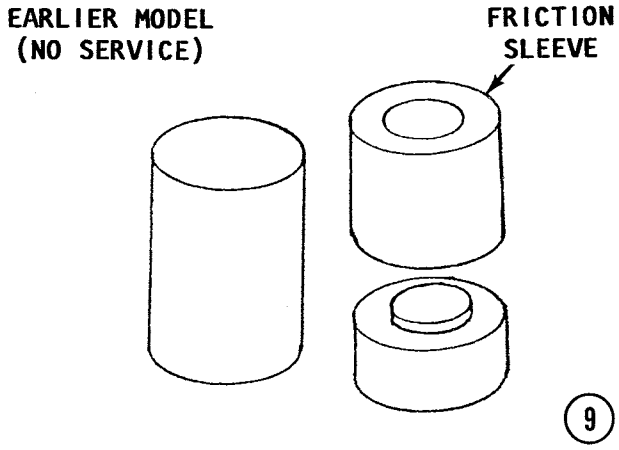
the detent ball follower and the detent ball into their recess in the control module housing.

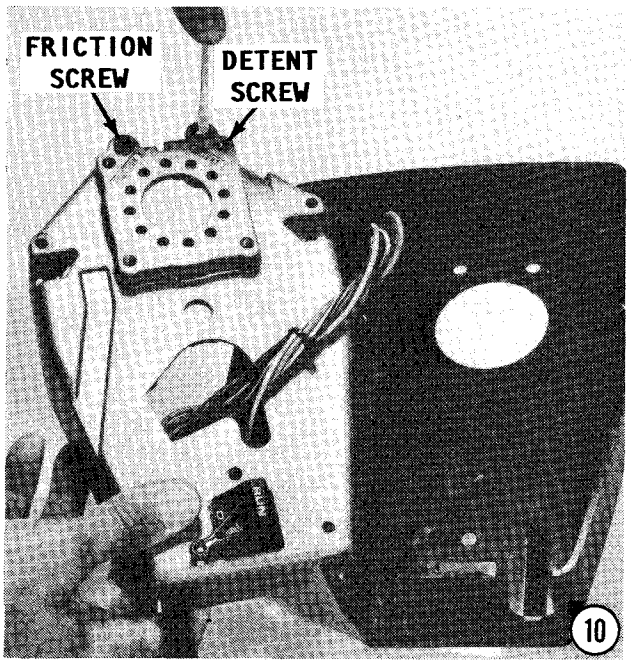
9- If the friction sleeve is not a part of the friction pad, then place the control handle friction sleeve into its recess in the control module housing.

SPECIAL WORDS

In Step 16 of the disassembling procedures, instructions were given to count the number of turns required to remove the detent adjustment screw and the control handle friction screw. The number of turns is now necessary for ease in performing the next step.

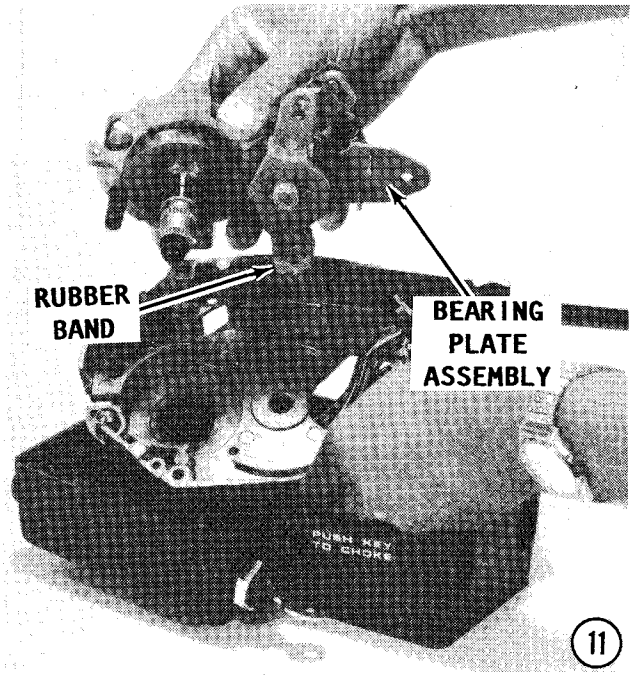






10- Thread the detent adjustment screw and the control handle friction screw the exact number of turns as recorded during Step 16 of the disassembling procedures. A fine adjustment may be necessary after the unit is completely assembled.

11- Place the compression spring (if removed) in position on the shift lever and shift pinion gear assembly against the bearing plate, as shown. Use a rubber band to secure the shift pinion gear to the bearing plate. Lower the complete bearing plate assembly into the control module housing.



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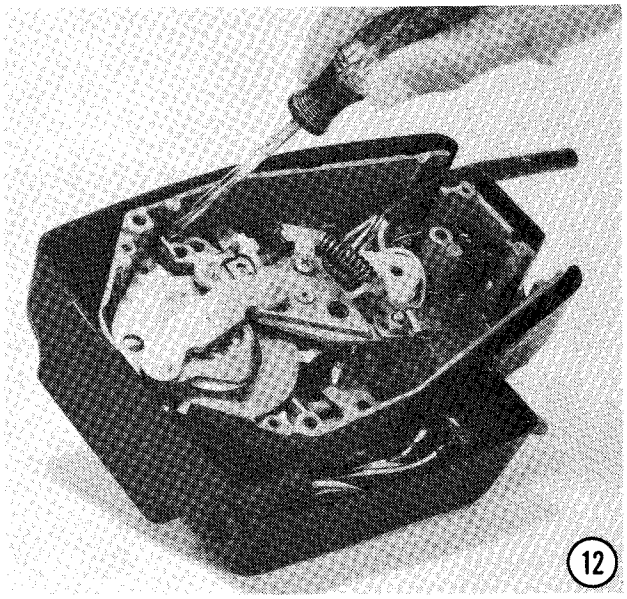
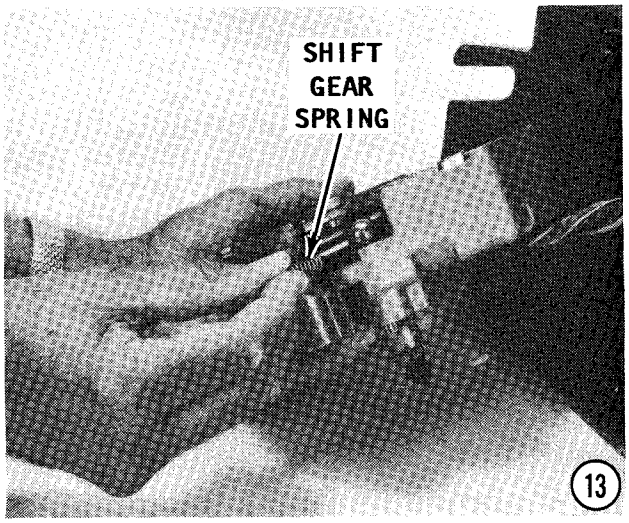


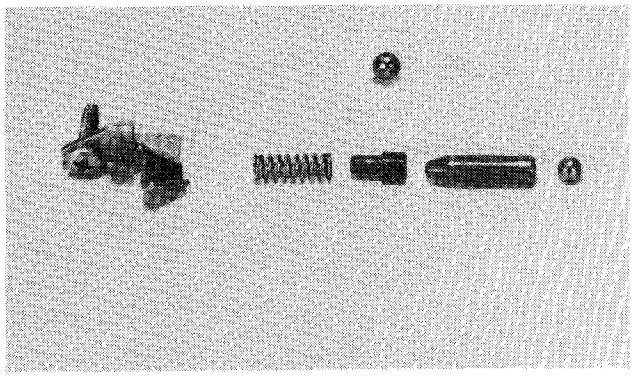
12- Secure the bearing plate assembly to the control module housing with the three Phillips head screws, remove the rubber band.

13- Insert the gear shift ball (inner) into the recess of the shift gear and hole in the "throttle only" shaft barrel. Now, insert the shift gear pin into the recess with the rounded end of the pin away from the control shaft. Insert the nylon pin or shift gear ball (outer) into the same recess. Next, insert the gear shift spring.

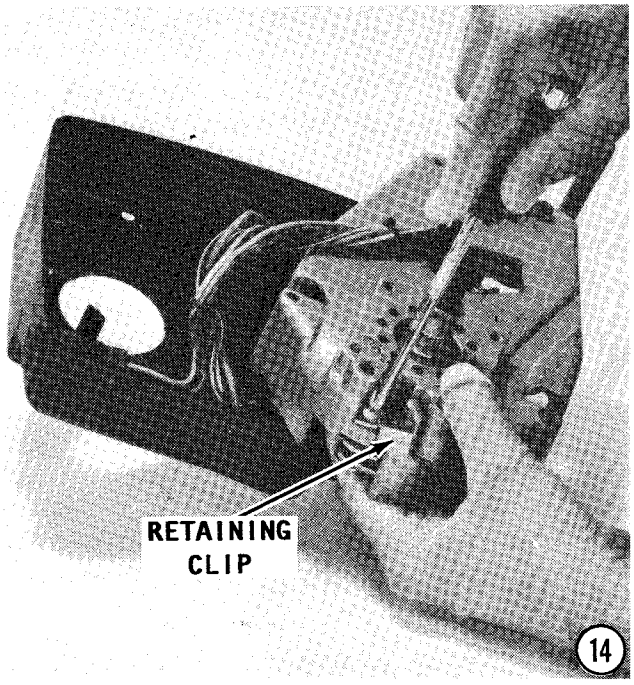
14- Hold these small parts in place and at the same time secure them with the retaining clip and the Phillip head screw. (On power trim/tilt units, this retaining clip also secures the trim wire to the control module.)

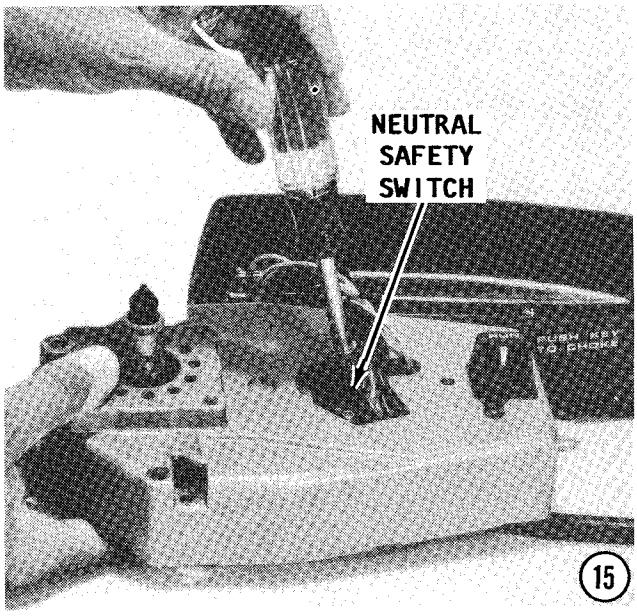
15- Insert the neutral safety microswitch into the recess of the plate assembly and secure it with the two locknuts.





Arrangement of parts, cleaned and ready for installation into the control module recess.





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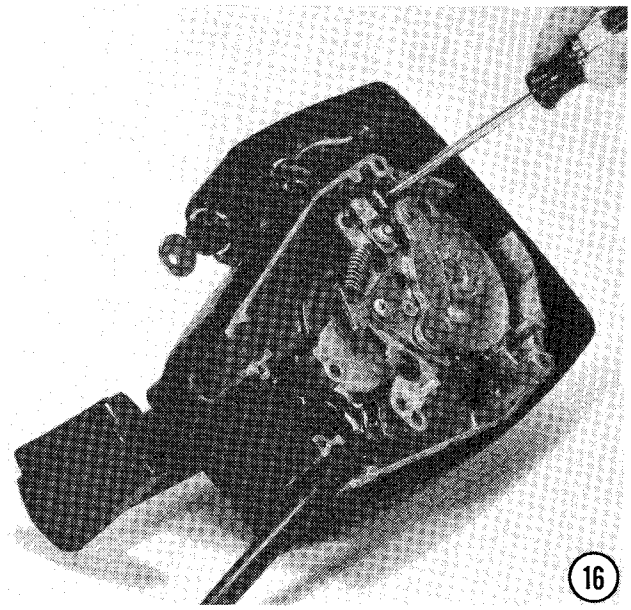
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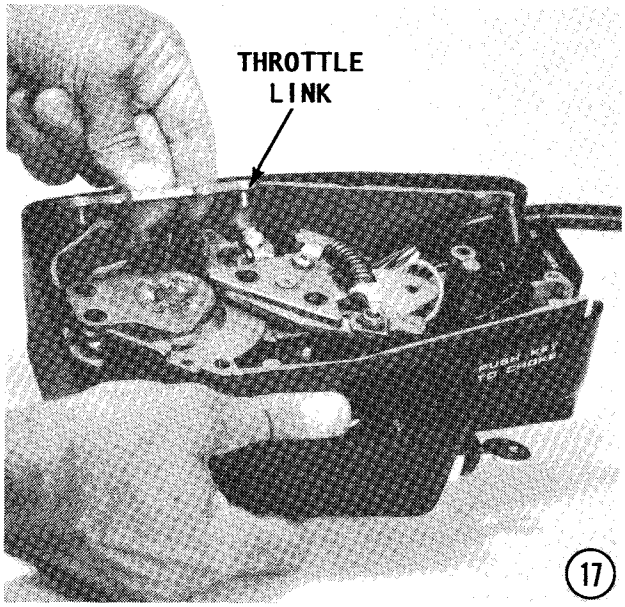

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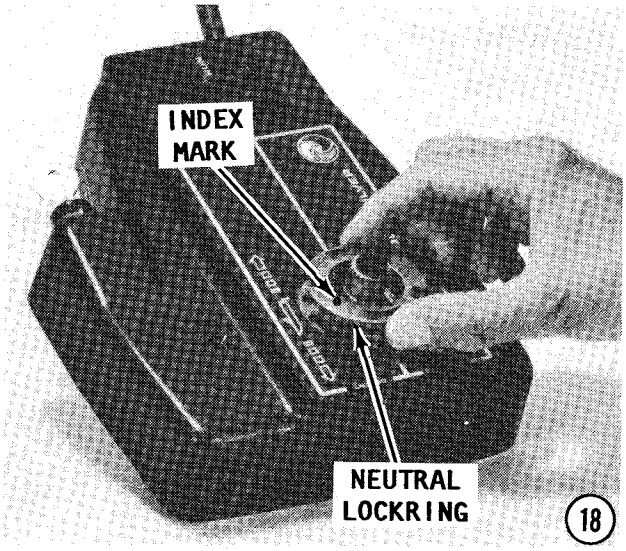


18

16- Secure the control module to the plastic control housing case with the three Phillips head screws. Two are located on either side of the bearing plate and the third in the recess where the throttle cable enters the control housing.

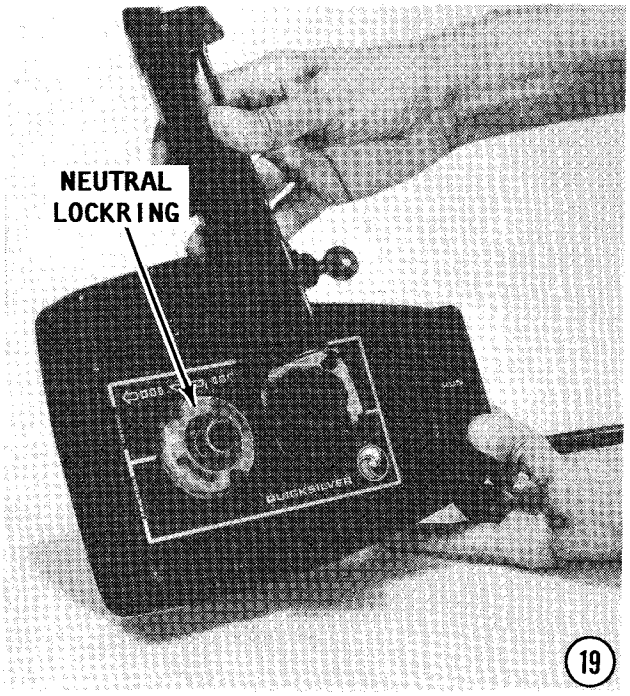
17- Temporarily install the control handle onto the control shaft. Shift the unit into forward detent **ONLY,** not full forward, to align the holes for installation of the throttle link. After the holes are aligned, remove the handle. Install the throttle link.

18- Again, temporarily install the control handle onto the control shaft. This time shift the unit into the **NEUTRAL** position, and then remove the handle. Place the neutral lockring over the control shaft, with the index mark directly beneath the small boot on the front face of the cover.

19- Install the control onto the splines of the control shaft. **TAKE CARE** not to cut, pinch, or damage the trim wires on the power trim/tilt unit.

CRITICAL WORDS

When positioning the control handle, ensure the trim wire bushing is aligned with its locating pin against the corresponding slot in the control handle. On a Power Trim/Tilt unit only: if this bushing is **NOT** installed correctly, it will not move with the control handle as it is designed to move -- when shifted. This may pinch or cut the trim wires, causing serious problems.



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On a Non-Power Trim/Tilt unit, misplacement of this bushing (it is possible to install this bushing upside down) will not allow the control handle to seat properly against the lockring and housing. This situation will lead to the Allen screw at the base of the control handle to be incorrectly tightened to seat against the splines on the control shaft, instead of gripping the smooth portion of the shaft. Subsequently the control handle will feel "sloppy" and could cause the neutral lock to be ineffective.

WARNING

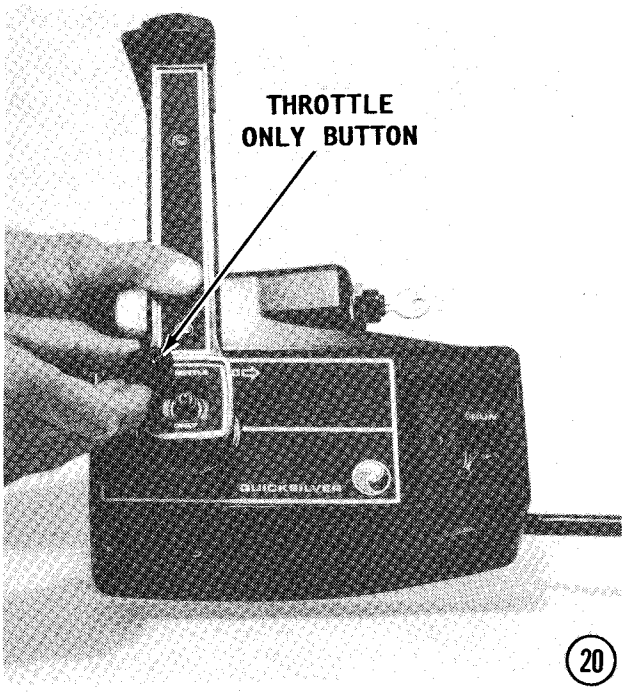
IF THIS HANDLE IS NOT SEATED PROPERLY, A SLIGHT PRESSURE ON THE HANDLE COULD THROW THE LOWER UNIT INTO GEAR, CAUSING SERIOUS INJURY TO CREW, PASSENGERS, AND THE BOAT.

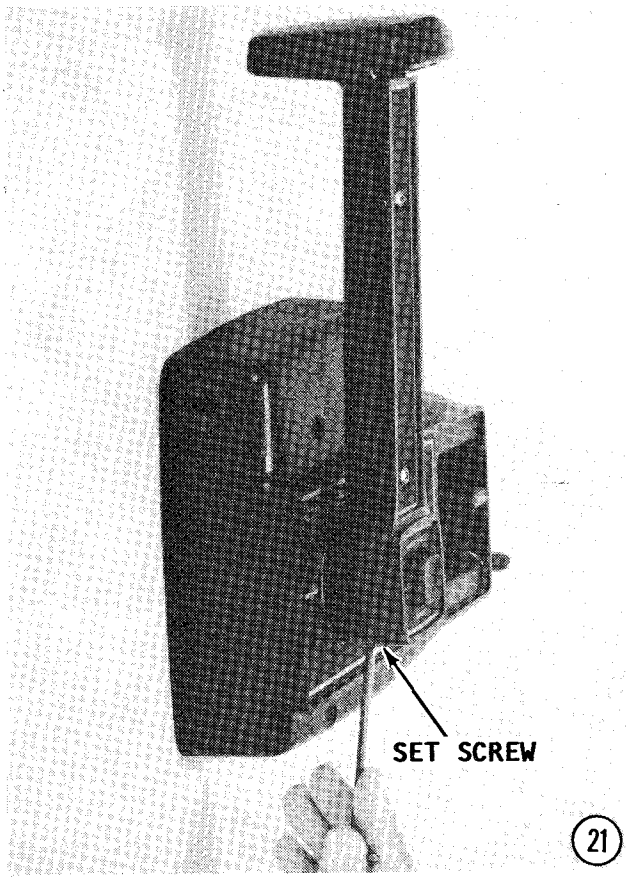
20- Push the "throttle only" button in place on the control shaft.

21- Ensure the control handle has seated properly, and then tighten the set screw at the base of the handle to a torque value of 70 in. lbs (7.9Nm).

SAFETY WORDS

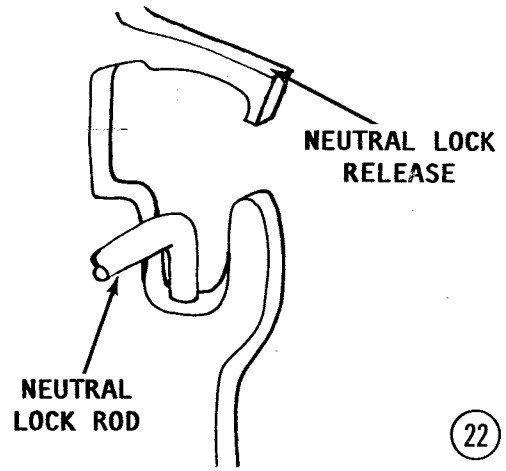
FAILURE to tighten the set screw to the required torque value, could allow the handle to disengage with a loss of throttle and shift control. An extremely **DANGEROUS** condition.





Power Trim/Tilt Models
or
Non-Power Models
If Handle Cover Was Removed

22- Slide the hooked end of the neutral lock rod into the slot in the neutral lock release. Route the trim wires in the control handle in their original locations. Connect them with the wires remaining in the handle and secure the connections with the wire retainer. Install the handle cover and tighten the two Phillips head screws.



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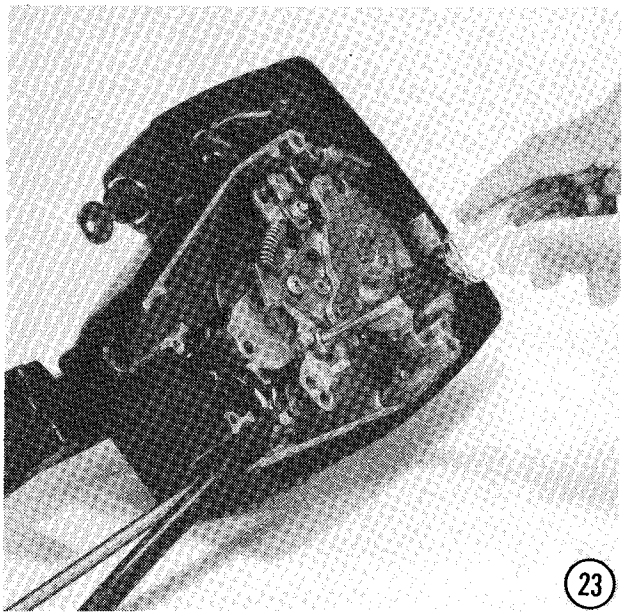
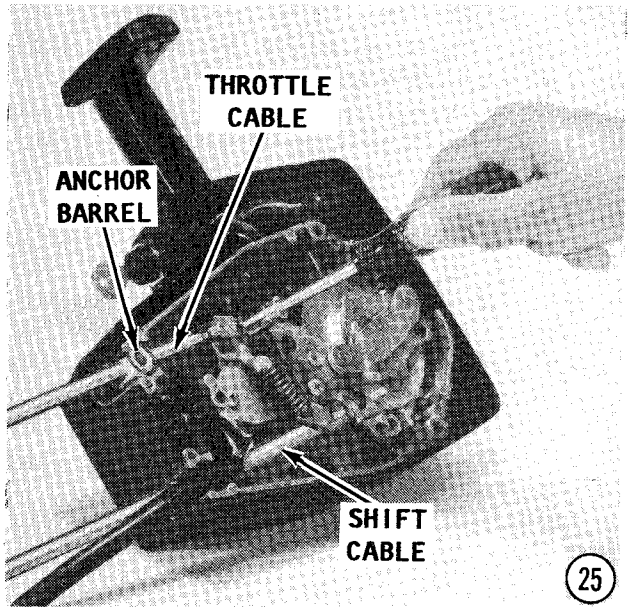




23- Move the wiring harness clear of the barrel recess. Thread the shift cable anchor barrel to the end of the threads, away from the cable converter, and place it into the recess. Hook the pin on the end of the cable fastener through the outer hole in the shift lever. Depress the **NEUTRAL** lock bar on the control handle and shift the handle into the **REVERSE** position. **TAKE CARE** to ensure the cable fastener will clear the neutral safety micro-switch. The access hole is now aligned with the locknut.

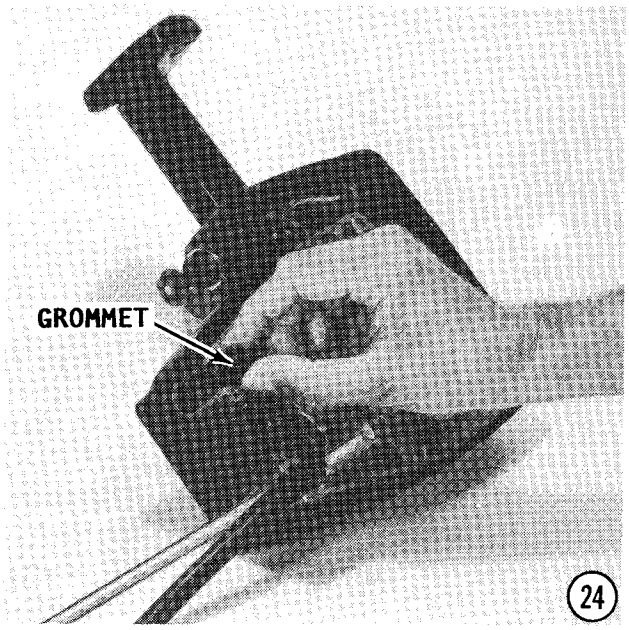
STOP

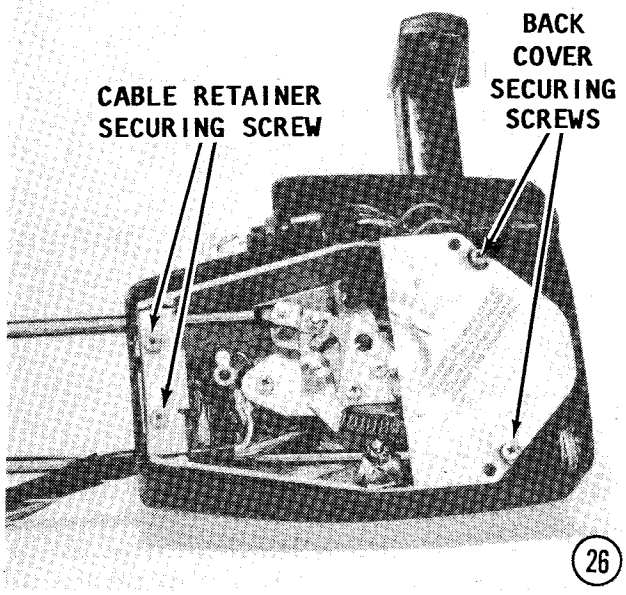
Check to be sure the pin on the cable fastener is all the way through the cable end and the shift lever. A pin partially engaging the cable and the shift lever may cause the cable fastener to **BEND** when the nut is tightened.

Tighten the locknut with a 3/8" deep socket to a torque value of 20 to 25 in. lbs (2.26 to 2.82 Nm). Position the wiring harness over the installed shift cable.

24- Install the grommet into the throttle cable recess.

25- Thread the throttle cable anchor barrel to the end of the threads, away from the cable connector, and then place it into the recess over the grommet. Hook the pin on the end of the cable fastener through the outer hole in the shift lever.





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STOP AGAIN

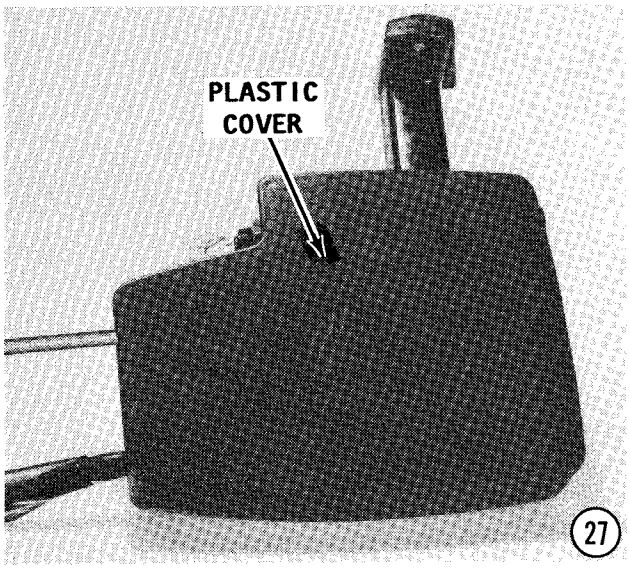
Check to be sure the pin on the cable fastener is all the way through the cable end and the throttle lever. A pin partially engaging the cable and throttle lever may cause the cable fastener to **BEND** when the nut is tightened.

