TABLE OF CONTENTS

4 FUEL

5 IGNITION

6 ELECTRICAL

7 ACCESSORIES

8 TILT MECHANISM

9 COOLING

10 STERN DRIVE

11 INTERMEDIATE HOUSING

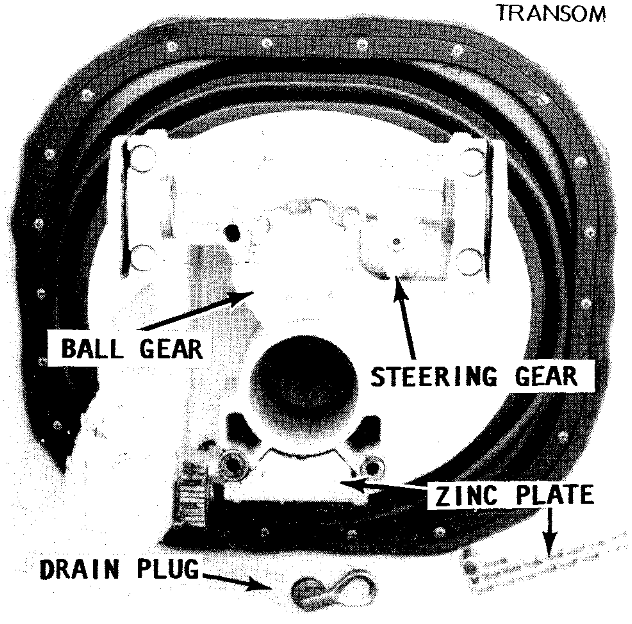
12 MAINTENANCE

APPENDIX

1
SAFETY

1-1 INTRODUCTION

Your boat probably represents a sizeable investment for you. In order to protect this investment- and to receive the maximum amount of enjoyment from your boat it must be cared for properly while being used and when it is out of the water. Always store your boat with the bow higher than the stern and be sure to remove the transom drain plug and the inner hull drain plugs. If you use any type of cover to protect your boat, plastic, canvas, whatever, 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.



When storing the boat, raise the bow and remove the stem drain plug to drain all bilge water. Failure to drain the bilge will cause rot. Attach the plug to the steering wheel so it will not be forgotten when the boat is launched the next time.

1-2 CLEANING, WAXING, AND POLISHING

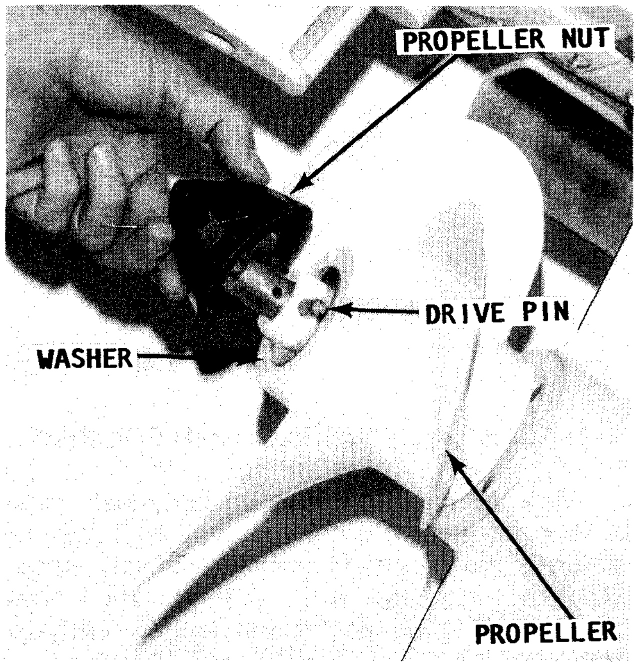
Any boat should be washed with clear water after each use to remove surface dirt and any salt deposits from use in salt water. Regular rinsing will extend the time between waxing and polishing. It will also give you "pride of ownership", by having a sharp looking piece of equipment. Elbow grease, a mild 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 compound 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, particularily the undersides, similar metals should be used whenever and wherever possible.

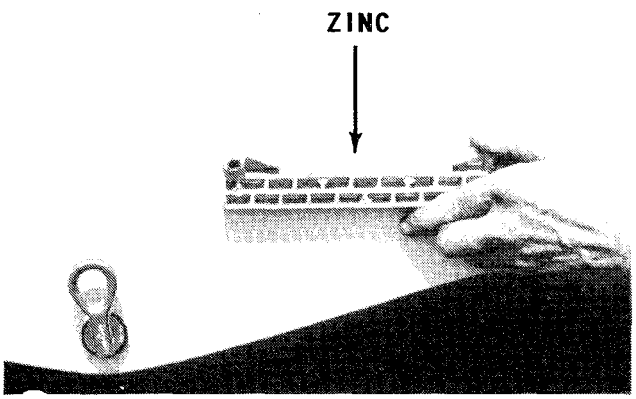
A second defense against corrosion is to insulate dissimilar metals. This can be done by using an exterior coating of Sea Skin or by insulating them with plastic or rubber gaskets.



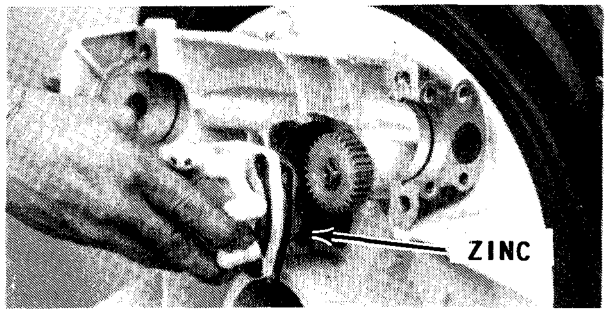
The propeller wosher is installed on the hub prior to inserting the drive pin through the propeller and shcft. The propeller, washer, nut, and drive pin should be checked regularly for cracks and wear.

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 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 plate attached to the boat transom A ground wire from one of the zinc attaching bolts must be connected to the negative battery terminal.

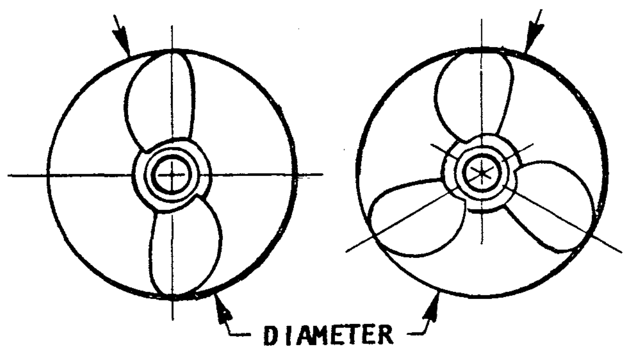


A zinc plate attached to the bottom side of the intermediate housing.

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. Two types of zincs may be purchased from the local OMC dealer. One type bolts to the boat transom with a wire connected to the battery. The other type is bolted to the bottom side of the intermediate housing. In later years, OMC stern drive units are sold with the zinc attached to the intermediate housing as standard factory equipment.

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 water in the shape of this cone pushing on the surrounding water is what propels the boat.



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

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.

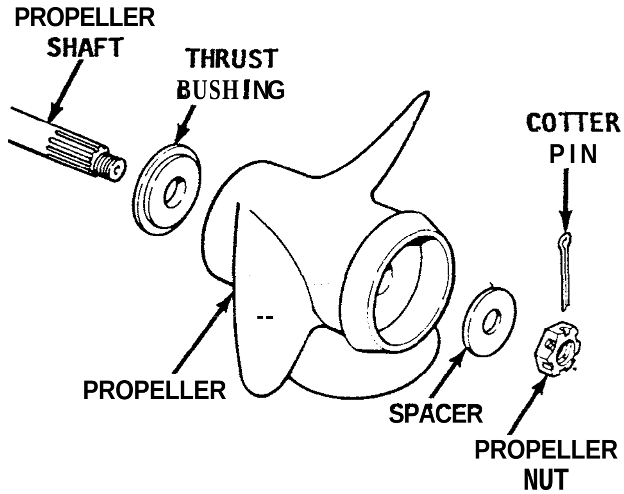
The diameter is the measured distance from the tip of one blade to the tip of the other as shown in the accompanying illustration.

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 stern drive 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.



Associated parts for a prop exhaust propeller installation.

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

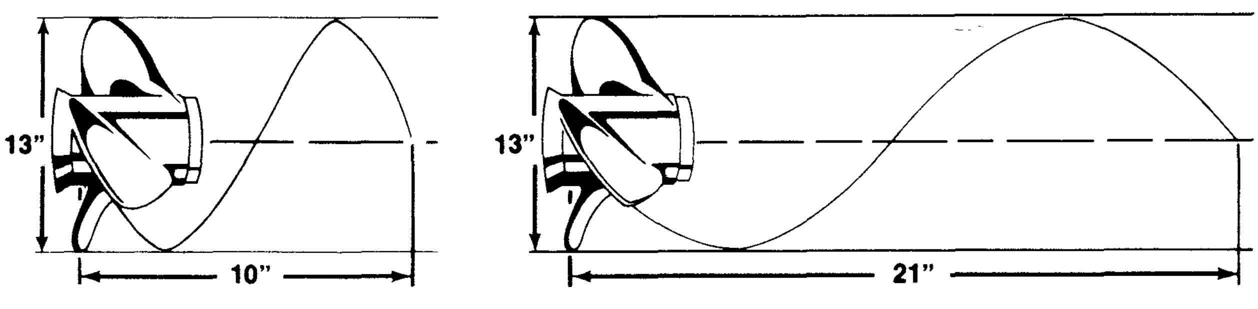


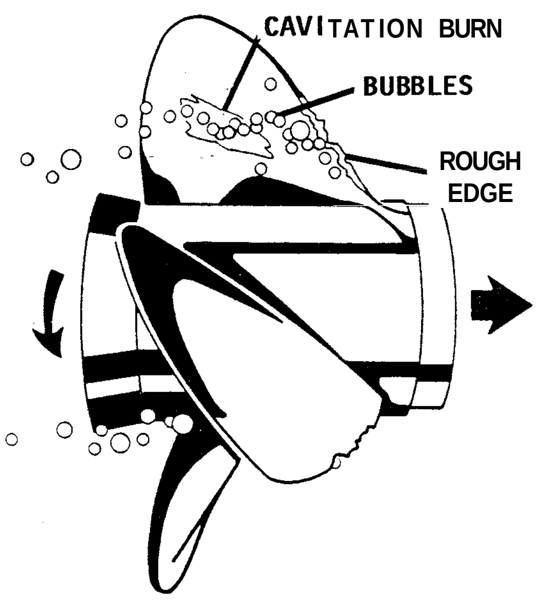
Diagram to explain the pitch dimension of a propeller. The pitch is the theoretical distance a propeller would travel through the water in one revolution, if there was no slippage.

It stands to reason, and it's true, that the high pitch propeller will require more horsepower, but will give faster boat speed if the engine is allowed to turn to its rated rpm.

If a higher-pitched propeller is installed on a boat, in an effort to get more speed, extra. horsepower will be required. If the extra power is not available, the rpms will be reduced to a less efficient level and the actual boat speed will be less than if the lower-pitched propeller had been left installed.

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 rprn 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.



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

Observe the tachometer at full throttle. **NEVER** run the engine at a high rprn when a flush attachment is installed. 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.

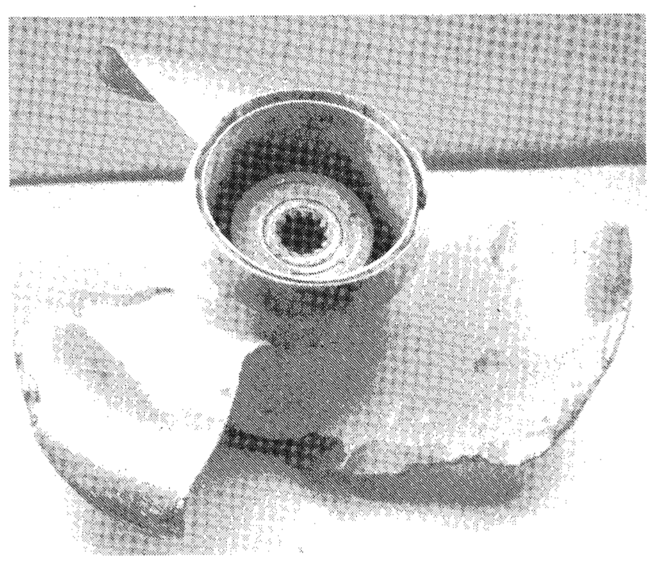
If the engine is unable to deliver top performance and you feel it is properly tuned, then the propeller may not be to blame. Operating conditions have a marked effect on performance. For instance, an engine will lose rprn when run in very cold water. It will also lose rprn when run in salt water as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

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 speedometer pickup, depth sounder, or bait tank pickup.

Vibration

Your propeller should be checked regularly to be sure all blades are in good



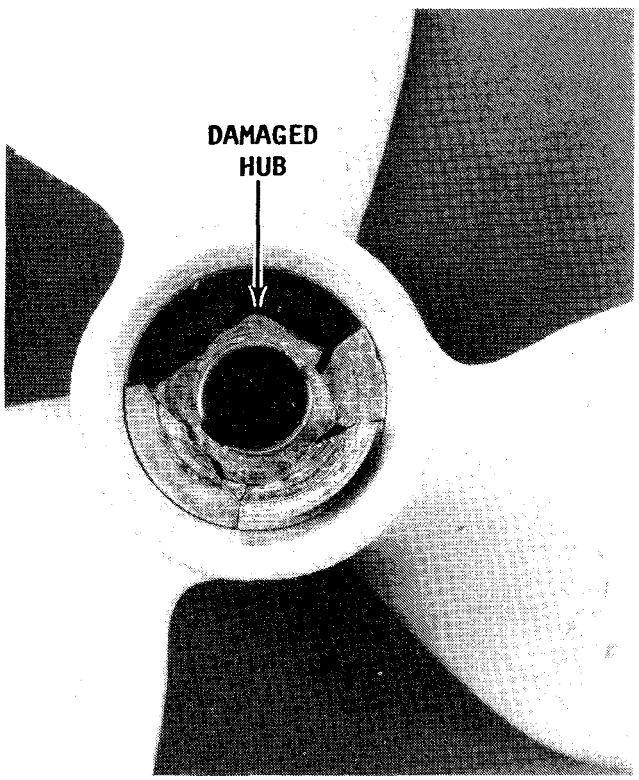
Example of a damaged propeller. This unit should have been replaced long before this amount of damage was sustained.

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 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.



A cracked hub, caused ~ ~ h the propeller struck on underwater object. The rubber hub and propeller sleeve may be replaced at nominal cost.

How much impact the propeller is able to withstand before causing the clutch hub 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 would start to slip, a new hub and shock absorber would have to. be installed.

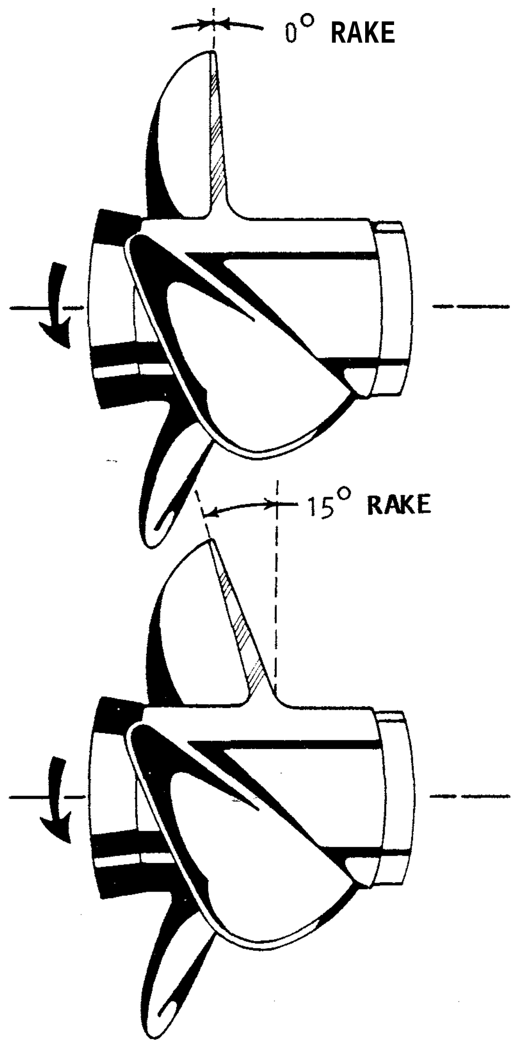


Illustration depicting the rake of a propeller, as explcined in the text.

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.

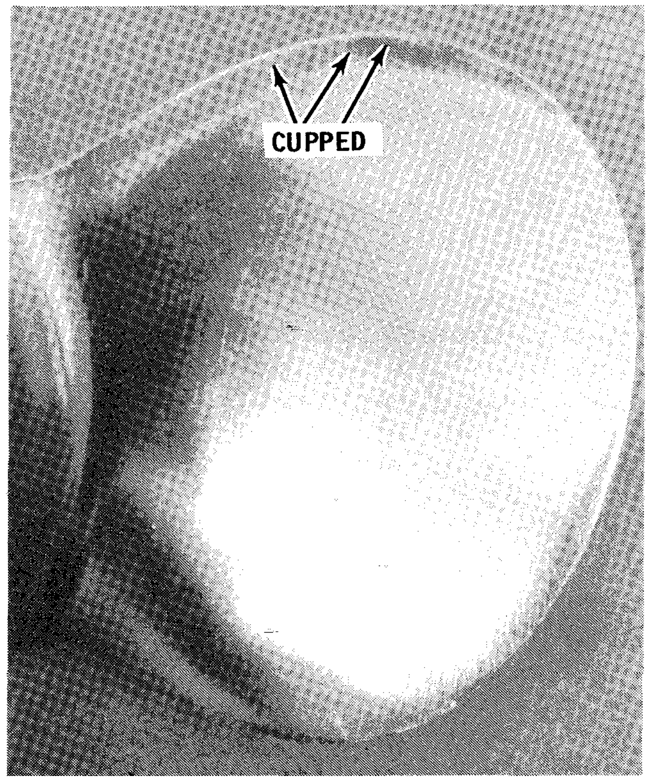
Progressive Pitch

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

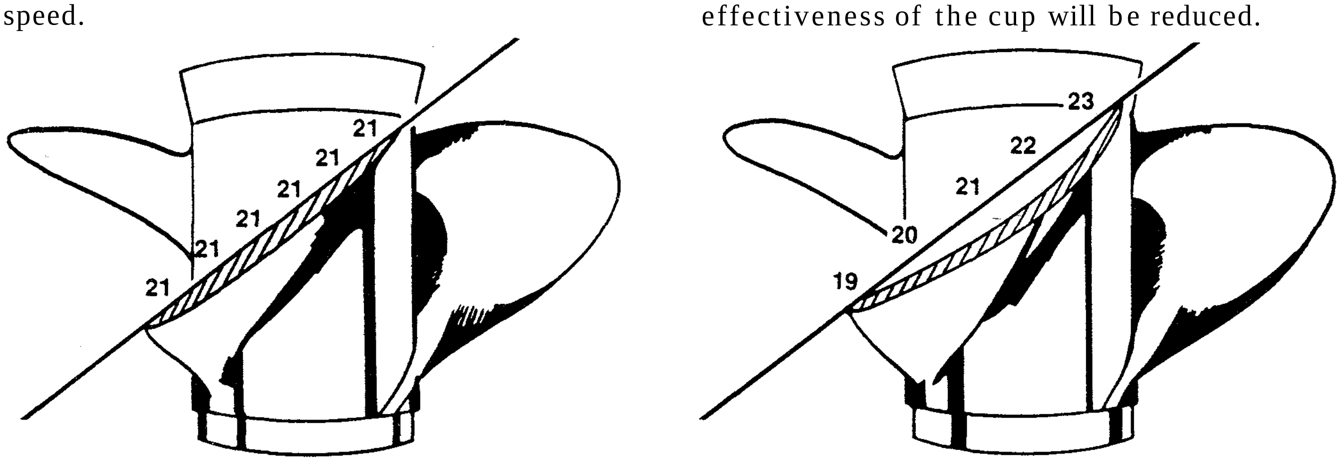
If the propeller is cast with a edge curl inward on the trailing edge, the blade is said to have a cup. In most cases, cupped blades improve performance. The cup helps the blades to "HOLD" and not break loose, when operating in a cavitating or ventilating situation. This action permits the engine to be trimmed out further, or to be mounted higher on the transom. This is especially true on high-performance boats. Either of these two adjustments will usually add to higher speed.



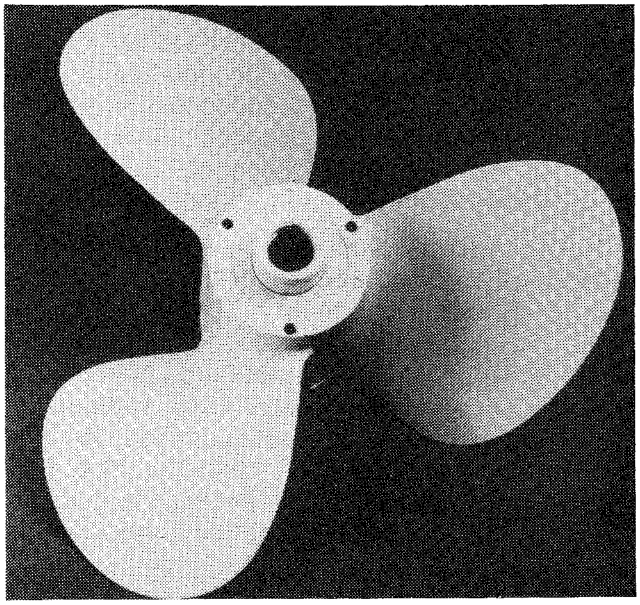
Propeller with a "cupped" leading edge. "Cupping" gives the propeller a better "hold" in the water.

The cup has the effect of adding to the blade pitch, as well as the rake. Cupping usually will reduce full-throttle engine speed about 150 to 300 rpm below the same pitch propeller without a cut 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.



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.



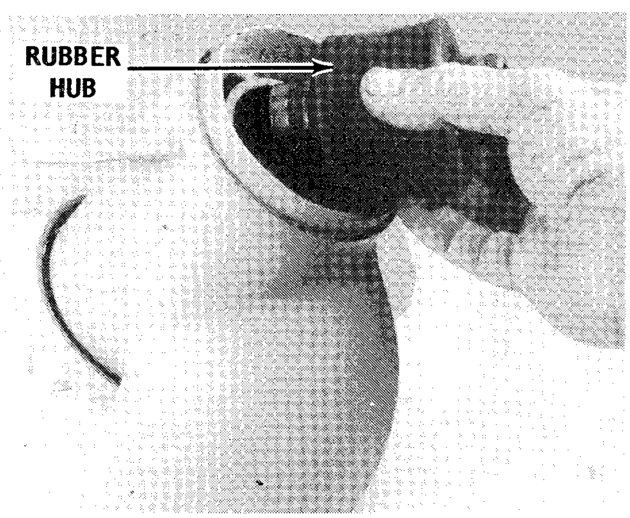
A rebuilt propeller ready for service.

Rotation

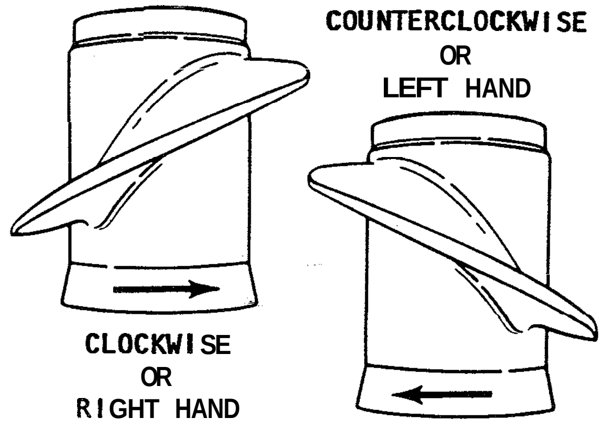
Propellers are manufactured as right-hand rotation (RH), and as left-hand rotation (LH). The standard propeller for outboards is RH rotation.

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

When the 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.



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

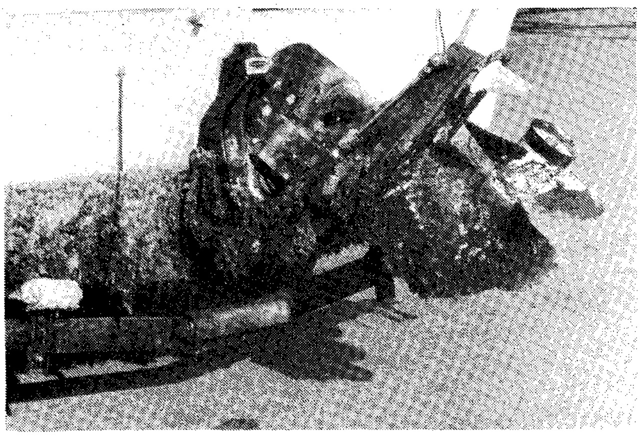


Right- and left-hand propellers showing how the angle of the blades is reversed. Right-hand propellers are by far the most popular.

Propeller Exhaust

To improve engine and boat performance, some OMC propellers feature a hub design with a flared trailing edge or "Diffuser Ring". This feature assists exhaust gas flow, and provides a pressure barrier to help prevent exhaust gases from feeding back into the blades. This arrangement results in more quiet engine operation and the exhaust fumes are buried far behind the boat.

Taking on fuel in preparotion for a day of fun on the water.



A neglected boat and stern drive. Such corrosion and marine growth will be costly to the owner and greatly reduce his boating enjoyment through poor performance.

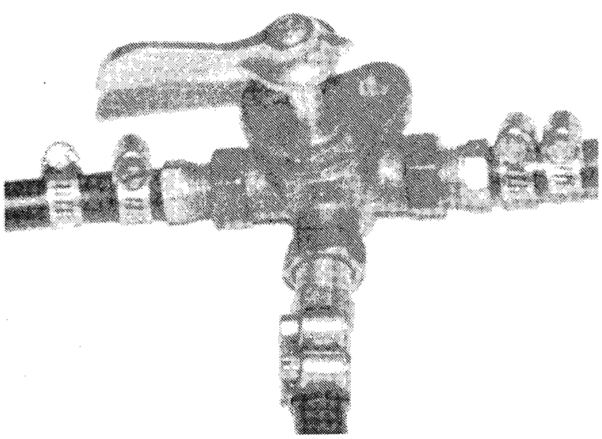
1-5 FUEL SYSTEM

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 three-position valve permits fuel to be drawn from either tank or to be shut off completely. Such an arrangement prevents accidental siphoning of fuel from the tank.

All fittings and outlets must come out the top of the tank. An anti-siphon device should be installed close to the tank. This spring-loaded valve will automatically prevent fuel from being siphoned out of the tank if the line from the tank to the fuel pump should be damaged and begin to leak.

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.

Fuel tanks should be mounted in dry, well ventilated places. Ideally, the fuel tanks should be installed above the cockpit floors, where any leakage will be quickly detected.

In order to obtain maximum circulation of air around fuel tanks, the tank should not come in contact with the boat hull except through the necessary supports. 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 non-absorbent material. Fuel tanks installed in the forward portion of the boat should be

At least one gallon of emergency fuel should be kept on board in an approved container.

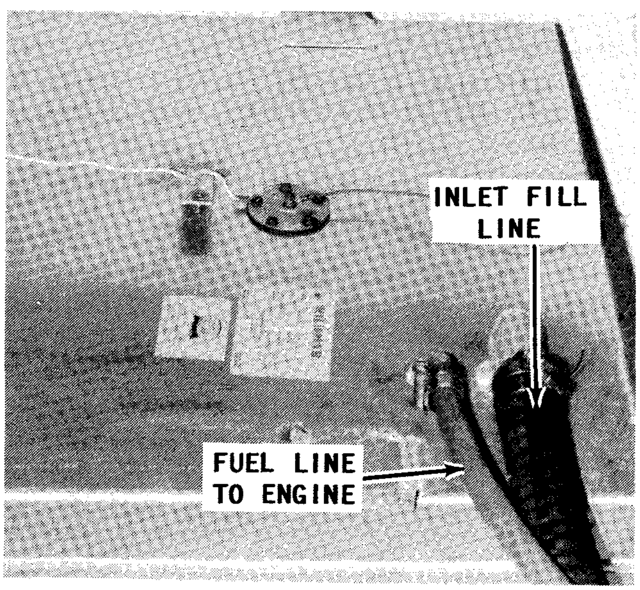
especially well secured and protected because shock loads in this area can be as high as 20 to 25 g's ("g" equals force of gravity).

Engine Compartment Ventilation

All motorboats built after April 25, 1940 and before August 1, 1980, powered by a gasoline engine or by fuels having a flash-point of 110° F. or less **MUST** have the following, which is quoted from a Coast Guard publication dated 1984:

> ***At least two ventilation ducts fitted with cowls or their equivalent for the purpose of properly and efficiently ventilating the bilges of every engine and fuel tank compartment. There shall be at least one exhaust duct installed so as to extend to the lower portion of the bilge and at least one intake duct installed so as to extend to a point at least midway to the bilge or at least below the level of the carburetor air intake.***

All boats built after July 31, 1978 but prior to August 1, 1980, the requirement for ventilation of the fuel tank compartment can be omitted if there is no electrical source of ignition in the fuel tank compartment and if the fuel tank vents to the outside of the boat. After August 1, 1980, all boats with gasoline engines must be built with ventilation systems which comply with Coast Guard standards. The standard requires the engine compartment to be equipped with a blower. Now, if the blower and ventilation system do not meet Coast Guard regulations, the owner can recall the manufacturer to make it right. Owners can not recall the manufacturer for boats built prior to August 1, 1980. The operator is required to keep the system in proper operating condition.



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

In addition to the blower requirement for the engine compartment, a tag **MUST** be affixed to the dashboard stating the blower must be operated for at least four minutes before an attempt is made to start the engine.

This tag requirement is made to the boat manufacturer and the boat owner is responsible for keeping it in place and in readable condition. The tag must be yellow and able to withstand salt spray.

Citation

An owner may receive a citation --ticket and fine -- if the ventilation system is not Coast Guard Approved, in good operating order, and the blower tag is not affixed to the dashboard.

Flame Arrestors

A gasoline engine installed in a motorboat or motor vessel after April 25, 1940, except outboard motors, must have a Coast Guard Approved flame arrestor fitted to the carburetor. This requirement applies if the engine is enclosed or if the carburetor is below the gunwale of the boat.

Automotive Replacement Parts

When replacing fuel, electrical, and other parts, check to be sure they are marine type and Coast Guard Approved. Automotive parts are not made to the high standards of marine parts. The carburetors must **NOT** leak fuel; alternators, generators, and voltage regulators **MUST** be able to operate in a gas fume enclosed area without exploding; etc. Automotive parts could cause a fire endangering the crew and the craft. The part may look the same and even have a similar number, but if it is not **MARINE** it is not safe to use on the boat and will not pass Coast Guard inspection.

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 forrning 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 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 your 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.

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. One method of grounding is to run a copper wire around the tank from the fill pipe to the fuel line. However, such a wire does not ground the fuel in the tank. Manufacturers should imbed a wire in the fiberglass and it should be connected to the intake and the outlet fittings. This wire would avoid corrosion which could occur if a wire passed through the fuel. **CAUTION: It is not advisable to use a fiberglass fuel tank if a grounding wire was not installed..**

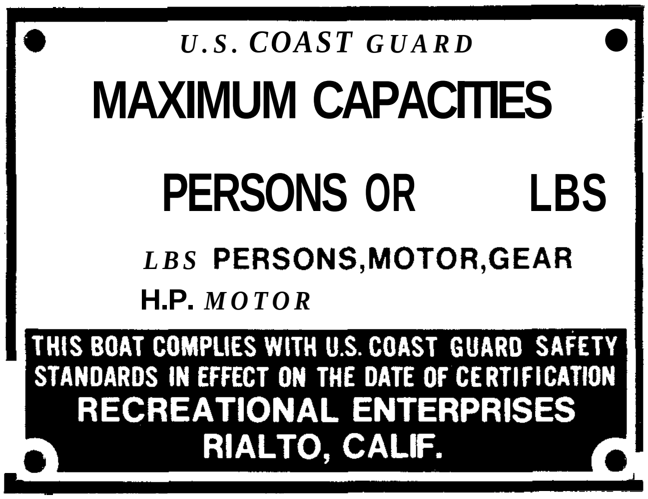
Anything you can feel as a "shock" is enough to set off an explosion. Did you know that under certain atmospheric conditions you can cause a static explosion yourself, particularly if you are wearing synthetic clothing. It is almost a certainty you could cause a static spark if you are **NOT** wearing 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 people 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.

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 planning.



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

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 infornnation 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.

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

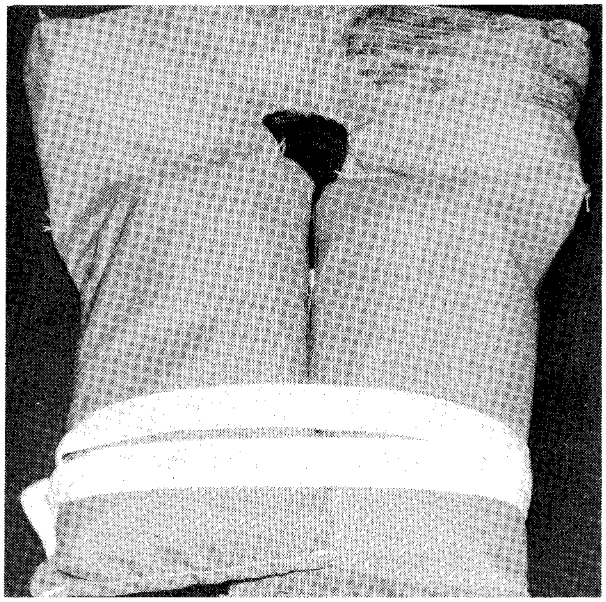
If your boat is-less than 20 ft. overall, a Coast Guard or BIA (Boating Industry of America) now changed to NMMA (National Marine Manufacturers Association) requirement is that the boat must have buoyant material built into the hull (usually foam) to keep it from sinking if it should become swamped. 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 equiprnent aboard does not exceed the maximum load capacity listed on the plate.

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 indestructible.

Life preservers have been classified by the Coast Guard into five type categories. All PFDs presently acceptable on recreational

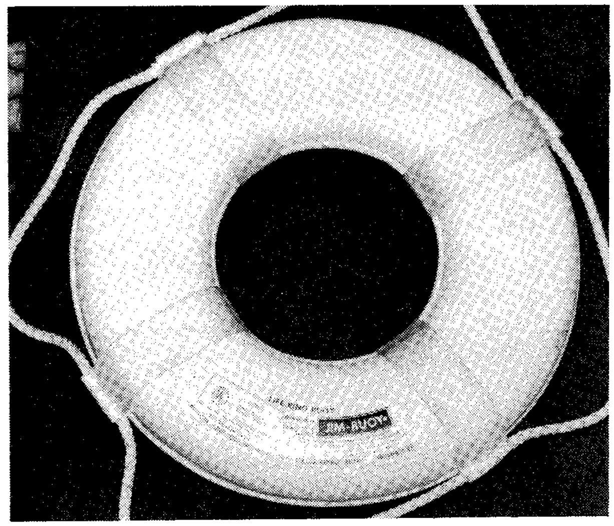


Type I PFD Coast Guard Approved life jacket. This type flotation device provides the greatest amount of buoyancy. ***NEVER*** *use them for cushions or other purposes.*

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

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.



Type IV PFD ring buoy designed to be thrown. On ocean cruisers,-this type device usually has a weighted pole with flag, attached to the buoy.

face down position to a vertical or slightly 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.

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.

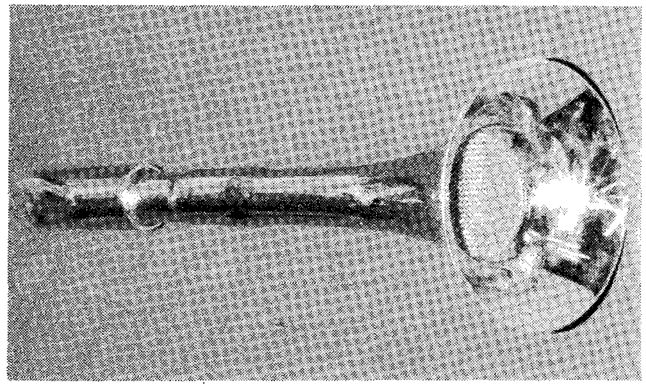
Boats participating in organized events such as races, regattas or marine parades.

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.



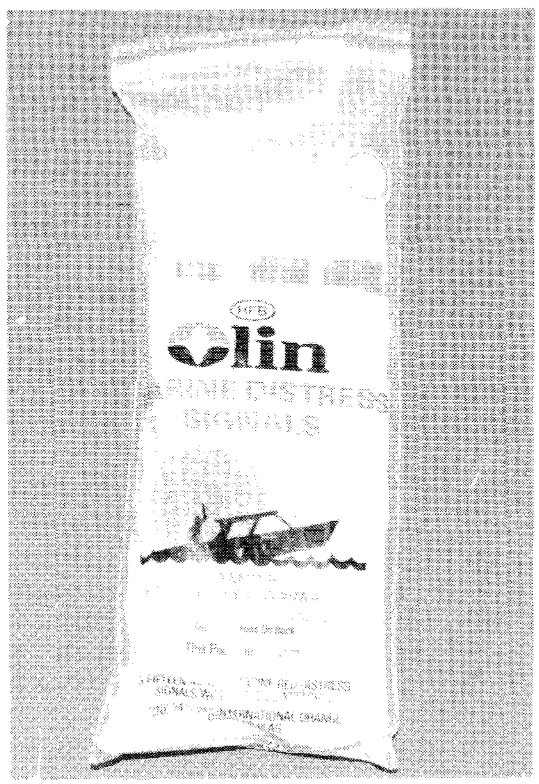
A sounding device should be mounted close to the helmsman for use in sounding an emergency alarm.

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.



Moisture protected flares should be carried on board for use as a distress signal in an emergency.

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

None-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.

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. Re 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.

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 bottorns 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:

B-I contains 1-1/4 gallons foam, or 4 pounds carbon dioxide, or 2 pounds dry chemical agent, or 2-1/2 pounds Halon.

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

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. When the engine compartment of a motorboat is equipped with a fixed (built–in) extinguishing system, one less portable B–I unit is required.

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.

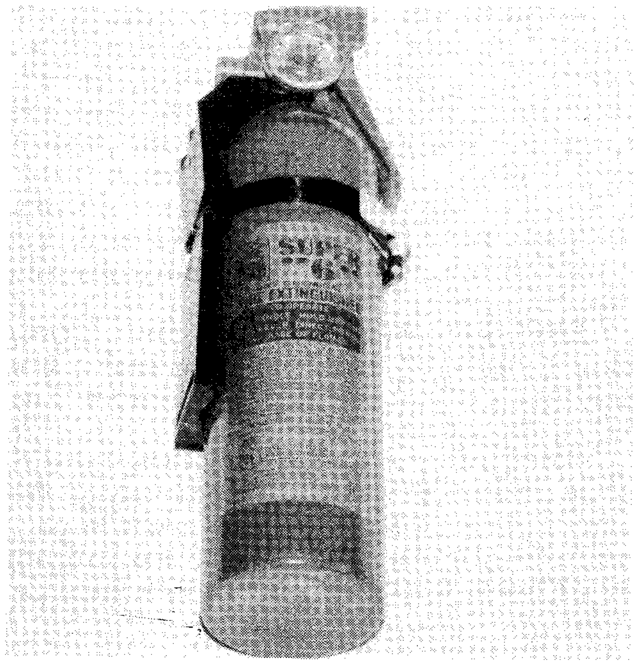
READ labels on fire extinguishers. If the extinguisher is **U.L.** listed, it is approved for marine use.

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

1–10 COMPASS

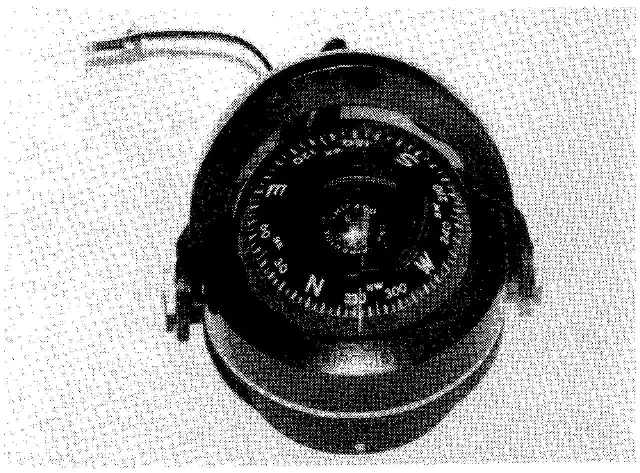
Selection

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 visibilty. 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.



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

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 an the chart for the expected area. Any stranding, even for a short time, can be an unnerving experience.



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

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.

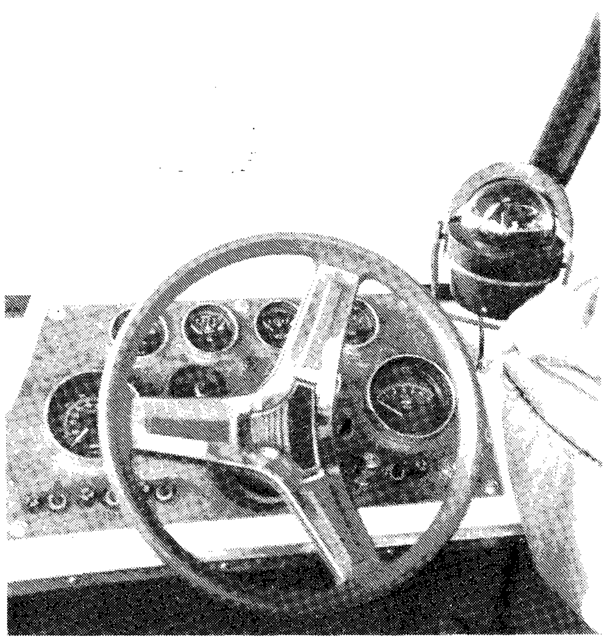
Lift each compass, tilt and turn it, simulating expected motions of the boat. The compass card should have a smooth and stable reaction.

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.



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 helmsman.

Secondly, 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.

Thirdly, inspect the compass site to be sure the instrument will be at least two feet 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 cause a slight deviation, it may be necessary for you to make a different deviation table to use only when certain pieces of equipment is 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.

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.

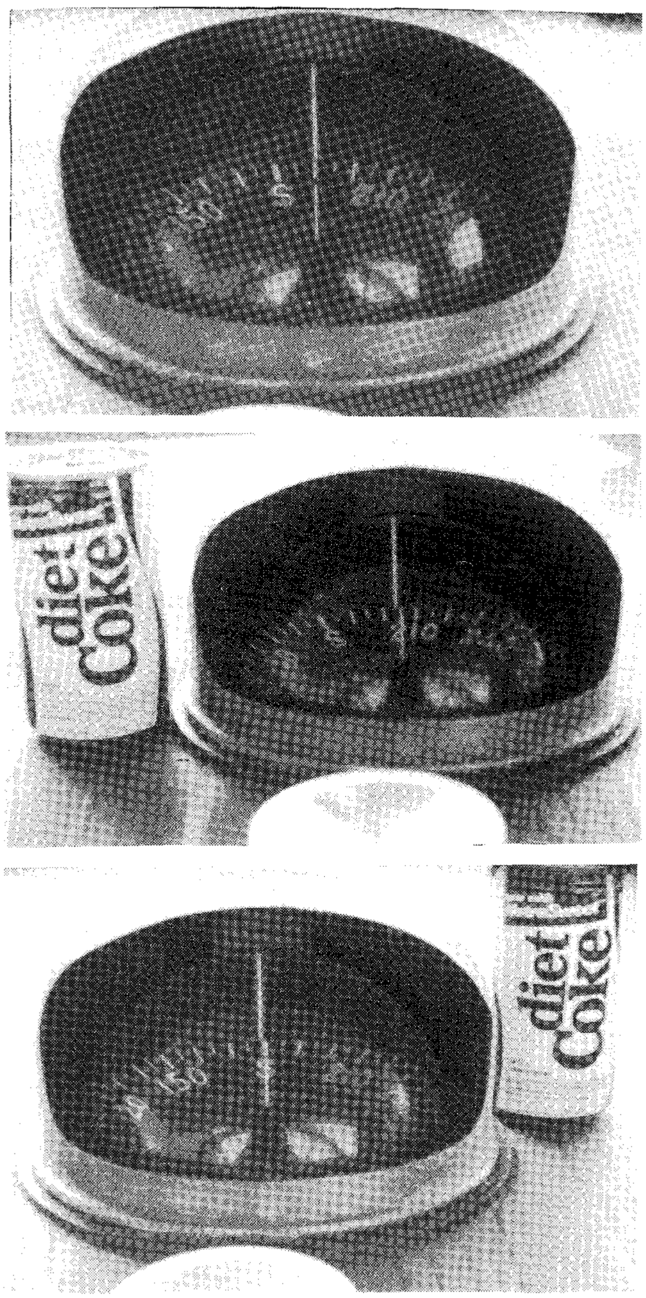
Next a full can of diet coke in an **aluminum** can was placed on one side and the compass read as 204 degrees, a good 14 degrees off.

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.

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.



"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.

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 STEERING

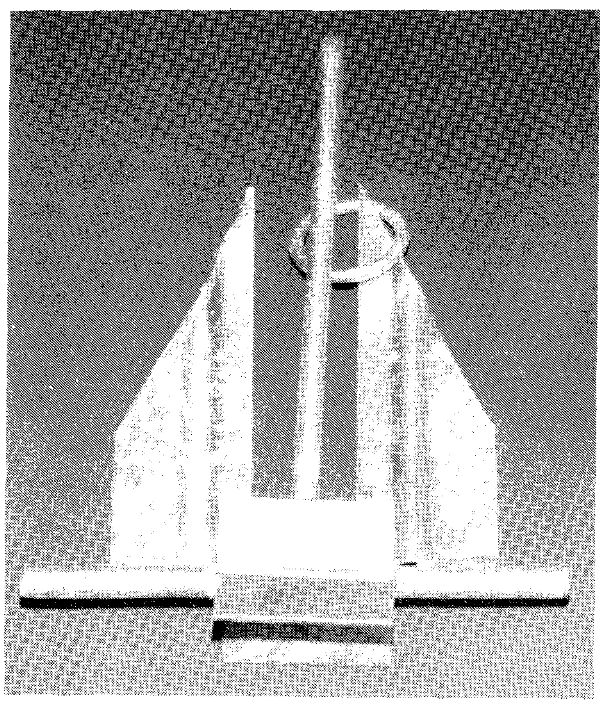
USCG or BIA certification of a steering system means that all materials, equipment, and installation of the steering parts meet or exceed specific standards for strength, type, and maneuverability. Avoid sharp bends when routing the cable. Check to be sure the pulleys turn freely and all fittings are secure. See Chapter 7 for details.

1-12 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.

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.



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

1-13 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."

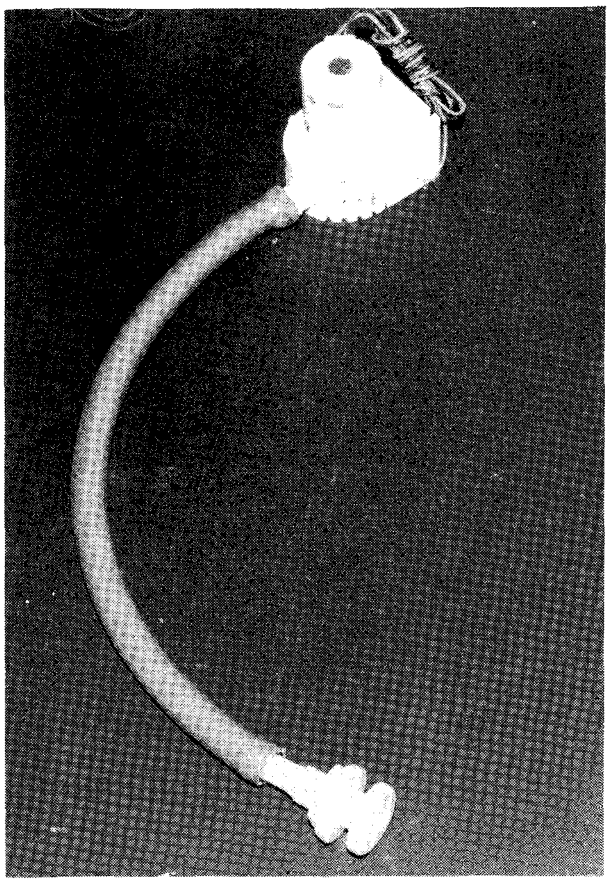
Bilge **Pumps**

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 or ohmmeter. 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 entire bilge pump system will be able to perform properly in an emergency.

1-14 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 $500.00. Some states require reporting of accidents with property damage less than $500.00 or a total boat loss. A **$1,000.00** 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 filled 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.

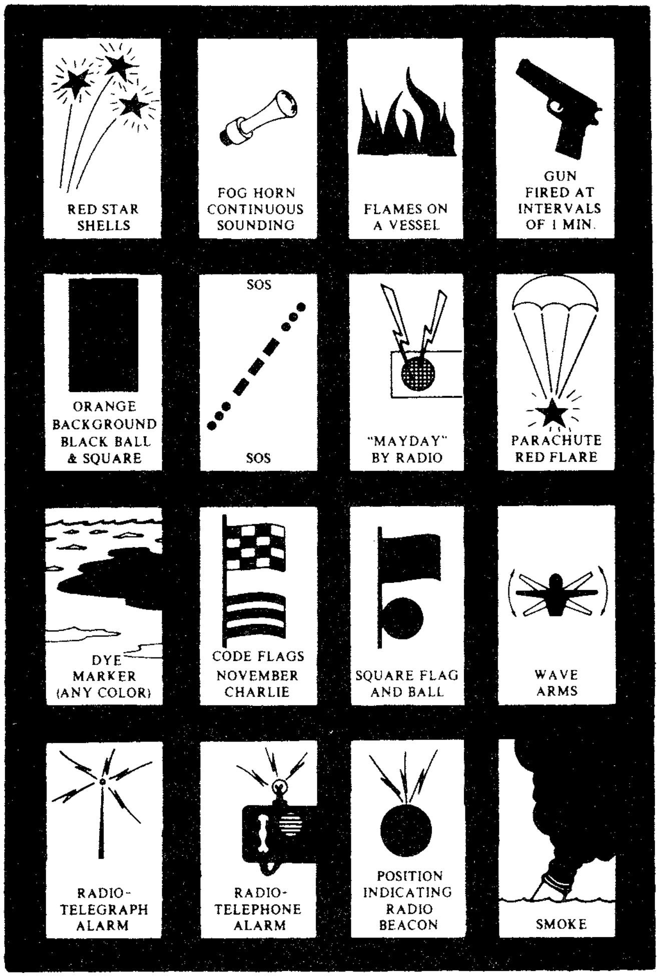
If the operator cannot file the report for any reason, each person on aboard **MUST** notify the authorities, or determine that the report has been filed.

1-15 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 spon-



Internationally accepted distress signals.

sored 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.

The modifications mentioned moved ahead rapidly in the mid and late 1980's and were scheduled to be completed in the early 1990's.

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.

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 -- almost a synopsis of the rules and 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.)

2
TUNING

2-1 INTRODUCTION

The efficiency, reliability, fuel economy and enjoyment you receive from the engine's 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. Do not rely on your memory.

Before beginning to tune any engine, check to be sure the engine cylinders have satisfactory compression. An engine with worn piston rings, burnt valves, or a blown gasket cannot be made to perform properly no matter how much time and expense is spend on the tune-up. Poor compression must be corrected or the tune-up will not give the desired results.

2-2 TUNING FOR PERFORMANCE

First, check the battery to be sure it will deliver enough energy. The battery must not only crank the engine rapidly enough to draw in the proper amount of air-fuel mixture and compress it, but the battery must also have enough energy left to energize the ignition system for a hot spark to ignite the mixture.

Mechanical checks and service includes adjusting the fan belt, checking the compression, tightening the cylinder head and manifold bolts, and adjusting the valve.

Ignition system service includes replacing and adjusting the contact points, checking the ignition advance, and adjusting the timing.

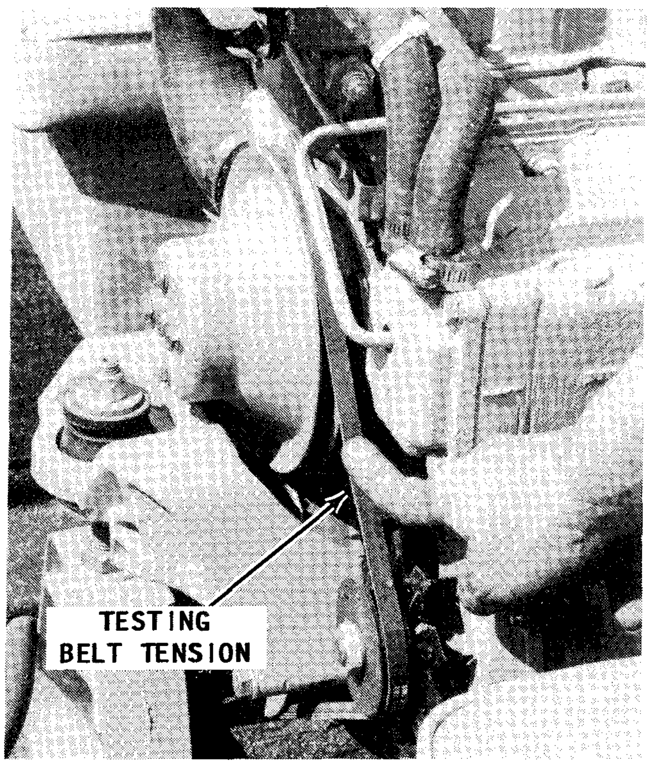
Fuel system service and carburetor adjustments are made after all ignition checks and adjustments have been completed. It is very important to complete the ignition work before moving to the fuel system because the ignition adjustments have so much affect on the carburetion.

2-3 MECHANICAL TASKS

Check the drive belt at least once a year or during each tune-up. Replace the belt if there is any evidence of a crack or tear on the under surface.

If it is necessary to install a new belt, be sure to use only the size and type recommended by the engine manufacturer.

Adjust the belt tension by first loosening the brace and pivot bolts, and then pivoting



Adjust the drive belt until the belt will depress approximately 1/4-inch under finger pressure.

the alternator away from the engine until the belt deflection is 1/4 inch (6.35mm) when you exert a downward pressure against the belt. Make the belt deflection measurement midway between the circulating pump pulley and the alternator pulley. Tighten the alternator bracket and pivot bolts securely.

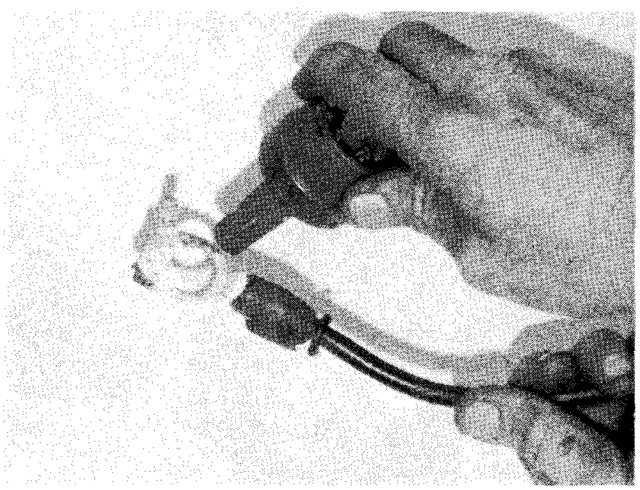
If the battery has a record of not holding a full charge, check the tension of the drive belt. The failure to hold a full charge may also be caused by a faulty alternator or a defective voltage regulator. The cause of a battery using too much water is usually attributed to the voltage regulator being set too high. In this case, replace the regulator. Refer to Chapter 6 for service details of the electrical system.

Battery Service

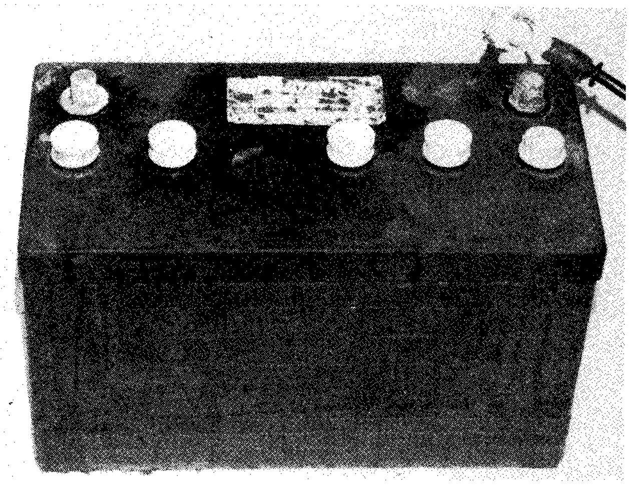
Check the battery, cables, and surrounding area for signs of corrosion. Look for loose or broken carriers; cracked or bulged cases; dirt and acid; electrolyte leakage; and low electrolyte level. Add distilled water to the cells to bring them up to the proper level. Keep the top of the battery clean and be sure the battery is securely fastened in position.

When cleaning the battery BE SURE the vent plugs are tight to prevent any of the cleaning solution from entering the cells. First, wash the battery with a diluted ammonia or soda solution to neutralize any acid, and then flush the solution off with clean water.

Keep the battery hold-down device tight enough to prevent any movement but not so tight that it puts the battery case under a strain.

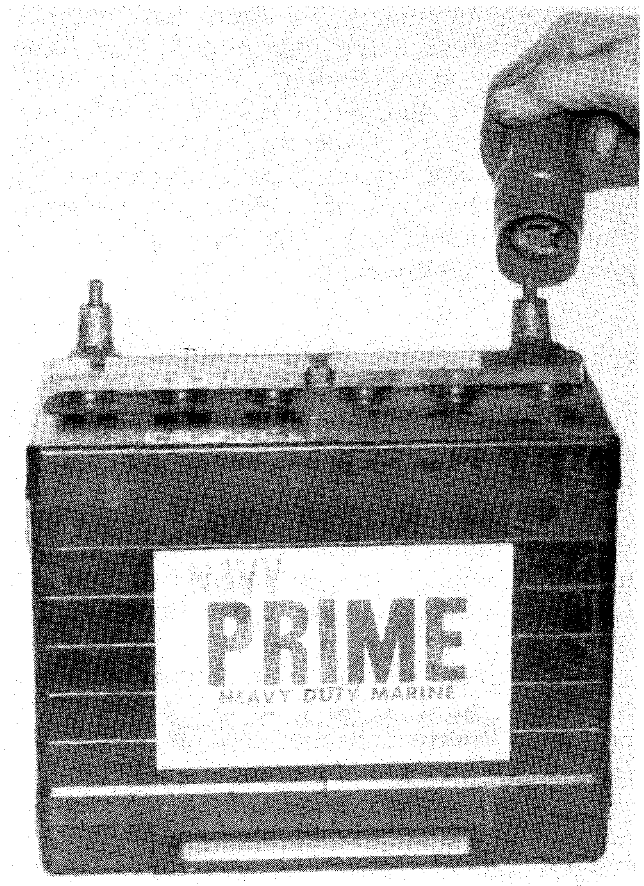


An inexpensive brush is the best tool for cleaning the inside diameter of battery cable connectors.

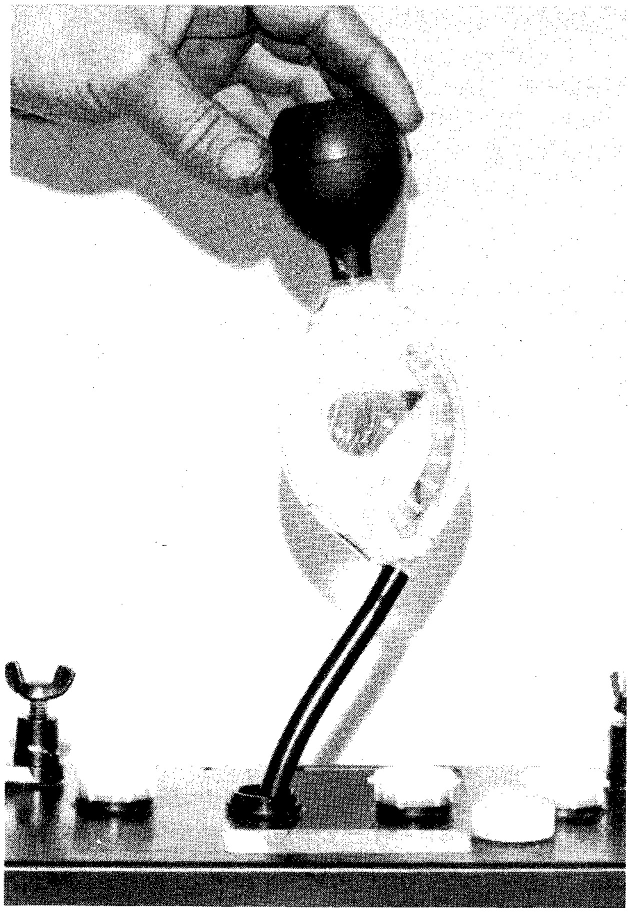


Many electrical problems can be traced to corroded battery terminals. The most serious damage could be a burned-out alternator.

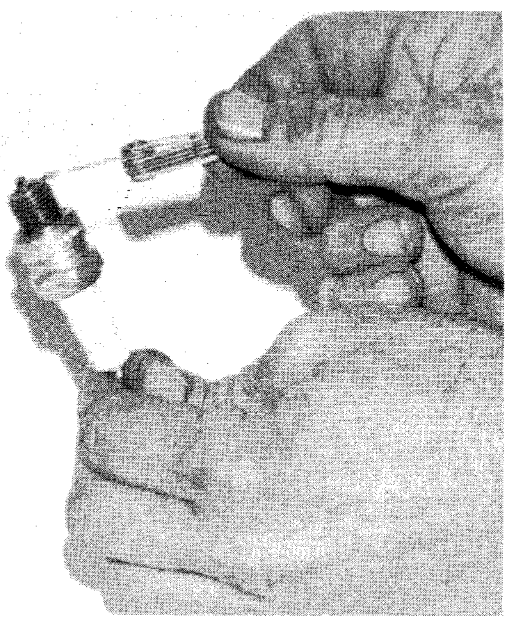
Tighten the battery cables on the battery posts to ensure a good contact. Clean the posts or cable terminals with a wire brush if they have become corroded. After the posts and terminals are clean, apply a thin coating of Multipurpose Lubricant to both as a preventative measure against corrosion forming.



Using a special tool to clean the battery terminals. After cleaning and the cables have been connected, coat the terminals and connectors with lubricant to prevent further corrosion.



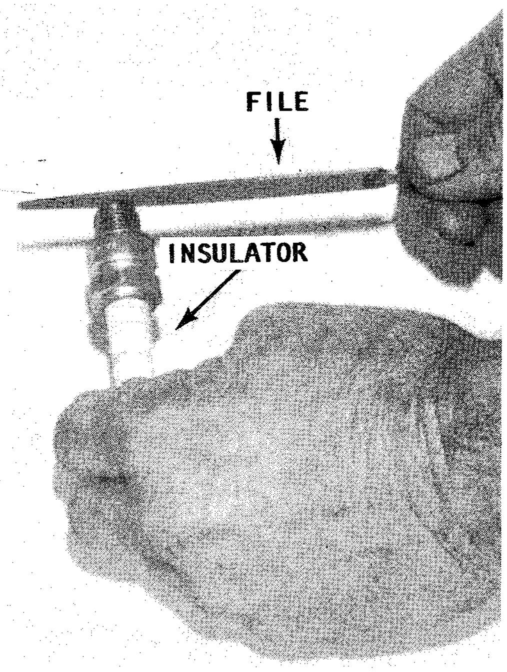
Test the battery electrolyte at regular intervals.



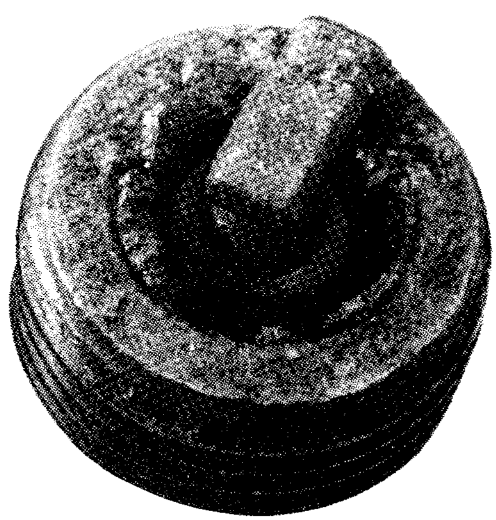
ALWAYS use a round gauge to measure spark plug gap. A flat gauge will not give an accurate reading. NEVER use a gasket on a spark plug with a tapered seat.

Spark Plug Cleaning

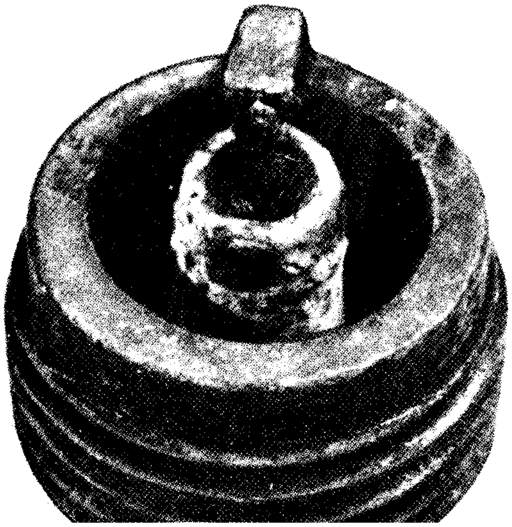
Grasp the molded cap, then twist slightly and pull it loose from the plug. Do not pull on the wire, or the connection inside the cap may become separated or the boot may be damaged. Remove the spark plugs and be careful not to tilt the socket, to prevent cracking the insulator. Compare the spark plugs with the illustrations on this page and the next page to determine how the engine has been running. Clean and gap the spark plugs. Use the specifications in the Appendix for the proper gap dimension.



Engine misfire and poor fuel economy can be caused by corroded spark plug electrodes. To regain performance, file and reset each spark plug, if they are the least bit corroded.

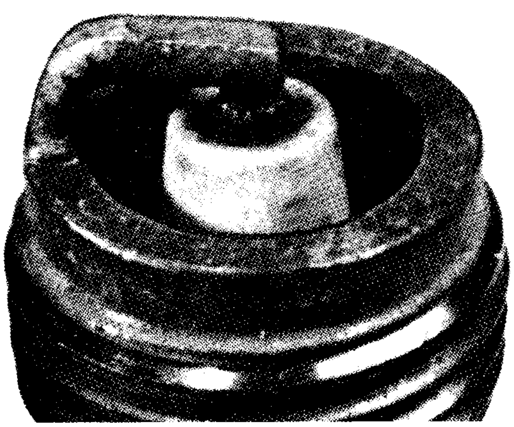


Spark plug fouled by oil. The engine may need an overhaul.



Excessive overheating, heavy load. Use a spark plug with a lower heat mting.

Powdery deposits have melted and shorted-out this spark plug.



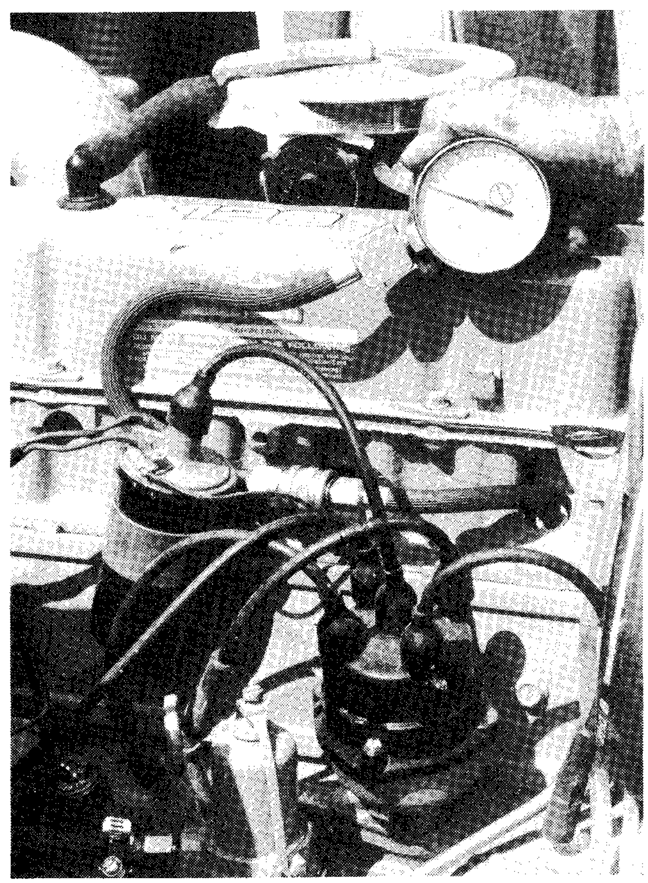
Red, brown, or yellow deposits are by-products of combustion from fuel and lubricating oil.

Cylinder and Manifold Bolt Tightening

Tighten the cylinder head and manifold bolts in the sequence detailed by the diagrams in Chapter **3,** Engine Service, and according to the torque specification given in the Appendix.

Compression Testing

Insert a compression gauge in each spark plug opening one-at-a-time; crank the engine and check the compression. A significant variation between cylinders is far more important than the actual reading of each one individually. A difference of over 20 psi, indicates a ring or valve problem. To determine which needs attention, insert a teaspoonful of oil into the spark plug opening of the low reading cylinder, and then crank the engine a few times to distribute the oil. Now, check the compression again to see if inserting the oil caused a change. If the reading went up, then the compression loss is due to worn rings. If the reading remained the same, the loss is due to a burned valve.



Check the compression of each cylinder.