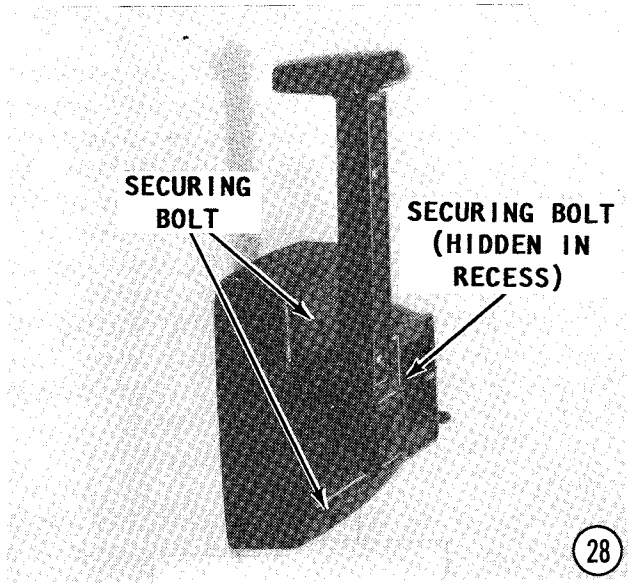
Tighten the locknut to a torque value of 20 to 25 in. lbs (2.26 to 2.82 Nm).

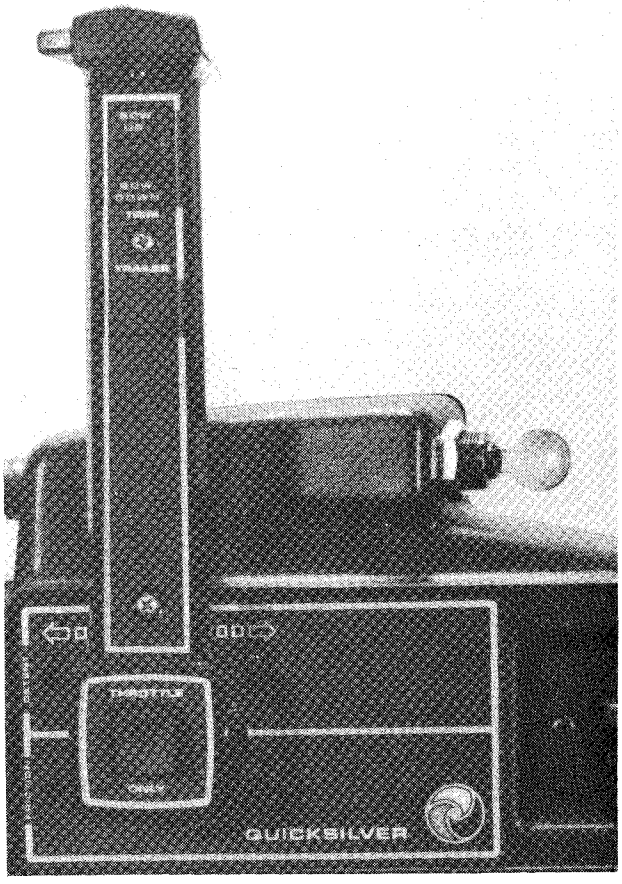
26- Position the control module back cover in place and secure it with the two Phillips-head screws. Tighten the screws to a torque value of 60 in. lbs (6.78 Nm). Install the cable retainer plate over the two cables and secure it in place with the two Phillip-head screws.

27- Place the plastic access cover over the control housing.

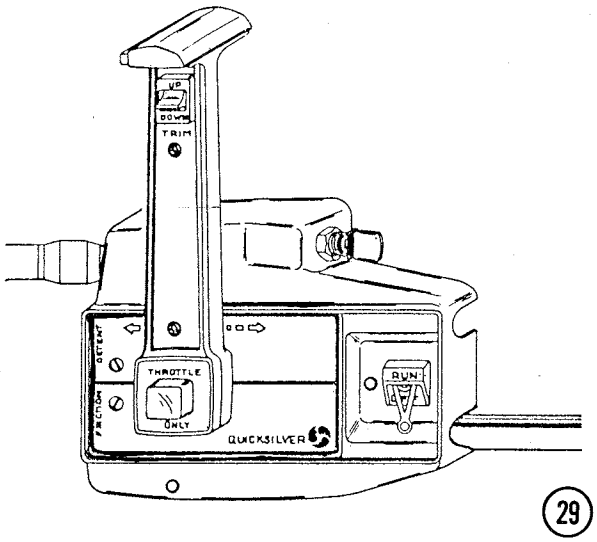
28- Position the control housing in place on the mounting panel and secure it with the three long (3-1/2") bolts, flat washers, and locknuts. One is located next to the **RUN** button (the ignition safety stop switch). The second is beneath the control handle on the power portion of the plastic case. The third bolt goes in behind the control handle when the handle is in the **NEUTRAL** position.







Commander shift box ready for installation.



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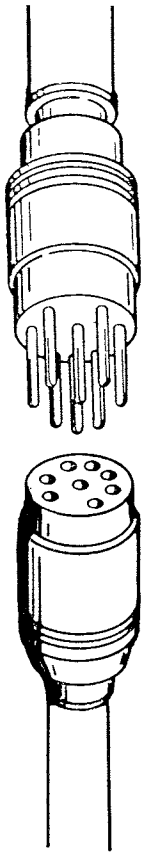

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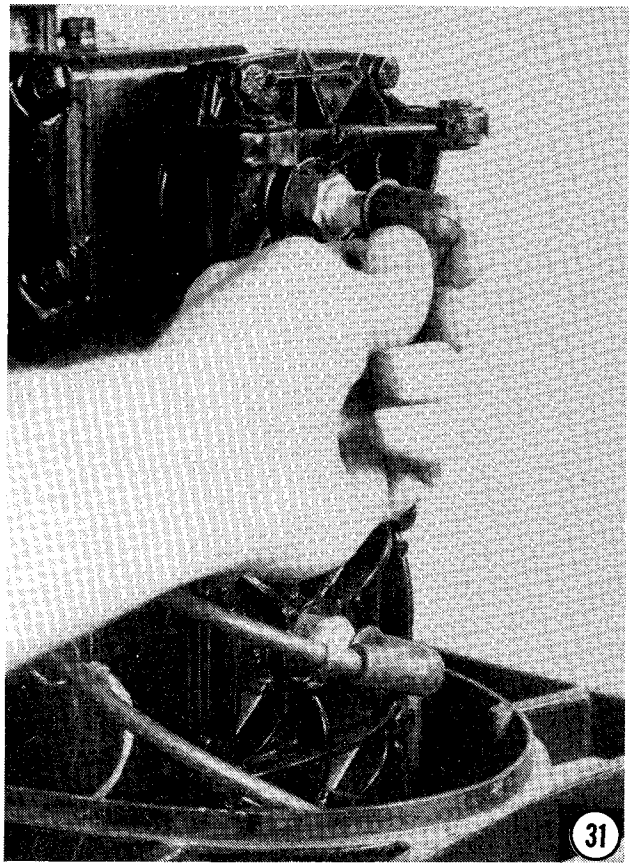

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Therefore, in order to install this bolt, shift the handle into the **FORWARD** or the **REVERSE** position, and then install the bolt. After the bolt is secure, shift the handle back to the **NEUTRAL** position for the next few steps.

29- Connect the tachometer wiring plug to the forward end of the control housing.

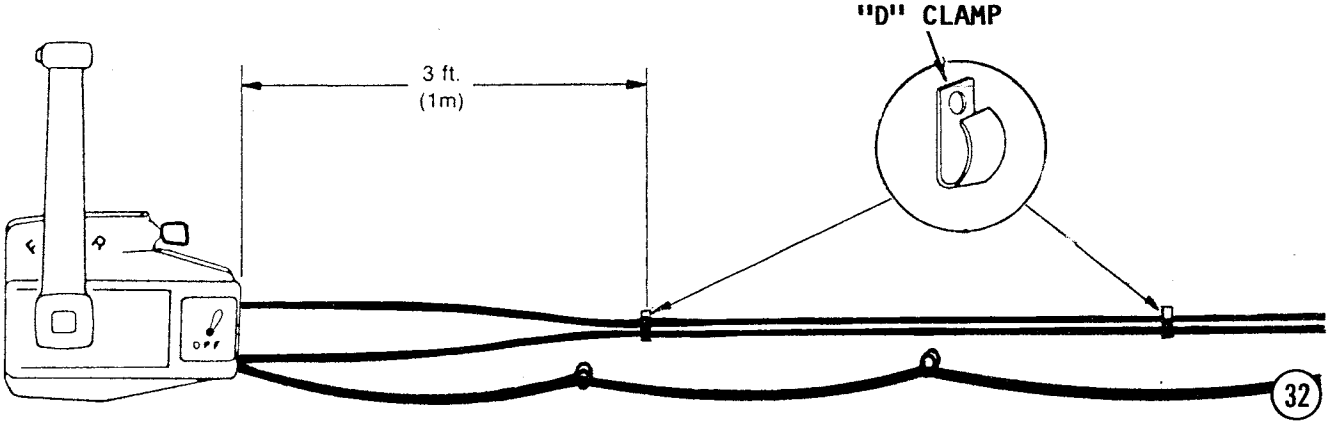
GOOD WORDS

Clean the prongs of the connector with crocus cloth to ensure the best connection possible. Exercise care while cleaning to prevent bending the prongs.

30- Connect the remote control wiring harness plug from the outboard trim/tilt motor and pump assembly.

31- Install the high-tension leads to their respective spark plugs.

32- Route the wiring harness alongside the boat and fasten with the "Sta-Straps". Check to be sure the wiring will not be pinched or chafe on any moving part and will not come in contact with water in the bilge. Route the shift and throttle cables the best possible way to make large bends and as few as possible. Secure the cables approximately every three feet (one meter).



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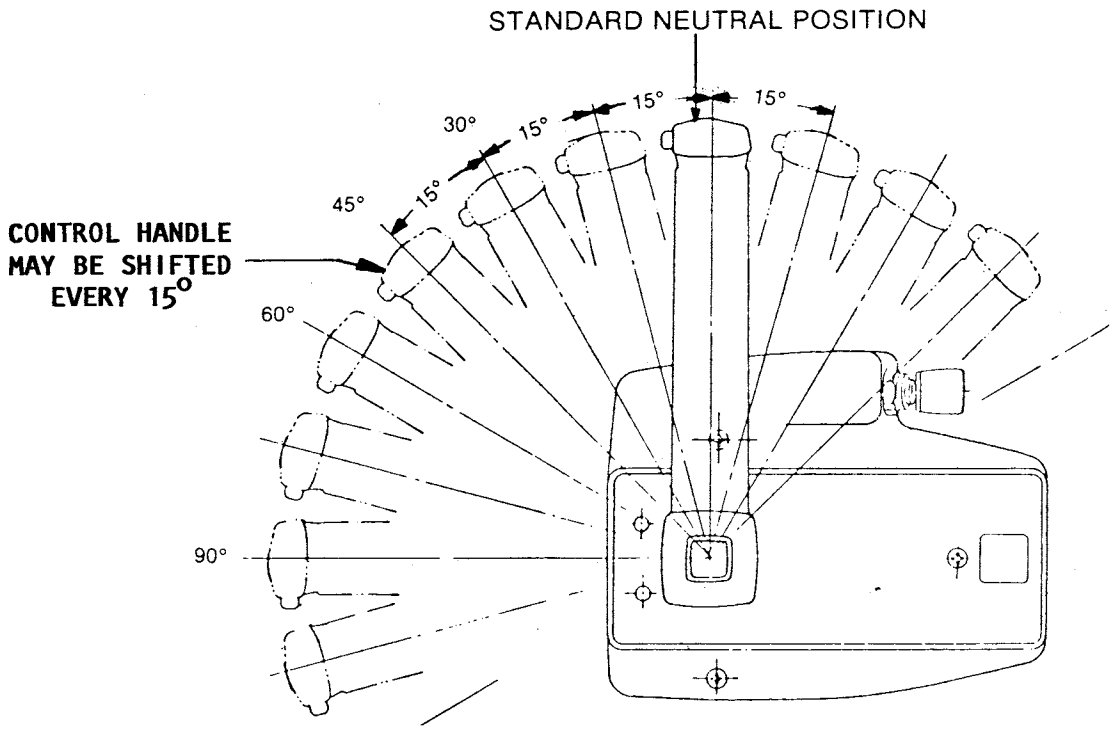

The neutral position of the remote control handle may be changed to any one of a number of convenient angles to meet the owner's preference. The change is accomplished by shifting the handle one spline on the shaft at a time. Each spline equals 15° of arc, as shown. The procedures on Page 12-15 explain the positioning in detail.

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13
HAND REWIND STARTER

13-1 INTRODUCTION

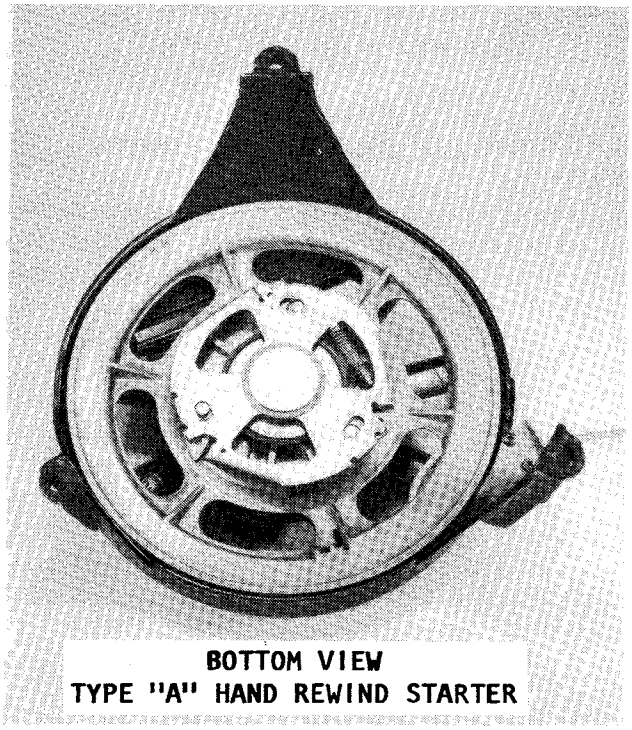
Two different hand rewind starters have been used over the years on the 4-cylinder 45hp and 50hp powerheads covered in this manual.

For convenience, one model has been identified as Type "A" and the other model, Type "B". Both designs have been used on both horsepower units.

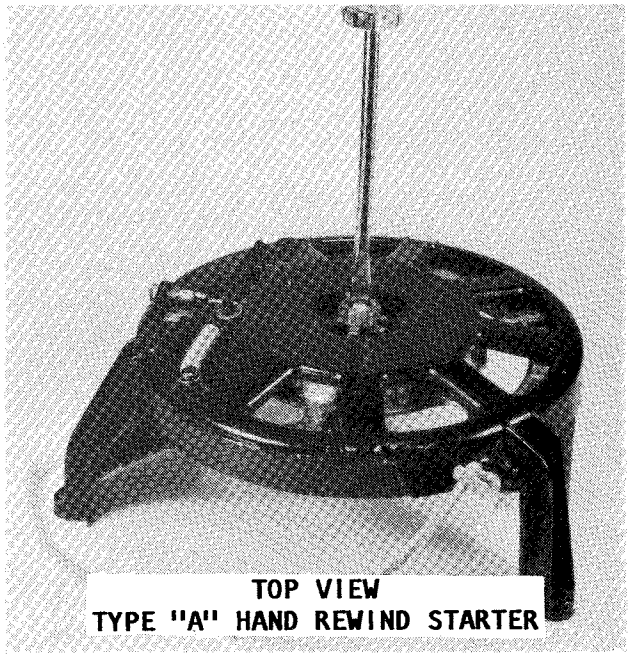
The illustrations on this page and the following page will be most helpful to determine which model is installed on the powerhead being serviced.

Separate and complete detailed procedures are presented in this chapter to service each Type.

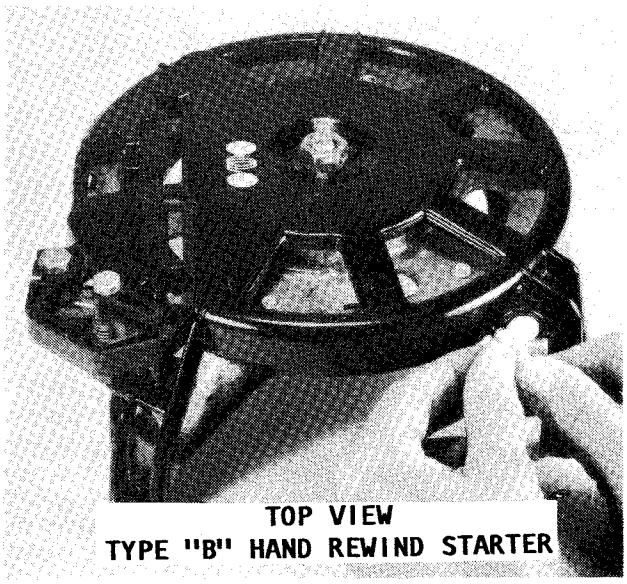
Procedures for the Type "A" model begin on the next page under Section 13-2. Procedures for the Type "B" model begin on Page 13-13 under Section 13-3.



BOTTOM VIEW
TYPE "A" HAND REWIND STARTER



TOP VIEW
TYPE "A" HAND REWIND STARTER



TOP VIEW
TYPE "B" HAND REWIND STARTER

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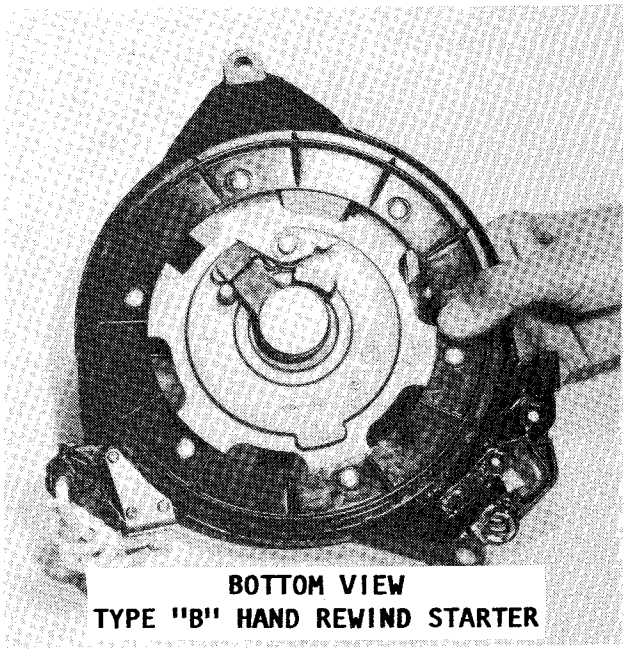
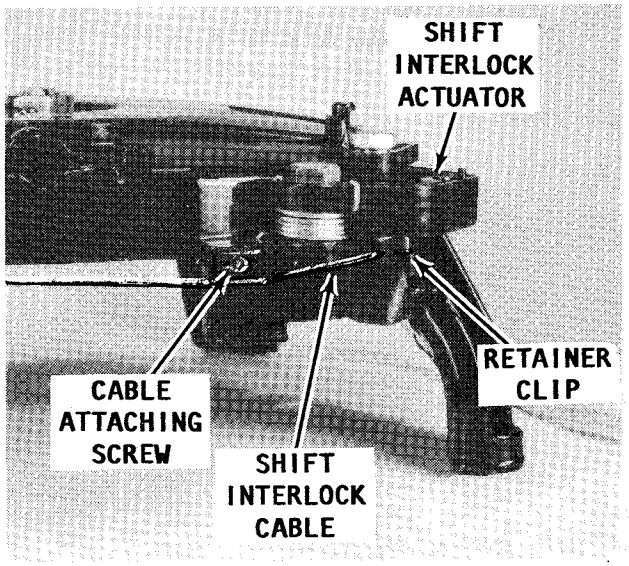


BOTTOM VIEW
TYPE "B" HAND REWIND STARTER

Perform only the necessary steps to restore the hand rewind starter to satisfactory performance and disregard work not directly related to the task involved.

13-2 TYPE "A" HAND REWIND STARTER

The following procedures provide all necessary steps to completely service Type "A" hand rewind starter. Check first section of this chapter to be sure proper starter has been identified and correct work sequence has been selected for the model to be serviced.



Later model rewind starters are equipped with a shift interlock cable mounted on the side of the starter housing. Early models have the cable mounted on the top of the housing. The interlock cable of both models is secured in the same manner.

REMOVAL AND DISASSEMBLING

PRELIMINARY TASKS

First, remove the wrap around cowling. Next, remove the rope retainer (handle) from the rope. This is accomplished by simply pushing the inner portion through the outer shell of the handle. Untie the "stop" knot in the rope and allow the rewind spring to unwind within the recess of the sheave.

If the choke rod passes down through the top of the cowl, disconnect the upper portion of the shaft from the lower portion by pulling the cotter pin securing the two together. Pull the upper portion of the choke shaft up through the cowling.

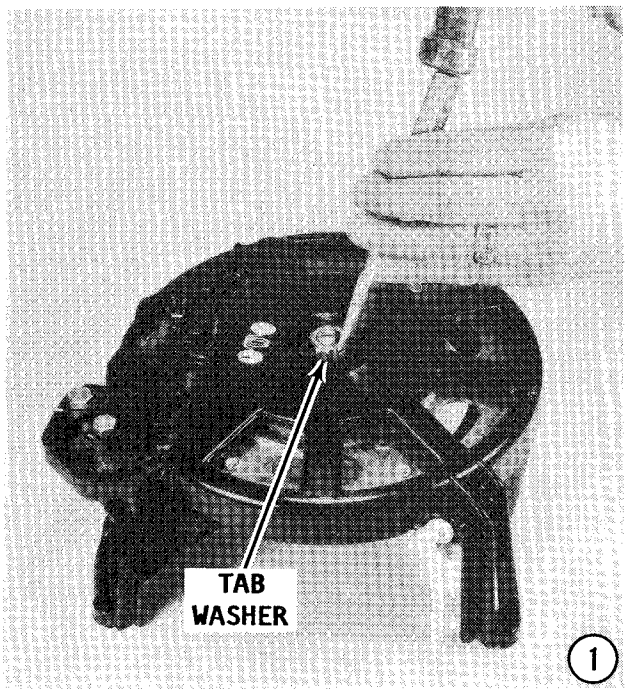
All powerheads covered in this chapter have a shift interlock system. The system includes a shift interlock actuator (cable). Remove the cable attaching screw and the retainer clip, as shown in the accompanying illustration.

Now, remove the cowling. Remove the screws securing the three legs of the hand rewind starter mechanism to the powerhead.

The following steps pickup the work after these few preliminary tasks have been completed.

DISASSEMBLING

1- Place the hand starter on a suitable work surface. Pry out the one tab bent into



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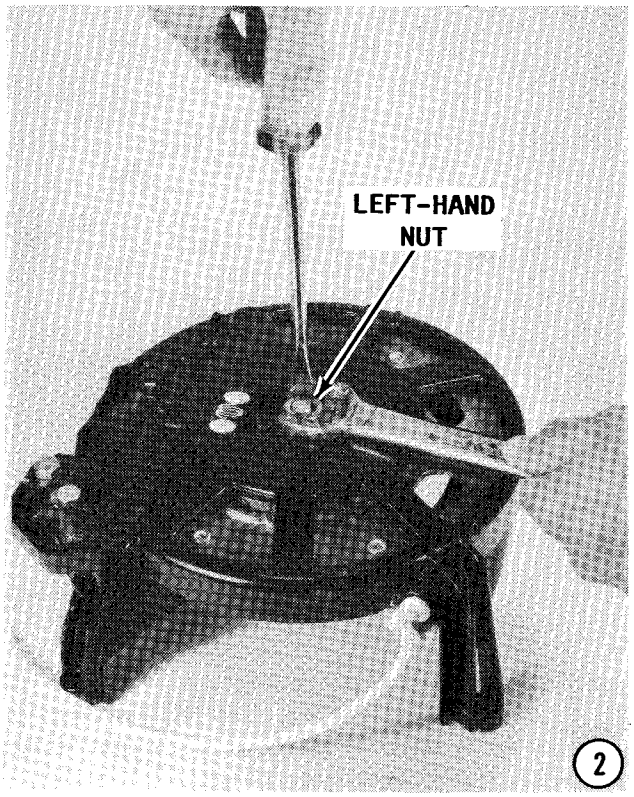
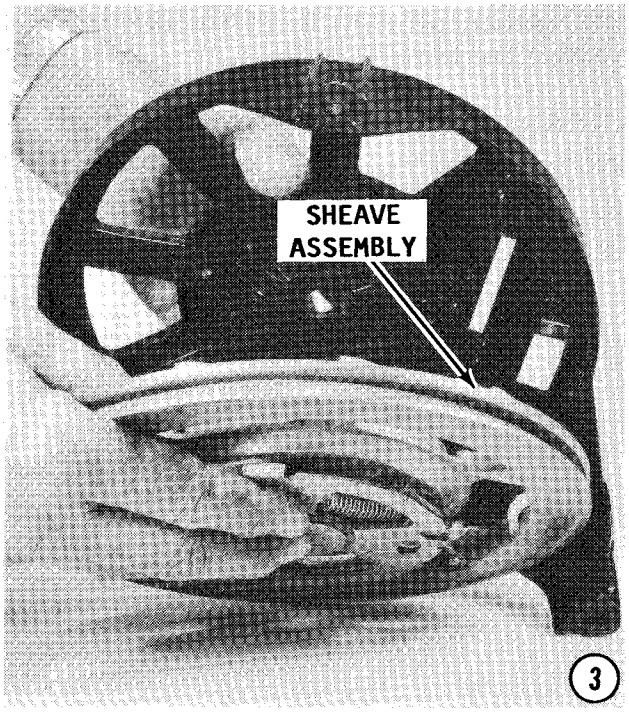
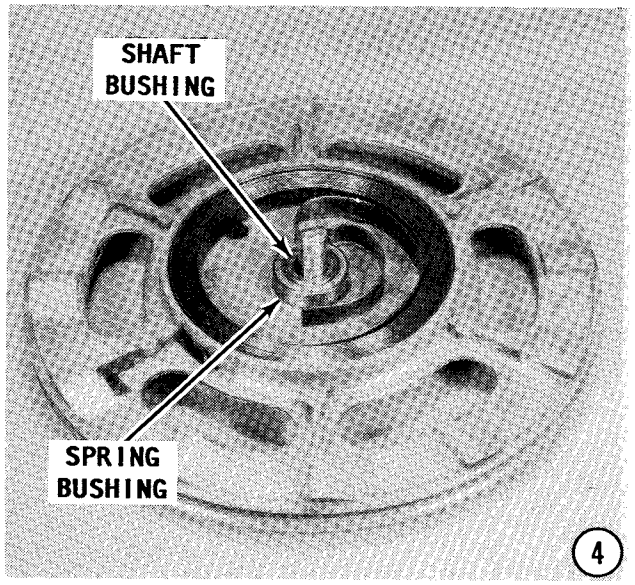


the recess in the rewind housing. Use a hammer and flat punch to push aside the two tabs of the tab washer. This washer secures the sheave shaft retaining nut.

CRITICAL WORDS

The sheave shaft retaining nut has **LEFT-HAND** threads.





2- Remove the nut with a 3/4" end wrench by rotating the nut **CLOCKWISE** because it is a **LEFT-HAND** nut.

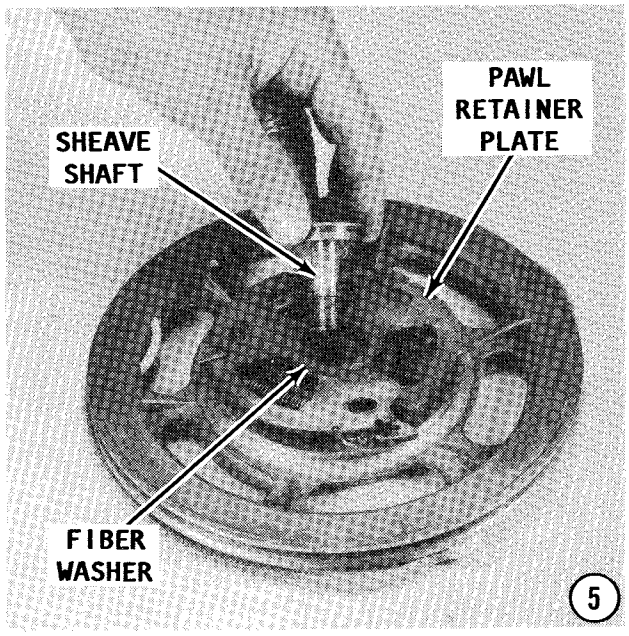
3- Carefully lift the starter housing from the sheave assembly so as not to disturb the rewind spring encased in the sheave. Place the sheave face down on a flat surface.

4- Lift off the spring retainer plate, and then remove the shaft bushing and the spring bushing from the sheave.

5- Remove the sheave shaft, the fiber washer, and the pawl retainer plate from the sheave.

GOOD WORDS

The return spring will come away with the pawl retainer plate.



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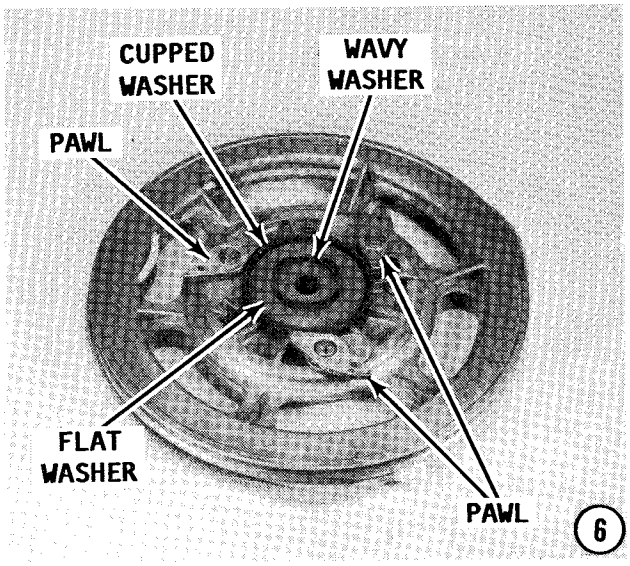
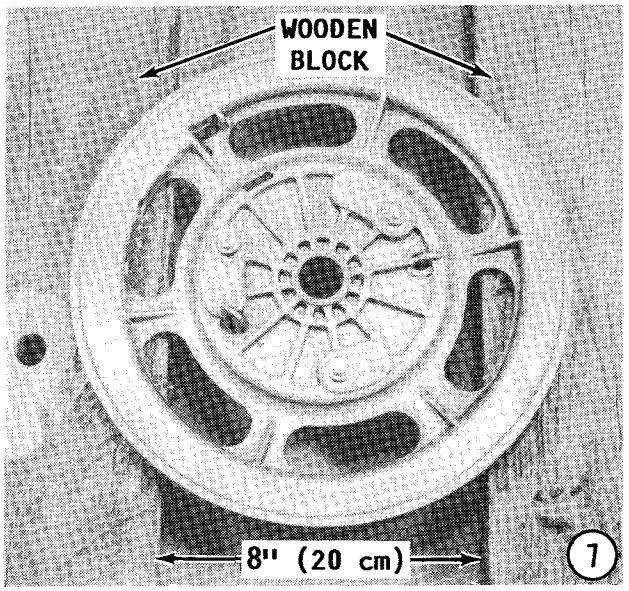


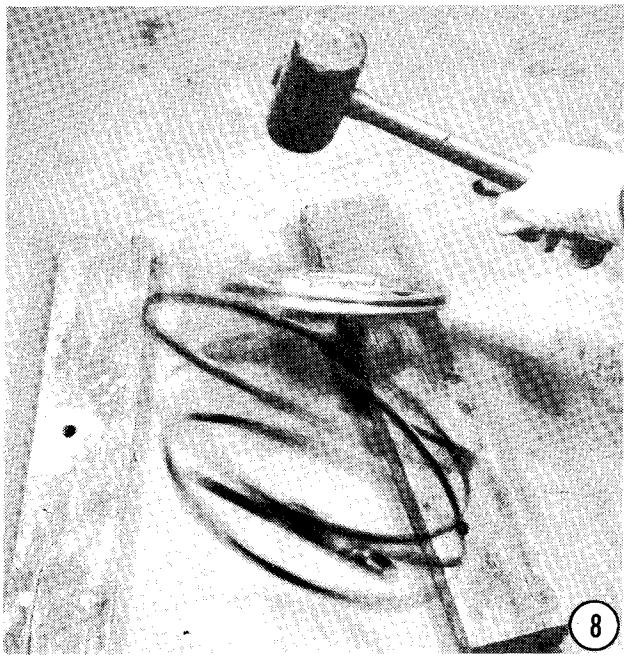
6- Remove and **DISCARD** the wavy washer. It cannot be used a second time. Remove the flat washer and the cupped washer. Lift off the three pawls from their pins. Remove and **DISCARD** the wavy washer under each pawl.

7- Obtain two pieces of wood, a short 2" x 4" (5cm x 10cm) will work fine. Place the two pieces of wood approximately 8" (20 cm) apart on the floor. Center the sheave on top of the wood with the spring side facing **DOWN.** Check to be sure the wood is not touching the spring.

WARNING

THE REWIND SPRING IS A POTENTIAL HAZARD. The spring is under tremendous tension when it is wound -- a real **"tiger"** in a cage! If the spring should accidentally be released, severe personal injury could result from being struck by the spring with force. Therefore, the following step **MUST** be performed with care to pervent personal injury to self and others in the area.



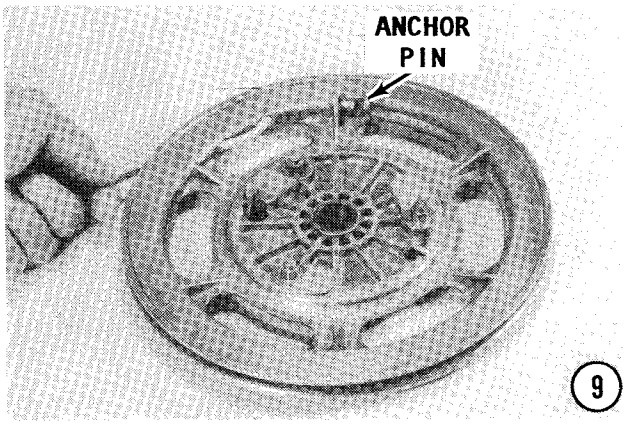


8- Stand behind the wood, keeping away from the openings as the spring unwinds with considerable force. Tap the sheave with a soft mallet. The spring retainer plate will drop down releasing the spring. The spring will fall and unwind almost instantly and with **FORCE.**

9- Unwind the rope from around the sheave and feed it through the holes. Turn the anchor pin 90° in either direction to release the rope.

CLEANING AND INSPECTING

Wash all parts except the rope and the handle in solvent, and then blow them dry with compressed air.



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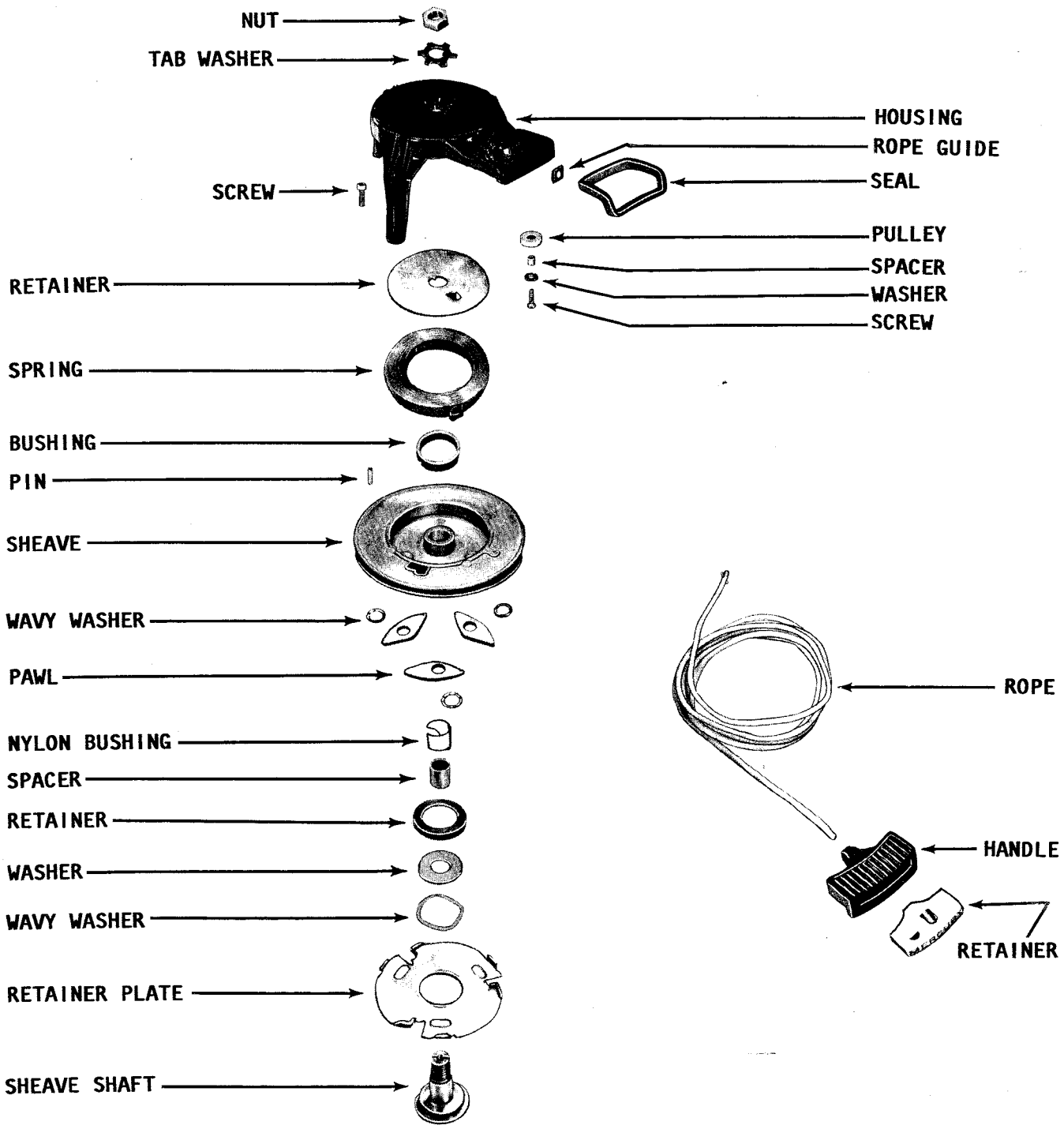

Arrangement of parts, in order, for the hand rewind starter covered in this section.

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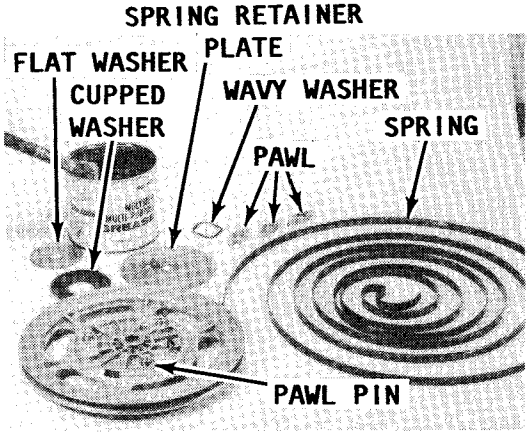
Remove any trace of corrosion and wipe all metal parts with an oil dampened cloth.

Inspect the rope. Replace the rope if it appears to be weak or frayed. If the rope is frayed, check the holes through which the rope passes for rough edges or burrs. Remove the rough edges or burrs with a file and polish the surface until it is smooth. Inspect the starter spring end hooks. Replace the spring if it is weak, corroded or cracked. Inspect the tab on the spring retainer plate. This tab is inserted into the inner loop of the spring. Therefore, be sure it is straight and solid. Inspect the inside surface of the sheave rewind recess for grooves or roughness. Grooves may cause erratic rewinding of the starter rope.

Check the condition of the pawl pivot pins for excessive wear. These pins are a part of the sheave casting. They **CANNOT** be serviced. Therefore, if they are not acceptable, a new sheave **MUST** be purchased and installed.

Inspect the pawls for wear around the pivot holes and for rounded outer edges. Replace the pawls in sets of **THREE ONLY.** Check the pawl retainer plate for wear, especially the center hole and the areas where the sides of the pawls contact the retainer plate.

Inspect the pawl retainer plate return spring (if equipped). The manufacturer recommends this spring be replaced each time the rewind starter is disassembled for service. A weak spring could allow the pawls to contact the flywheel while the powerhead is operating and cause a very unpleasant noise and even damage to the edge of the flywheel. A weak spring will also cause excessive wear to the pawls.



After the parts shown have been cleaned and are ready for assembling, apply a coating of low-temperature lubricant to ensure long time service.

It is **STRONGLY** recommended the wavy washer under the pawl retainer plate, and the three wavy washers under the pawls be **REPLACED.** New wavy washers will ensure smooth operation of the rewind mechanism.

Coat the following parts with low-temperature lubricant: the entire length of the used rewind spring (a new spring will be coated with lubricant from the package), the pawl pins, both sides of the cupped washer, the flat washer, the shoulder on the sheave shaft, and the tab on the spring retainer plate.

ASSEMBLING AND INSTALLATION TYPE "A" REWIND HAND STARTER

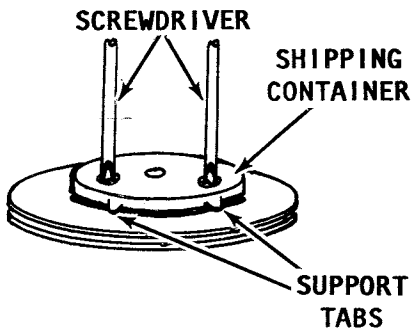
SPECIAL WORDS

The rewind starter may be assembled with a new rewind spring or a used one. Procedures for assembling are **NOT** the same because the new spring will arrive in a shipping container already wound and ready for installation. The used spring must be manually wound into its recess.

NEW REWIND SPRING INSTALLATION

The situation may arise when it is only necessary to replace a broken spring. The following few procedures outline the tasks required to replace the spring. A new spring is already properly wound and will arrive in a special shipping container. This container is designed to be used as an aid to installing the new spring.

a- Remove the retainers from the shipping container used to keep the spring from accidentally falling out of the container. Place the shipping container over the spring recess with the tabs resting on the outer edge of the recess.



A new rewind spring is installed into the sheave using the shipping container as a helpful tool. Two screwdrivers are used to tap the coiled spring out of the container and into the sheave.

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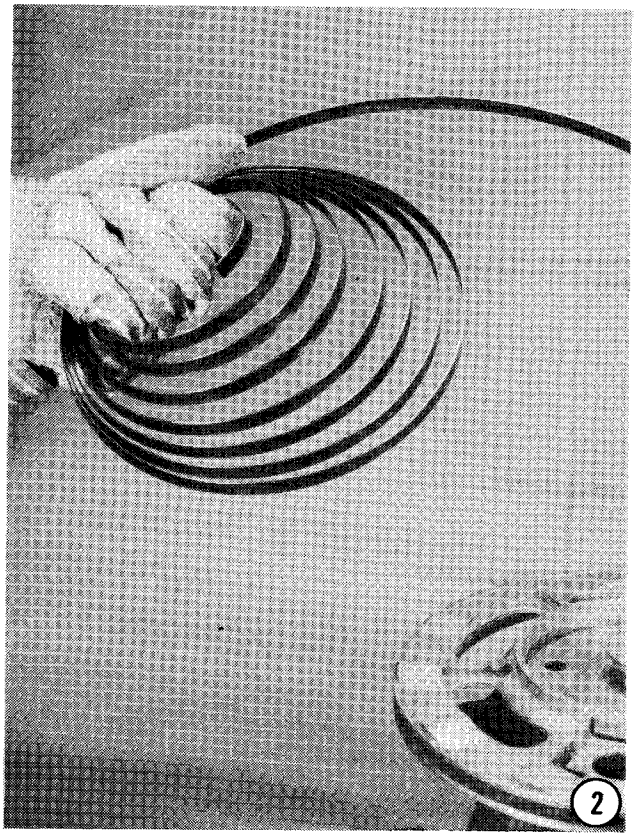
b- Align the hook on the outer end of the spring with the sheave anchor or notch.

c- Place two large blade screwdrivers into the holes of the shipping container over the tensioned spring. Push on both screwdrivers at the same time to press the spring out of the shipping container and into the spring recess of the sheave.



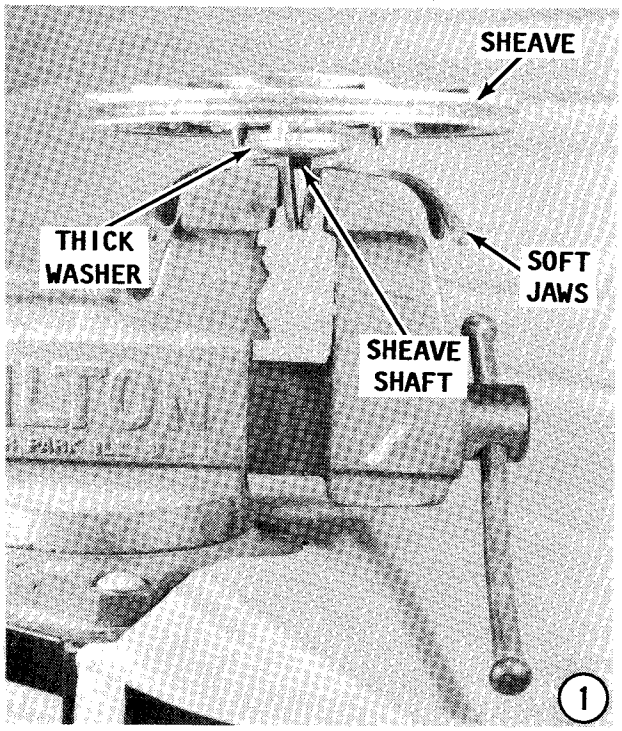
USED REWIND SPRING INSTALLATION

A used spring naturally will not be wound. Therefore, special instructions are necessary for installation.

SAFETY WORDS

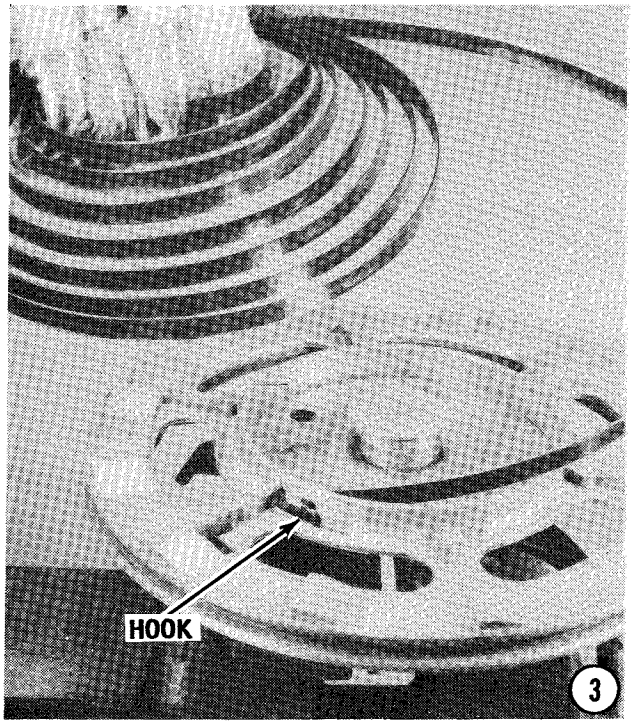
Wear a good pair of gloves while winding and installing the spring. The spring will develop tension and the edges of the spring steel are extremely sharp. The gloves will prevent cuts to the hands and fingers.

1- Insert the sheave shaft through the sheave with the spring recess facing **UPWARD.** Obtain two large washers and place them over the sheave shaft. Hold the washers in place and at the same time clamp the sheave shaft in a vise equipped with soft jaws. Shift the shaft in the vise to allow for "up and down" clearance and permit the shaft to rotate freely while the rewind spring is being installed.



SAFETY WORDS

It is **STRONGLY** recommended a pair of safety goggles or a face shield be worn while the spring is being installed. As the work progresses a "tiger" is being forced into a cage. If the spring is accidentally



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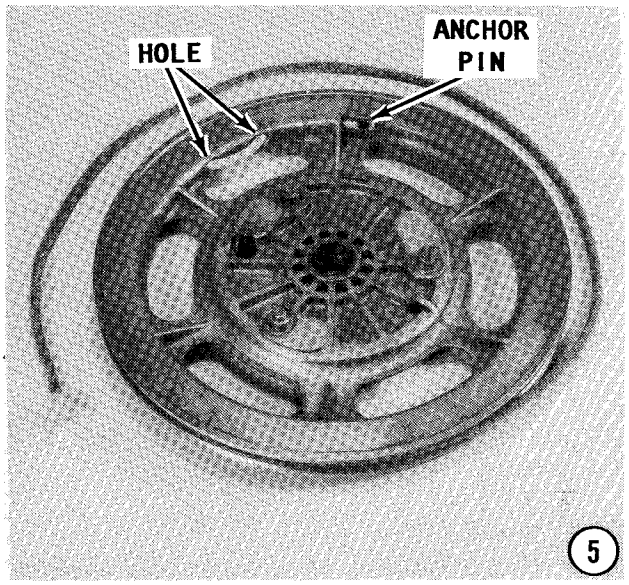
Protect your eyes with a face mask or safety glasses while working with the rewind spring, especially a used one. The spring is a real ***"tiger in a cage"****, almost 13' (4 m), of spring steel wound into less than 4" (about 10cm).*

released, it will lash out with tremendous ferocity and very likely could cause personal injury to the installer or other persons nearby.

2- Loop the spring loosely into a coil to enable it to be fed into its recess.



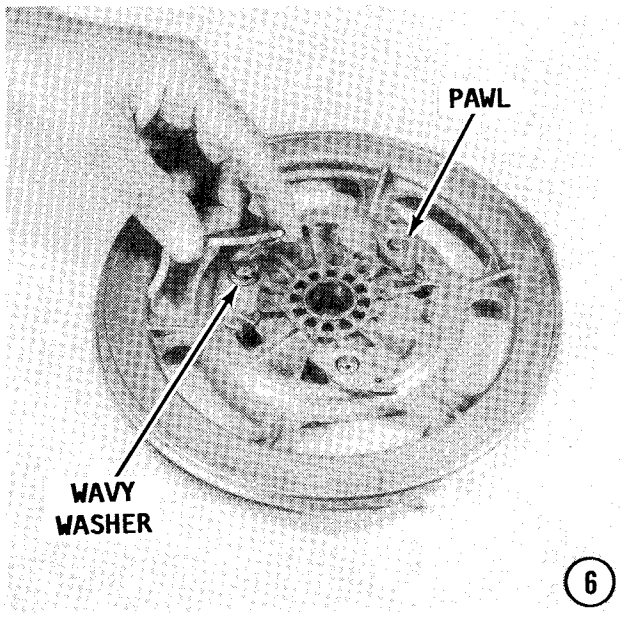


3- Insert the hook on the end of the spring into the notch of the recess.

4- Feed the spring around the inner edge of the recess and at the same time rotate the sheave **CLOCKWISE.** Proceed **WITH GREAT CARE.** Guide the spring into place. The spring will be slippery with lubrication. **DO NOT** lose control of the spring. Carefully remove the sheave from the vise and the sheave shaft and washers from the sheave.

5- Thread the starter rope thru the holes in the sheave and secure it with the anchor pin. Wind the rope **COUNTERCLOCKWISE** around the outer rim of the sheave (when viewed from the pawl side of the sheave).

6- Place one **NEW** wavy washer on each pawl pin. Slide the pawls over the pins and



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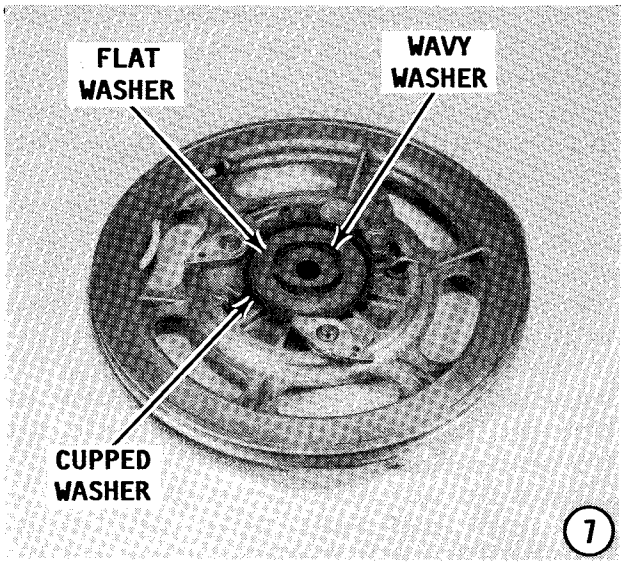
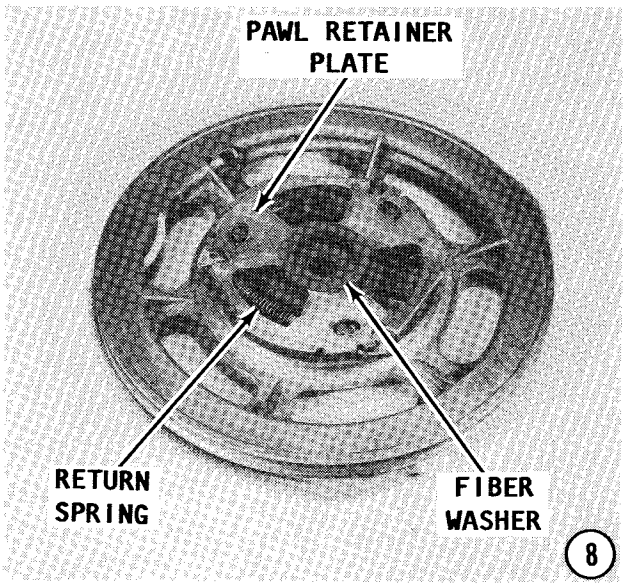


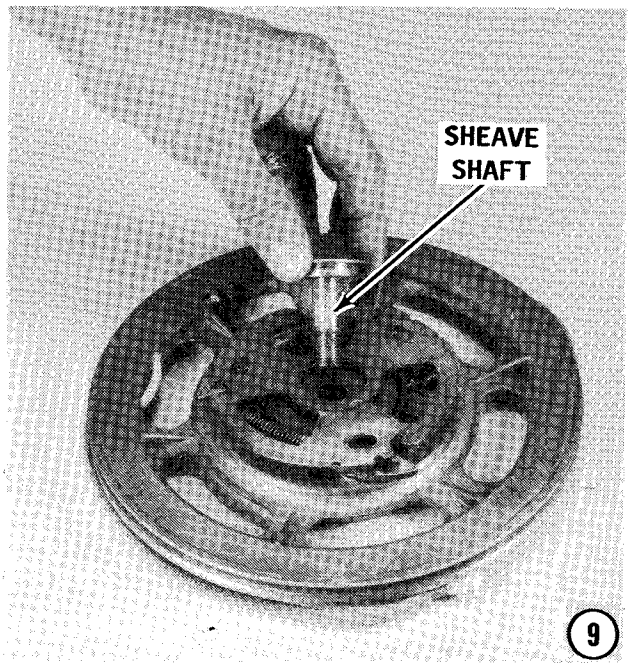
wavy washers. Check to be sure the "dot" or depression on the pawl is facing **UPWARD** and angled **OUTWARD,** as shown.

7- Place the cupped washer, with the cupped side facing **UPWARD** over the center hole of the sheave. Place the flat washer over the cupped washer with the chamfered side of the flat washer facing **OUTWARD** (away from the sheave). Install another **NEW** wavy washer onto the flat washer.

8- Install a **NEW** return spring between the sheave and the pawl retainer plate, and then position the plate over the pawls. Place the fiber washer over the pawl retainer plate.

9- Insert the sheave shaft into the pawl retainer plate. The large diameter of the shoulder on the sheave shaft **MUST** be flush against the pawl retainer plate. If the wavy washer is not centered beneath the pawl

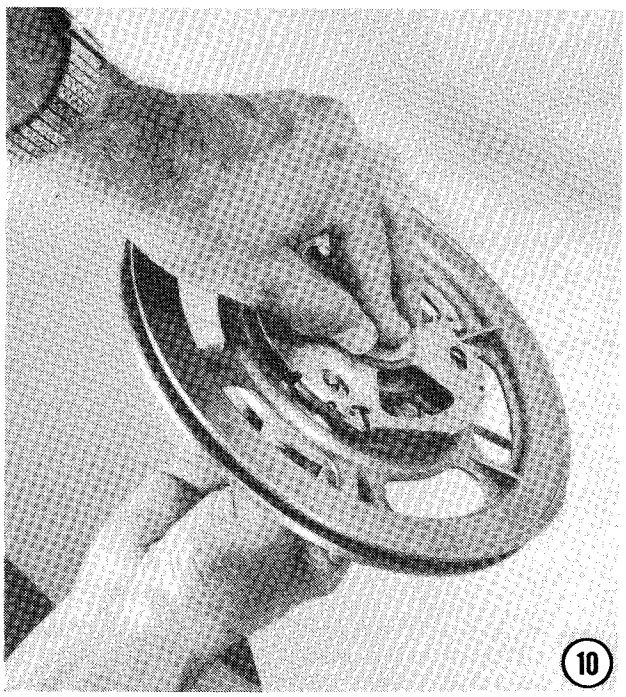




retainer plate, the sheave shaft will appear misaligned. To correct this condition, remove the shaft and the retainer plate, then center the wavy washer and again install the plate and shaft. Again, check the alignment of the sheave shaft.

10- Lift the sheave assembly off the work bench, grasp the threaded end of the sheave shaft and turn the assembly over. Place the unit on the work bench with the spring side **UPWARD.**

11- Slide the shaft bushing and the spring bushing over the sheave shaft.