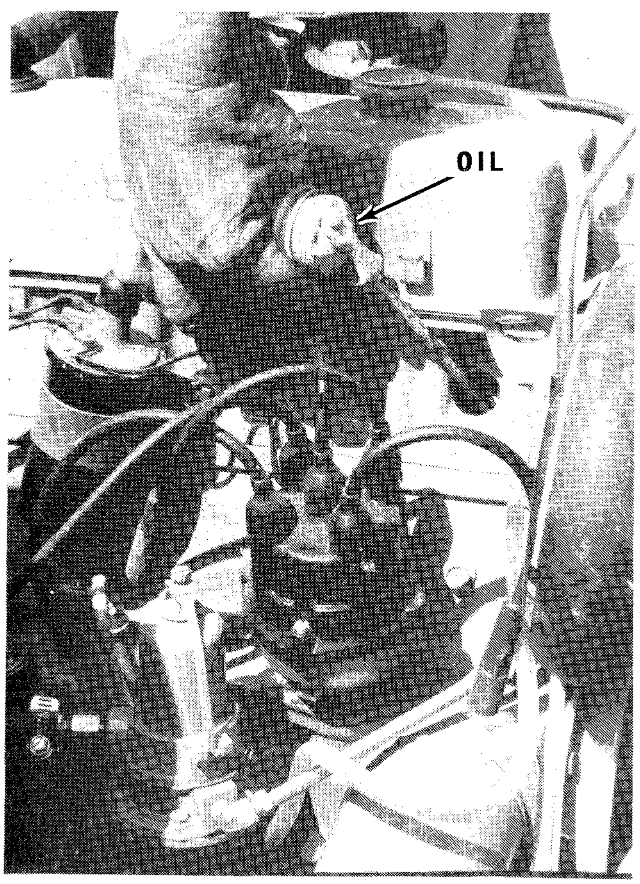
Valve Adjusting

Proper valve adjustment allows the hydraulic lifters to operate in the center of their designed travel. Valve adjusting is not a simple one-two operation. Therefore, this procedure is covered in detail in Chapter 3, in the following sections:

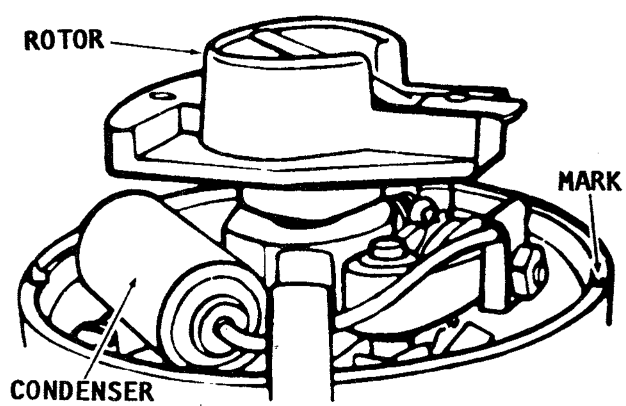
CMC 4- and 6-cyl. in-line engines -- 3-7.
GMC V6 engines -- 3-12
GMC V8 engines -- 3-29.
Ford V8 engines -- 3-40.

2-4 IGNITION SERVICE

It is not possible to do a good job of replacing the contact points with the distributor in the engine. To remove the distributor, turn the crankshaft until the rotor points to the No. 1 cylinder position. Most distributor caps have a "1" stamped on the cap. Remove the hold-down bolt. Remove the distributor slowly and you will notice the rotor turn. When the rotor stops turning, the distributor gear is free of the camshaft gear. At this point scribe a mark on the distributor housing in line with the edge of the rotor as an aid to installation.



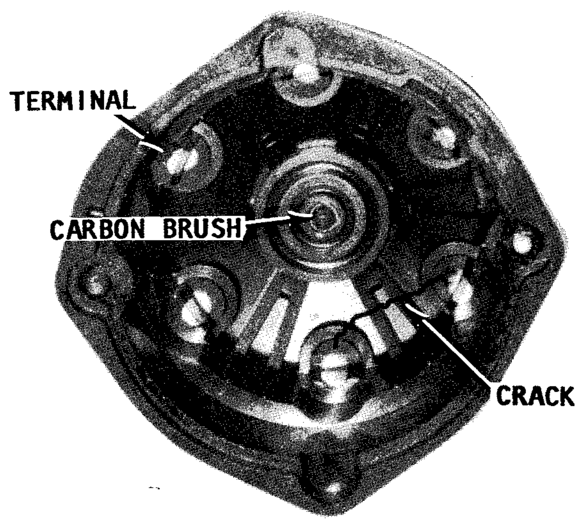
Use a couple squirts of engine oil into the cylinder to determine if the compression loss is a burned valve or worn piston'rings, as explained in the text.



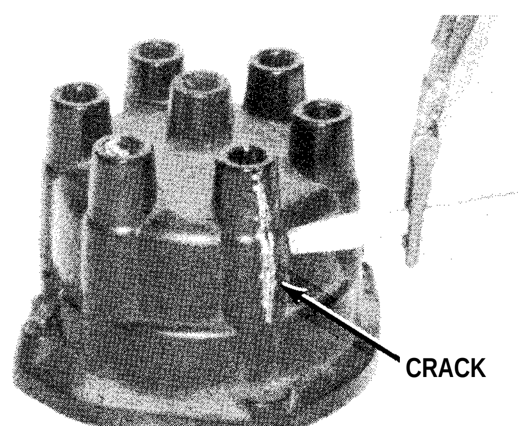
Replace a pitted rotor.

At the time of installation, align the rotor on the mark you scribed on the housing, then lower the distributor slowly and you will see the rotor turn back until it is pointing to the No. 1 cylinder position.

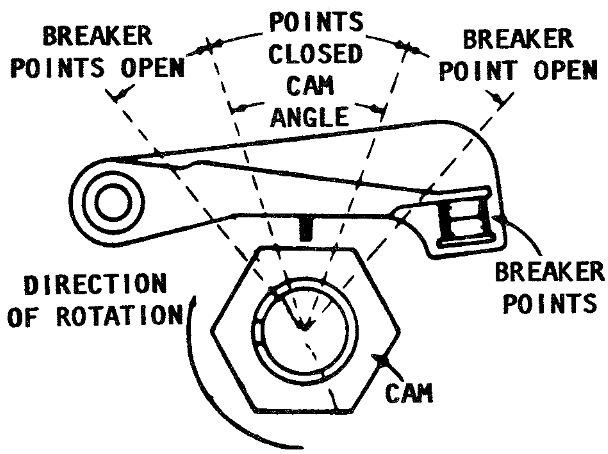
Always replace the contact points rather



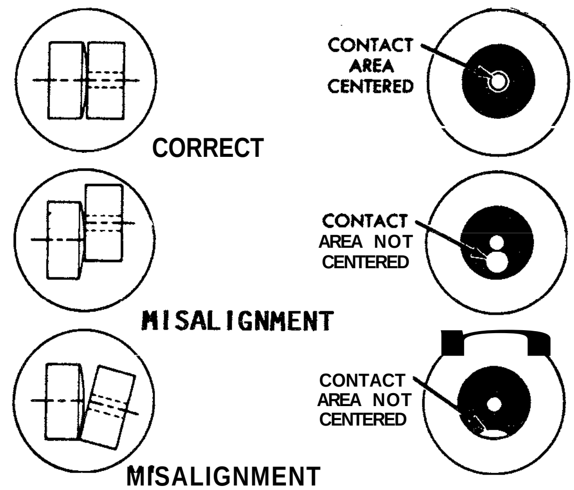
A crack in the distributor cap can cause hard starting and misfire, especially at high speed.



A cracked distributor cap may be the cause of hard starting or misfiring.



The dwell angle is directly related to the point gap.



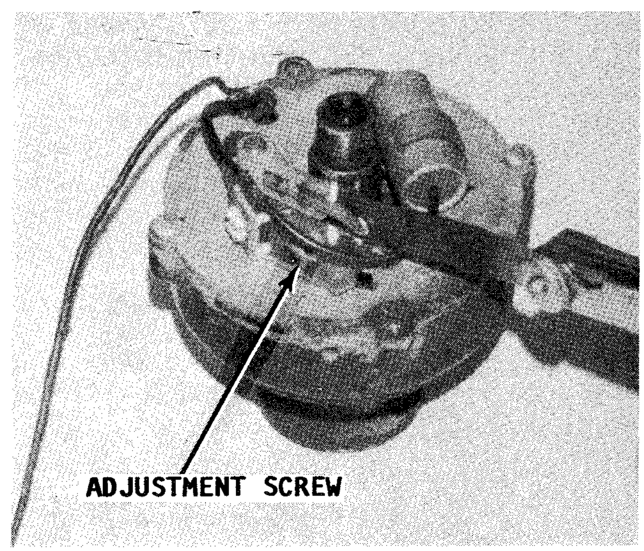
Breaker point alignment guide.

than filing, them. It is seldom necessary to replace the condenser.

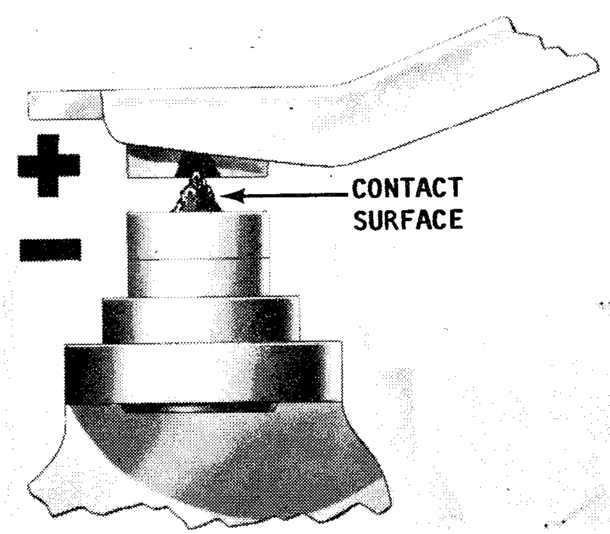
Adjust the point gap according to the specifications listed in the Appendix. Keep the feeler gauge blade clean, because the slightest amount of oil film will cause trouble when it oxidizes.

It is best to add 0.003" to the clearance specification when installing a new set of contact points to compensate for initial rubbing block wear. **ALWAYS** keep the contact point retaining screw SNUG during the adjustment to prevent the gap from changing when it is finally tightened.

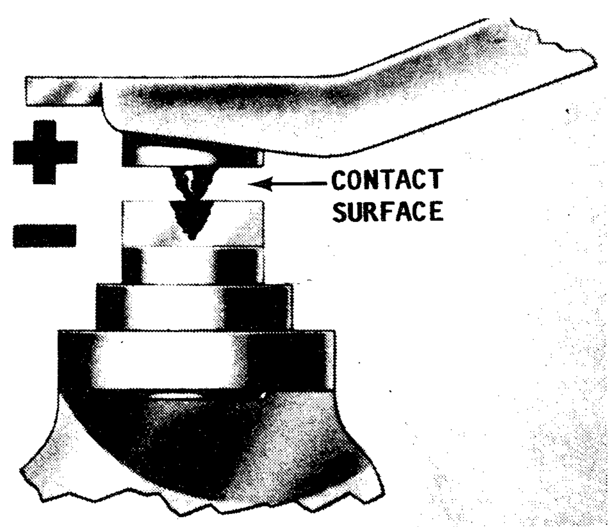
After the proper gap adjustment has been made, apply a light layer of heavy grease to coat the distributor cam. Turn the distributor shaft in the normal direction of rotation so the lubricant is wiped off against the back of the rubbing blodk. The grease will remain on the rubbing block as a



.Adjusting the point gap.



Check the contact points for abnormal wear, burning, or pitting.



A faulty condenser will cause abnormal contact point wear and loss of engine performance.

reservoir to supply lubricant as the block wears. Wipe off any excess lubricant. Leave only the grease stored on the rubbing block.

Replace the distributor in the engine, with the rotor pointing toward the mark you scribed on the housing. Tighten the hold-down bolt. The ignition timing will be adjusted after the engine is running, as described in the following paragraphs.

Ignition Timing

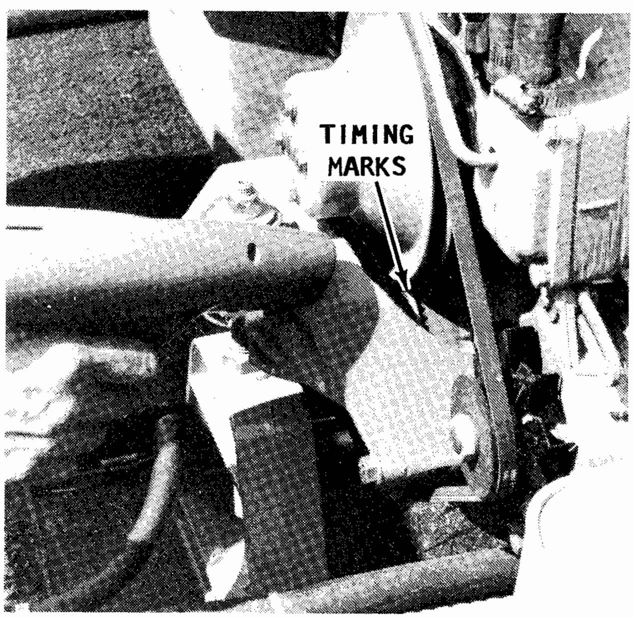
Connect a tachometer to the coil leads. Connect a power timing light to the No. 1 spark plug. Do not puncture the wire or boot when you install the timing light because a puncture could start a voltage leak and lead to problems later.

Start the engine and adjust the speed and timing to the specifications listed in the Appendix.

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 a point adjustment is required, stop the engine, remove the cap, and make the adjustment. Remember, the dwell setting (gap) of the contact points affects the ignition timing; therefore, it is essential the dwell be set before adjusting the ignition timing.

Idle the engine at 600 rpm or less to be sure no centrifugal advance is taking place.



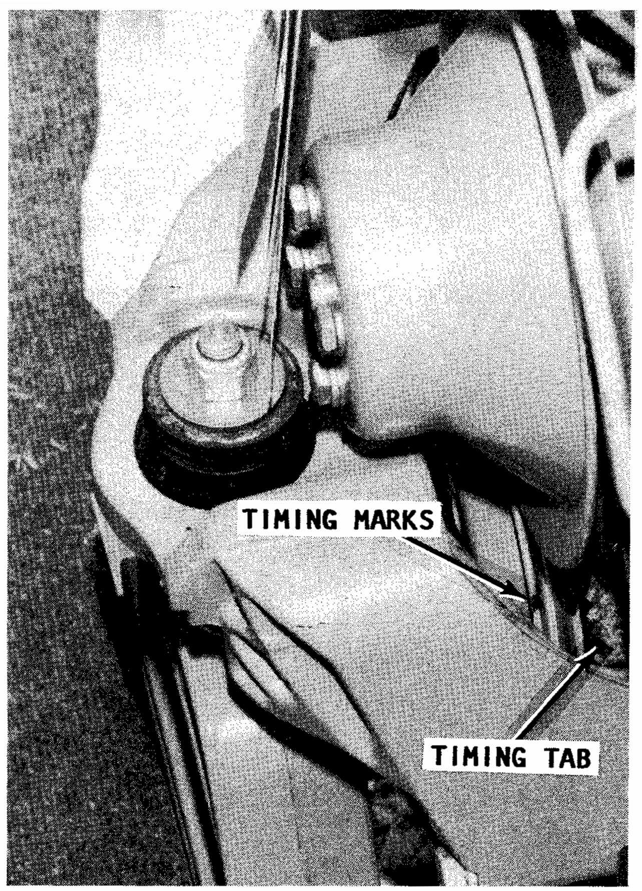
Using a timing light connected to the No. 1 spark plug lead to adjust the timing.

Idle the engine at 600 rpm or less to be sure no centrifugal advance is taking place. Loosen the hold-down bolt, adjust the ignition timing by rotating the distributor housing, then tighten the hold-down bolt.

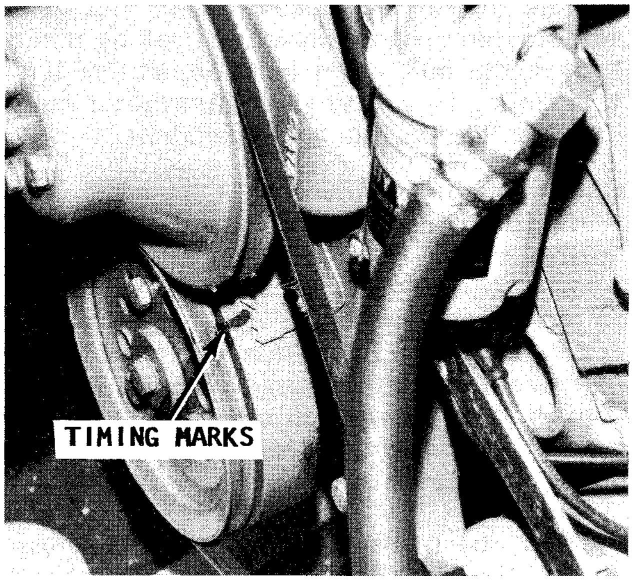
Checking Ignition Advance

Ignition timing is varied according to engine speed by means of a centrifugal advance unit. During tune-up, it is essential to check the operation of this unit. An accurate check can be made using a timing light with a timing gauge and an advance control knob. If you do not have this piece of test equipment,' a rough check can be made to be sure the system is functioning properly.

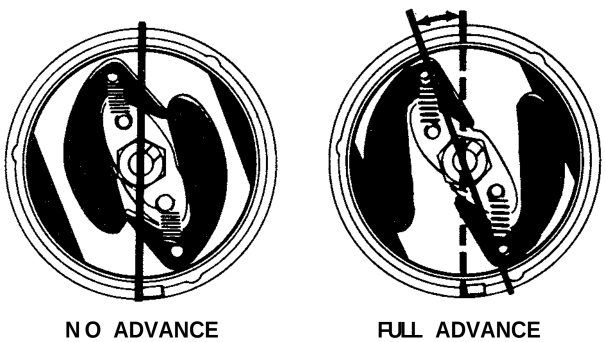
With the ignition timing properly adjusted and the.timing light connected to No. I spark plug wire, increase engine speed to the rpm given in the Centrifugal Timing Table in the Appendix. The ignition timing must advance to the range (in degrees) shown in the table. If the speed fails to advance to the required range, remove the distributor and check the advance mechanism under the breaker plate.



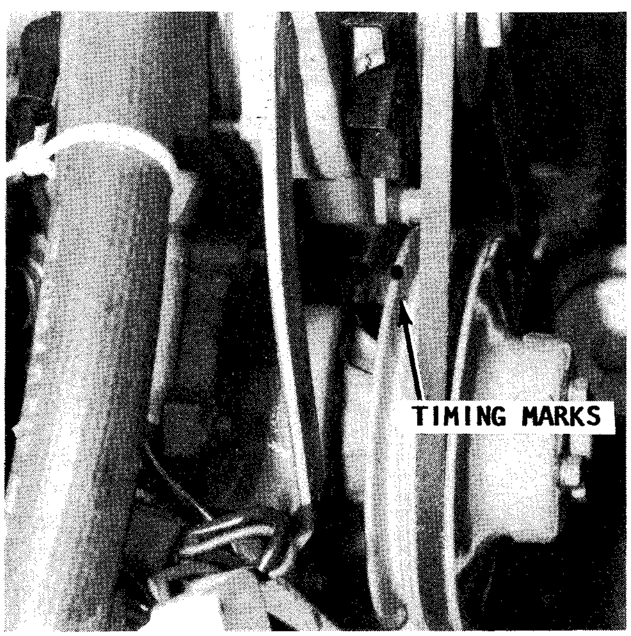
Timing marks on late model in-line engines.



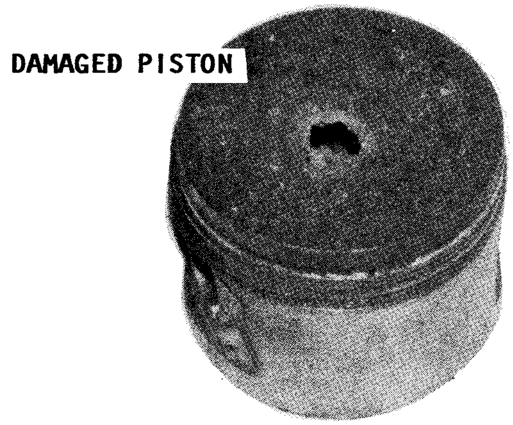
Typical timing marks.



Twist the rotor and check the automatic advance weights for good movement. The rotor must feel springy in one directon and solid in the opposite direction. Engine performance will suffer if the rotor turns sluggish&.



Typical timing marks on the crankshaft pulley.



Damage to this piston was caused by abnormal combustion because the fuel exploded violently, causing the spark plug, piston, and valves to overheat. Proper adjustment of the spark advance or a change in fuel to a higher octane rating may correct the problem.

2-5 FUEL SYSTEM SERVICE

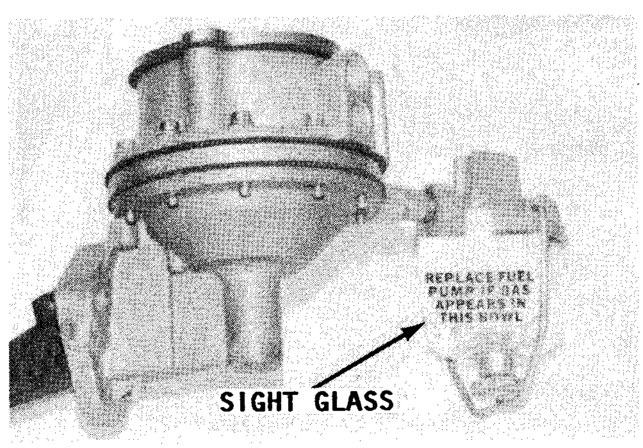
General Practices

Change the fuel filter in the base of the carburetor at least once a year. When the filter is changed, be sure to use a new gasket under the nut to prevent fuel from leaking out of the filter.

Change the water separator every year. Clean the flame arrestor after every 100 hours of operation.

Dual-Diaphragm Fuel Pump

As the name implies, the dual-diaphragm fuel pump has two diaphragms separated by a metal spacer and an attached sight gauge. Three important safety features are built into this type of pump. The pump will continue to operate on the second diaphragm if the main diaphragm fails. Gasoline can only leak into the space between



Fuel in the sight glass means the diaphragms are leaking and the fuel pump must be replaced.

the two diaphragms and not out of the pump. If gasoline is detected in the sight gauge, it means the pump is defective.

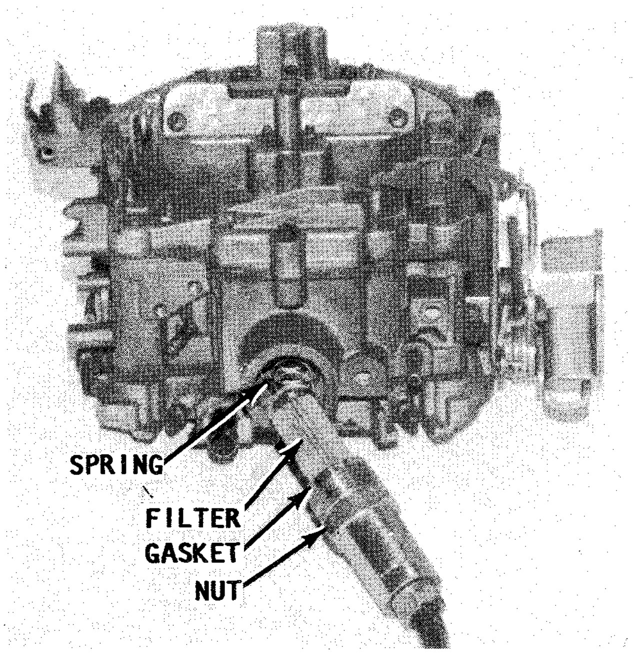
If the dual-diaphragm becomes defective for any reason, it must be replaced. Do not attempt to repair this type of pump.

Carburetor Adjustment

Because the carburetor is required to accurately control and mix the air and fuel quantities entering the combustion chamber, proper adjustments are critical to efficient engine operation. Dirt and gum in the passages restrict the flow of air or fuel causing a lean operating condition; hesitation on acceleration; and lack of power on demand.

The carburetor control linkage is subject to wear which will change the synchronization and fuel mixture. These changes will affect engine performance and fuel economy. Therefore, accurate fine carburetor adjustments can hardly be made or expected if the carburetor is not in satisfactory condition. If considerable difficulty is encountered in making the adjustments, the remedy may be to take time for a carburetor overhaul, see Chapter 4.

To make a preliminary adjustment, turn the idle mixture adjusting needles inward until they **BARELY** make contact with their seats, then back the needle out the specified number of turns.



The fuel filter in the base of the carburetor should be replaced every year.

NEVER turn the idle mixture screws **TIGHTLY** against their seats or they will be **DAMAGED.** Disconnect the throttle cable. Start the engine and run it at idle speed.

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.

Adjust each idle mixture needle to obtain the highest and steadiest manifold vacuum reading. If a vacuum gauge is not available, obtain the smoothest running, maximum idle speed by turning one of the idle adjusting needles in until. engine speed begins to fall off, then back the needle off over the "high spot" until the engine rpm again drops off. Set the idle adjusting needle halfway between the two points for an acceptable idle mixture setting. Repeat this procedure with the other needle.

If these adjustments result in an increase in idle rpm, reset the idle speed adjusting screw to obtain the specified idle rpm and again adjust the idle mixture adjusting needles.

Shift the unit into forward gear and readjust the idle speed screw to obtain the recommended idle speed as given in the Appendix.

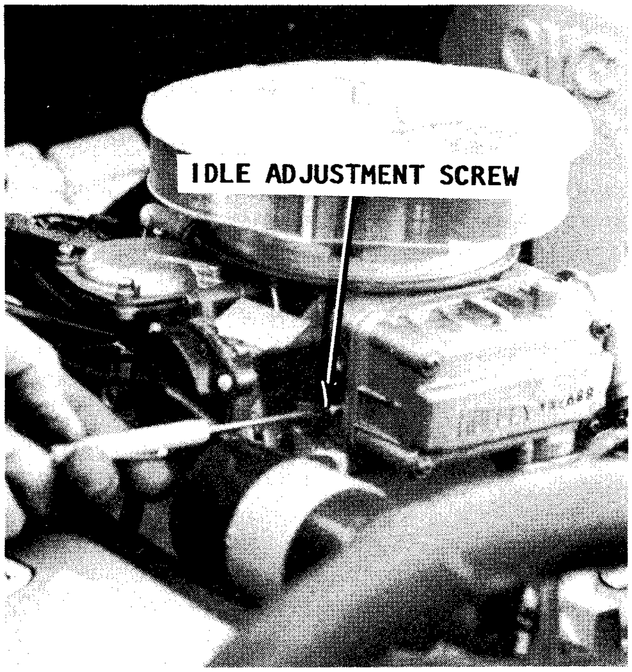
Stop the engine and install the throttle cable. Check to be sure the throttle valves are in the full open position when the remote-control is in the full forward position. On the 120 hp to 165 hp units, with the throttle valves fully open, turn the wide-open throttle stop adjusting screw clockwise until the screw just touches the throttle lever. Tighten the set nut securely ta prevent the adjustment screw from turning. Return the shift lever to the neutral gear and idle position. The idle-stop screw should be against its stop.

Calibration for High Altitudes

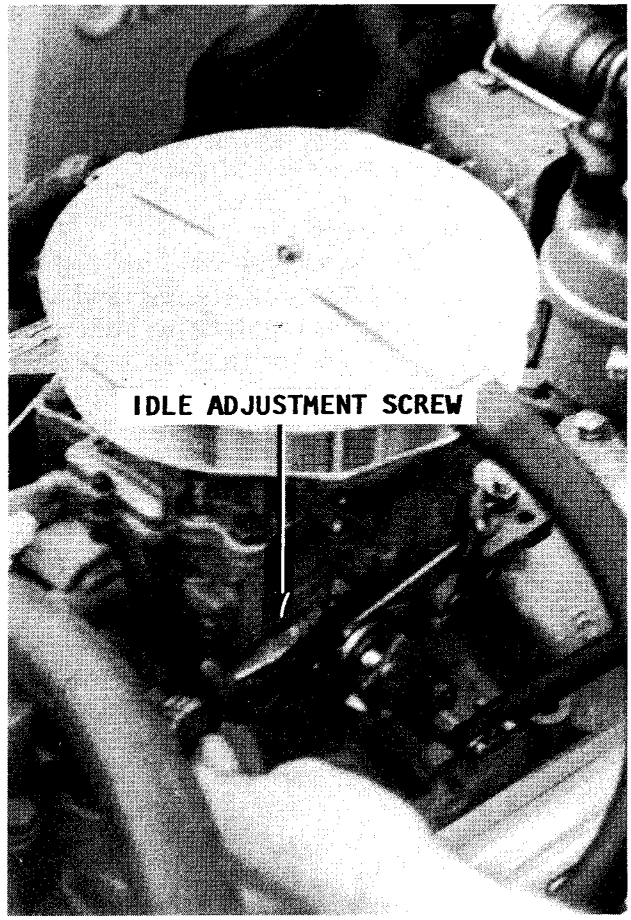
Increased spark advance or carburetor recalibration have very little affect on high-altitude performance. Tests have proven this statement to be true. However, a marked increase in performance can be obtained by changing propellers for high-altitude operation.

Changing the prop should be the only modification considered to obtain the rated rpm. Any other recommendation should be considered a special case and should be referred to the factory branch or area distributor for specific jet sizes and spark timing settings.

Changing jet sizes and spark timing settings will: Cause engine failure if operated at lower elevations; result in increased fuel economy but will not have any significant affect on performance; and may cause added problems at much lower elevations.



Idle speed adjusting screw location on GMC engines.



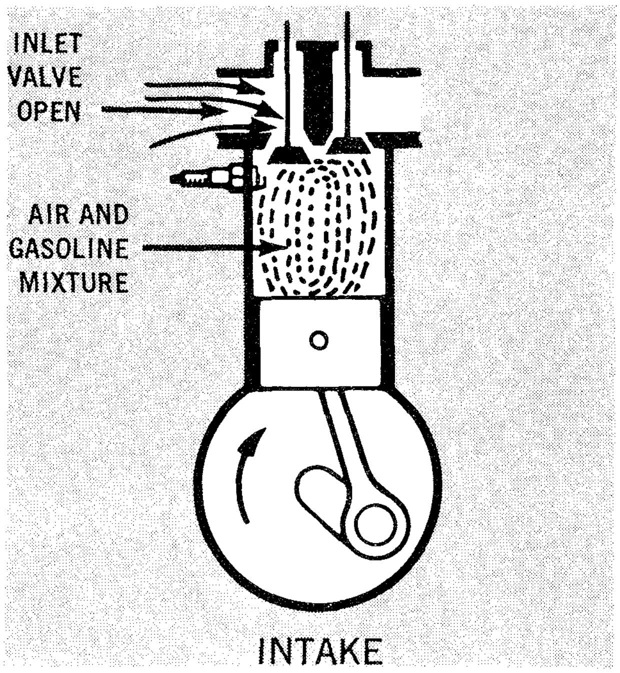
The idle mixture adjusting screw on early Ford V8 engines. A second adjusting screw is located on the opposite side of the carburetor.

3
ENGINE

GENERAL PRINCIPLES

Engine specification charts are located in the Appendix. These charts can be used to determine the engine type, size, and specifications.

All engines used to power inboard-outboard boats, except some of the two-cycle engines operate on the four-stroke cycle principle. During this cycle, the piston travels the length of its stroke four times. As the piston travels up and down, the crankshaft is rotated half way (180 degrees). To complete one full cycle, the crankshaft rotates two complete turns; the camshaft, which controls the valves, is driven by the crankshaft at half crankshaft speed. Valve action, intake and exhaust, occurs once in each four-stroke cycle, and the piston acts as an air pump during the two remaining strokes.

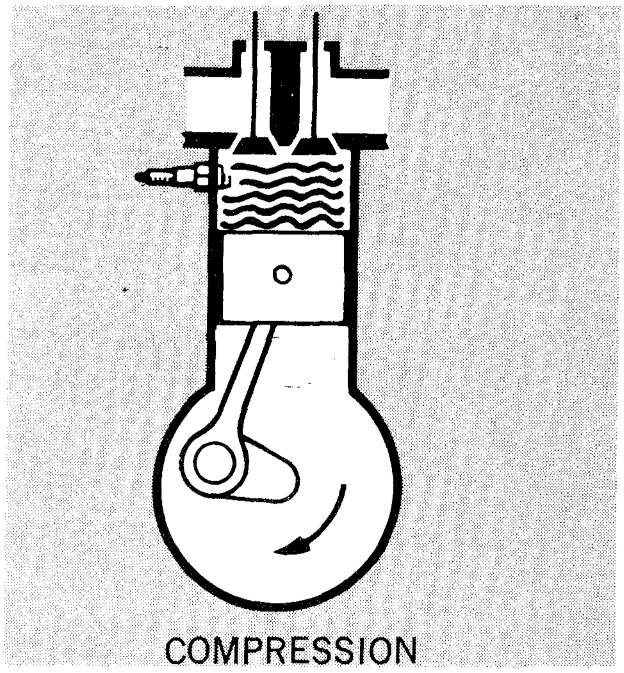


Intake Stroke

The intake valve is opened as the piston moves down the cylinder, and this creates an area of pressure lower than the surrounding atmosphere. Atmospheric pressure will cause air to flow into this low-pressure area. By directing the air flow through the carburetor, a measured amount of vaporized fuel is added. When the piston reaches the bottom of the intake stroke, the cylinder is filled with air and vaporized fuel. The exhaust valve is closed during the intake stroke.

Compression Stroke

When the piston starts to move upward, the compression stroke begins. The intake valve closes, trapping the air-fuel mixture in the cylinder. The upward movement of



the piston compresses the mixture to a fraction of its original volume; exact pressure depends principally on the compression ratio of the engine.

Power Stroke

The power stroke is produced by igniting the compressed air-fuel mixture. When the spark plug arcs, the mixture ignites and burns very rapidly during the power stroke. The resulting high temperature expands the gases, creating very high pressure on top of the piston, which drives the piston down. This downward motion of the piston is transmitted through the connecting rod and is converted into rotary motion by the crankshaft. Both the intake and exhaust valves are closed during the power stroke.

Exhaust Stroke

The exhaust valve opens just before the piston completes the power stroke. Pressure in the cylinder at this time causes the exhaust gas to rush into the exhaust manifold (blowdown). The upward movement of the piston on its exhaust stroke expels most of the remaining exhaust gas.

As the piston pauses momentarily at the top of the exhaust stroke, the inertia of the exhausting gas tends to remove any remaining gas in the combustion chamber; however, a small amount always remains to dilute the incoming mixture. This unexpelled gas is captured in the clearance area between the piston and the cylinder head.

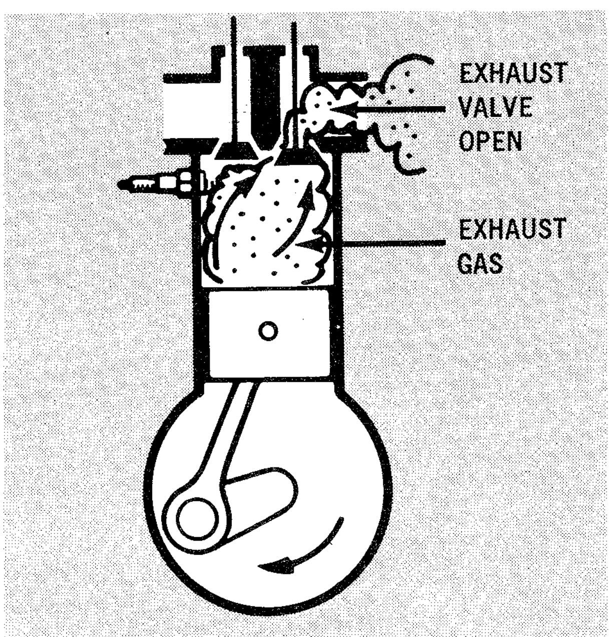
Combustion

The power delivered from the piston to the crankshaft is the result of a pressure increase in the gas mixture above the piston. This pressure increase occurs as the mixture is heated, first by compression, and then (on the down stroke) by burning. The burning fuel supplies heat that raises temperature and, at the same time, raises pressure. Actually, about 75 percent of the mixture in the cylinder is composed of nitrogen gas that does not burn but expands when heated by the burning of the combustible elements, and it is this expanding nitrogen that supplies most of the pressure on the piston.

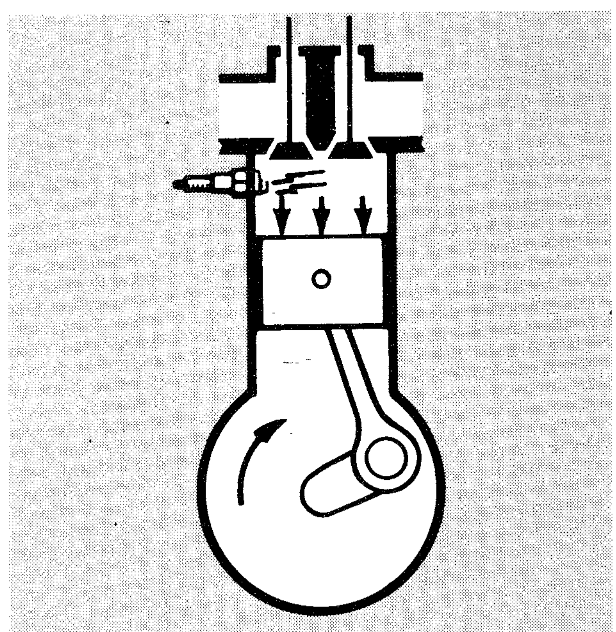
The fuel and oxygen must burn smoothly within the combustion chamber to take full advantage of this heating effect. Maximum power would not be delivered to the piston if an explosion took place, because the entire force would be spent in one sharp hammer-like blow, occurring too fast for the piston to follow.

Instead, burning takes place evenly as the flame moves across the combustion chamber. Burning must be completed by the time the piston is about half-way down so maximum pressure will be developed in the cylinder at the time the piston applies its greatest force to the crankshaft. This will be when the mechanical advantage of the connecting rod and crankshaft is at a maximum.

At the beginning of the power stroke (as



EXHAUST



POWER

the piston is driven down by the pressure), the volume above the piston increases, which would normally allow the pressure in the cylinder to drop However, combustion is still in progress, and this continues to raise the temperature of the gases, expanding them and maintaing a continuous pressure on the piston as it travels downward. This provides a smooth application of power throughout the effective part of the power stroke to make the most efficient use of the energy released by the burning fuel.

VALVE TIMING

On the power stroke, the exhaust valve opens before bottom dead center in order to get the exhaust gases started out of the combustion chamber under the remaining pressure (blowdown). At the end of the exhaust stroke, the intake valve opens before top dead center in order to start the air-fuel mixture moving into the combustion chamber. These processes are functions of camshaft design and valve timing.

Valves always open and close at the same time in the cycle; the timing is not variable with speed and load as is ignition timing. There is, however, one particular speed for each given engine at which the air-fuel mixture will pack itself into the combustion chambers most effectively. This is the speed at which the engine puts out its peak torque. At low engine speeds, compression is somewhat suppressed due to the slight reverse flow of gases through the valves just as they open or close when the mixture is not moving fast enough to take advantage of the time lag. At high speeds, the valve timing does not allow enough time during the valve opening and closing periods for effective packing of the air-fuel mixture into the cylinders.

ENGINE TYPES

The most popular engines used are:

- GMC 4- and 6-cylinder in-line
- GMC V6
- GMC V8
- Ford V8

Engines with strong similarities are grouped in this chapter for the prupose of discussing common service procedures. The following heads and the engine sizes that apply to that group are as follows:

GMC In Line
- 4-cylinder -- 153 CID and 181 CID
- 6-cylinder -- 250 CID

GMC V6 (Buick & Kaiser) 225 CID
CMC V6 3.8 Litre, 229 CID
GMC V6 4.3 Litre, 262 CID
GMC V8 Chevrolet -- 283, 300, 305, 307, & 454 CID
GMC V8 5.0 Litre & 5.7 Litre

Ford V8 -- 302 CID & 351 CID

SERVICE PROCEDURES

The first part of this chapter will deal with troubleshooting specific engine problems; the second part will cover the specific service procedures for the engines in the engine grouped section. Most major repairs require pulling the engine out of the boat. The job sequence covered in this chapter for each engine type is: (1) Removing the engine for service. (2) Servicing the cylinder head. (3)Servicing the cylinders. (4) Servicing the camshaft. (5) Servicing the crankshaft. (6) Servicing the timing gear and chain. Tuning the engine is covered in the tuning section of Chapter 5, IGNITION SYSTEM.

The following service procedures are common to all engines discussed in this chapter. You should make reference to this section before doing any engine work and it should be used in conjunction with the specific model instructions following these general Service Procedures.

TROUBLESHOOTING

Troubleshooting must be a well thought-out procedure. To be successful, you must start by accurately determining the problem; then you must use a logical approach to arrive at the proper solution. The common phrase, "shotgun approach" only leads to wasted time, money, and frustration. Obviously, if the instructions are to be of maximum benefit as a guide, they must be fully understood and followed exactly.

When an engine does not start, the trouble must be localized to one of four general areas; starting system, ignition, fuel, or compression. Each of these areas must be systematically inspected until the trouble is located in one of them, and then detailed tests of that system must be made to isolate the part causing the starting problem.

TROUBLESHOOTING CHECK

When using this Troubleshooting Check, proceed sequentially through each of the tests until a defect is uncovered. Then skip to the detailed testing procedure and check for that system. For example, if, when using the Troubleshooting Check procedure, the first two systems, starter and ignition test OK, but the third test shows there is trouble in the fuel system, proceed to the detailed test under the Fuel System Troubleshooting Check in Chapter 4.

CRANKING SYSTEM TEST

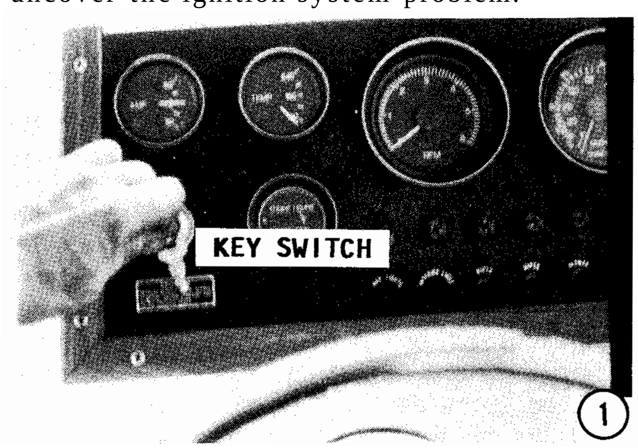
1- Turn the ignition switch to the START position, and the starter should crank the engine at a normal rate of speed.

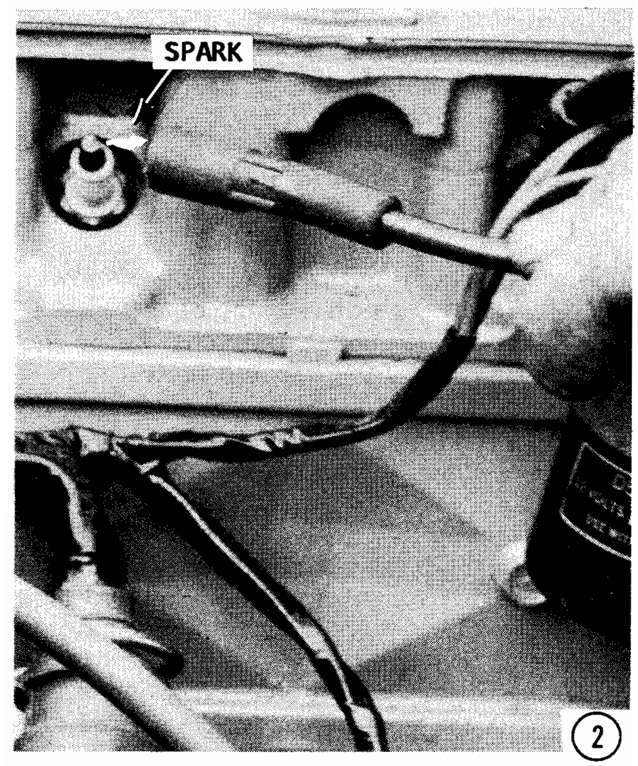
If the starter cranks the engine slowly or doesn't crank it at all, the trouble is in the cranking system, and you should proceed to the Cranking System in Chapter 6 for the detailed testing procedure that will help you uncover the starting problem.

IGNITION SYSTEM TEST

2- Disconnect a spark plug wire and hold it about 1/4 inch from a spark plug or ground. Crank the engine with the ignition switch turned ON.

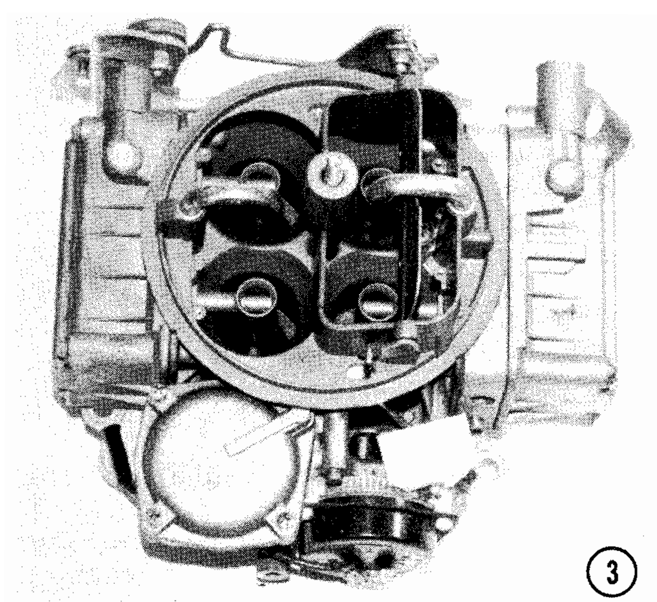
If there is no spark or if the spark is very weak, the trouble'is in the ignition system, and you should proceed to the Ignition Troubleshooting in Chapter 5 for the detailed testing procedure' that will help you' to uncover the ignition system problem.





FUEL SYSTEM TEST

3- This test is to determine whether or not there is fuel in the carburetor. Remove the flame arrestor, and look down into the throat of the carburetor. Open and close the throttle several times to see if fuel is squirting out of the pump jets as shown in the accompanying illustration. *Note: The top of the carburetor has been removed in this illustration for photographic clarity.*



Consider whether the fuel in the tank is fresh or several months old. Many fuels tend to "sour" in three to four months. Others take longer but in no case should you be attempting to start the engine if the fuel has been in the tank over a year.

If no fuel is discharged from the pump jets, then the trouble is in the fuel system, and you should proceed to the Fuel Troubleshooting in Chapter 4 to isolate the problem.

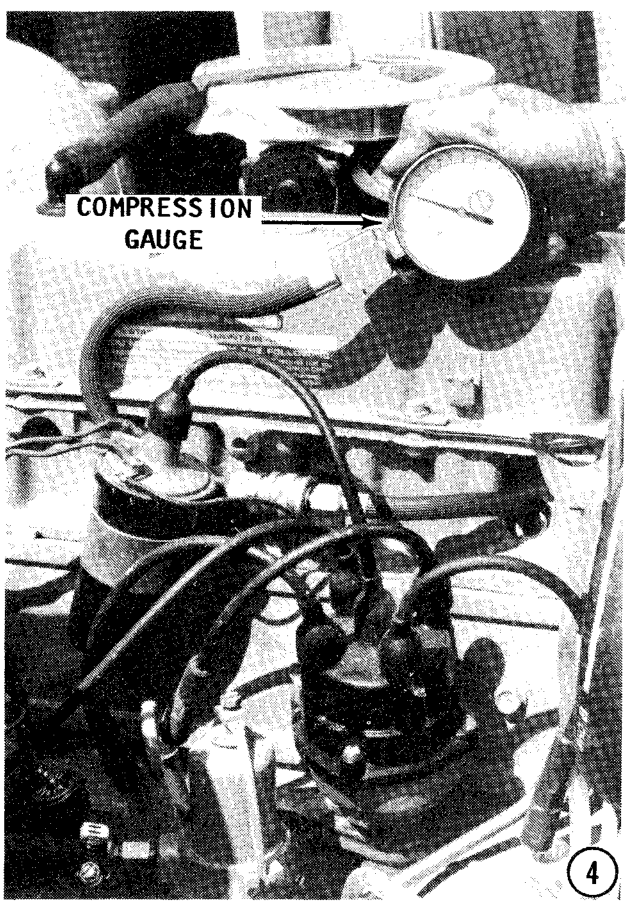
COMPRESSION TEST

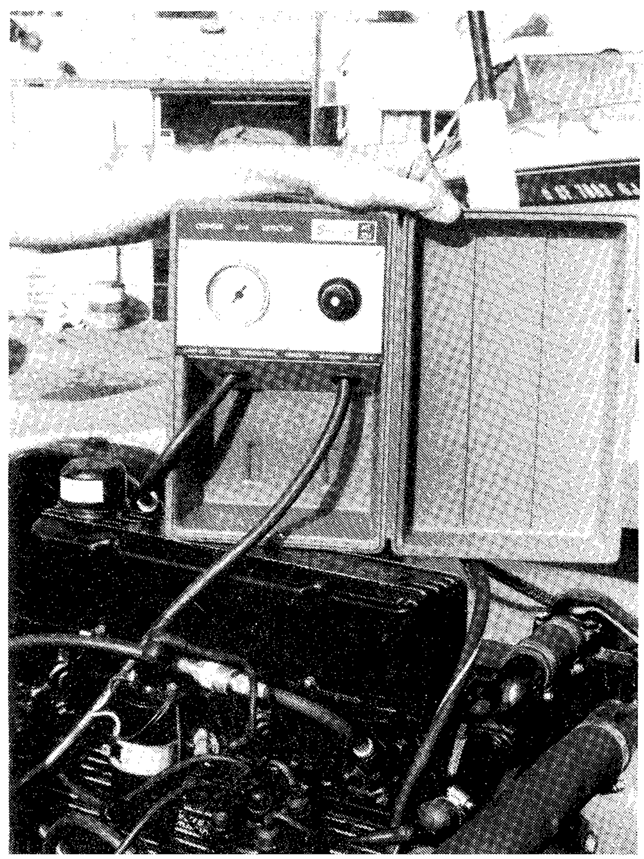
4- Good compression is the key to engine performance. An engine with worn piston rings, burned valves, or blown gaskets cannot be made to perform satisfactorily until the mechanical defects are corrected. Generally, a compression gauge is used to determine the cranking pressure within each cylinder. However, today's large displacement engines generally have considerable valve overlap, and the resulting compression reading may be much lower than the manufacturer's specifications of about 150-170 psi. It is entirely possible to obtain a reading as low as 120 psi on a modern engine which is in good mechanical condition. Such an engine is said to "exhale" at cranking speed, even though everything is perfectly normal at operating speeds.

To make a compression test, remove the spark plugs and lay them out in the order of removal. This is extremely important so you can "read" the firing end of each spark plug. After the spark plugs are removed, insert the rubber adapter of the compression gauge into one cylinder and have a helper crank the engine.

GROUND the **PRIMARY SIDE** of the coil to prevent **DAMAGE** to it. The throttle valve and choke **MUST** be in the **WIDE OPEN** position in order to obtain maximum readings. Crank the engine through several revolutions to obtain the highest reading on the compression gauge or record an equal number of pulses for each cylinder.

The significance in a compression test is the variation in pressure readings between cylinders. As long as this variation is within 20-30 psi, the engine is normal. If a greater





Use compressed air in a cylinder when the piston is at TDC, firing position and listen carefully. The source of leaking air will indicate the source of the problem. A hissing sound through the carburetor indicates a leaking intake valve.

variation exists, then the low-reading cylinder should be checked by making a cylinder leak test. A simple leak test can be made by first inserting a teaspoonful of oil into the spark plug opening of the low reading cylinder, and then cranking the engine a few times to distribute the oil. Check the compression again to see if inserting the oil caused a change. If the reading went up, then the compression loss is probably due to worn rings. If the reading remained the same, the loss may be due to a burnt valve.

TROUBLESHOOTING MECHANICAL ENGINE PROBLEMS

LEAK TEST

A more definite and scientific method of performing a leak test and determining the problem area than the simple method described in the previous paragraph is to use compressed air.

Install an air hose adapter into the spark plug port. With the piston at top dead center, firing position, apply 60–70 psi of air. On commercially built air adapter units, a gauge indicates percent of leakage. Over 20% leakage, in most cases, is considered excessive.

Listening at the point from which the compressed air is escaping indicates the nature of the defect. Insert a short length of heater hose into the various areas being tested and listen at the other end. The hose helps to amplify the leakage noise. Air hissing from the exhaust manifold indicates a leaking exhaust valve. Air heard in the carburetor air horn indicates a leaking intake valve. If you hear air hissing at the oil filler pipe, the rings are worn.

VACUUM GAUGE

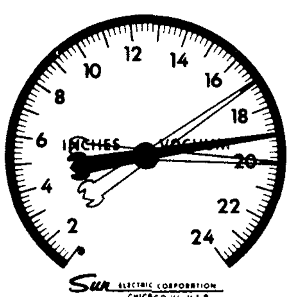
A vacuum gauge is a relatively inexpensive piece of test equipment that can be very handy in isolating mechanical troubles in an internal–combustion engine. As with a compression gauge, you cannot rely soley on the actual numerical reading of the vacuum gauge. Instead, relative readings and typical actions of the needle provide clues to some types of troubles.

Normal idle vacuum in the intake manifold ranges from 15 to 22" Hg. On later-model engines, lower and less steady intake manifold vacuum readings are becoming increasingly common because of the greater use of high–lift cams and the increase in the amount of valve overlap.

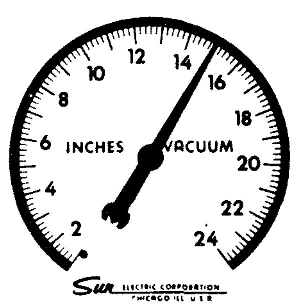
In addition to these factors, altitude affects a- vacuum gauge reading. That's right. At high elevations, a vacuum gauge will read about one inch lower for each 1,000 ft. of elevation above sea level. Another outside influence on the vacuum gauge is a change in barometric pressure. Because of these factors, which are not determined by the condition of the engine, it is much more important for you to watch the action of the needle than its actual reading. After you have worked with a vacuum gauge just a few times you will be able to recognize such problem areas as sticking valves, a tight valve lash adjustment, or a restriction in the exhaust system.

DYNAMOMETER TESTING

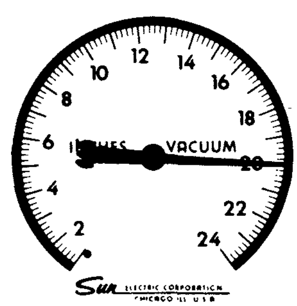
An inexpensive method of making a dynamometer–type of engine test, is to use a vacuum gauge and a set of shorting wires. With these two items, it is possible to isolate mechanical troubles to one or more cylinders. When making this type of test,



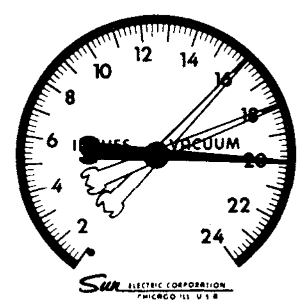
With motor at idling speed floating motion right and left of vacuum pointer indicates carburetor too rich or too lean



With motor at idling speed low reading of vacuum pointer indicates late timing or intake manifold air leak



With motor at idling *speed* vacuum pointer should hold steady between 15 and 21



With motor at idling speed dropping back of vacuum pointer indicates sticky valves.

the spark plugs are shorted out one-at-a-time until the engine is running on one cylinder. Now, if a vacuum gauge is attached to the intake manifold, a reading can be obtained to compare the efficiency of each cylinder. A low-reading cylinder can be the result of inefficiency in the ignition, fuel, or compression system.

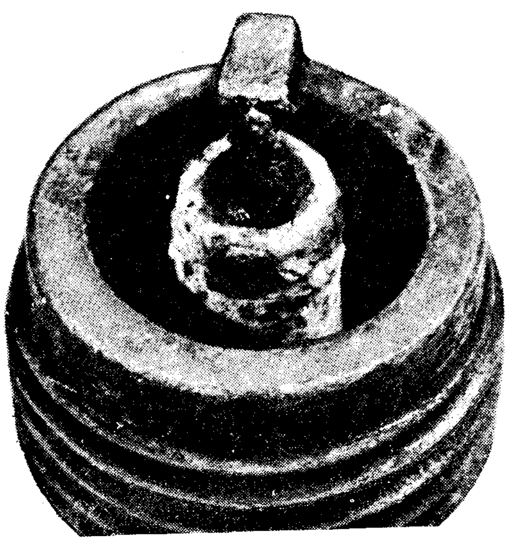
To make this test the ground clip of the shorting wires must be attached to a **good ground.**

Start the engine.

CAUTION: Water must circulate through the stern drive to the engine any time the engine is run to prevent damage to the water pump in the stern drive.

Have a helper advance the throttle as you successively short out all of the cylinders until the engine is running on one cylinder. You will discover it will be necessary to open the throttle wide in order to keep the engine running on one cylinder at a time.

Observe the vacuum gauge reading, and then move the shorting clip from one of the spark plugs to the spark plug of the cylinder you just tested. Observe the vacuum gauge reading, and then test each of the other cylinders in turn by running the engine on that one spark plug. A weak cylinder or a cylinder that is not firing is easily determined, but the most important part of this test is the ability to compare the relative power (vacuum) of each firing stroke.



Ignition system defects will cause engine misfire. If the spark plug electrodes are improperly gapped, excessively worn, or corroded, the engine will misfire during acceleration.

EXCESSIVE OIL CONSUMPTION

High oil comsumption can usually be traced to one of four general areas:

1- A clogged positive crankcase ventilation system.

2- Piston rings not sealing.

3- Excessive valve stem-to-guide clearance.

4- Cracked intake manifold (the type that serves as a valve chamber cover).

High oil consumption complaints many times are the result of oil leaks rather than actual consumption by the engine. For this reason, before assuming an engine is burning oil, examine the exterior for evidence of oil Leaks. In analyzing the problem, consideration must be given to the fact that oil has only three routes available to enter the combustion-chambers. The oil may get past the piston rings, enter through the valve guides, or seap in through the intake manifold. Two very definite clues will indicate the engine is actually burning excessive oil. One is carbon deposits in the exhaust outlet and the other is oil-fouled spark plugs.

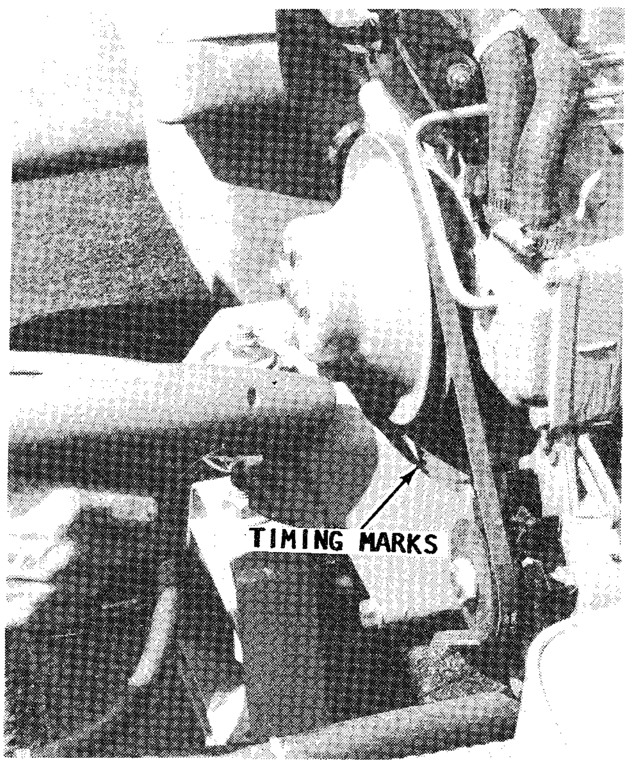
ENGINE NOISES

Engine noises can be generally classified as knocks, slaps, clicks, or squeaks. These noises are usually caused by loose bearings, sloppy pistons, worn gears, or other moving parts of the engine. Most common types of noises are either synchronized to engine speed or to one-half engine speed. Noises that are timed to engine speed are sounds that are related to the crankshaft, rods, pistons, and pins. The cause of noises that seem to be timed to one-half engine speed are usually in the valve-train. To determine whether the noise is timed to engine speed or one-half engine speed, operate the engine at a slow idle and observe whether the noise is synchronized with the flashes of a timing light.

A main bearing knock is usually identified by a dull thud that is noticeable when the engine is under a load. Attempting to move the boat under power with it tied to the dock will bring out a main bearing knock. If you pull the spark plug wire from one plug at-a-time and the noise desappears when a particular wire is removed, then the noise is probably coming from that cylinder, either the rod bearing, piston pin, or the piston. If a rod bearing is loose, the noise will be loudest when the engine is decelerating. ,Piston pin noise and piston slap are generally louder when a cold engine is first started.

Many times the source of an unusual sound may be isolated by using a stethoscope or other listening device. One such device is a long shank screwdriver. Allow your hand to extend over the end of the handle, press an ear to your hand, and then probe with the other end of the screwdriver by touching it firmly against the block at each cylinder or noise area. Take care and use good judgment when using this method of attempting to detect the cause of a problem because the noise will travel through other metallic parts of the engine and could lead to a false interpretation of what you are hearing.

Carbon build-up in the combustion chamber can cause interference with a piston. Fuel pumps can knock, belts can be noisy, distributors can emit clicking noises, and alternators can contribute to unusual sounds. Flywheels, water pumps, and loose manifolds can also cause noise problems.



Use a timing light to accurately adjust the ignition timing to the manufacturer's specifications. Performance and fuel consumption are both directly dependent on precise timing.

GMC IN-LINE ENGINES

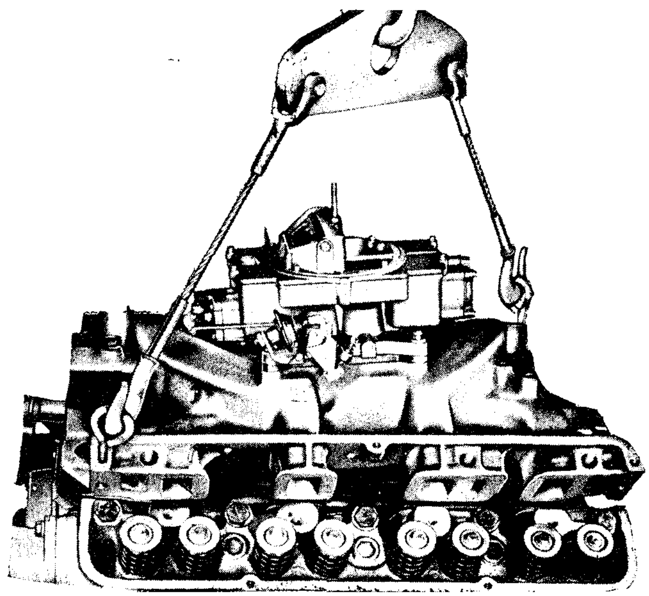
A new generation of more efficient engines has been developed with various capacites as follows: 153, 181, and 250. The 153-181 CID engines are four-cylinder powerplants. The 250 has six cylinders. The four-cylinder engine has four main bearings, while the six-cylinder engine has seven. These engines have many interchangeable parts, because most have a bore of 3.875" and a stroke of 3.25". The 181 unit has a larger bore of 4.000" and a stroke of 3.60", while the 250 engine has a shorter stroke of 3.53". All have a center-to-center bore spacing of 4.40".

Standard numbering of the cylinders is from the front of the engine. The firing order is also standard, 1-5-3-6-2-4 for 6-cylinder engines, and 1-3-4-2 for the 4-cylinder unit.

The following service sections are coded to assist you in referring to a particular section quickly when performing other work. You will find these numbers referenced in other chapters.

3-1 ENGINE REMOVAL

In many cases, the design of the boat and the method of engine installation will cause extra work in order to pull the powerplant. Engine covers and panels around the engine may have to be removed. The



*Lifting the engine with a bracket and assembled cables. If a chain is used, pass the chain through the lifting bracket and eye **bolts,** then secure the ends together with a bolt and nut.*

engine must move about *6* inches forward in order to clear the driveshaft assembly. If you do not have room to move the engine forward, then it will necessary to remove the driveshaft assembly as discussed in Chapter 10.

Disconnect the battery cables, engine-to-dash wiring, water hoses, throttle cable, exhaust hoses, and fuel lines. **CAUTION:** Be **sure to plug the fuel line to prevent fuel from siphoning out of the fuel tank.**

Drain all of the water from the block by opening all drain valves.

The engine has two lifting brackets to be used with a length of chain. Run the chain through the holes in the lifting brackets, and then fasten the ends together with a bolt and nut. Attach the lifting device in the center of the chain, and then tie the chains together to prevent the lifting device from riding down the chain as the engine is lifted from the boat.

Remove the bell housing-to-engine bolts. Remove the lag bolts on the mounting to the deck. If the engine compartment is too small for the engine to clear, it may be necessary to remove the mounting brackets from the engine. Slide the engine forward about *6* inches, and then lift it straight up and out. If you do not have enough room to move it forward, then it will be necessary to remove the stern drive unit. See Chapter 10.

ENGINE INSTALLATION

Lower the engine into the compartment and align the engine to the guide pins on the bell housing. Slide the engine back onto the drive assembly. **Note:** *It may be necessary to turn the driveshaft to align the splines. The driveshaft can be easily turned, by putting the stern drive in forward gear, and then turning the propeller.*

Install and tighten the bell housing-to-engine bolts, alternating around the bell housing. Install the lag bolts through the mounting brackets in the deck. If the engine brackets were removed, they have to be installed first.

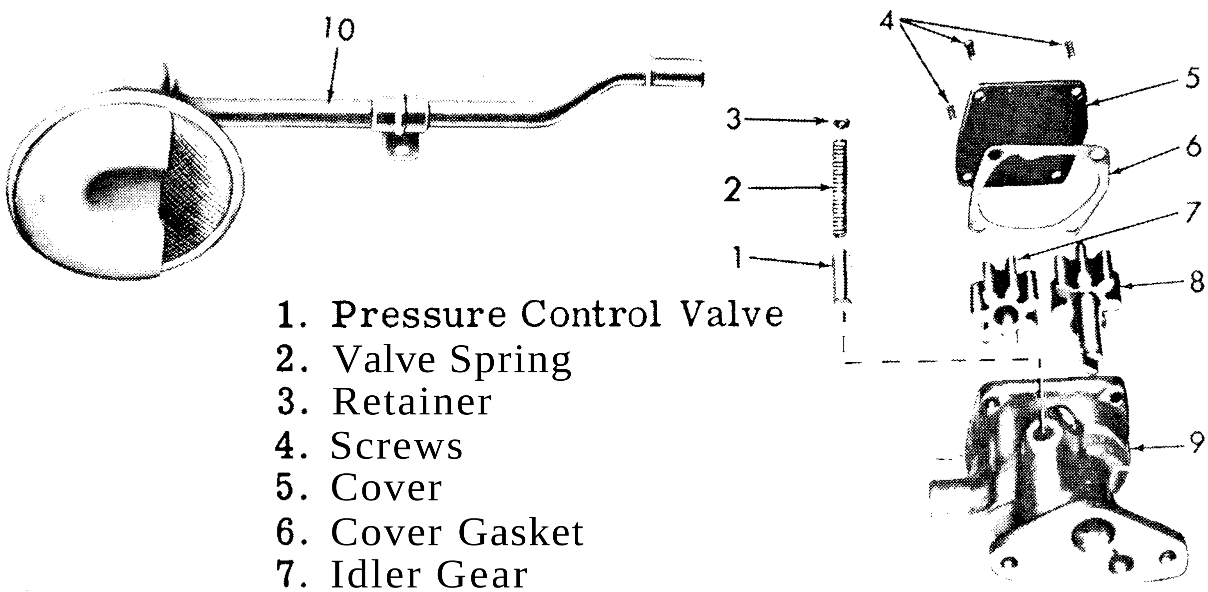
Install the fuel line, water hoses, engine-to-dash wiring, exhaust hose, throttle cable, and battery cables. Close all water drain valves. Fill the crankcase with proper weight oil.

Start the engine and check for leaks.

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.

3-2 OIL PAN

Before the oil pan can be removed, the engine must be removed from the boat; see Section 3-1.



1. Pressure Control Valve
2. Valve Spring
3. Retainer
4. Screws
5. Cover
6. Cover Gasket
7. Idler Gear
8. Drive Gear and Shaft
9. Pump Body
10. Pick-up Screen and Pipe

Exploded view of the oil pump installed on in-line engines.

Remove the oil drain plug and drain the oil. On late-model engines a kit has been attached to the oil drain plug to help in draining the oil when the engine is in the boat. This kit can be installed on any engine and should be installed the first time the engine is removed from the boat.

Remove the oil pan bolts, and then pry the pan free from the engine block.

INSTALLATION

Carefully clean all gasket sealing surfaces. Remove the rear seal from a new gasket set, and install it in the rear main bearing cap. Install the front seal on the crankcase front cover. Be sure to press the tip of the seal into the holes provided in the cover. Install the side gaskets to the engine block. Use a gasket sealer with enough body to act as a retainer.

Install the oil pan. Tighten the retaining bolts to the torque value given in the Specifications in the Appendix.

Install the engine, see Section 3-1.

Fill the crankcase with proper weight oil.

Start the engine and check for oil leaks.

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.

3-3 OIL PUMP

The oil pump consists of two gears and a pressure regulator valve, enclosed in a two-piece housing. The oil pump is driven by the distributor shaft, which is dirven by a helical gear on the camshaft. A baffle is installed on the pickup screen to eliminate pressure loss due to sudden stops.

REMOVAL

Remove the engine; see Section 3-1.

Remove the oil pan; see Section 3-2.

Remove the two flange mounting bolts and the pickup pipe bolt. Remove the pump and screen as an assembly.

INSTALLATION

Align the oil pump driveshaft to match the distributor tang, and then push the pump into the block at the same time positioning the flange over the distributor lower bushing. No gasket is needed. The oil pump MUST slide into place with ease. If it does not, remove the pump and reposition the slit to align with the distributor tang properly.

Install the oil pan; see Section 3-2. Be sure to use new gaskets.

Install the engine; see Section 3-1. Fill the crankcase with the proper weight oil.

Start the engine and check ıor oil leaks.

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.

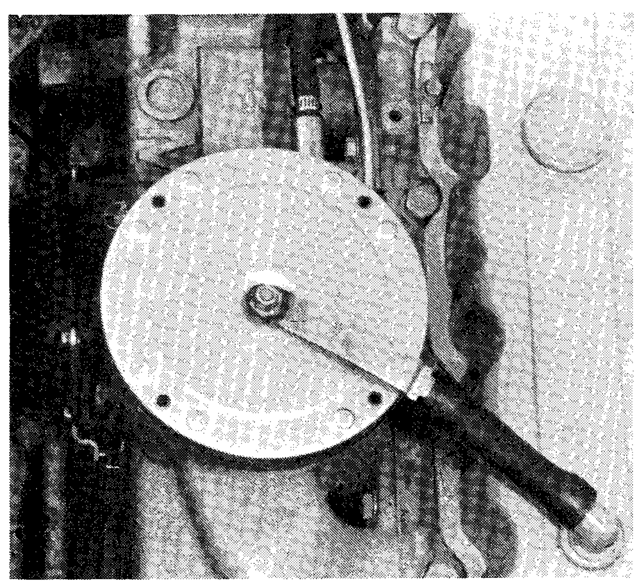
3 4 INTAKE MANIFOLD

Intake manifolds seldom create any problems. This short section is included for the sole purpose of enabling you to remove the manifold-in order to accomplish other work.

REMOVAL

Remove the flame arrestor nut and the flame arrestor. Disconnect the throttle rod at the bellcrank, and then remove the throttle return spring. Disconnect the fuel and vacuum lines from the carburetor and the crankcase ventilation hose at the rocker arm cover. Remove the carburetor.

Remove the water hoses from the exhaust manifold to the thermostat housing. Remove the exhaust hose. Remove the manifold-to-head attaching bolts and clamps. Remove the manifold. The intake manifold and exhaust manifold are one unit.



Intake and exhaust manifold, four-cylinder engine.

CLEANING

Scrape all gasket material from the gasket surface. Remove any deposits in the combustion chambers with a wire brush. Take care not to damage the gasket surface.

INSTALLATION

Apply a light coating of Permatex, Form-A-Gasket, or equivalent, to both sides of the manifold gasket. Place the gasket over the manifold end studs and carefully install the manifold. The Form-A-Gasket will hold the gasket in proper place. Install the bolts and clamps with one hand while holding the manifold in place with the other. Tighten all manifold bolts to the torque value given in the Specifications in the Appendix. Connect the exhaust hoses to the manifold. Replace the water hoses from the thermostat-to-exhaust manifold.

Install the carburetor, flame arrestor, and the crankcase ventilation hose. Connect the throttle rod and replace the return spring. Replace the flame arrestor.

Start the engine and check for leaks.

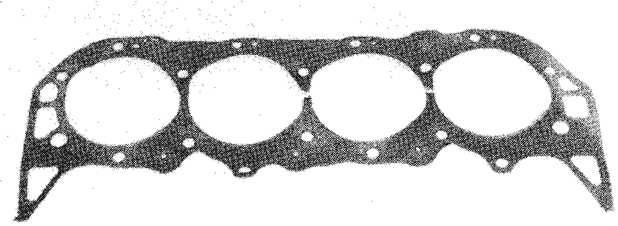
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

3-5 EXHAUST MANIFOLD

On in-line engines the intake manifold and exhaust manifold are one assembly. Exhaust manifolds seldom create any problems. This short section is included to enable you to remove the manifold in order to accomplish other work.

REMOVAL

Remove all water hoses connected to the exhaust manifold. Remove the exhaust hose from the elbow to the side of the exhaust housing.



Compression loss may be caused by a blown head gasket between cylinders.

Remove the carburetor, throttle cable, choke line, and fuel line. Studs are located along the side of the head to support the exhaust manifoid. Remove the nuts from the studs, and then take off the manifold. If any further service is required on the exhaust manifold, see Chapter 9, Cooling.

INSTALLATION

Apply a light coating of Permatex, Form-A-Gasket, or equivalent, to both sides of a new gasket. Place the gasket on the end plates and elbow. Install the manifold to the cylinder head and thread the nuts onto the studs. The form-a-gasket will hold the gasket to proper position. Tighten the nuts alternately. The manufacturer does not install a gasket between the exhaust manifold and the engine block. However, if there is any evidence of an exhaust leak, purchase a new gasket at your local automotive parts dealer and install it between the manifold and the head.

Replace the inlet, outlet, and exhaust hoses to the manifold. Install the carburetor, throttle cable, choke line, and fuel line.

Start the engine and check for fuel or exhaust leaks.

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,

3-6 CYLINDER HEAD SERVICE

The procedures in this section provide removing, disassembling, cleaning, inspecting, and installing the cylinder head including some work that may be accomplished while the head is removed.

REMOVAL

Remove the flame arrestor. Disconnect the crankcase ventilation hoses at the rocker arm cover. Disconnect all wires from the rocker arm cover clips. Remove the rocker arm cover.

Drain the block, and then disconnect the water hoses. Disconnect the spark plug wires. Remove the spark plugs and take care not to tilt the spark plug socket. If you do not keep the socket straight with the plug you are likely to crack the insulator.

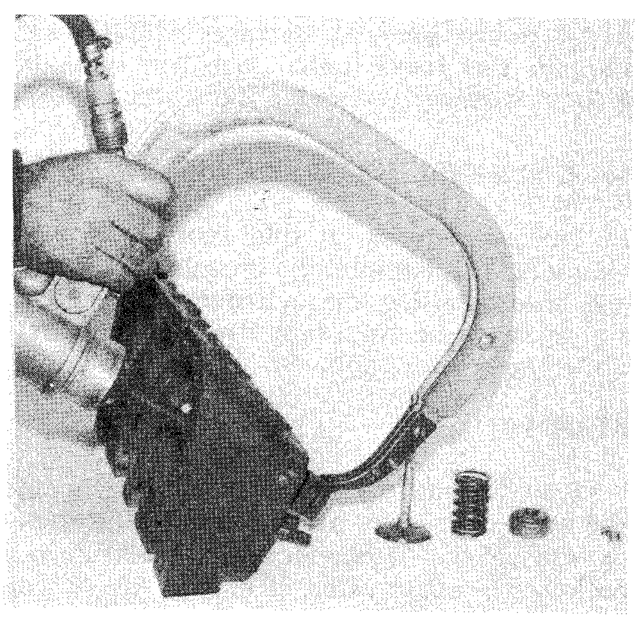
Remove the intake and exhaust manifold assembly; see Section 3-4.

Remove the rocker arm nuts, rocker arms, and push rods. Take time and care to place all the parts in a rack so each item can be reinstalled in the same position from which it was removed.

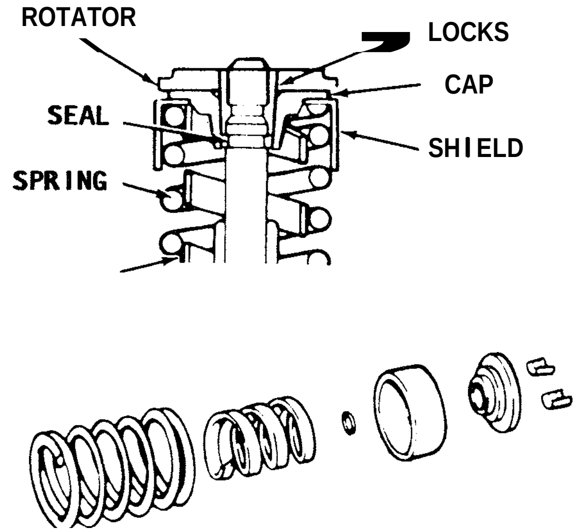
Disconnect the fuel and vacuum lines from the retaining clip, and then disconnect the wires from the temperature sending units. Disconnect the battery ground strap at the cylinder head. Remove the ignition coil. Loosen and remove the cylinder head bolts, take off the head, and **DISCARD** the gasket.

HEAD DISASSEMBLING

Use a tool to compress the valve springs to remove the keys. Release the compressor, and then take off the spring caps, spring shields, springs, spring dampers, oil seals, and valve spring shims. Pay attention to the number of shims under each of the valve springs. This will be very important during assembly. Remove the valves from the cylinder head and place them in a rack in their proper sequence so they can be installed back in their original positions.



Valve locks are removed by first compressing the spring, and then taking off the locks, caps, springs, dampers, and oil seal. Push the valve out and ALWAYS keep it in sequence to ensure replacement in the same location.



Component parts of the valve mechanism.

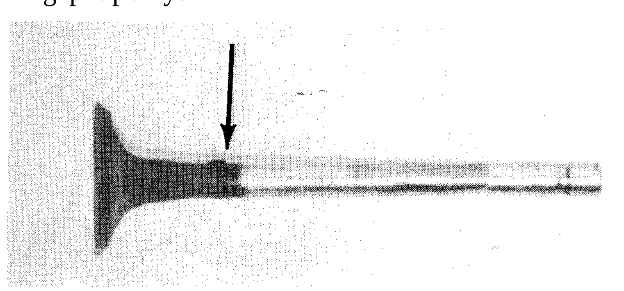
CLEANING AND INSPECTING

Clean all carbon from the combustion chambers and valve ports. Use lacquer thinner to cut the gum on the valve guides. It is this gum that causes sticky valves. Clean all carbon and sludge from the push rods, rocker arms, and push rod guides. Clean all carbon deposits from the head gasket mating surface. **TAKE CARE** not to damage the gasket surface.

Check the flatness of the gasket surface with a straightedge and a feeler gauge. Surface irregularity must not exceed 0.003" in any six-inch space, and the total must not exceed 0.007" for the entire length of the head. If necessary, the cylinder head gasket surface can'be machined.

CAUTION: Do not remove more than 0.010" of stock.

Clean the inside of the valve guides with a wire brush and lacquer thinner to remove all gum and carbon deposits. Any gum or deposits could prevent the valve from closing properly.



The arrow points to a wear lip on the valve stem. Accurate measurement of valve stem wear is made with a micrometer.

Inspect the cylinder head for cracks in the exhaust ports, combustion chambers, or external cracks to the water chamber. Inspect the valves for burned heads, cracked faces, or damaged stems. Bear-in-mind, excessive valve stem-to-bore clearance will increase oil consumption and may cause valve breakage. Insufficient clearance will result in noisy and sticky valves and also disturb engine smoothness.

ROCKER ARM STUDS

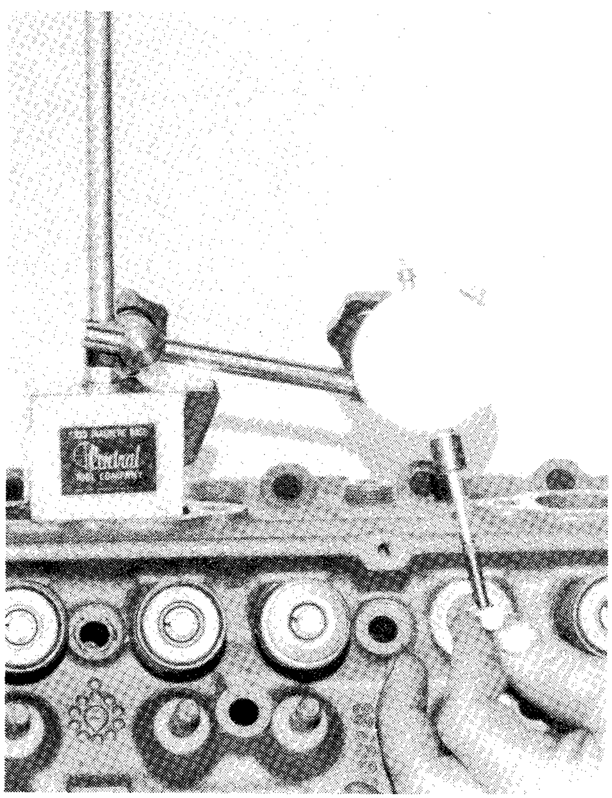
Replace any rocker arm studs with damaged threads with standard studs. If the studs are loose in the head, oversize studs are available in 0.003" or 0.010" oversize. These oversize studs can be installed after reaming the holes with Tool 3-7515 for 0.003" oversize and Tool 3-6036 for 0.013" oversize as follows: First remove the old stud by placing Tool J-5802 over the stud. Next, install the nut and flat washer and remove the stud by turning the nut. Now, ream the hole for an oversize stud using the proper size tool just listed. After the hole has been properly reamed, coat the press-fit area of the stud with hypoid axle lubricant. Finally, install a new stud using Tool J-6880. The tool must bottom on the head.

VALVE MECHANISM

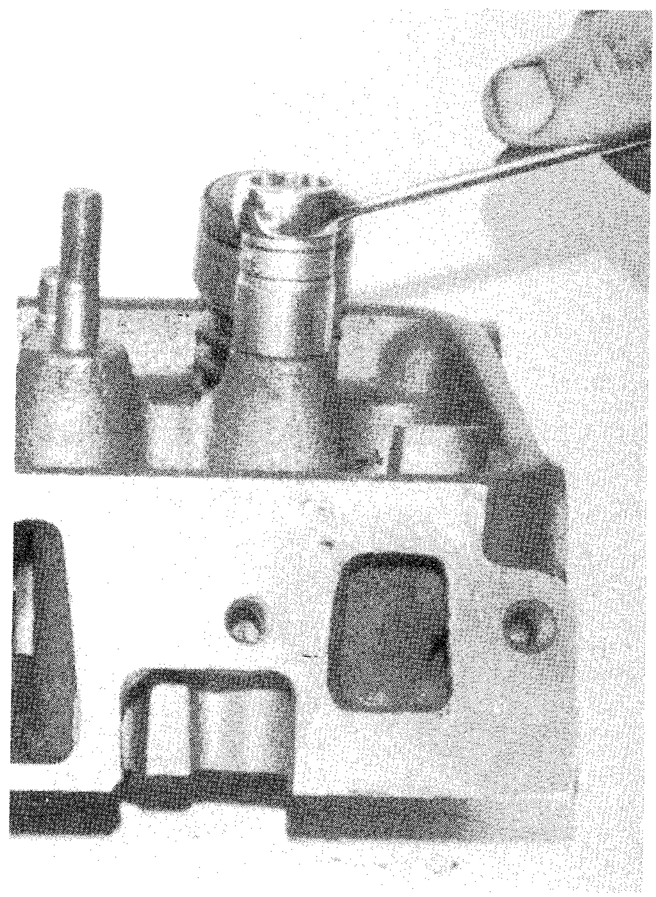
Clean the valves, springs, spring retainers, locks, and sleeves in solvent, and then blow the parts dry. Inspect the valve face and the head for pits, grooves, and scores. Inspect the stem for wear and the end for grooves. The face must be trued on a valve grinding machine, which will remove minor pits and grooves. Valves with serious defects, or those having heads with a knife edge, must be replaced.

VALVE GUIDES

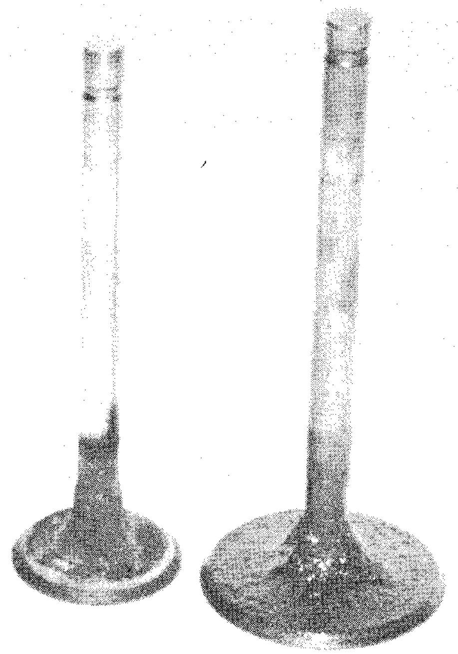
Measure the valve stem clearance with a dial indicator clamped on one side of the cylinder head. Locate the indicator so movement of the valve stem will cause a



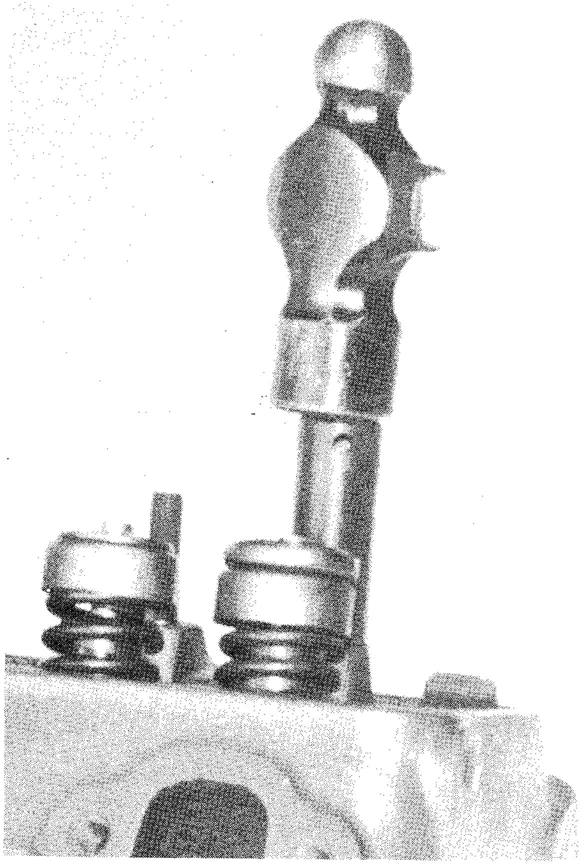
The wear limit for intake valve guides is 0.001" and for the exhaust guides, 0.002". Valve guide wear can be accurately measured by checking the deflection of a new valve stem with a dial gauge, as shown.



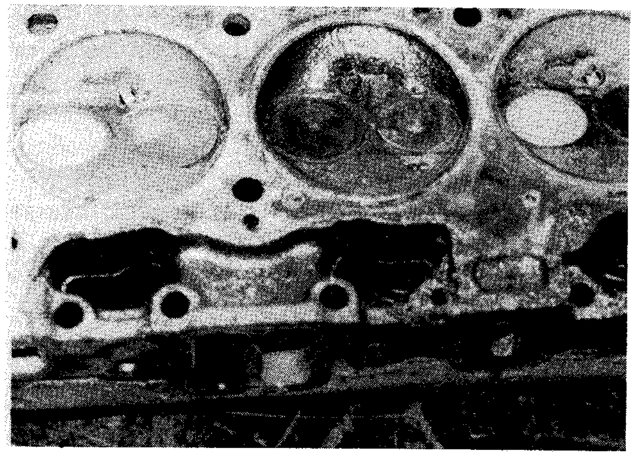
A pressed in valve rocker arm stud can be removed using tool J-5802.



Concentrated heat to one area on the valve face will cause it to crack. Notice the difference between the crack in the upper valve and the lower valve. Such cracks start with a small concentrated hot spot, possibly from a piece of white-hot carbon on the seat.

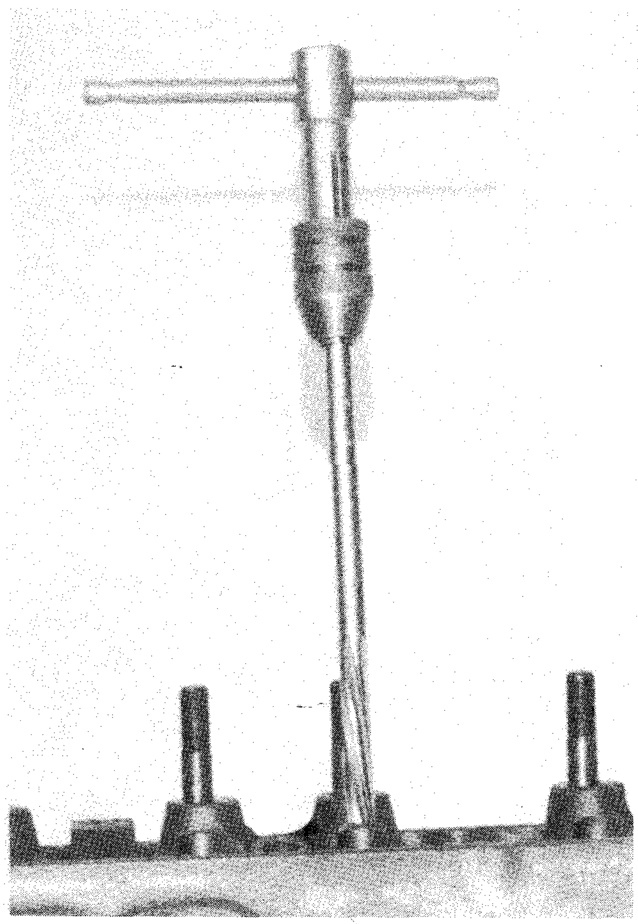


Before driving the new rocker arm stud into place with an installer tool, ALWAYS coat the parts with hypoid gear lubricant.

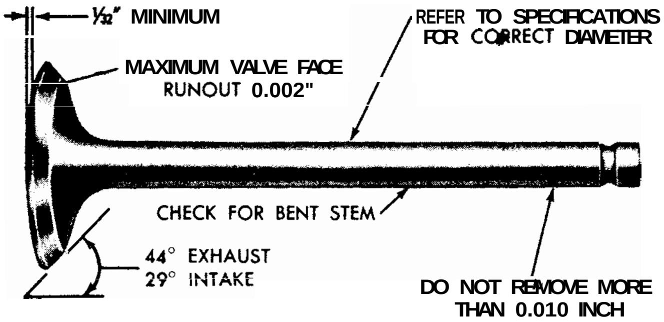


Notice the oil around the intake valve and the darker coloring of the exhaust valve in the right combustion chamber. The compression in the right cylinder was lower than in the left. Also the intake valve guide and seal are defective allowing oil to leak into the combustion chamber.

direct movement of the indicator stem. The indicator stem must contact the side of the valve stem just above the valve guide. With a new valve and the head dropped about 1/16" off the valve seat, move the stem of



To restore production clearances, worn valve guides can be reamed oversize, and then valves with oversize stems installed.



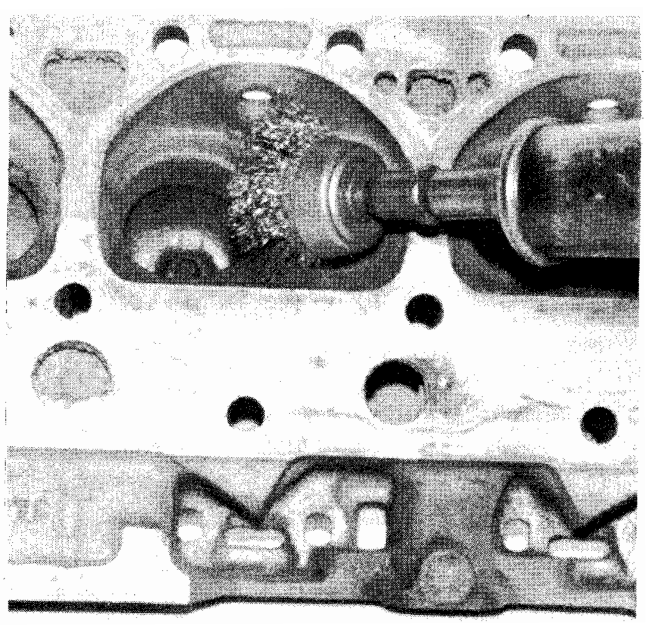
Critical valve tolerances.

the valve from side-to-side, with a light pressure to obtain a clearance reading. If the clearance exceeds 0.001" for the intake or 0.002" for the exhaust, it will be necessary to ream the valve guides for oversize valve stems.

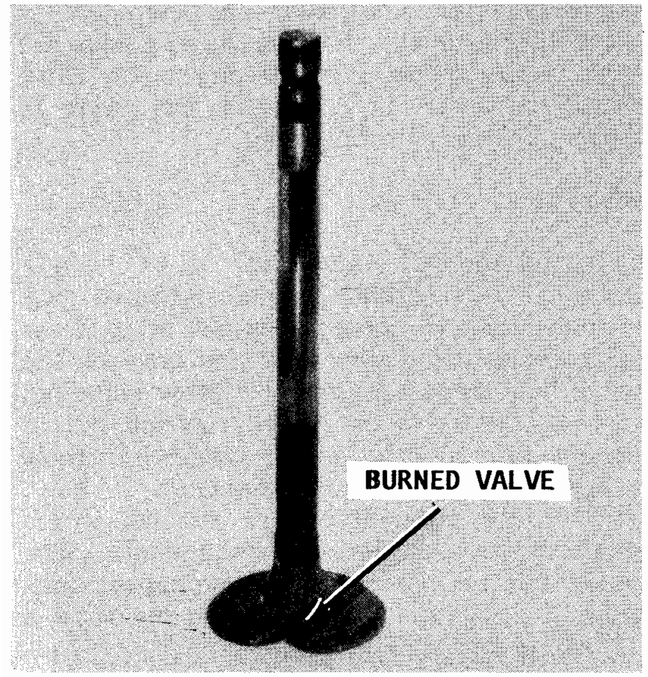
Valves with oversize stems are available for inlet and exhaust valves in the following sizes: 0.003", 0.015", and 0.030". Use the 3/8" diameter reamer sizes from Reamer Tool Set J-7049 which are: J-7049-7 Standard; J-7049-4, 0.003" oversize; J-7049-5, 0.015" oversize; and 5-7049-6, 0.030" oversize to ream the bores for new valves.

VALVE SEATS

Reconditioning the valve seats is very important, because the seating of the valves must be perfect for the engine to deliver the power and performance intended by the manufacturer. Another important factor is

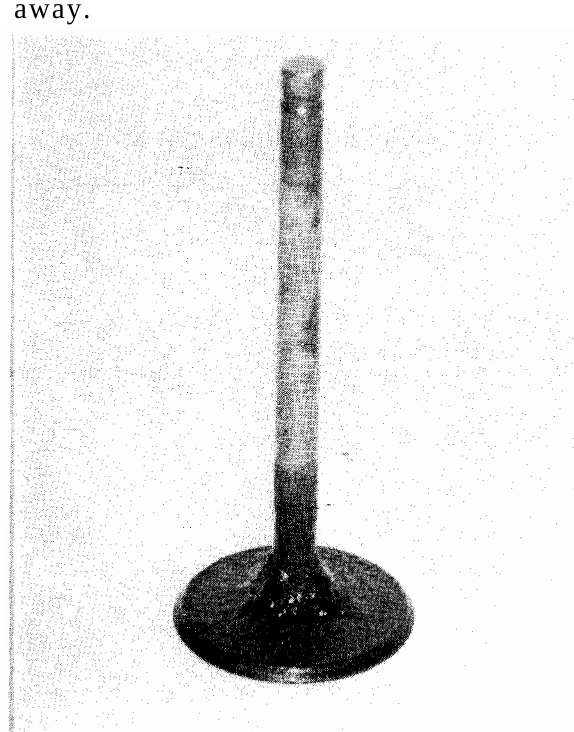


Clean all of the carbon from the cylinder with a wire brush.



*A severely burned exhaust valve face. The valve was sticking in the guide as evidenced by the gum on the neck of the stem. TAKE **TIME** to clean the valve guide thoroughly.*

the cooling of the valve heads. Good contact between each valve and its seat in the head is a **MUST** to ensure that the heat in the valve head will be properly carried away.



Excessive lubricant leaking past the seal and valve guides caused this wet, oily condition.

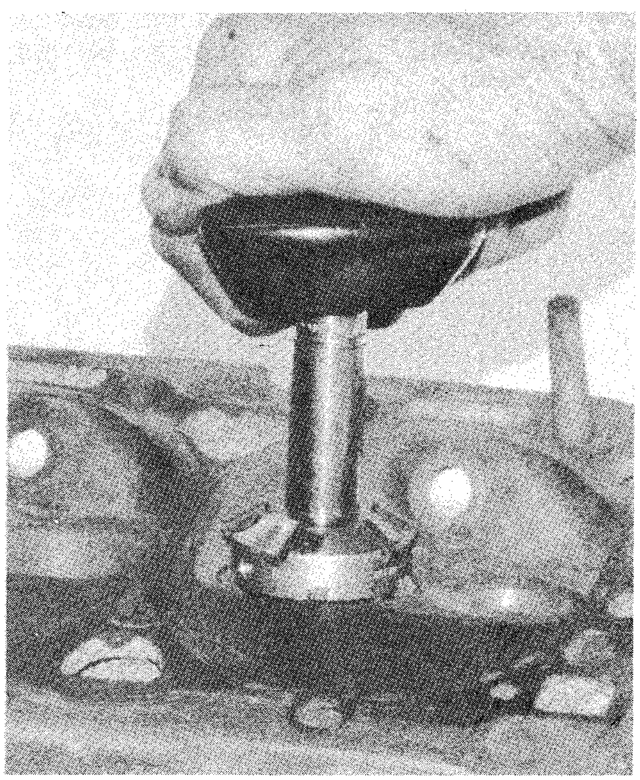
No matter what type of equipment is used, it is essential that the valve guides are free from carbon, gum, or dirt. The valve MUST be clean in order for the pilot to center properly in the guide.

VALVES

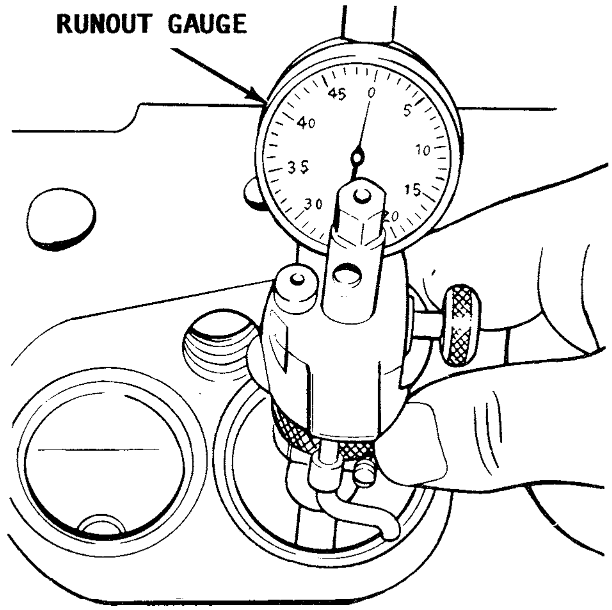
Grind the 45° valve face to 44° angle for a 1° interference angle. Remove only enough stock to correct run-out or to dress off the pits and grooves. If the edge of the valve head is less than 1/32" after grinding, replace the valve as it will run too hot in the engine. Lightly lap the valves into their seats with fine grinding compound.

Measure the valve seat widths, which should be as specified in the Appendix. The seats can be narrowed by removing stock from the top and bottom edges by using a 30° stone and a 60° stone.

The finished seat should contact the approximate center of the valve face. To determine the position of the seat on the valve face, coat the seat with Prussiar blue, and then rotate the valve in place with a light pressure. The blue pattern on the valve face will show the position of the seat.



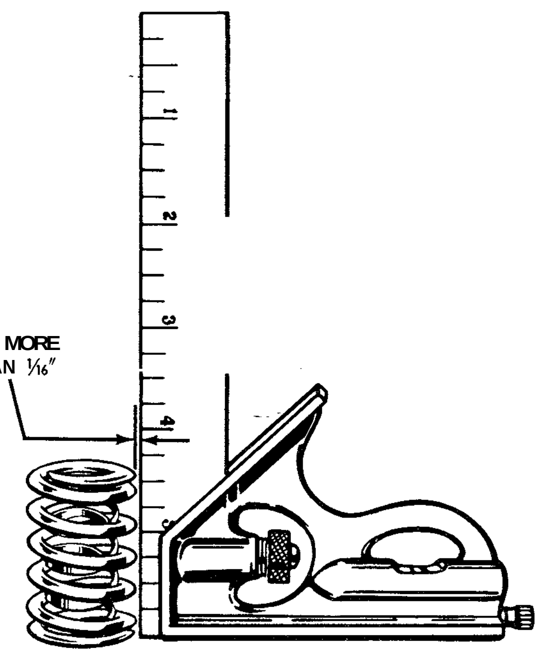
Refacing the valve seat using a grinding stone. ALWAYS lift the special driver several times to allow the grinding particles to fly out, or the valve seat will become grooved.



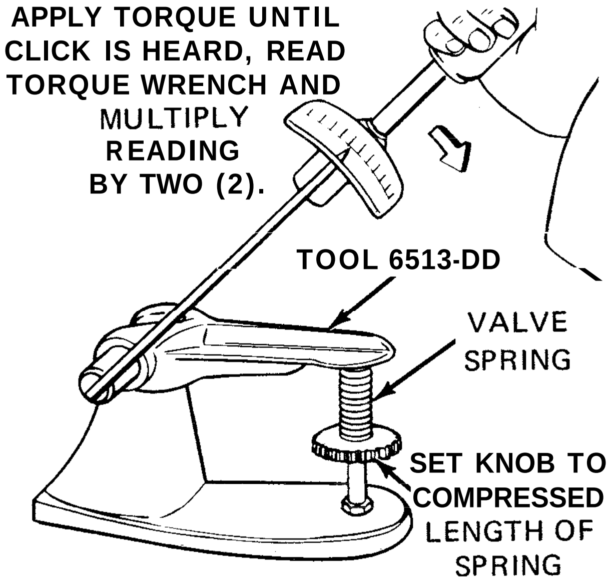
After the seat has been reground, check to be sure it is concentric with the guide by using a dial gauge. The run-out should not exceed 0.002".

VALVE SPRINGS

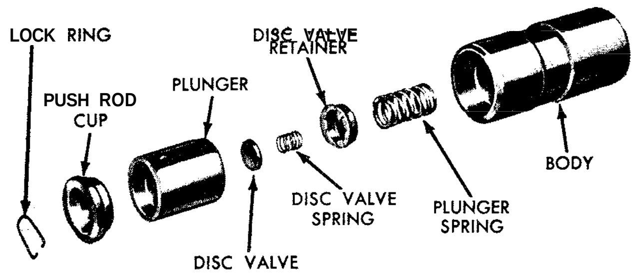
Check the valve springs for the correct tension against the Specifications in the Appendix. A quick check can be made by laying all of the springs on a flat surface and comparing the heights, which **must** be even. Also, the ends **must** be **square** or the spring will tend to cock the valve stem. Weak valve springs cause poor engine performance; therefore replace any spring that is weak or out of square by more than 1/16".



A valve spring should not be out by more than 1/16" when it is rotated against a square on a flat surface, as shown. If it is, the spring should be replaced.



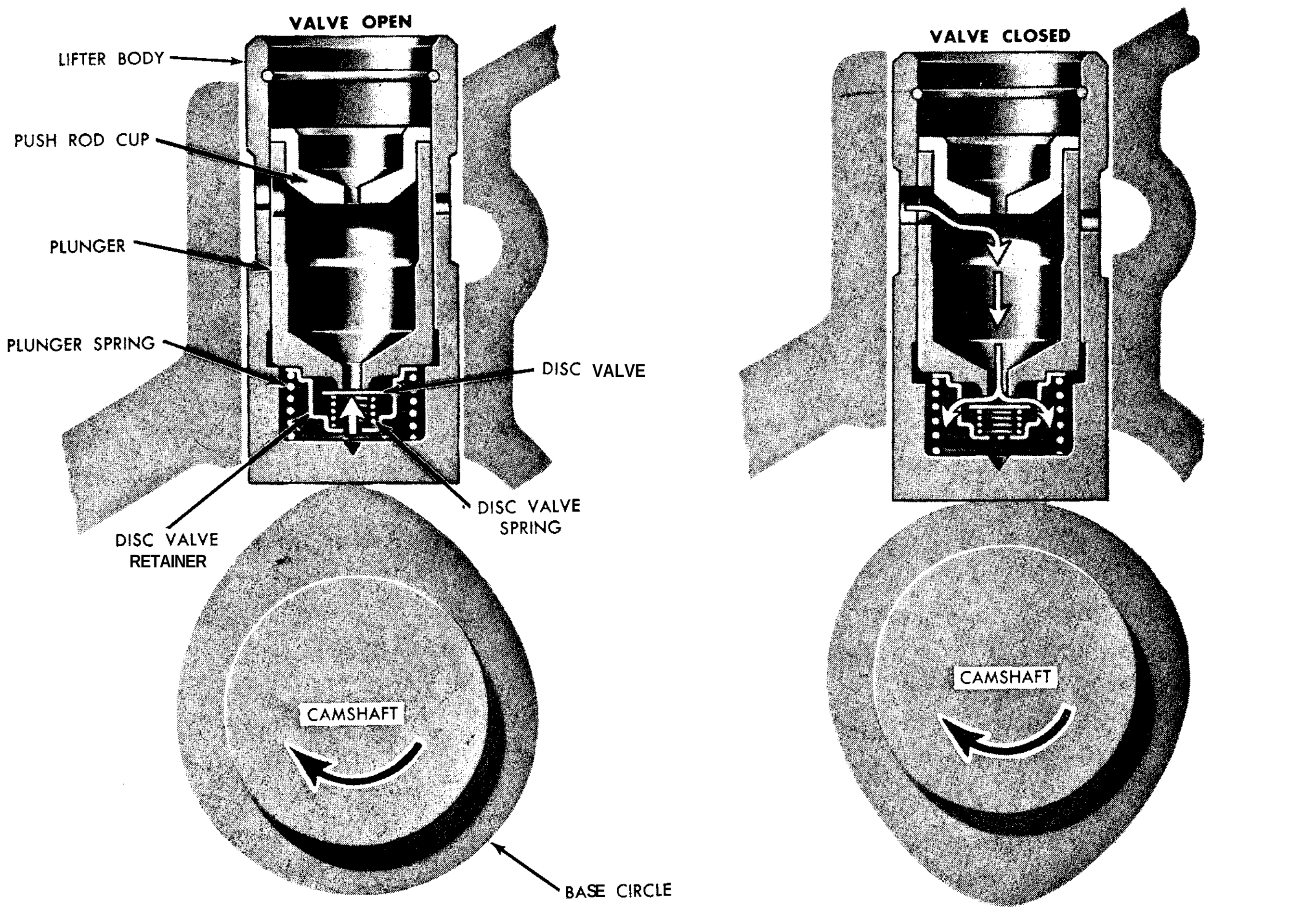
The valve spring tension should be checked with on accurate tester and torque wrench.



Arrangement of valve mechanism parts.

HYDRAULIC LIFTERS

Dirt, deposits of gum, and air bubbles in the lubricating oil can cause the hydraulic lifters to wear enough to cause failure. The dirt and gum-can keep a check valve from seating, which in turn will cause the oil to return to the reservoir during the time that the push rod is being lifted. Excessive movement of the parts of the lifter causes wear, which soon destroys the lifters effectiveness.

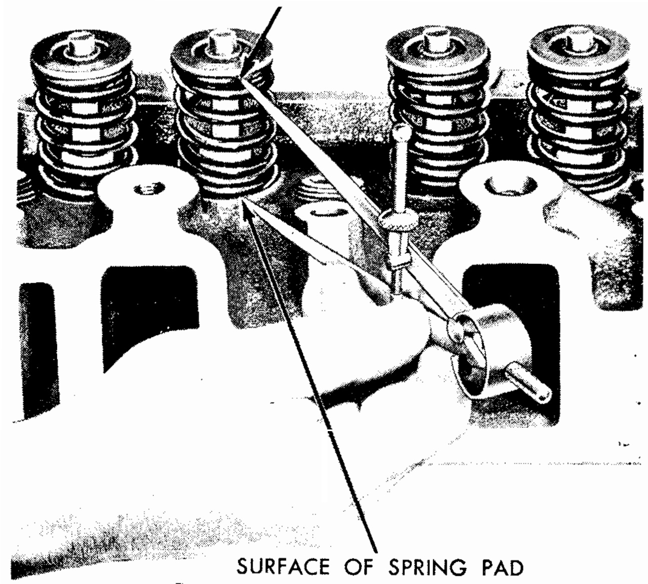


Kelationship of the cam lobe as the camshaft rotates, The cam moves the valve lifter to the valve open position (left)and then to the valve closed position (right).

The valve lifter assemblies must be kept in the proper sequence in order for them to be re-installed in their original position. Clean, inspect, and test each lifter separately so as not to intermix the internal parts. If any one part of a lifter needs to be replaced, replace the entire assembly.

To test a cleaned lifter, assemble the parts dry, and then quickly depress the plunger with your finger. The trapped air should partially return the plunger if the lifter is operating properly. If the lifter is worn, or if the check valve is not seating, the plunger will not return.

Install the assembled lifters in the engine dry. They will bleed to their correct operating position quicker than if you filled them with lubricating oil before installing.

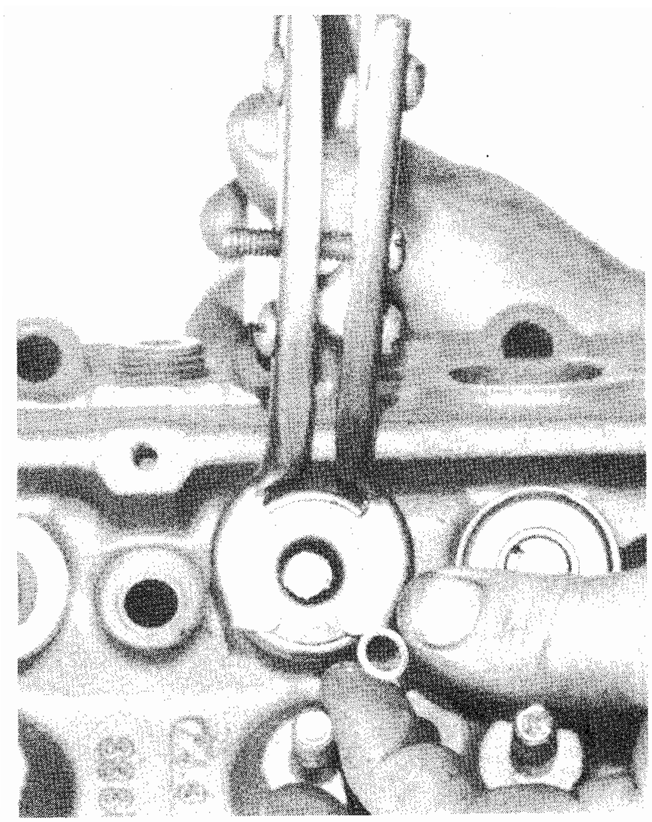


Measuring the height of the installed valve spring. Compare this measurement with the Specifications in the Appendix.

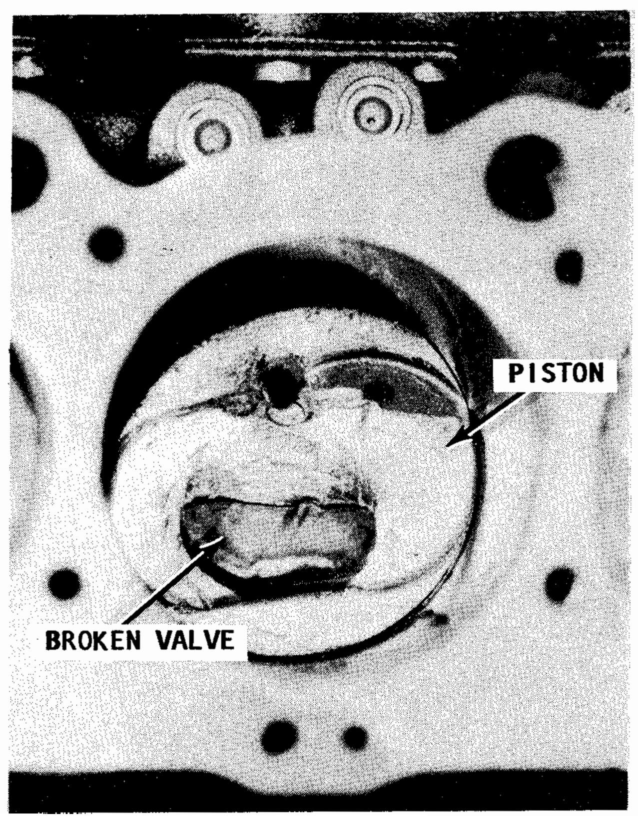
CYLINDER HEAD RECONDITIONING

Start with No. 1 cylinder. Lubricate the exhaust valve with a generous amount of oil. Place the well-lubricated valve in the port and the valve spring and cap in position at the same time. The spring end with the closed coil **must** be against the cylinder head. Place the spring and rotator on the exhaust valves, and then compress the spring and install the oil seal and valve keys. Pay special attention that the seal is **flat** and not twisted in the valve stem groove and that the keys seat properly.

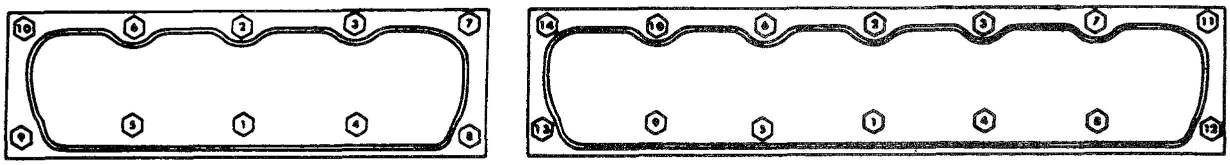
Assemble the remaining valves, valve springs, rotators, spring caps, oil seals, and



Installing the valves into the cylinder head, as explained in the text.



Improper installation techniques caused this valve to drop out and strike the piston.



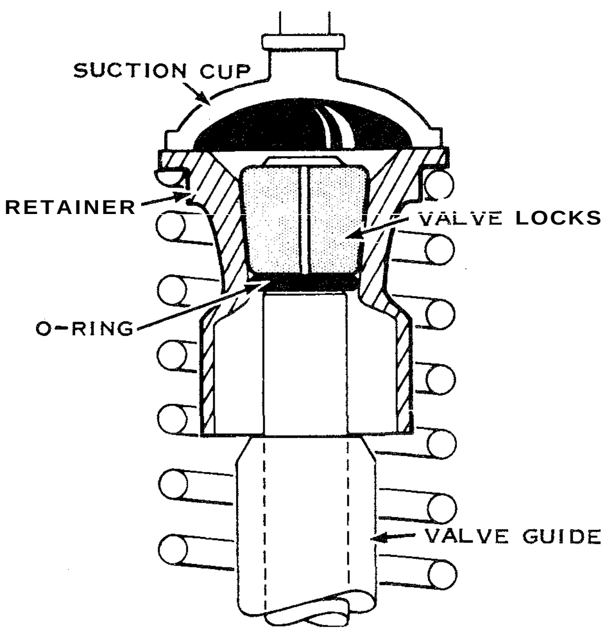
Tightening sequence for cylinder head bolts on a four- or six-cylinder in-line engine.

valve keys in the cylinder head in the same manner as the first. Check the seals by placing a vacuum cup over the valve stem and cap; squeeze the vacuum cup to make sure there is no leak past the oil seals.

Measure the valve spring compressed height. This measurement should be 1-21/32" to 1-23/32". If necessary, shims can be placed between the lower end of the spring and the spring recess in the cylinder head to obtain the required dimension.

CYLINDER HEAD INSTALLATION

The gasket surfaces on both the head and the block must be clean of any foreign material and free of nicks or heavy scratches. Bolt threads in the block and threads on the cylinder head bolts must be clean. Dirt on the threads will affect bolt torque values. **Do not** use any kind of gasket sealer on a composition steel-asbestos gasket. **Always** use a marine head gasket due to the possibility of the boat being used in salt water.

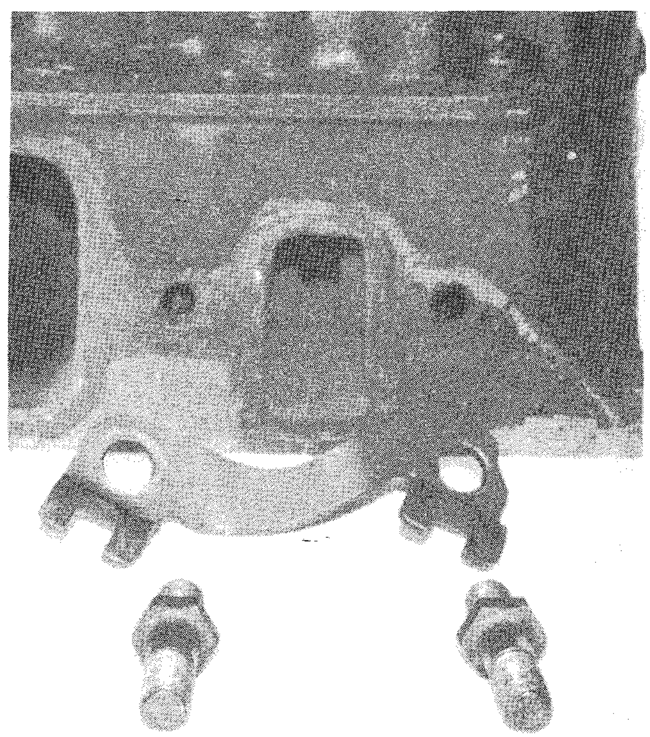


To prevent an oil leak into the combustion chamber, check to be sure the O-ring seal is not leaking. This can be done by applying vacuum to the assembly with a suction cup.

Place the gasket in position over the dowel pins, with the bead facing up. Carefully guide the cylinder head into place over the dowel pins and gasket. Coat the threads of the cylinder head bolts with sealing compound and install them fingertight. Tighten the cylinder head bolts a little at-a-time in the sequence shown in the accompanying illustration. Tighten the head bolts according to the Specifications in the Appendix.

Install the push rods and rocker arms. Install the manifold assembly.

Install the coil, spark plugs, and high-tension wires. Connect the upper water hose and the engine ground strap. Connect the temperature sending unit wires and install the fuel and vacuum lines in the clip at the water outlet. Replace the manifold assembly. See Section 3-4.



Proper arrangement of rocker arm studs and push rod guides prior to installation in the cylinder head.

3-7 VALVE LASH ADJUSTMENT

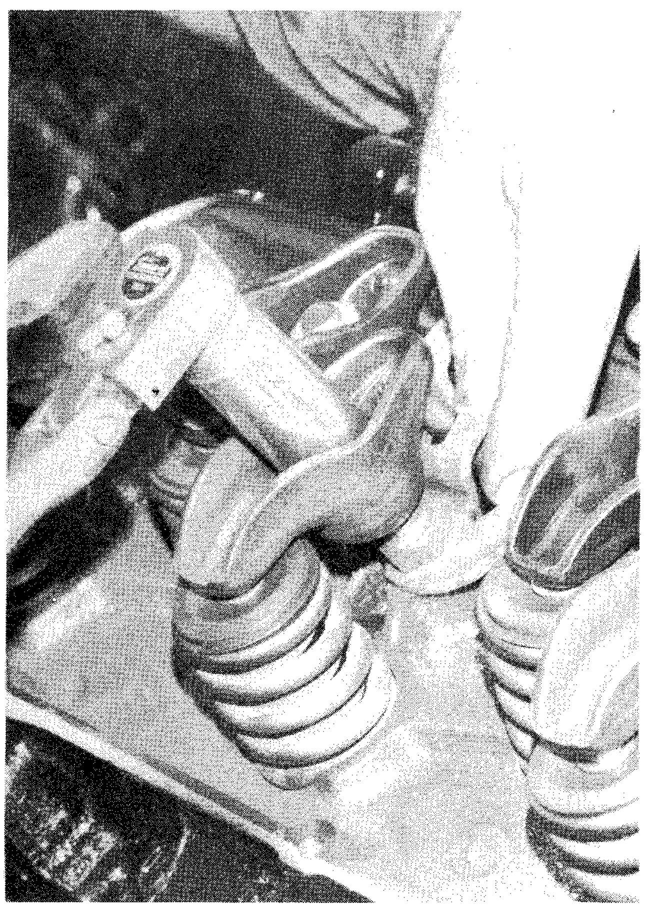
Proper valve lash can be done with the engine hot and idling or with the engine cold and not running. In either case, the adjustment is one turn down from the zero-lash position.

With the engine running:

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.

Loosen the adjusting nut until the valve clatters, indicating a loose adjustment. Next, turn the push rod while you tighten the adjusting nut until all noise just disappears and you feel resistance to turning the push rod. Now, turn the adjusting nut down exactly one complete turn to position the plunger in the center of its Lifter travel.

GOOD WORDS The engine may run rough until the lifter stabilizes itself, then it should smooth out. If it does not smooth out, replace the lifter, because it is sticky.



Making the valve lash adjustment, as described in the text.

With the engine **NOT** running: Disconnect the spark plug wires, and then remove the spark plugs. Adjust the nut until all the lash is removed. This position may be determined by checking push rod side play. Turn the push rod and at the same time adjust the nut very slowly. When no movement is felt on the push rod, turn the nut one full turn down.

SIX-CYLINDER ADJUSTMENT – COLD

Crank the engine until the distributor rotor points to No. 1 cylinder position and the breaker points are open. The following valves can be adjusted with the engine in the No. 1 firing position: Exhaust, 1,3,5. Intake, 1,2,4.

Crank the engine until the distributor rotor points to No. 6 cylinder position and the breaker points are open. The following valves can be adjusted with the engine in the No. 6 firing postion: Exhaust, 2,4,6. Intake, 3,5,6.

FOUR-CYLINDER ADJUSTMENT-COED

Remove the spark plug wires, and then the spark plugs and the distributor cap. Crank the engine until the distributor rotor points to the No. 1 cylinder position and the breaker points are open. At this position, both valves of the No. 1 cylinder are closed. Make the adjustment to both the No. 1 valves. Turn the adjusting nut until all the lash is removed. This position may be determined by checking push rod side play. Turn the push rod and at the same time adjust the nut very slowly. When movement is felt on the push rod, turn the nut one full turn down.

After the adjustment to the No. 1 valves has been completed, -crank the engine until the distributor rotor points to the No. 2 cylinder position and repeat the procedure given in the previous paragraph. Continue in a like manner until No. 3 and No. 4 cylinder valves have been properly adjusted.

Install the rocker arm cover and tighten the nuts to the torque value given in the Specifications in the Appendix. Connect the crankcase ventilation hoses.

3-8 PISTON RING AND ROD SERVICE

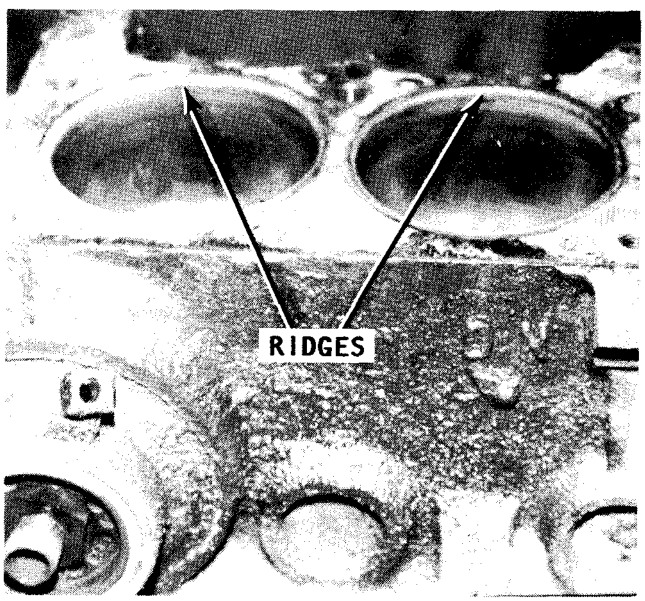
This section provides detailed procedures for removing, disassembling, cleaning, inspecting, assembling, and installing the complete piston-rod assembly. All parts **MUST** be kept together because if the old pistons are serviceable, they **MUST** be installed on the rods and back into the bore from which they were removed.

REMOVAL

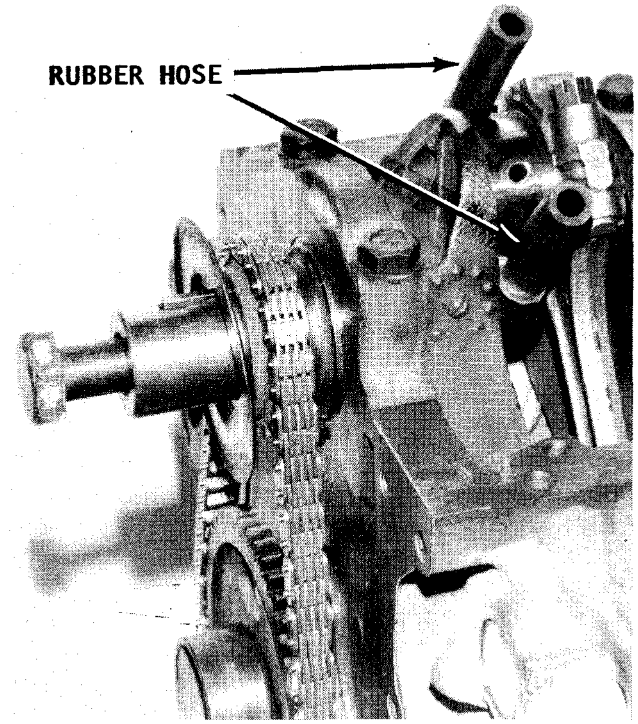
Remove the engine; see Section 3-1.
Remove the oil pan; see Section 3-2.
Remove the oil pump; see Section 3-3.
Remove the head; see Section 3-6.

After the oil pan, oil pump, and cylinder head have been removed, use a ridge reamer to remove the ridge and deposits from the upper end of the cylinder bore. Before the ridge and/or deposits are removed, turn the crankshaft until the piston is at the bottom of its stroke and place a cloth on top of the piston to collect the cuttings. After the ridge is removed, turn the crankshaft until the piston is at the top of its stroke to remove the cloth and cuttings.

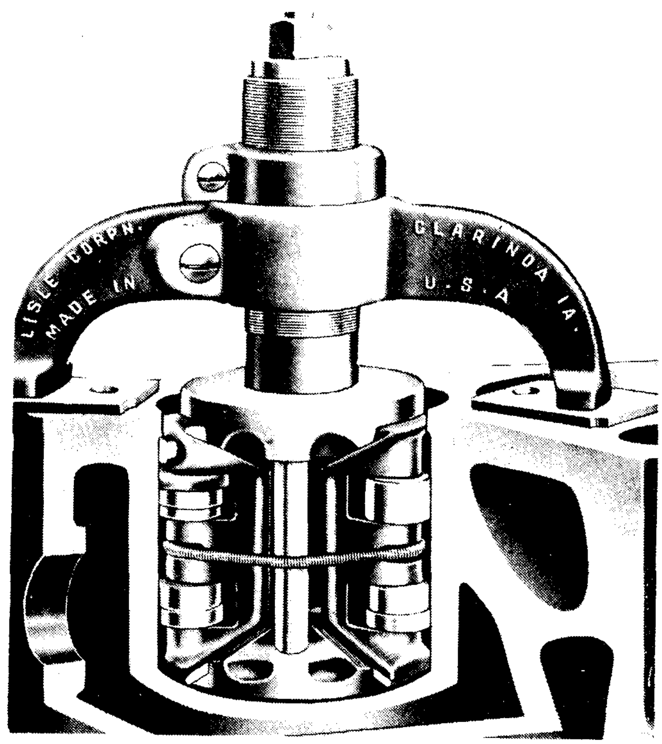
Identify each piston, connecting rod, and cap with a quick drying paint or silver pencil to ensure each part will be replaced in the exact position from which it was removed.



*Due to borderline lubrication conditions, the cylinder walls wear the most at the top. All measurements **MUST** be made in this worn area. This cylinder bore has been surfaced with a fine hone to remove the glaze for better piston ring seating.*



The rod bolt threads must always be covered with a piece of rubber hose to prevent damage to the bearing surface by the rod threads scraping as the piston assembly is removed.



*A ridge remover **MUST** be used to cut the ridge from the top of the cylinder walls. The stop under the blade prevents cutting into the walls too deeply. **NEVER** cut more than 1/32" below the bottom of the ridge.*

Remove the connecting rod cap nuts and caps, then install a thread-protecting tool on the studs.

Push the connecting rod-and-piston assembly out the top of the cylinder block. It will be necessary to turn the crankshaft slightly to disconnect some of the connecting rod-and-piston assemblies and push them out of the cylinders.

CLEANING AND INSPECTING

Check the rod bolts and nuts for defects in the threads. Inspect the inside of the rod bearing bore for evidence of galling, which indicates the insert is loose enough to move around. Check the parting cheeks to be sure the cap or rod has not been filed. Replace any defective rods.

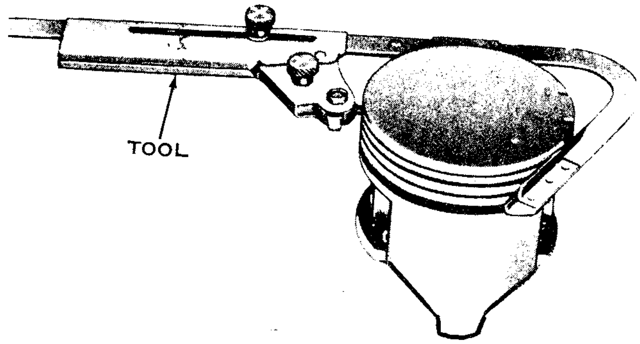
If the engine has over 750 hours of service, or if the piston and rod assembly has been removed, it is considered good shop practice to replace the piston pins. Loose piston pins, coupled with tight piston assemblies such as new piston rings, will cause piston pin noises. These noises may disappear as the engine loosens, but strange noises are difficult to explain to a customer who has just paid the bill.

Most mechanics have the piston pin work done by a machine shop with the necessary equipment and trained people to perform a precision job. If done in the machine shop the connecting rods will be aligned so the pistons and rings will run true with the cylinder walls.

Wash the connecting rods in cleaning solvent and dry with compressed air. Check far twisted or bent rods and inspect for nicks or cracks. Replace any damaged connecting rods.

Use a cleaning solvent to remove the varnish from the piston skirts and pins. **NEVER** use a wire-brush on any part of the piston. Clean the ring grooves with a groove cleaner and make sure the oil ring holes and slots are clean. Inspect the pistons for cracked ring lands, skirts, or pin bosses; wavy or worn ring lands; scuffed or damaged skirts; and eroded areas at the top of the pistons.

Replace any piston that is damaged or shows signs of excessive wear. Inspect the grooves for nicks or burrs that might cause the rings to hang-up. Measure the piston skirt (across the centerline of the piston pin) and check the clearance in the cylinder bore. The clearance should not be greater than 0.0025".

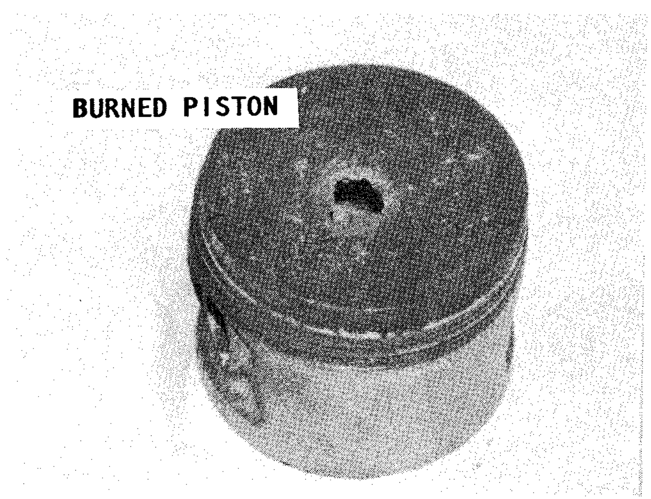


The ring grooves must be thoroughly cleaned to permit the new rings to seat properly.- TAKE CARE not to nick the sealing surfaces, or the ring will leak compression.

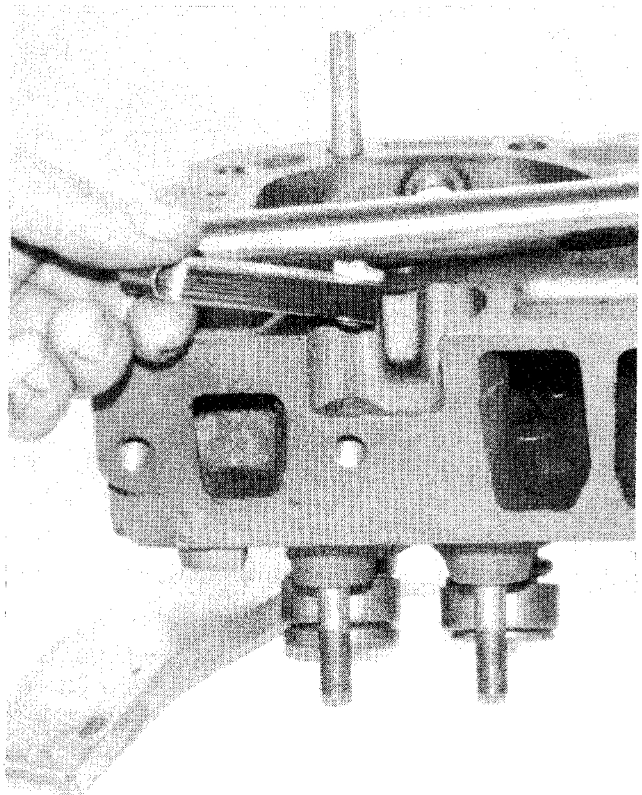
Inspect the piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured. The piston pin bore should be measured with a dial bore gauge or an inside micrometer. If the clearance is greater than 0.001", the piston and/or piston pin should be replaced.

DISASSEMBLING

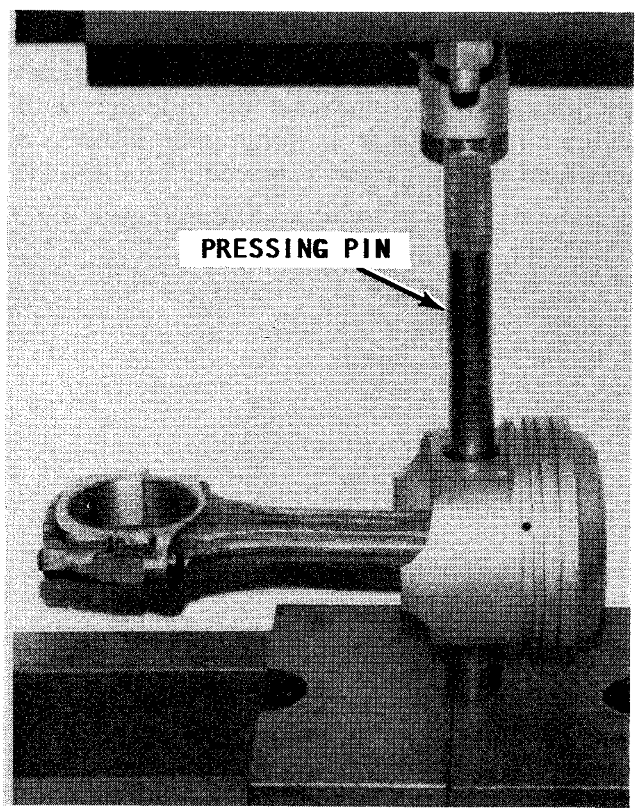
Install the pilot part of tool J-6994 (Piston Pin Removing & Installation Tool), on the piston pin. Place the piston-and-rod assembly on a support and position the assembly in an arbor press as shown. Press the pin out of the connecting rod. Remove the assembly from the press. Lift the piston pin from the support, and remove the tool from the piston and rod.



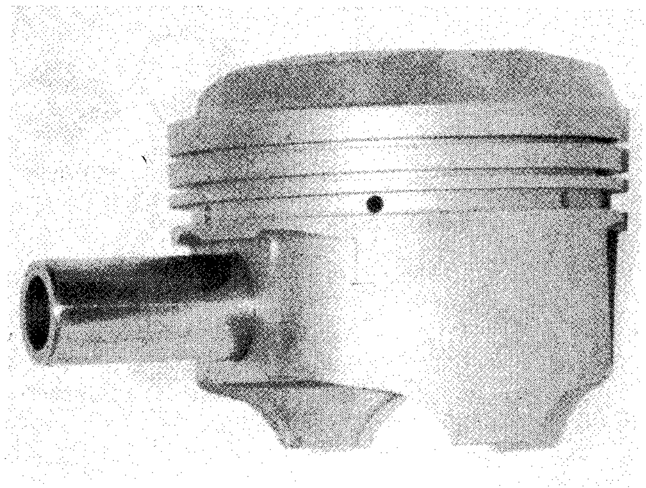
Preignition caused this piston crown to melt.



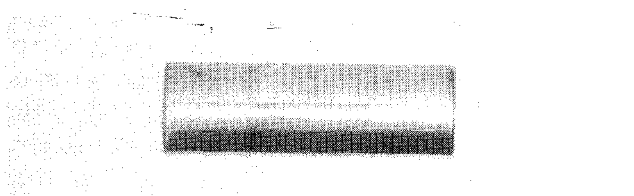
The cylinder head gasket surface must be checked for any uneven condition. Surface irregularities **MUST** *NOT exceed 0.003" in any six-inch space.*



An arbor press and a special tool should be used to remove pressed-in piston pins.

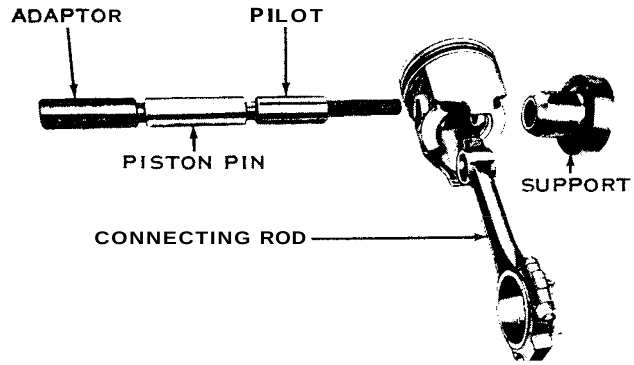


A properly fitted pin should support its own weight in either pin boss when it has been coated with light engine oil at room temperature.



Three measurements with a micrometer should be made to determine piston pin wear. One, on the unworn section (center), the second and third, on both ends. Comparing any difference will indicate the amount of wear.

Using a micrometer to measure the piston circumference. Check used pistons for out-of-roundness at the same time.

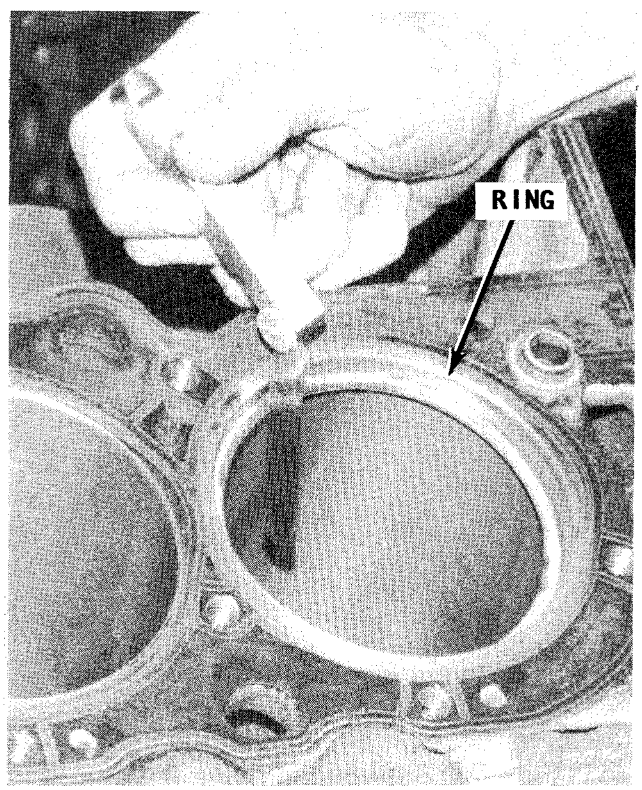


Arrangement of special tools required to properly install a piston pin through the piston.