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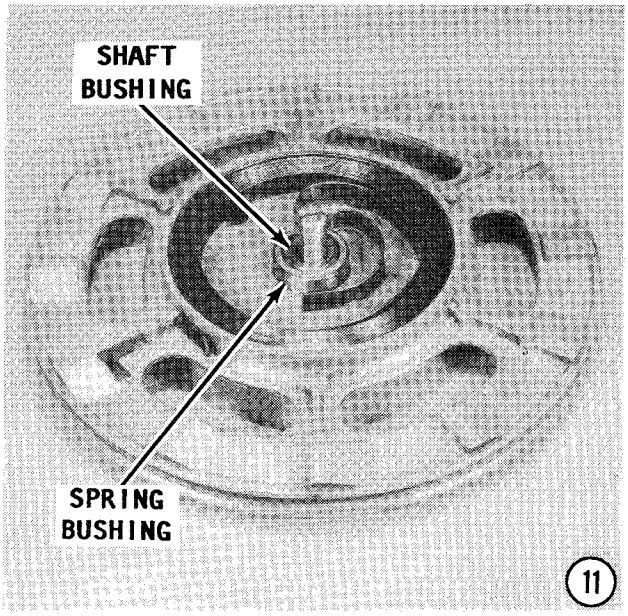
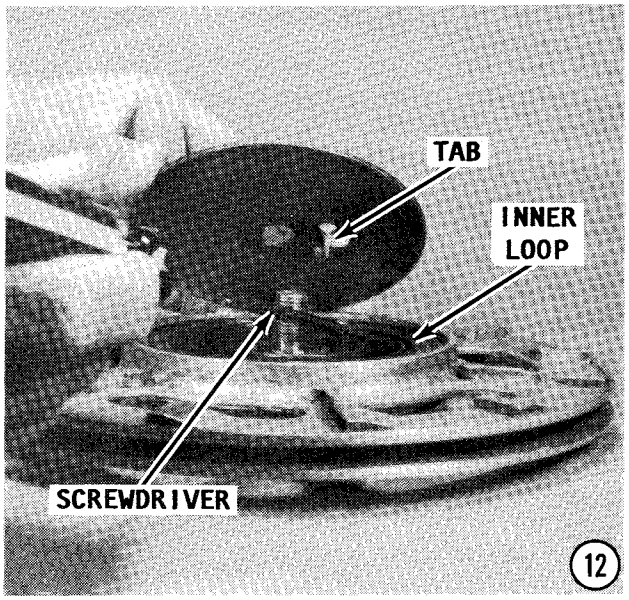
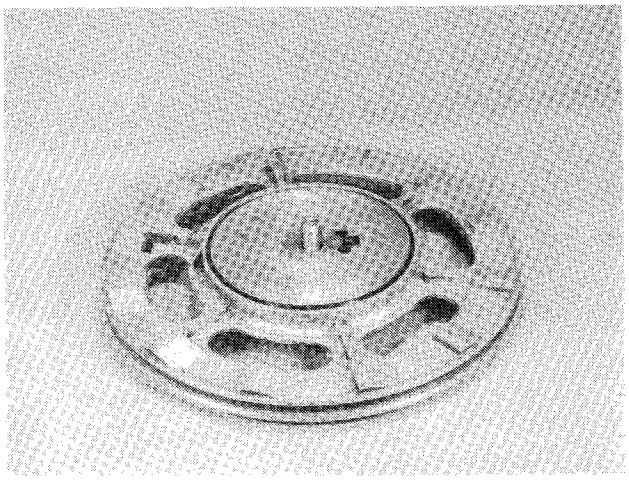






Assembly of the sheave, with the spring retainer plate installed, is now ready for installation into the rewind starter housing.

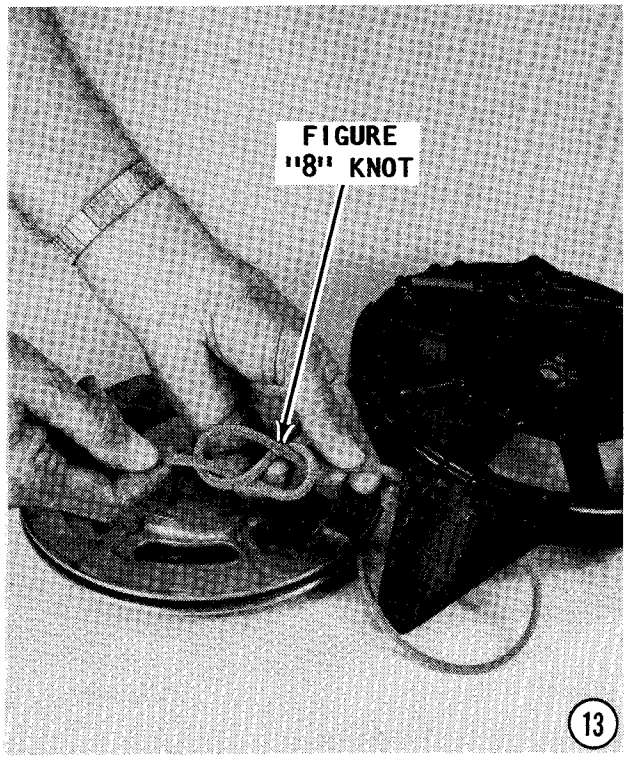
12- Lower the spring retainer plate over the shaft. Insert the tab on the plate with the inner loop of the rewind spring. It may be necessary to hook a thin long screwdriver into the loop as an assist to aligning the loop and the tab.

13- Feed the rope through the rope guide. Tie a figure "8" knot in the rope about 1 foot (30 cm) from the end. Place the sheave assembly into the rewind housing.

14- Support the sheave assembly with one hand. Slide a **NEW** tab washer over the threaded portion of the sheave shaft with the cupped side of the washer facing **DOWN.** Thread the left-hand sheave shaft retaining nut onto the shaft in a **LEFT-HAND (COUNTERCLOCKWISE)** direction until it is just **FINGER-TIGHT,** at this time.

ADJUSTING REWIND SPRING TENSION

15- Insert a large blade screwdriver into the slot of the sheave shaft. Hold the retaining nut with the proper size wrench and at the same time rotate the shaft with the screwdriver **COUNTERCLOCKWISE** until the figure "8" knot in the rope rests against the rope guide. Continue to rotate the shaft through **TWO** full turns after the knot is against the rope guide. The correct tension has now been placed on the rewind spring.



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16- Hold the tension on the spring with the screwdriver in the shaft slot and at the same time tighten the retaining nut securely. **REMEMBER** -- left-hand thread --tighten **COUNTERCLOCKWISE.**

GOOD WORDS

DO NOT bend the tabs on the washer up against the retaining nut until **AFTER** the rewind operation has been checked.

CHECK REWIND OPERATION

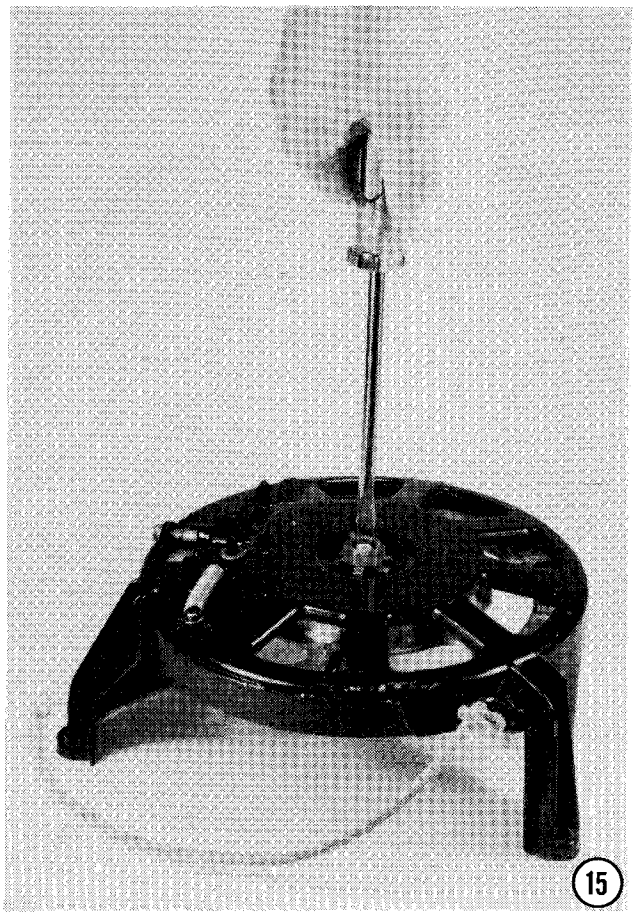
SLOWLY pull the starter rope outward. The pawls must move to the engaged position as the pawl retainer plate begins to turn. If the pawls fail to engage, check the alignment or replace the wavy washers between the pawls. Again, extend the rope to its full length and allow it to rewind. The rope should rewind smoothly without catching. **NEVER** release the rope from the fully extended position.

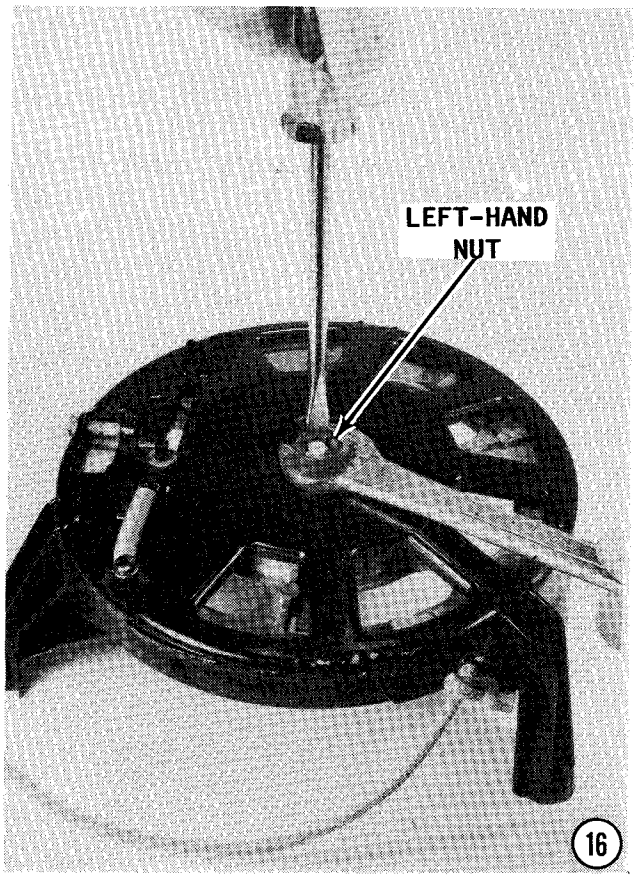
If the rewind mechanism catches, but fails to rewind, the sheave shaft and its wavy washer are not correctly aligned. The unit **MUST** be disassembled to correct the condition.

Once the rewind operation is satisfactory, proceed to the next step.

17- Bend two tabs of the tab washer up against the flats of the retaining nut. Use tabs opposite each other. Bend one other tab down into the recess of the rewind







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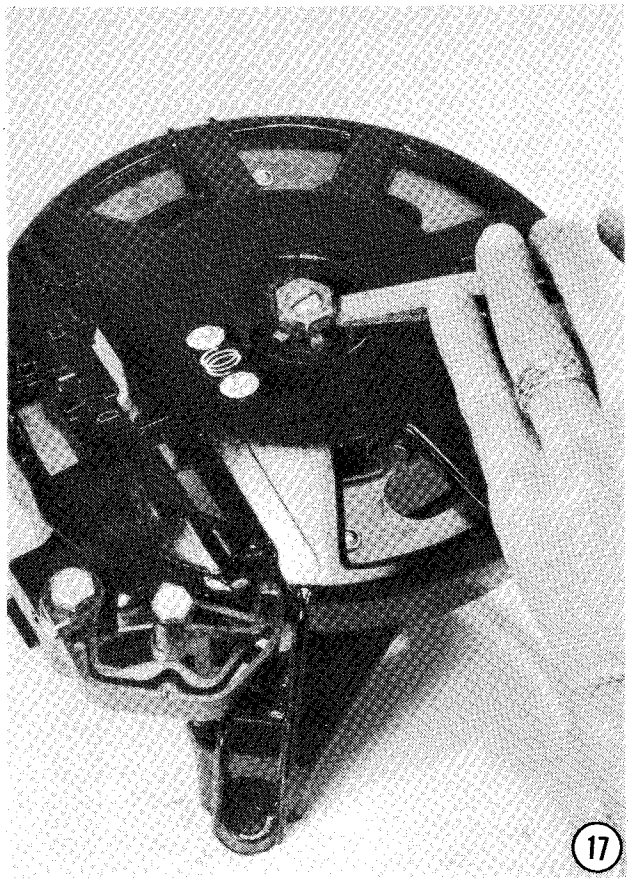
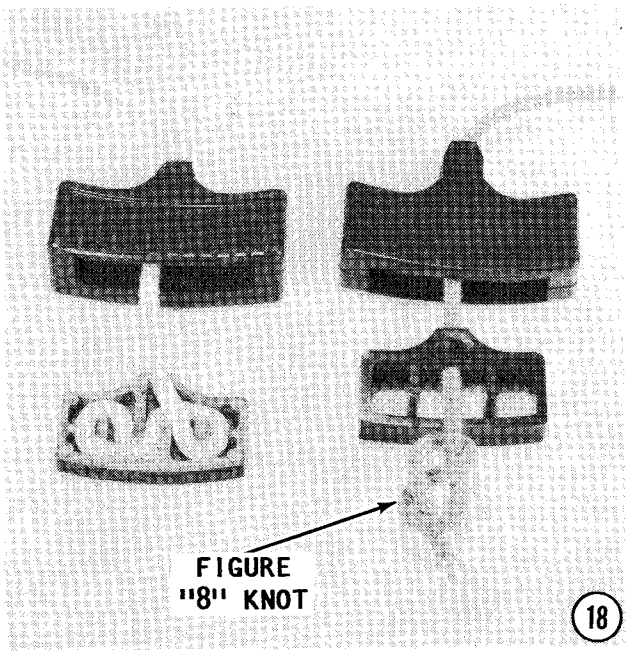
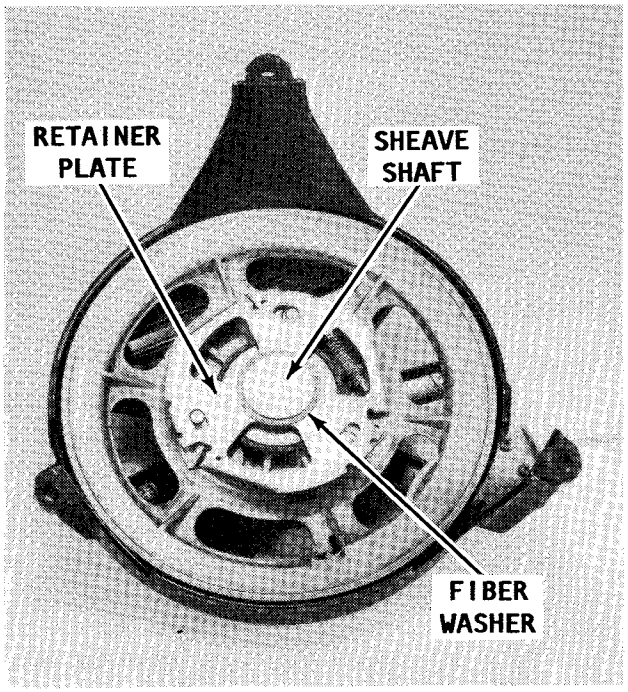


housing. Install the rewind starter onto the powerhead and secure the legs with the screws and lockwashers.

Attach the cable securing screw and the retainer clip, as shown in the accompanying illustration.

If the choke handle shaft passes through the top of the cowling, feed it through and





The sheave shaft must be flush with the retainer plate for correct alignment during installation.

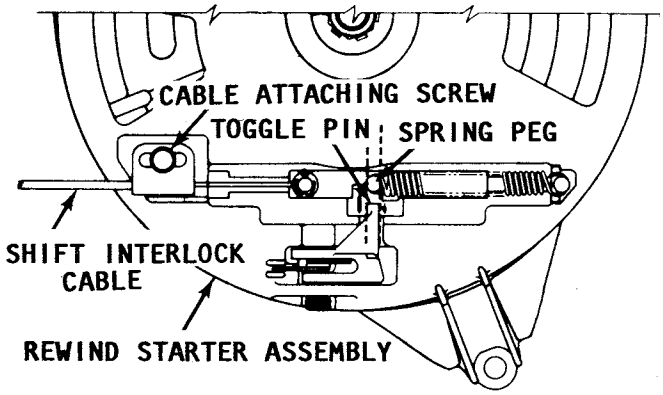
make the connection to the lower portion of the shaft with the cotter pin.

18- Feed the rope through the top cowling and install the rope retainer. Two styles of retainer are used on this model rewind starter. Secure the one handle with a figure "8" knot in the end of the rope, as shown.

SHIFT INTERLOCK ADJUSTMENT

Early Model Units

Secure the cable attaching screw, but **DO NOT** tighten it at this time. Final adjustment will be made later. Hook the end of the cable over the sliding cam and fasten it with the flat washer and cotter pin.



Detailed drawing of an early model rewind housing with the interlock cable installed on top.

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Shift the control handle into the **NEUTRAL** position and adjust the cable to position the toggle pin in line with the spring peg. Tighten the cable attaching screw to hold this position.

Shift the control handle into the **FORWARD** position and try to pull the handle outward. The attempt should fail.

Shift the control handle back into the **NEUTRAL** position and again pull on the handle. The rope should rewind normally.

Late Model Units

Secure the cable attaching screw to the side of the rewind housing, but **DO NOT** tighten it at this time. Hook the interlock cable over the peg on the interlock actuator with a flat washer and cotter pin. **BE SURE** the control handle is in the **NEUTRAL** position. Adjust the cable until the interlock actuator is positioned on the rise of the interlock cam. Tighten the cable attaching screw to hold this position.

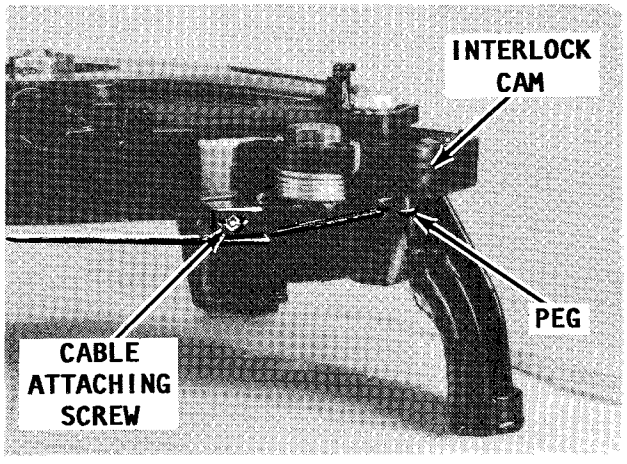
Shift the control handle into the **FORWARD** position and try to pull the handle outward. The attempt should fail.

Shift the handle back into the **NEUTRAL** position and again pull on the handle. The rope should rewind normally.

13-3 TYPE "B" REWIND HAND STARTER WITH SINGLE PAWL

FIRST, THESE WORDS

Be sure to read Section 13-1, and be convinced the starter being serviced is a Type **"B"** as identified from the photographs on Page 13-2.



Late model rewind starter with the interlock cable installed on the side of the housing.

PRELIMINARY TASKS

First, remove the wrap around cowling. Disconnect the high tension leads from the spark plugs. Next, remove the rope retainer (handle) from the rope. This is accomplished by simply pushing the inner portion through the outer shell of the handle. Untie the "stop" knot in the rope and allow the rewind spring to unwind within the recess of the sheave.

If the choke rod passes down through the top of the cowling, disconnect the upper portion of the shaft from the lower portion by pulling the cotter pin securing the two together. Pull the upper portion of the choke shaft up through the cowling.

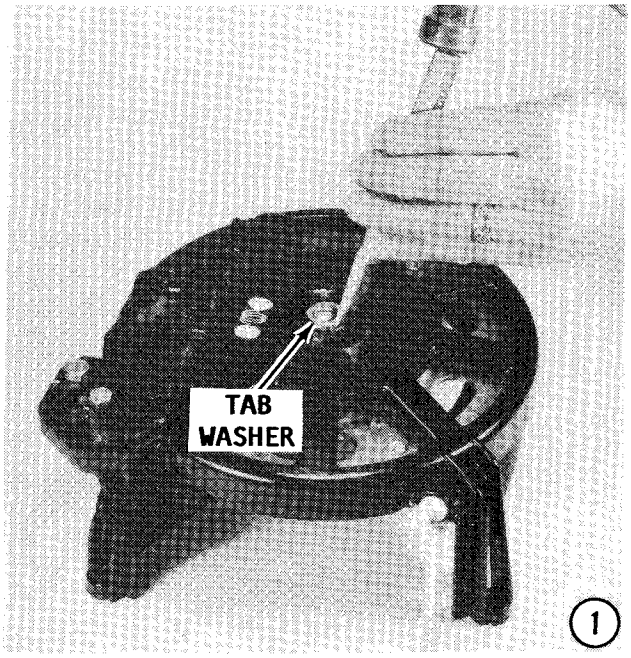
Remove the shift interlock actuator cable attaching screw and the retainer clip, as shown in the accompanying illustration.

Now, remove the cowling. Remove the screws securing the three legs of the hand rewind starter assembly to the powerhead.

The following steps pickup the work after these few preliminary tasks have been completed.

DISASSEMBLING

1- Place the hand starter on a suitable work surface. Pry out the one tab bent into the recess in the rewind housing. Use a hammer and flat punch to push aside the two tabs of the tab washer. This washer secures the sheave shaft retaining nut.



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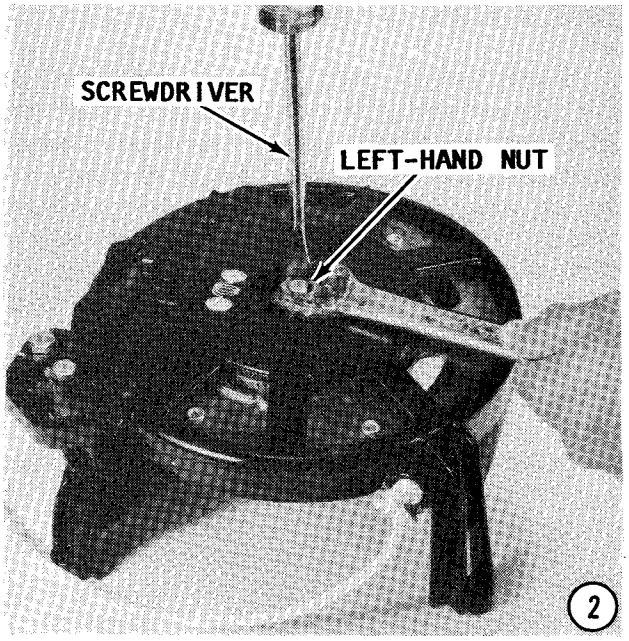


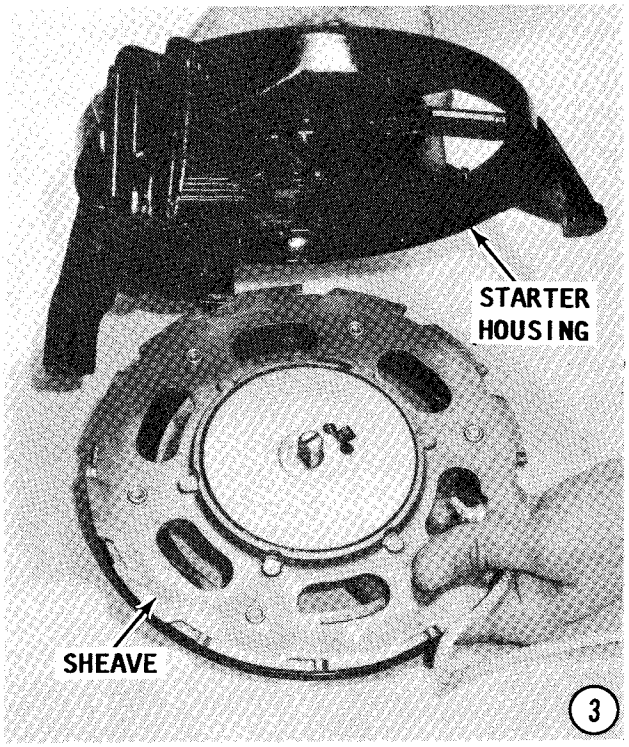
CRITICAL WORDS

The sheave shaft retaining nut has **LEFT-HAND** threads.

2- Remove the nut by rotating the nut **CLOCKWISE** because it has **LEFT-HAND** threads.

SAFETY WORDS

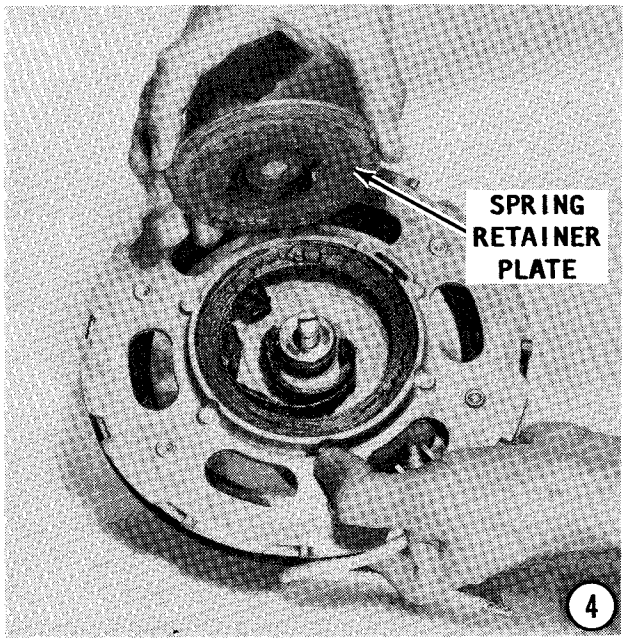
THE REWIND SPRING IS A POTENTIAL HAZARD. The spring is under tremendous tension when it is wound -- a real **"tiger"** in a cage! If the spring should accidentally be released, severe personal injury could result from being struck by the spring with force. Therefore, the following steps **MUST** be performed with care to prevent personal injury to self and others in the area.

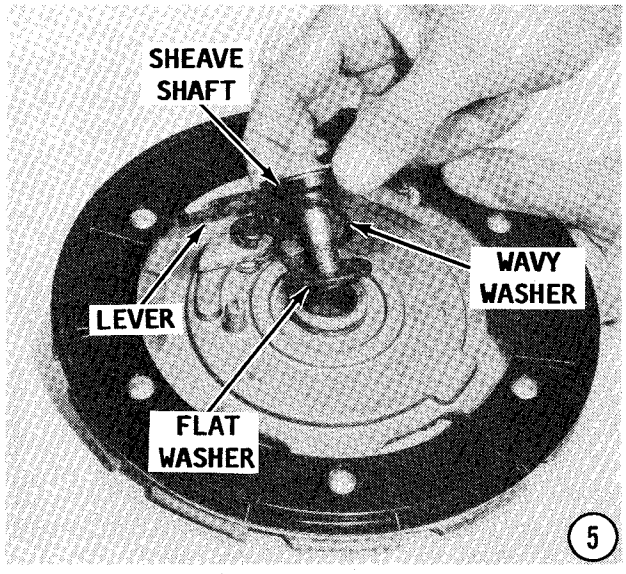


3- Carefully lift the starter housing from the sheave assembly so as not to disturb the rewind spring encased in the sheave. Place the sheave face down on a flat surface.

4- Lift off the spring retainer plate.

5- **CAREFULLY** turn the sheave over. Remove the sheave shaft, lever, wavy washer, and the flat washer from the sheave. **DISCARD** the wavy washer -- it cannot be used a second time. A new one must be obtained.





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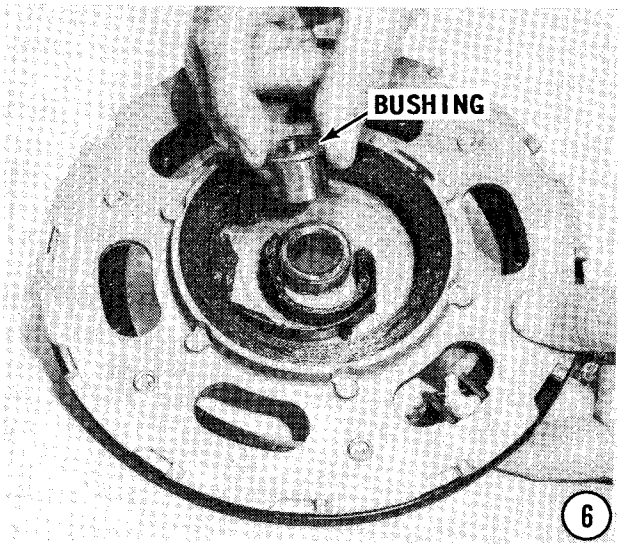


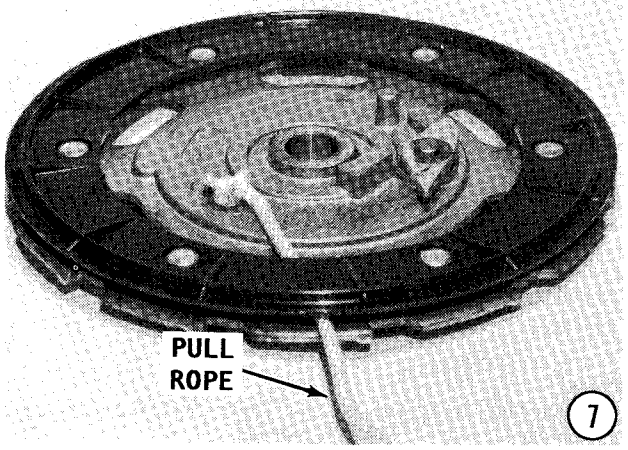
6- **CAREFULLY** turn the sheave over again. Remove the bushing from the sheave shaft opening.

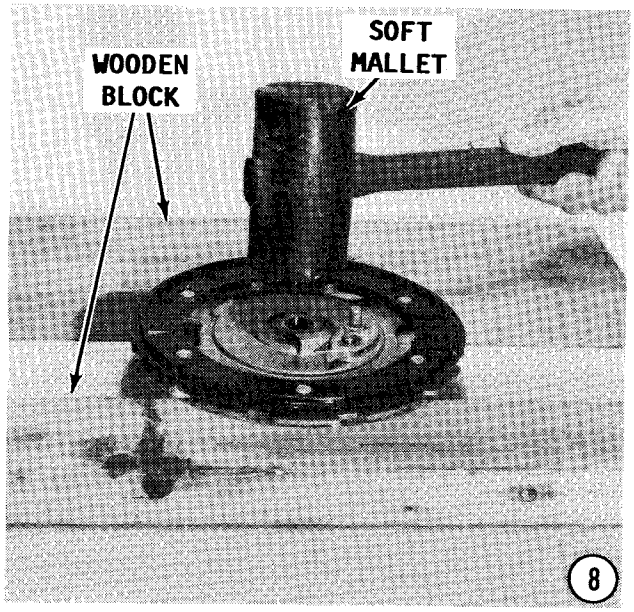
7- Turn the sheave over again. Untie the knot, and then remove the pull rope from the sheave.

8- Obtain two pieces of wood, a short 2" x 4" (5cm x 10cm) will work fine. Place the two pieces of wood approximately 8" (20 cm) apart on the floor. Center the sheave on top of the wood with the spring side facing **DOWN.** Check to be sure the wood is not touching the spring.

WARNING

THE REWIND SPRING IS A POTENTIAL HAZARD. The spring is under tremendous tension when it is wound -- a real tiger in a cage. If the spring should accidentally be released, severe personal injury could result from being struck by the spring with force. Therefore, the following step **MUST** be performed with care to prevent personal injury to self and others in the area.

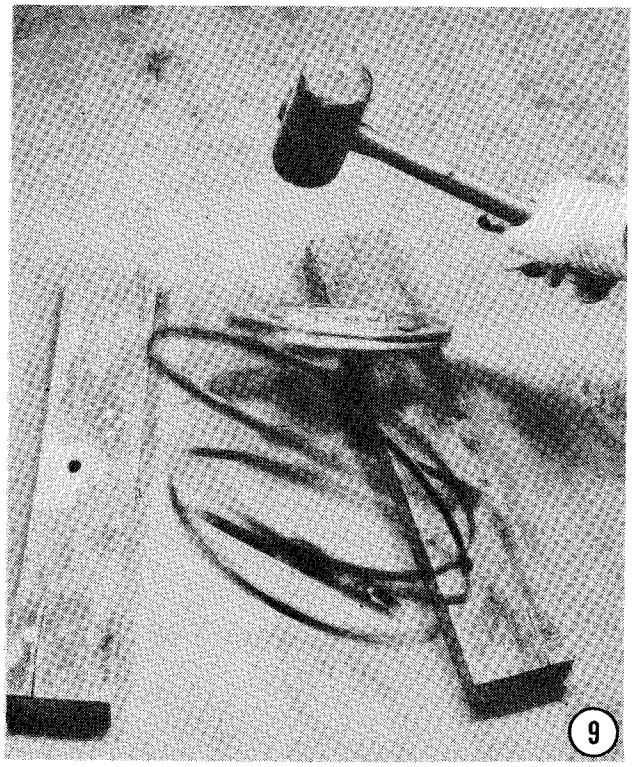




9- Stand behind the wood, keeping away from the openings as the spring unwinds with considerable force. Tap the sheave with a soft mallet. The spring retainer plate will drop down releasing the spring. The spring will fall and unwind almost instantly and with **FORCE.**

10- Snap the circlip out of the groove on the pawl post.

11- Slide the pawl up and free of the post. The spring may come free with the pawl or it may remain on the post. Observe and **REMEMBER,** how one end of the spring



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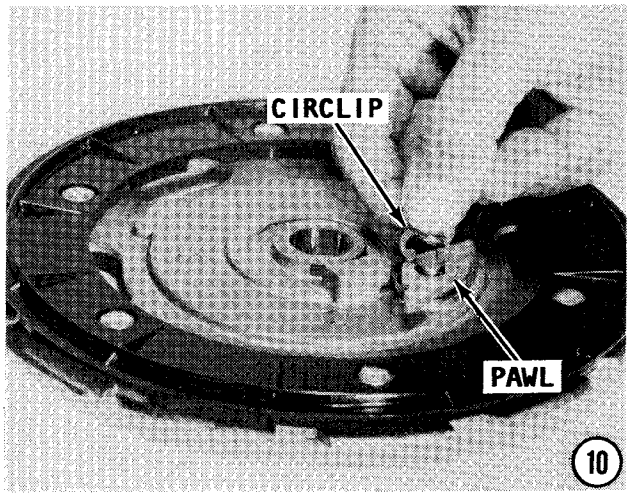


is snapped onto the pawl and the other end of the spring indexes into the recess of the sheave.

CLEANING AND INSPECTING

Wash all parts except the rope and the handle in solvent, and then blow them dry with compressed air.

Remove any trace of corrosion and wipe all metal parts with an oil dampened cloth.

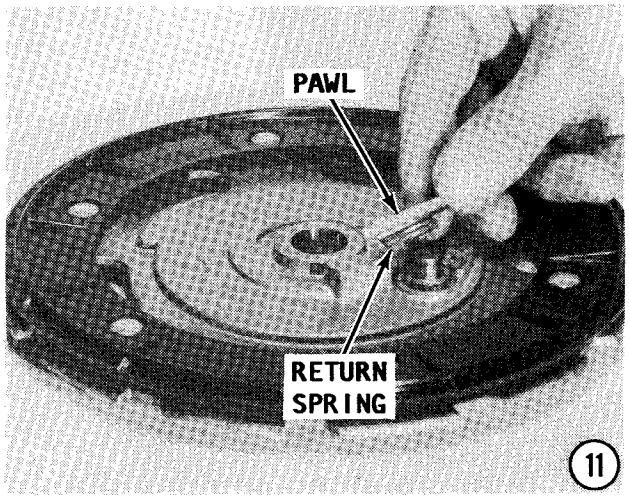
Inspect the rope. Replace the rope if it appears to be weak or frayed. If the rope is frayed, check the holes through which the rope passes for rough edges or burrs. Remove the rough edges or burrs with a file and polish the surface until it is smooth.

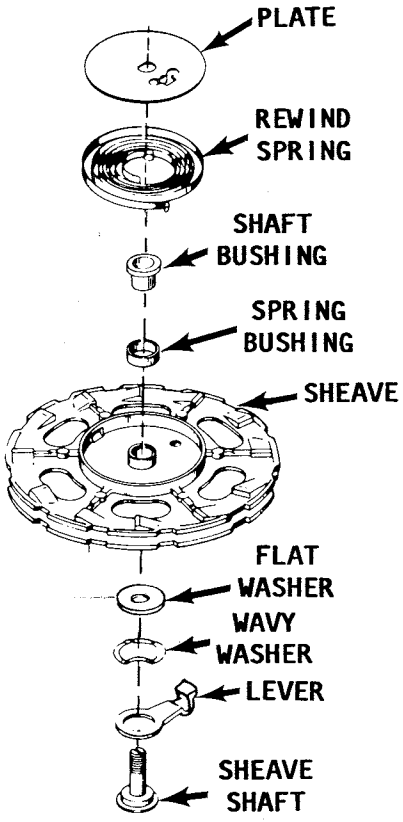
Inspect the starter spring end hooks. Replace the spring if it is weak, corroded or cracked. Inspect the tab on the spring retainer plate. This tab is inserted into the inner loop of the spring. Therefore, be sure it is straight and solid. Inspect the inside surface of the sheave rewind recess for grooves or roughness. Grooves may cause erratic rewinding of the starter rope.

Check the condition of the pawl pivot post for excessive wear. The post is a a part of the sheave casting. The post **CANNOT** be serviced. Therefore, if it is not acceptable, a new sheave **MUST** be purchased and installed.

Inspect the pawl for wear around the pivot holes and for rounded outer edges. Check the pawl retainer plate for wear, especially the center hole and the areas where the sides of the pawl contact the retainer plate.

Inspect the pawl retainer plate return spring (if equipped). The manufacturer recommends this spring be replaced each time the rewind starter is disassembled for service. A weak spring could allow the pawl to contact the flywheel while the powerhead is operating and cause a very unpleasant noise and even damage to the edge of the flywheel. A weak spring will also cause excessive wear to the pawl.





Exploded drawing of the Type "B" hand rewind starter, with major parts identified.

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ASSEMBLING AND INSTALLATION TYPE "B" REWIND STARTER

SAFETY WORDS

Wear a good pair of gloves while winding and installing the spring. The spring will develop tension and the edges of the spring steel are extremely sharp. The gloves will prevent cuts to the hands and fingers.

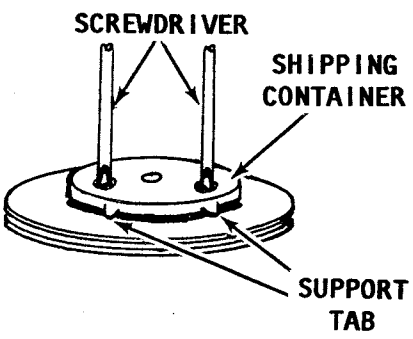
It is **STRONGLY** recommended a pair of safety goggles or a face shield be worn while the spring is being installed. As the work progresses a "tiger" is being forced into a cage, over 14' (4.3 m) of spring steel wound into about 4" (10.2cm) circumference. If the spring is accidentally released, it will lash out with tremendous ferocity and very likely could cause personal injury to the installer or other persons nearby.

SPECIAL WORDS

The rewind starter may be assembled with a new rewind spring or a used one. Procedures for assembling are **NOT** the same because the new spring will arrive in a shipping container already wound, lubricated, and ready for installation. The used spring must be manually wound into its recess.

NEW REWIND SPRING INSTALLATION

The situation may arise when it is only necessary to replace a broken spring. The following few procedures outline the tasks required to replace the spring. A new spring is already properly wound and will arrive in a special shipping container. This container is designed to be used as an aid to installing the new spring.



A new rewind spring is installed into the sheave using the shipping container as a helpful tool. Two screwdrivers are used to tap the coiled spring out of the container and into the sheave.

a- Remove the retainers from the shipping container used to keep the spring from accidentally falling out of the container. Place the shipping container over the spring recess with the tabs resting on the outer edge of the recess.

b- Align the hook on the outer end of the spring with the sheave anchor or notch.

c- Place two large blade screwdrivers into the holes of the shipping container over the tensioned spring. Push on both screwdrivers at the same time to press the spring out of the shipping container and into the spring recess of the sheave.

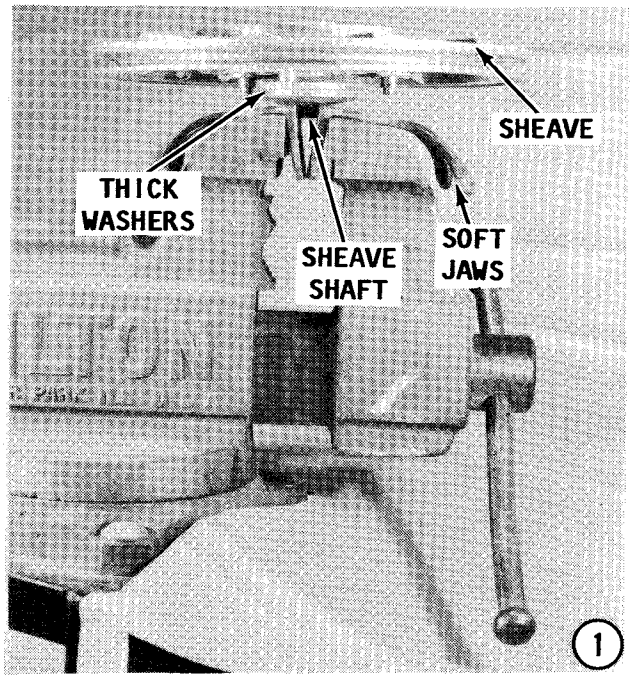
USED REWIND SPRING INSTALLATION

A used spring naturally will not be wound. Therefore, special instructions are necessary for installation.

SAFETY WORDS

Wear a good pair of gloves while winding and installing the spring. The spring will develop tension and the edges of the spring steel are extremely sharp. The gloves will prevent cuts to the hands and fingers.

1- Insert the sheave shaft through the sheave with the spring recess facing **UPWARD.** Obtain two large washers and place them over the sheave shaft. Hold the washers in place and at the same time clamp the sheave shaft in a vise equipped with soft jaws. Shift the shaft in the vise to



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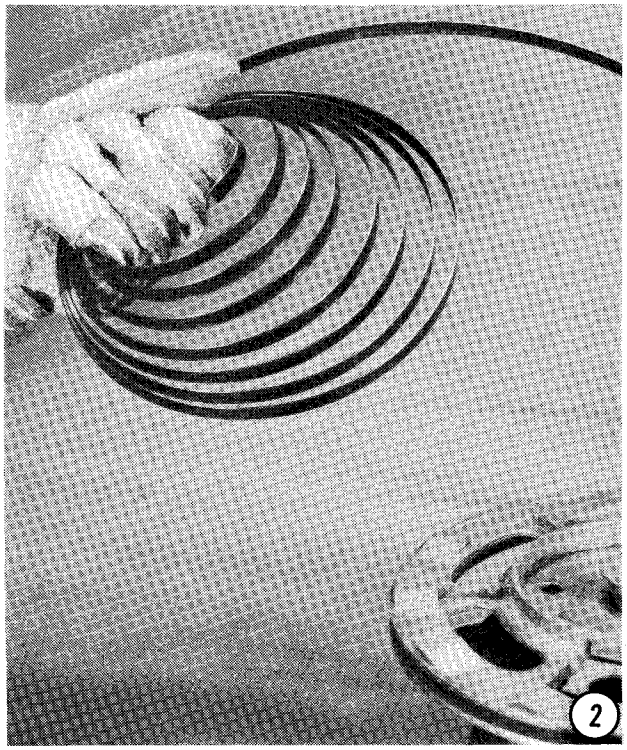
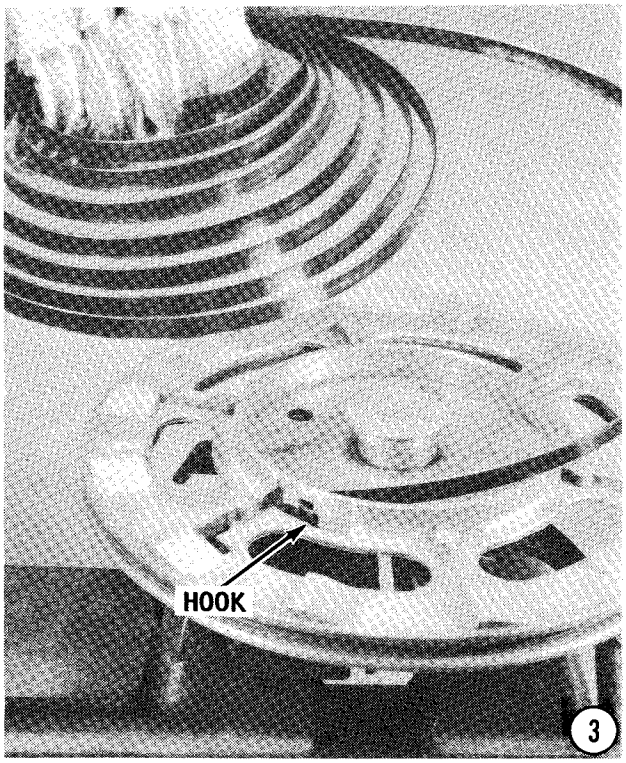
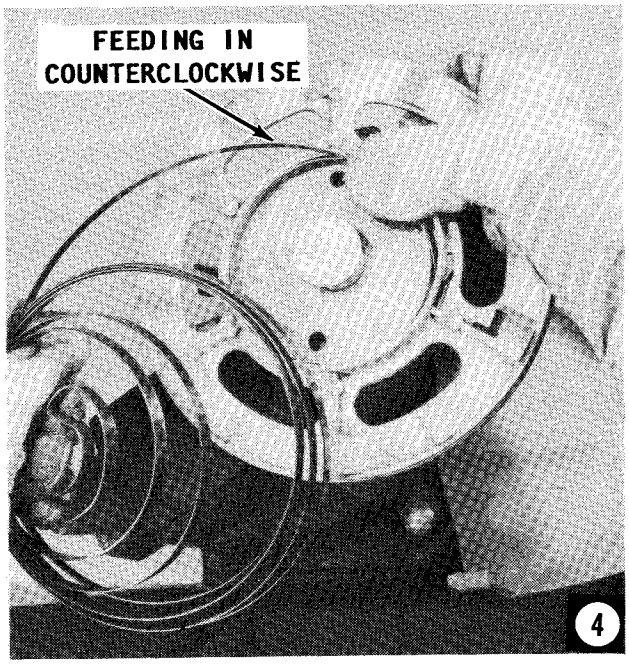


allow for "up and down" clearance and permit the shaft to rotate freely while the rewind spring is being installed.

SAFETY WORDS

It is **STRONGLY** recommended a pair of safety goggles or a face shield be worn while the spring is being installed. As the work progresses a "tiger" is being forced





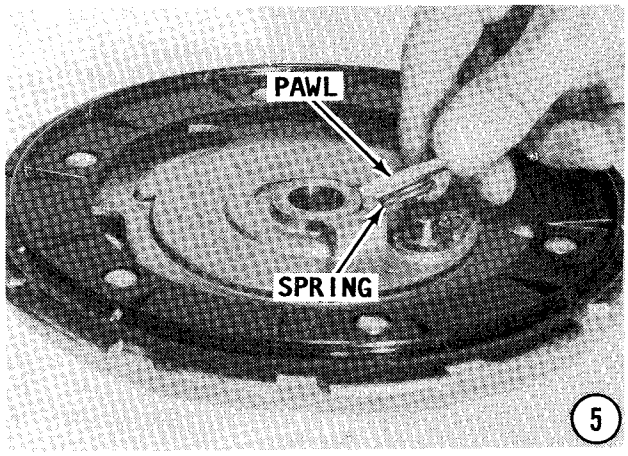
into a cage. If the spring is accidentally released, it will lash out with tremendous ferocity and very likely could cause personal injury to the installer or other persons nearby.

2- Loop the spring loosely into a coil to enable it to be fed into its recess.

3- Insert the hook on the end of the spring into the notch of the recess.

4- Feed the spring around the inner edge of the recess and at the same time rotate the sheave **CLOCKWISE.** Proceed **WITH GREAT CARE.** Guide the spring into place. The spring will be slippery with lubrication. **DO NOT** lose control of the spring. Carefully remove the sheave from the vise and the sheave shaft and washers from the sheave.

5- Coat the pawl post with a small amount of Multi-Purpose lubricant. Place the spring in position on the underside of the



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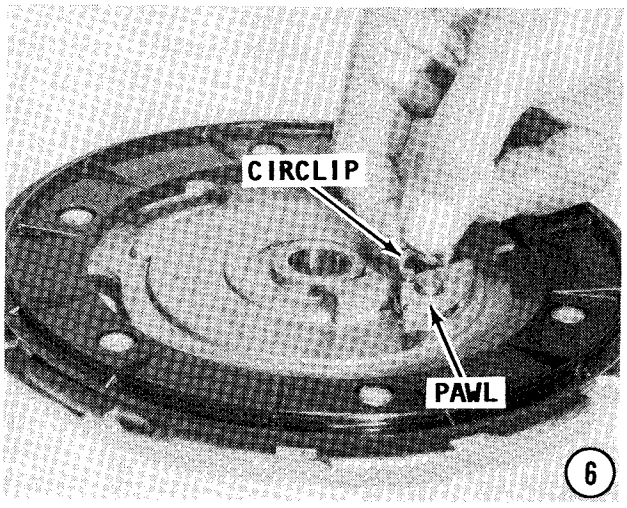


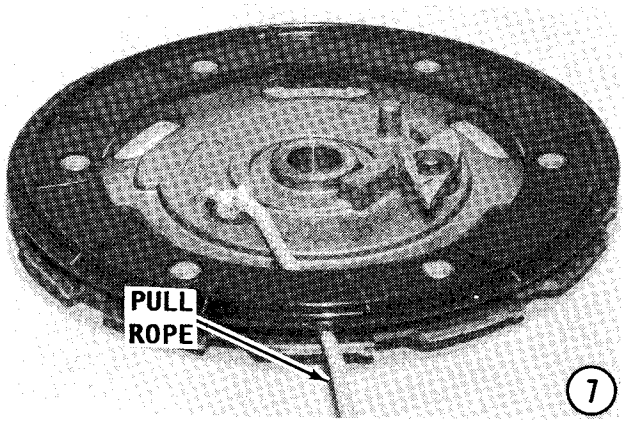
pawl with the hook of the spring over the side of the pawl. Slide the pawl and spring onto the pawl post with the other end of the spring indexed into the spring recess in the sheave.

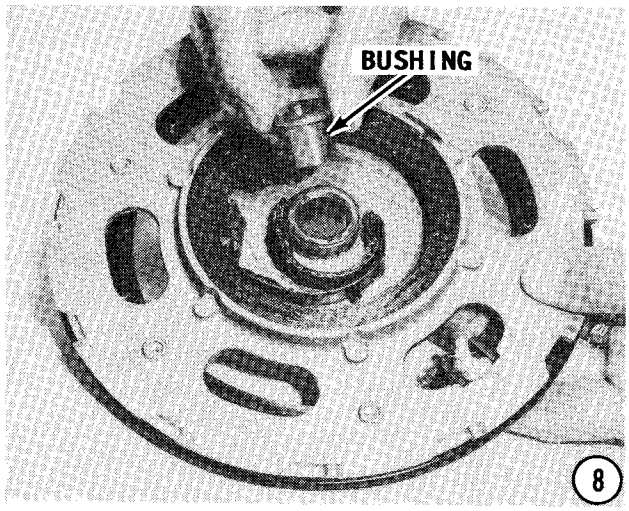
6- Check to be sure the sheave is in the proper position, as shown. Snap the circlip onto the post and into the groove to secure the sheave and spring in place.

7- Feed a new rope through the hole in the sheave. Tie a figure "8" knot near the rope end. Pull the rope back against the knot, and then wrap it around the sheave **CLOCKWISE.**

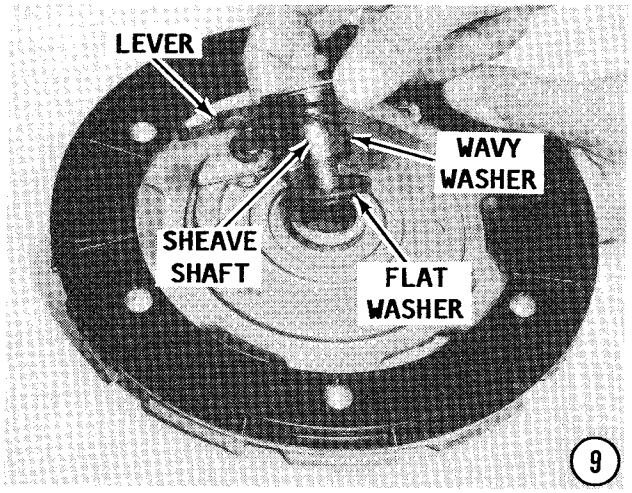
8- Lubricate the bushing with Multi-Purpose lubricant. Insert the bushing into the center of the sheave.

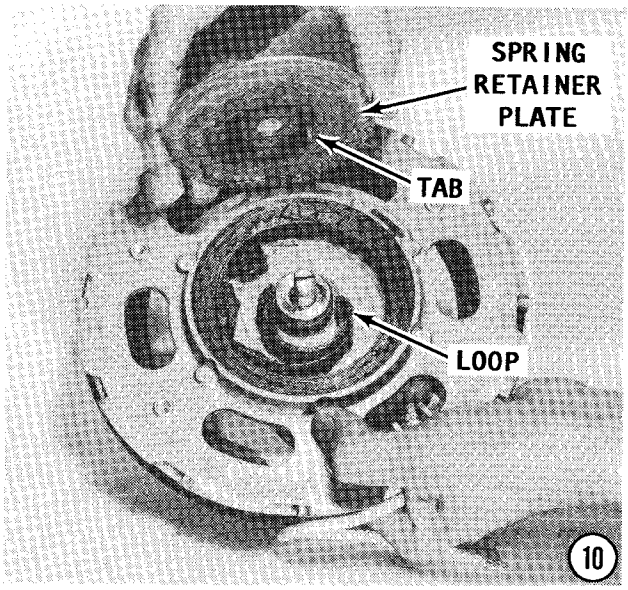
9- Turn the sheave over -- with the pawl side facing up. Slide the lever onto the sheave shaft, then a **NEW** wavy washer and finally a flat washer. Hold the pieces on the shaft and slide the shaft down through the bushing. The large diameter of the shoulder on the sheave shaft **MUST** be flush against the sheave. Hold the shaft in place and turn the sheave over for the next step.





10- Place the spring retainer plate over the shaft and down into the sheave cavity on top of the spring. The tab on the plate must index into the loop on the end of the spring. If necessary, a small screwdriver may be used to help index the tab into the loop.





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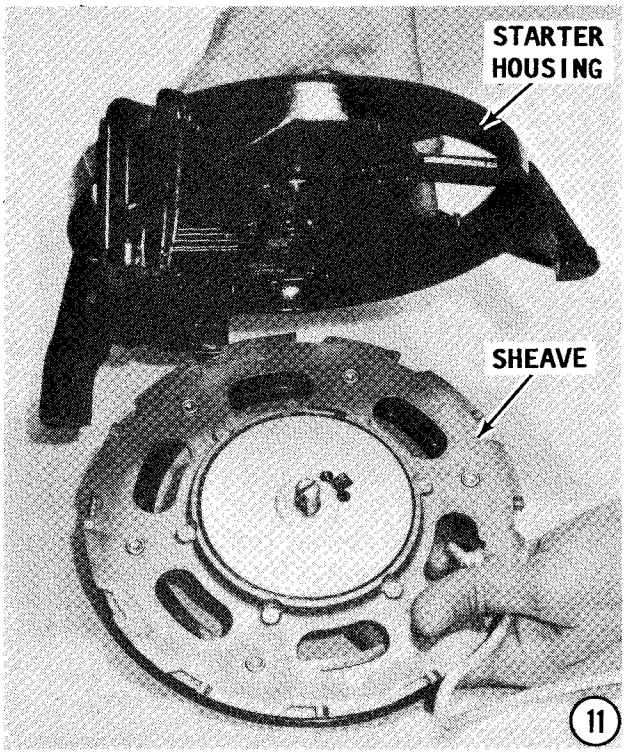


11- Hold the starter housing with one hand. With the other hand, hold the sheave assembly together, then lift the assembly up and into the housing with the sheave shaft indexed through the hole in the starter housing. Feed the rope through the rope guide. Tie a figure "8" knot in the rope about 1' (30cm) from the end. Place the sheave assembly into the rewind housing.

12- Support the sheave assembly with one hand. Slide a **NEW** tab washer over the threaded portion of the sheave shaft with the cupped side of the washer facing **DOWN.** Thread the left-hand sheave shaft retaining nut onto the shaft in a **LEFT-HAND (COUNTERCLOCKWISE)** direction until it is just **FINGER-TIGHT,** at this time.



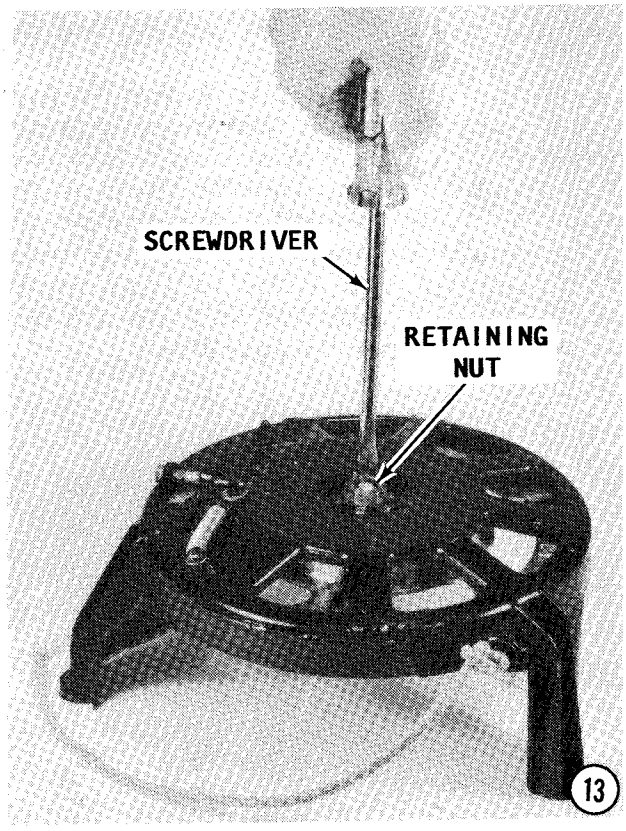
ADJUSTING REWIND SPRING TENSION

13- Insert a large blade screwdriver into the slot of the sheave shaft. Hold the retaining nut with the proper size wrench and at the same time rotate the shaft with the screwdriver **COUNTERCLOCKWISE** until the figure "8" knot in the rope rests against the rope guide. Continue to rotate the shaft through **TWO** full turns after the knot is against the rope guide. The correct tension has now been placed on the rewind spring.