ASSEMBLING

Apply a liberal amount of oil in the piston holes and the connecting rod holes to aid the press fit of the pin. Place the connecting rod in its respective piston with the flange or heavy side of the rod at the bearing end toward the **FRONT** of the piston. The front of the piston is identified by the cast depression in the top of the piston head.

Install the piston pin on the installer. Place the pilot spring and the pilot in the support. Install the piston and rod on the support, with the pilot indexing through the



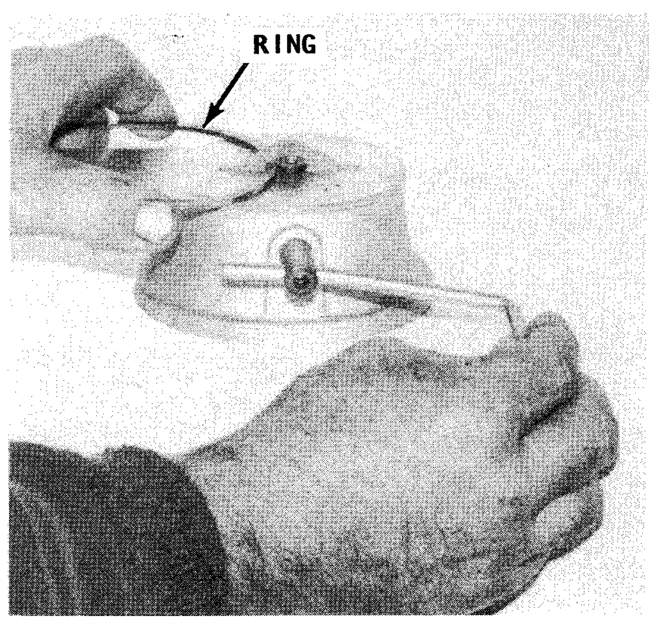
Check the piston ring end gap with a feeler gauge, as shown.

*The piston-ring side clearance **MUST NOT** exceed 0.004".*

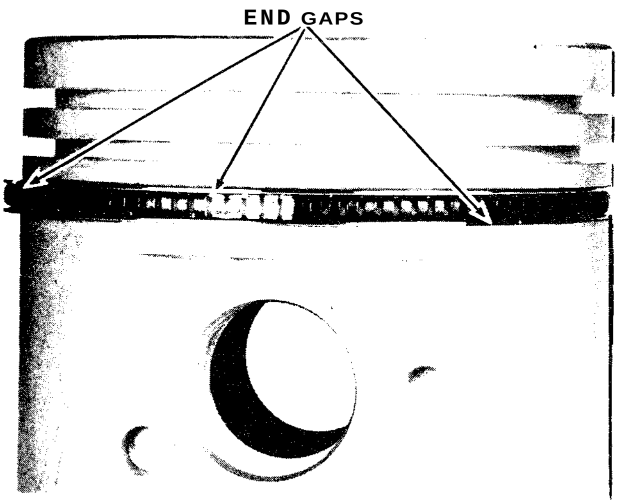
piston and rod. Place the support on the arbor press. Start the pin into-the piston, and press on the installer until the pin pilot bottoms. Remove the installer and support assembly from the piston and connecting rod assembly. Check the piston pin to be sure there is free movement in the piston bores.

RINGS

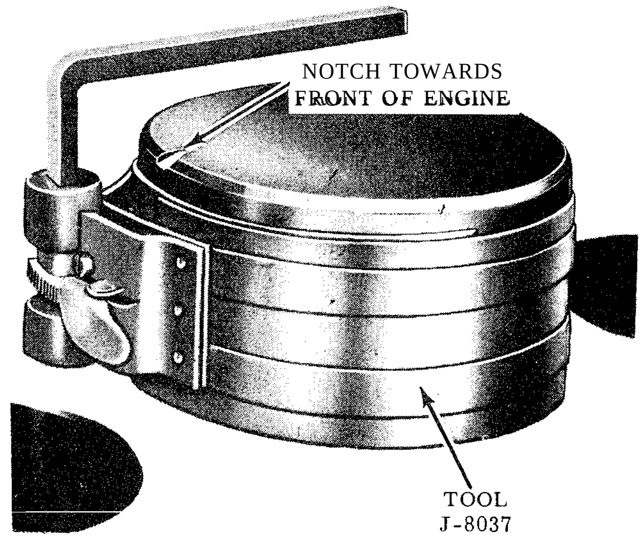
Always install a new set of rings when overhauling an engine. Order the ring set according to the amount of cylinder wall wear. If the wear is less than 0.005", a standard set of piston rings can be used. If



Grinding ring ends to obtain proper end gap.



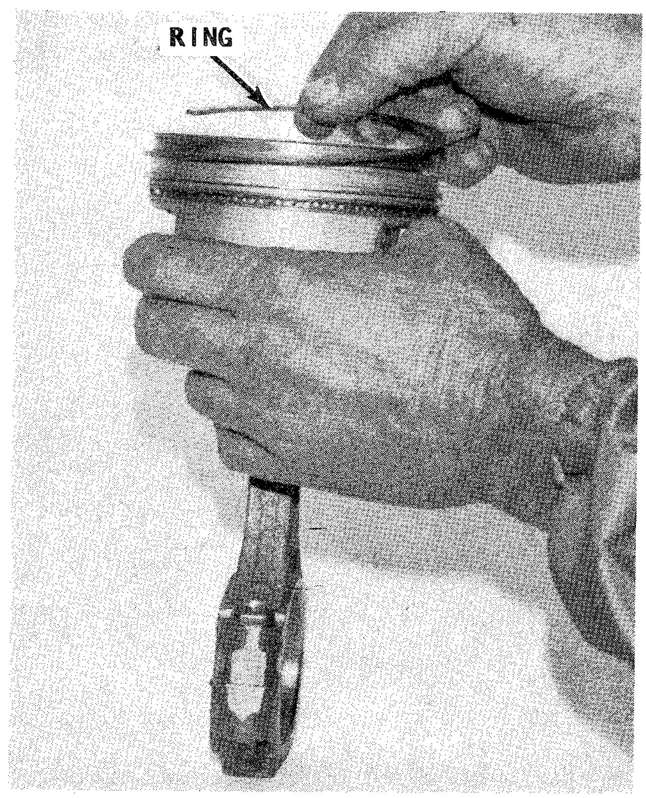
Proper method of spacing the rail gaps and the spacer gap on a compound oil ring.



A piston ring expanding tool must ALWAYS be used when installing the rings onto the piston. If such a tool is not used, the ring may be distorted and bind in the ring groove.

the cylinder wall wear is between 0.006" and 0.012", a set of piston rings with a special oil ring and expanders MUST be used to keep the engine from pumping oil. If the cylinder bore is worn over 0.012", the cylinder should be reconditioned by boring or honing in order to straighten the cylinder walls. This operation is necessary to enable the new piston rings to make a proper seal.

Before installing a set of piston rings, the end gaps and the side clearance between the piston ring groove and the ring must be

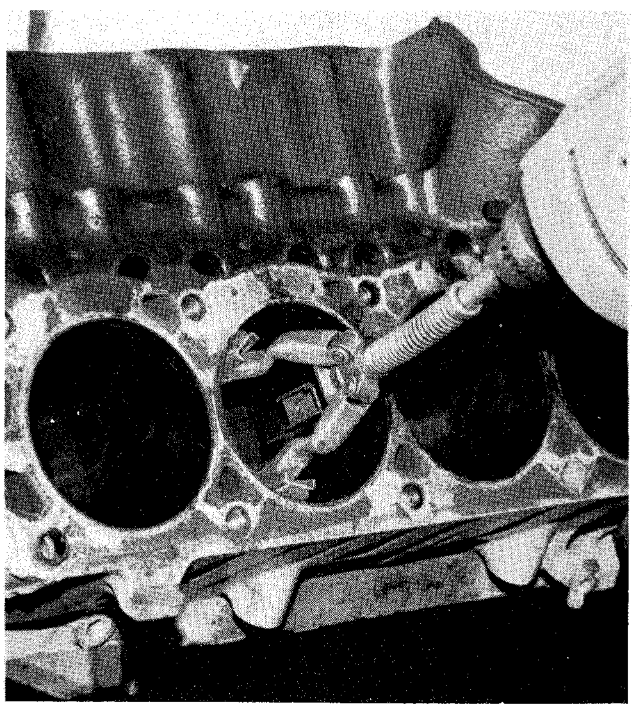


Proper installation of a new ring into the piston ring groove. Notice how the ring is bent slightly upward (left). After the ring is started, the ring is rotated around and over the top of the piston (right). The ring will feed into the groove and the end will finally snap into place.

checked. The correct side clearance should be 0.002" to 0.004", with a wear limit of 0.006". The side clearance of a new ring is not excessive unless the ring groove is worn. A burr in the soft piston metal may cause the ring to bind. To check for burrs, rotate the back of each piston ring around the groove and be sure it does not bind any where around the piston.

The end gap of each ring must be checked to be sure the ring is not too long and there is enough gap where the two ends come together to handle expansion of the ring when it becomes hot. The two ends must never come completely together during operation of the piston.

The end gap is checked by first inserting each piston ring into its cylinder bore at the bottom, where very little cylinder wear exists, and then squaring up the ring. The ring can be squared quickly by inserting the piston into the cylinder upside down. Now, measure the end gap between the ends of the ring. The standard clearance is 0.010" to 0.020", except for the steel rails of the oil rings. The gap for these rings is 0.015" to 0.030". The exception to all of these measurements would be as listed in the specifications for a particular group of engines. If the end gap is too small, the ends of the ring can be filed to increase the gap measurement.



Refinishing the cylinder wall using an electric drill and a hone. ALWAYS keep the hone moving in long even strokes over the entire depth of the cylinder.

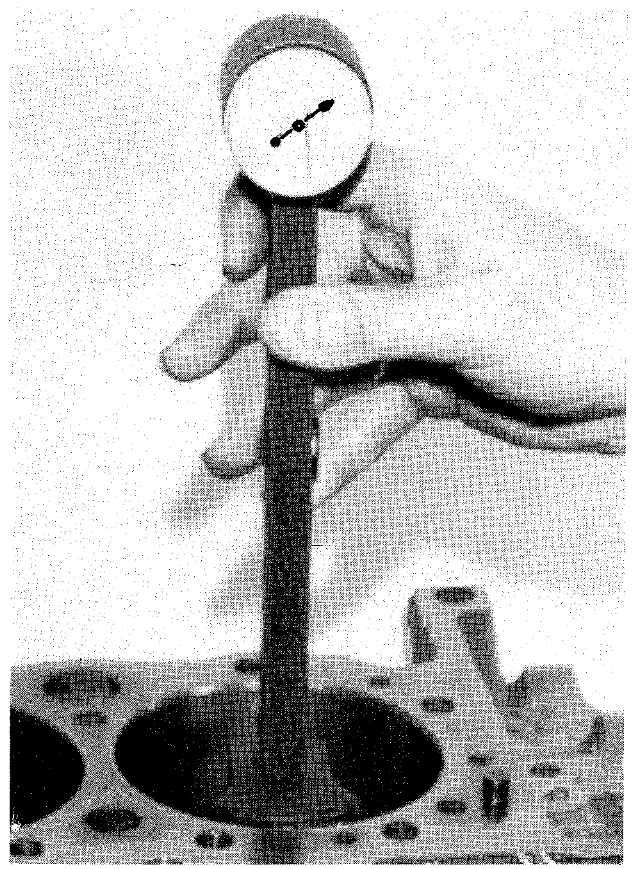
When installing the rings onto the piston, be sure to check the compression and scraper rings for the proper method of installation. Some rings have the word **TOP** stamped on the side that **MUST** face up. A compression ring with a groove in its outer face must be installed with this groove facing **DOWN**. If the groove is cut into the rear face of the ring, the groove **MUST** face UP when installed.

If a steel spacer is used along with a top compression ring in order to compensate for machine work on the groove, the steel spacer **MUST** be installed **ABOVE** the cast iron ring.

CLEANING AND INSPECTING

All cleaning and inspection work should be done in an organized and thorough manner. A complete and thorough job in this area will justify the hours of work and cost of new parts involved in the engine reconditioning task.

An oversight of letting a defective part be reinstalled, or assembling parts that have not been properly cleaned will nullify much of the other work and may restrict performance of the engine after the job is completed.



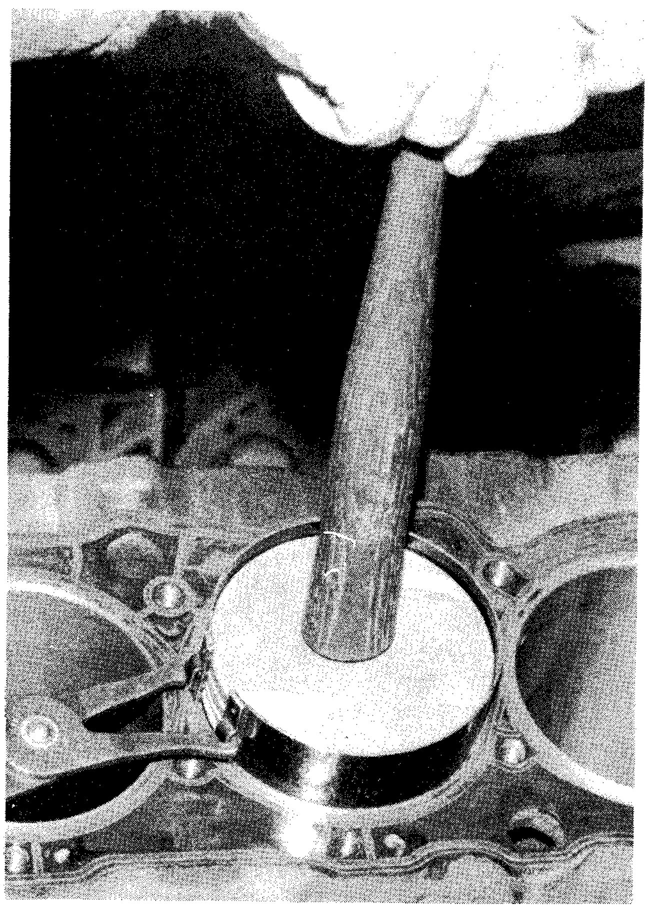
Cylinder wall taper and wear measured with a bore gauge indicator.

CYLINDER BLOCK

Check the cylinder block for cracks in the cylinder walls, water jacket, and the main bearing webs. Check the cylinder bores for taper, out-of-round, or excessive ridge wear at the top of the ring travel. This should be done with a dial indicator.

Set the gauge so the thrust pin is forced in about 1/4" to enter the gauge in the cylinder bore. Center the gauge in the cylinder and turn the dial to "0". Slowly move the gauge up and down the cylinder to determine the amount of taper. Move the gauge around in the cylinder to determine if it is out-of-round.

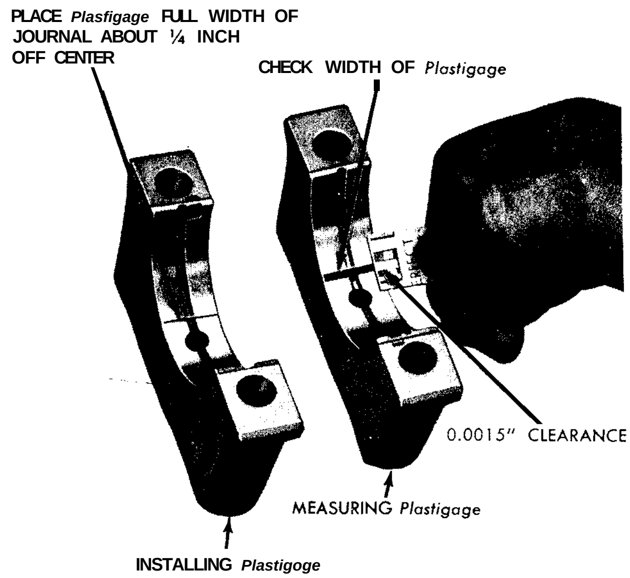
If a cylinder is more than 0.002" out-of-round, it will be necessary to rebore the cylinder for satisfactory service. If the cylinder bores are not worn excessively, use a 220-grit stone to remove the wall glaze to enable the new rings to seat quickly. To prevent excessive engine wear, **ALWAYS** use a solution of soap and hot water to remove all traces of abrasives.

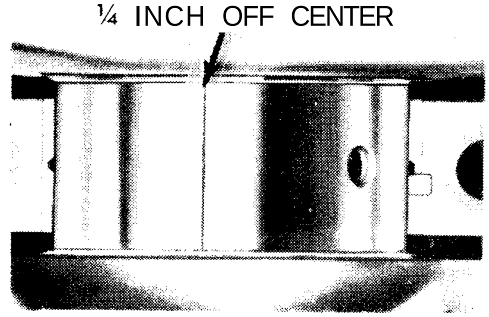


Installation of a well-lubricated piston and ring assembly into its proper cylinder. NEVER hammer on the piston head because a ring may have popped out of its groove and be broken.

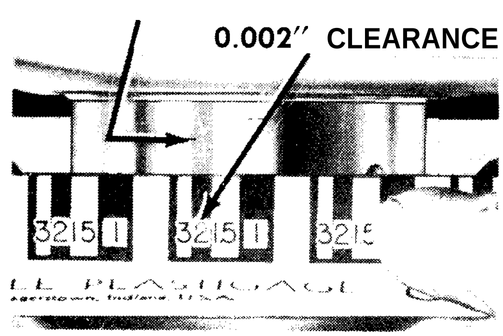
PISTON AND ROD ASSEMBLY INSTALLATION

Coat the piston, rings, and cylinder walls with light-weight engine oil. With the bearing cap removed, install Tool J-5239 on the bearing cap bolts. Install each piston in its





INSTALLING PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

respective bore. If the old pistons are being used BE **SURE** each piston is installed in the same bore from which it was removed. Compress the piston rings. The side of the piston with the cast depression in the head **MUST** be to the **FRONT** of the cylinder block, and the oil hole in the connecting rod **MUST** face the camshaft side of the engine.

Clean the journal thoroughly of all traces of oil, and then place a piece of Plastigage on the bearing surface, the full width of the cap. Install the cap and torque the retaining bolts according to the specifications listed in the Appendix. **DO NOT** turn the crankshaft with the Plastigage in place or you will distort it and the reading will have no value. Remove the bearing cap. Use the scale on the plastic strip to determine the clearance. The bearing journal is tapered and so is the Plastigage. Measure the Plastigage at the widest point and also at the narrowest point. These measurements will give you the minimum and maximum clearances. If the clearance exceeds 0.0025", a new insert should be installed. After you have installed the new insert make another Plastigage measurement. If the new clearance still does not give the proper clearance according to the specifications, then an undersized insert should be used.

Guide the connecting rod bearing into place on the crankshaft journal. Install the bearing cap and tighten the cap nuts to the torque value given in the Specifications in the Appendix. Check the bearing side clearance against the specifications.

Install the oil pump, see Section 3-2.

Install the oil pan gaskets, seals, and oil pan; see Section 3-3.

Install the cylinder head gasket and head; see Section 3-6.

Install the intake and exhaust manifold; see Section 3-4.

Replace all water hoses and wiring. Refill the crankcase with the proper amount and grade of oil.

Start the engine and check for leaks.

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,

3-9 CAMSHAFT SERVICE

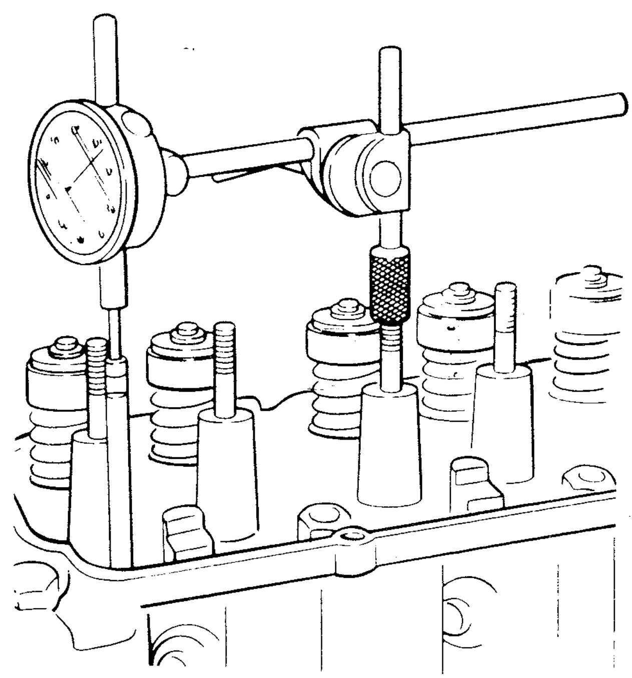
If the engine is to perform properly, the valves must open and close at a predetermined precise moment for maximum efficiency. On the power stroke, the exhaust valve must open just before bottom dead center in order to permit the exhaust gases to leave the combustion chamber under the remaining pressure (blowdown). On the exhaust stroke, the intake valve must open just before top dead center in order to permit the air-fuel mixture to enter the combustion chamber. The movement of the valves are functions of the camshaft design and the valve timing. Therefore, excessive wear of any camshaft part will affect engine performance.

CAMSHAFT LIFT MEASUREMENT

If improper valve operation is indicated, measure the lift of each push rod in consecutive order and record the readings. Remove the valve mechanism. Position a dial indicator with ball socket adapter (Tool J-8520) on the push rod. Rotate the crankshaft slowly in the operating direction until the lifter is on the heel of the cam lobe. At this point, the push rod will be in its lowest position.

Set the dial indicator on zero, then rotate the crankshaft slowly, or attach an auxiliary starter switch and "bump" the engine over, until the push rod is in the fully raised position.

The distributor primary lead **MUST** be disconnected from the negative post on the coil and the ignition switch **MUST** be in the



Checking cam lift using Tool 58520.

ON position, or the grounding circuit in the ignition switch will be **DAMAGED.**

Compare the total lift recorded from the dial indicator with the specifications listed in the Appendix.

Continue to rotate the camshaft until the indicator reads zero. This point will be a check on the accuracy of the original indicator reading.

If the camshaft readings for all lobes are within specifications, remove the dial indicator assembly.

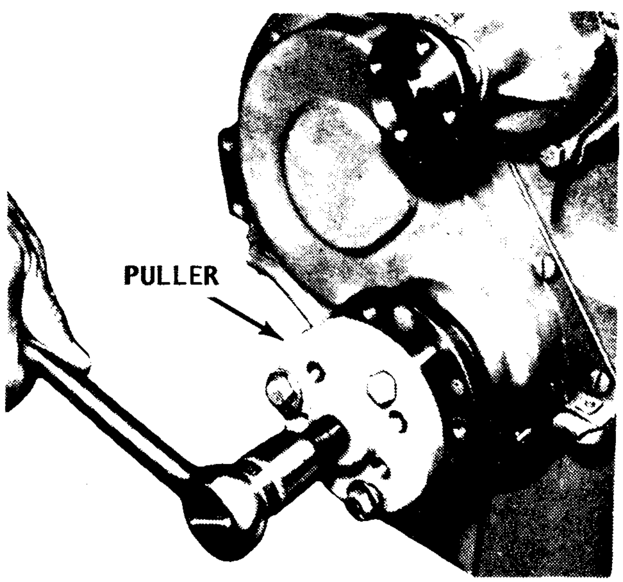
Install the valve mechanism; see Section 3-6

Adjust the valve mechanism; see Section 3-7.

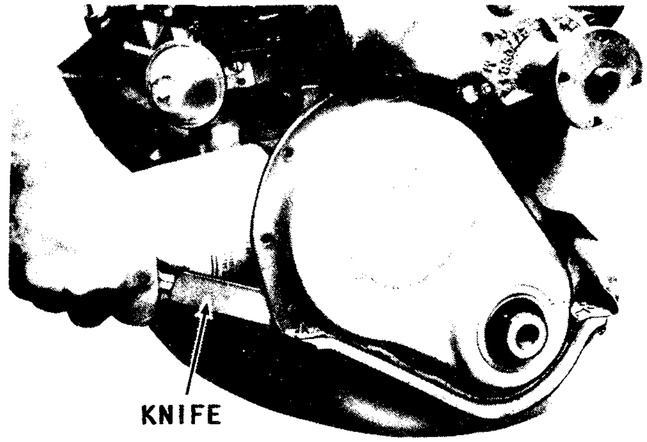
REMOVAL

The engine does not have to be removed from the boat if the camshaft merely needs servicing. However, if the camshaft bearings require replacement, then considerable work must be done including removal of the engine as described later in this section under the heading: CAMSHAFT BEARING SERVICE.

To remove the camshaft, begin by removing the valve cover and gasket. Next, loosen the valve rocker arm nuts until the pivot rocker arms clear the push rods. Now, note the position of the distributor rotor, and then remove the distributor. Next, remove the ignition coil and side cover gasket.



Attach a puller to remove the harmonic (torsional) balancer.



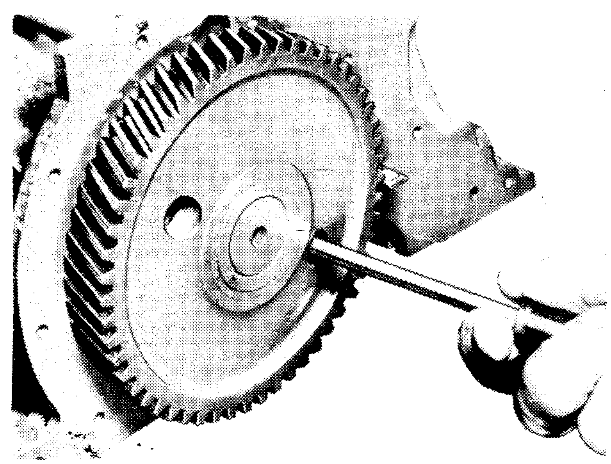
Before removing the crankcase front cover, the ends of the oil pan gaskets must be cut with a knife.

TAKE TIME to set up a systern to keep the push rods, and valve lifters in order to **ENSURE** each will be installed back into the exact location from which it was removed. Pull out the push rods and valve lifters in order.

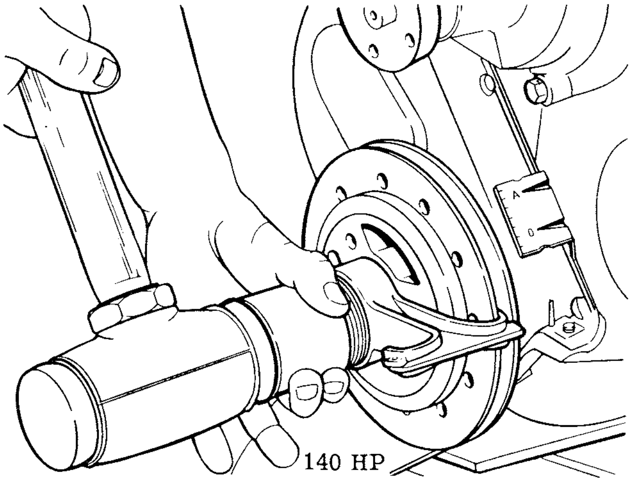
Pull off the harmonic (torsional) balancer. Remove the two oil pan-to-front cover screws, and then take out the front cover-to-block attaching screws. Pull the cover slightly forward.

Cut the oil pan front seal flush with the cylinder block at both sides of the cover with a sharp knife, as shown in the accompanying illustration. Remove the front cover gasket.

Rotate the camshaft gear until the holes in the gear align with the thrust plate screws, then remove the two screws. Pull the camshaft gear and camshaft straight out of the block.



Remove the screws securing the gear to the camshaft.



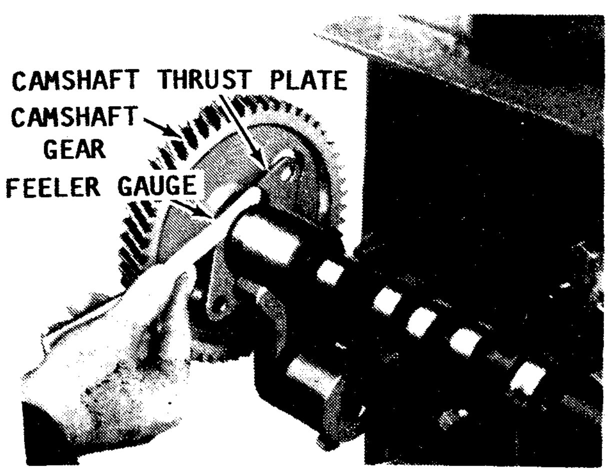
Using a puller to remove the pulley.

Check the gear and thrust plate end-play. Compare your measurement against the limits given in the Specifications in the Appendix.

If the decision is made to replace the camshaft, gear, or the thrust plate, the gear will have to be removed from the shaft. Gear removal from the shaft requires the use of Camshaft Gear Remover Tool J-791. Place the camshaft through the gear remover; place the end of the remover on the table of an arbor press; and press the shaft out of the gear.

The thrust plate **MUST** be positioned so the woodruff key in the shaft does not damage the shaft when the shaft is pressed out of the gear. Also, be sure to support the hub of the gear or the gear will be seriously **DAMAGED.**

To assemble the camshaft parts, first firmly support the camshaft at the back of the front journal in an arbor press. Next, place the gear spacer ring and the thrust



Check end play of the gear.

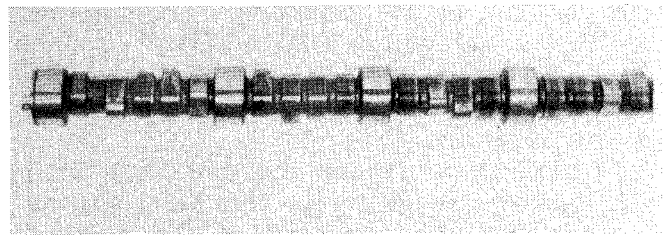

Cam with scored lobes.

plate over the end of the shaft, and install the woodruff key in the shaft keyway. Install the camshaft gear and press it onto the shaft until it bottoms against the gear spacer ring. Measure the end play of the thrust plate. This clearance should be 0.001" to 0.005".

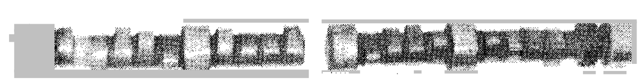
CLEANING

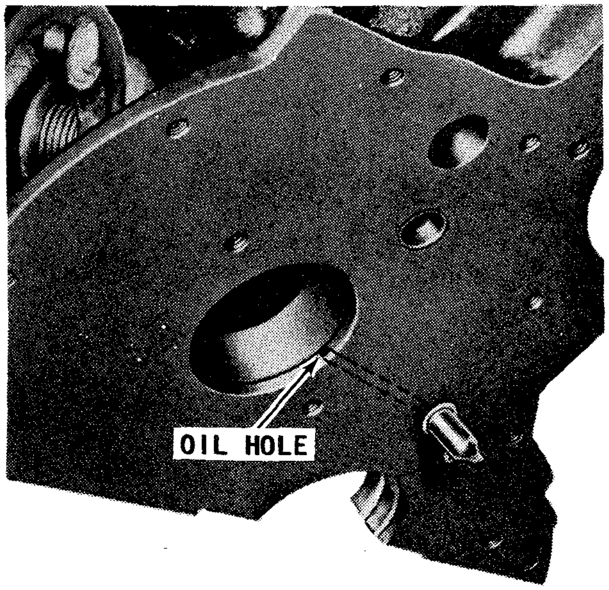
Clean the camshaft with solvent and wipe the journals dry with a lint-free cloth. **ALWAYS** handle the shaft **CAREFULLY** to avoid damaging the highly finished journal surfaces. Blow out all of the oil passages with compressed air.

Clean the gasket surfaces on the block and crankcase front cover. Cut the tabs from the new oil pan front seal. Use a sharp knife to ensure a clean cut.

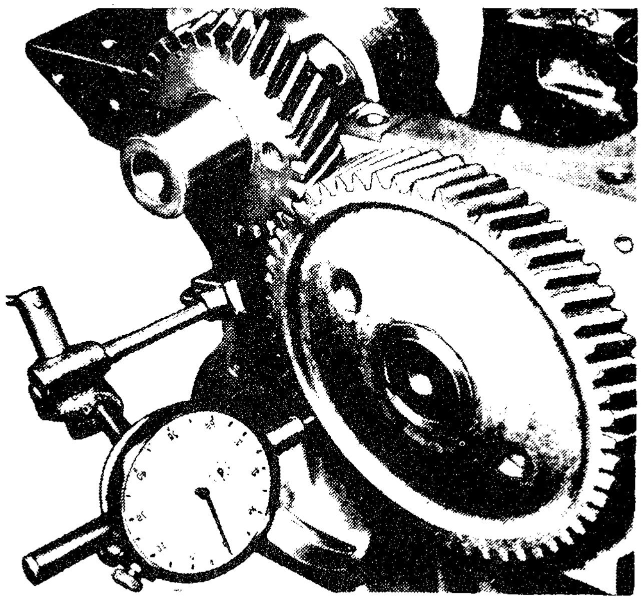
Check the diameter of the three camshaft bearings with a micrometer for out-of-round condition. If the journals are out-of-round more than 0.001", the camshaft should be replaced. Compare your findings with the Specifications in the Appendix.

Check the camshaft for alignment. This is best done using "V" blocks and a dial indicator. The dial indicator will indicate the exact amount the camshaft is out of true. If it is out more than 0.002" dial indicator reading, the camshaft should be replaced. When using the dial indicator in this manner the high reading indicates the high point of the sha-ft. Examine the camshaft bearings and if any one bearing needs to be replaced, **ALL THREE** should be replaced.


Handle the camshaft CAREFULLY to prevent damage to the lobes or the bearings in the block.



The cam MUST clear the oil hole.



Checking camshaft and crankshaft run out.

CAMSHAFT INSTALLATION

Coat the cam lobes with G.M. Super Engine Oil Supplement (G.M. P/N 1051858) or equivalent, and then add the remainder in the can to the crankcase oil. Install the camshaft assembly in the engine block. Take care to move the shaft straight into the block and not to damage the bearings or cams.

Rotate the crankshaft and camshaft until the valve timing marks on the gear teeth align, then push the camshaft into final position. Install the camshaft thrust plate screws and tighten them to the torque value given in the Specifications in the Appendix.

Check the camshaft and crankshaft gear runout with a dial-indicator. The camshaft gear runout should not exceed 0.004" and the crankshaft gear runout should not exceed 0.003".

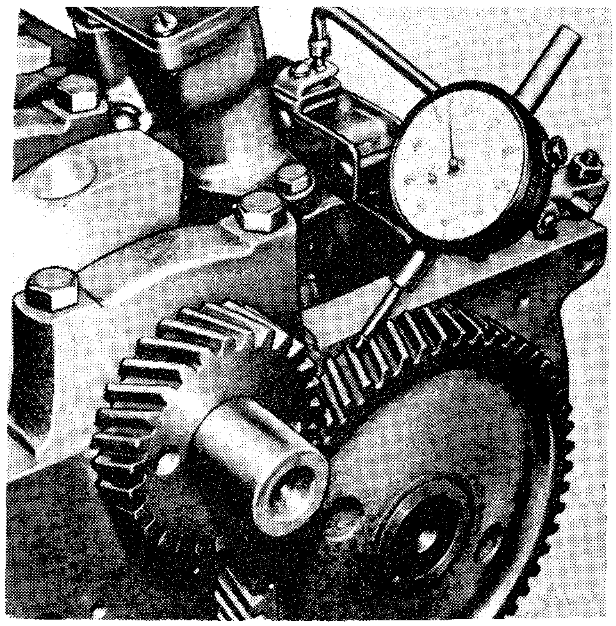
If the gear runout is more than the 0.003" limit, the gear will have to be removed and any burrs cleaned from the shaft. If this does not reduce the runout to 0.003", then either the shaft or the gear will have to be replaced.

Check the backlash between the timing gear teeth with a narrow feeler gauge or dial indicator. The backlash should not be less than 0.004" nor more than 0.006".

Install the seal on the front cover, pressing the tips into the holes provided in the cover. Coat the gasket with sealer and place it in position on the cover. Apply a 1/8" bead of RTV (Part No. 105-1435) Silicone Rubber Seal to the joint at the oil pan and cylinder block as shown.

Install the centering tool J-23042 into the crankcase front cover seal. A centering tool **MUST** be used to align the crankcase front cover, to ensure the torsional damper installation will not damage the seal. The centering tool will also position the seal **EVENLY** around the balancer.

Install, and partially tighten, the two oil pan-to-front cover screws. Install the front



Checking timing gear backlash.

cover-to-block attaching screws. Remove the centering tool. Tighten all of the cover attaching screws to the torque value given in the Specifications. Install the torsional damper.

Coat the oil seal contact area on the hub (or harmonic balancer 140HP) with engine oil. Position the hub over the crankshaft and key, then start the hub into position with a mallet. Drive the hub onto the crankshaft using tool J-5590 and a mallet until the hub bottoms against the crankshaft gear. The crankshaft extends slightly through the hub, therefore a hollow tool **MUST** be used to drive the hub completely to the bottom position. Install the pulley onto the hub. There are two 3/8" holes and one 5/16" hole that **MUST** be matched on the hub in order to properly position the timing mark.

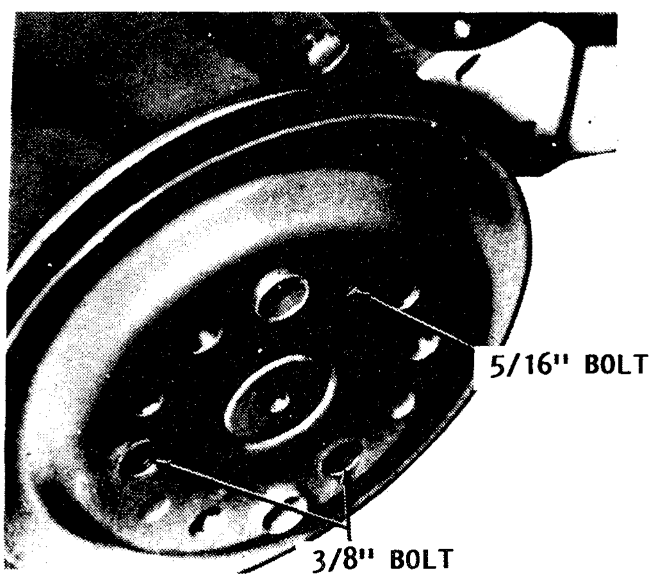
Install the valve lifters and push rods. Install the rocker arms onto the push rods and tighten the rocker arm nut **ONLY** enough- to hold the push rod until the valves are adjusted. Replace the side cover using a new gasket. Install the ignition coil. Install the distributor rotor and cap.

Adjust the valves; see Section 3-7.

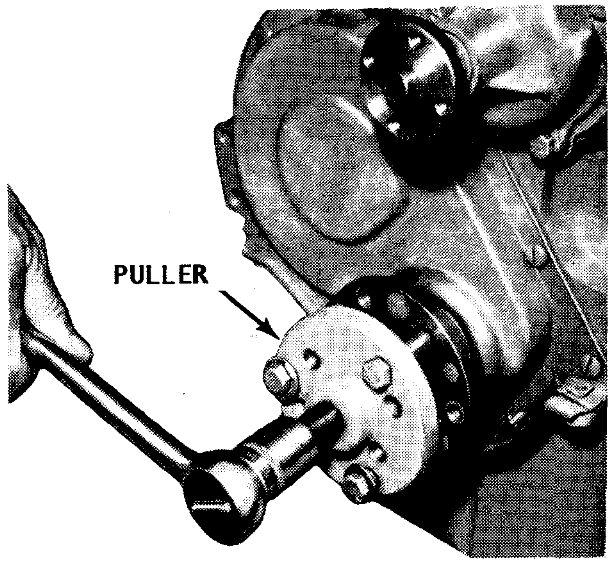
Install the alternator belt and adjust it according to the Specifications listed in the Appendix.

Start the engine and check for leaks.

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.



TAKE CARE to align the one 5/16" and the two 3/8" holes.



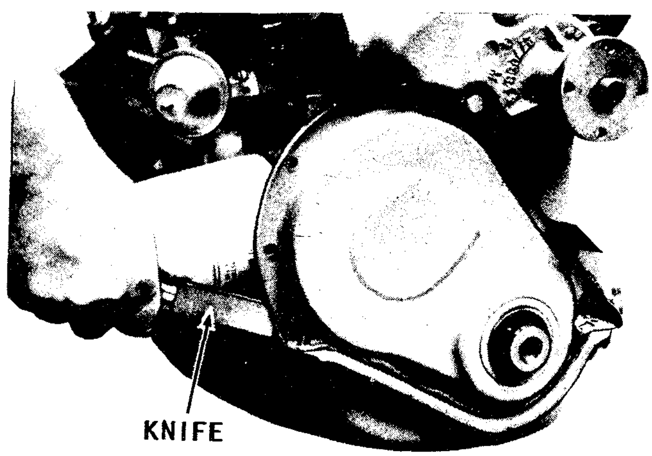
A puller must be used to remove the harmonic balancer.

CAMSHAFT BEARING SERVICE

Removal and replacement of the camshaft bearings should be performed by qualified mechanics in a shop equipped to handle such work. However, in most cases the block bores for the bearings can be bored to a larger size and oversize bearings installed. **BE SURE** to check with your local marine dealer for oversize bearings available.

3-10 CRANKCASE FRONT COVER

The crankcase cover must be removed before removing the camshaft, the crankshaft timing gear, or to merely inspect these gears or to check the timing between the two.



Before removing the crankcase front cover, the ends of the oil pan gaskets must be cut with a knife.

REMOVAL

Pull off the torsional damper. Remove the two oil pan-to-front cover screws and then take out the front cover-to-block attaching screws. Pull the cover forward a bit.

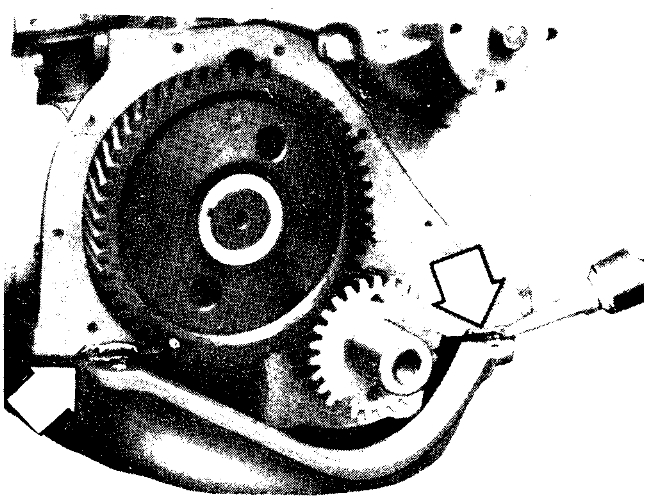
Use a sharp knife and cut the oil pan front seal flush with the cylinder block at both sides of the cover, as shown in the accompanying illustration. Remove the front cover and attached portion of the oil pan front seal. Remove the front cover gasket.

INSTALLATION

Clean the gasket surfaces on the block and crankcase front cover. Cut the tabs from the new oil pan front seal. Use a sharp knife to get a clean cut. Install the seal on the front cover. Press the tips into the holes provided in the cover. Coat the gasket with sealer and place it in position on the cover. Apply a 1/8" bead of RTV (Part No. 105-1435) Silicone Rubber Seal or equivalent, to the joint at the oil pan and the cylinder block.

Install the centering tool J-23042 into the crankcase front cover seal. A centering tool **MUST** be used to align the crankcase front cover, to ensure the torsional damper installation will not damage the seal. The centering tool will also position the seal **EVENLY** around the balancer.

Install the crankcase front cover to the block. Install, and partially tighten, the two oil pan-to-front cover screws. Install the front cover-to-block attaching screws. Remove the centering tool. Tighten all of the cover attaching screws to the torque value given in the Specifications in the Appendix. Install the torsional damper.



Apply sealer to the ends of the gasket.

3-11 CRANKSHAFT AND MAIN BEARINGS

REMOVAL

Remove the engine; see Section 3-1.
Remove the oil pan; see Section 3-2.
Remove the oil pump; see Section 3-3.
Remove the flywheel and coupler from the crankshaft.

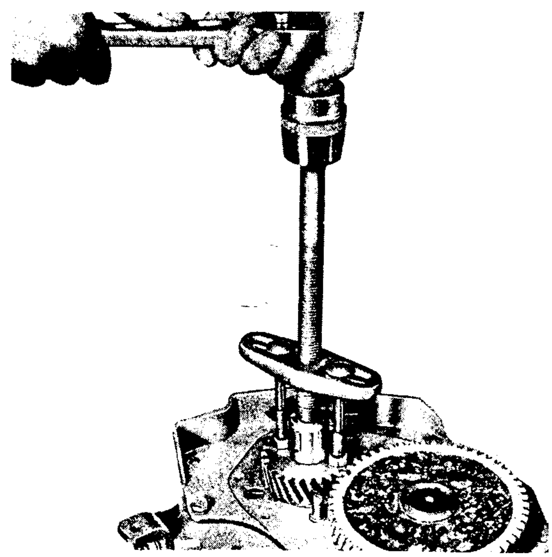
Remove the main bearing caps and the connecting rod caps. **TAKE TIME** to mark each bearing cap so you will be able to install it back onto the same rod from which it was removed.

Lift the crankshaft out of the block. **ALWAYS** handle the shaft carefully to avoid damaging the highly finished journal surfaces.

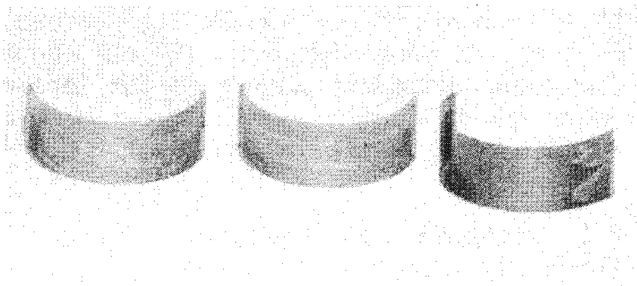
CLEANING

Clean the crankshaft with solvent and wipe the journals dry with a lint-free cloth. Blow out all of the oil passages with compressed air. Oil passageways lead from the rod journal to the main bearing journal. **BE CAREFUL** not to blow the dirt into the main bearing journal bore.

Measure the diameter of each journal at four places to determine the out-of-round,



A puller must be used to remove the crankshaft gear.



Details of bearing failures.

taper, and wear. The out-of-round limit is 0.001"; the taper must not exceed 0.001"; and the wear limit is 0.0035". If any one of the limits is exceeded, the crankshaft **MUST** be reground to an undersize, and undersized bearing inserts must be installed. Check the Specifications listed in the Appendix.

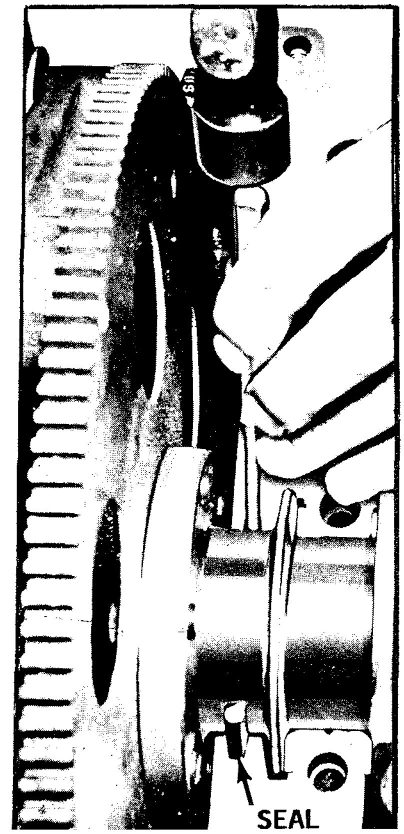
Remove the old bearing shells and the rear oil seal.

INSTALLATION

Install new bearing shells. The upper half of the bearing shell has a hole. This half of the shell **MUST** be inserted between the crankshaft and the block. **CAREFULLY** place the crankshaft into the bearing halves on the block.

Clean the journal thoroughly of all traces of oil, and then place a piece of Plastigage on the bearing surface, the full width of the cap. Install the cap and torque the retaining bolts according to the specifications listed in the Appendix. DO **NOT** turn the crankshaft with the Plastigage in place or you will distort it and the reading will have no value.

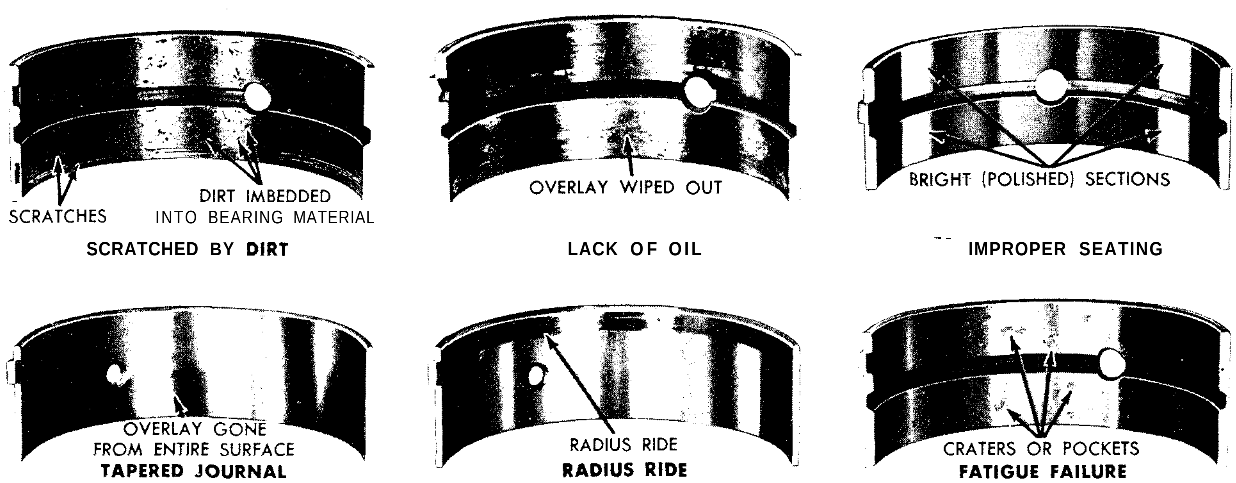
Remove the bearing cap. Use the scale



Installation of a new seal in the rear main.

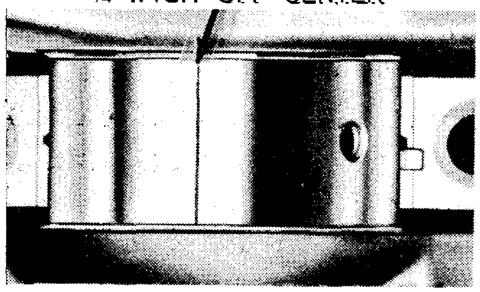
on the plastic strip to determine the clearance. The bearing journal is tapered and so is the Plastigage. Measure the Plastigage at the widest point and also at the narrowest point. These measurements will give you the minimum and maximum clearances.

If the clearance exceeds 0.0025", a new insert should be installed. After you have installed the new insert make another Plastigage measurement. If the new clearance still does not give the proper clearance



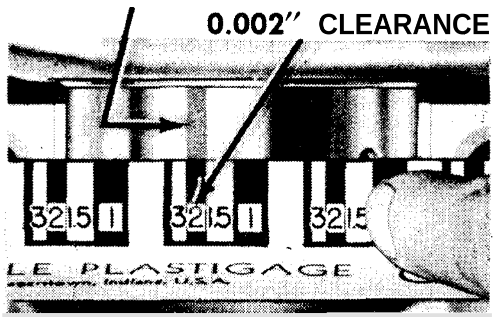
Examples of various wear patterns on bearing halves, including possible reasons for the condition.

PLACE PLASTIGAGE FULL WIDTH OF JOURNAL ABOUT ¼ INCH OFF CENTER



INSTALLING PLASTIGAGE

CHECK WIDTH OF PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Pastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

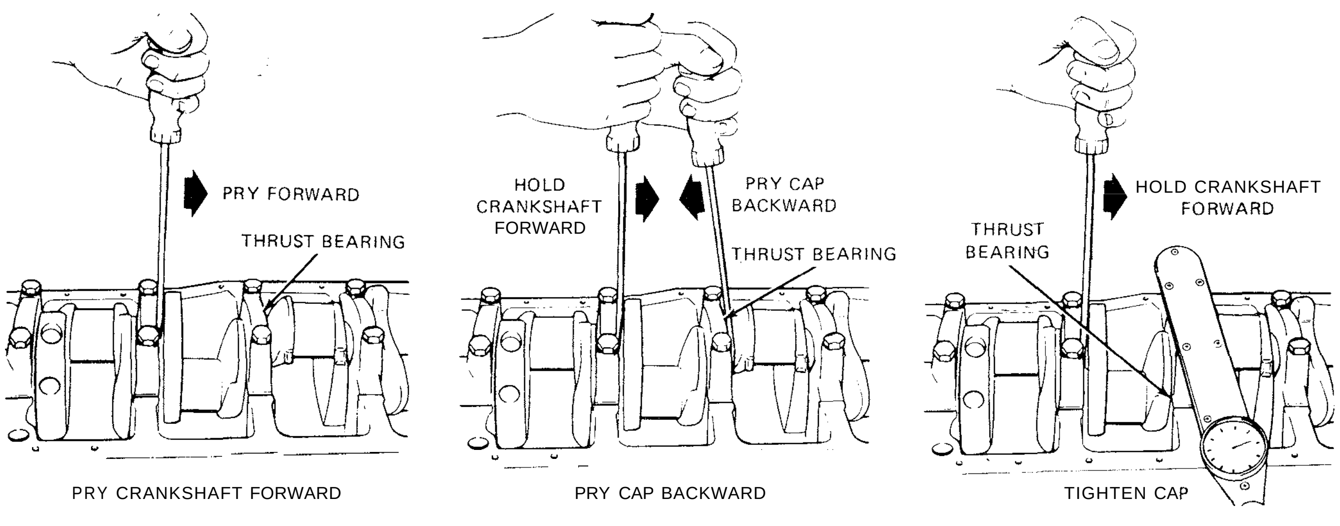
according to the specifications, then an undersized insert should be used.

Lubricate the rear bearing seal with oil. DO NOT allow any oil to get on the patting surface. Gradually push the seal with a hammer handle until the seal is rolled into place. To replace the upper half of the seal, use a small hammer and brass punch. Tap one end of the seal into the block groove, and then push the seal until it protrudes out the other side.

Install the thrust bearing cap and tighten the bolts just fingertight. Pry the crankshaft forward against the thrust surface of the upper half of the bearing; Hold the crankshaft forward and pry the thrust bearing cap to the rear. This action will align the thrust surfaces of both halves of the bearing. Retain the forward pressure on the crankshaft; and tighten the cap bolts to the torque value given in the Specifications in the Appendix.

Install the rod caps; see Section 3-8.
Install the oil pump; see Section 3-3.
Install the oil pan; see Section 3-2.
Install the flywheel and coupler.
Install the engine; see Section 3-1.
Start the engine and check for leaks.

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.**



*The thrust bearing **MUST** be aligned properly before it is tightened. The thrust bearing is aligned by first prying the crankshaft forward, then prying the main bearing cap backward, and finally tightening the bolts to the torque value given in the Specifications in the Appendix.*

GMC V6 ENGINES 1964 -- 1972 ALSO 1981 AND ON

From 1964 thru 1972, the V-6 engine had a bore and stroke of 3.750 x 3.400" to provide 225 CID. When the V6 engine was re-entered as an OMC power unit in 1981, the bore and stroke had been changed to 3.800 x 3.400 increasing the CID slightly to 229. In 1982 the bore and stroke were again changed slightly to 3.736 x 3.480, holding the displacement at 229 CID.

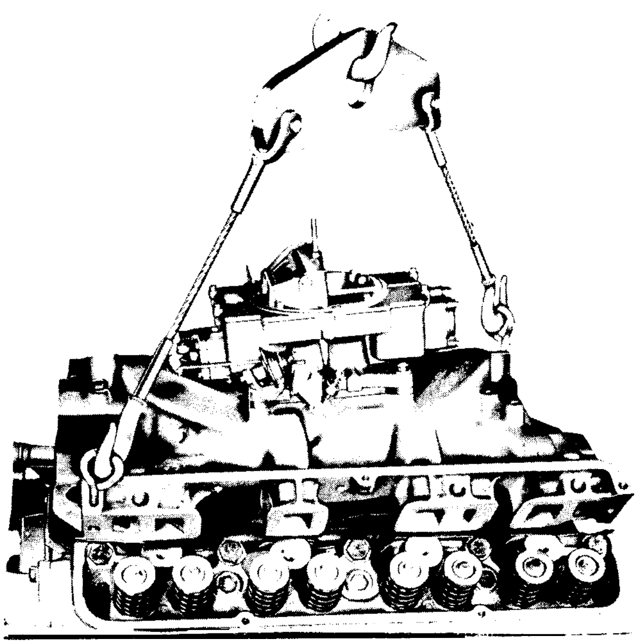
In 1986, the 4.3 Litre model was introduced. The bore for this unit was increased to 4.000", but the stroke remained at 3.480", providing 262 CID.

The cylinders in the starboard bank are numbered 2-4-6, and those in the port bank, 1-3-5. The engine has an unusual valve arrangement for the port bank of E-I-E-I-I-E, and for the starboard bank of E-I-I-E-I-E, both stated from the front of the engine.

The distributor is mounted at the front of the block. The firing order is 1-6-5-4-3-2.

3-12 ENGINE REMOVAL

Engine hood covers and panels around the engine may have to be removed before the engine will clear. In all cases, the engine must be moved about 6-inches forward in order to clear the driveshaft assembly.



Removing an engine from the boat using a lifting bracket.

Disconnect the battery cables, engine-to-dash wiring, water hoses, throttle cable, exhaust hoses, and fuel lines.

CAUTION: Be sure to plug the fuel line to prevent fuel from siphoning out of the tank.

Drain the water from the block by opening all of the drain valves.

The engine has two lifting brackets to be used with a length of chain. Run the chain through the holes in the lifting brackets, and then fasten the ends together with a bolt and nut. Attach the lifting device in the center of the chain, and then tie the chains together to prevent the lifting device from riding down the chain as the engine is lifted from the boat.

Kemove the bell housing-to-engine bolts. Remove the lag bolts on the mounting to the deck. If the engine compartment is too small for the engine to clear, it may be necessary to remove the mounting brackets from the engine. Slide the engine forward about 6 inches, and then lift it straight up and out. If you do not have enough room to move it forward, then it will be necessary to remove the stern drive unit, see Chapter 10.

ENGINE INSTALLATION

Lower the engine into the compartment and line the engine to the guide pins on the bell housing. Slide the engine back onto the drive assembly. It may be necessary to turn the driveshaft to align the splines. The driveshaft can be easily turned, by putting the stern drive in forward gear and then turning the propeller.

Install and tighten the bell housing-to-engine bolts, alternating around the bell housing. Install the lag bolts through the mounting brackets in the deck. If the engine brackets were removed, they have to be installed first.

Install the fuel line, water hoses, engine-to-dash wiring, exhaust hose, throttle cable, and battery cables. Close all water drain valves. Fill the crankcase with the proper weight oil.

Start the engine and check for leaks.

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.

3-13 OIL PAN SERVICE

REMOVAL

Before the oil pan can be removed, the engine must be removed; see section 3-12. The following procedures pickup the work after the engine is out of the boat.

Remove the oil drain plug and drain the oil. **A good word about draining engine oil:** On late-model engines, a kit has been attached to the oil drain plug to help in draining the oil when the engine is in the boat. This kit can be installed on any engine and should be done the first time the engine is removed from the boat.

Remove the oil pan bolts and lower the oil pan enough to remove the oil pump pipe and screen-to-cylinder block bolts.

Clean the oil pan with solvent. Pry the screen out of the housing to examine it for any evidence of clogging. Clean the screen and housing thoroughly in solvent and blow it dry with compressed air. Snap the screen into the housing.

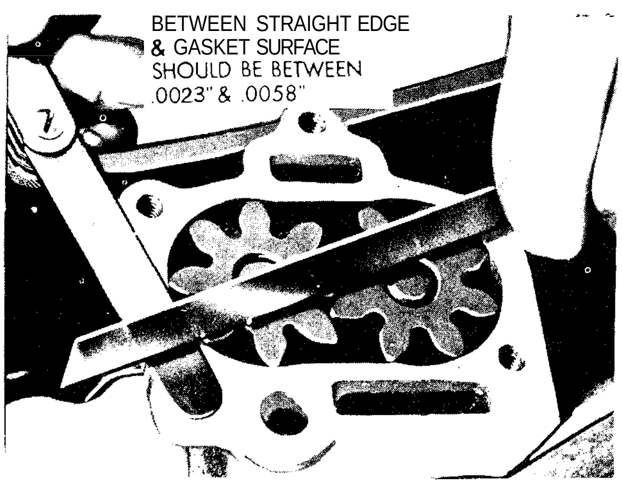
INSTALLING

ALWAYS install a new pan gasket. Move the oil pan into position, and then install the oil pump pipe and screen-to-cylinder block bolts. Install and tighten the oil pan bolts to the torque value given in the specifications in the Appendix. **TAKE CARE** to tighten the bolts evenly and not to overtighten them. Replace the lower flywheel housing.

Install the engine; see Section 3-12.

Fill the crankcase with the proper weight oil. Close the water drain valves.

Start the engine and check for leaks.



Measuring the oil pump end clearance.

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.

3-14 OIL PUMP

The oil pump consists of two gears and a pressure regulator valve, enclosed in a two-piece housing. The oil pump is mounted on the outside of the block and is driven by the distributor shaft, which is driven by a helical gear on the camshaft. A baffle is installed on the pickup screen to eliminate pressure loss due to sudden stops.

REMOVING

Remove- the oil filter. Remove the screws attaching the oil pump cover assembly to the timing chain cover. Remove the cover assembly and slide out the oil pump gears.

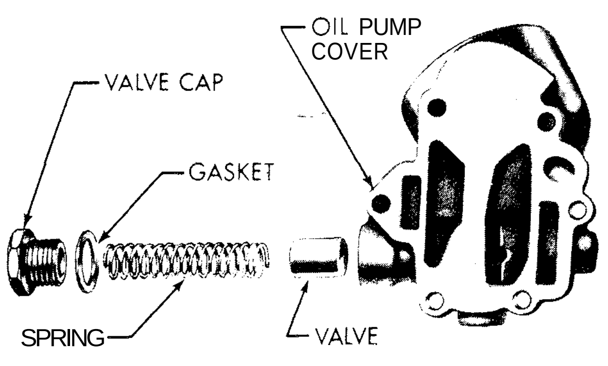
CLEANING AND INSPECTING

Wash the gears thoroughly and inspect them for wear and scores. If either gear is defective, they must be replaced as a pair.

Remove the oil pressure relief valve cap, spring, and valve. The oil filter bypass valve and spring **MUST NOT** be removed because they are staked in place.

Wash the parts removed and check each one carefully. Inspect the relief valve for wear or scores. Check the relief valve spring to be sure it is not worn on its side or collapsed. If in doubt about the condition of the spring, install a new one. Clean the screen staked in the cover.

Check the relief valve in its bore in the cover. The clearance for the valve should



Arrangement of parts for the oil pump pressure valve in a V6 engine.

be only a slip fit. If any side clearance can be felt the valve or the cover should be replaced.

Inspect the filter bypass valve for cracks, nicks, or warping. The valve should be flat with no nicks or scratches.

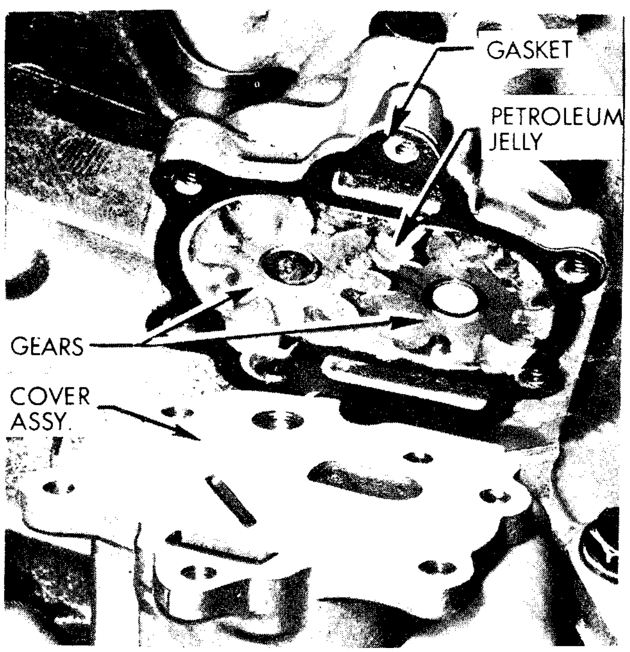
ASSEMBLING

Apply a generous amount of oil to the pressure relief valve and spring. Install the lubricated valve and spring into the bore of the oil pump cover. Install the cap and gasket. Tighten the cap bolts to torque value given in the Specifications in the Appendix.

Install the oil pump gears and shaft into the oil pump body section of the timing chain cover to check the gear end clearance. Place a straight-edge over the gears, and then measure the clearance between the straight-edge and the gasket surface as shown in the accompanying illustration. The clearance should be 0.0023" to 0.0058". If the clearance is less than 0.0023", check the timing chain cover gear pocket for signs of wear.

If the gear end clearance is okay, remove the gears and pack the gear pocket full of petroleum jelly. **DO NOT** use chassis lube.

CAUTION: Unless the pocket is packed with petroleum jelly, it may not prime itself when the engine is started.



Packing *the oil* pump.

Install the gears. Place a new gasket in position, and then install the cover assembly screws. Tighten the screws alternately and evenly to the torque value given in the Specifications in the Appendix. Install the oil filter on the nipple.

Check the crankcase for the proper amount of oil.

Start the engine and check for leaks.

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.**

3-15 EXHAUST MANIFOLDS AND ELBOWS

REMOVAL

Remove all water hoses and exhaust hoses from the elbow to the side of the exhaust housing.

Remove the nuts from the manifold studs, and then lift off the manifolds.

For other service on the exhaust manifolds, see Chapter 9, Cooling System.

INSTALLATION

Install the manifolds to the cylinder head and start the nuts onto the studs. Tighten the nuts alternately. The manufacturer does not always install a gasket between the exhaust manifold and the engine block, however, if any evidence indicates an exhaust leak, a new gasket should be installed. They are readily available at the nearest automotive parts dealer.

A substitute for a new gasket would be to coat the surfaces of the manifolds and the matching surfaces on the block with Permatex "Form-A-Gasket" or equivalent.

Install the water hoses and exhaust hoses to the manifold. Close the water drain valves.

Start the engine and check for leaks.

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.

3-16 INTAKE MANIFOLD

REMOVAL

Drain the water from the block. Remove the flame arrestor from the carburetor. Disconnect the battery cables at the battery. Disconnect the hoses, fuel line, and throttle linkage at the carburetor. Disconnect the wires to the coil and temperature sending switch.

Remove the distributor cap and mark the distributor housing indicating the position of the rotor. Remove the distributor clamp and then pull the distributor out of the block. Move the distributor cap out of the way. Remove the coil and bracket.

Remove the bolts attaching the intake manifold to the head. **TAKE NOTE** that the bolts are of varying lengths. Therefore, identify them in some way with the holes from which they are removed, as an aid to assembling. Lift the manifold with the carburetor attached from the engine. **DISCARD** all gaskets and seals.

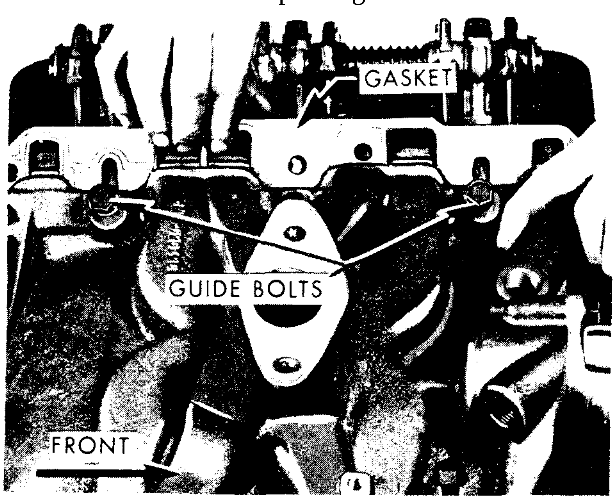
CLEANING

Clean the gasket surfaces of the intake manifold and the heads. Check the old gaskets to determine if there has been any exhaust leakage. Any evidence of exhaust leakage would indicate a crack in the head. Any sign of water in an intake manifold port would indicate either a crack in the manifold or a crack in the head.

INSTALLATION

Place new rubber manifold seals in position at the front and rear rails of the cylinder block. **BE SURE** the pointed ends of the seal fit snuggly against the block and head.

Apply a light coating of Permatex, Form-A-Gasket or equivalent, to the area between the water passages on the head and the manifold. Install the intake manifold gaskets onto the heads. **CAREFULLY** set the intake manifold in place and start the two guide bolts on each side. Lift the manifold slightly and slip the gaskets into position as shown. **TAKE CARE** to see that the gasket is installed with the three intake manifold ports aligned with the head and manifold. The gasket should be installed as shown for the left side and reversed for the right side installation.



Replacing the intake manifold.

Install a manifold attaching bolt in the open bolt hole as shown. The open bolt hole is held to close tolerances and the bolt in this location serves to locate the manifold perfectly fore-and-aft. Install the remaining intake manifold-to-cylinder head bolts with the longer bolts at the forward location. Tighten the bolts in the sequence shown in the accompanying illustration, and to the torque value given in the specifications in the Appendix.

Install the coil. Slide the distributor into place with the rotor pointing to the mark you made prior to removing the distributor. Snap the distributor cap in place. If the crankshaft was rotated while the distributor was out of the block, the engine will have to be timed. See Chapter 5 for detailed procedures to time the engine properly.

Connect the battery cables at the battery; the hoses to the thermostat housing; the throttle linkage and fuel line at the carburetor; and the wires to the coil and temperature sending switch.

Close the water drain valves.

Start the engine and check for leaks.

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.