14- Hold the tension on the spring with the screwdriver in the shaft slot and at the same time tighten the retaining nut securely. **REMEMBER** -- left-hand thread -- tighten **COUNTERCLOCKWISE.**

GOOD WORDS

DO NOT bend the tabs on the washer up against the retaining nut until **AFTER** the rewind operation has been checked.



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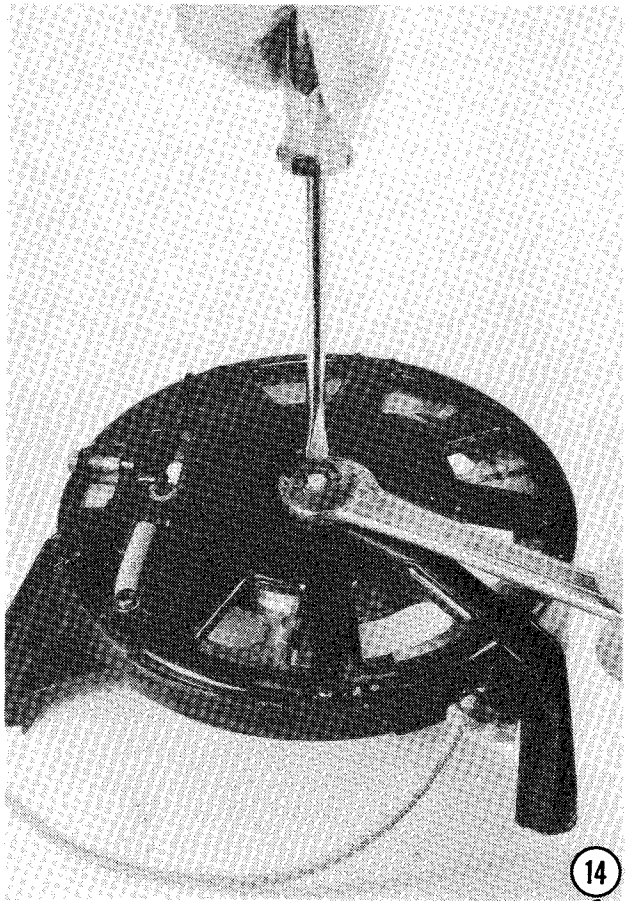
CHECK REWIND OPERATION

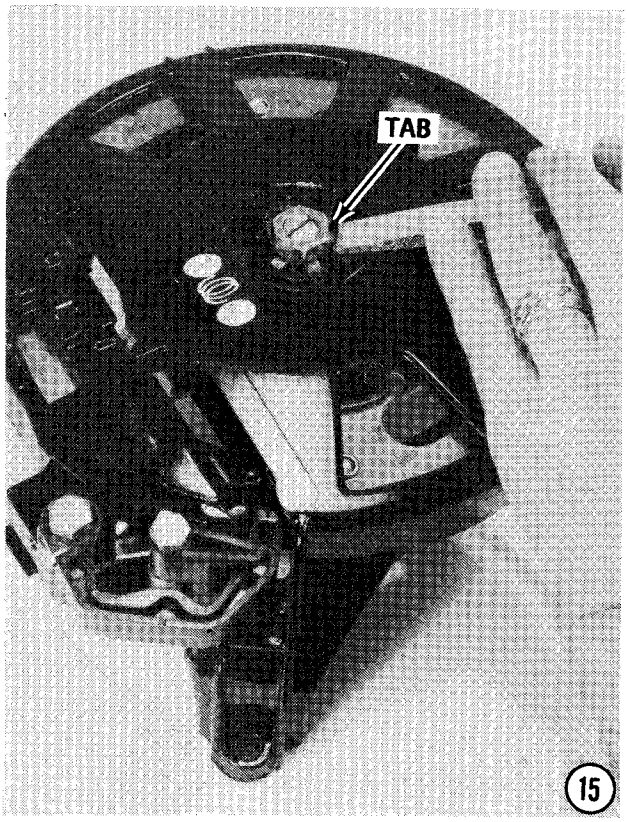
SLOWLY pull the starter rope outward. The pawls must move to the engaged position as the pawl retainer plate begins to turn. If the pawls fail to engage, check the alignment or replace the wavy washers between the pawls. Again, extend the rope to its full length and allow it to rewind. The rope should rewind smoothly without catching. **NEVER** release the rope from the fully extended position.

If the rewind mechanism catches, but fails to rewind, the sheave shaft and its wavy washer are not correctly aligned. The unit **MUST** be disassembled to correct the condition.

Once the rewind operation is satisfactory, proceed to the next step.

15- Bend two tabs of the tab washer up against the flats of the retaining nut. Use tabs opposite each other. Bend one other tab down into the recess of the rewind housing. Install the rewind starter onto the powerhead and secure the legs with the screws and lockwashers.

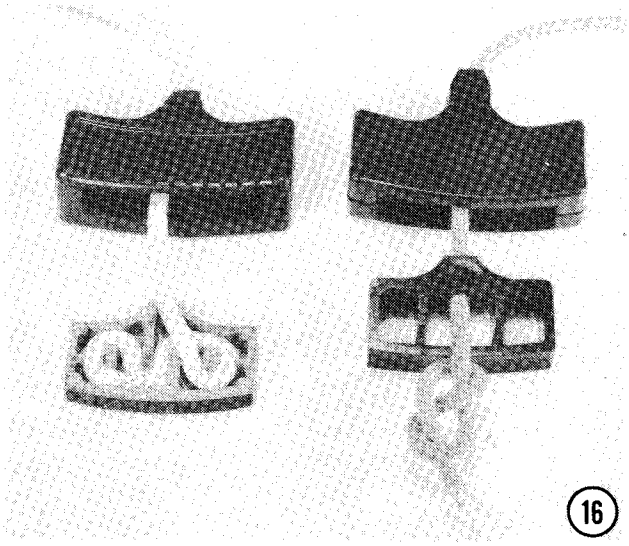




Attach the shift interlock actuator cable securing screw and the retainer clip, as shown in the accompanying illustration.

If the choke handle shaft passes through the top of the cowl, feed it through and make the connection to the lower portion of the shaft with the cotter pin.

16- Feed the rope through the top cowl and install the rope retainer. Two styles of retainer are used on this model rewind starter. Secure the one handle with a figure "8" knot in the end of the rope, as shown.



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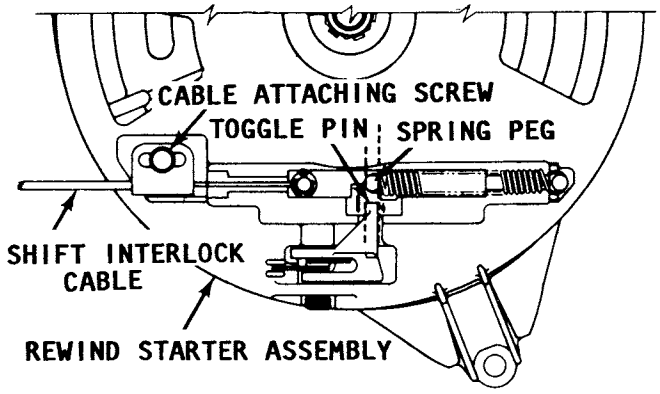
SHIFT INTERLOCK ADJUSTMENT

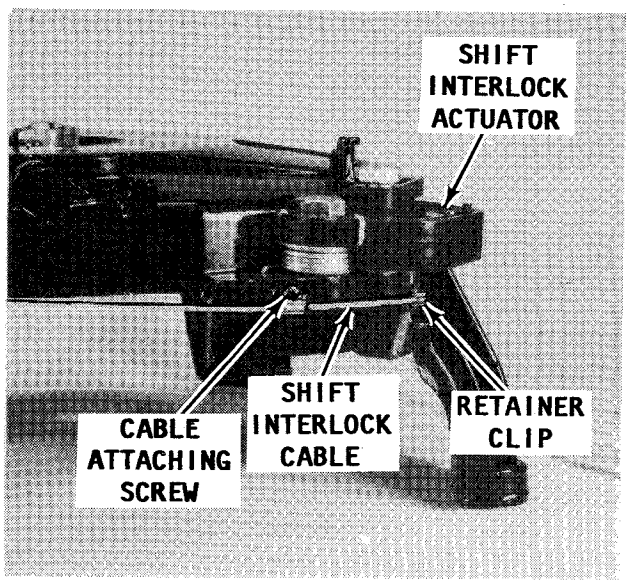
Secure the cable attaching screw to the side of the rewind housing, but **DO NOT** tighten it at this time. Hook the interlock cable over the peg on the interlock actuator with a flat washer and cotter pin. **BE SURE** the control handle is in the **NEUTRAL** position. Adjust the cable until the interlock actuator is positioned on the rise of the interlock cam. Tighten the cable attaching screw to hold this position.



Detailed drawing of an early model rewind housing with the interlock cable installed on top.

Shift the control handle into the **FORWARD** position and try to pull the handle outward. The attempt should fail.

Shift the handle back into the **NEUTRAL** position and again pull on the handle. The rope should rewind normally.



Later model rewind starters are equipped with a shift interlock cable mounted on the side of the starter housing. Early models have the cable mounted on the top of the housing. The interlock cable of both models is secured in the same manner.

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APPENDIX

METRIC CONVERSION CHART

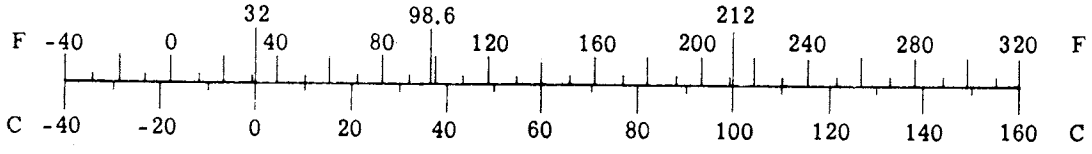
LINEAR		
inches	X 25.4	= millimetres (mm)
feet	X 0.3048	= metres (m)
yards	X 0.9144	= metres (m)
miles	X 1.6093	= kilometres (km)
inches	X 2.54	= centimetres (cm)
AREA		
$inches^2$	X 645.16	= $millimetres^2$ (mm^2)
$inches^2$	X 6.452	= $centimetres^2$ (cm^2)
$feet^2$	X 0.0929	= $metres^2$ (m^2)
$yards^2$	X 0.8361	= $metres^2$ (m^2)
acres	X 0.4047	= hectares (10^4 m^2) (ha)
$miles^2$	X 2.590	= $kilometres^2$ (km^2)
VOLUME		
$inches^3$	X 16387	= $millimetres^3$ (mm^3)
$inches^3$	X 16.387	= $centimetres^3$ (cm^3)
$inches^3$	X 0.01639	= litres (l)
quarts	X 0.94635	= litres (l)
gallons	X 3.7854	= litres (l)
$feet^3$	X 28.317	= litres (l)
$feet^3$	X 0.02832	= $metres^3$ (m^3)
fluid oz	X 29.60	= millilitres (ml)
$yards^3$	X 0.7646	= $metres^3$ (m^3)
MASS		
ounces (av)	X 28.35	= grams (g)
pounds (av)	X 0.4536	= kilograms (kg)
tons (2000 lb)	X 907.18	= kilograms (kg)
tons (2000 lb)	X 0.90718	= metric tons (t)
FORCE		
ounces - f (av)	X 0.278	= newtons (N)
pounds - f (av)	X 4.448	= newtons (N)
kilograms - f	X 9.807	= newtons (N)
ACCELERATION		
$feet/sec^2$	X 0.3048	= $metres/sec^2$ (m/S^2)
$inches/sec^2$	X 0.0254	= $metres/sec^2$ (m/s^2)

ENERGY OR WORK (watt-second - joule - newton-metre)		
foot-pounds	X 1.3558	= joules (j)
calories	X 4.187	= joules (j)
Btu	X 1055	= joules (j)
watt-hours	X 3500	= joules (j)
kilowatt - hrs	X 3.600	= megajoules (MJ)
FUEL ECONOMY AND FUEL CONSUMPTION		
miles/gal	X 0.42514	= kilometres/litre (km/l)

Note:
235.2/(mi/gal) = litres/100km
235.2/(litres/100 km) = mi/gal

LIGHT		
footcandles	X 10.76	= $lumens/metre^2$ (lm/m^2)
PRESSURE OR STRESS (newton/sq metre - pascal)		
inches HG (60 F)	X 3.377	= kilopascals (kPa)
pounds/sq in	X 6.895	= kilopascals (kPa)
inches H_2O (60 F)	X 0.2488	= kilopascals (kPa)
bars	X 100	= kilopascals (kPa)
pounds/sq ft	X 47.88	= pascals (Pa)
POWER		
horsepower	X 0.746	= kilowatts (kW)
ft-lbf/min	X 0.0226	= watts (W)
TORQUE		
pound-inches	X 0.11299	= newton-metres (N·m)
pound-feet	X 1.3558	= newton-metres (N·m)
VELOCITY		
miles/hour	X 1.6093	= kilometres/hour (km/h)
feet/sec	X 0.3048	= metres/sec (m/s)
kilometres/hr	X 0.27778	= metres/sec (m/s)
miles/hour	X 0.4470	= metres/sec (m/s)

TEMPERATURE



Celsius = 0.556 (°F -32) F = (1.8°C) +32

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ENGINE SPECIFICATIONS AND

NOTE: See Appendix Pages A-8 and A-9 for special notes called out in this table.

MODEL	CYL	CU IN DISPL.	CU CM DISPL.	BORE INCHES	STROKE INCHES	SPARK PLUG CHAMP	SPARK PLUG NGK
				1977			
85	4	66.6	1091	2.875	2.563	L78V	BUHW-2
				1978			
80	4	66.6	1091	2.875	2.563	L78V	BUHW-2
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
140	L6	99.8	1635	2.875	2.563	L76V	BUHW
				1979			
80	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
140	L6	99.8	1635	2.875	2.563	L76V	BUHW
175	V6	121.9	1998	3.125	2.625	L76V	BUHW
				1980			
70	3	49.8	816	2.875	2.563	L78V	BUHW-2
80	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
140	L6	99.8	1635	2.875	2.563	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
175	V6	121.9	1998	3.125	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
				1981			
70	3	49.8	816	2.875	2.563	L78V	BUHW-2
80	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
				1982			
50	4	43.8	718	2.565	2.125	L78V	BUHW-2
70	3	49.8	816	2.875	2.563	L78V	BUHW-2
80	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW

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TUNE-UP ADJUSTMENTS

NOTE: See Appendix Pages A-8 and A-9 for special notes called out in this table.

CARB TYPE	PRIMARY PICKUP TIMING	MAXIMUM SPARK ADV CRANKING RPM	MAXIMUM SPARK ADV AT WOT	IDLE RPM	OPERATING RANGE RPM	FIRING ORDER
			1977			
B	2°BTDC-2°ATDC	--	27°BTDC	600	4800-5500	1-3-2-4
			1978			
B	Note 1	30°BTDC	27°BTDC	600	5000-5500	1-3-2-4
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
D	5°BTDC	Note 3	Note 3	600	5300-5800	1-4-5-2-3-6
			1979			
B	Note 4	30°BTDC	27°BTDC	600	5000-5800	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
D	5°BTDC	Note 3	Note 3	600	5300-5800	1-4-5-2-3-6
E	Note 6	20°BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
			1980			
B	--	27°BTDC	23°BTDC	700	5300-5800	Note 7
B	Note 4	30°BTDC	27°BTDC	600	5000-5800	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
D	5°BTDC	Note 3	Note 3	600	5300-5800	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 6	20BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
			1981			
B	--	27°BTDC	23°BTDC	700	5300-5800	Note 7
B	Note 4	30°BTDC	27°BTDC	600	5000-5800	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
			1982			
A	TDC	33°BTDC	30°BTDC	600	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	Note 7
B	Note 4	30°BTDC	27°BTDC	600	5000-5800	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6

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ENGINE SPECIFICATIONS AND

NOTE: See Appendix Pages A-8 and A-9 for special notes called out in this table.

MODEL	CYL	CU IN DISPL.	CU CM DISPL.	BORE INCHES	STROKE INCHES	SPARK PLUG CHAMP	SPARK PLUG NGK
				1983			
50	4	43.8	718	2.565	2.125	L78V	BUHW-2
70	3	49.8	816	2.875	2.563	L78V	BUHW-2
80	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
				1984			
50	4	43.8	718	2.565	2.125	L78V	BUHW-2
60	3	49.8	816	2.875	2.563	L78V	BUHW-2
75	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
				1985			
50	4	43.8	718	2.565	2.125	L78V	BUHW-2
60	3	49.8	816	2.875	2.563	L78V	BUHW-2
75	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
150 (Magnum)	V6	121.9	1998	3.125	2.625	L76V	BUHW
175	V6	142.2	2330	3.375	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
				1986			
45	4	43.8	718	2.565	2.125	L78V	BUHW-2
50	3	49.8	816	2.875	2.563	L78V	BUHW-2
60	3	49.8	816	2.875	2.563	L78V	BUHW-2
75	4	66.6	1091	2.875	2.563	L78V	BUHW-2
90	L6	99.8	1635	2.875	2.563	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
135	V6	121.9	1998	3.125	2.625	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
150 (Magnum)	V6	121.9	1998	3.125	2.625	L76V	BUHW
175	V6	142.2	2330	3.375	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW

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TUNE-UP ADJUSTMENTS

NOTE: See Appendix Pages A-8 and A-9 for special notes called out in this table.

CARB TYPE	PRIMARY PICKUP TIMING	MAXIMUM SPARK ADV CRANKING RPM	MAXIMUM SPARK ADV AT WOT	IDLE RPM	OPERATING RANGE RPM	FIRING ORDER
			1983			
A	TDC	33°BTDC	30°BTDC	600	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	Note 7
B	Note 4	30°BTDC	27°BTDC	600	5000-5800	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
			1984			
A	TDC	33°BTDC	30°BTDC	600	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	Note 10	30°BTDC	27°BTDC	600	5000-5500	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
			1985			
A	TDC	33°BTDC	30°BTDC	600	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	Note 10	30°BTDC	27°BTDC	600	5000-5500	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 11	22°BTDC	Note 11	650	5300-5800	1-2-3-4-5-6
E	Note 6	20°BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
			1986			
A	Note 12	--	30°BTDC	650	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	Note 10	30°BTDC	27°BTDC	600	5000-5500	1-3-2-4
D	Note 5	Note 5	Note 5	600	4500-5500	1-4-5-2-3-6
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 11	22°BTDC	Note 11	650	5300-5800	1-2-3-4-5-6
E	Note 6	20°BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6

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ENGINE SPECIFICATIONS AND

NOTE: See Appendix Pages A-8 and A-9 for special notes called out in this table.

MODEL	CYL	CU IN DISPL.	CU CM DISPL.	BORE INCHES	STROKE INCHES	SPARK PLUG CHAMP	SPARK PLUG NGK
				1987			
45	4	43.8	718	2.565	2.125	L78V	BUHW-2
50	3	49.8	816	2.875	2.563	L78V	BUHW-2
60	3	49.8	816	2.875	2.563	L78V	BUHW-2
75	3	71.1	1165	3.375	2.650	L78V	BUHW-2
90	3	71.1	1165	3.375	2.650	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
135	V6	121.9	1998	3.125	2.625	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
150 (Magnum II)	V6	121.9	1998	3.125	2.625	L76V	BUHW
175	V6	142.2	2330	3.375	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
220 (Magnum W/EFI)	V6	142.2	2330	3.375	2.625	L76V	BU8H
				1988			
45	4	43.8	718	2.565	2.125	L78V	BUHW-2
50	3	49.8	816	2.875	2.563	L78V	BUHW-2
60	3	49.8	816	2.875	2.563	L78V	BUHW-2
75	3	71.1	1165	3.375	2.650	L78V	BUHW-2
90	3	71.1	1165	3.375	2.650	L76V	BUHW
100	4	105	1721	3.375	2.930	L76V	BUHW
115	L6	99.8	1635	2.875	2.563	L76V	BUHW
135	V6	121.9	1998	3.125	2.625	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
150 (Magnum II)	V6	121.9	1998	3.125	2.625	L76V	BUHW
175	V6	142.2	2330	3.375	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BUHW
220 (Magnum W/EFI)	V6	142.2	2330	3.375	2.625	L76V	BU8H
				1989			
45	4	43.8	718	2.565	2.125	L78V	BUHW-2
50	3	49.8	816	2.875	2.563	L78V	BUHW-2
60	3	49.8	816	2.875	2.563	L78V	BUHW-2
75	3	71.1	1165	3.375	2.650	L78V	BUHW-2
90	3	71.1	1165	3.375	2.650	L76V	BUHW
100	4	105	1721	3.375	2.930	L76V	BUHW
115	4	105	1721	3.375	2.930	L76V	BUHW
135	V6	121.9	1998	3.125	2.625	L76V	BUHW
150	V6	121.9	1998	3.125	2.625	L76V	BUHW
150 (Magnum II)	V6	121.9	1998	3.125	2.625	L76V	BUHW
175	V6	142.2	2330	3.375	2.625	L76V	BUHW
175 (SKI W/EFI)	V6	142.2	2330	3.375	2.625	L76V	BUHW
200	V6	142.2	2330	3.375	2.625	L76V	BU8H

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TUNE-UP ADJUSTMENTS

NOTE: See Appendix Pages A-8 and A-9 for special notes called out in this table.

CARB TYPE	PRIMARY PICKUP TIMING	MAXIMUM SPARK ADV CRANKING RPM	MAXIMUM SPARK ADV AT WOT	IDLE RPM	OPERATING RANGE RPM	FIRING ORDER
			1987			
A	Note 12	--	30°BTDC	650	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
C	Note 10	30°BTDC	27°BTDC	600	5000-5500	1-3-2
C	Note 5	Note 5	Note 5	600	4750-5250	1-3-2
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	7°ATDC	26°BTDC	22°BTDC	675	5500-6000	1-2-3-4-5-6
E	Note 6	20°BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
EFI	8°-10°ATDC	20°BTDC	25°BTDC	650	5600-6000	1-2-3-4-5-6
			1988			
A	Note 12	--	30°BTDC	650	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
C	Note 10	30°BTDC	27°BTDC	600	5000-5500	1-3-2
C	Note 5	Note 5	Note 5	600	4750-5250	1-3-2
C	--	27°BTDC	23°BTDC	675	5000-5500	1-3-2-4
D	Note 2	Note 2	Note 2	600	5000-5500	1-4-5-2-3-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	7°ATDC	26°BTDC	22°BTDC	675	5500-6000	1-2-3-4-5-6
E	Note 6	20°BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6
EFI	8°-10°ATDC	20°BTDC	25°BTDC	650	5600-6000	1-2-3-4-5-6
			1989			
A	Note 12	--	30°BTDC	650	5000-5500	1-3-2-4
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
B	--	27°BTDC	23°BTDC	700	5300-5800	1-3-2
C	Note 10	30°BTDC	27°BTDC	600	5000-5500	1-3-2
C	Note 5	Note 5	Note 5	600	4750-5250	1-3-2
C	--	27°BTDC	23°BTDC	675	5000-5500	1-3-2-4
C	--	27°BTDC	23°BTDC	675	5000-5500	1-3-2-4
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	Note 8	18°BTDC	16°BTDC	650	5000-5500	1-2-3-4-5-6
E	7°ATDC	26°BTDC	22°BTDC	675	5500-6000	1-2-3-4-5-6
E	Note 6	20°BTDC	18°BTDC	650	5300-5800	1-2-3-4-5-6
EFI	8°-10°ATDC	20°BTDC	25°BTDC	650	5600-6000	1-2-3-4-5-6
E	Note 9	Note 9	Note 9	650	5300-5800	1-2-3-4-5-6

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SPECIAL NOTES

NOTE 1
Set primary pickup timing at TDC for units with serial number 5763340 and below. Set primary pickup timing at 4°BTDC for units with serial number 5763341 and above.

NOTE 2
For units with serial number 5430526 and below:
Set primary pickup timing at 5°BTDC.
Set maximum spark advance, at cranking speed, at 23°BTDC.
Set maximum spark advance, at WOT, at 21°BTDC.

For units with serial number 5430527 to 5738890:
Set primary pickup timing at 6°ATDC.
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

For units with serial number 5738891 to 6050770:
Set primary pickup timing at 2°BTDC (with idle speed control disconnected, if so equipped).
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

For units with serial number 6050771 and above:
Set primary pickup timing at 5°BTDC (with idle speed control disconnected, if so equipped).
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

NOTE 3
For units with serial number 5443029 and below:
Set maximum spark advance, at cranking speed, at 23°BTDC.
Set maximum spark advance, at WOT, at 21°BTDC.

For units with serial number 5443030 and above:
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

NOTE 4
For units with serial number 5763340 and below:
Set primary pickup timing at TDC.

For units with serial number 5763341 and above:
Set primary pickup timing at 4°BTDC.

NOTE 5
For units with serial number 5721323 and below:
Set primary pickup timing at 2°BTDC.
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

For units with serial number 5721324 to 6038185:
Set primary pickup timing at 5°ATDC.
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

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For units with serial number 6038186 and above:
Set primary pickup timing at 6°BTDC.
Set maximum spark advance, at cranking speed, at 25°BTDC.
Set maximum spark advance, at WOT, at 23°BTDC.

NOTE 6
Set primary pickup timing at 14°ATDC (with idle speed control disconnected, if so equipped).

NOTE 7
Units with serial numbers 5579016 and below have firing order 1-2-3. Units with serial numbers 5579017 and above have firing order 1-3-2.

NOTE 8
Set primary pickup timing at 11°ATDC (with idle speed control disconnected, if so equipped).

NOTE 9 For units with serial number 6055032 and below:
Set primary pickup timing at 11°ATDC (with idle speed control disconnected, if so equipped).
Set maximum spark advance, at cranking speed, at 20°BTDC.
Set maximum spark advance, at WOT, at 18°BTDC.

For units with serial number 6055033 to 6537932:
Set primary pickup timing at 12°ATDC (with idle speed control disconnected, if so equipped).
Set maximum spark advance, at cranking speed, at 22°BTDC.
Set maximum spark advance, at WOT, at 20°BTDC, below 5400 rpm.
Ignition advance module advances the timing a further 6° above 5400 rpm.

For units with serial number 6537933 and above:
Set primary pickup timing at 7°ATDC (with idle speed control disconnected, if so equipped).
Set maximum spark advance, at cranking speed, at 22°BTDC.
Set maximum spark advance, at WOT, at 20°BTDC.

NOTE 10
For units with serial number 6616405 and below:
Set primary pickup timing at 4°BTDC.

For units with serial number 6616406 and above:
Set primary pickup timing at 3°BTDC.

NOTE 11
Set primary pickup timing at 11°ATDC (with idle speed control disconnected, if so equipped).
Set maximum spark advance, at WOT, at 20°BTDC, below 5400 rpm. Ignition advance module advances the timing a further 6° above 5400 rpm.

NOTE 12
For units with serial number 5531629 and below:
Set primary pickup timing at 8°BTDC.

For units with serial number 5531630 and above:
Set primary pickup timing at TDC. If set correctly, the timing at 600 to 700 rpm, will be 3°-10°ATDC.

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PISTON AND CYLINDER SPECIFICATIONS

NOTE: All dimensions given in inches.