3-17 CYLINDER HEAD SERVICE

The procedures in this section provide removing, disassembling, cleaning and inspecting, and installing the cylinder head, including some of the work that may be accomplished while the head is removed.

REMOVAL

Remove the intake manifold; see Section 3-16.

Drain the water from the block by opening all of the drain valves.

Pull the spark plug wire retainers from the brackets on the rocker arm covers. Disconnect the spark plug wires at the plugs and swing the wires and retainer out of the way. Remove the screws attaching the rocker arm cover to the cylinder head.

Remove the rocker arm covers and gaskets. Remove the rocker arm shaft bracket-to-cylinder head attaching bolts. Remove the rocker arm-and-shaft assembly. BE **SURE to** identify the rocker arms to ensure they will be installed on the same side from which they were removed.

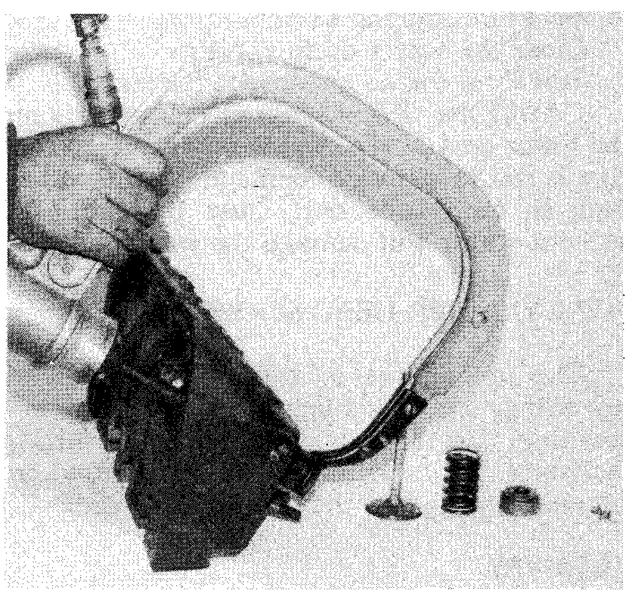
If the lifters are **NOT** to be serviced, protect the lifters and camshaft by covering the area with suitable cloths.

If the lifters **ARE** to be serviced, then set up some kind of system to hold the push rods. Remove each one in order so they will be installed back in the identical hole from which they were removed. Remove the lifters and keep them in order similar to the push rods. Each **MUST** be installed into the hole from which it was removed. The oil baffle is mounted under the rear bolts on the right rocker arm-and-shaft assembly.

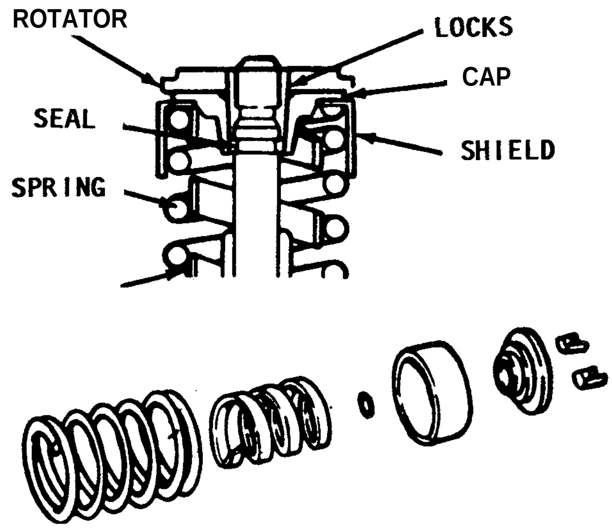
Remove the alternator mounting bracket and brace attaching bolts. Move the alternator out of the way.

Remove the exhaust manifolds; see Section 3-15.

Remove the cylinder head bolts, and then lift off the cylinder heads.



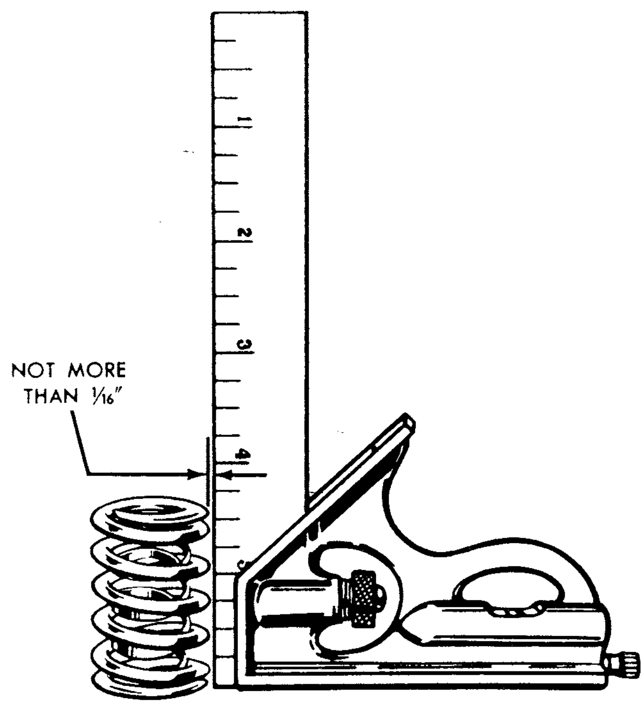
Valve locks are removed by first compressing the spring, and then taking off the locks, caps, springs, dampers, and oil seal. Push the valve out and ALWAYS keep it in sequence to ensure replacement in the same location.



Arrangement of valve mechanism parts before and after installation.

VALVE MECHANISM

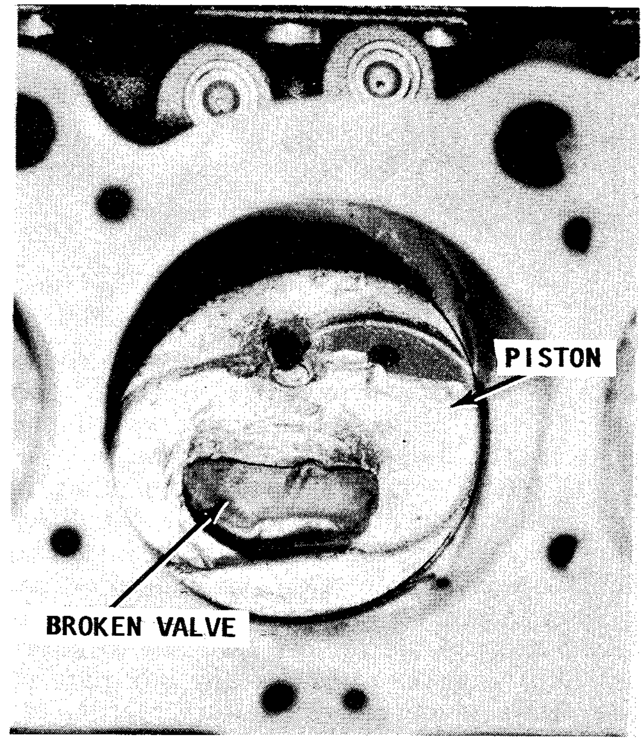
Clean the valves, springs, spring retainers, locks, and sleeves in solvent, and then blow the parts dry with compressed air. Inspect the valve face and the head for pits, grooves, and scores. Inspect the stem for wear and the end for grooves. The face must be trued on a valve grinding machine, which will remove minor pits and grooves. Valves with serious defects, or those having heads with a knife edge must be replaced.



A valve spring should not be out by more than 1/16" when it is rotated against a square on a flat surface, as shown. If it is, the spring should be replaced.

VALVE SPRINGS

Compare the valve spring tension against those listed in the Specifications in the Appendix. A quick check can be made by laying all of the springs on a flat surface and comparing their heights. The heights **MUST** all be the same. Both ends of each spring **MUST** be square or the spring will tend to cock the valve stem. Weak valve springs cause poor engine performance. Therefore, if a spring is weak or the ends are not square by more than 1/16", it **MUST** be replaced.

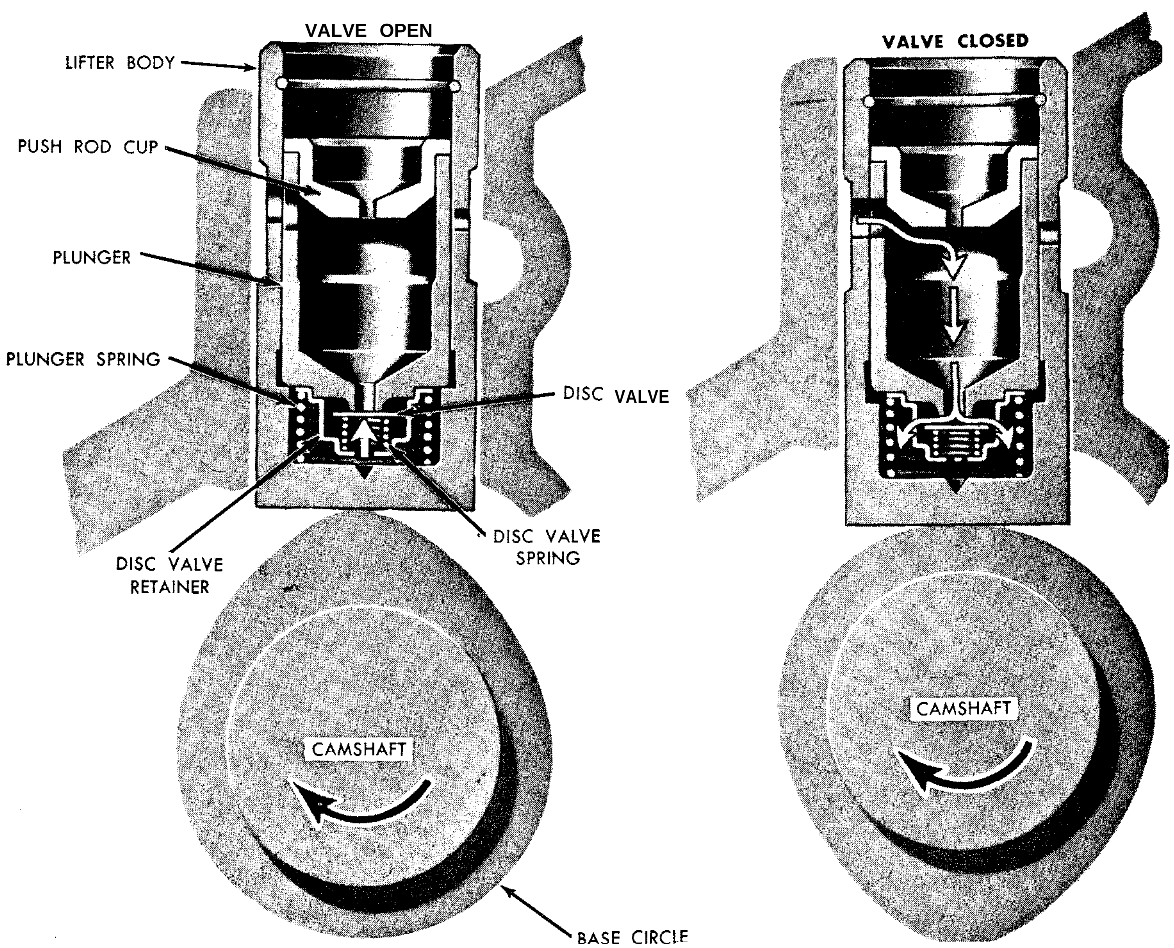


Improper installation techniques caused this valve to drop out and strike the piston.

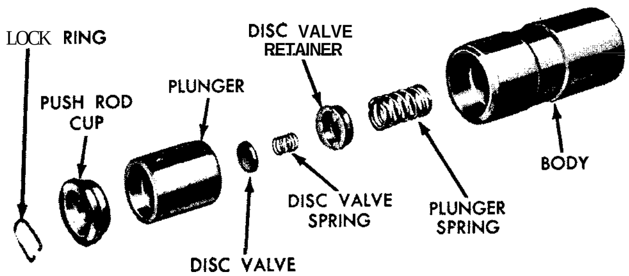
HYDRAULIC LIFTERS

Work on the lifters one–at–a–time and keep them in order to ensure each one will be installed back into the orignal position from which it was removed.

Dirt, deposits of gum, and air bubbles in the lubricating oil can cause the hydraulic lifters to wear enough to cause failure. The dirt and gum can keep a check valve from seating, which will cause the oil to return to



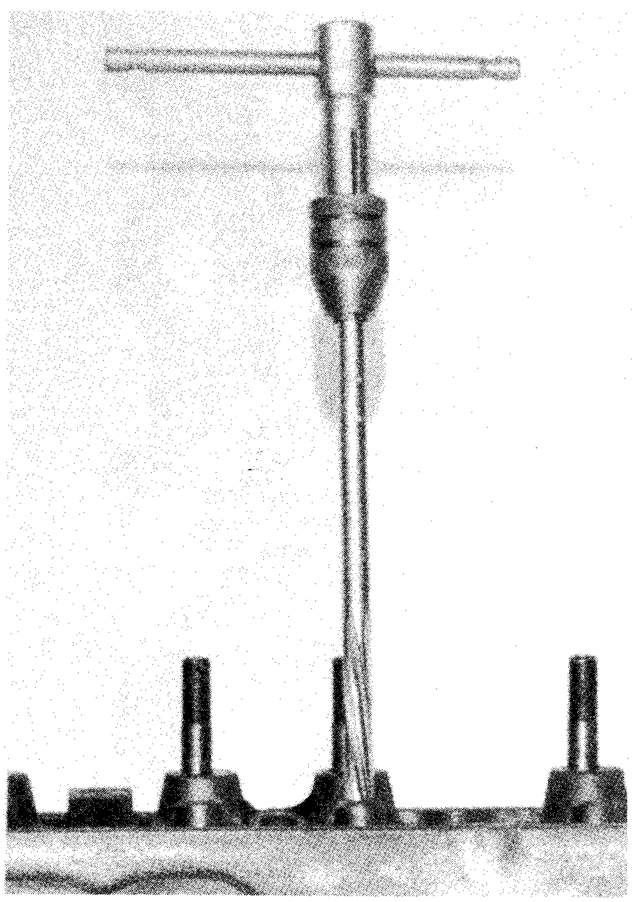
Relationship of the cam lobe as the camshaft rotates. The cam moves the valve lifter to the valve open position (left)and then to the valve closed position (right).



Arrangement of hydraulic valve lifter parts.

the reservoir during the time the push rod is being lifted. Excessive movemknt of the lifter parts causes wear and destroys the lifter's effectiveness in a short time.

ALWAYS keep the lifter assemblies in proper sequence when they are being removed. This is the only way they can be installed back into their original position. Clean, inspect, and test each lifter separately and use the utmost care not to intermix the internal parts. If any one part of the lifter is defective for any reason, replace the complete lifter assembly, **NEVER** just one part.



If the valve guide is worn it must be reamed oversize because the guides cannot be removed. A valve with an oversize stem is then installed to obtain the proper clearance.

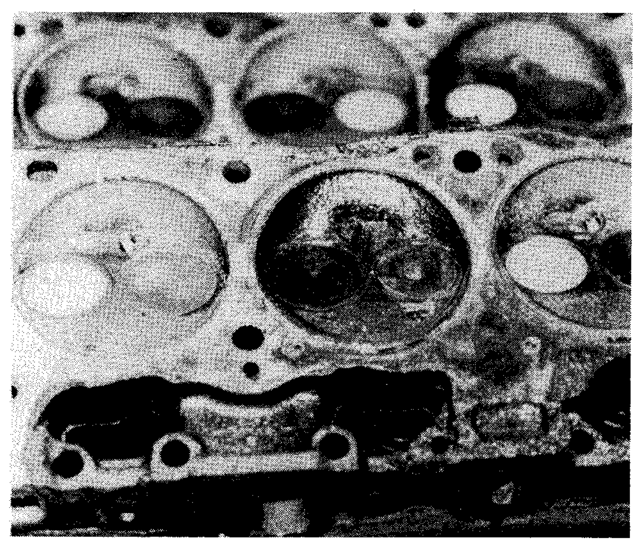
After the lifter has been cleaned, dried, and assembled; a quick test of its operation can be made by depressing the plunger with your finger. The trapped air should partially return the plunger if the lifter is operating properly. If the lifter is worn, or if the check valve is not seating, the plunger will not return.

Install the assembled lifters in the engine dry, paying careful attention to ensure each one is returned to its original position. The lifters will bleed to their correct operating position quicker if installed dry than if you fill them with lubricating oil prior to installation.

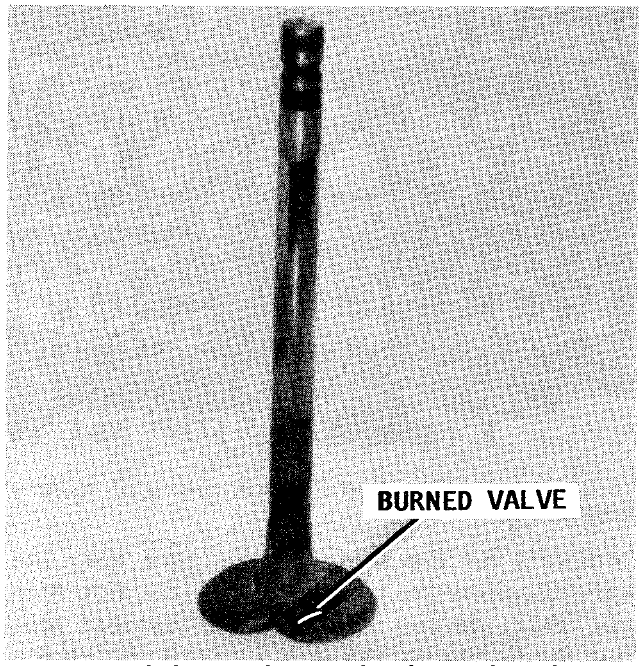
RECONDITIONING VALVES AND GUIDES

Place the cylinder head on a clean, smooth surface. Compress the valve spring with a suitable tool, and remove the cap retainers. Release the tool and remove the spring and cap. Repeat the procedure for each of the valves. **KEEP** the valves in order in a suitable holder to ensure they will be installed back in their original position in the head.

Remove the carbon from the combustion chambers. Use care to avoid scratching the head or the valve seats. Clean all carbon and gum deposits from the valve guide bores. Clean the valves. Inspect the valve faces and seats for pits, burnt spots, or evidence of poor seating.



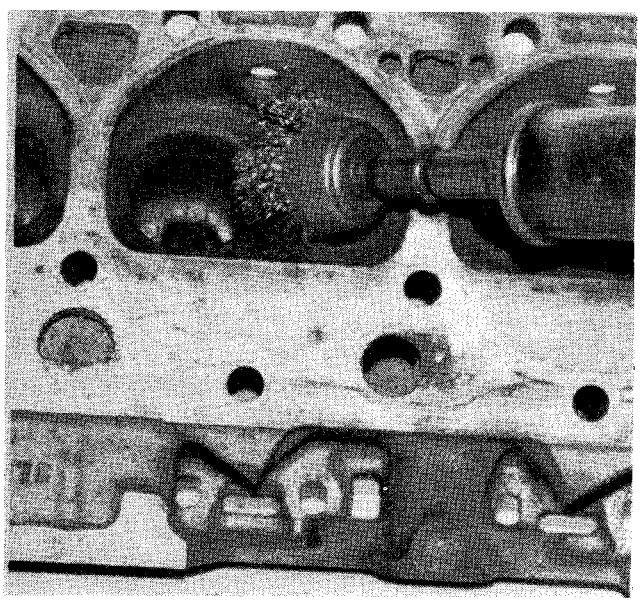
Notice the oil around the intake valve and the darker coloring of the exhaust valve in the right combustion chamber. The compression in the right cylinder was lower than in the left. Also the intake valve guide and seal are defective allowing oil to leak into the combustion chamber.



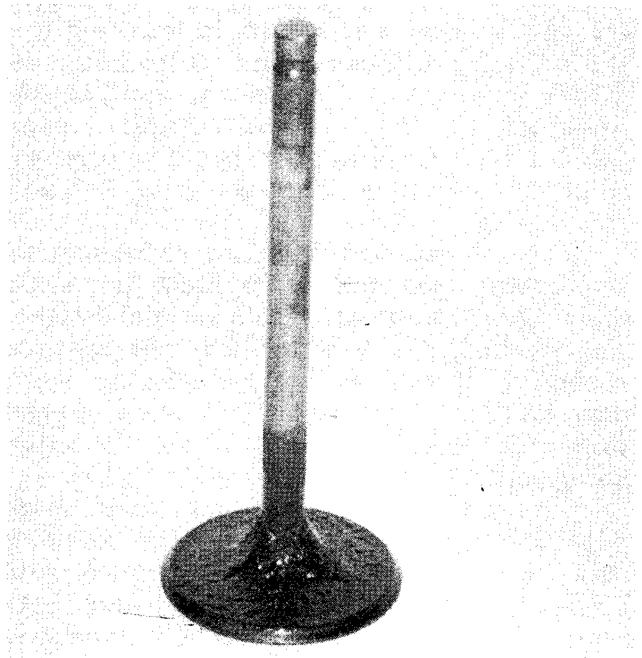
A severely burnt exhaust valve face. The valve was sticking in the guide as evidenced by the gum on the neck of the stem. ***TAKE TIME*** *to clean the valve guides thoroughly.*

Grind or replace valves, if necessary. A valve should be replaced if the head must be ground to a knife edge in order to obtain a true face. A 45° angle is the correct angle for the valve face. If the angle is any sharper, the valve will run too hot.

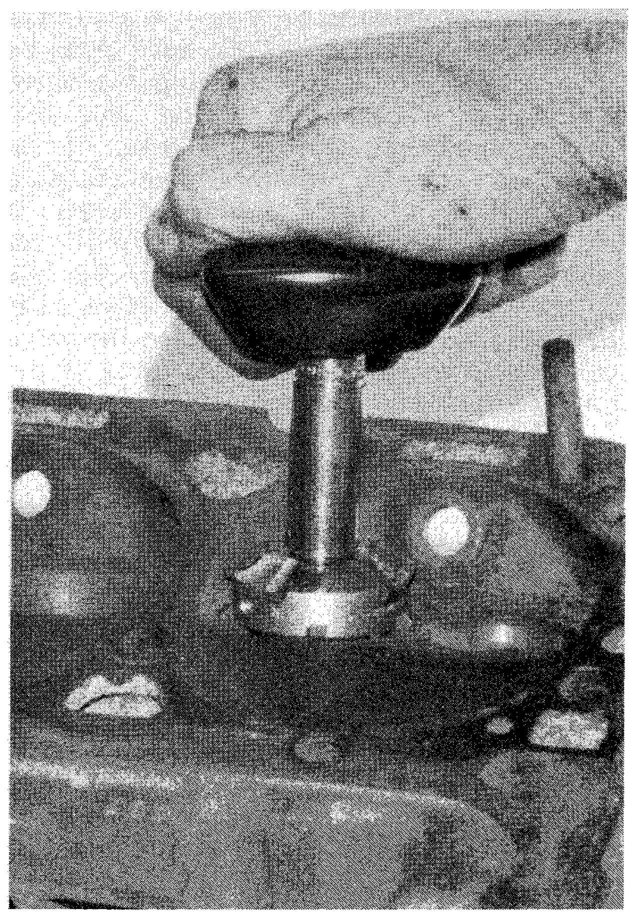
Valve stem guides are not replaceable. If a valve stem has excessive clearance, the guide must be reamed 0.003" oversize, using reamer J-5830-1. Valves with 0.003" oversize stems are available for service.



Use a wire brush to clean carbon from the cylinder head. Take time to do a thorough cleaning for maximum benefit.



Excessive lubricant leaking past the seal and valve guides caused this wet, oily condition.



Refacing the valve seat using a arinding stone. ALWAYS lift the special driver several"times to allow the grinding particles to fly out, or the valve seat will become grooved.

True the valve seats to a 45° angle. Cutting a valve seat results in lowering the valve spring pressure and increases the width of the seat. The nominal width of the valve seat is 1/16". If a valve seat is over 5/64" wide after truing, it should be narrowed to the specified width by using 20° and 70° stones.

If the valve and seat are refinished to the extent that the valve stem is raised more than 0.050" above its normal height, the hydraulic valve lifter will not operate properly. If this condition exists, the worn part must be replaced. The normal height of the valve stem retainer above the valve spring seat surface of the head is 1.925".

Lap the valves lightly into their seats with fine grinding compound. The refacing and reseating operation should leave the refinished surfaces smooth and true. Actually, if the refinishing job is done properly, only a minimum of lapping is required. Excessive lapping will groove the valve face, preventing a proper seat when the valve is hot.

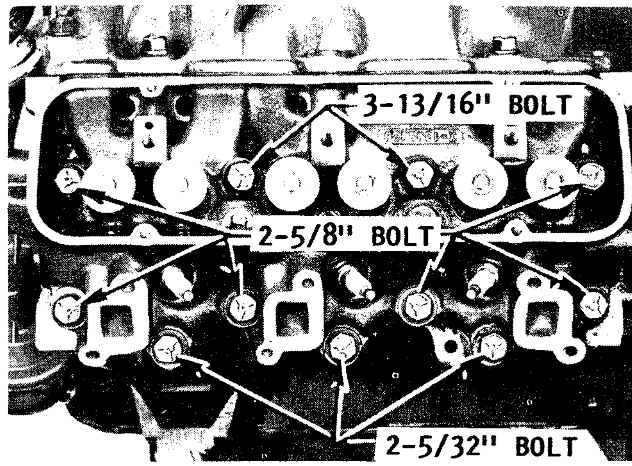
Test each valve to be sure it seats in the center of the seat. This test can be accurately done by first coating the valve face lightly with Prussian blue, and then rotating the valve against the seat. If the valve seat is true with the valve guide, a mark will be made all around the seat. If the seat is not true (concentric with the guide), a mark will be made on only one side of the seat. Next, coat the valve seat lightly with Prussian blue. Rotate the valve again against the seat to determine if the valve face is true with the valve stem and if the valve is seating all the way around. Both tests are necessary to prove each valve is making a proper seat. PAY **ATTENTION** to install each valve spring with the CLOSELY wound coils **TOWARD** the cylinder head.

ROCKER ARM SERVICE

Remove the rocker arm-and-shaft assembly. Take out the cotter pin, plain washer, and spring washer from each end of the rocker arm shaft. Remove the bracket bolts. Slide the rocker arms and brackets off the shaft.

Clean and inspect all parts. Pay particular attention to cleaning all of the oil holes. Replace any part excessively worn.

Assemble the springs, rocker arms, and



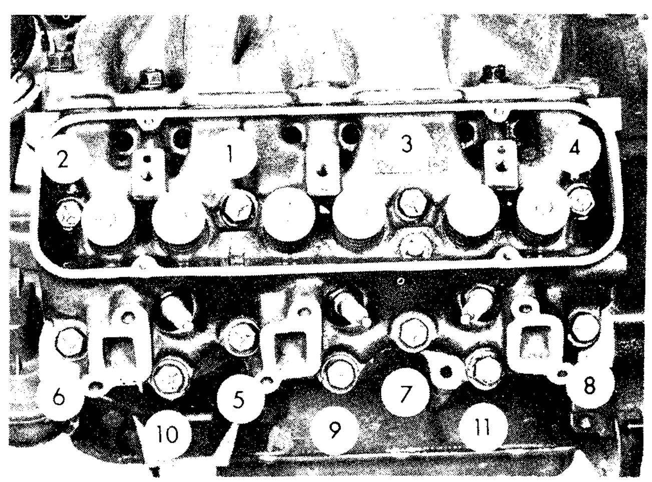
Location of the three different lengths of cylinder head bolts.

brackets on the shaft. Take care that the assembly for the right side has the notch in the shaft facing forward and the left side has the notch to the rear. Install the spring washer, flat washer, and cotter pin on each end of the shaft in the order named.

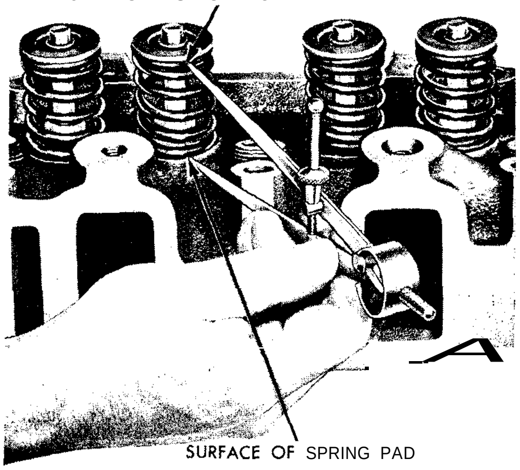
Install the bolts, with plain washers, through the brackets and shaft so the notch in the right assembly is facing up and forward; and the notch in the left assembly is facing up and aft.

CYLINDER HEAD INSTALLATION

Clean the engine block gasket surfaces. Check carefully to be sure no foreign material has fallen into the cylinder bores, bolt holes, or valve lifter area. Clean out all bolt holes with compressed air. One further step for a good job, is to run the correct size tap down each bolt hole.



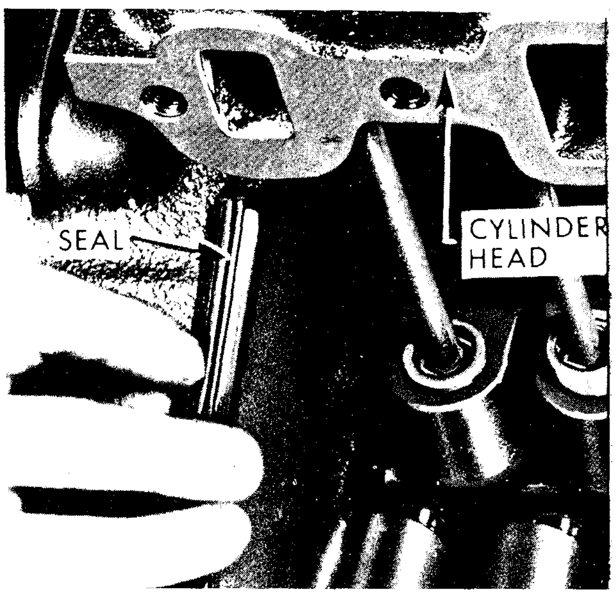
Tightening sequence for the cylinder head bolts on a V6 engine.



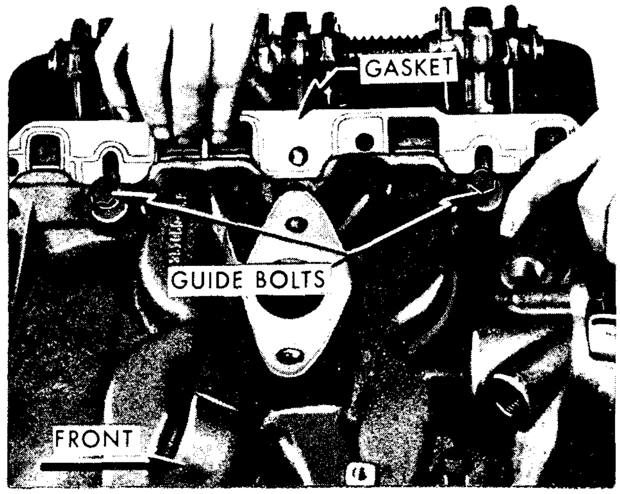
Measuring the height of the installed valve spring. Compare this measurement with the Specifications in the Appendix.

Install new head gaskets on the cylinder block. ALWAYS use marine head gaskets to minimize salt water corrosion. Dowels in the block will hold the gaskets in position. USE CARE when handling the gaskets to prevent kinking or damaging the surfaces. DO NOT use any sealing compound on head gaskets, because they are coated with a special lacquer to provide a good seal, once the parts have warmed to operating temperature.

Clean the gasket surface of the cylinder heads and carefully set each in place on the engine block, with the holes in the heads indexed over the dowel pins in the block. Clean and coat the head bolts with sealer. Install the bolts as shown. Tighten the head bolts in the sequence shown, but only a little



Installation of the front seal on the rail of the cylinder block.



The intake manifold is notched to fit around the attaching bolts. Lift the manifold slightly and TAKE CARE to install the gasket properly.

at a time,- making about three rounds. On the final round, tighten each bolt in the same sequence to the torque value given in the Specifications in the Appendix. BEAR IN MIND, uneven tightening of the head bolts can distort the cylinder bores, causing compression loss and excessive oil consumption.

Install the exhaust manifold to each cylinder head, see Section 3-15. Tighten the bolts to the torque value given in the Specifications in the Appendix. Install the exhaust hoses to the exhaust housing.

ROCKER ARM-AND-SHAFT ASSEMBLY INSTALLATION

Install the push rods through the cylinder head openings. Clean the base of the rocker arm shaft brackets and each bracket boss on the cylinder head. Check to be sure the notch on the end of the rocker arm shaft for the right side is facing forward and the notch for the left side is facing aft.

Tilt the rocker arms toward the push rods and carefully position the top of each push rod in its rocker arm seat. Pull the rocker arm-and-shaft assembly down by tightening the bracket bolts a little at a time. Finally, tighten the bracket bolts to the torque value given in the Specifications in the Appendix.

Install the rocker arm cover and gasket. On the right side, connect the positive crankcase ventilation system. Connect the spark plug wires and set the wire retainers in position on the brackets.

Install the intake manifold; see Section 3-16.

Replace the water hoses to the thermostat housing. The **TOP** hose from the exhaust nipple hose is connected to the **BOTTOM** nipple on the thermostat housing. Install the large hose from the thermostat housing to the engine water pump.

Close the water drain valves.

Start the engine and check for leaks.

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.

3-18 PISTON AND ROD SERVICE

This section provides detailed procedures for removing, disassembling, cleaning, inspecting, assembling, and installing the complete piston-rod assembly. All parts **MUST** be kept together because if the old pistons are serviceable, they **MUST** be installed on the rods from which they were removed and installed in the same bore.

REMOVAL

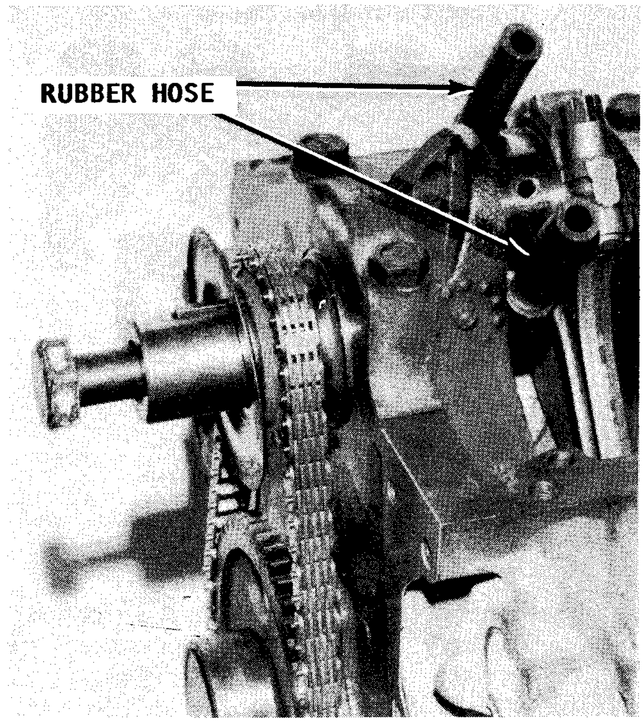
Remove the engine; see Section 3-12.

Remove the cylinder heads; see Section 3-17.

Remove the oil pan; see Section 3-13.

If a shoulder or ridge exists in the cylinder bores above the ring travel, they must be removed with a ridge reamer or the rings may be damaged or the ring lands cracked during removal.

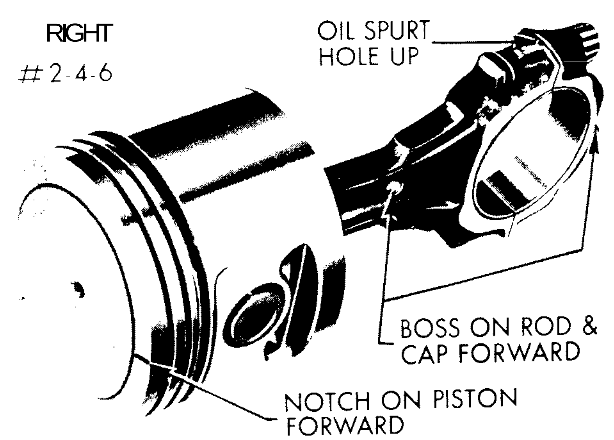
Before using the reamer, turn the crankshaft until the piston is at the bottom of its stroke, and then place a cloth on top of the piston to collect the cuttings. After the ridge is removed, turn the crankshaft until the piston is at the top of its stroke to remove the cloth and cuttings.



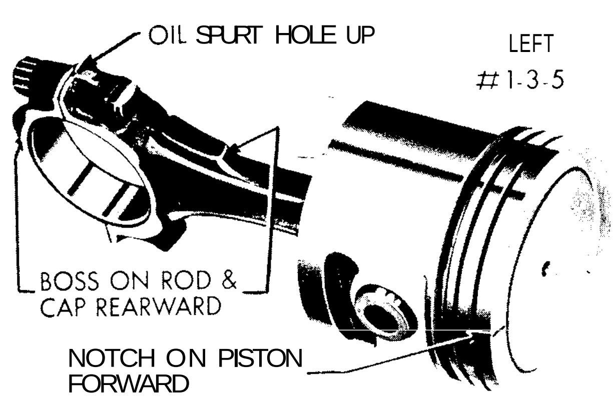
The rod bolt threads must always be covered with a piece of rubber hose to prevent damage to the bearing surface by the rod threads scraping as the piston assembly is removed.

Identify each piston, connecting rod, and cap with a quick drying paint or silver pencil to ensure each part will be replaced in the exact position from which it was removed. Beginning at the forward end of the crankcase, the cylinders in the port bank are numbered 1-3-5, and in the starboard bank 2-4-6.

Remove the cap and bearing shell from No. 1 connecting rod, then install a connecting rod bolt guide hose on the bolts to hold the upper half of the bearing shell in place. Push the piston and rod assembly up and out of the cylinder. It will be necessary



Arrangement of piston and rod assembly parts for the port bank of a V6 engine.



Arrangement of piston and rod assembly parts for the starboard bank of a V6 engine.

to turn the crankshaft slightly to disconnect some of the connecting rod and piston assemblies and to push them out of their cylinders. Remove the guides and install the bearing shells and cap on the rod.

Continue in a similar manner until all of the piston and rod assemblies have been removed, partially reassembled to keep the parts matched, and the assemblies hung or placed in order.

CLEANING AND INSPECTING

If the engine has over 750 hours of service, or if the piston and rod assembly has been removed, it is considered good shop practice to replace the piston pins. Loose piston pins, coupled with tight rings, will cause piston pin noises. These noises may disappear as the engine loosens, but strange noises are difficult to explain to a customer who has just paid the bill.

Most mechanics have the piston pin work done by a machine shop with the necessary equipment and trained people to perform a precision job. If done in the machine shop, the connecting rods will be aligned so the pistons and rings will run true with the cylinder walls.

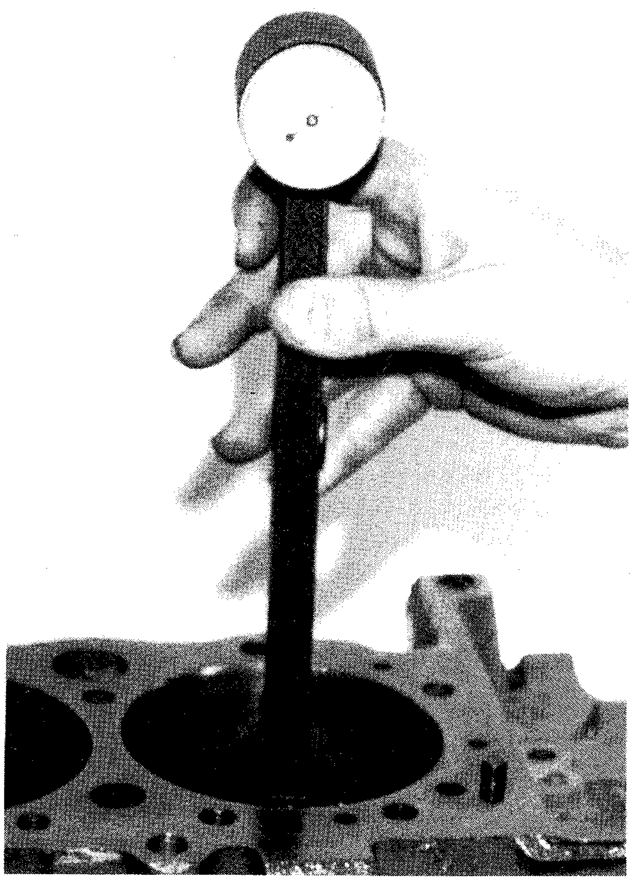
CYLINDER BORES

Inspect the cylinder walls for scoring,, roughness, or ridges which indicate excessive wear. Check the cylinder gauge at the top, middle, and bottom of the bore, both parallel and at right angles to the centerline of the engine.

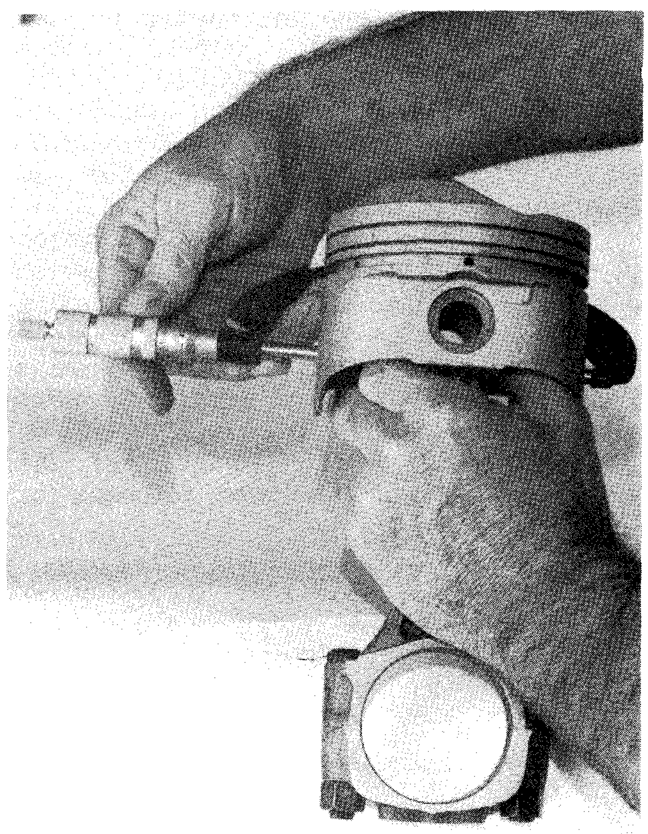
A cylinder bore which is tapered 0.005" or more, or is out-of-round 0.003" or more, must be reconditioned.

ROD BOLTS AND NUTS

Check the rod bolts and nuts for defects in the threads. Inspect the inside of the rod bearing bore for evidence of galling, which indicates the insert is loose enough to move around. Check the parting cheeks to be sure the cap or rod has not been filed. Replace any defective rods.



Cylinder wall taper and wear measured with a bore gauge indicator.



Using a micrometer to check the amount of piston wear.

PISTONS AND PINS

Remove the compression rings with an expander. Remove the oil ring by removing the two rails and the spacer-expander, which are separate pieces in each piston's third groove.

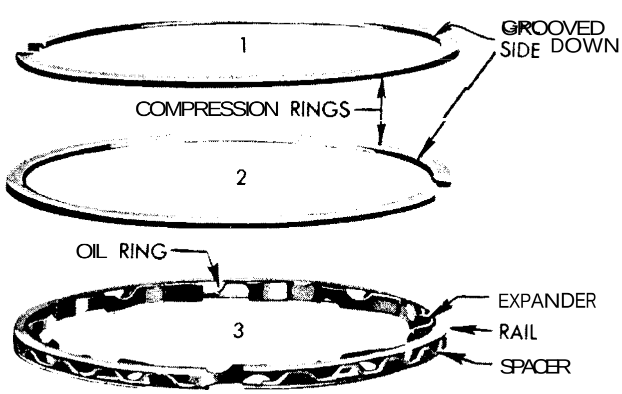
Use a cleaning solvent to remove the varnish from the piston skirts and pins. **NEVER** use a wire-brush on any part of the piston. Clean the ring grooves with a groove cleaner and make sure the oil ring holes and slots are clean. Inspect the pistons for cracked ring lands, skirts, or pin bosses; wavy or worn ring lands; scuffed or damaged skirts; and eroded areas at the top of the pistons.

Replace any piston that is damaged or shows signs of excessive wear. Inspect the grooves for nicks or burrs that might cause the rings to hang-up. Measure the piston skirt (across the centerline of the piston pin) and check the clearance in the cylinder bore. The clearance should not be greater than 0.0025".

The pistons are cam-ground, which means the diameter at a right angle to the piston pin is more than the diameter parallel to the piston pin. When a piston is checked for size, it must be measured with micrometers applied to the skirt at points 90° to the piston pin. The piston should be measured for fitting purposes 1/4" below the bottom of the oil ring groove.

Inspect the piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured with a dial bore gauge or an inside micrometer. If the clearance is greater than 0.0001", the piston and/or piston pin should be replaced.

Inspect the bearing surfaces of the piston pins. Use a micrometer to check for wear by measuring the worn and unworn surfaces. Rough or worn pins **MUST** be replaced. Test the fit of each pin with its piston boss. If the boss is worn out-of-round or is oversize, the piston and pin assembly **MUST** be replaced. **NEVER** attempt to use an oversize pin because the pin is a press-fit in the connecting rod. An easy finger push fit at 70°F is all that should be required to insert the pin into the piston. Such a fit should allow 0.0003" to 0.0005" clearance.

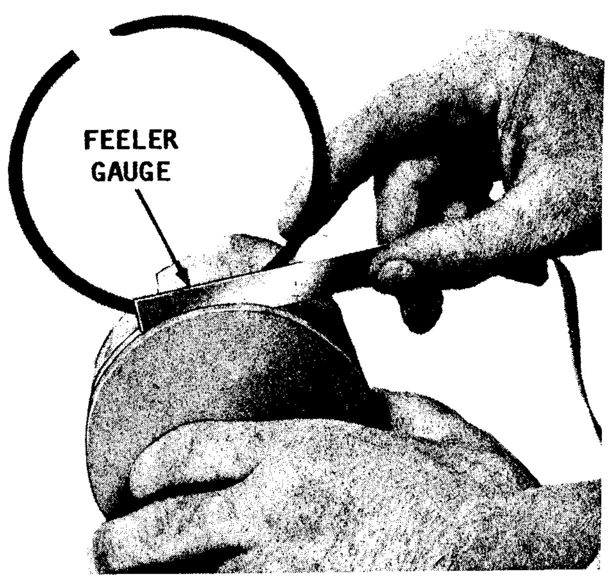


Proper arrangement of piston rings.

RINGS

The glazed cylinder walls should be slightly dulled without increasing the bore diameter, if new piston rings are to be installed. This glazing is best accomplished using the finest grade of stones of a cylinder hone. The-cylinder bores and piston grooves must be clean, dry, and free of any carbon deposits or burrs. New piston rings must be checked for clearance in the piston grooves and for end gap in the cylinder bores. The oil rings are flexible and do not need to be checked for end gap.

To check the end gap of compression rings, first place each ring in the cylinder into which it will be used. Next, square the ring in the bore using the upper end of a piston. Now measure the gap with a feeler gauge. Piston rings should have at least a 0.010" end gap when measured in the cylinder bore. If the gap is less then 0.010", the ends of the ring can be filed carefully with a fine file until the proper gap is reached.



Checking piston ring side clearance.

After the rings are installed on the piston, the clearance in the grooves needs to be checked with a feeler gauge. The recommended clearance between the ring and the upper land is 0.006". Ring wear forms a step at the inner portion of the upper land. If the piston grooves have worn to the extent to cause high steps on the upper land, the step will interfere with the operation of new rings and the ring clearance will be too much. Therefore, if steps exist in any of the upper lands the piston should be replaced.

New compression rings on new pistons should have a side clearance of 0.003" to 0.005". The oil ring should have a side clearance of 0.0035" to 0.0095".

PISTON ASSEMBLING

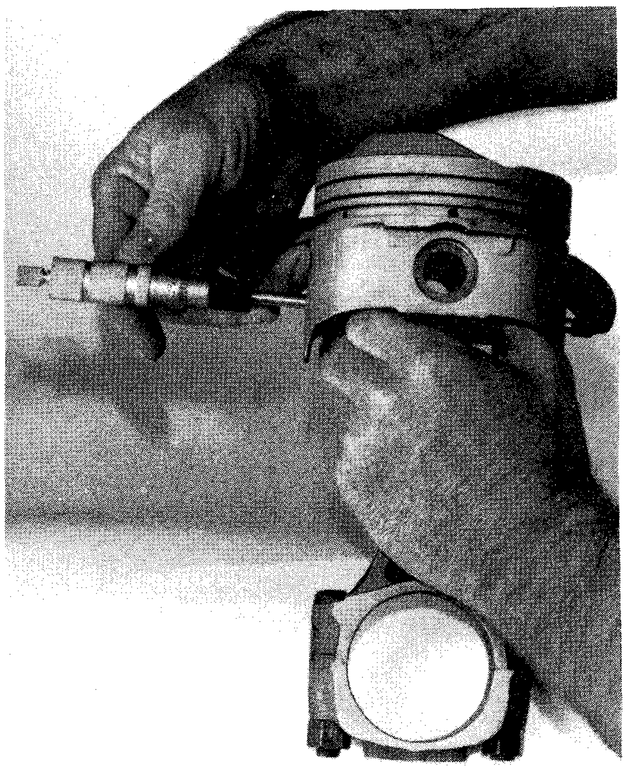
Set up Tool BT-6408 and Adapter BT-6408-4, as shown. The piston and rod assembly must be mated as shown for right and left bank rods. The notch in the piston **MUST** face forward for the right bank cylinders, and face aft for the left bank cylinders.

Assemble the piston and rod on the spring-loaded guide pin. Lubricate the piston pin to avoid damage when it is pressed through the connecting rod. Install the drive pin in the upper end of the piston pin. Press on the drive pin until the piston pin bottoms. Remove the piston and rod assembly from the press.

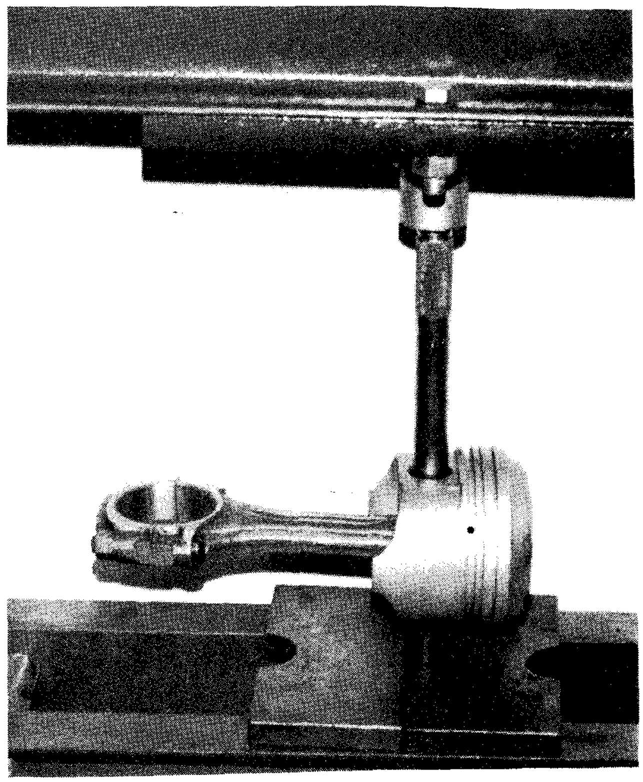
Rotate the piston on the pin to be sure the pin was not damaged during the pressing operation.

Install the piston rings as shown. Position the expander ends over the piston pin. Install the oil ring rail spacer and oil ring rails. Position the gaps in the rails on the same side of the piston as the oil split hole in the connecting rod. Install the compression rings in the upper two grooves. If a single chrome plated compression ring is used, it **MUST** be installed in the **TOP** groove. All compression rings are marked with a dimple, a letter **"T"** a letter **"O",** or the word **TOP** to identify the side of the ring which must be assembled toward the top of the piston.

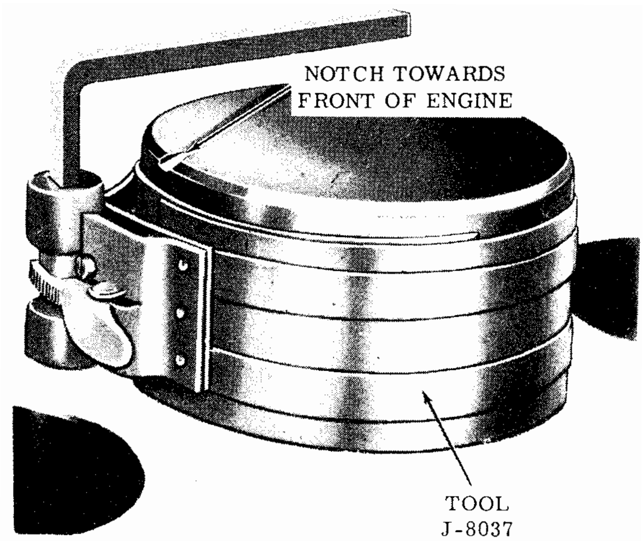
After you are satisfied the cylinder bores, pistons, connecting rod bearings, and crankshaft journals are as clean as possible, then coat all of the bearing surfaces with engine oil. Position the crankpin straight down. Remove the connecting rod cap and with the bearing upper shell seated in the



Using a micrometer to check the amount of piston wear.



An arbor press and a special tool should be used to remove pressed-in piston pins.



Installation of a well-lubricated piston and ring assembly into its proper cylinder. The rings should ***ALWAYS*** *be compressed with a ring clamp to prevent breaking a ring while pushing the piston into the cylinder. NEVER hammer on the piston head, because a ring may have popped out of its groove and be broken.*

rod, install the connecting rod guides to hold the upper bearing shell in place and prevent damage to the crankpin.

Rotate the oil ring rails until the gap is toward the center of the engine. Rotate the compression rings until the gaps are **NOT** in line with each other and **NOT** in line with the gaps in the oil ring rails. Make sure the ends of the oil ring spacer-expander are not lapped over, but just butt together.

Coat the piston and rings with engine oil, and then install the assembly in the proper numbered cylinder bore by compressing the rings with a ring compressor. Use the wooden end of a hammer handle to push the piston down into the cylinder. **NEVER** hammer on the piston in an attempt to get it into the cylinder because a ring may be caught and you could snap it. Install the cap with a new lower bearing shell and tighten both nuts to the torque value given in the Specifications in the Appendix.

Install the other piston assemblies in a similar manner paying particular attention to install each used piston assembly into the same cylinder from which it was removed.

After all piston and rod assemblies are properly installed and the bearing cap nuts have been tightened to the proper torque value, check to be sure the oil spit holes in the connecting rods are facing the camshaft, and the edge of the rod cap is on the same side as the conical boss on the connecting rod web. These marks (the rib and boss) will be toward the other connecting rod on the same crankpin. Check the end clearance between the connecting rods on each crankpin. The clearance should be between 0.005" and 0.012".

Install the oil pan; see Section 3-13.

Install the cylinder heads; see Section 3-17.

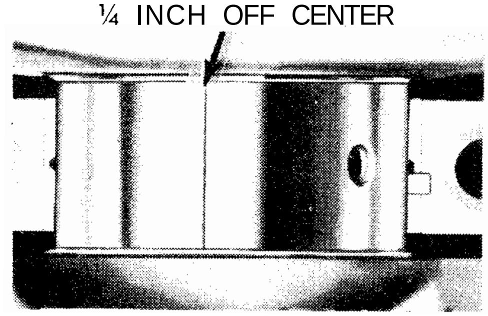
Install the engine; see Section 3-12.

Fill the crankcase with the proper weight oil. Close the water drain valves.

Start the engine, run it at reduced speed for the first hour, and check for leaks.

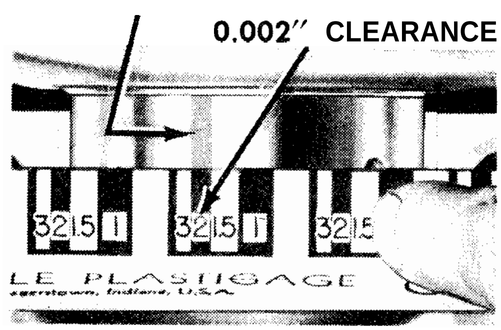
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

PLACE PLASTIGAGE FULL WIDTH OF JOURNAL ABOUT ¼ INCH OFF CENTER



INSTALLING PLASTIGAGE

CHECK WIDTH OF PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

3-19 CAMSHAFT SERVICE

If the engine is to perform properly, the valves must open and close at a predetermined precise moment. On the power stroke, the exhaust valve must open just before bottom dead center in order to permit the exhaust gases to leave the combustion chamber under the remaining pressure (blowdown). On the exhaust stroke, the intake valve must open just before top dead center in order to permit the air-fuel mixture to enter the combustion chamber. Valve movement is a function of the camshaft design and the valve timing. Therefore, excessive wear of any camshaft part will affect engine performance.

CAMSHAFT REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the intake manifold; see Section 3-16.

Remove the timing gear cover and chain; see Section 3-22.

Pull the spark plug wires from the brackets on the rocker arm covers. Remove the spark plug wires from the spark plugs.

Remove the four screws securing each valve cover to the heads, and then remove the covers.

Remove the three bolts holding each rocker arm, and then remove the rocker arms from the heads. **BE SURE** to identify the rocker arms to ensure they will be installed on the same side from which they were removed.

Set up some kind of system to hold the push rods, and then remove each one in order so they will be installed back in the identical hole from which they were removed. Remove the lifters and keep them in order similar to the push rods. Each **MUST** be installed into the hole from which it was removed.

Pull the camshaft straight forward out of the block. Use **UTMOST CARE** not to damage the bearing surfaces in any way.

CLEANING

Clean the camshaft with solvent and wipe the journals dry with a lint-free cloth. **ALWAYS** handle the shaft **CAREFULLY** to avoid damaging the highly finished journal surfaces. Blow out all of the oil passages with compressed air.

Clean the gasket surfaces on the block and crankcase front cover. Check the diameter of the three camshaft bearings with a micrometer for out-of-round condition, taper, and wear. Check your findings with the Specifications in the Appendix. If any of the limits listed is exceeded, the camshaft **MUST** be reground to an undersize, and undersized bearing inserts must be installed.

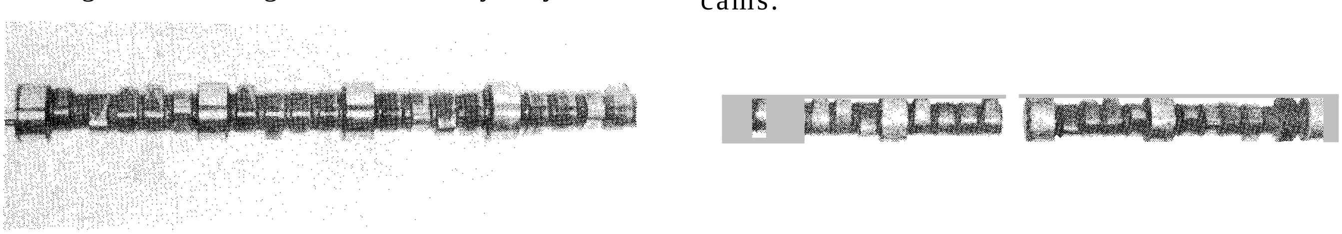
Check the camshaft for alignment. This is best done using "V" blocks and a dial indicator. The dial indicator will indicate the exact amount the camshaft is out of true. If it is out more than 0.002" dial indicator reading, the camshaft should be replaced. When using the dial indicator in this manner the high reading indicates the high point of the shaft. Examine the camshaft bearings and if any one bearing needs to be replaced, **ALL THREE** should be replaced.

CAMSHAFT BEARING REMOVAL

Removal and replacement of the camshaft bearings should be performed by qualified mechanics in a shop equipped to handle such work. However, In most cases the block bores for the bearings can be bored to a larger size and oversize bearings installed. **BE SURE** to check with your local marine dealer for available oversize bearings.

CAMSHAFT INSTALLATION

Coat the cam lobes with Molykote or equivalent, and then add the remainder in the can to the crankcase oil. Install the camshaft assembly into the engine block. **TAKE CARE** to move the shaft straight into the block and not to damage the bearings or cams.



TAKE CARE when handling the camshaft not to damage the cams or the bearings in the block.

Install the timing gear, timing chain, and cover; see Section 3-22.

Replace the intake manifold; see Section 3-16.

Install the engine; see Section 3-12.

Close all of the water drain valves.

Start the engine and check for leaks.

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.

3-20 CRANKSHAFT

Service work affecting the crankshaft or the crankshaft bearings may also affect the connecting rod bearings. Therefore, it is highly recommended that the rod bearings be carefully inspected as they are removed; see Section 3-18.

If the crankpins are worn to the extent that the crankshaft should be replaced or reground, then this work should be done in a qualified shop. Attempting to save time and money by merely replacing the crankshaft bearings will not give satisfactory results or performance.

REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the engine; see Section 3-12.

Remove the oil pan; see Section 3-13.

Remove the timing gears; see Section 3-22.

Remove the flywheel.

Remove each rod bearing cap, clean and inspect the lower bearing shell, and identify it plainly to ensure it will be installed on the same rod from which it was removed. Inspect each rod bearing journal surface. If the journal surface is scored or ridged, the crankshaft must be replaced or reground to ensure satisfactory performance with new bearings. A slight roughness may be polished out with fine-grit polishing cloth thoroughly wet-ted with engine oil. Burrs may be honed off with a fine stone.

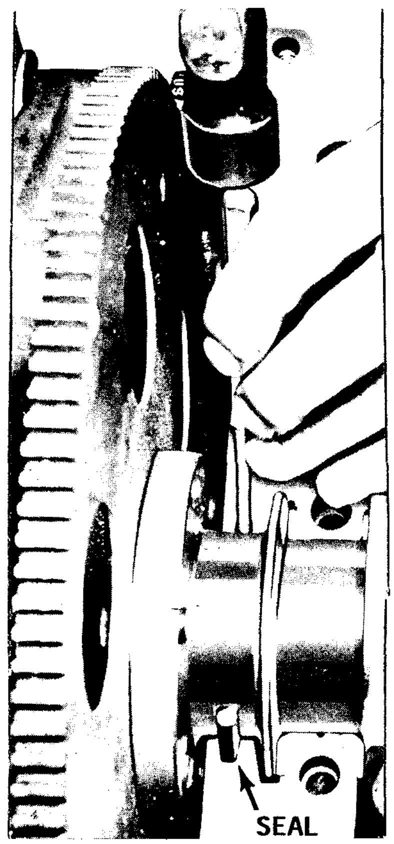
Remove and identify the bearing caps of the crankshaft bearings. Inspect the caps and journals for signs of excessive wear. Remove the crankshaft from the block and support it on "V" blocks at the No. 1 and No. 4 main bearing journals. Use a dial indicator to check the runout at the No. 2 and No. 3 main bearing journals. Total indicator readings at each journal should not exceed 0.003".

CLEANING

Clean the crankshaft with solvent and wipe the journals dry with a lint-free cloth. **ALWAYS** handle the shaft carefully to avoid damaging the highly finished journal surfaces. Blow out all of the oil passages with compressed air. Oil passageways lead from the rod to the main bearing journal. **TAKE CARE** not to blow dirt into the main bearing journal bore.

Measure the diameter of each journal at four places to determine the out-of-round, taper, and wear. The out-of-round limit is 0.001"; the taper must not exceed 0.001"; and the wear limit is 0.0035". If any of these limits is exceeded, the crankshaft must be reground to an undersize, and undersized bearing inserts must be installed.

While checking the runout at each journal, **TAKE-TIME** to note the relation of "high" spot (or maximum eccentricity) on each journal to the others. "High" spots on all journals should come at the same angular location. If the "high" spots do not appear to be in the same angular locations, the crankshaft has a "crook" or "dogleg" in it, making it unsatisfactory for service.



Installation of the main bearing rear seal.

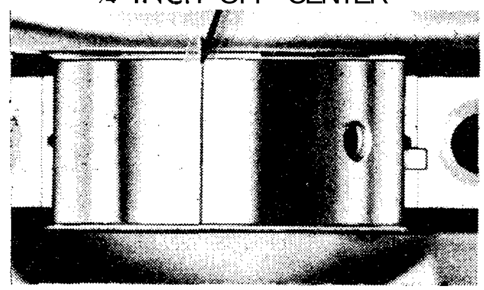
BEFORE INSTALLATION

TAKE TIME to read the good words in the next few paragraphs before starting the crankshaft installation work. Many of the facts given, you probably already know, others may be new, and all of the information will assist you in completing the work in the shortest time and with assurance of satisfactory engine performance after the work is completed.

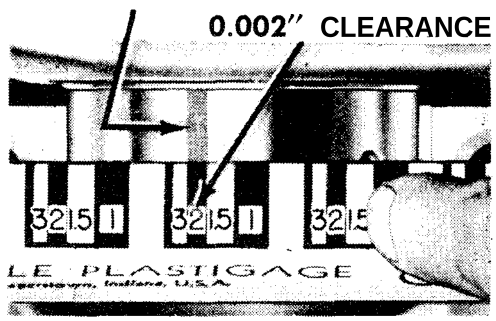
A crankshaft bearing consists of two halves. These halves are **NOT** alike and are **NOT** interchangeable in the cap and crankcase. The upper (crankcase) half of the bearing is grooved to supply oil to the connecting rod bearings while the lower (bearing cap) half of the shell is not grooved. The two bearing halves **MUST** not be interchanged. All crankshaft bearings, except the No. 2 thrust bearing and the rear main bearing are identical.

The thrust bearing is longer and flanged to take end thrust. When the shells are placed in the crankcase and bearing cap, the ends extend slightly beyond the parting surfaces. The reason for them to extend slightly in this manner is to ensure positive seating and to prevent turning when the cap bolts are tightened. The ends of the shells must **NEVER** be filed flush with the parting surface of the crankcase or bearing cap.

If the thrust bearing shell is disturbed or replaced, it is necessary to line-up the thrust surfaces of the bearing shell **BEFORE** the cap bolts are tightened. To align the thrust surfaces, tighten the bearing cap

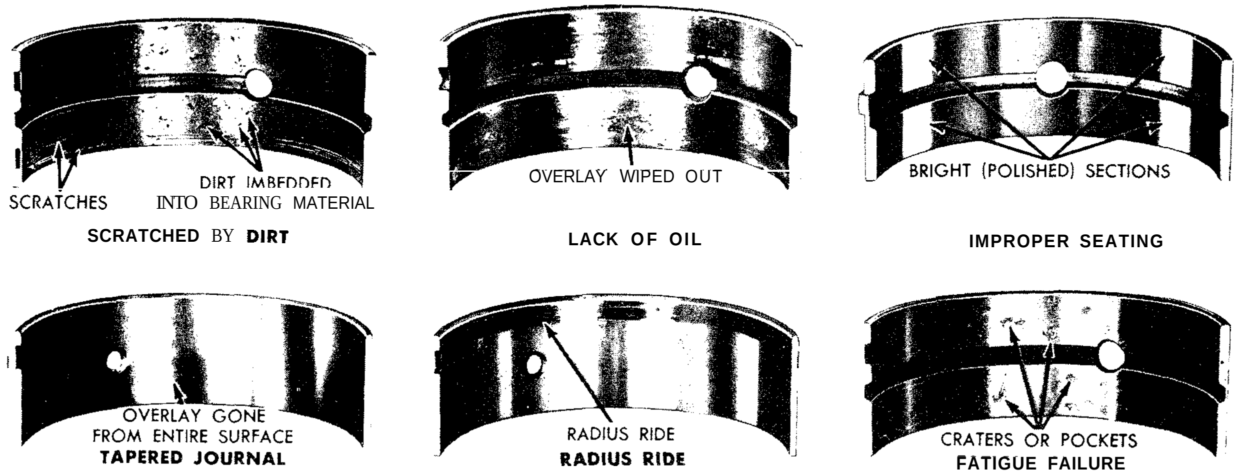


INSTALLING PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.



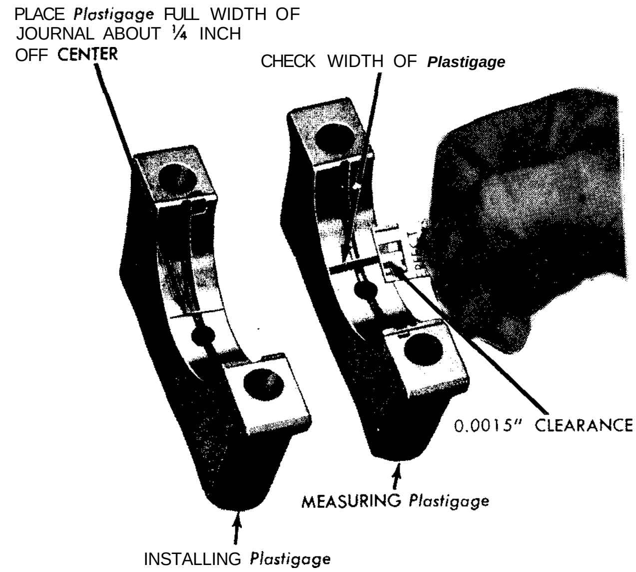
Examples of various wear patterns on bearing halves, including possible reasons for the condition.

bolts just finger tight, then move the crankshaft fore and aft the limit of its travel several times. Make the last movement forward.

Crankshaft bearings are of the precision type which do not require reaming to size or other fitting. Shims are not provided for adjustment since worn bearings are readily replaced with new bearings of the proper size. Bearings for service replacement are furnished in standard size and undersizes. NEVER file a bearing cap to adjust for wear in old bearings.

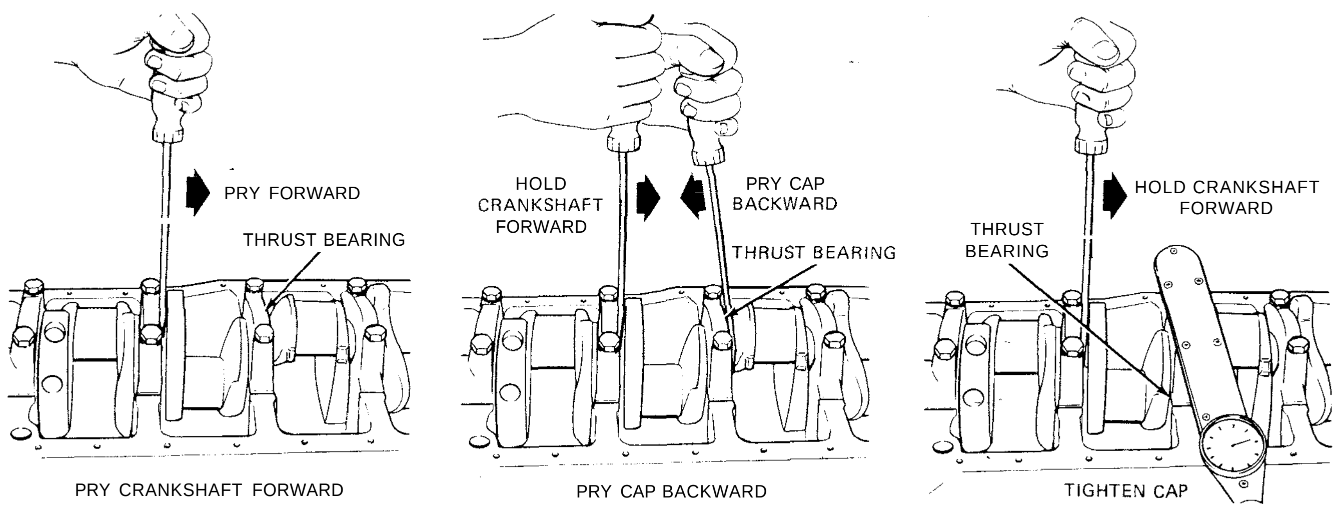
INSTALLATION

Install the upper half of each bearing in its proper location. Carefully lower the crankshaft into position in the bearing halves on the block. Plastigage is soluble in oil, therefore, clean the crankshaft journal thoroughly of all traces of oil, and then turn the crankshaft until the oil hole is up to avoid dripping oil on the Plastigage. Whenever you turn the crankshaft with the rear bearing cap removed, hold the oil seal to prevent it from rotating out of position in the crankcase. Place paper shims in the upper half of adjacent bearings and tighten the cap bolts to take the weight off of the shell of the bearing being checked.



After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

Place a piece of Plastigage lengthwise along the bottom center of the lower bearing shell, and then install the cap with the shell and tighten the bolt nuts to a torque value given in the Specifications in the Appendix.



*The thrust bearing **MUST** be aligned properly before it is tightened. Alignment is accomplished **by** first prying the crankshaft forward, then prying the main bearing cap backward, and finally tightening the bolts to the torque value given in the Specifications in the Appendix.*

Remove the bearing cap and measure the flattened Plastigage at its widest point using the scale printed on the Plastigage envelope. The number within the graduation which most closely corresponds to the width of the Plastigage indicates the bearing clearance in thousandths of an inch.

Compare the bearing clearance against the Specifications in the Appendix. If the bearing clearance exceeds the specifications, it is advisable to install a new bearing. However, if the bearing is in good condition and is not being checked because of bearing noise, it is not necessary to replace the bearing, After doing the Plastigage check, install the bearing cap again and tighten the cap bolts to the torque value given in the Specifications in the Appendix, then loosen it 1/2 turn.

Continue making the Piasti–age test at each bearing. When all bearings have been installed and tested, tighten the cap bolts again to the required torque value.

Install the flywheel.

Install the rod caps; see Section 3-18.

Install the oil pan; see Section 3-13.

Install the timing gear and cover; see Section 3-22.

Install the engine; see Section 3-12.

Fill the crankcase with the proper weight oil. Close all water drain valves.

Start the engine and check for leaks.

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.

3-21 MAIN BEARINGS

A crankshaft bearing consists of two halves. These halves are **NOT** alike and are **NOT** interchangeable in the cap and crankcase. The upper (crankcase) half of the bearing is grooved to supply oil to the connecting rod bearings while the lower (bearing cap) half of the shell is not grooved. The two bearing halves **MUST** not be interchanged. All crankshaft bearings, except the No. 2 thrust bearing and the rear main bearing are identical.

The thrust bearing is longer and flanged to take end thrust. When the shells are placed in the crankcase and bearing cap, the ends extend slightly beyond the parting surfaces. The reason for them to extend slightly in this manner is to ensure positive seating and to prevent turning when the cap bolts are tightened. The ends of the shells must **NEVER** be filed flush with the parting surface of the crankcase or bearing cap.

REMOVAL

Drain the water from the block by opening all drain valves.

Remove the engine; see Section 3-12.

Remove the oil pan; see Section 3-13.

Remove the oil pump pipe, and oil screen; see Section 3-14.

Remove one main bearing cap. Clean and inspect the lower bearing shell and the crankshaft journal. If the journal surface is scored or ridged, the crankshaft must be replaced. Slight roughness can be polished out with fine-grit polishing cloth thoroughly wetted with engine oil. Burrs can be honed off with a fine stone.

If the lower bearing shell and crankshaft journal are in satisfactory condition, check the bearing clearance with Plastigage, and then compare the measurement with the limits given in the Specifications in the Appendix.

To make the Plastigage test, first turn the crankshaft until the oil hole is up to prevent oil from dripping on the Plastigage which is oil soluble. Clean all the oil possible from the bearing journal with a lint-free cloth. Place a piece of Plastigage lengthwise along the bottom center of the lower bearing shell. Install the cap with the shell and then tighten the bolt nuts to the torque value given in the Specifications in the Appendix.

Remove the bearing cap and measure the flattened Plastigage at its widest point using the scale printed on the Plastigage envelope. The number within the graduation which most closely corresponds to the width of the Plastigage indicates the bearing clearance In thousandths of an inch. If the clearance exceeds the limits given in the Specifications, then the bearing should be replaced.

INSTALLATION

To replace the main bearing inserts, first loosen all of the crankshaft bearing cap nuts 1/2 turn, and then remove the cap of the bearing to be replaced. Remove the upper bearing shell.

Before installing new bearing shells, clean the crankshaft journal and the bearing seats in the crankcase. Coat the inside surface of the upper bearing shell with engine oil and place the shell against the crankshaft journal so the tang on the shell will engage the notch in the crankcase when the shell is rotated into position.

REMEMBER, the upper bearing shells have an oil groove in the center, while the lower shells do not have a groove. The shells MUST NOT be interchanged. Rotate the bearing shell into place.

Place the lower bearing shell in the bearing cap, and then check the clearance with Plastigage as described earlier in this Section. The recommended clearance with a new bearing is 0.0005" to 0.0025". If this clearance cannot be obtained with a standard size bearing, insert an undersize bearing and check the clearance. NOTICE, each undersize shell has a number stamped on the outer surface on or near the tang to indicate the amount of undersize.

After the proper size bearing has been selected, clean out all of the Plastigage, oil the lower shell, and then install the bearing cap again. Clean the bolt holes and lube the bolts. Tighten the cap bolts to the torque value given in the Specifications in the Appendix. The crankshaft should turn freely at the flywheel rim. A small amount of drag is acceptable if an undersize bearing has been installed. Now loosen the cap nuts 1/2 turn and move on to the next bearing and repeat the procedure until all of the bearings have been installed, tested with the Plastigage, and the caps reinstalled.

Tighten all of the cap nuts again to the required torque value. If the thrust bearing shell has been replaced, it is necessary to line up the thrust surfaces of the bearing shell before the cap bolts are tightened the final time. To align the thrust surfaces, move the crankshaft fore-and-aft several times to the limit of its travel. Make the final movement forward.

REAR BEARING OIL SEAL

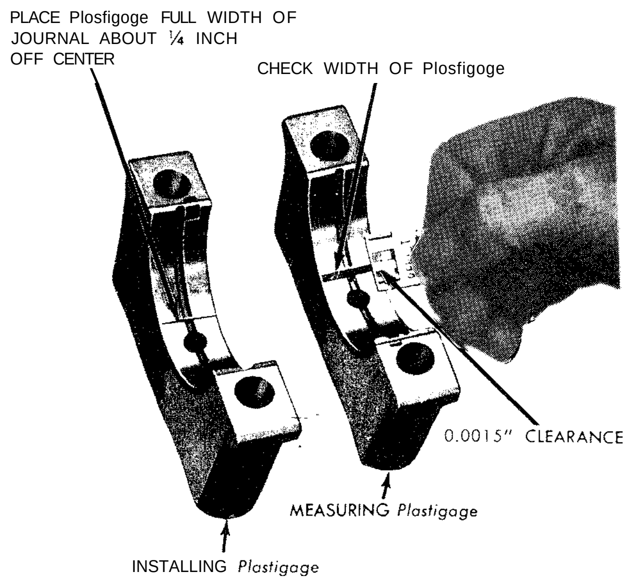
The rear bearing oil seal should be replaced every time the main bearings are serviced. Braided fabric seals are pressed into grooves formed in the crankcase and rear bearing cap to the rear of the oil-collecting groove. Their purpose is to seal against leakage of oil around the crankshaft. Neoprene composition seals are placed in grooves in the sides of the bearing cap to seal against leakage in the joints between the cap and crankcase. The neoprene composition swells in the presence of oil and heat. They are undersize when newly installed and may even leak for a short time until they have had time to swell and seal the opening.

The only time the braided fabric seal can be installed is when the crankshaft is removed. However, the seal can be replaced in the cap whenever the cap is removed.

REMOVAL AND INSTALLATION

Remove the old seal. Coat a new seal with heavy engine oil. Position the lubricated seal in the groove, with both ends projecting above the parting surface of the cap. Use Tool J-8753-1 to force the seal into the groove. Continue working the seal until it is just above the groove, but not more than 1/16". Cut the ends off flush with the surface of the cap. Use a sharp knife or razor blade to ensure a good clean cut.

The neoprene composition seals are longer than the grooves in the bearing cap. DO NOT cut the seals to length. Prior to installing the seal, coat it with heavy engine oil. Install the seal in the bearing cap with the upper end protruding about 1/16". Install the bearing cap and then force the



After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

seals up into the cap with a blunt tool. This will ensure a good seal at the upper parting line between the cap and the case.

Install the oil screen and oil pan; see Section 3-13.

Install the engine; see Section 3-12.

Fill the crankcase with the proper weight of oil. Close all water drain valves.

Start the engine, run it at reduced speed for the first hour, and check for leaks.

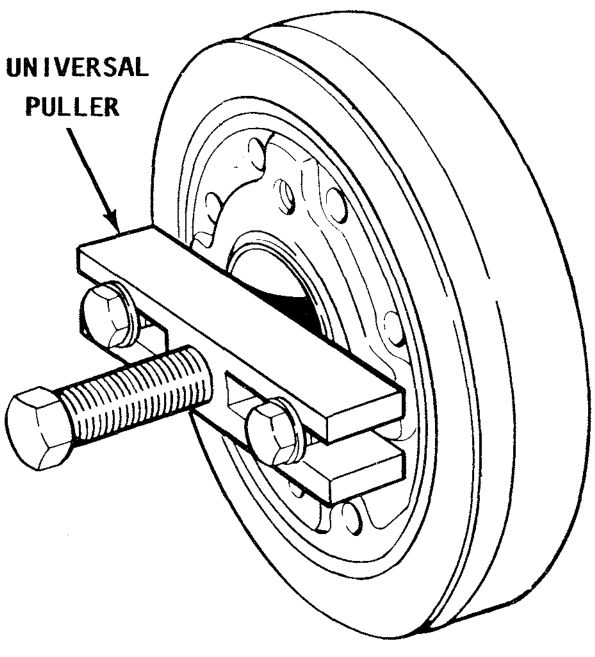
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

3-22 TIMING CHAIN SERVICE

The camshaft is driven at half engine speed by a single-row chain and a sprocket on the crankshaft. The chain is automatically tensioned by two dampers as shown in the accompanying illustration. Timing chains are subject to stretching after prolonged use, and therefore, require replacement. Access to the chain is gained by first removing the cover.

TIMING CHAIN COVER REMOVAL

Drain the water from the block by opening all drain valves. Disconnect the upper hose at the water pump. Disconnect the lower hose.



A special tool MUST be used to remove the harmonic balancer. A wheel puller will not do the job.

Remove the crankshaft pulley. Remove the harmonic balancer-to-crankshaft bolt and washer. Using the special tool, as shown, pull off the harmonic balancer. Tapping the balancer with a plastic mallet may help to start it off the crankshaft.

Disconnect the fuel lines and remove the fuel pump. **CAUTION:** Be **sure to plug the fuel line to stop fuel from siphoning out of the fud tank.**

Remove the alternator and brackets. Remove the distributor cap and pull the spark plug wire retainers off the brackets on the rocker arm cover. Move the distributor cap, with the wires still in place out of the way. Disconnect the distributor primary lead. If the timing chain and sprockets are not going to be disturbed, mark the position of the distributor rotor, and then remove the distributor.

Remove the bolts securing the timing chain cover to the cylinder block. Remove the two oil pan-to-timing chain cover bolts. Remove the timing chain cover and gasket. Clean the cover thoroughly. Use care not to damage the gasket surfaces.

TIMING CHAIN REMOVAL

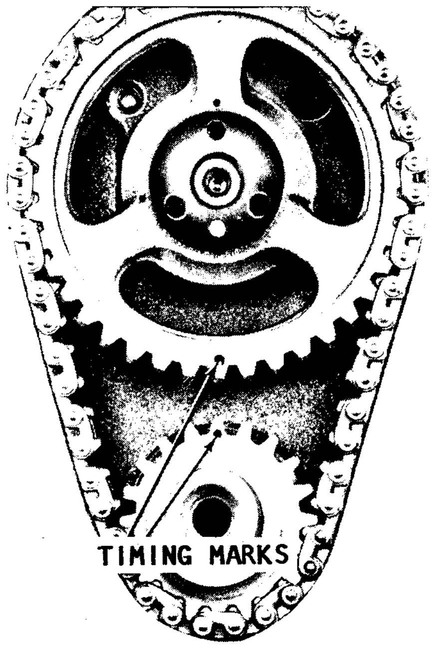
After the timing chain cover has been removed, install the harmonic balancer bolt and washer in the end of the crankshaft. Now, rotate the crankshaft until the timing marks on both sprockets are aligned through the center of the crankshaft and the center of the camshaft, as shown. Positioning the sprockets at this time will simplify the job of installing new parts.

Remove the harmonic balancer bolt and washer without moving the sprockets. The timing chain dampers do not have to be removed unless they are worn or damaged and you intend to replace them.

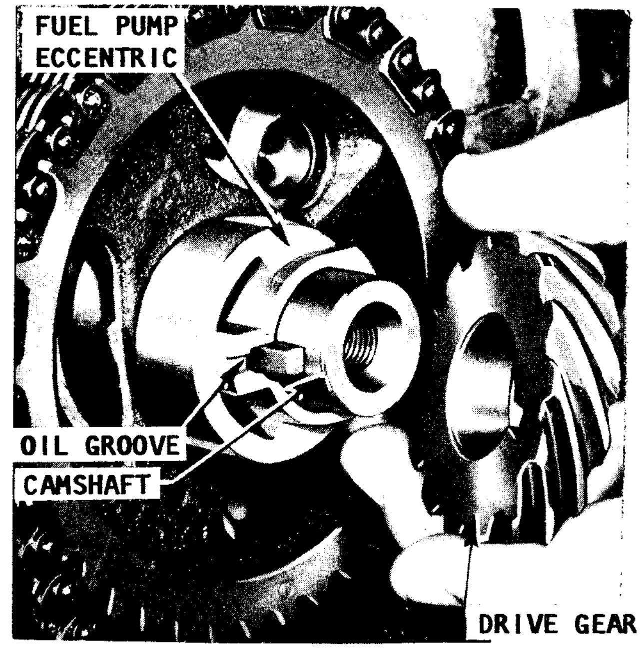
Remove the front crankshaft oil slinger. Remove the bolt and special washer retaining the camshaft distributor drive gear and fuel pump eccentric to the camshaft forward end. Slide the gear and eccentric off the camshaft.

Work the camshaft sprocket and the crankshaft sprocket off together by prying first one and then the other forward until the camshaft sprocket is free. Remove the timing chain and then finish removing the crankshaft sprocket.

Clean the sprockets, timing chain, distributor drive gear, crankshaft oil slinger, and the fuel pump eccentric.



Alignment of the timing marks through the centers of the crankshaft and the camshaft.



Timing gear installation onto the camshaft.

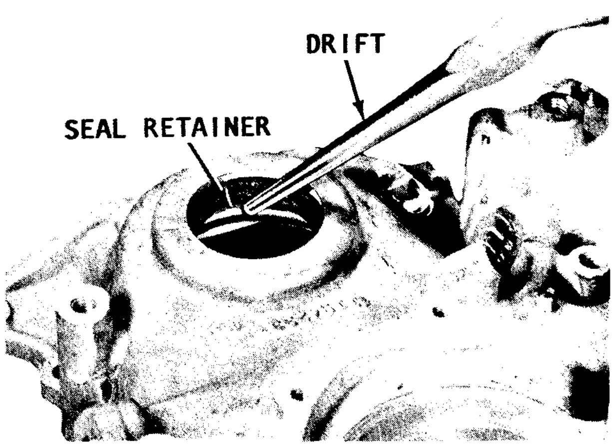
TIMING CHAIN INSTALLATION

Rotate the crankshaft until No. 1 piston is at top dead center. Slide the camshaft sprocket temporarily onto the camshaft, and then rotate the camshaft until the timing mark on the sprocket is at the straight down position, as shown. Remove the sprocket.

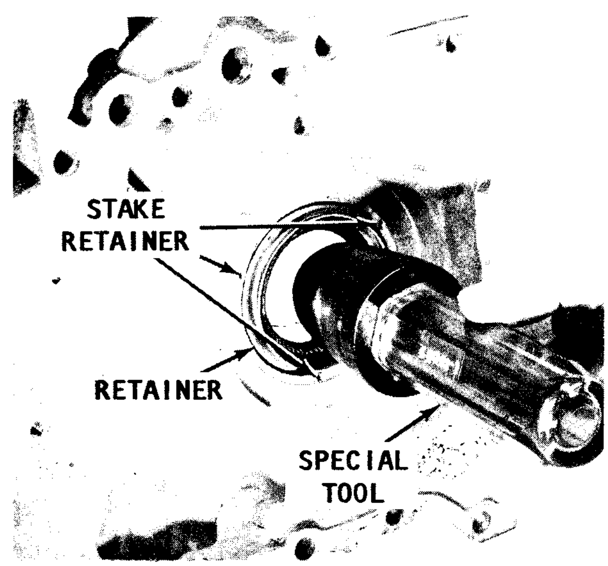
Engage the timing chain onto both sprockets, and then slide the sprockets onto the shafts with the timing marks as close as possible and in line with the sprocket hubs as shown. As you work the sprockets onto the shafts it will be necessary to retract the spring-loaded timing chain dampers out of the way.

Slide the oil slinger onto the crankshaft with the ID against the sprocket. The concave side of the slinger **MUST** be toward the front of the engine. Slide the fuel pump eccentric onto the camshaft and key with the oil groove facing forward. Install the distributor drive gear, eccentric, retaining washer, and bolt. Tighten the bolt to the torque value given in the Specifications in the Appendix.

Install the timing chain cover. **ALWAYS** use a new gasket. Remove the oil pump cover and -pack the space around the oil



Removal of the front oil seal with a drift.



A special tapered tool is designed to form the front oil seal in place.

pump gears completely full of petroleum jelly so as to leave NO air space inside the pump. Install the oil pump cover with a new gasket. If the pump cover is not removed and the pump properly packed, the pump may lose its prime and may not begin to pump as soon as the engine is started.

Clean the gasket surface of the block and the timing chain cover. **ALWAYS** use a new gasket and take care to ensure it is properly positioned. If the pan gasket was cut, it will be necessary to cut a new piece of pan gasket to fit. Install the gasket onto the front of the pan and seal the joints with silicone rubber seal.

Lubricate the timing chain cover bolt threads, and then place the timing chain cover against the block. Be sure the dowel pins index in the dowel pin holes before installing the attaching bolts.

Lubricate the OD of the harmonic balancer before installing it to prevent damage to the seal during installation and when the engine is first started.

Install distributor, then the distributor primary lead to the coil, the distributor cap and wires to the spark plugs, the brackets and alternator, the fuel pump, the fuel lines, and the water hoses,

Close all water drain valves.

Start the engine, run it at idle speed, and check for leaks.

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.

COMPRESSION TESTING CHART

It is recommended the following quick reference chart be used when checking cylinder compression pressures. The chart has been calculated so that the lowest reading number is 75% of the highest reading.

Example:

After checking the compression pressures in all cylinders, it was found that the highest reading obtained was 196 psi. The lowest pressure reading was 155 psi. The engine is within specifications and the compression is considered satisfactory.

Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI
134	101	174	131	214	160
136	102	176	132	216	162
138	104	178	133	218	163
140	105	180	135	220	165
142	107	182	136	222	166
144	108	184	138	224	168
146	110	186	140	226	169
148	111	188	141	228	171
150	113	190	142	230	172
152	114	192	144	232	174
154	115	194	145	234	175
156	117	196	147	236	177
158	118	198	148	238	178
160	120	200	150	240	180
162	121	202	151	242	181
164	123	204	153	244	183
166	124	206	154	246	184
168	126	208	156	248	186
170	127	210	157	250	187
172	129	212	158		

GMC V8 ENGINES

The first of the modern large-block engines was produced in 1965 with a 396 CID. Since 1965, the engine has been progressively increased in size to 402, 427, and 454 CID. These engines are called Mark IV to separate them from the small-block engines. These 90° blocks have a center-to-center bore spacing of 4.84". The port bank cylinders are numbered 1-3-5-7 and the starboard bank 2-4-6-8. The firing order is 1-8-4-3-6-5-7-2.

The block and cylinder heads of production models are made of cast iron. An unusual feature of the heads is the angled pattern of the tilted valves to allow gas to flow smoother through intake and exhaust ports. This feature contributes to increased volumetric efficiency.

One of these larger engines may have been installed in your boat as original equipment or you may have had one installed as a replacement engine. Therefore, all of the GMC V8 engines will be covered in this section.

In order to IDENTIFY the engines covered in a particular procedure, and to AVOID REPETITION the engines are classified as follows: The 265, 283, 300, 305, 307, 327, 350, and 400 CID engines are identified as SMALL V8. The 5.0 Litre and 5.7 Litre engines fall into this category. The 396, 402, 427, and 454 CID engines are identified as MARK IV's. Many of the engines, assemblies, and individual parts are not only similar, but they are interchangeable. Therefore, typical illustrations and procedures are provided, except where specific details differ.

The following service sections are coded to assist you in refering to a particular section quickly when performing other work. You will find these numbers referenced in other chapters.

3-23 ENGINE REMOVAL

In some cases, the design of the boat will hinder removing and installing the engine. Engine hood covers and panels around the engine may have to be removed before the engine will clear. In all cases, the engine must be moved about 6-inches forward in order to clear the driveshaft assembly.

If the engine cannot be moved forward far enough to clear the driveshaft, it may be necessary to remove the out drive unit. See Chapter 10.

Disconnect the battery cables, engine-to-dash wiring, water hoses, throttle cable, exhaust hoses, and fuel lines.

Be sure to plug the fuel line to stop fuel from siphoning out of the fuel tank.

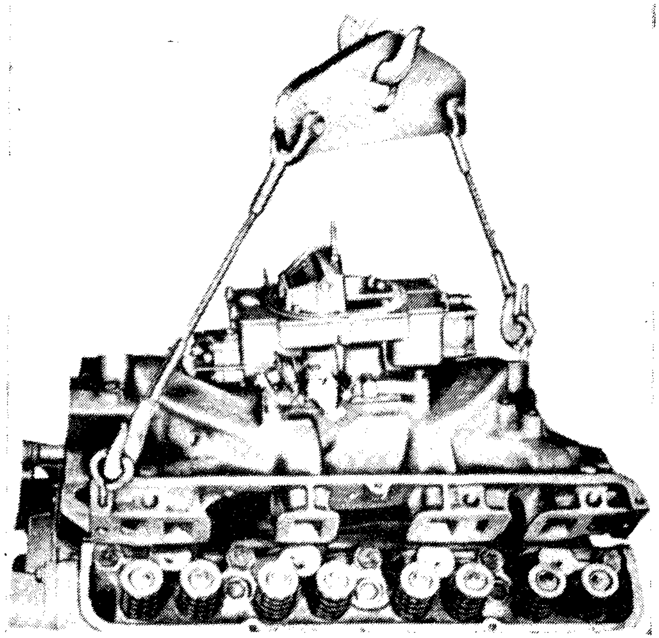
Drain the water from the block by opening all of the drain valves.

The engine has two lifting brackets to be used with a length of chain. Run the chain through the holes in the lifting brackets, and then fasten the ends together with a bolt and nut. Attach the lifting device in the center of the chain, and then tie the chains together to prevent the lifting device from riding down the chain as the engine is lifted from the boat.

Remove the bell housing-to-engine bolts. Remove the lag bolts on the mounting to the deck. If the engine compartment is too small for -the engine to clear, it may be necessary to remove the mounting brackets from the engine. Slide the engine forward about 6 inches, and then lift it straight up and out. If you do not have enough room to move it forward, then it will be necessary to remove the stern drive unit, see Chapter 10.

ENGINE INSTALLATION

Lower the engine into the compartment and align the engine with the guide pins on the bell housing. Slide the engine aft onto the driveshaft assembly. It may be necessary to turn the driveshaft in order to mate



Removing an engine from the boat using a lifting bracket.

the splines. The driveshaft can be rotated easily by simply putting the outdrive in forward gear, and then turning the propeller.

Install the bell housing-to-engine bolts, alternating evenly around the bell housing. Install the lag bolts through the mounting brackets into the deck. Of course, if the engine brackets were removed for the engine to clear during removal, they will have to be installed before the lag bolts.

If the outdrive assembly was removed, install it, see Chapter 10.

Install the fuel line, water hoses, engine-to-dash wiring, exhaust hose, throttle cable, and battery cables. Close all water drain valves. Fill the crankcase with the proper weight oil.

Start the engine and check for leaks.

CAUTION: Water must circulate through the Eower unit to the engine any time the engine is run to prevent damage to the water pump in the lower wit. Just five seconds without water will damage the water pump.

3-24 OIL PAN SERVICE

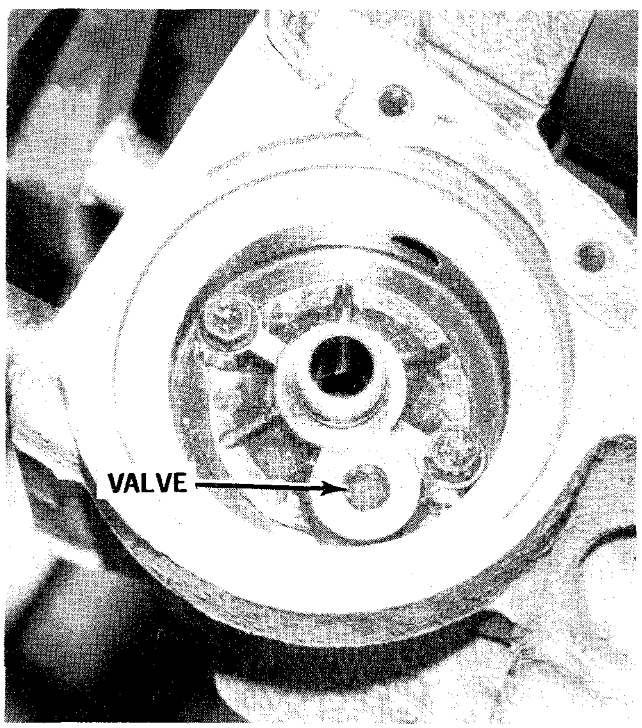
REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the engine, see Section 3-23.

Remove the oil drain plug and drain the oil. On late-model engines, a kit has been attached to the oil drain plug to help in draining the oil when the engine is in the boat. This kit can be installed on any engine and **SHOULD** be done the first time the engine is removed from the boat.

Remove the oil pan bolts, and then separate the pan from the engine block.



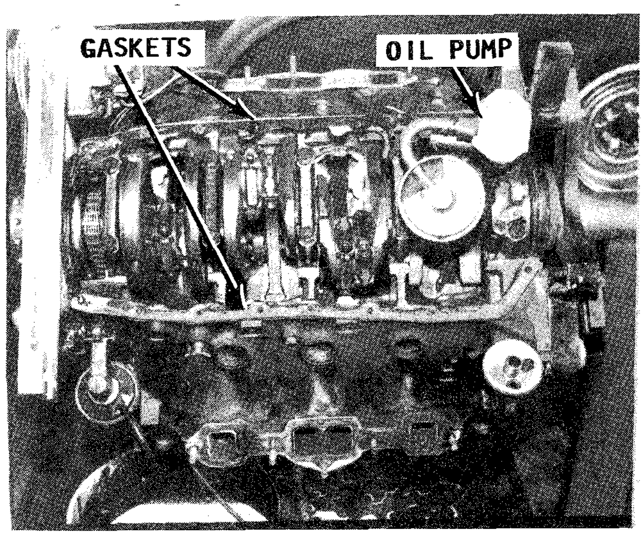
The oil filter bypass valve is installed with the valve side facing toward the engine, as shown.

CLEANING

Clean the oil pan with solvent. Clean the oil pickup screen and examine it for any evidence of clogging.

INSTALLATION

ALWAYS install a new pan gasket set. Thoroughly clean all gasket sealing surfaces. Install the rear seal in the rear main bearing cap. Install the front seal on the crankcase front cover. Press the tins of the seal into the holes provided in the cover. Install the side gaskets to the engine block. Use a sealer with enough body to act as a retainer. Place the pan in position on the block, and then install and tighten the pan bolts to the torque value given in the Specifications in the Appendix. **TAKE CARE** to tighten the bolts evenly all around and not to over tighten them.



Proper arrangement of the side gaskets. The gaskets are held in place with a sealer.

Install the engine, see Section **3-23.**
Close the water drain valves.
Fill the crankcase with the proper weight oil.
Start the engine and check for leaks.

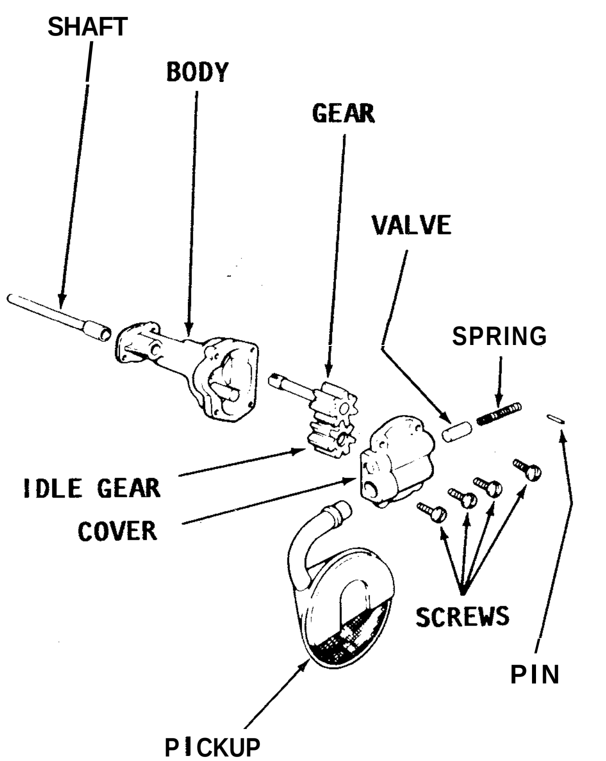
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump-

3-25 OIL PUMP

The oil pump consists of two gears and a pressure regulator valve, enclosed in a two-piece housing. The oil pump is driven by the distributor shaft, which is driven by a helical gear on the camshaft. A baffle is installed on the pickup screen to eliminate pressure loss due to sudden stops.

REMOVAL

Drain the water from the block by openinn all of the drain valves.
Remove the engine, see Section 3-23.
Remove the oil pan, see Section 3-24.
Remove the pump-to-rear main bearing cap bolt, and then remove the pump and extension shaft.



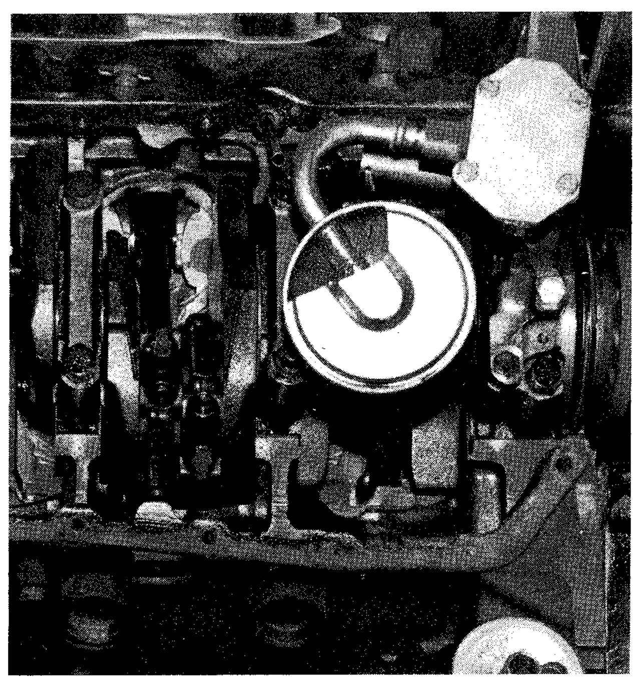
*Arrangement of parts **for** the oil pump assembly used on a small-block V8 engine.*

CLEANING AND INSPECTING

Wash the gears thoroughly and inspect them for wear and scores. If either gear is defective, they must be replaced as a **PAIR.**
Remove the oil pressure regulator valve cap, spring, and valve. The oil filter bypass valve and spring **MUST NOT** be removed because they are staked in place.
Wash the parts removed and check each one carefully. Inspect the regulator valve for wear or scores. Check the regulator valve spring to be sure it is not worn on its side or has collapsed. If in doubt about the condition of the spring, install a new one. Clean the screen staked in the cover.
Check the regulator valve in its bore in the cover. The clearance for the valve should be only a slip fit. If any side clearance can be felt, the valve or the cover should be replaced.
Inspect the filter bypass valve for cracks, nicks, or warping. The valve should be flat with no nicks or scratches.

ASSEMBLING

Apply a generous amount of oil to the pressure regulator valve and spring. Install the lubricated valve and spring into the bore of the oil pump cover and then slide the retaining pin in place.
Install the gears and shaft into the oil pump body. Check the gear end clearance. Place a straightedge over the gears, and



Oil pump properly installed.

then measure the clearance between the straightedge and the gasket surface. The clearance should be 0.0023" to 0.0058".

If the gear end clearance is okay, remove the gears and pack the gear pocket full of petroleum jelly. **DO NOT** use chassis lube.

CAUTION: Unless the pocket is packed with petroleum jelly it may not prime itself when the engine is started.

Install the gears and shaft again, pushing the gears into the petroleum jelly. Place a new gasket in position, and then install the cover screws. Tighten the screws alternately and evenly to the torque value given in the Specificiations in the Appendix.

If the oil pump pickup screen was removed, apply sealer to the mating surfaces before you drive the pipe into position. An **AIR LEAK** could cause a **LOSS** of **OIL PRESSURE.**

INSTALLATION

Assemble the pump and extension shaft to the rear main bearing cap with the slot in the top end of the extension shaft aligned with the drive tang on the lower end of the distributor driveshaft. Install the pump-to-rear bearing cap bolt. The correct position for the oil pump screen is with the bottom edge parallel to the oil pan rails.

Install the oil pan, see Section 3-24.

Install the engine, see Section 3-23.

Fill the crankcase with the proper oil.

Close the water drain valves.

Start the engine and check for leaks.

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.

3-26 INTAKE MANIFOLD

REMOVAL

Drain the water from the block by opening all of the drain valves. Remove the flame arrestor from the carburetor. Disconnect the battery cables at the battery. Disconnect the hoses, fuel line, and throttle linkage at the carburetor. Disconnect the wires to the coil and temperature sending switch.

Remove the distributor cap and mark the distributor housing indicating the position of the rotor. Remove the distributor clamp and then pull the distributor out of the block. Move the distributor cap out of the way. Remove the coil and bracket.

Remove the bolts attaching the manifold to the head, then lift the intake manifold, with the carburetor attached, from the engine. Discard all gaskets and seals.

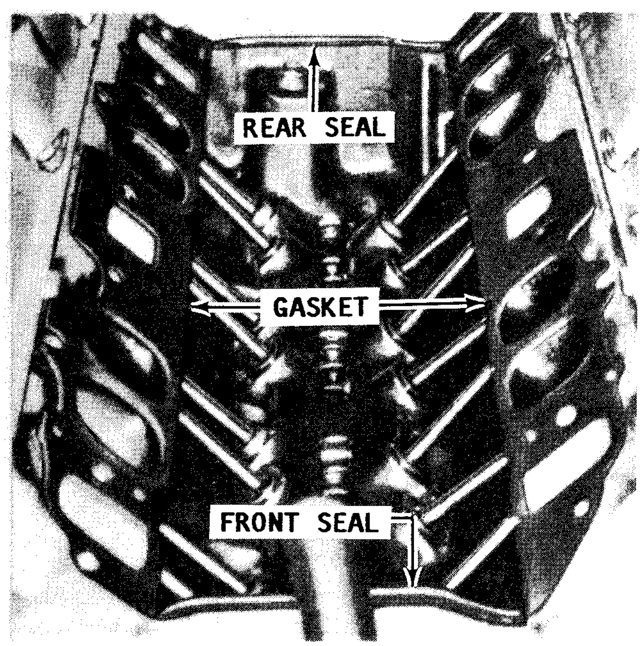
CLEANING

Clean the gasket surfaces of the intake manifold and the heads. Check the old gaskets to determine if there has been any exhaust leakage. Any evidence of exhaust leakage would indicate a crack in the head. Any sign of water in an intake manifold port would indicate either a crack in the manifold or a crack in the head.

INSTALLATION

Place new rubber intake manifold seals in position at the front and rear rails of the cylinder block. **BE SURE** the pointed ends of the seal fit snugly against the block and head.

Apply a light coating of Permatex, Form-A-Gasket, or equivalent, to the area between the water passages on the head and the manifold. Install the intake manifold gaskets onto the heads. Set the intake manifold in place carefully and start the two guide bolts on each side.



Placement of manifold gaskets and seals prior to installing the manifold.

Lift the manifold slightly and slip the gaskets into position as shown. TAKE CARE to align the three intake manifold holes in the gasket with the matching ports in the head and the manifold. The gasket should be installed as shown for the left side and reversed for the right side installation.

Install a manifold attaching bolt in the open bolt hole, as shown. The open bolt hole is held to close tolerances and the bolt in this location serves to locate the intake manifold perfectly fore-and-aft. Install the remaining manifold-to-cylinder head bolts with the longer bolts at the forward location. Tighten the bolts in the sequence shown in the accompanying illustration, and to the torque value given in the Specifications in the Appendix.

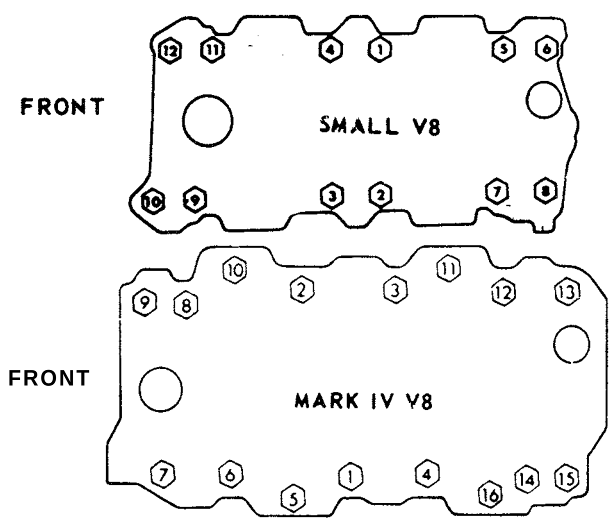
Install the coil. Slide the distributor into place with the rotor pointing to the mark you made prior to removing the distributor. Snap the distributor cap in place. If the crankshaft was rotated while the distributor was out of the block, the engine will have to be timed. See Chapter 5 for detailed procedures to time the engine properly.

Connect the battery cables at the battery; the hoses to the thermostat housing; the throttle linkage and fuel line at the carburetor; and the wires to the coil and temperature sending switch.

Close the water drain valves.

Start the engine and check for leaks.

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.



Tightening sequence for the intake manifold bolts on a small-block engine.

3-27 EXHAUST MANIFOLDS AND ELBOWS

REMOVAL

Remove all water hoses and exhaust hoses from the elbow to the side of the exhaust housing.

Remove the nuts from the manifold studs, and then lift off the manifolds.

For other service on the exhaust manifolds, see Chapter 9, Cooling System.

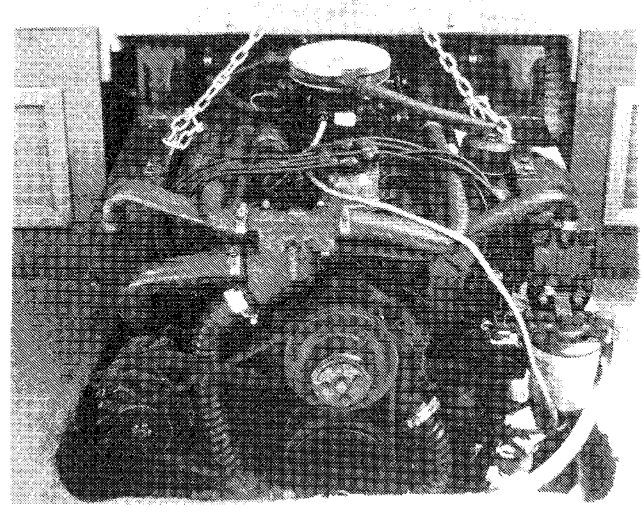
INSTALLATION

Install the manifolds to the cylinder head and start the nuts onto the studs. Tighten the nuts alternately. The manufacturer does not always install a gasket between the exhaust manifold and the engine block, however, if any evidence indicates an exhaust leak, a new gasket should be installed. They are readily available at the nearest automotive parts dealer. A substitute for a new gasket would be to coat the surfaces of the manifolds and the matching surfaces on the block with Permatex "Form-A-Gasket" or equivalent.

Install the water hoses and exhaust hoses to the manifold.

Start the engine and check for leaks.

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.



Installation of the manifold.

3-28 CYLINDER HEAD SERVICE

The cylinder head and valve mechanism are the most important areas affecting the power, performance, and economy of an engine. Time and much care are required when reconditioning the cylinder head and valves to maintain the correct valve stem-to-guide clearance; to grind the valves properly; and to make the correct valve adjustment.

The procedures in this section provide removing, disassembling, cleaning and inspecting, and installing the cylinder head, including some of the work that may be accomplished while the head is removed.

REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the intake manifold, see Section 3-26.

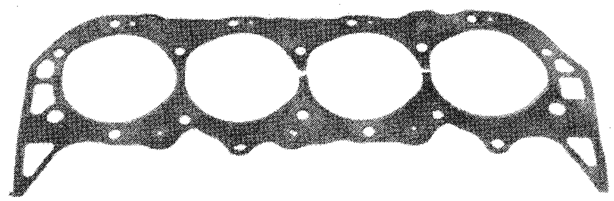
Remove the exhaust manifolds, see Section 3-27.

Pull the spark plug wire retainers from the brackets on the rocker arm covers. Disconnect the spark plug wires at the plugs and swing the wires and retainer out of the way. Remove the screws attaching the rocker arm cover to the cylinder head.

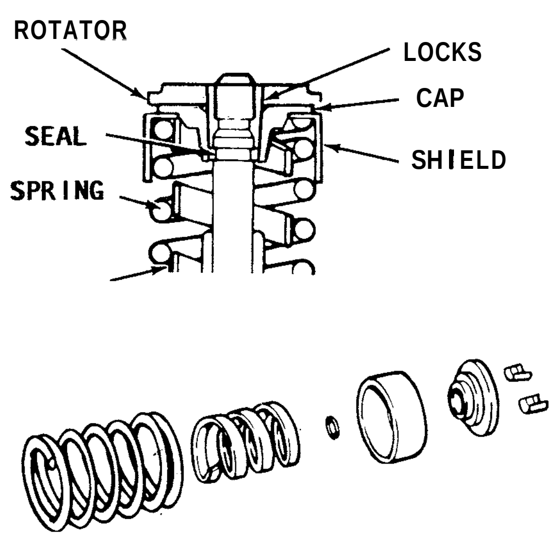
Remove the rocker arm covers and gaskets. Remove the rocker arm nuts, rocker arm balls, and rocker arms. **TAKE TIME** to set up a system for keeping the pushrods, valve lifters, valves and their associated parts in absolute order to ensure each and every part will be installed in exactly the same position from which it was removed.

Remove the push rods and valve lifters.

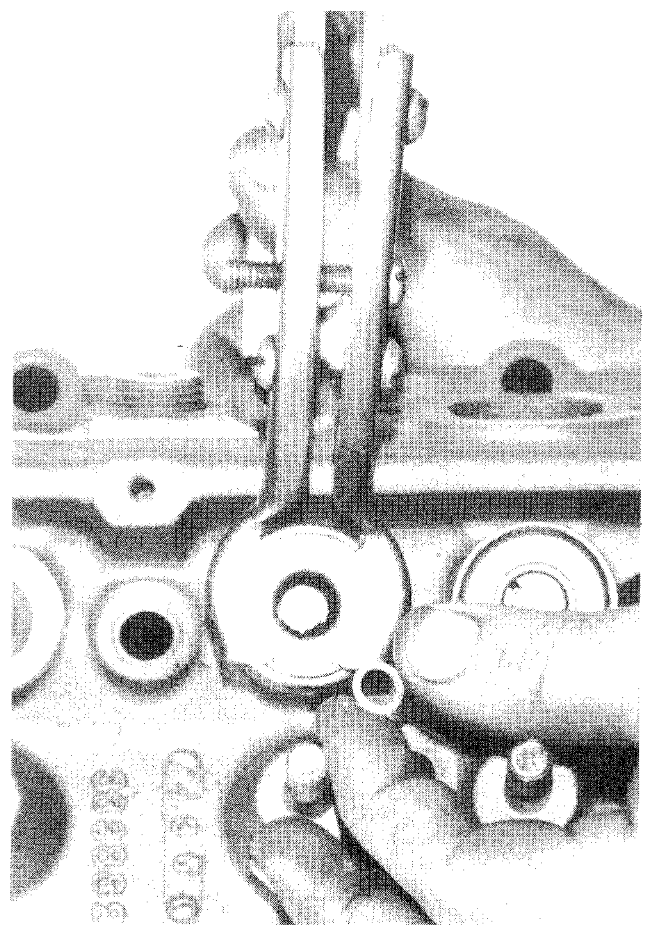
Remove the cylinder head bolts, cylinder heads, and gaskets. Place each head assembly on its side. Use a valve compression tool, and compress each valve spring to remove the valve locks, seal, spring cup, and spring.



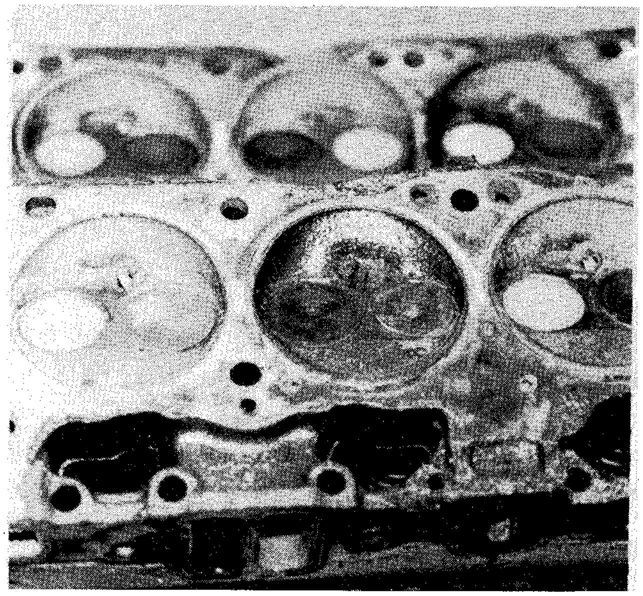
Compression loss may be caused by a blown head gasket between cylinders.



Valve parts arranged in order and assembled with each item identified. In addition to the parts shown, some late models have a valve rotator and some models do not have a damper spring.



Removal of the valve locks which release the other valve parts.

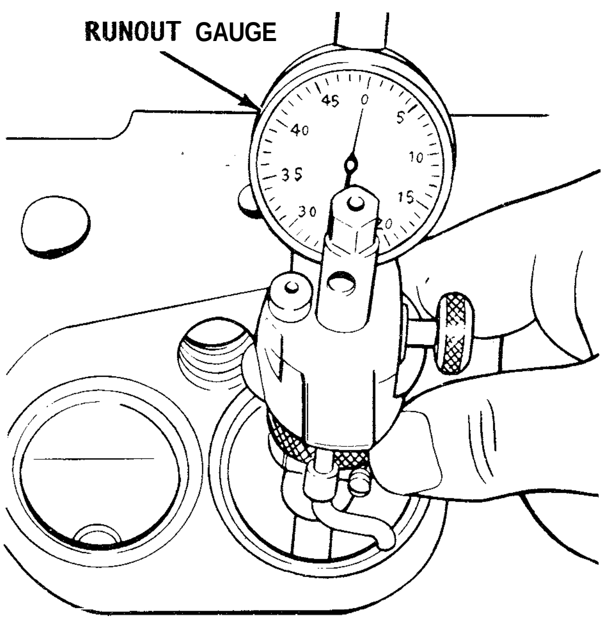


Notice the oil around the intake valve and the darker coloring of the exhaust valve in the right combustion chamber. The compression in the right cylinder was lower than in the left. Also, the intake valve guide and seal are defective allowing oil to leak into the combustion chamber.

Continue removing the parts until all valves have been released. Remove the valves from the head one-at-a-time and keep them in order by number and the head from which they were removed.

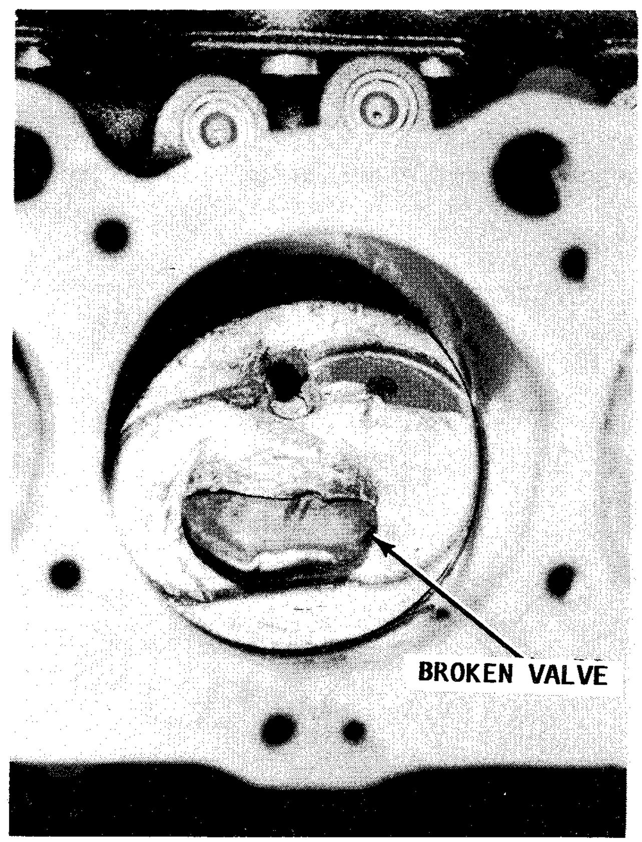
VALVE MECHANISM

Clean the valves, springs, spring retainers, locks, and sleeves in solvent, and then



After the seat has been reground, check to be sure it is concentric with the guide by using a dial gauge. The run-out should not exceed 0.002".

Example of a severely burned exhaust valve face. The valve was sticking in the guide as evidenced by the gum on the neck of the stem. TAKE TIME to clean the valve guide thoroughly.



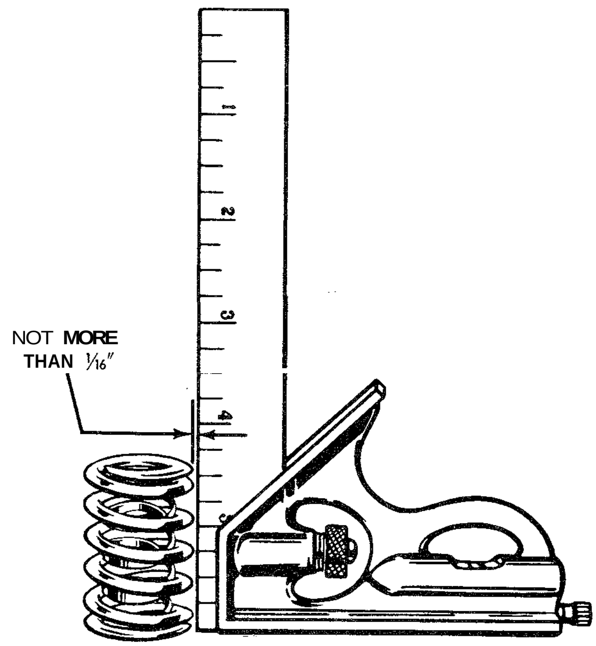
Improper installation techniques caused this valve to drop out and strike the piston.

blow the parts dry with compressed air. Inspect each valve face and the head for pits, grooves, and scores. Inspect the stem for wear and the end for grooves. The face must be trued on a valve grinding machine, which will remove minor pits and grooves. Valves with serious defects, or those having heads with a knife edge must be replaced.

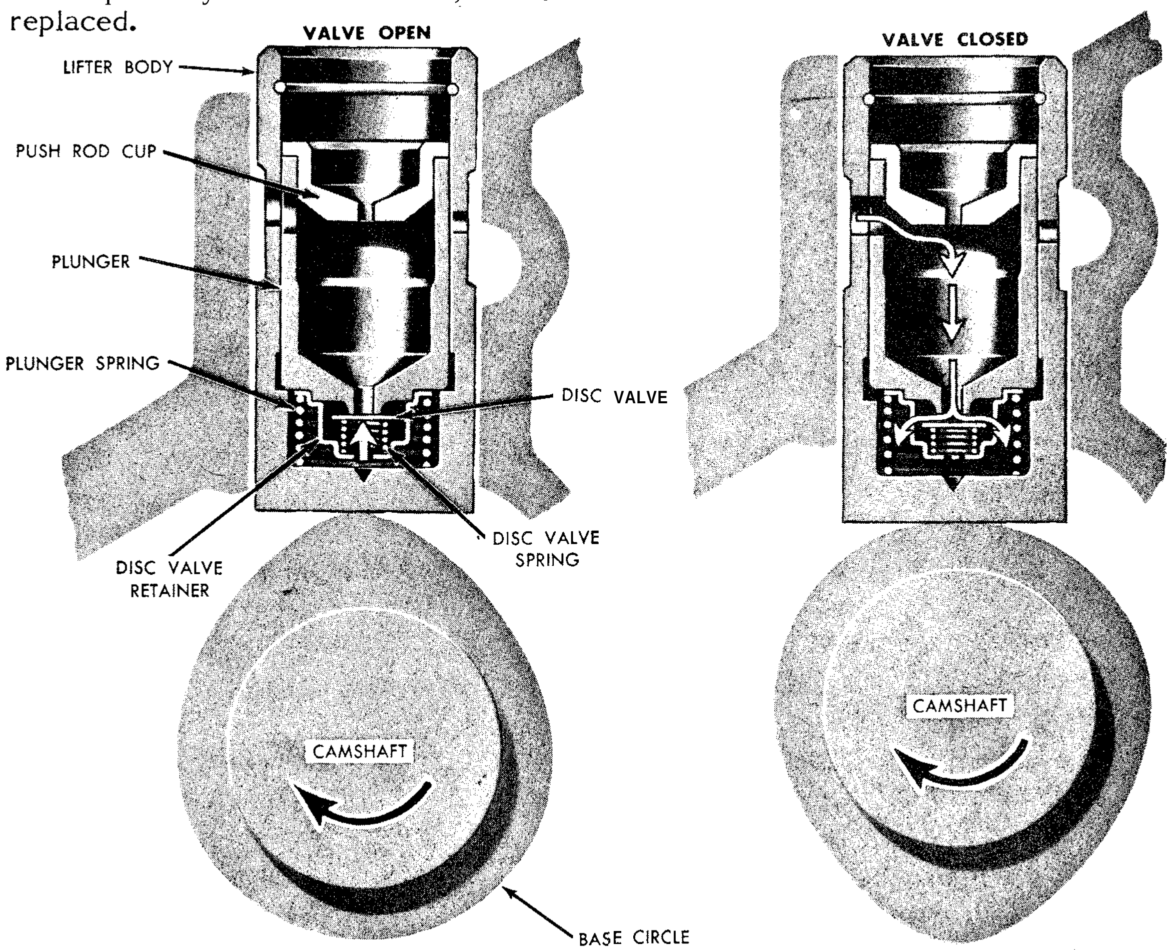
Grind or replace valves, if necessary. A valve should be replaced if the head must be ground to a knife edge in order to obtain a true face. A 45° angle is the correct angle for the valve face. If the angle is any sharper, the valve will run too hot.

VALVE **SPRINGS**

Compare the valve spring tension against those listed in the Specifications in the Appendix. A quick check can be made by laying all of the springs on a flat surface and comparing their heights. The heights **MUST** all be the same. Both ends of each spring **MUST** be square or the spring will tend to cock the valve stem. Weak valve springs cause poor engine performance. Therefore, if a spring is weak or the ends are not square by more than 1/16", it **MUST** be replaced.



A valve spring should not be out by more than 1/16" when it is rotated against a square on a flat surface, as shown. If it is, the spring should be replaced.



Relationship of the cam lobe as the camshaft rotates. The cam moves the valve lifter to the valve open position (left) and then to the valve closed position (right).

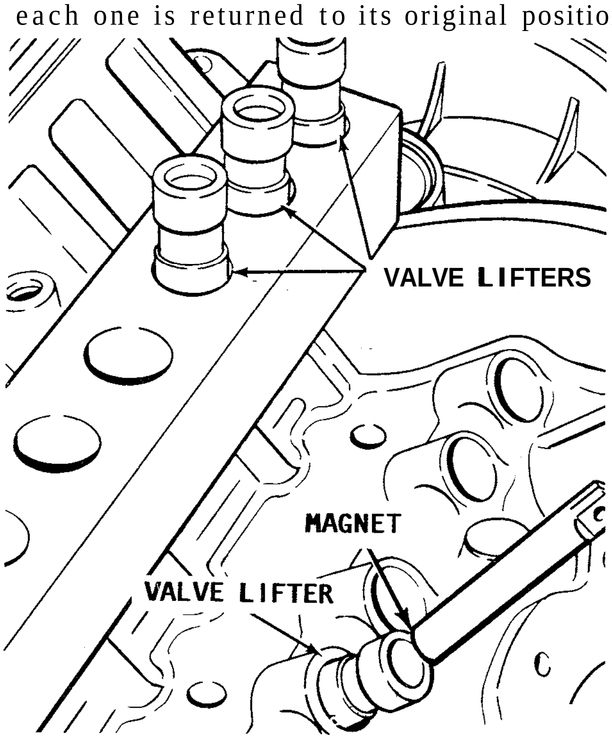
HYDRAULIC VALVE LIFTERS

Dirt, deposits of gum, and air bubbles in the lubricating oil can cause the hydraulic lifters to wear enough to cause failure. The dirt and gum can keep a check valve from seating, which will cause the oil to return to the reservoir during the time the push rod is being lifted. Excessive movement of the lifter parts causes wear and destroys the lifter's effectiveness in a short time.

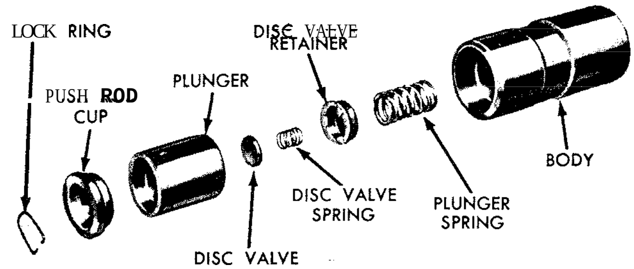
ALWAYS keep the lifter assemblies in proper sequence when they are being removed. This is the only way they can be installed back into their original position. Clean, inspect, and test each lifter separately and use the utmost care not to intermix the internal parts. If any one part of the lifter is defective for any reason, replace the complete lifter assembly, **NEVER** just one part.

After the lifter has been cleaned, dried, and assembled, a quick test of its operation can be made by depressing the plunger with your finger. The trapped air should partially return the plunger if the lifter is operating properly. If the lifter is worn, or if the check valve is not seating, the plunger will not return.

Install the assembled lifters in the engine dry, paying careful attention to ensure each one is returned to its original position.



Removing the valve lifter using a magnet and a device for keeping the lifters in sequence as an aid to proper installation in the same location from which they are removed.



Arrangement of hydraulic valve lifter parts.

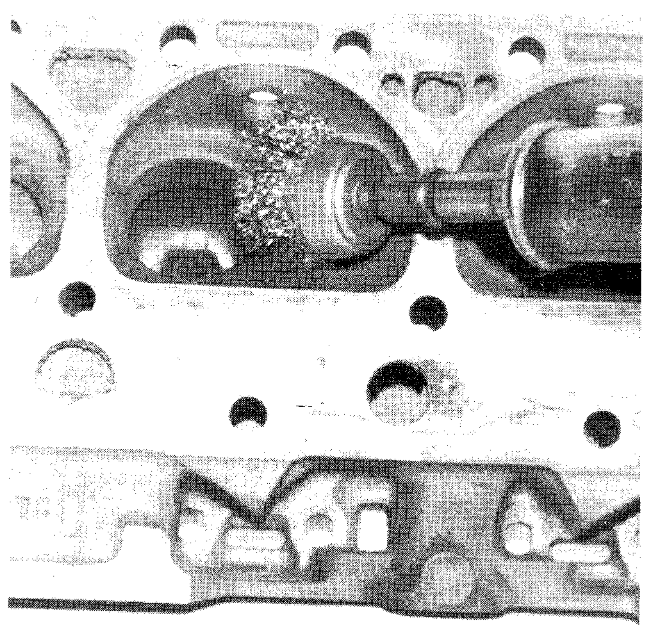
The lifters will bleed to their correct operating position quicker if installed dry than if you fill them with lubricating oil prior to installation.

RECONDITIONING VALVES AND SEATS

Remove the carbon from the combustion chambers. Use care to avoid scratching the head or the valve seats. Clean all carbon and gum deposits from the valve guide bores.

Valve stem guides are not replaceable. If a valve stem has excessive clearance, the guide must be reamed 0.003" oversize, using reamer J-5830-1. Valves with 0.003" oversize stems are available for service.

True the valve seats to a 45° angle. Cutting a valve seat results in lowering the valve spring pressure and increases the



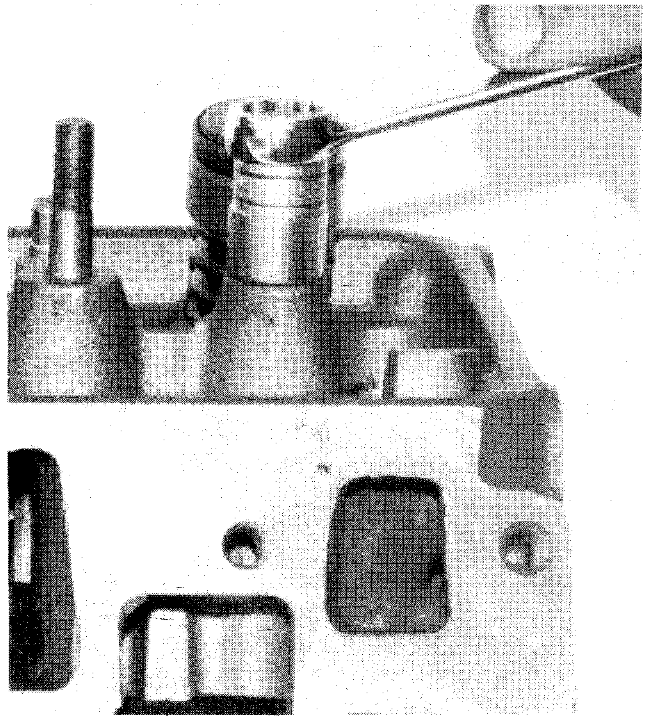
Use a wire brush to clean carbon from the cylinder head. Take time to do a thorough cleaning for maximum benefit.

width of the seat. The nominal width of the valve seat is 1/16". If a valve seat is over 5/64" wide after truing, it should be narrowed to the specified width by using 20° and 70° stones.

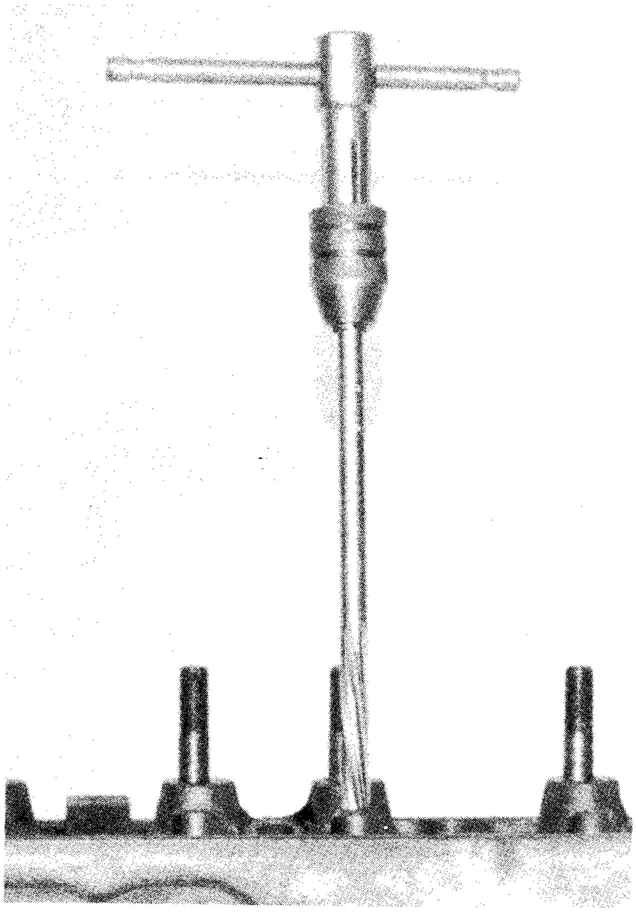
If the valve and seat are refinished to the extent that the valve stem is raised more than 0.050" above its normal height, the hydraulic valve lifter will not operate properly. If this condition exists, the worn part must be replaced. The normal height of the valve stem retainer above the valve spring seat surface of the head is 1.925".

Lap the valves lightly into their seats with fine grinding compound. The refacing and reseating operation should leave the refinished surfaces smooth and true. Actually, if the refinishing job is done properly, only a minimum of lapping is required. Excessive lapping will groove the valve face, preventing a proper seat when the valve is hot.

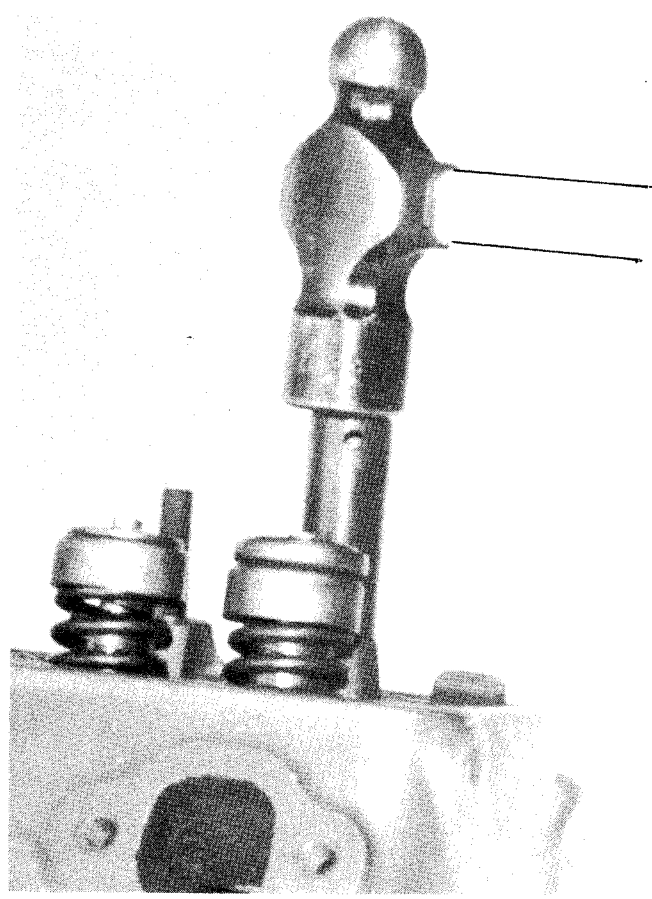
Test each valve to be sure it seats in the center of the seat. This test can be accurately done by first coating the valve face



A damaged rocker arm stud in a small-block engine must be removed with a stud puller, because the studs are pressed in.



To restore production clearances, worn valve guides can be reamed oversize, and then valves with oversize stems installed.



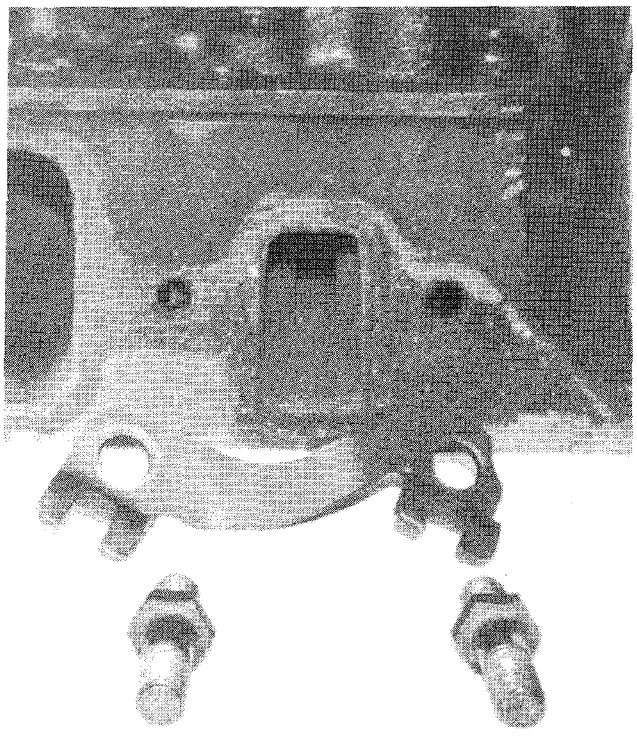
Coat a new rocker arm stud with EP lubricant, and then drive it into place with the tool shown. This tool will establish the proper depth for the stud.

lightly with Prussian blue, and then rotating the valve against the seat. If the valve seat is true with the valve guide, a mark will be made all around the seat. If the seat is not true (concentric with the guide), a mark will be made on only one side of the seat. Next, coat the valve seat lightly with Prussian blue. Rotate the valve again against the seat to determine if the valve face is true with the valve stem and if the valve is seating all the way around. Both tests are necessary to prove each valve is making a proper seat. **PAY ATTENTION** to install each valve spring with the **CLOSELY** wound coils **TOWARD** the cylinder head.