MODEL	CYLINDER	YEAR	CRANKSHAFT TOP ROLLER BEARING JOURNAL	CRANKSHAFT TOP BALL BEARING JOURNAL	CRANKSHAFT CENTER MAIN BEARING JOURNAL	CRANKSHAFT MAIN ROLLER BEARING JOURNAL	CRANKSHAFT CONNECTING ROD JOURNAL	CRANKSHAFT BOTTOM BALL BEARING JOURNAL	CONNECTING ROD PISTON PIN END INSIDE DIAMETER	CONNECTING ROD CRANKPIN END INSIDE DIAMETER	PISTON OUTER DIAMETER ABOVE RING LAND	PISTON OUTER DIAMETER AT SKIRT (90° TO PIN)	CYLINDER BORE FINISH HONE	RING END GAP
45	4	1986 & On	--	1.180	0.984	1.000	0.882	1.180	0.750	1.137	2.551	2.558	2.565	0.016
50	4	1982-85	--	1.180	0.984	1.000	0.882	1.180	0.750	1.137	2.551	2.558	2.565	0.016
50	3	1986 & On	--	1.378	1.238	1.238	1.139	1.378	0.957	1.453	2.863	2.872	2.875	0.018
60	3	1984 & On	--	1.378	1.238	1.238	1.139	1.378	0.957	1.453	2.863	2.872	2.875	0.018
70	3	1980-83	--	1.378	1.238	1.238	1.139	1.378	0.957	1.453	2.863	2.872	2.875	0.018
75	4	1984-86	--	1.181	1.238	1.238	1.139	1.181	0.957	1.453	2.863	2.872	2.875	0.018
75	3	1987 & On	--	*	*	*	*	*	*	*	*	3.371	3.375	0.020
80	4	1987-83	--	1.181	1.238	1.238	1.139	1.181	0.957	1.453	2.863	2.872	2.875	0.018
85	4	1977	--	1.181	1.238	1.238	1.139	1.181	0.957	1.453	2.863	2.872	2.875	0.018
90	L6	1979-86	--	1.181	1.238	1.238	1.139	1.182	0.957	1.453	2.863	2.872	2.875	0.018
90	3	1987 & On	--	*	*	*	*	*	*	*	*	3.371	3.375	0.020
100	4	1988 & On	--	*	*	*	*	*	*	*	*	3.371	3.375	0.020
115	L6	1978-88	--	1.181	1.238	--	1.139	1.181	0.957	1.453	2.857	2.865	2.875	0.018
115	4	1989 & On	--	*	*	*	*	*	*	*	*	3.371	3.375	0.020
135	V6	1986 & On	1.498	--	--	1.375	1.181	1.575	0.957	1.499	3.108	3.115	3.125	0.019
140	L6	1978-80	--	1.181	1.238	1.238	1.139	1.181	0.957	1.453	2.857	2.865	2.875	0.018
150	V6	1980 & On	1.498	--	--	1.375	1.181	1.575	0.957	1.499	3.108	3.115	3.125	0.019
175	V6	1979-80	1.498	--	--	1.375	1.181	1.575	0.957	1.500	3.108	3.115	3.125	0.019
175	V6	1985 & On	1.498	--	--	1.375	1.181	1.575	0.957	1.499	3.108	3.115	3.125	0.019
200	V6	1980 & On	1.498	--	--	1.375	1.181	1.575	0.957	1.499	3.363	3.372	3.375	0.020
220	V6	1987-88	1.498	--	--	1.375	1.181	1.575	0.957	1.499	3.363	3.372	3.375	0.020

* Information unavailable at press time.

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REED STOP OPENING

MODEL	CYLINDER	YEAR	REED STOP OPENING INCHES	REED STOP OPENING MILLIMETERS
45	4	1986 & On	.156	3.96
50	4	1982-85	.156	3.96
50	3	1986 & On	.180	4.57
60	3	1984 & On	.180	4.57
70	3	1980-83	.180	4.57
75	4	1984-86	.162	4.11
75	3	1987 & On	--	--
80	4	1978-83	.162	4.11
85	4	1977	.162	4.11
90	3	1987 & On	--	--
90	L6	1979 & On	.162	4.11
100	4	1988 & On	--	--
115	4	1989 & On	--	--
115	L6	1979-88	.162	4.11
135	V6	1986 & On	Note 1	
140	L6	1979-80	.162	4.11
150	V6	1980 & On	.200*	5.08*
175	V6	1979-80	.300	7.62
175	V6	1985 & On	Note 1	
200	V6	1980 & On	.300*	7.62*
220	V6	1987-88	Note 1	

Note 1 Since about 1981, reed stops have not been used, therefore, no measurement is necessary.

* If equipped.

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LOWER UNIT GEAR BACKLASH TABLE

MODEL	YEAR	CYL.	H.P.	FORWARD GEAR Inches	FORWARD GEAR mm	REVERSE GEAR Inches	REVERSE GEAR mm
45	1986 & On	4	45	.003-.005	.076-.127	.003-.005	.076-.127
50	1982-85	4	50	.003-.005	.076-.127	.003-.005	.076-.127
50	1986 & On	3	50	.003-.005	.076-.127	.003-.005	.076-.127
60	1984 & On	3	60	.003-.005	.076-.127	.003-.005	.076-.127
70	1980-83	3	70	.003-.005	.076-.127	.003-.005	.076-.127
75	1984-86	4	75	.008-.012	.203-.304	.040-.060	1.016-1.524
75	1987 & On	3	75	.012-.019	.304-.483	Note 1	---
80	1978-83	4	80	.014-.016	.356-.406	.040-.060	1.016-1.524
85	1977	4	85	.014-.016	.356-.406	.040-.060	1.016-1.524
90	1987 & On	3	90	.012-.019	.304-.483	Note 1	---
90	1979 & On	L6	90	.014-.016	.356-.406	.040-.060	1.016-1.524
100	1988 & On	4	100	.015-.022	.381-.559	Note 1	---
115	1989 & On	4	115	.015-.022	.381-.559	Note 1	---
115	1978-88	L6	115	.014-.016	.356-.406	.040-.060	1.016-1.524
135	1986 & On	V6	135	.008-.013*	.203-.330	Note 1	---
140	1978-80	L6	140	.014-.016	.356-.406	.040-.060	1.016-1.524
150	1980 & On	V6	150	.008-.013*	.203-.330*	Note 1	---
175	1979-80	V6	175	.008-.013*	.203-.330*	Note 1	---
175	1985 & On	V6	175	.008-.013*	.203-.330	Note 1	---
200	1980 & On	V6	200	.008-.013*	.203-.330*	Note 1	---
220	1987-88	V6	220	.008-.013*	.203-.330*	Note 1	---

* Serial No. 5464486 & up, fwd gear .016-.019" (.406-.483mm).

Note 1 Reverse gear not adjustable, but should be .040-.060" (1.016-1.524mm).

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LOWER UNIT OIL CAPACITY AND GEAR CHART

MODEL	YEAR	CYLINDER	H.P.	CAPACITY FLUID OZ.	NO. TEETH FORWARD	NO. TEETH PINION	GEAR RATIO
45	1986 & On	4	45	12.5	26	13	2:1
50	1982-85	4	50	12.5	26	13	2:1
50	1986 & On	3	50	12.5	23	14	2:1*
60	1984 & On	3	60	12.5	23	14	2:1*
70	1980-83	3	70	12.5	23	14	2:1*
75	1984-86	4	75	21	30	13	2.3:1
75	1987 & On	3	75	22.5	32	14	2.3:1
80	1978-83	4	80	21	30	13	2.3:1
85	1977	4	85	21	30	13	2.3:1
90	1987 & On	3	90	22.5	30	14	2.3:1
90	1979 & On	L6	90	21	28	14	2:1
100	1988 & On	4	100	22.5	29	14	2.07:1
115	1989 & On	4	115	22.5	29	14	2.07:1
115	1978-88	L6	115	21	28	14	2:1
135	1986 & On	V6	135	24.25	28	14	2:1
140	1978-80	L6	140	21	28	14	2:1
150	1980 & On	V6	150	24.25	28	14	2:1
175	1979-80	V6	175	24.25	28	14	2:1
175	1985 & On	V6	175	24.25	28	15	1.87:1
200	1980 & On	V6	200	24.25	28	14	2:1**
220	1987-88	V6	220	24.25	28	15	1.87:1

* Indicates gear ratio changes to 1.83:1 for units with serial numbers 5579017 and above.

** Indicates gear ratio changes to 1.83:1 for units with serial numbers 6201970 and above.

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CARBURETOR JET SIZE / ELEVATION CHART

ALL IN-LINE POWERHEADS

MODEL	YEAR	CYL.	JET. TYPE	ZERO TO 2500FT (0-765M)	2501 TO 5000FT (766 to 1525M)	5001 TO 7500FT 1526 to 2285M)	COMMENT
45	1986 & On	4	Main	.057	.055	.053	
			Vent	.098	.096	.094	
50	1982-85	4	Main	.057	.055	.053	
			Vent	.098	.096	.094	
50	1986 & On	3	Main	.058	.054	.052	
			Vent	.096	.094	.092	
60	1984 & On	3	Main (Top)	.078	.076	.074	
			Main (Bottom)	.072	.070	.068	
			Vent	.096	.094	.092	
70	1980-83	3	Main	.058	.054	.052	
			Vent	.096	.094	.092	
75	1984-86	4	Main	.090	.088	.086	
			Vent	.072	.070	.068	
75	1987 & On	3	Main	.068	.066	.064	
			Vent	.094	.092	.090	
80	1978-83	4	Main	.090	.088	.086	
			Vent	.072	.070	.068	
85	1977	4	Main	.090	.088	.086	
			Vent	.072	,070	.068	
90	1987 & On	3	Main	.072	.070	.068	
			Vent	.094	.092	.090	
90	1979 & On	L6	Main	.070	.068	.066	
			Vent	.092	.090	.088	
100	1988 & On	4	Main	.054	.052	.050	
			Vent	--	--	--	
115	1989 & On	4	Main	.054	.052	.050	
			Vent	--	--	--	
115	1978 & On	L6	Main	.072	.070	.068	Note 1
			Vent	.098	.096	.094	
115	1979 & On	L6	Main	.074	.072	.070	Note 2
			Vent	.096	.096	.096	
140	1978-80	L6	Main	.080	.078	.076	Note 3
			Vent	.092	.090	.088	
140	1979-81	L6	Main	.074	.072	.070	Note 4
			Vent	.090	.088	.086	

Note 1 Below Serial No. 5050763

Note 2 Serial No. 5050763 & Above.

Note 3 Below Serial No. 5327663.

Note 4 Serial No. 5327663 & Above.

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CARBURETOR JET SIZE / ELEVATION CHART

V6 POWERHEADS

CARBURETOR NO. (STAMPED ON TOP OF CARBURETOR MOUNTING FLANGE)	STANDARD JET CHART *NOTE: Jets listed are for engine operation from 0-2500 feet (0-762m) of elevation.*																	
	MAIN JET						IDLE JET						VENT JET					
	CYL 1	CYL 2	CYL 3	CYL 4	CYL 5	CYL 6	CYL 1	CYL 2	CYL 3	CYL 4	CYL 5	CYL 6	CYL 1	CYL 2	CYL 3	CYL 4	CYL 5	CYL 6
Top WH1-1	.074	.074					.048	.048					.090	.090				
Center WH1-2			.074	.074					.048	.048					.082	.082		
Bottom WH1-3					.074	.074					.048	.048					.082	.082
Top WH2-1	.056	.056					.060	.060					.098	.098				
Center WH2-2			.056	.056					.060	.060					.098	.098		
Bottom WH2-1					.056	.056					.060	.060					.098	.098
Top WH3-1	.078	.078					.046	.046					.084	.084				
Center WH3-2			.078	.078					.046	.046					None	.084		
Bottom WH3-3					.078	.078					.046	.046					None	.084
Top WH3-1A	.078	.078					.044	.044					.084	.084				
Center WH3-2A			.078	.078					.044	.044					None	.084		
Bottom WH3-3A					.078	.078					.044	.044					None	.084
Top WH3M11	.082	.082					.044	.044					.084	.084				
Center WH3M12			.082	.082					.044	.044					None	.084		
Bottom WH3M13					.082	.082					.044	.044					None	.084
Top WH4-1	.074	.074					.048	.048					.094	.094				
Center WH4-2			.074	.074					.048	.048					.094	.094		
Bottom WH4-3					.078	.074					.048	.048					.094	.094
Top WH5-1	.078	.078					.048	.048					.094	.094				
Center WH5-2			.078	.078					.048	.048					.094	.094		
Bottom WH5-3					.078	.078					.048	.048					.094	.094
Top WH6-1	.074	.074					.046	.046					.090	.090				
Center WH6-2			.074	.074					.046	.046					None	.082		
Bottom WH6-3					.078	.074					.046	.046					None	None
Top WH7-1	.074	.074					.044	.044					.090	.090				
Center WH7-2			.074	.074					.044	.044					None	.082		
Bottom WH7-3					.078	.074					.044	.044					None	None
Top WH7-1A	.074	.074					.044	.044					.090	.090				
Center WH7-2A			.074	.074					.044	.044					None	.082		
Bottom WH7-3A					.078	.074					.044	.044					None	None
Top WH8-1	.082	.082					.044	.044					.084	.084				
Center WH8-2			.082	.082					.044	.044					None	.084		
Bottom WH8-3					.082	.082					.044	.044					None	.084
Top WH9-1	.048	.048					.060	.060					.098	.098				
Center WH9-2			.048	.048					.060	.060					.098	.098		
Bottom WH9-1					.048	.048					.060	.060					.098	.098
Top WH11-1	.062	.062					.052	.052					.096	.096				
Center WH11-2			.062	.062					.052	.052					.096	.096		
Bottom WH11-1					.062	.062					.052	.052					.096	.096
Top WH11-1	.062	.062					.052	.052					.096	.096				
Center WH11-2			.062	.062					.052	.052					.096	.096		
Bottom WH11-3					.068	.068					.052	.052					None	None
Top WH12-1	.048	.048					.060	.060					.098	.098				
Center WH12-2			.048	.048					.060	.060					.098	.098		
Bottom WH12-3					.048	.048					.060	.060					.098	.098
Top WH13-1	.074	.074					.044	.044					.090	.090				
Center WH13-2			.074	.074					.044	.044					None	.082		
Bottom WH13-3					.078	.074					.044	.044					None	None
Top WH14-1	.062	.062					.052	.052					.096	.096				
Center WH14-2			.062	.062					.052	.052					.096	.096		
Bottom WH14-3					.068	.062					.052	.052					None	None
Top WH15-1	.072	.072					.042	.042					None	None				
Center WH15-2			.072	.072					.042	.042					None	None		
Bottom WH15-3					.072	.072					.042	.042					None	None
Top WH17-1	.074	.074					.044	.044					.090	.090				
Center WH17-2			.074	.074					.044	.044					None	.082		
Bottom WH17-3					.078	.074					.044	.044					None	None
Top WH17-1R	.074	.074					.048	.048					.090	.090				
Center WH17-2R			.074	.074					.048	.048					None	.082		
Bottom WH17-3R					.078	.074					.048	.048					None	None
Top WH18-1	.062	.062					.052	.052					.096	.096				
Center WH18-2			.062	.062					.052	.052					None	.096		
Bottom WH18-3					.068	.062					.052	.052					None	None
Top WH20-1	.072	.074					.046	.046					None	None				
Center WH20-2			.072	.072					.046	.046					None	None		
Bottom WH20-3					.072	.072					.046	.046					None	None
Top WH21-1	.076	.076					.050	.050					.092	.092				
Center WH21-2			.076	.076					.050	.050					None	.092		
Bottom WH21-3					.076	.076					.050	.050					None	.092
Top WH22-1	.074	.076					.046	.046					.096	None				
Center WH22-2			.074	.074					.046	.046					.096	.096		
Bottom WH22-3					.076	.074					.046	.046					None	.096
Top WH23-1	.064	.064					.052	.052					.096	None				
Center WH23-2			.064	.064					.052	.052					.096	.096		
Bottom WH23-3					.064	.064					.052	.052					None	.096
Top WH1-1	.074	.074					.048	.048					.090	.090				
Center WH4-2			.074	.074					.048	.048					.094	.094		
Bottom WH4-3					.078	.074					.048	.048					.094	.094

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CARBURETOR JET SIZE / ELEVATION CHART

V6 POWERHEADS

CARBURETOR NO. (STAMPED ON TOP OF CARBURETOR MOUNTING FLANGE)		STANDARD JET CHART *NOTE: Jets listed are for engine operation from 0-2500 feet (0-762m) of elevation.*																	
		MAIN JET						IDLE JET						VENT JET					
		CYL 1	CYL 2	CYL 3	CYL 4	CYL 5	CYL 6	CYL 1	CYL 2	CYL 3	CYL 4	CYL 5	CYL 6	CYL 1	CYL 2	CYL 3	CYL 4	CYL 5	CYL 6
Top	WH26-1	.074	.076					.048	.048					.096	None				
Center	WH26-2			.074	.074					.048	.048					.096	.096		
Bottom	WH26-3					.076	.074					.048	.048					None	.096
Top	WH27-1	.064	.064					.054	.054					None	None				
Center	WH27-2			.064	.064					.054	.054					None	None		
Bottom	WH27-3					.064	.064					.054	.054					None	None
Top	WH28-1	.074	.076					.056	.056					.096	None				
Center	WH28-2			.074	.074					.056	.056					.096	.096		
Bottom	WH28-3					.076	.074					.056	.056					None	.096
Top	WH29-1	.064	.064					.056	.056					None	None				
Center	WH29-2			.064	.064					.056	.056					None	None		
Bottom	WH29-3					.064	.064					.056	.056					None	None

V6 POWERHEADS

HIGH ALTITUDE JET CHART		
Engine Operating Elevation (Above Sea Level)	**Jet**	**Install jet with an orifice:**
2500'-5000' (762-1524m)	Main	.002" smaller (than standard jet).
	Vent*	.002" smaller (than standard jet).
	Idle	.002" larger (than standard jet).
5000'-7500' (1524-2286m)	Main	.004" smaller (than standard jet).
	Vent*	.004" smaller (than standard jet).
	Idle	.004" larger (than standard jet).
7500' and Up (2286m and Up)	Main	.006" smaller (than standard jet).
	Vent*	.006" smaller (than standard jet).
	Idle	.006" larger (than standard jet).

**If standard vent jet is listed as none, then DO NOT install a jet.*

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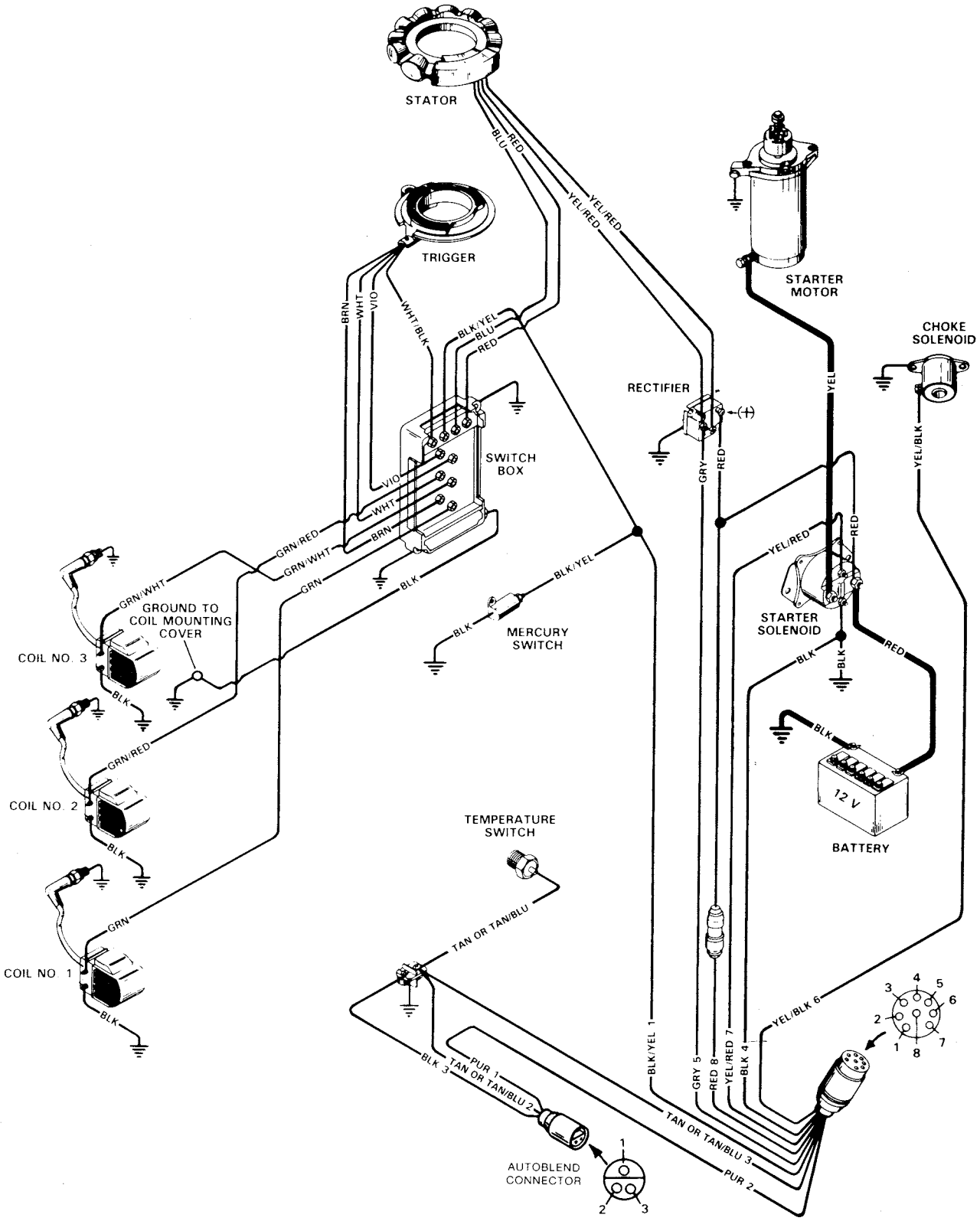

Wire identification for 3-Cylinder Powerheads, Models 50, 60, and 70.

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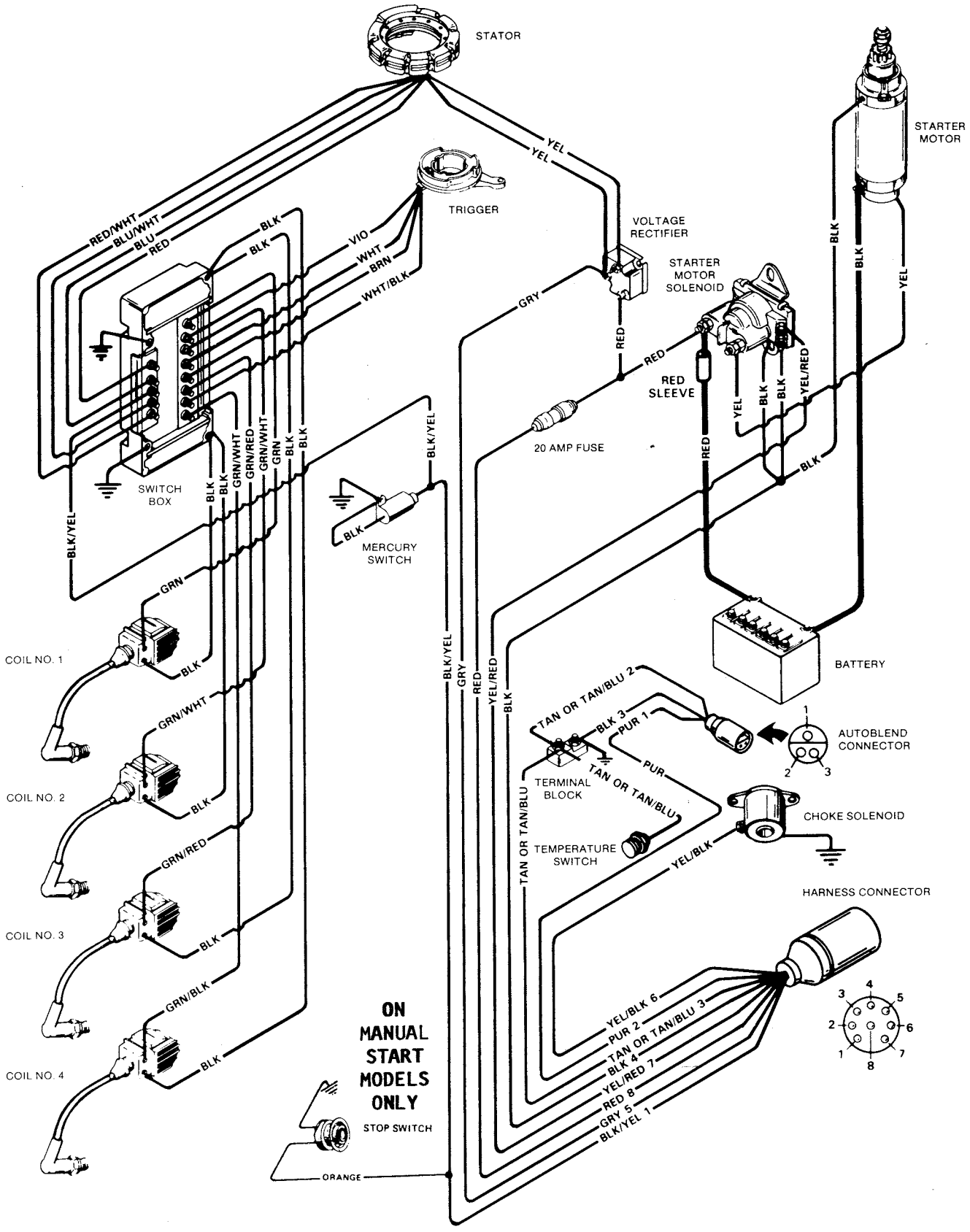

Wire identification for 4-Cylinder Powerheads, Models 45, 50, 75, 80, and 85.

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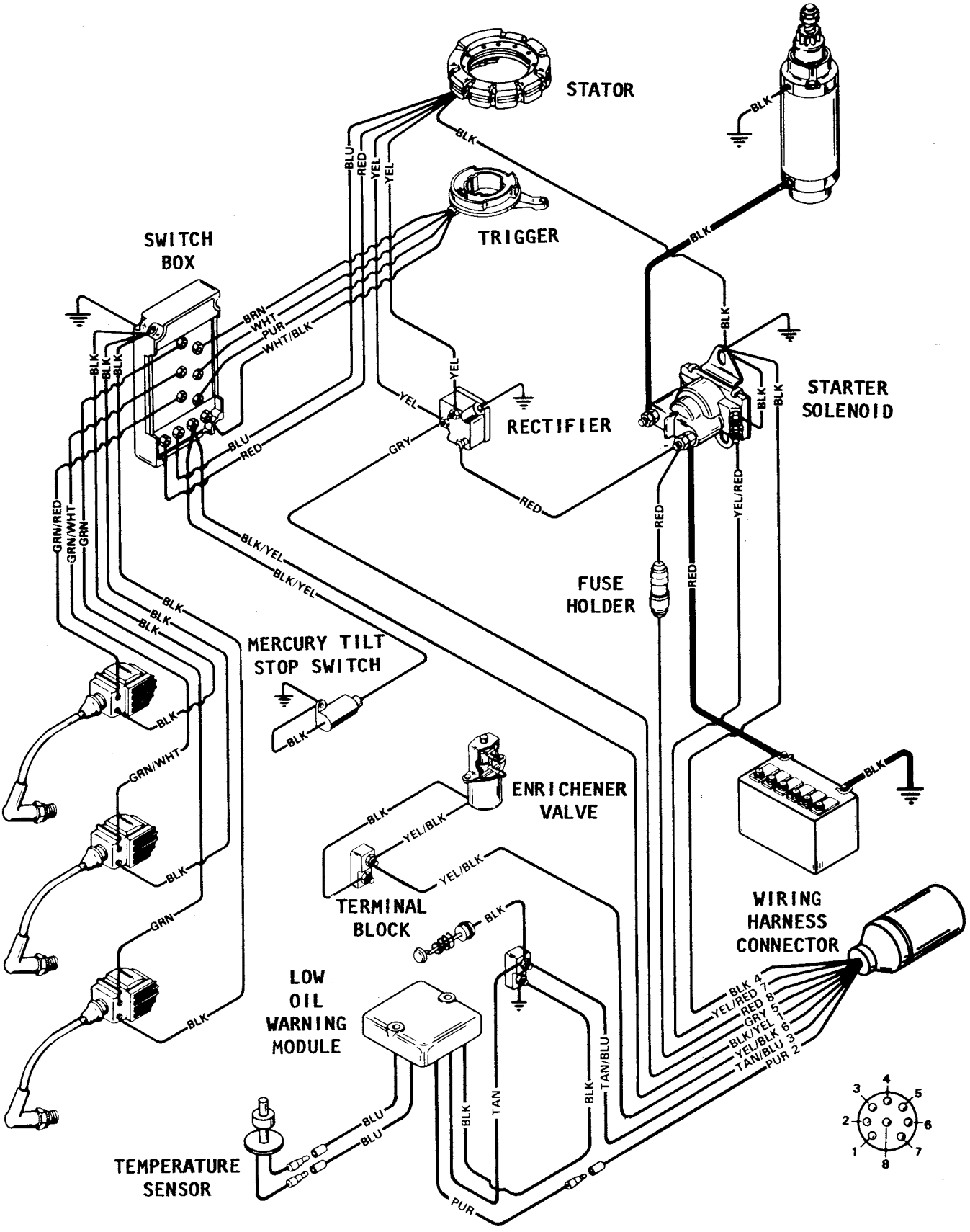

Wire identification for 3-Cylinder Powerheads, Models 75 and 90.