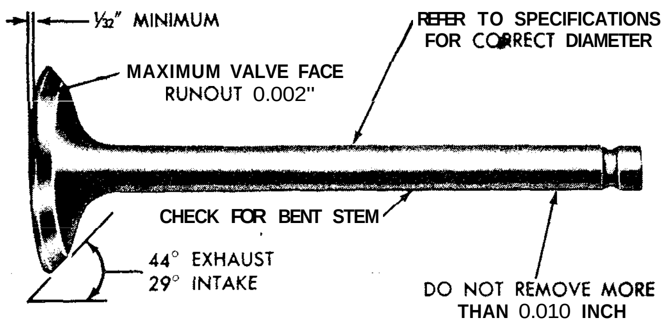
ROCKER ARM SERVICE

Remove the rocker arm-and-shaft assembly. Take out the cotter pin, plain washer, and spring washer from each end sf the rocker arm shaft. Remove the bracket bolts. Slide the rocker arms and brackets eff the shaft.

Clear. and inspect all parts. Pay particular attention to cleaning all of the oil holes. Replace any part excessively worn.



Proper arrangement of rocker arm studs and push rod guides prior to installation in the cylinder head. When installing a new rocker arm stud on this type, coat it with sealer to prevent a water leak and tighten the stud to a torque value of 50 ft-lbs. If the engine has an aluminum head, use anti-seize compound on the threads.



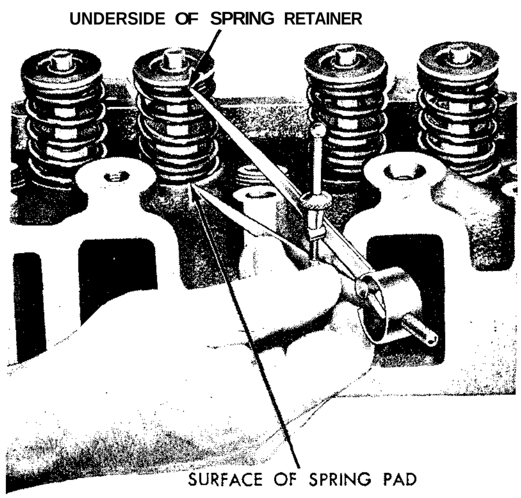
Critical valve tolerance.

Assemble the springs, rocker arms, and brackets on the shaft. Take care that the assembly for the right side has the notch in the shaft facing forward and the left side has the notch to the rear. Install the spring washer, flat washer, and cotter pin on each end of the shaft in the order named.

Install the bolts, with plain washers, through the brackets and shaft so the notch in the right assembly is facing up and forward; and the notch in the left assembly is facing up and aft.

CYLINDER HEAD INSTALLATION

The small V8 engines and the Mark IV's have Sifferent valve assemblies. Therefore, the cylinder heads will be discussed under separate headings.



Measuring the height of the installed valve spring. Compare this measurement with the Specifications in the Appendix.

SMALL V8 ENGINES

Begin, by coating the valves with a liberal coating of engine oil. Next, place each valve in the same guide from which it was removed. Now, place the valve spring, damper, valve shield, and valve cup in place. **CAUTION: The close-coil end of the spring must be against the cylinder head.**

Compress the spring and install the oil seal in the lower groove sf the stem. **MAKE SURE** the seal is flat and not twisted. A light coating of oil on the seal will help prevent it from twisting. Install the valve locks and release the compressor. Check to be sure the locks seat properly in the upper groove of the valve stem. A little dab of grease will usually hold the lock in place while the compressor is released.

MARK IV ENGINES

Coat the valves with a liberal coating of engine oil. Place each valve over the same valve guide from which it was removed. Set the valve spring, damper, and cap (or cap and seal assembly) in place.

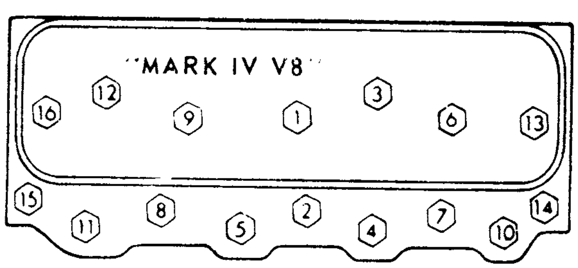
CAUTION: The closed-coil end of the spring must be against the cylinder head.

Compress the spring and install the valve locks, then release the compressor. Check to be sure the locks seat properly in the groove of the valve stem. A little dab of grease will usually hold the lock in place while the compressor is released.

CYLINDER HEAD INSTALLATION

Clean the engine block gasket surfaces. Check carefully to be sure no foreign material has fallen into the cylinder bores, bolt holes, or valve lifter area. Clean out all bolt holes with compressed air. One further step for a good job, is to run the correct size tap down each bolt hole.

Install new head gaskets on the cylinder block. **ALWAYS** use marine head gaskets to minimize salt water corrosion. Dowels in the block will hold the gaskets in position. **USE CARE** when handling the gaskets to prevent kinking or damaging the surfaces. **DO NOT** use any sealing compound on head gaskets, because they are coated with a special lacquer to provide a good seal, once the parts have warmed to operating temperature.



Tightening sequence for head bolts.

Clean the gasket surface of the cylinder heads and carefully set each in place on the engine block, with the holes in the heads indexed over the dowel pins in the block. Clean and coat the head bolts with sealer. Install the bolts as shown. Tighten the head bolts in the sequence shown, but only a little at a time, making about three rounds. On the final round, tighten each bolt in the same sequence to the torque value given in the Specifications in the Appendix. **BEAR IN MIND,** uneven tightening of the head bolts can distort the cylinder bores, causing compression loss and excessive oil consumption.

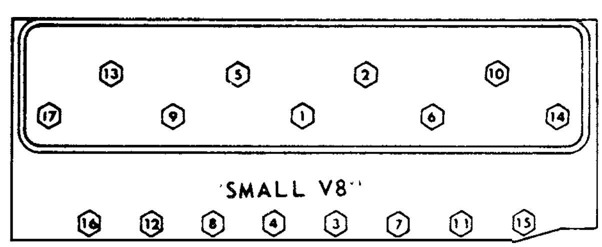
Install the exhaust manifold to each cylinder head, see Section 3-27. Tighten the bolts to the torque value given in the Specifications in the Appendix. Install the exhaust hoses to the exhaust housing.

Install the intake manifold between the cylinders heads, see Section 3-26.

ROCKER ARM-AND-SHAFT ASSEMBLY INSTALLATION

Install the push rods through the cylinder head openings. Clean the base of the rocker arm shaft brackets and each bracket boss on the cylinder head. Check to be sure the notch on the end of the rocker arm shaft for the right side is facing forward and the notch for the left side is facing aft.

Tilt the rocker arms toward the push rods and carefully position the top of each push rod in its rocker arm seat. Pull the rocker arm-and-shaft assembly down by tightening the bracket bolts a little at a time. Finally, tighten the bracket bolts to the torque value given in the Specifications in the Appendix.



Tightening sequence for head bolts.

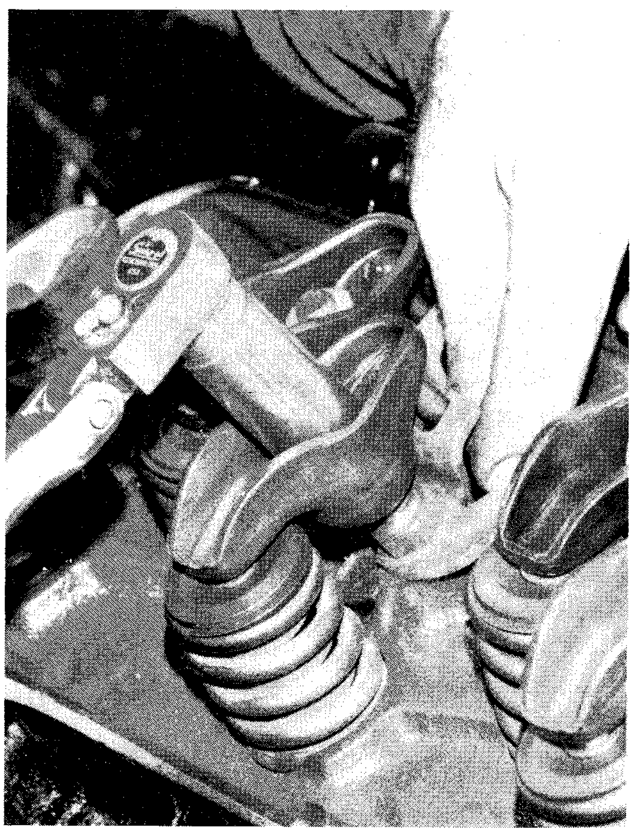
3-29 VALVE LASH ADJUSTMENT

The first procedure in this section covers: **EXHAUST VALVES** *8*, **3**, **4**, and 8; **INTAKE VALVES 1, 2, 5,** and **7.**

Crank the engine **SLOWLY** until two conditions exist: (1) the No. 1 piston is in the firing position, and (2) the mark on the harmonic balancer is aligned with the center or "O" mark on the timing tab fastened to the timing chain cover.

These two conditions may be determined by placing your fingers on the No.1 cylinder valves as the mark on the balancer comes near the "O" mark. If the valves are not moving, the engine is in the No. 1 firing position. If the valves move as the mark .comes up to the timing tab, the engine is in the No. 6 firing position. This means the engine must be turned over one more time to reach the No. 1 position.

The actual valve lash adjustment is made by first, backing off the adjusting nut (rocker arm stud nut) until there is a small amount of play in the push rod. Next, tighten the adjusting nut to barely remove the clearance between the push rod and rocker arm. This position may be determined by rotating the push rod with your fingers while at the same time you tighten the nut, as shown in the accompanying illustration.



Rotate the push rod as the rocker arm nut is tightened to determine the Zero lash position, then tighten the adjusting nut one additional full turn for proper adjustment.

At the point when you can not rotate the push rod easily, the clearance has been eliminated. Now, tighten the adjusting nut 3/4 turn more to place the hydraulic lifter plunger in the center cf its travel. No further adjustment is required.

'This procedure covers: **EXHAUST VALVES** 2, **5, 6,** and **7; INTAKE VALVES 3, 4, 6,** and 8.

Crank the engine **SLOWLY** one revolution from its position in the previous procedure until the No. 6 piston is in the firing position and the mark on the harmonic balancer is again aligned with the center or "O" mark on the timing tab fastened to the timing chain cover.

Repeat the sequence given in the previous procedure until the valves listed have been adjusted.

Continue in the sane manner for the same numbered valves on the other head.

For those who prefer to adjust the valve lash while the engine is running, the preferred method is to find the "zero lash" described in the first procedure of this section, and then to slowly turn the adjusting nut 1/4 turn and wait several engine revolutions for the lifter to bleed down before making a further adjustment. **DO NOT** attempt to turn the adjusting nut one full turn while the engine is operating. Adjustment in this manner will not allow the lifters to bleed down which could result in valve train damage, most likely a bent push rod or rods.

Continue making this adjustment 1/4 turn at-a-time until the nut is one complete turn down from "zero lash" point. Repeat the sequence until all of the valves have been properly adjussuted.

Install the rocker arm covers. **ALWAYS** use new gaskets. Check to be sure the cover hole reinforcements are in place. Tighten the screws to the torque value given in the Specifications in the Appendix.

Close the water drain valves.

Start the engine and check for leaks.

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.

3-30 PISTON, RING, AND ROD SERVICE

This section provides detailed procedures for removing, disassembling, cleaning, inspecting, assembling, and installing the complete piston-rod assembly. All parts **MUST** be kept together because if the old pistons are serviceable, they **MUST** be installed on the rods from which they were removed and installed in the same bore.

REMOVAL

Drain the water from the block by opening all of the drain valves.

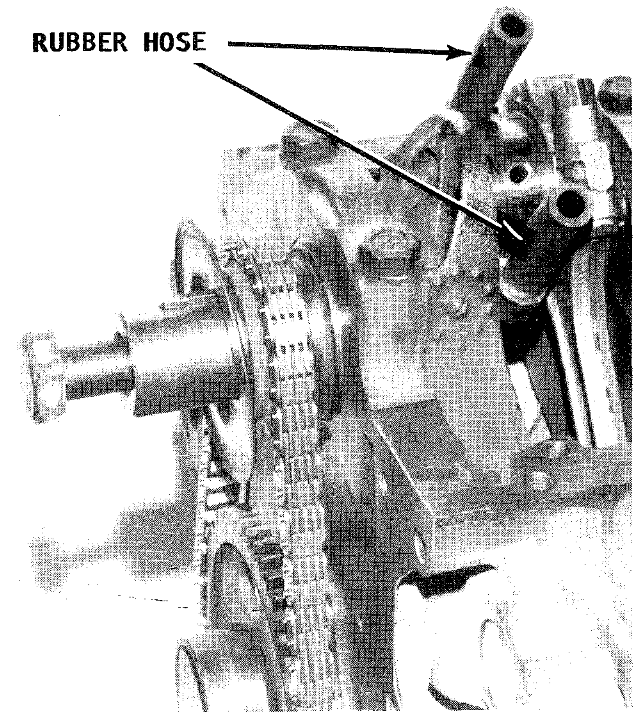
Remove the engine, see Section 3-23.

Remove both cylinder heads, see Section 3-28.

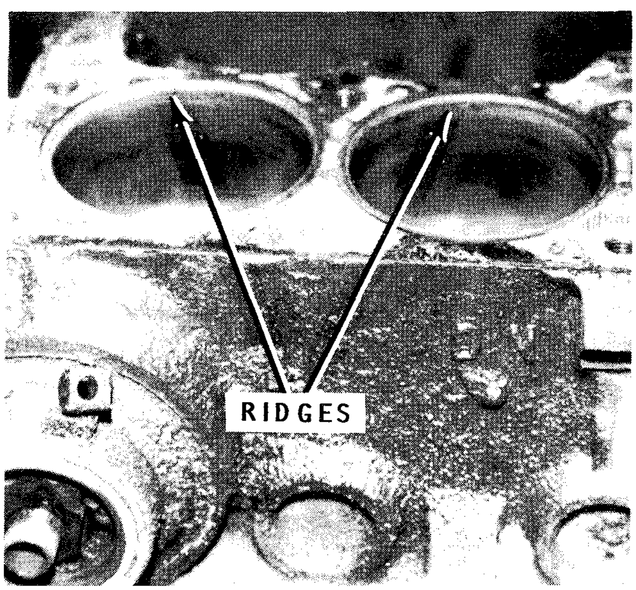
Remove the oil pan, see Section 3-24.

If a shoulder or ridge exists in the cylinder bores above the ring travel, they must be removed with a ridge reamer or the rings may be damaged or the ring lands (the area between the grooves) may be damaged during removal.

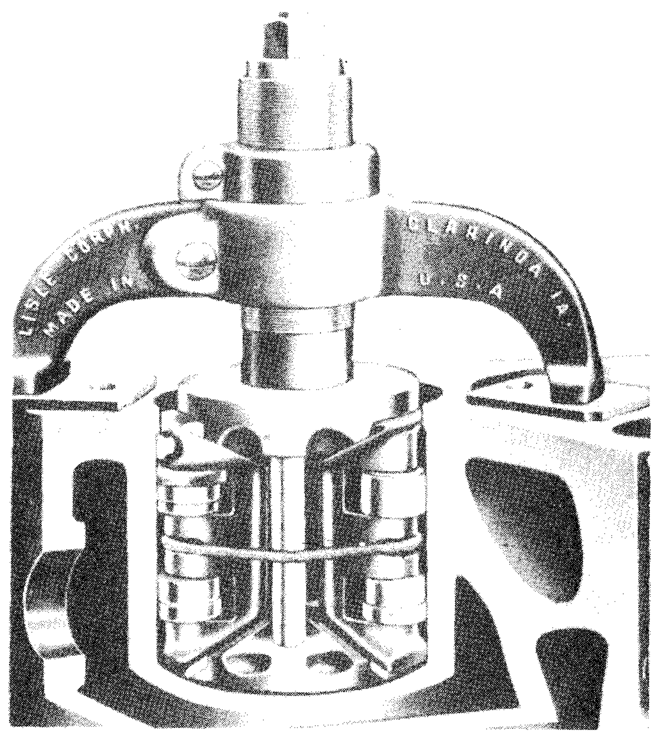
Before using the reamer, turn the crankshaft until the piston is at the bottom of its stroke, and then place a cloth on top of the piston to collect the cuttings. After the ridge is removed, turn the crankshaft until the piston is at the top of its stroke to remove the cloth and cuttings.



The rod bolt threads must always be covered with a piece of rubber hose to prevent damage to the crankshaft bearing surface by the rod threads scraping as the piston assembly is removed.



*Due to borderline lubrication conditions, the cylinder walls wear the most at the top. All measurements **MUST** be made in this worn area. This cylinder bore has been surfaced with a fine hone to remove the glaze for better piston ring seating.*



*A ridge remover **MUST** be used to cut the ridge from the top of the cylinder walls. The stop under the blade prevents cutting into the walls too deeply. **NEVER** cut more than 1/32" below the bottom of the ridge.*

Identify each piston, connecting rod, and cap with a quick drying paint or silver pencil to ensure each part will be replaced in the exact position from which it was removed. Beginning at the forward end of the crankcase, the cylinders in the port bank are numbered 1-3-5-7 and in the starboard bank 2-4-6-8.

Remove the cap and bearing shell from No. 1 connecting rod, then install a connecting rod bolt guide hose on the bolts to hold the upper half of the bearing shell in place. Push the piston and rod assembly up and out of the cylinder. It will be necessary to turn the crankshaft slightly to disconnect some of the connecting rod and piston assemblies and to push them out of their cylinders. Remove the guides and install the bearing shells and cap on the rod.

Continue in a similar manner until all of the piston and rod assemblies have been removed, partially reassembled to keep the parts matched, and the assemblies hung or placed in order.

CLEANING AND INSPECTING

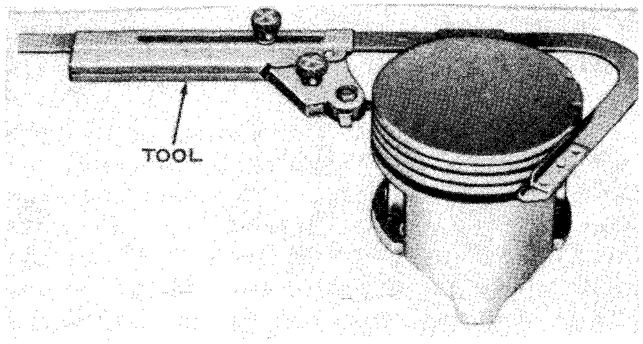
If the engine has over 750 hours of service, or if the piston and rod assembly has been removed, it is considered good shop practice to replace the piston pins. Loose piston pins, coupled with tight rings, will cause piston pin noises. These noises may disappear as the engine loosens.

Most mechanics have the piston pin work done by a machine shop with the necessary equipment and trained people to perform a precision job. If done in the machine shop, the connecting rods will be aligned so the pistons and rings will run true with the cylinder walls.

PISTONS AND PINS

Remove the compression rings with an expander. Remove the oil ring by removing the two rails and the spacer-expander, which are separate pieces in each piston's third groove.

Use a cleaning solvent to remove the varnish from the piston skirts and pins. **NEVER** use a wire-brush on any part of the piston. Clean the ring grooves with a groove cleaner and make sure the oil ring holes and slots are clean. Inspect the piston ring lands (the material between the ring grooves) the skirts, and pin bosses for

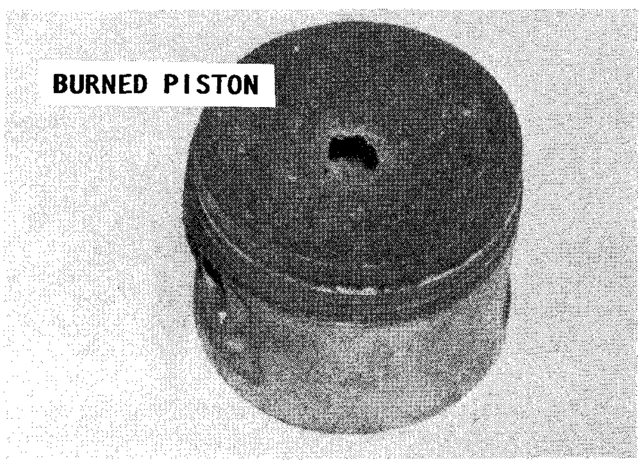


The ring grooves must be thoroughly cleaned to permit the new rings to seat properly. TAKE CARE not to nick the sealing surfaces, or the ring will leak compression.

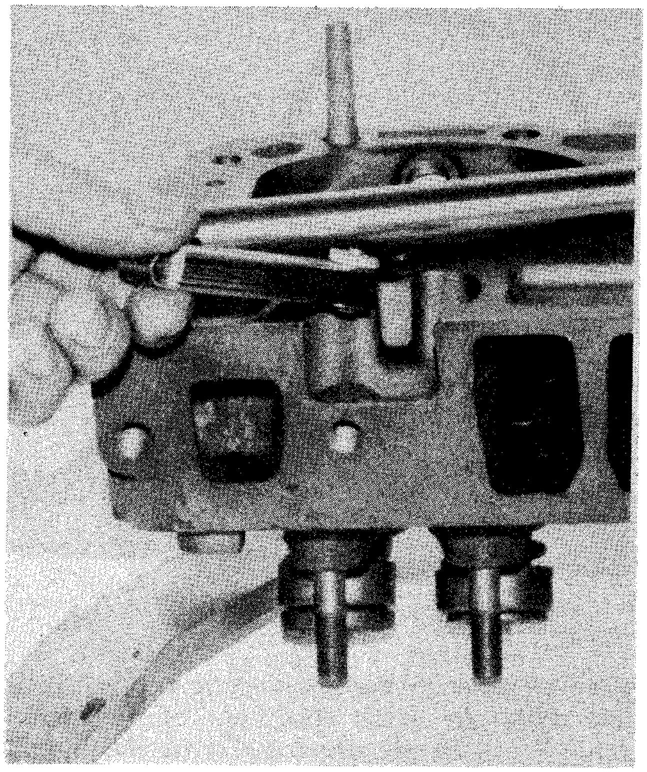
cracks, or other damage. Check the top of the piston for any sign of "piston burn" caused by pre-ignition, poor quality gasoline, improper timing, or water in gas.

Replace any piston that is damaged or shows signs of excessive wear. Inspect the grooves for nicks or burrs that might cause the rings to hang-up. Measure the piston skirt (across the centerline of the piston pin) and check the clearance in the cylinder bore. The clearance should not be greater than 0.0023".

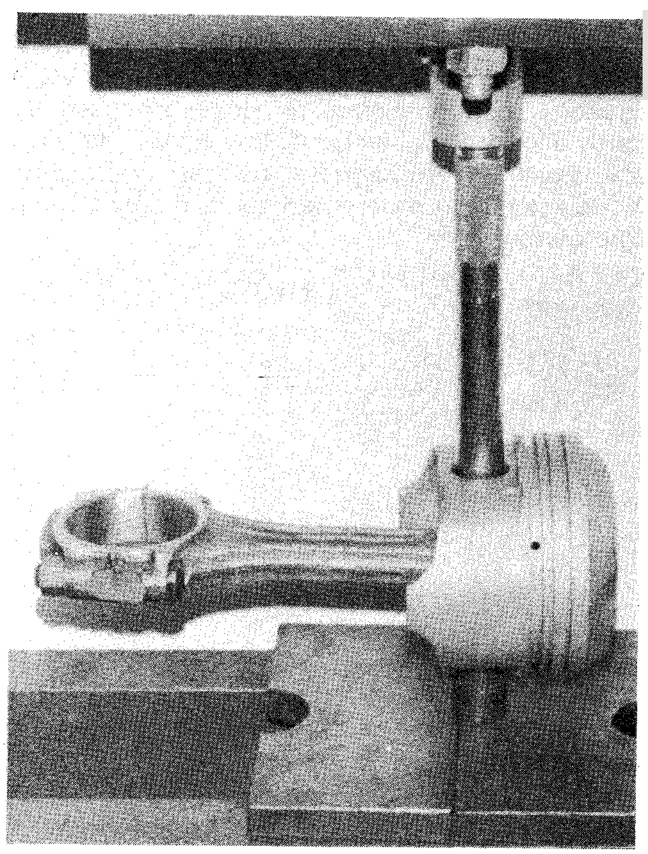
After the rings are installed on the piston, the clearance in the grooves needs to be checked with a feeler gauge. The recommended clearance between the ring and the upper land is 0.006". Ring wear forms a step at the inner portion of the upper land. If the piston grooves have worn to the extent to cause high steps on the upper land, the step will interfere with the operation of new rings and the ring clearance will be too much. Therefore, if steps exist in any of the upper lands the piston should be replaced.



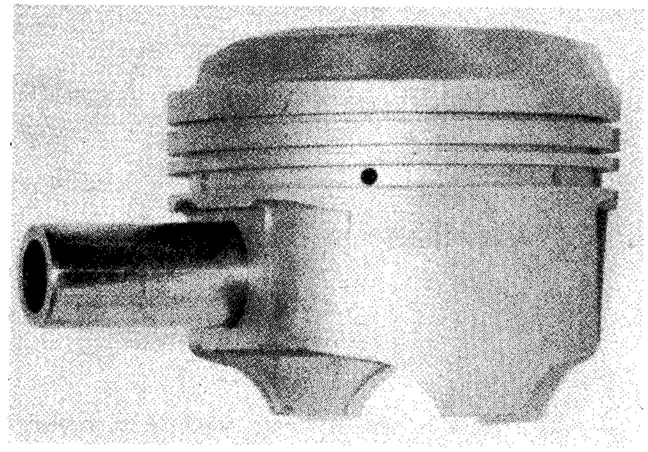
Pre-ignition caused this piston crown to melt.



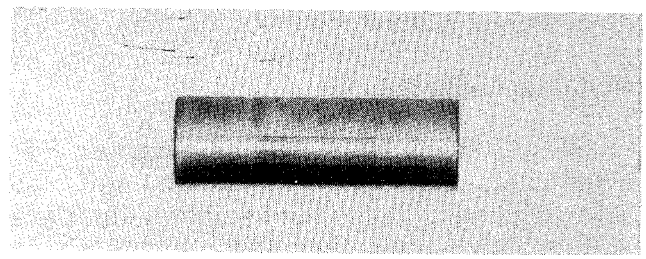
The lc head gasket face must be checked for any uneven condition. Surface irregularities ***MUST NOT*** *exceed 0.003" in any six-inch space.*



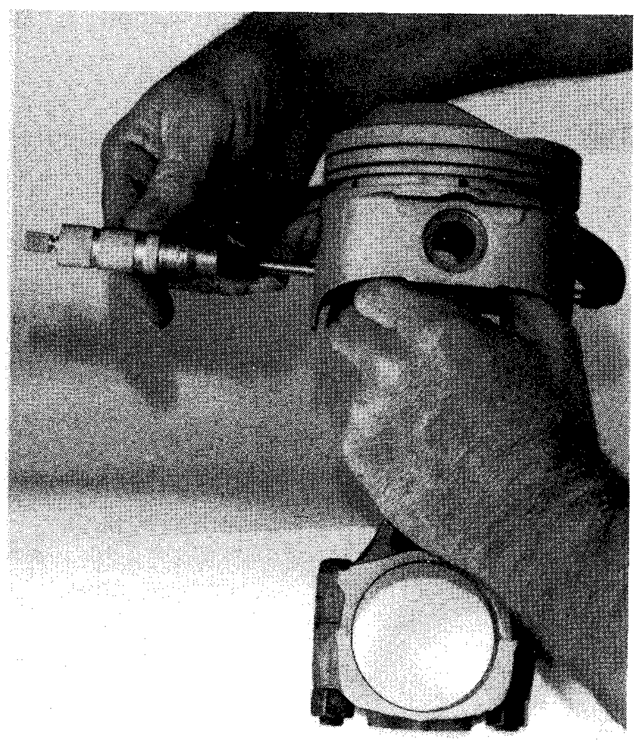
An arbor press and a special tool should be used to remove pressed-in piston pins.



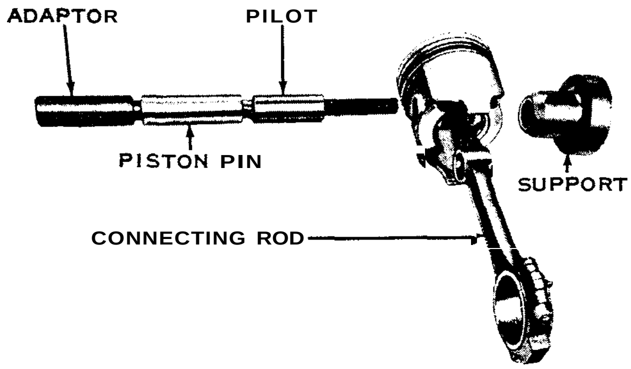
A properly fitted pin should support its own weight in either pin boss when it has been coated with light engine oil at room temperature.



Three measurements with a micrometer should be made to determine piston pin wear. One, on the unworn section (center), the second and third, on both ends. Comparing any difference will indicate the amount of wear.



Using a micrometer to measure the piston circumference. Check used pistons for out-of-roundness at the same time.



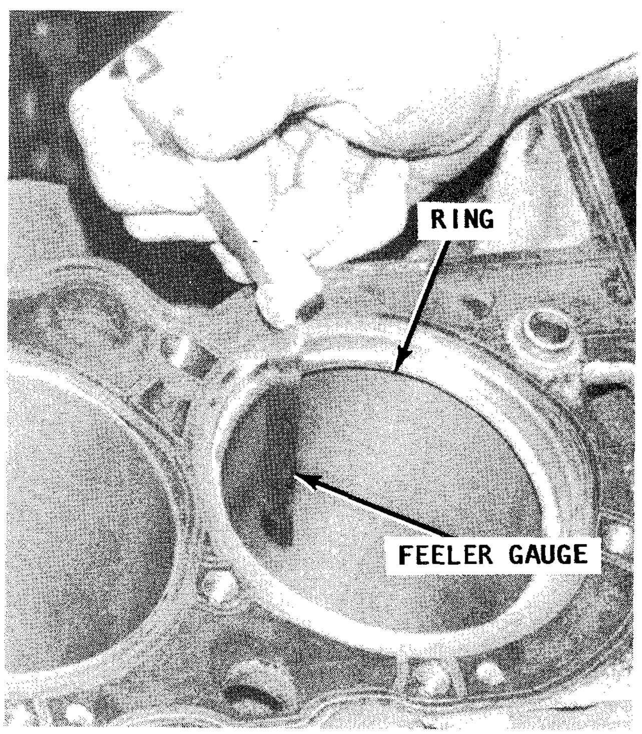
Arrangement of special tools required to properly install a piston pin through the piston.

New compression rings on new pistons should have a side clearance of 0.0012" to 0.0032". The oil ring should have a side clearance of 0.0005" to 0.0065".

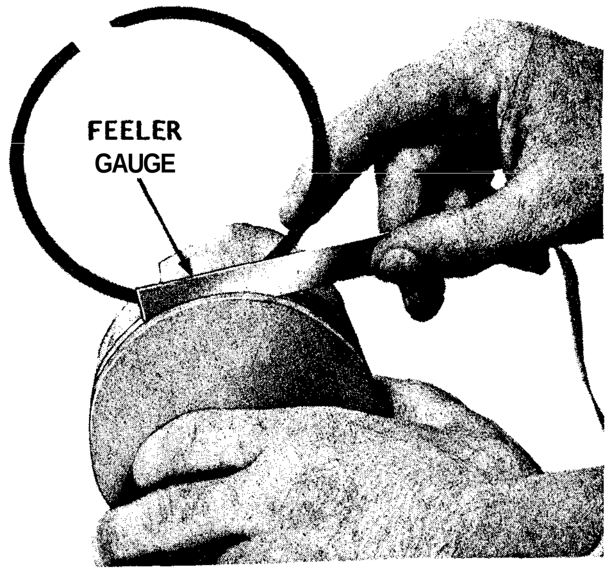
PISTON ASSEMBLING

Set up Tool BT-6408 and Adapter BT-6408-4, as shown. The piston and rod assembly must be mated as shown for right and left bank rods. The notch in the piston **MUST** face forward for the right bank cylinders, and face aft for the left bank cylinders.

Assemble the piston and rod on the spring-loaded guide pin. Lubricate the piston pin to avoid damage when it is



Check the piston ring end gap with a feeler gauge, as shown.

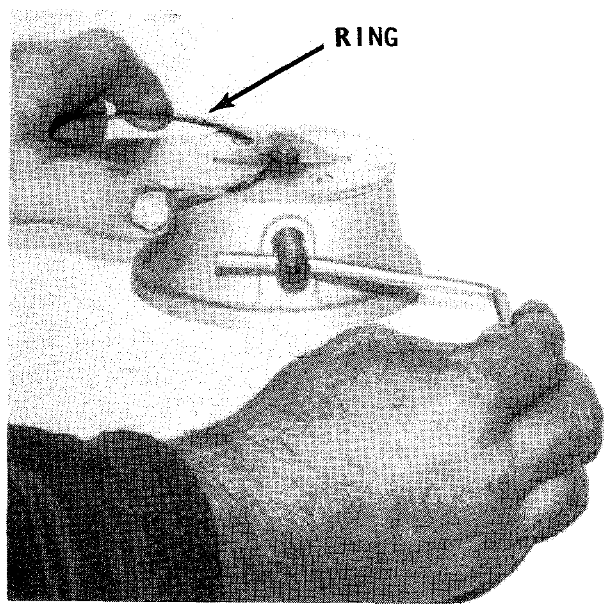


*The piston ring side clearance **MUST** NOT exceed 0.004".*

pressed through the connecting rod. Install the drive pin in the upper end of the piston pin. Press on the drive pin until the piston pin bottoms. Remove the piston and rod assembly from the press.

Rotate the piston on the pin to be sure the pin was not damaged during the pressing operation.

If a single chrome plated compression ring is used, it **MUST** be installed in the **TOP** groove. All compression rings are marked with a dimple, a letter **"T"** a letter **"O"**, or the word **TOP** to identify the side of the ring which must be assembled toward the top of the piston.



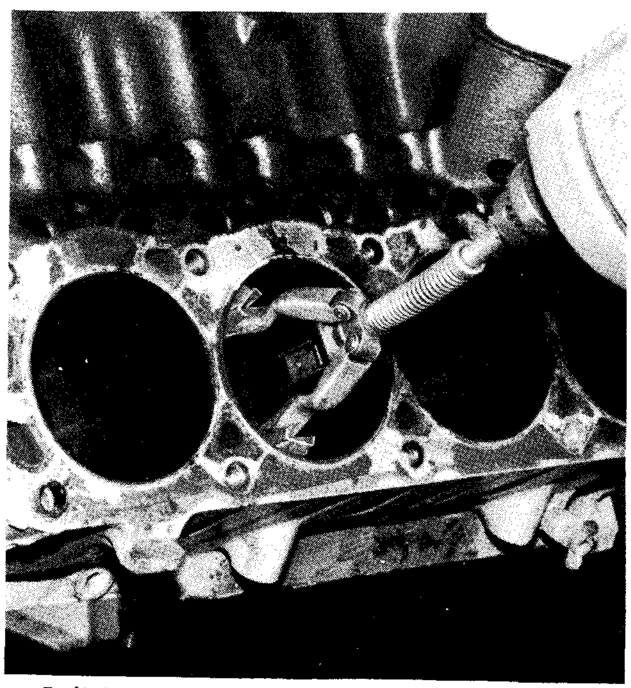
Grinding ring ends to obtain proper end gap.

Install the oil ring spacer in the oil ring groove and align the ring gap with the piston pin hole. Hold the spacer ends butted, and then install a steel rail on the top side of the spacer. Position the gap at least 1" to the left of the spacer gap, and then install the second rail on the lower side of the spacer. Position the gap at least 1" to the right of the spacer gap. Flex the oil ring assembly in its groove to make sure the ring is free and does not bind in the groove at any point.

The pistons are cam-ground, which means the diameter at a right angle to the piston pin is more than the diameter parallel to the piston pin. When a piston is checked for size, it must be measured with micrometers applied to the skirt at points 90° to the piston pin. The piston should be measured for fitting purposes 1/4" below the bottom of the oil ring groove.

Inspect the piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured with a dial bore gauge or an inside micrometer. If the clearance is greater than 0.0001", the piston and/or piston pin should be replaced.

Inspect the bearing surfaces of the piston pins. Use a micrometer to check for wear by measuring the worn and unworn sufaces. Rough or worn pins **MUST** be replaced. Test the fit of each pin with its piston boss. If the boss is worn out-of-round, the piston and pin assembly **MUST** be replaced.



Refinishing the cylinder wall using an electric drill and a hone. ALWAYS keep the tool moving in long even strokes over the entire depth of the cylinder.

The pistons are locked in the rod by a press fit and the pins turn in the pistons. Oversize pins are available in 0.0015", 0,003", 0.005", and 0.010" oversize.

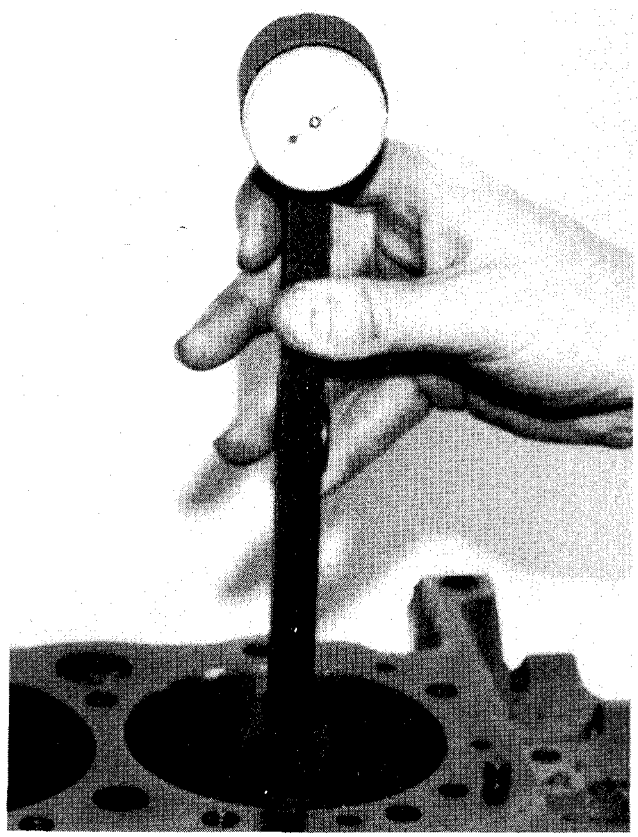
CYLINDER BORES

Inspect the cylinder walls for scoring, roughness, or ridges which indicate excessive wear. Check the cylinder gauge at the top, middle, and bottom of the bore, both parallel and at right angles to the centerline of the engine.

A cylinder bore which is tapered 0.005" or more, or is out-of-round 0.003" or more, must be reconditioned.

ROD BOLTS AND NUTS

Check the rod bolts and nuts for defects in the threads. Inspect the inside of the rod bearing bore for evidence of galling, which indicates the insert is loose enough to move around. Check the parting cheeks to be sure the cap or red has not been filed. Replace any defective rods.

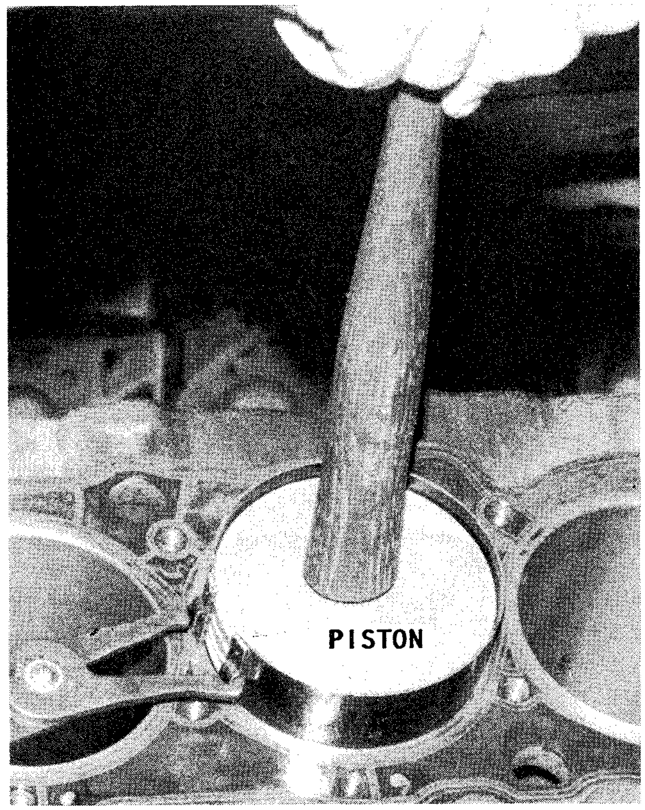


Cylinder wall taper and wear measured with a bore gauge indicator.

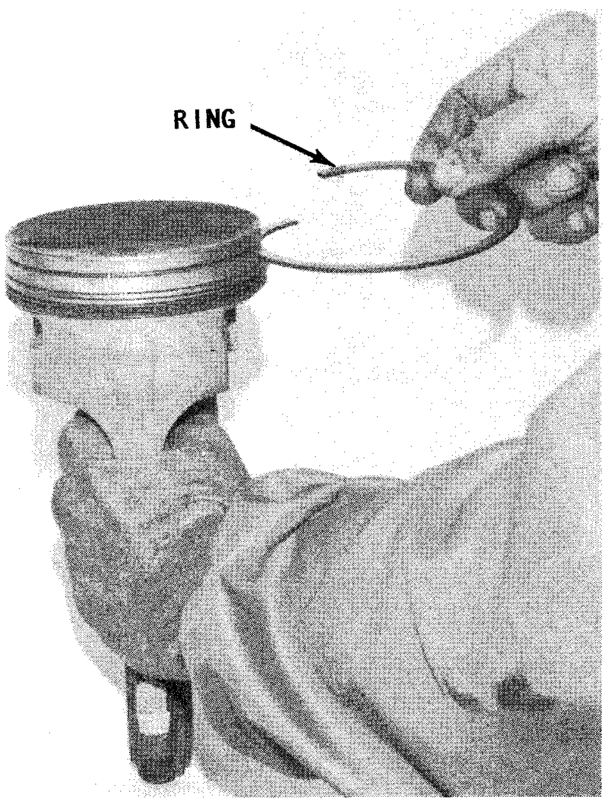
RINGS

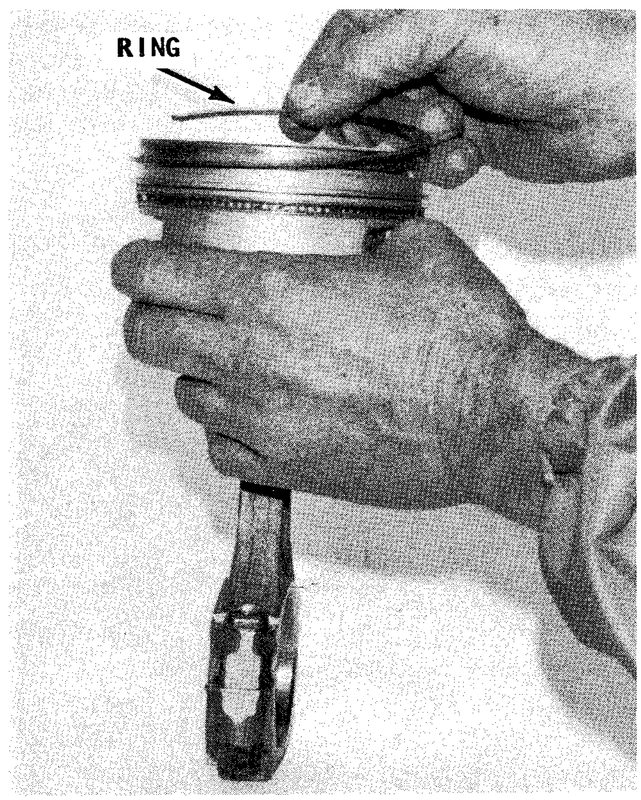
The glazed cylinder walls should be slightly dulled, without increasing the bore diameter, if new piston rings are to be installed. This glazing is best accomplished using the finest grade of stones of a cylinder hone. The cylinder bores and piston grooves must be clean, dry, and free of any carbon deposits or burrs. New piston rings must be checked for clearance in the piston grooves and for end gap in the cylinder bores.

The oil-control rings consist of two segments (rails) and a spacer. Piston rings are furnished in standard sizes and 0.020", 0.030", and 0.040" oversize. To check the end gap of compression rings, first place each ring in the cylinder into which it will be used. Next, square the ring in the bore using the upper end of a piston. Now measure the gap with a feeler gauge. End gap for the top ring should be 0.010" to 0.020"; for the second ring, 0.013" to 0.023". The oil ring rail gap should be 0.015" to 0.055". If the gap is less than specified, the ends of the ring can be filed carefully with a fine file until the proper gap is reached.



Using a ring compressor to install the assembled piston into the cylinder. Tap LIGHTLY with the wooden handle of a tool to work the piston into position.





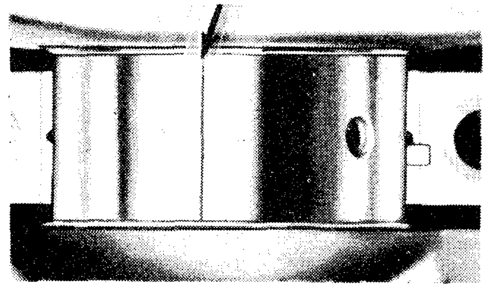
Proper installation of a new ring into the piston ring groove. Notice how the ring is bent slightly upward (left). After the ring is started, the ring is rotated around and over the top of the piston (right). The ring will feed into the groove and the end will finally snap into place.

After you are satisfied the cylinder bores, pistons, connecting rod bearings, and crankshaft journals are as clean as possible, then coat all of the bearing surfaces with engine oil. Position the crankpin straight down. Remove the connecting rod cap and with the bearing upper shell seated in the rod, install the connecting rod guides to hold the upper bearing shell in place and prevent damage to the crankpin.

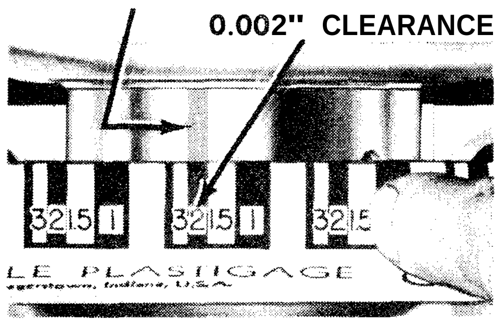
Coat the piston and rings with engine oil, and then install the assembly in the proper numbered cylinder bore by compressing the rings with a ring compressor. Use the wooden end of a hammer handle to push the piston down into the cylinder. **NEVER** hammer on the piston in an attempt to get it into the cylinder because a ring may be caught and you could snap it. Install the cap with a new lower bearing shell and tighten both nuts to the torque value given in the Specifications in the Appendix.

Install the other piston assemblies in a similar manner paying particular attention to install each used piston assembly into the same cylinder from which it was removed.

After all piston and rod assemblies are properly installed and the bearing cap nuts have been tightened to the proper torque value, check to be sure the oil spit holes in the connecting rods are facing the camshaft, and the edge of the rod cap is on the same side as the conical boss on the connecting rod web. These marks (the rib and boss) will be toward the other connecting rod on the same crankpin. Check the end clearance between the connecting rods on each crankpin. The clearance should be between 0.005" and 0.012".

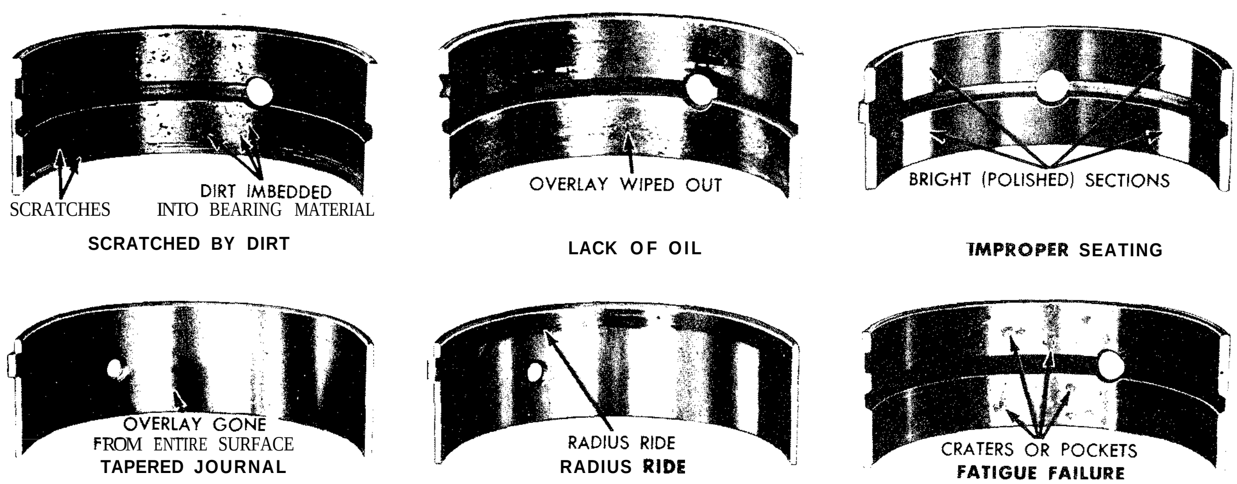


INSTALLING PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.



Examples of various wear patterns on bearing halves, including possible reasons for the condition.

Install the oil pan, see Section 3-24.

Install the cylinder heads, see Section 3-28.

Install the engine, see Section 3-23.

Fill the crankcase with the proper weight oil.

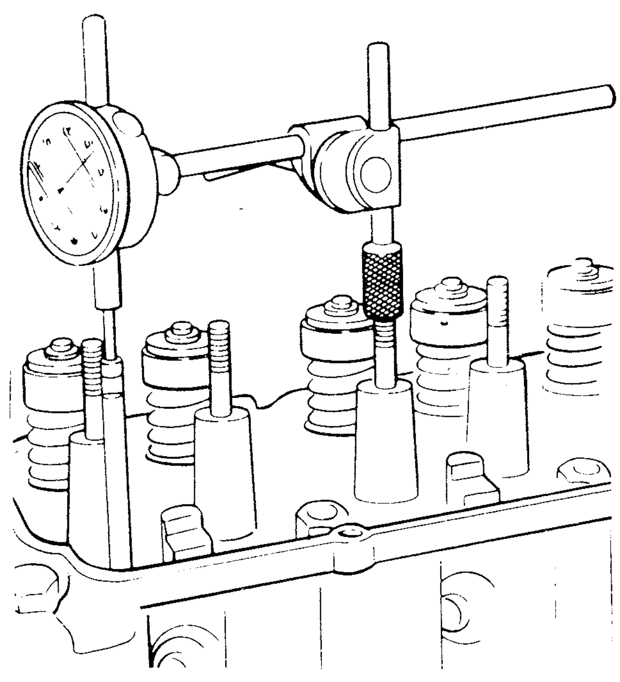
Close the water drain valves.

Start the engine, run it at reduced speed for the first hour, and check for leaks.

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.

3-31 CAMSHAFT

If the engine is to perform properly, the valves must open and close at a predetermined precise moment. On the power stroke, the exhaust valve must open just before bottom dead center in order to permit the exhaust gases to leave the combustion chamber under the remaining pressure (blowdown). On the exhaust stroke, the intake valve must open just before top dead center in order to permit the air-fuel mixture to enter the combustion chamber. The movement of the valves are functions sf the camshaft design and the valve timing. Therefore, excessive wear of any camshaft part will affect engine performance.



Checking the cam shaft lift using a special tool inserted through the push rod hole in the head.

REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the intake manifold, see Section 3-26.

Remove the timing gear, see Section 3-33.

Pull the spark plug wires from the brackets on the rocker arm covers. Remove the spark plug wires from the spark plugs.

. Remove the rocker arm covers. Loosen the rocker arm nuts, and then turn the rocker arms aside.

Set up some kind of system ts hold the push rods, and then remove each one in order so they will. be installed back in the identical hole from which they were removed.

TAKE CARE not to get any dirt into the engine particularly into the valve lifters. Use cloths and compressed air to clean the cylinder heads and adjacent parts.

Remove the valve lifters and keeo them in order. Each **MUST** be installed into the same valve guide from which it was removed.

Remove the fuel pump and push rod.

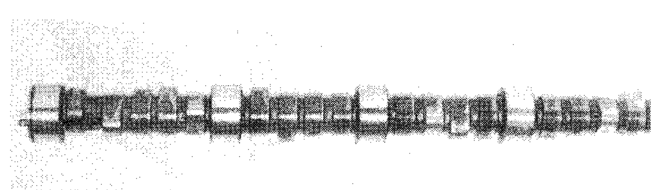
CAUTION: Be **sure to plug the fuel line to prevent fuel from siphoning out of the tank.**

Install two 5/16"x18x5" bolts in the camshaft sprocket and carefully pull the camshaft straight out of the block. Use **UTMOST CARE** not to damage the bearing surfaces in any way.

CLEANING

Clean the camshaft with solvent and wipe the journals dry with a lint-free cloth. **ALWAYS** handle the shaft **CAREFULLY** to avoid damaging the highly finished journal surfaces. Blow out all of the oil passages with compressed air.

Clean the gasket surfaces on the block and crankcase front cover. Check the diameter of the five camshaft bearings with a



Example of damaged cam lobes.

micrometer for out-of-round condition, taper, and wear. If the journals are out-of-round more than 0.001", the camshaft should be replaced.

Check the camshaft for alignment. This is best done using "V" blocks and a dial indicator. The dial indicator will indicate the exact amount the camshaft is out of true. If it is out more than 0.002" dial indicator reading, the camshaft should be replaced. When using the dial indicator in this manner the high reading indicates the high point of the shaft. Examine the camshaft bearings and if any one bearing needs to be replaced, **ALL FIVE** should be replaced.

CAM SHAFT BEARING REMOVAL

Removal and replacement of the camshaft bearings should be performed by qualified mechanics in a shop equipped to handle such work. However, in most cases the block bores for the bearings can be bored to a larger size and oversize bearings installed. BE **SURE** to check with your local marine dealer for oversize bearings available.

CAMSHAFT INSTALLATION

Lubricate the camshaft journals with engine oil and the camshaft lobes with "Moly-kote" or equivalent. Add the remainder in the can to the crankcase oil.

Install the two 5/16"-18x4" bolts in the camshaft bolt holes. Install the camshaft assembly into the engine block. **TAKE CARE** to move the shaft straight into the block and not to damage the bearings or cams.

Install the timing sprocket, timing chain, and cover, see Section 3-33.

Install the fuel pump. Install the valve lifters and push rods in the **SAME POSITION** from which they were removed. Position the rocker arm over the push rods and start the rocker arm nuts. Tighten the rocker arm nuts slowly and at the same time rotate the push rod. **STOP** tightening the nut when the push rod turns with difficulty, and move on to the next valve. Continue in a similar manner until all of the nuts have been tightened as just described. For the actual valve adjustment, see Section 3-29.

Install the intake manifold, see Section **3-26.**

Close the water drain valves.

Start the engine and check to be sure oil is circulating through the valve train and the lifters are not making excessive noise.

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.

Install the valve covers with **NEW** gaskets.

Handle the camshaft CAREFULLY to prevent damage to the lobes or the bearings in the block.

3-32 CRANKSHAFT AND MAIN BEARING SERVICE

Service work affecting the crankshaft or the crankshaft bearings may also affect the connecting rod bearings. Therefore, it is highly recommended that the rod bearings be carefully inspected as they are removed, see Section 3-30.

If the crankpins are worn to the extent that the crankshaft should be replaced or reground, then this work should be done in a qualified shop. Attempting to save time and money by merely replacing the crankshaft bearings will not give satisfactory engine performance.

CRANKSHAFT REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the engine, see Section 3-23.

Remove the oil pan, see Section 3-24.

Remove the oil pump, see Section 3-25.

Remove the flywheel and coupler.

Remove the main bearing caps and connecting rod caps Push the pistons to the top of the cylinders. Lift the crankshaft out of the cylinder block.

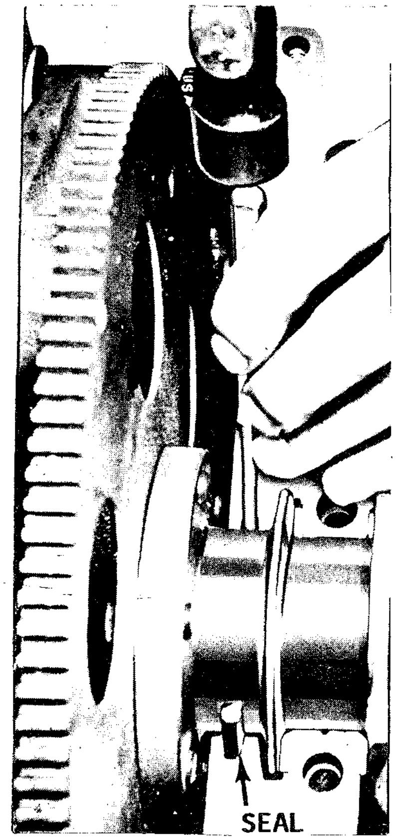
Inspect the crankshaft. The No. 1, 2, 3, and 4 main bearings are ground to 2.4484" to 2.4493". The No. 5 bearing is ground to 2.4479" to 2.4488", and the crankpin journals are ground to 2.099" to 2.100". Check these dimensions with a micrometer for ou-of-round, taper, or undersize. If the journals exceed 0.001" our-of-round or taper, the crankshaft should be replaced or reconditioned to an undersize figure to permit installation of undersize precision-type bearings.

CLEANING

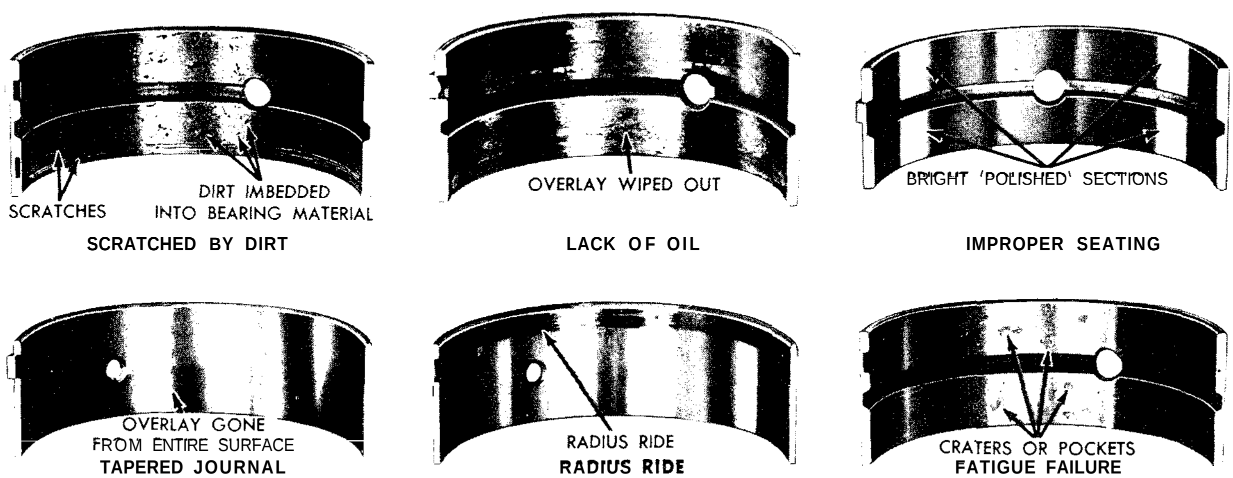
Clean the crankshaft with solvent and wipe the journals dry with a lint-free cloth. **ALWAYS** handle the shaft carefully to avoid damaging the highly finished journal surfaces. Blow out all of the oil passages with compressed air. Oil passageways lead from the rod to the main bearing journal. TAKE CARE not to blow dirt into the main bearing journal bore.

Measure the diameter of each journal at four places to determine the out-of-round, taper, and wear. The out-of-round limit is 0.001"; the taper must not exceed 0.001"; and the wear limit is 0.0035". If any of these limits is exceeded, the crankshaft must be reground to an undersize, and undersized bearing inserts must be installed.

While checking the runout at each journal take time to note the relation of the "high" spot (or maximum eccentricity) on each journal to the others. "High" spots on all journals should come at the same angular location. If the "high" spots do not appear to be in the same angular locations, the crankshaft has a "crook" or "dogleg" in it making it unsatisfacory for service.



Removing the rear main bearing cap oil seal using a screwdriver.



Examples of various wear patterns on bearing halves, including possible reasons for the condition.

BEFORE INSTALLATION

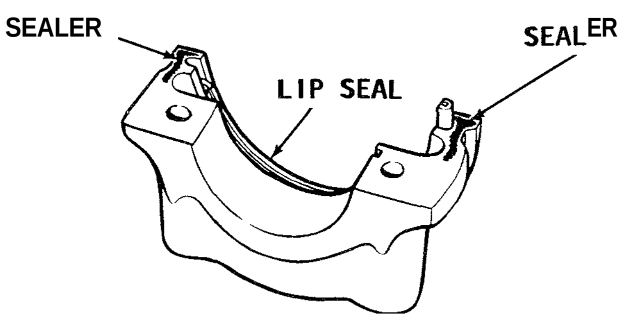
TAKE TIME to read the good words in the next few paragraphs before starting any crankshaft or main bearing work. Many of the facts given, you probably already know, others may be new, and all of the information will assist you in completing the work in the shortest time and with assurance of satisfactory engine performance after completion.

Main bearings are of the precision insert type and do not utilize shims for adjustment. If clearances are found to be excessive, a new bearing, both upper and lower halves, must be installed. Bearings are available in standard size and as 0.001", 0.009", and 0.020" undersize.

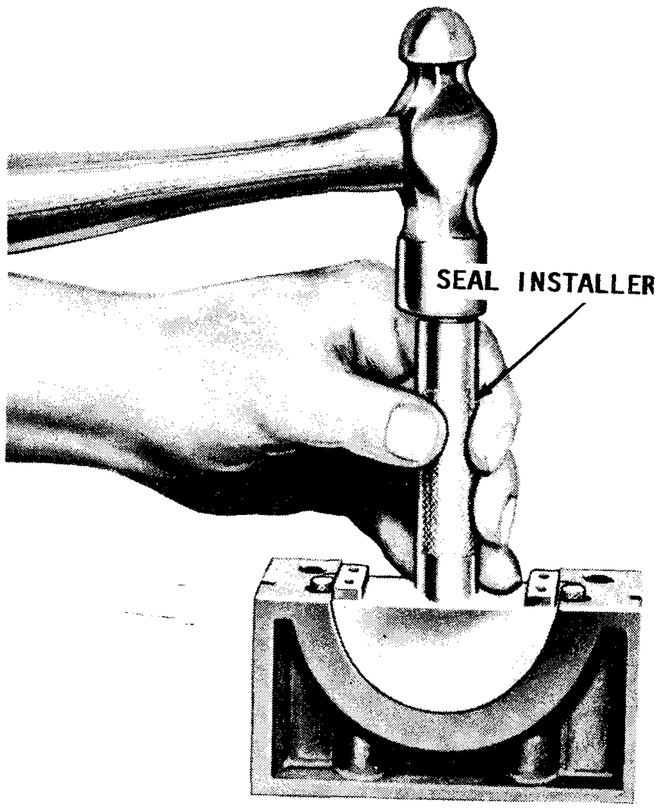
In order to obtain close tolerances in production, selective fitting sf both rod and main bearing inserts is necessary. For this reason you may find one half of a standard insert with one half of a 0.001" undersize insert which will decrease the clearance 0.0005" from using a full standard bearing.

If a production crankshaft cannot be precision fitted by this method, it is then ground 0.009" undersize only on the main journals. A 0.009" undersize bearing and a 0.010" undersize bearing may be used for precision fitting in the same manner as just described. Any engine fitted with a 0.009" undersize crankshaft will be identified by the following markings: **".009"** will be stamped on the crankshaft counterweight forward of the center main bearing journal. A figure **"9"** will be stamped on the block at the left front oil pan rail.

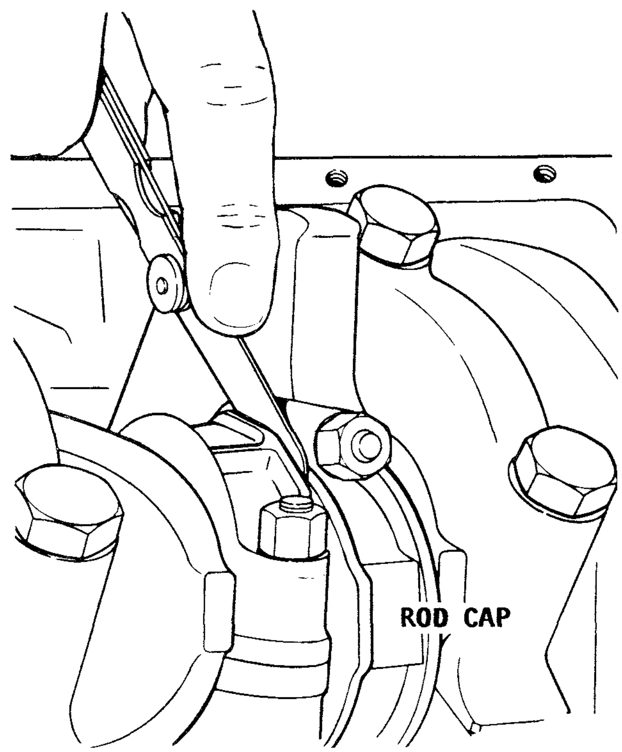
If, for any reason, the main bearing caps are replaced, it may be necessary to shim the bearing. Laminated shims for each cap are available for service. The amount of shimming required will depend on the bearing clearance.



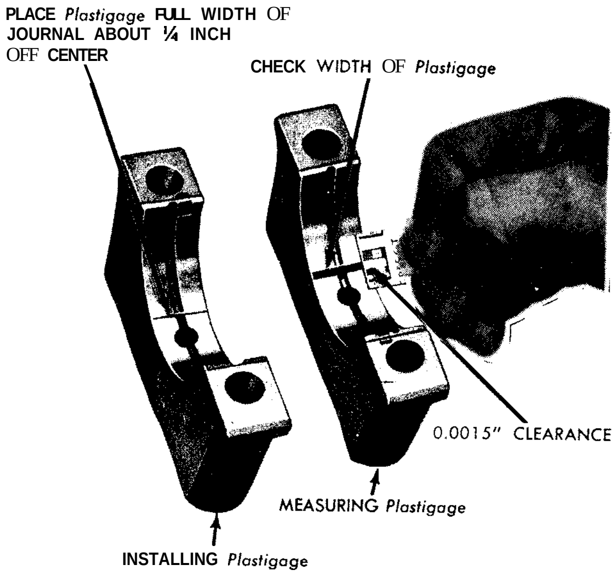
Proper installation of the seal in the rear main bearing cap.



Use a rounded tool to roll the top oil seal into its groove after it has been well lubricated.



After new main bearing inserts have been installed, measure the crankshaft end play. The clearance for the small-block engine should be 0.002" to 0.006", and for the large-block engine, 0.006" to 0.010".



After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

INSTALLATION

With engine held in the bottom-up position, install the upper half of each bearing in its proper location. Carefully lower the crankshaft into position in the bearing halves on the block.

Plastigage is soluble in oil. Therefore, clean the crankshaft journal thoroughly of all traces of oil, and then turn the crankshaft until the oil hole is down to avoid getting oil on the Plastigage. Whenever you turn the crankshaft with the rear bearing cap removed, hold the oil seal to prevent it from rotating out of position in the crankcase. Place paper shims in the upper half of adjacent bearings and tighten the cap bolts to take the weight off of the shell of the bearing being checked.

Place a piece of Plastigage lengthwise along the bottom center of the lower bearing shell, and then install the cap with the shell and tighten the bolt nuts to a torque value given in the Specifications in the Appendix.

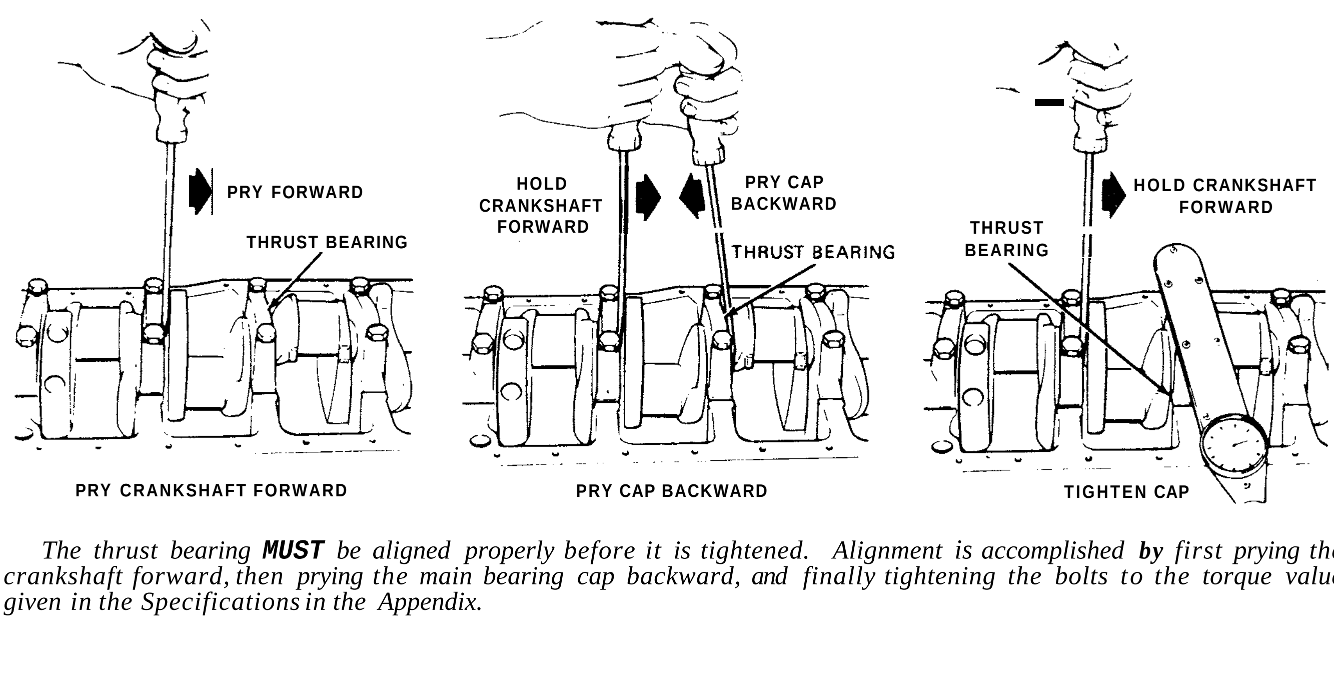
Remove the bearing cap and measure the flattened Plastigage at its widest point using the scale printed on the Plastigage envelope. The number within the graduation which most closely corresponds to the width of the Plastigage indicates the bearing clearance in thousandths of an inch.