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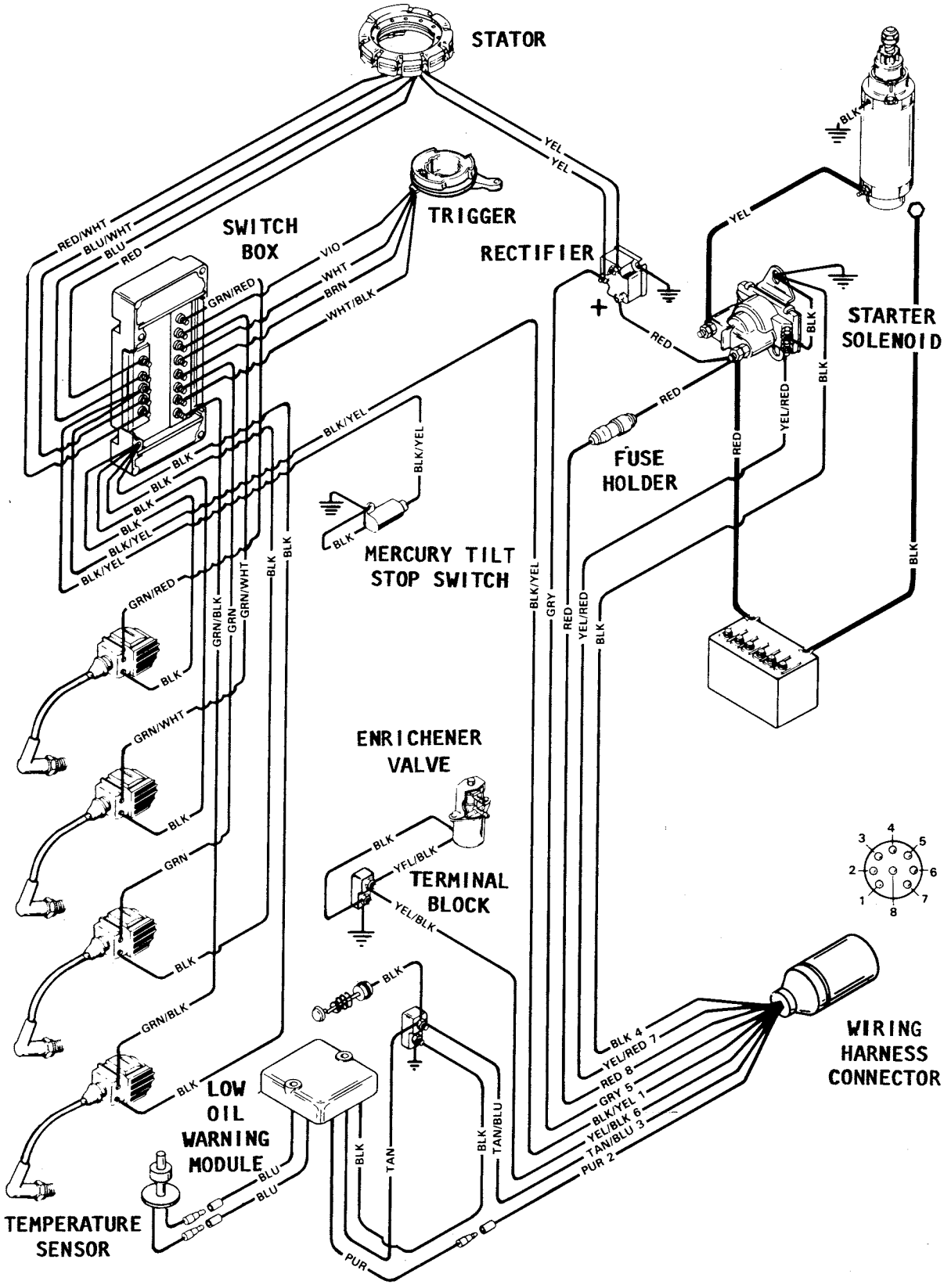

Wire identification for 4-Cylinder Powerheads, Models 100 and 115.

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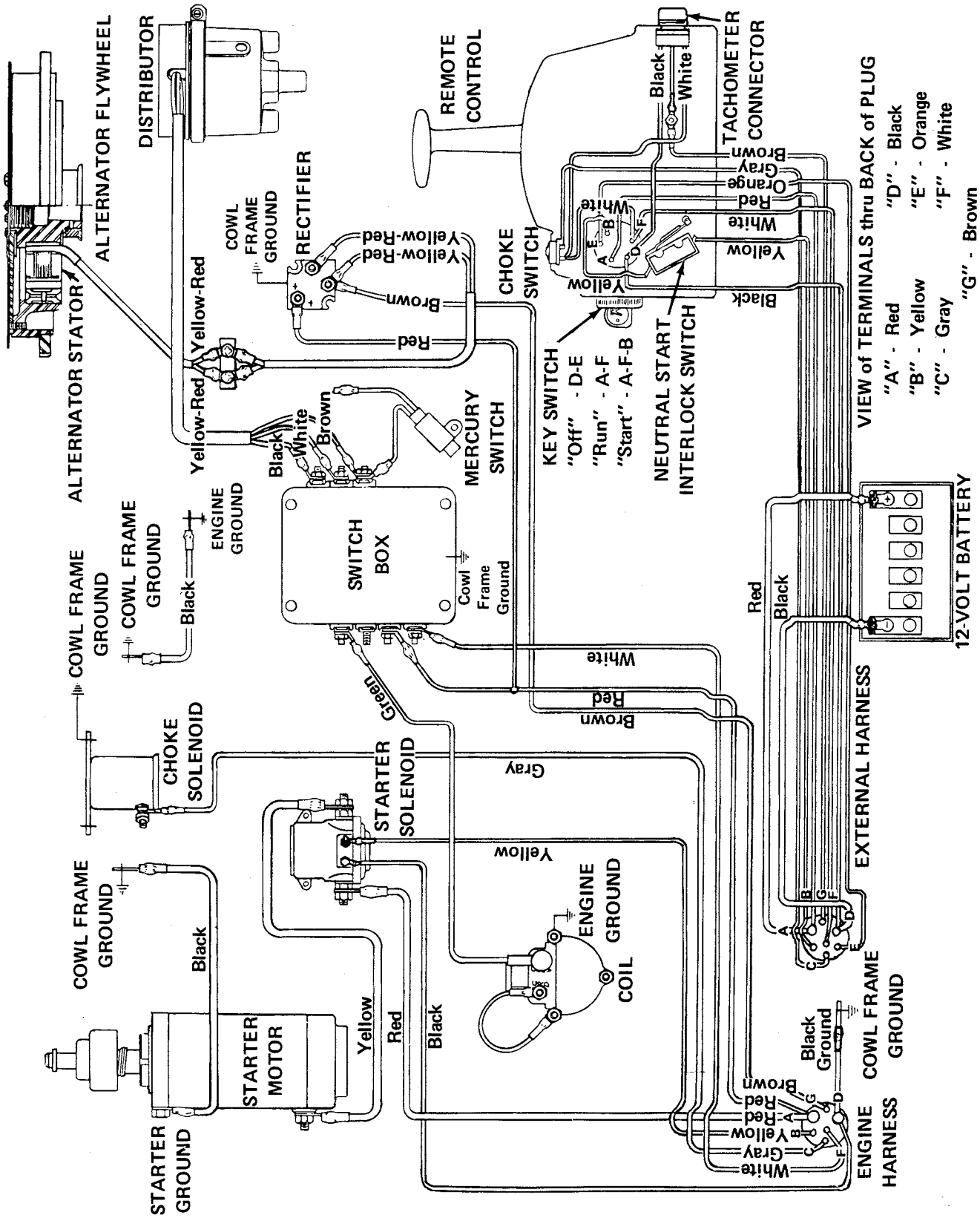

Wire identification for L6 Models 90, 115, and 140 with Distributor Ignition.

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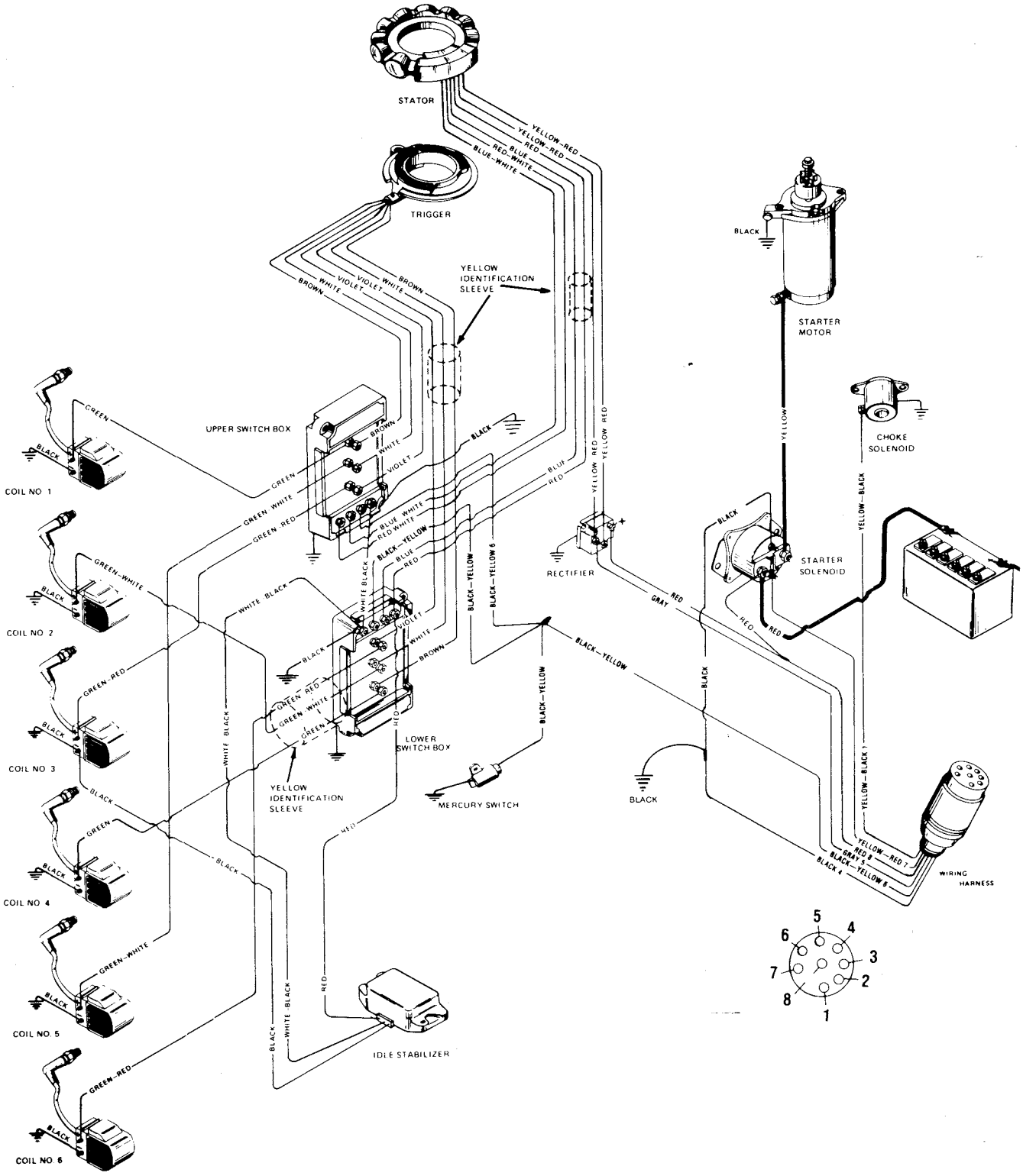

Wire identification for L6 Models 90, 115, and 140 with CD Type Ignition.

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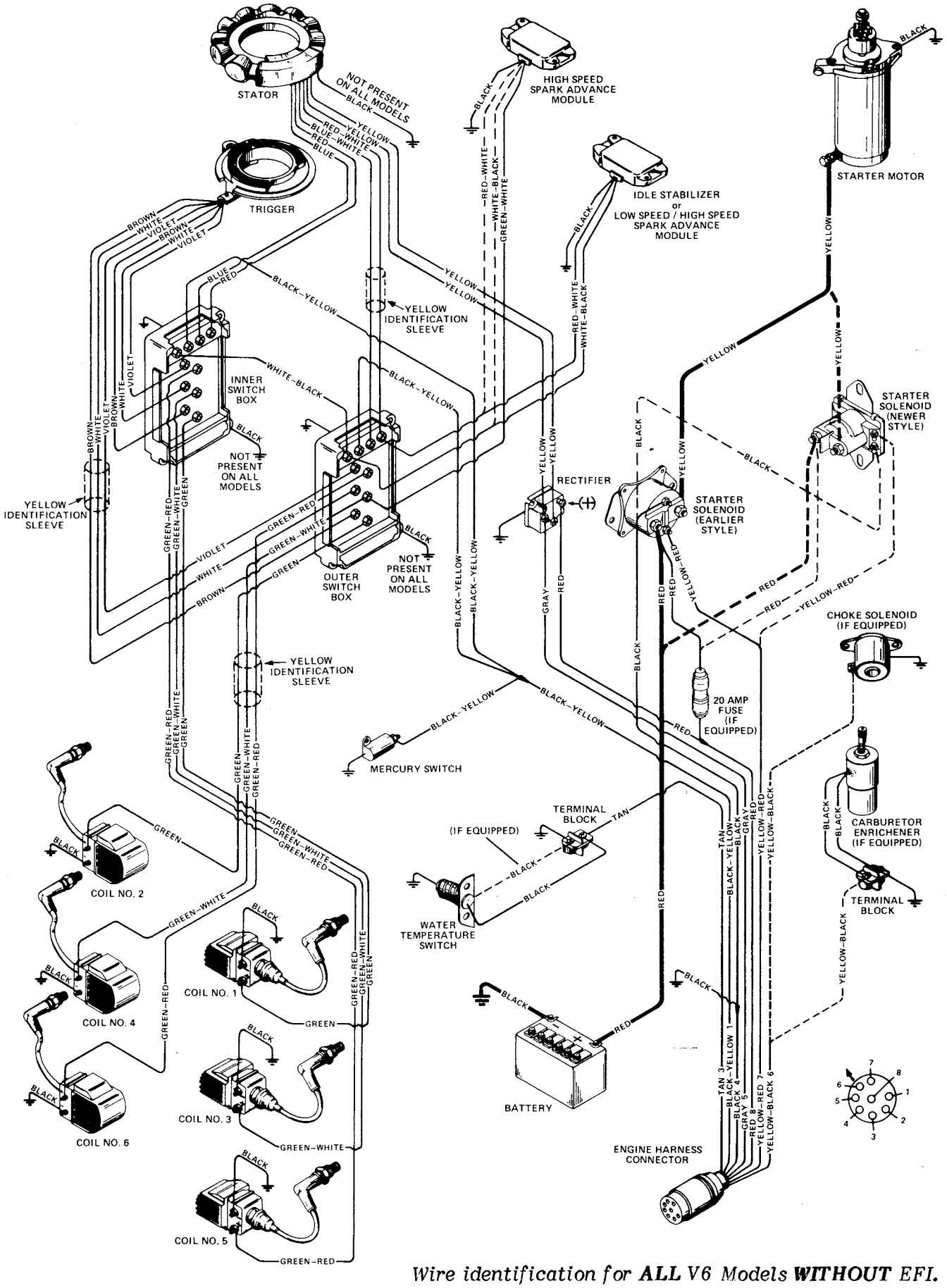

Wire identification for ***ALL*** *V6 Models* ***WITHOUT*** *EFI.*

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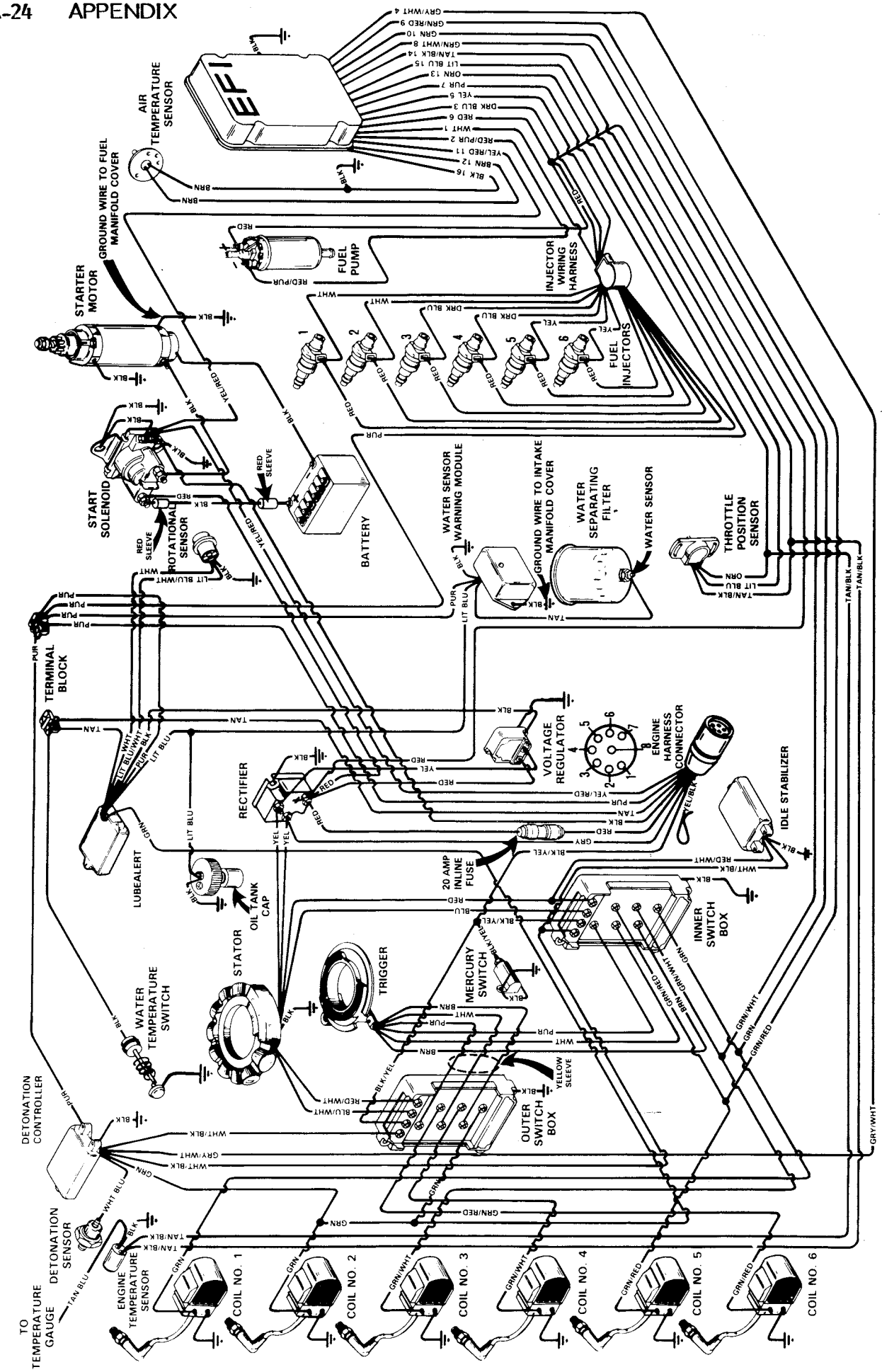

*Wire identification for **ALL** V6 Models equipped with EFI.*

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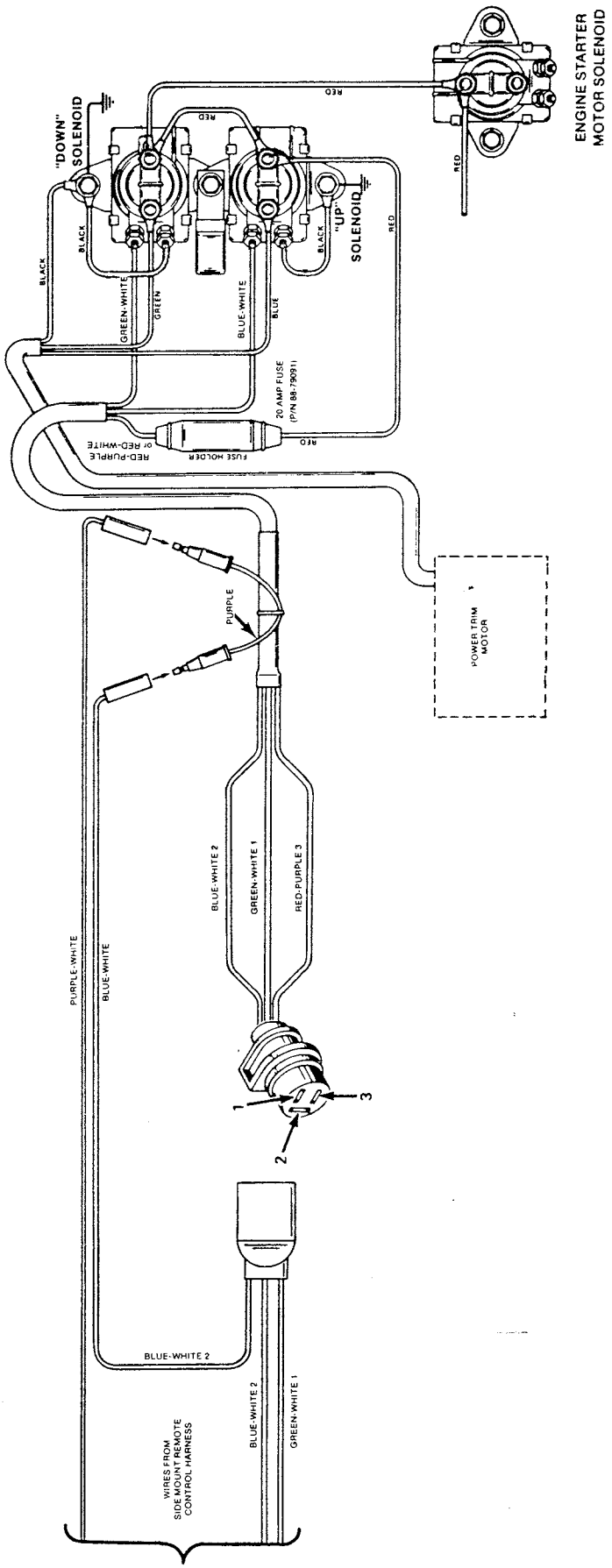

Wire identification — Type "B" power trim/tilt system (two trim cylinders and one tilt cylinder).

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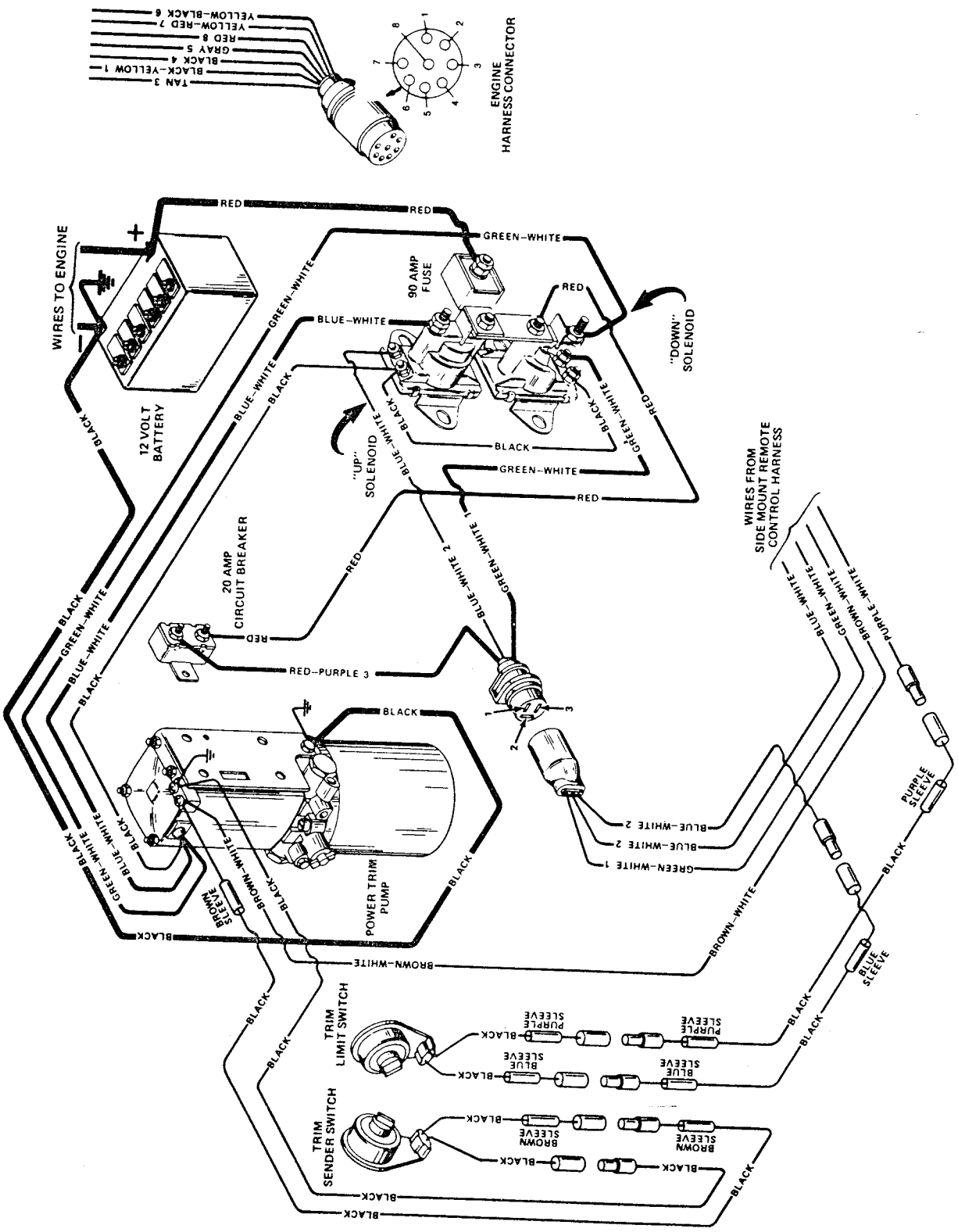

Wire identification -- Type "C" Power Trim/Tilt System.

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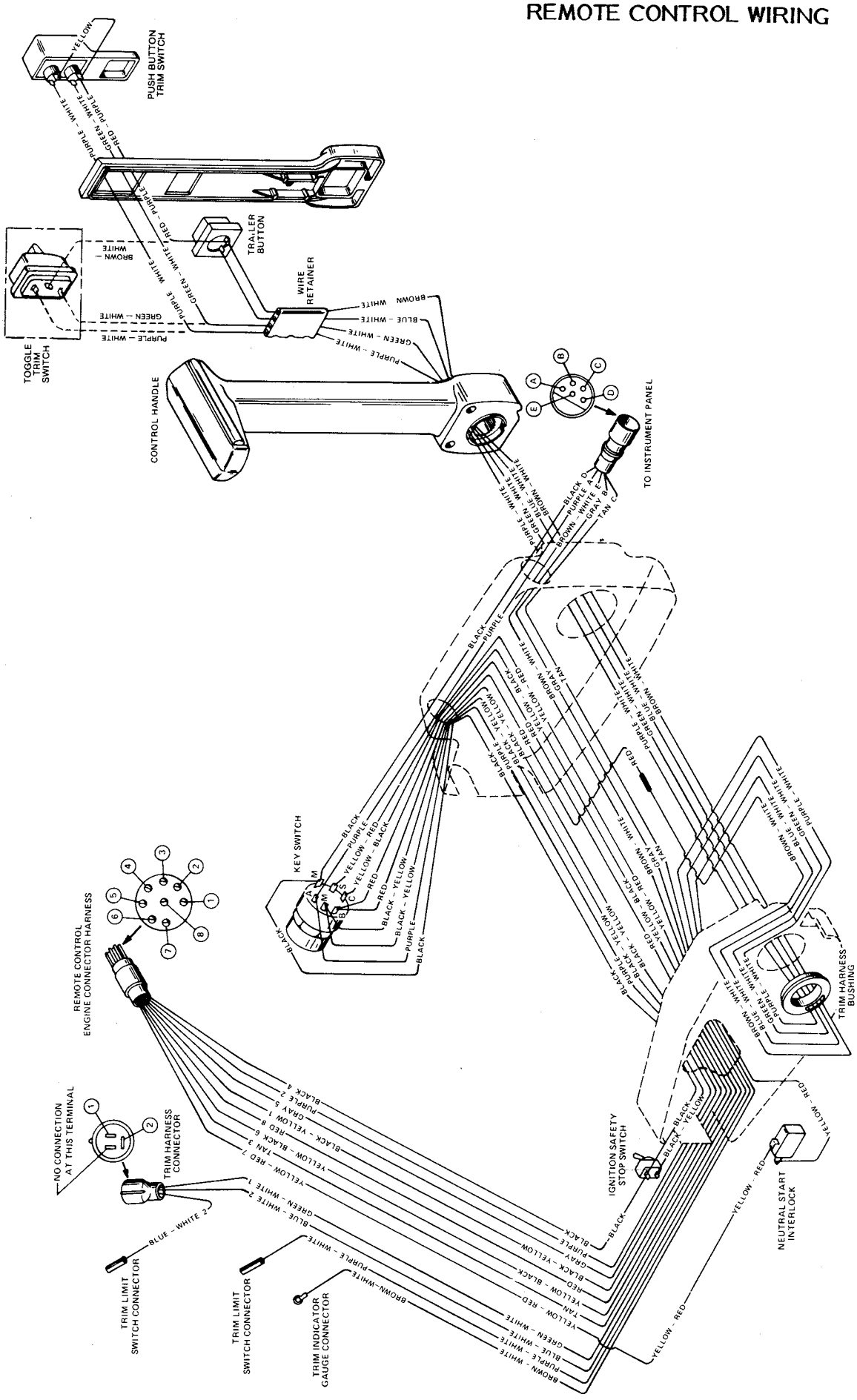

*Wire identification -- "Commander" side mount controls **WITH** power trim/tilt system.*