Compare the bearing clearance against the Specifications in the Appendix. If the bearing clearance exceeds the specifications, it is advisable to install a new bearing. However, if the bearing is in good condition and is not being checked because of bearing noise, it is not necessary to replace the bearing. After finishing the Plastigage check, install the bearing cap again and tighten the cap bolts to the torque value given in the Specifications in the Appendix, then loosen it 1/2 turn.

Continue making the Plastigage test at each bearing. When all bearings have been installed and tested, tighten the cap bolts again to the required torque valve.

Install the rod caps, see Section 3-30.

Install the oil pump, see Section 3-25.



*The thrust bearing **MUST** be aligned properly before it is tightened. Alignment is accomplished by first prying the crankshaft forward, then prying the main bearing cap backward, and finally tightening the bolts to the torque value given in the Specifications in the Appendix.*

Install the oil pan, see Section 24.
Install the flywheel and coupler.
Install the engine, see Section 3-23.
Fill the crankcase with the proper weight oil.
Close the water drain valves.
Start the engine and check for leaks.

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.

MAIN BEARING REMOVAL

Drain the water from the block by opening all of the drain valves.
Remove the engine, see Section 3-23.
Remove the oil pan, see Section 3-24.
Remove the oil pump, see Section 3-25.
Rotating the crank is much easier if the rod caps are removed, see Section 3-30.

BEFORE starting the actual removal of the main bearings, **TAKE TIME** to read the information in the next few paragraphs. You are probably familiar with many of the facts given, but some of it may be new for these engines and all of the good words will assist you in doing the work in the least amount of time and with assurance of satisfactory performance after the job is complete.

Main bearings are of the precision insert type and do not utilize shims for adjustment. If clearances are found to be excessive, a new bearing, both upper and lower halves must be installed. Bearings are available in standard size and as 0.001", 0.009", and 0.020" undersize.

In order to obtain close tolerances in production, selective fitting of both rod and main bearing inserts is necessary. For this reason you may find one half of a standard insert with one half of a 0.001" undersize insert which will decrease the clearance 0.0005" from using a full standard bearing.

If a production crankshaft cannot be precision fitted by this method, it is then ground 0.009" undersize only on the main journals. A 0.009" undersize bearing and a 0.010" undersize bearing may be used for precision fitting in the same manner as just described. Any engine fitted with a 0.009" undersize crankshaft will be identified by the following markings: **".009"** will be stamped on the crankshaft counterweight forward of the center main bearing journal. A figure **"9"** will be stamped on the block at the left front oil pan rail.

If, for any reason, the main bearing caps are replaced, it may be necessary to shim the bearing. Laminated shims for each cap are available for service. The amount of shimming required will depend on the bearing clearance.

In general, except for No. 1 bearing, the lower half of the bearing will show more wear and fatigue than the upper half. If you determine, from inspection, that the lower half is suitable for use, then it is safe to assume the upper half is also satisfactory. **HOWEVER,** if the lower half shows evidence of wear or damage, both the upper and lower halves **MUST** be replaced. **NEVER** replace one half of the bearing without replacing the other half.

Clean the crankshaft with solvent and wipe the journals dry with a lint-free cloth. Blow out all of the oil passages with compressed air. The oil passageways lead from the rod to the main bearing journal. **TAKE CARE** not to blow any dirt into the main bearing journal bore.

CHECKING MAIN BEARING CLEARANCE

Plastigage is soluble in oil, therefore, clean the crankshaft journal thoroughly of all traces of oil. With engine held in the bottom-up position, turn the crankshaft until the oil hole is down to avoid getting oil on the Plastigage. Whenever you turn the crankshaft with the rear bearing cap removed, hold the oil seal to prevent it from rotating out of position in the crankcase. Place paper shims in the upper half of adjacent bearings and tighten the cap bolts to take the weight off of the shell of the bearing being checked.

Place a piece of Plastigage lengthwise along the bottom center of the lower bearing shell, and then install the cap with the shell and tighten the bolt nuts to a torque value given in the Specifications in the Appendix.

Remove the bearing cap and measure the flattened Plastigage at its widest point using the scale printed on the Plastigage envelope. The number within the graduation which most closely corresponds to the width of the Plastigage indicates the bearing clearance in thousandths of an inch.

Under normal service conditions, main bearing journals will wear evenly and are seldom found to be out-of-round. However, if a bearing is being fitted to an out-of-round journal (0.001" maximum) be sure to fit the bearing to the maximum diameter of the journal, If the bearing is fitted to the minimum diameter and the journal is out-of-round by 0.001", interference between the bearing and the journal will result in rapid bearing failure. If the flattened gauging plastic tapers toward the middle or ends, there is a difference in clearance indicating taper, low spot, or other irregularity of the bearing or journal. **BE SURE** to measure the journal with a micrometer if the flattened Plastigage indicates more than 0.001" difference.

If the bearing clearance is within specifications, the bearing insert is satisfactory. If the clearance is not within specifications, replace the insert. **ALWAYS** replace both the upper and lower insert together as a unit. **NEVER** just one half.

If a new bearing is being installed in the cap, and the clearance is less than 0.001", inspect the cap for burrs or nicks. If none are found, then install shims on the bearing shoulders as required.

A standard 0.001" or 0.002" undersize bearing may give the proper clearance. If the undersize bearing does not give proper clearance, the crankshaft journal will have to be reground for use with the next undersize bearing.

Continue the procedure until all of the bearings have been checked. Rotate the crankshaft to be sure there is an even drag for the complete turn without binding in any one spot.

Measure the crankshaft end play by first forcing the crankshaft to the extreme front position. Next measure the clearance at the front end of the rear main bearing with a feeler gauge and compare the results with the Specifications given in the Appendix.

Install a new rear main bearing oil seal in the cylinder block and main bearing cap.

MAIN BEARING INSTALLATION

Install a main bearing removing and installing tool in the oil hole in the crankshaft journal. If such a tool is not available, a cotter pin may be bent as required to do the job.

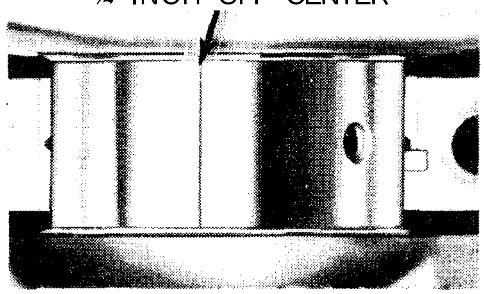
Rotate the crankshaft clockwise as viewed from the front of the engine to roll the upper bearing out of the block. If you have difficulties removing the bearing, it may be necessary to remove the crankshaft, see the first part of this section.

Clean the crankshaft journal with solvent and wipe it dry with a lint-free cloth. Inspect the journals and thrust faces (thrust bearing) for nicks, burrs, or bearing particles that would cause bearing wear.

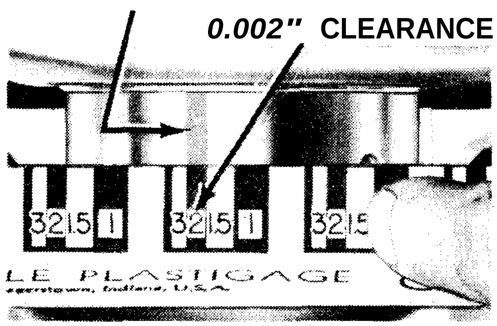
If the rear main bearing is being replaced, remove and discard the rear oil seal from the bearing cap. In order to remove the block half of the rear oil seal, it will be necessary to loosen all of the main bearing cap bolts, and then to raise the crankshaft just a hair (not over 1/32 inch).

The oil seal in the cylinder block may be removed with a seal removal tool or by inserting a metal screw into one end of the seal and then pulling on the screw to remove the seal. **USE EXTRA** CARE when working around the journals not to scratch or damage the highly finished surfaces in any way.

Coat the new selected size upper bearing with oil and then insert the plain (unnotched) end between the crankshaft and the



INSTALLING PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

indented (notched) side of the block. Slide the bearing into place by rotating the crankshaft, and then remove the tool from the oil hole in the crankshaft journal.

Coat the lower bearing with oil and install it in the bearing cap.

Install the main bearing cap with the **ARROWS** pointing toward the **FRONT** of the engine.

Tighten the main bearing cap bolts to the torque value given in the Specifications in the Appendix.

Replace the oil pump, see Section 3-25.

Replace the oil pan, see Section 3-24.

Replace the engine, see Section 3-23.

Fill the crankcase with the proper weight oil.

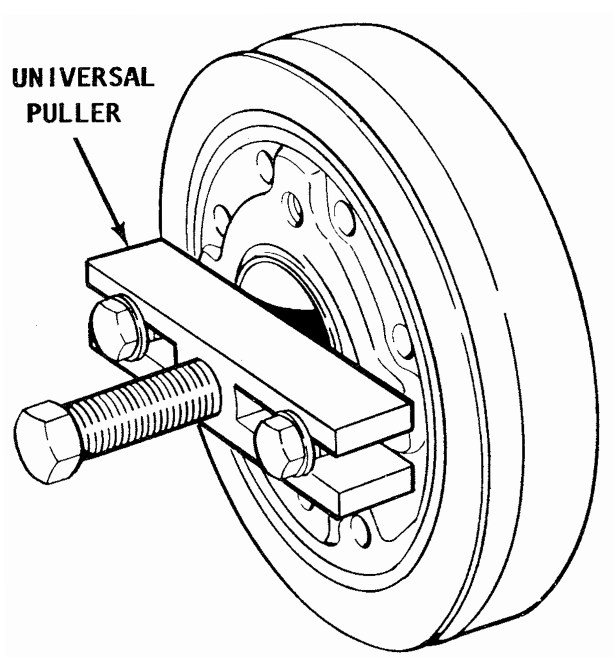
Close the water drain valves.

Start the engine, run it at reduced speed for the first hour, and check for leaks.

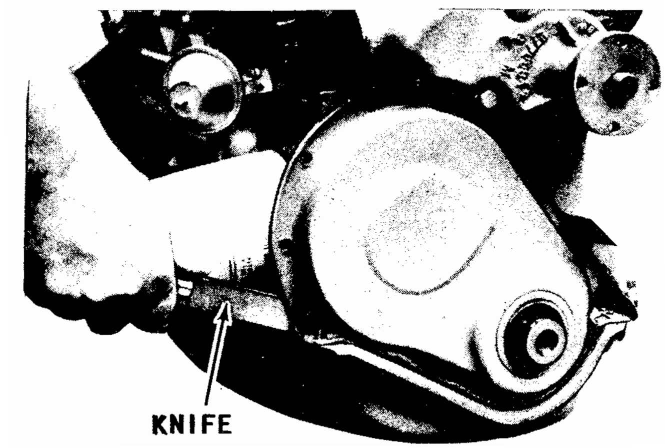
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

3-33 TIMING CHAIN

The camshaft is driven at half engine speed by a single-row chain and a sprocket on the crankshaft. Timing chains are subject to stretching after prolonged use, and therefore, require replacement. Access to the chain is gained by first removing the timing chain cover.



Use tool No. J-23523 to remove the torsional damper.



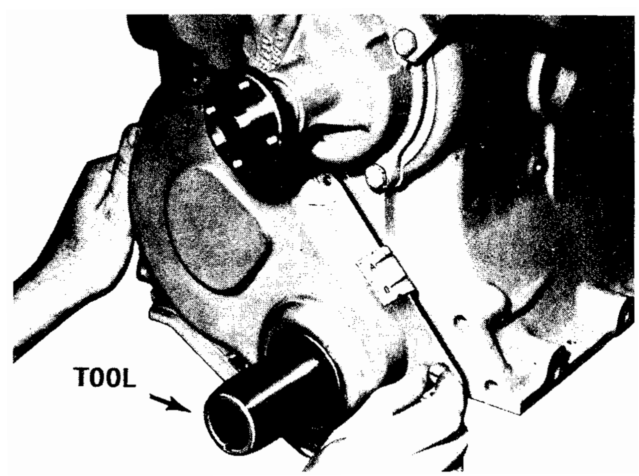
Cutting the ends of the new oil seal off flush with the cap faces with a knife after the seal has been driven firmly into its groove with the tool shown.

REMOVAL

Drain the water from the block by opening all drain valves. Remove the fan belt, fan, and pulley. Remove the water pump. Remove the accessory drive pulley, and then remove the torsional damper retaining bolt. Install Tool J-23523 onto the torsional damper, and remove the damper from the crankshaft by turning the puller screw with a wrench.

On the Mark IV engine, remove the two oil pan-to-front cover attaching bolts. Remove the front cover-to-block attaching bolts, and then pull the cover forward a little to allow room to cut the oil pan front seal with a sharp knife. Cut the seal, and then remove the front cover. Discard the gaskets.

Rotate the crankshaft until the timing mark on the camshaft sprocket is aligned



Removing the timing chain cover.

with the timing mark on the crankshaft sprocket, as shown.

Remove the three camshaft sprocket-to-camshaft bolts. The camshaft sprocket is a light press-fit onto the camshaft. Tap the sprocket lightly on the lower edge of the camshaft to dislodge it.

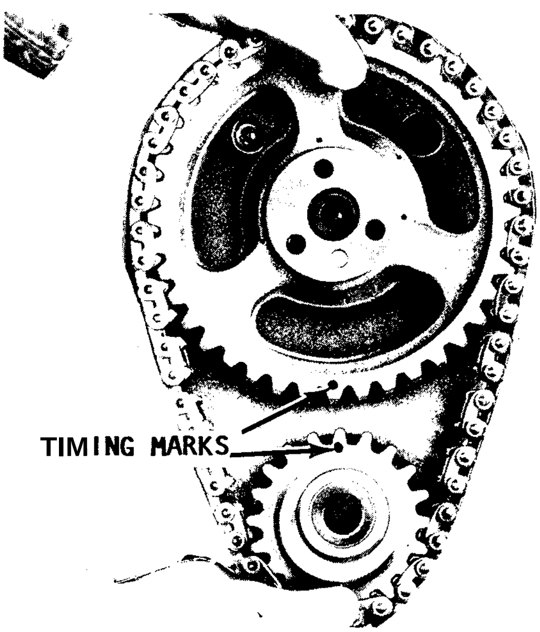
Remove the camshaft sprocket and the timing chain together. If the crankshaft sprocket is to be replaced, remove the sprocket using Tool J-5825 on a small V-8 engine, or Tool J-1619 on a Mark IV engine.

TIMING CHAIN INSTALLATION

Position the key in the keyway of the crankshaft. Align the keyway of the crankshaft sprocket with the key, and then install the sprocket, using the bolt and nut from Tool J-23523. Engage the timing chain onto the camshaft sprocket.

Hold the sprocket in the vertical position, with the chain hanging down, and then align the timing mark on the camshaft with the timing mark on the crankshaft sprocket. Now, align the dowel in the camshaft with the dowel hole in the camshaft sprocket, and then slide the sprocket onto the camshaft. **NEVER** try to drive the sprocket onto the camshaft because the **WELSH** PLUG at the rear of the engine will be dislodged.

Take up on the three mounting bolts to draw the camshaft sprocket onto the shaft. Check to be sure the dowel in the shaft indexes with the hole in the sprocket.



Remove the timing chain and camshaft sprocket as an assembly after the three camshaft sprocket retaining screws have been removed.

Tighten the bolts to the value given in the Specifications in the Appendix. Coat the timing chain with engine oil.

Coat the cover gasket with sealer and place it in position over the dowel pins in the cylinder block. Coat the timing cover seal lip with engine oil and place the cover in position over the dowel pins.

Install the attaching bolts and tighten them to the torque value given in the Spcifications in the Appendix.

Install the water pump and the alternator belt.

Coat the timing chain cover seal area on the harmonic balancer hub with engine oil. Align the keyway and start the balancer onto the crankshaft. Seat the harmonic balancer onto the crankshaft using a large washer and a 7/16"x18x4" bolt.

Remove the bolt and washer. Install the belt pulley and tighten the screws to the torque value given in the Specifications in the Appendix.

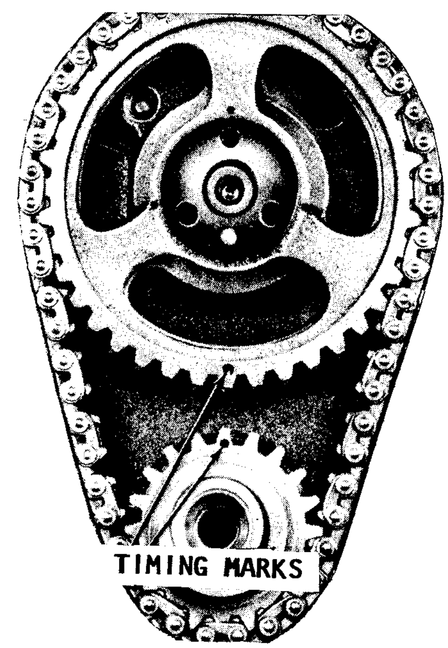
Thread a 7/16"x20x2" bolt and thick washer into the crankshaft and tighten it to the torque value given in the Specifications.

Install the fan belt and adjust the tension to Specification. Install the fan belt guard.

Close the water drain valves.

Start the engine and check for leaks.

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.



Alignment of the timing marks through the centers of the crankshaft and the camshaft.

FORD V-8 ENGINES

The Ford engines used are the 302 and 351 CID. These engines are considered light-weight in design. The 302 CID engine has a bore of 4.00" and a stroke of 3.00". The 351 engine has the same 4.00" bore with the stroke increased to 3.50". Crankshaft rotation is LEFT-HAND when viewed from the FLYWHEEL end.

Starting from the forward end of the engine, the valve arrangement on the starboard bank is I-E-I-E-I-E and on the port bank, E-I-E-I-E-I-E-I. Hydraulic lifters are used for a more quiet valve train operation.

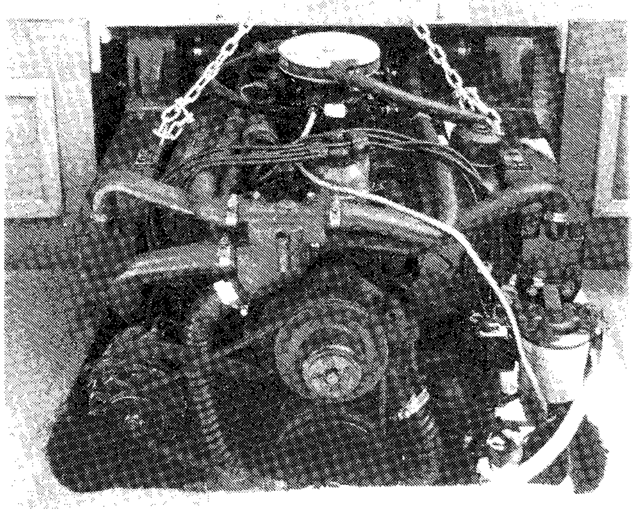
The firing order for the 302 CID, 175 hp from 1974-76 is 1-5-4-2-6-3-7-8. Another version of this 302 CID engine was rated at 190 hp. Amoung other things, the firing order was changed to 1-3-7-2-6-5-4-8. The valve adjustment also changed, see Section 3-40. Check the Appendix for other differences.

3-34 ENGINE REMOVAL

Engine hood covers and panels around the engine may have to be removed before the engine will clear. In all cases, the engine must be moved about 6-inches forward in order to clear the driveshaft assembly.

If the engine cannot be moved forward far enough to clear the driveshaft, it may be necessary to remove the outdrive unit. See Chater 10.

Disconnect the battery cables, engine-to-dash wiring, water hoses, throttle cable, exhaust hoses, and fuel lines.



Lifting the engine with a bracket and assembled cables. If a chain is used, pass the chain through the lifting bracket and eye bolts, then secure the ends together with a bolt and nut.

Be sure to plug the fuel line to stop fuel from siphoning out of the fuel tank.

Drain all of the water from the block by opening all drain valves.

The engine has two lifting brackets to be used with a length of chain. Run the chain through the holes in the lifting brackets, and then fasten the ends together with a bolt and nut. Attach the lifting device in the center of the chain, and then tie the chains together to prevent the lifting device from riding down the chain as the engine is lifted from the boat.

Remove the bell housing-to-engine bolts. Remove the lag bolts on the mounting to the deck. If the engine compartment is too small for the engine to clear, it may be necessary to remove the mounting brackets from the engine. Slide the engine forward about 6 inches, and then lift it straight up and out. If you do not have room to move it forward, then it will be necessary to remove the stern drive unit, see Chapter 10.

ENGINE INSTALLATION

Lower the engine into the compartment and align the engine with the guide pins on the bell housing. Slide the engine aft onto the driveshaft assembly. It may be necessary to turn the driveshaft in order to mate the splines. The driveshaft can be rotated easily by simply putting the outdrive in forward gear, and then turning the propeller.

Install the bell housing-to-engine bolts, alternating evenly around the bell housing. Install the lag bolts through the mounting brackets into the deck. Of course, if the engine brackets were removed for the engine to clear during removal, they will have to be installed before the lag bolts.

If the outdrive assembly was removed, install it; see Chapter 10.

Install the fuel line, water hoses, engine-to-dash wiring, exhaust hose, throttle cable, and battery cables. Close all water drain valves. Fill the crankcase with the proper weight oil.

Start the engine and check for leaks.

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,**

3-35 OIL PAN SERVICE

REMOVAL

Drain the water from the block by opening the water drain valves.

Remove the engine, see Section 3-34.

Remove the oil drain plug and drain the oil. On late-model engines, a kit has been attached to the oil drain plug to help in draining the oil when the engine is in the boat. This kit can be installed on any engine and should be done the first time the engine is removed from the boat.

Remove the oil pan bolts, and then separate the pan from the engine block. Remove the oil pump pickup tube-and-screen assembly.

CLEANING

Clean the oil pan with solvent. Clean the oil pickup tube and screen and examine them for any evidence of clogging. Clean the gasket surfaces of the block and the oil pan.

INSTALLATION

ALWAYS install a new pan gasket set. Position the oil pump pickup tube and screen in place with a **NEW** gasket. Install the two attaching bolts and tighten them to the torque value given in the Specifications in the Appendix. Install the rear seal in the rear main bearing cap. **BE SURE** the tabs on the seal are over the oil pan gasket. Install the front seal on the crankcase front cover. **BE SURE** the tabs on the seal are over the oil pan gasket. Use a sealer with enough body to act as a retainer. Place the pan in position on the block, and then install and tighten the pan bolts to the torque value given in the Specifications in the Appendix. **TAKE CARE** to tighten the bolts evenly all around and not to overtighten them.

Install the engine; see Section 3-34.

Fill the crankcase with the proper weight oil.

Close the water drain valves.

Start the engine and check for leaks.

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.

3-36 OIL PUMP

The oil pump consists of a single rotor and shaft, housed in a one-piece body; a relief valve; and an inlet tube-and-screen assembly. The oil pump is driven by the distributor shaft, which is driven by a helical gear on the camshaft. A baffle is installed on the pickup screen to eliminate pressure loss due to sudden stops.

OIL PUMP REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the engine; see Section 3-34.

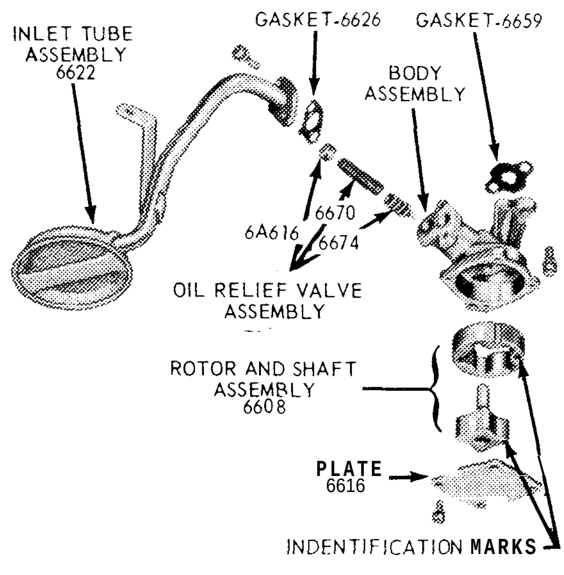
Remove the oil pan; see Section 3-35.

Remove the oil pump inlet tube-and-screen assembly. Remove the oil pump attaching bolts and remove the oil pump, gasket, and the oil pump-to-distributor shaft.

CLEANING

Wash the rotor and shaft thoroughly and inspect them for wear and scores. If either the rotor or the shaft is defective, they **MUST** be replaced as a **PAIR.**

Remove the oil pressure relief valve cap, spring, and valve. Wash the parts carefully. Inspect the relief valve for wear or scores. Check the relief valve spring to be sure it is not worn on its side or has not collapsed. If in doubt about the condition of the spring, install a new one. Check the relief valve in its bore in the housing. The clearance for



Exploded drawing showing principle parts of the oil pump on a Ford V8 engine.

the valve should be only a slip fit. If any side clearance can be felt, the valve or the housing should be replaced. Clean the pick-up tube and screen.

OIL PUMP INSTALLATION

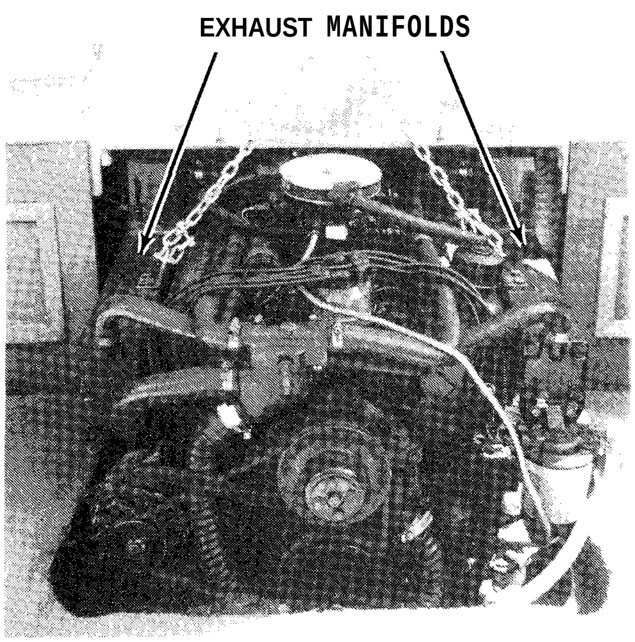
Prime the oil pump by filling either the inlet port or the outlet port with engine oil. Rotate the pump shaft to distribute the oil inside the pump housing.

Position the oil pump-to-distributor shaft into the distributor socket. The stop on the shaft should touch the roof of the crankcase when the shaft is firmly seated in the distributor socket. Remove the shaft and position the stop, if necessary.

Position a **NEW** gasket on the pump housing. With the stop properly positioned, insert the pump and driveshaft into the oil pump. Install the pump shaft as an assembly. **NEVER** attempt to force the pump into position if it does not seat **EASILY.** The driveshaft hex may be misaligned with the distributor shaft. To align the hex shaft, rotate the oil pump-to-distributor shaft.

Tighten the oil pump attaching screws to the torque value given in the Specifications in the Appendix.

Install the pickup tube and screen assembly.



V8 engine exhaust manifolds. Each manifold is secured by nuts to studs imbedded in the head.

Install the oil pan; see Section 3-35.

Install the engine; see Section 3-34.

Fill the crankcase with the proper weight oil.

Close the water drain valves.

Start the engine and check for leaks.

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.**

3-37 EXHAUST MANIFOLDS AND ELBOWS

REMOVAL

Drain the water from the block by opening all of the drain valves.

Remove the water hoses, and then take off the exhaust hoses from the exhaust housing to the engine.

Studs are located along the side of the head to support the exhaust manifolds. Nuts on these studs secure the manifolds to the head. Remove the nuts from the studs and, and then remove the manifolds.

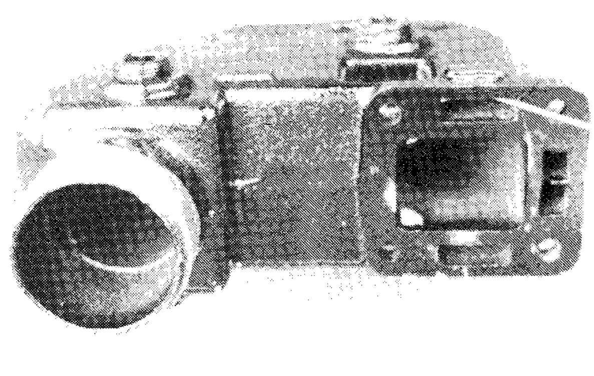
For other service on the exhaust manifolds, see Chapter 9, Cooling.

INSTALLATION

FACTORY GASKETS ARE USED between the exhaust manifolds and the engine block.

Install the manifolds to the cylinder heads and start the nuts onto the studs. After all of the nuts have been started, tighten them to the torque value given in the Specifications in the Appendix.

Replace the inlet, outlet, and exhaust hoses on the manifold.



Exhaust manifold, cleaned and ready for installation on a V8 engine.

Close the water drain valves.

Start the engine and check for leaks.

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.

3-38 INTAKE MANIFOLD

REMOVAL

Drain the water from the block by opening all of the drain valves. Remove the flame arrestor from the carburetor. Disconnect the battery cables at the battery. Disconnect the hoses, fuel line, and throttle linkage at the carburetor. Disconnect the wires to the coil and temperature sending switch.

Remove the distributor cap and mark the distributor housing indicating the position of the rotor. Remove the distributor clamp and then pull the distributor out of the block. Move the distributor cap out of the way. Remove the coil and bracket.

Remove the bolts attaching the manifold to the head, then lift the manifold with the carburetor attached from the engine. Discard all gaskets and seals.

CLEANING

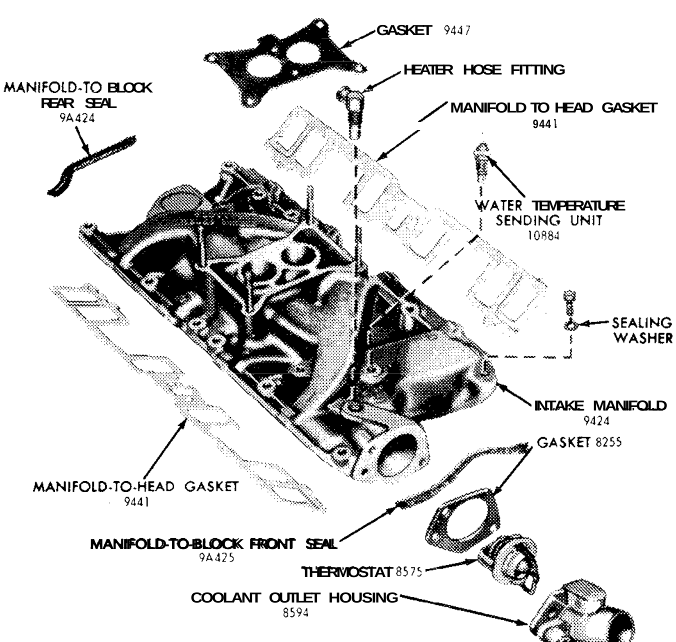
Clean the gasket surfaces of the intake manifold, the cylinder heads, and the block. Check the old gaskets to determine if there has been any exhaust leakage. Any evidence of exhaust leakage would indicate a crack in the head. Any sign of water in an intake manifold port would indicate either a crack in the manifold or a crack in the head.

INSTALLATION

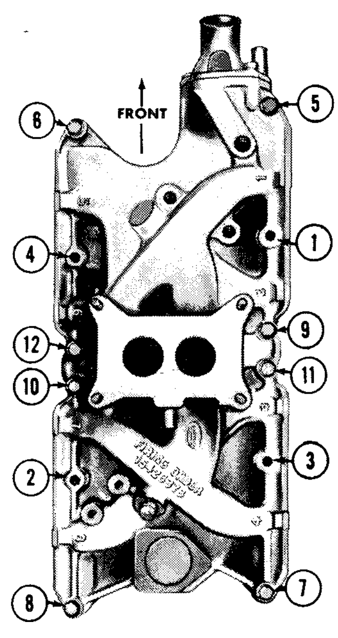
Position new seals on the cylinder block and new gaskets on the cylinder heads, with the gaskets interlocked with the seal tabs. BE **SURE** the holes in the gaskets are aligned with the holes in the cylinder heads. Apply a bead of sealer to the outer end of each intake manifold seal for the full width of the seal. This will be done in four places. The sealer will **SET UP** in **15 MINUTES.** Therefore, keep the work moving along.

Carefully lower the intake manifold into position on the cylinder block. After the manifold is in place, check to be sure the seals are in place by running your finger around the seal area. If the seals are not in place, lift the manifold and move the seals into their proper position. Start the intake manifold bolts, and then tighten them in the sequence shown to the torque value given in the Specifications in the Appendix.

Install the water pump bypass hose on the coolant outlet housing. Slide the clamp into position and tighten the clamp. Replace the water and exhaust hoses. Install the carburetor fuel inlet line and the automatic choke heat tube, if one is used.



Details of the intake manifold. 6



Tightening sequence of the intake manifold bolts.

Slide the distributor into place in the block with the rotor pointing to the mark you made prior to removing the distributor. Install and tighten the hold-down clamp. Install the distributor cap and return the spark plug wires back in the harness brackets on the valve rocker arm covers. Connect the spark plug wires to the spark plugs. Connect the high-tension lead and the coil wires. Connect the accelerator cable.

If the crankshaft was rotated while the distributor was out of the block, the engine will have to be timed. See Chapter 5 for detailed procedures to time the engine properly.

Close the water drain valves.

Start the engine and check for leaks.

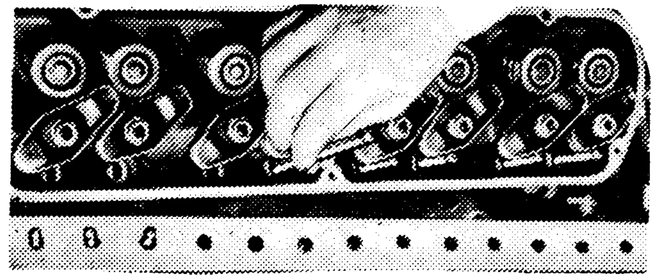
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

After the engine temperature has stabilized, adjust the engine idle speed and the idle fuel mixture; see Chapter 4.

Tighten the intake manifold bolts again to the torque value given in the Specifications in the Appendix.

3-39 CYLINDER HEAD SERVICE

The cylinder head and valve mechanism are the most important areas affecting the power, performance, and economy of an engine. Time and much care are required when reconditioning the cylinder head and



Take time to set-up a system for keeping the push rods in order as they are removed in order to ensure each one is replaced in exactly the same location from which it was removed. Note the rack for this purpose in this illustration.

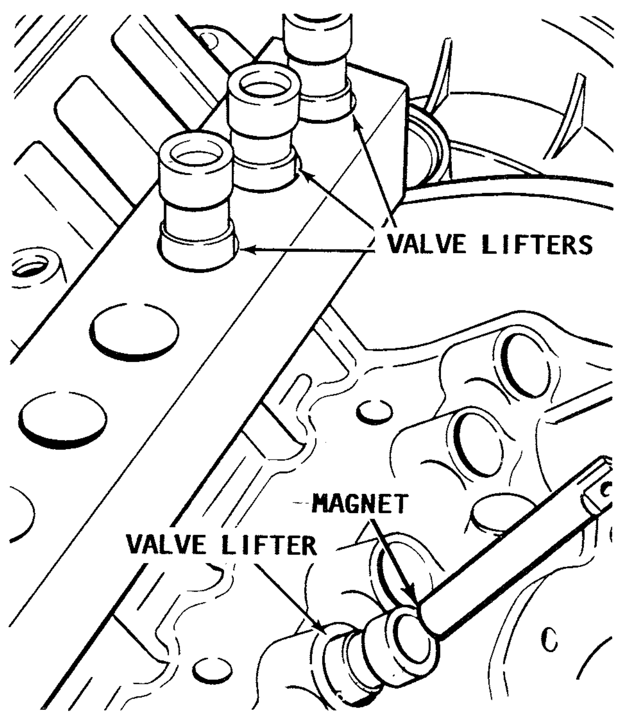
valves to maintain the correct valve stem-to-guide clearance, to grind the valves properly, and to make the correct valve adjustment.

The procedures in this section provide removing, disassembling, cleaning and inspecting, and installing the cylinder head, instructions, including some of the work that may be accomplished while the head is removed.

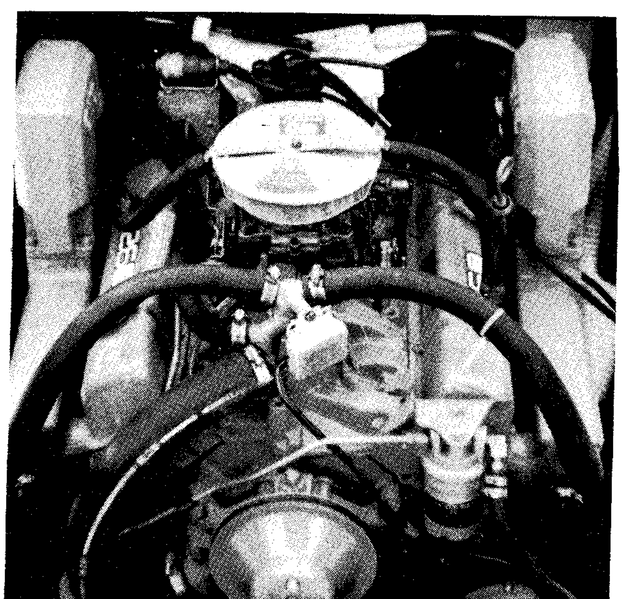
REMOVAL

Drain the water from the block by opening all of the drain valves.

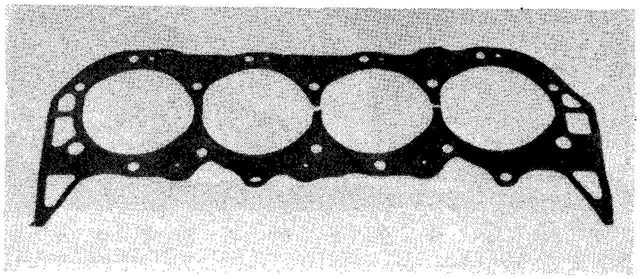
Remove the exhaust manifolds; see Section 3-37.



ALWAYS keep the valve lifters in order as they are removed so they will be installed in the same location from which they were removed.



General view of the V8 engine prior to removal of the intake manifold.

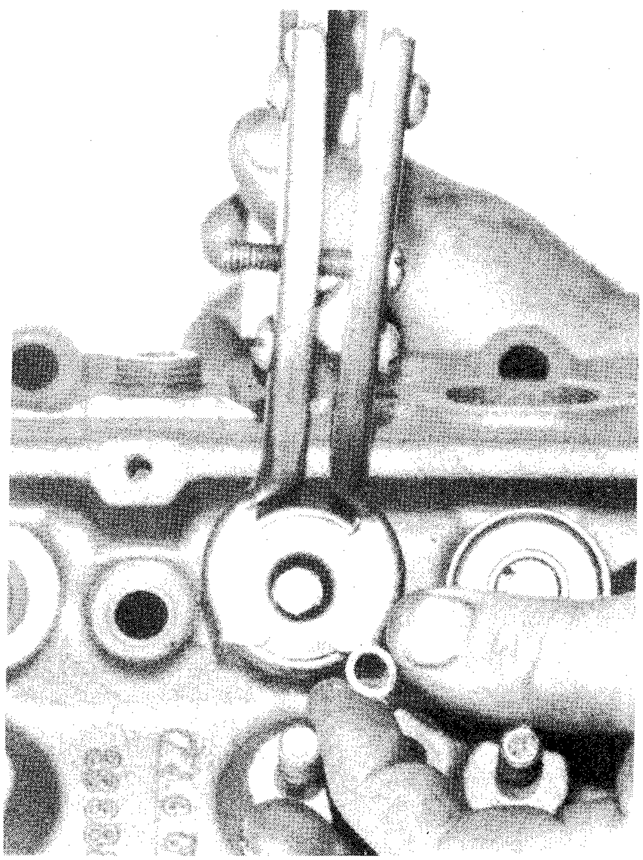


Compression loss may be caused by a blown head gasket between cylinders.

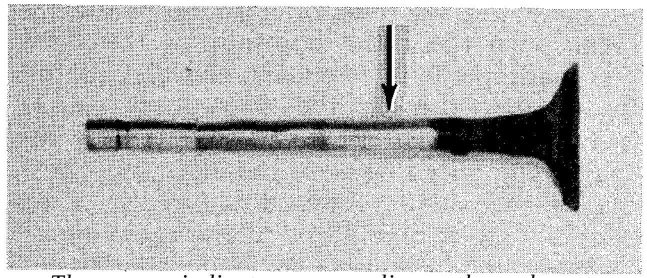
Remove the intake manifold and carburetor as an assembly; see Section 3-38.

Pull the spark plug wire retainers from the brackets on the rocker arm covers. Disconnect the spark plug wires at the plugs and swing the wires and retainer out of the way. Remove the screws attaching the rocker arm cover to the cylinder head.

Remove the rocker arm covers and gaskets. Remove the rocker arm nuts, rocker arm balls, and rocker arms. **TAKE TIME** to set up a system for keeping the push rods, valve lifters, valves, and their associated parts in absolute order to ensure each and every part will be installed in exactly the same position from which it was removed.



Removing the valve collet using a valve spring compressor.



The arrow indicates a wear lip on the valve stem. Accurate measurement of valve stem wear is made with a micrometer.

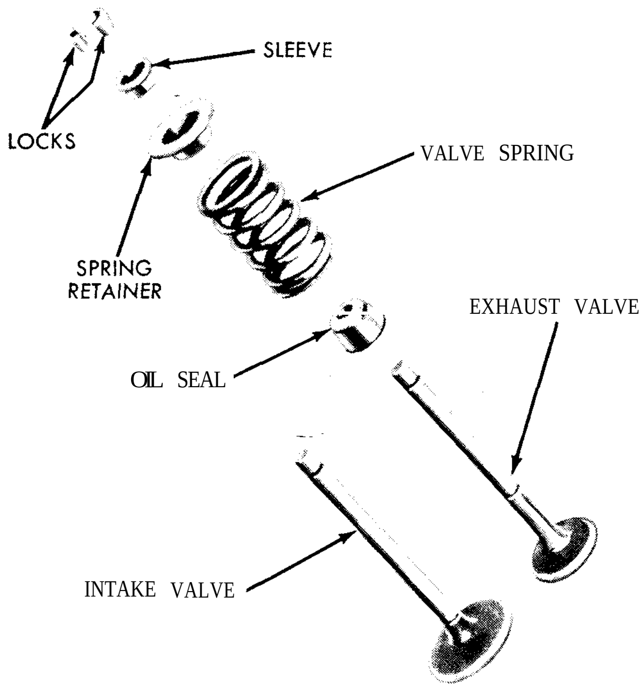
Remove the push rods and valve lifters in sequence and keep them in order. Remove the cylinder head bolts, cylinder heads, and gaskets.

Place each head assembly on its side. Use a valve compression tool, and compress each valve spring to remove the valve locks, seal, spring cup, and spring.

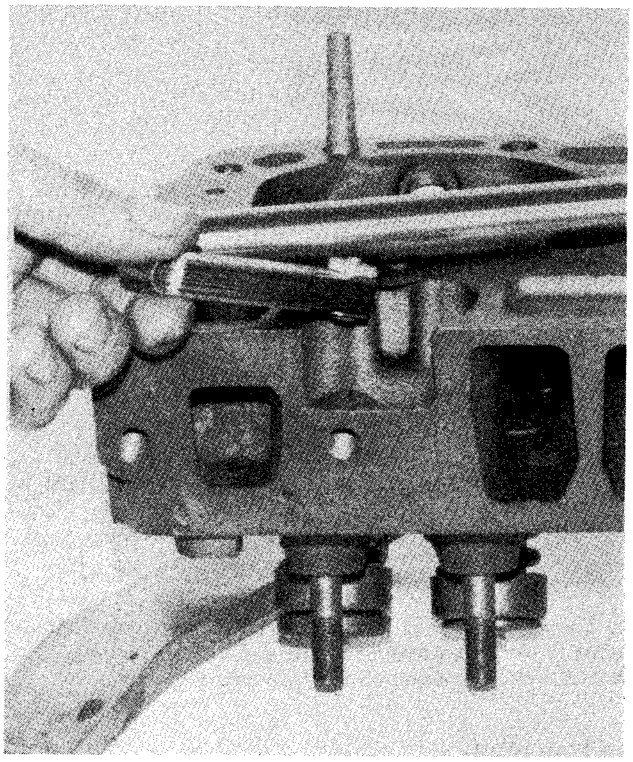
Continue removing the parts until all valves have been released. Remove the valves from the head one-at-a-time and keep them in order by number and the head from which they were removed.

VALVE MECHANISM

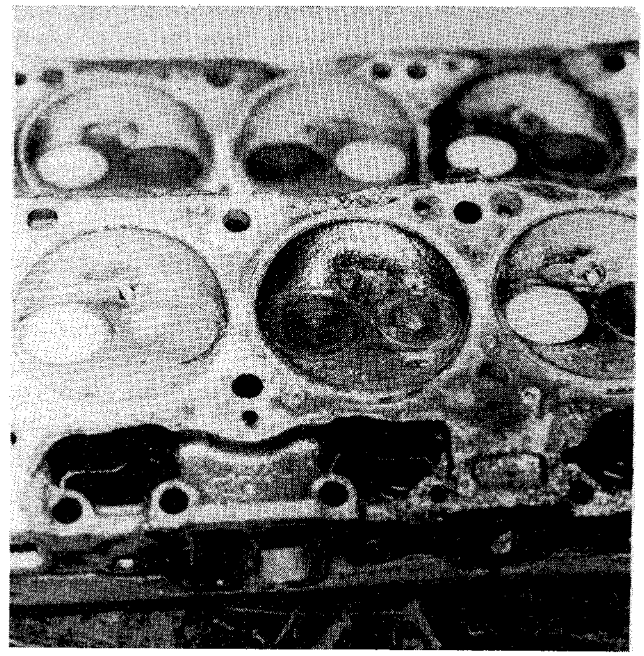
Clean the valves, springs, spring retainers, locks, and sleeves in solvent, and then blow the parts dry with compressed air. Inspect the valves for burned heads, cracked faces, or worn stems. Inspect the valve face and the head for pits, grooves, and



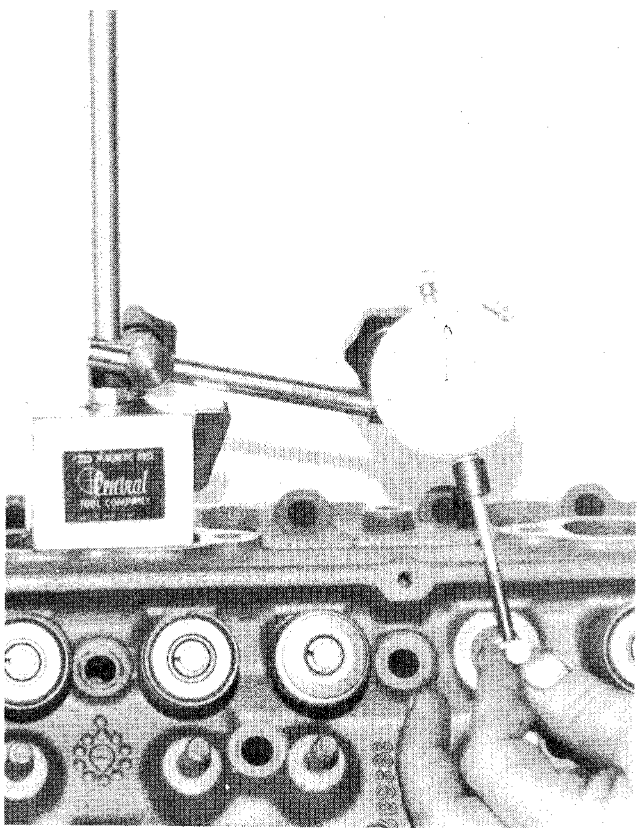
Exploded drawing showing principle parts of the valve mechanism on the Ford V8 engine.



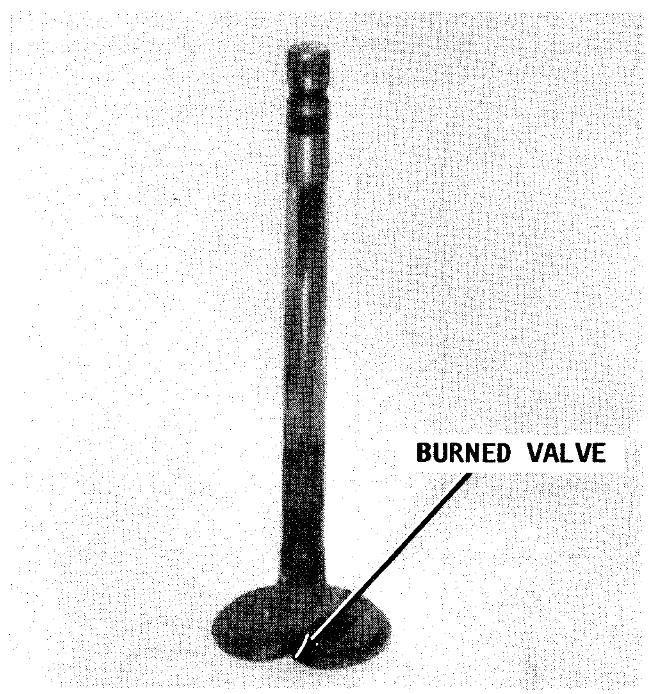
*The cylinder head gasket surface must be checked for any uneven condition. Surface irregularities **MUST NOT** exceed 0.003" in any six-inch space.*



Notice the oil around the intake valve and the darker coloring of the exhaust valve in the right combustion chamber. The compression in the right cylinder was lower than in the left. Also the intakevalve guide and seal are defective allowing oil to leak into the combustion chamber.



The wear limit for intake valve guides is 0.001" and for exhaust guides, 0.002". Valve guide wear can be accurately measured by checking the deflection of a new valve stem with a dial gauge.

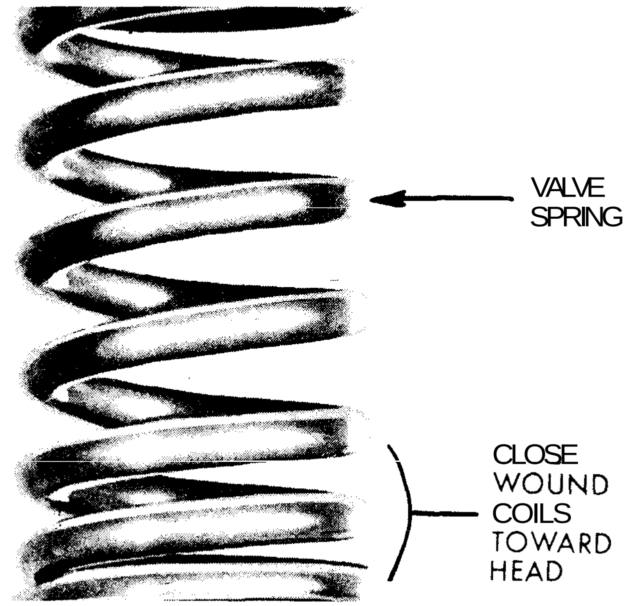


*A severely burned exhaust valve face. The valve was sticking in the guide as evidenced by the gum on the neck of the stem. **TAKE TIME** to clean the valve guide thorougly.*

scores. Inspect the stem for wear and the end for grooves. Check the fit of each valve stem in its respective guide. Excessive valve-to-guide clearance will cause lack of power, rough idling, excessive oil consumption, and noisy valve train operation.

The clearance should not exceed 0.004" for intake valves and 0.005" for exhaust valves. If the clearance is not within the limits, either the valve or the guide must be replaced.

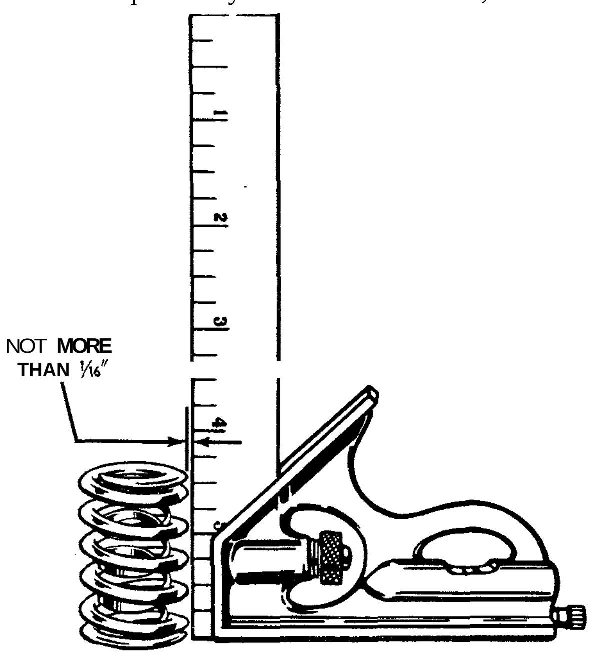
The valve face must be trued on a valve grinding machine, which will remove minor pits and grooves. Dress the valve-refacing machine grinding wheel to make sure it is smooth and true. Set the chuck at the 44° mark for grinding all valve faces. Valves with serious defects, or those having heads with a knife edge must be replaced.



Enlarged view of a coil spring to show the differences in the coil windings at the ends. Install the spring with the close wound coil end towards the head.

VALVE SPRINGS

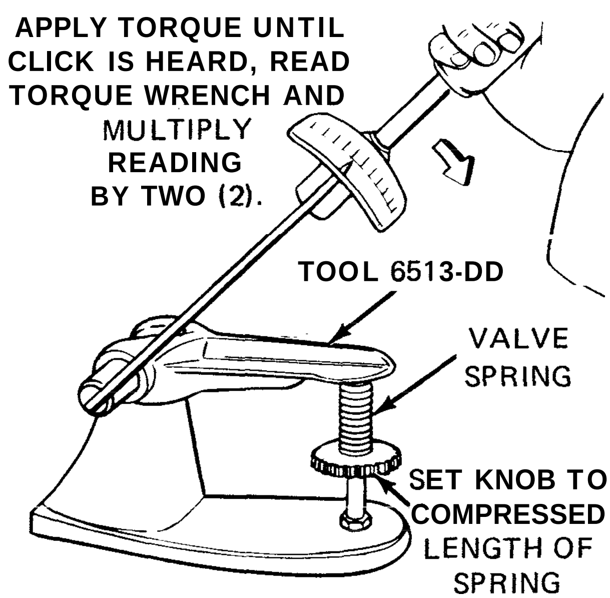
Compare the valve spring tension against those listed in the Specifications in the Appendix. A quick check can be made by laying all of the springs on a flat surface and comparing their heights. The heights **MUST** all be the same. Both ends of each spring **MUST** be square or the spring will tend to cock the valve stem. Weak valve springs cause poor engine performance. Therefore, if a spring is weak or the ends are not square by more than 1/16", it **MUST** be replaced.



A valve spring should not be out by more than 1/16" (1.59 rnm) when it is rotated against a square on a flat surface, as shown. Replace defective springs.

HYDRAULIC VALVE LIFTERS

Dirt, deposits of gum, and air bubbles in the lubricating oil can cause the hydraulic lifters to wear enough to cause failure. The dirt and gum can keep a check valve from seating, which will cause the oil to return to the reservoir during the time the push rod is being lifted. Excessive movernent of the lifter parts causes wear and destroys the lifter's effectiveness in a short time.

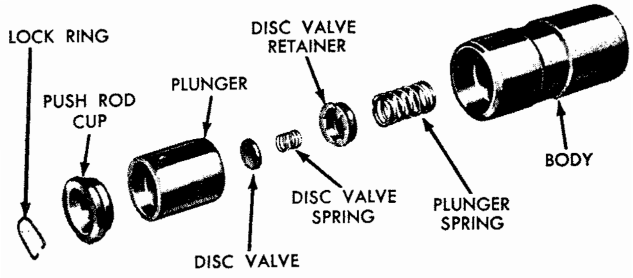


The valve spring tension should be checked with an accurate tester and torque wrench.

ALWAYS keep the lifter assemblies in proper sequence when they are being removed. This is the only way they can be installed back into their original position. Clean, inspect, and test each lifter separately and use the utmost care not to intermix the internal parts. If any one part of the lifter is defective for any reason, replace the complete lifter assembly, **NEVER** just one part.

After the lifter has been cleaned, dried, and assembled, a quick test of its operation can be made by depressing the plunger with your finger. The trapped air should partially return the plunger if the lifter is operating properly. If the lifter is worn, or if the check valve is not seating, the plunger will not return.

Install the assembled lifters in the engine dry, paying careful attention to ensure each one is returned to its original position. The lifters will bleed to their correct operating position quicker if installed dry than if you fill them with lubricating oil prior to installation.



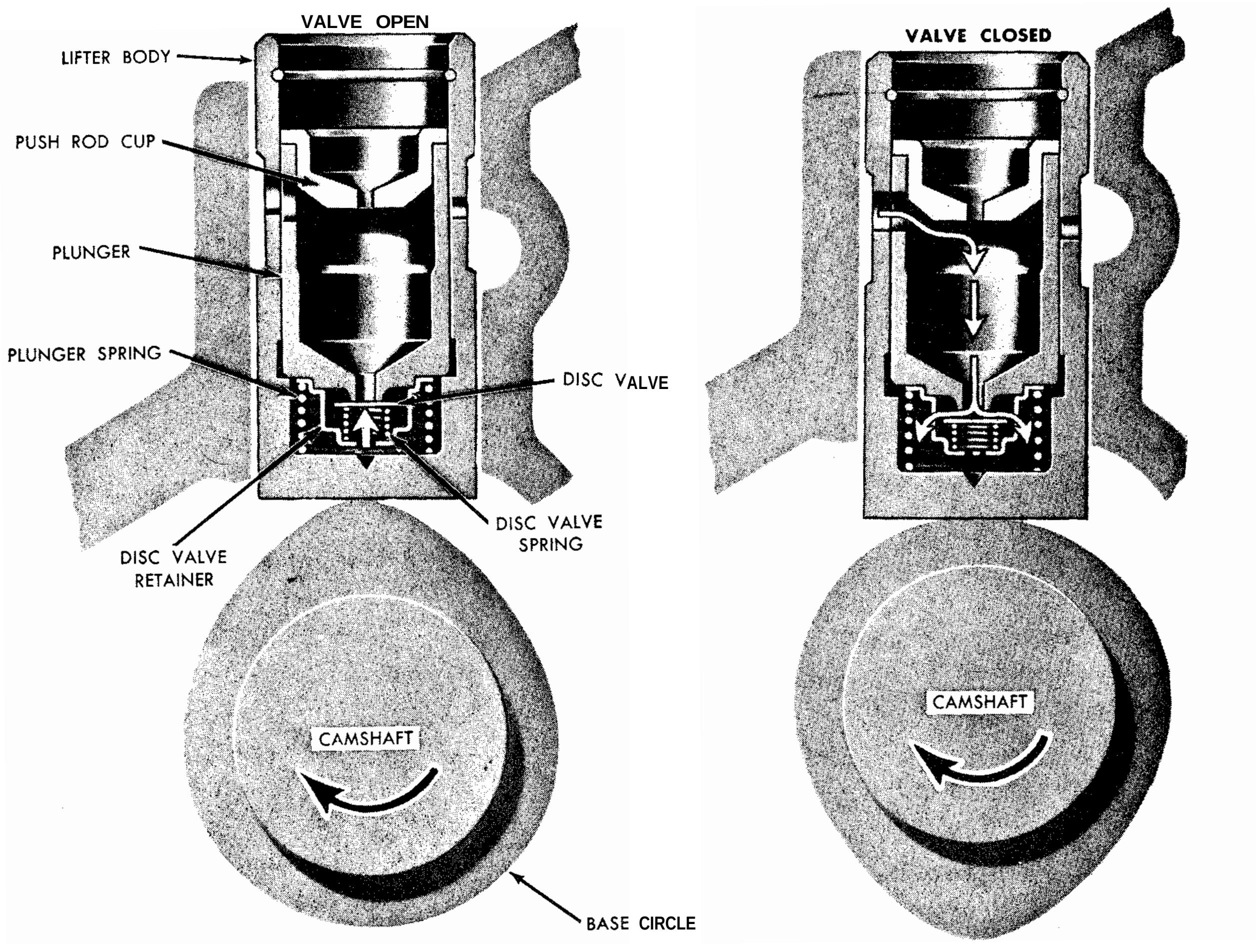
Arrangement of valve lifter parts.

RECONDITIONING GUIDES AND SEATS

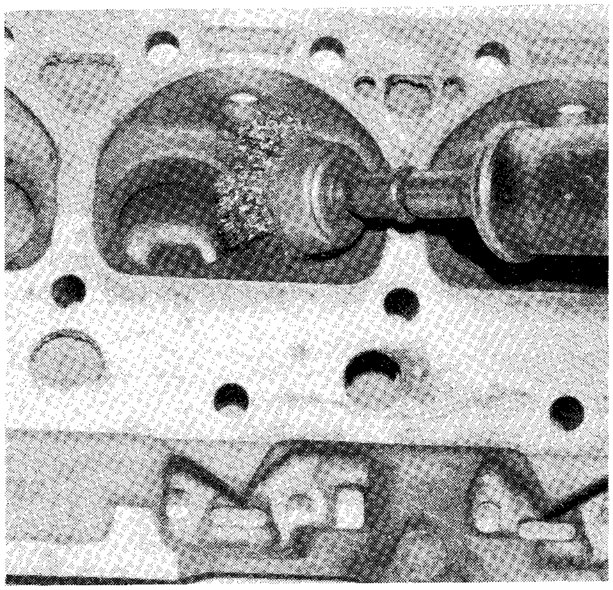
Remove the carbon from the combustion chambers. Use care to avoid scratching the head or the valve seats. Clean all carbon and gum deposits from the valve guide bores.

Valve stem guides are not replaceable. If a valve stem has excessive clearance, the guide must be reamed 0.003" oversize, with a reamer. Valves with 0.003" oversize stems are available for service.

The seating of the valves must be perfect for the engine to perform as the designer intended. Another important

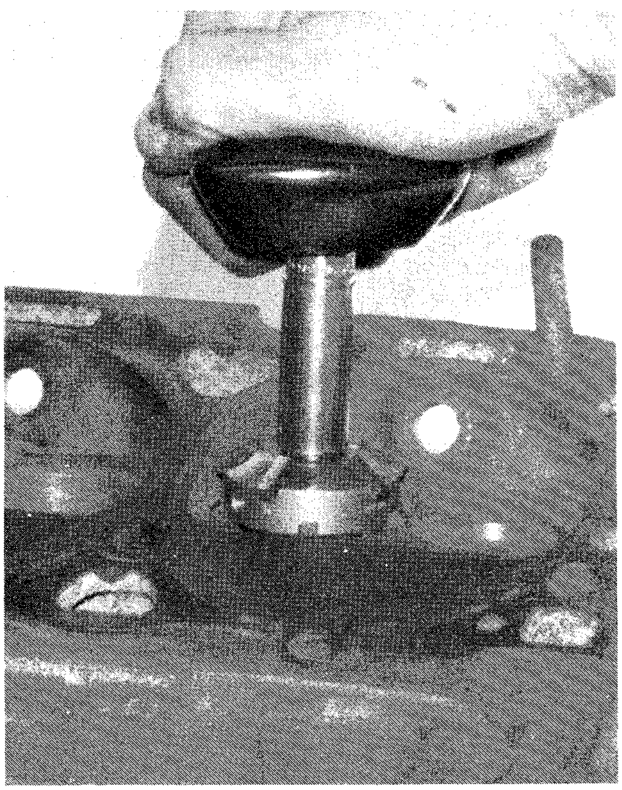


Relationship of the cam lobe as the camshaft rotates. The cam moves the valve lifter to the valve open position (left) and then to the valve closed position (right).

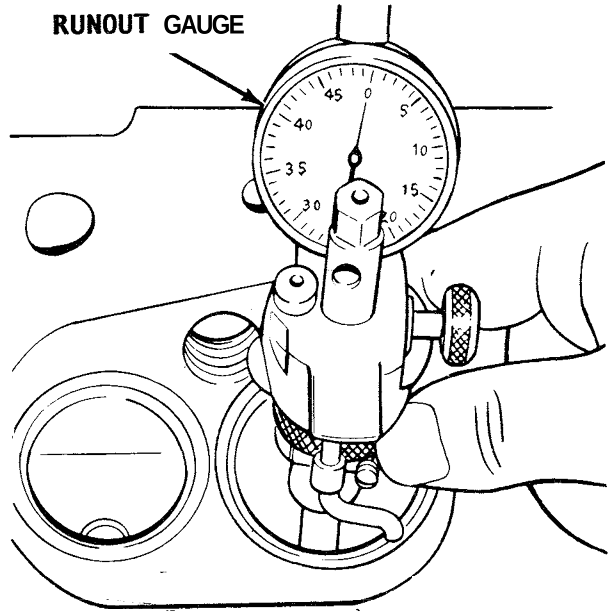


Use a wire brush to clean carbon from the cylinder head. Take time to do a thorough cleaning for maximum benefit.

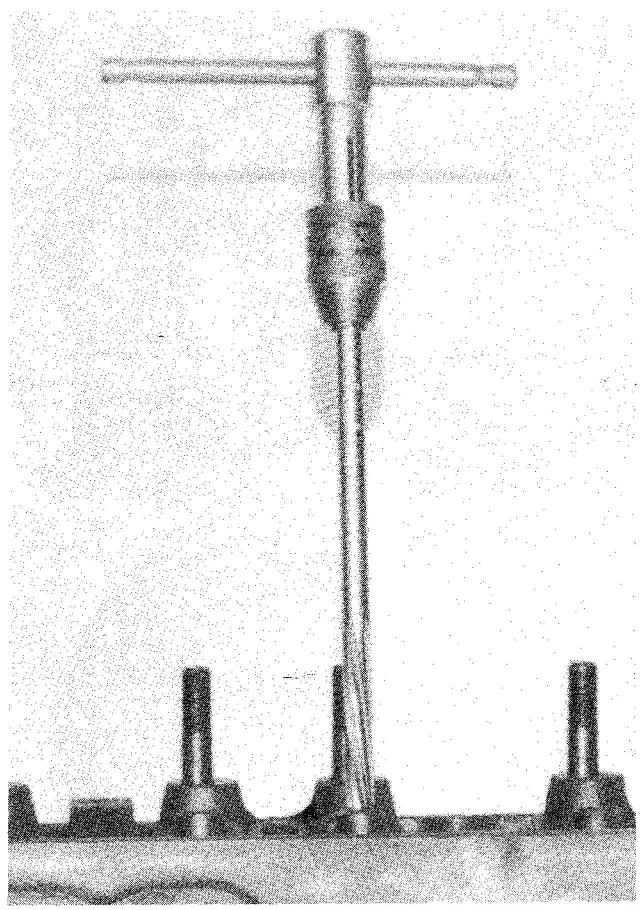
factor is the cooling of the valve heads. Good contact between each valve and its seat in the head is the only way to ensure that the heat in the valve head will be properly removed. Therefore, reconditioning the valve seats is extremely important.



Refacing the valve seat using a grinding stone. ALWAYS lift the special drive several times to allow the grinding particles to fly out, or the valve seat will become grooved.



After the seat has been reground, check to be sure it is concentric with the guide by using a dial gauge. The run-out should not exceed 0.002".



To restore production clearances, worn valve guides can be reamed oversize, and then valves with oversize stems installed.

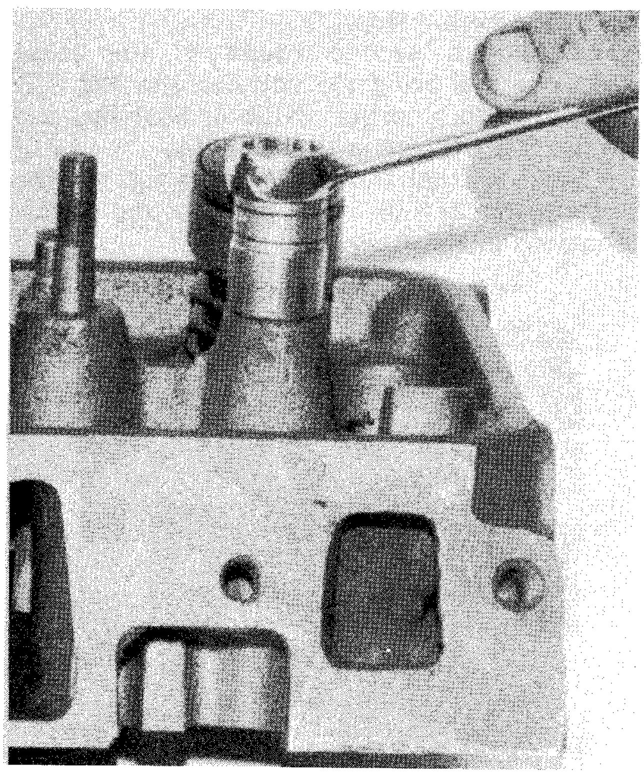
Use a 45° stone on the valve seats. Use a forming cutter of 30° and 60° at the top and bottom of the set to narrow it to 0.030" to 0.060" for an intake seat and 0.060" to 0.090" for an exhaust seat. Check the valve seat with a dial indicator. The seat must be concentric within a total indicator reading of 0.002".

ROCKER ARM STUD REPLACEMENT

If it is necessary to remove a rocker arm stud, tool kit T62F-6A527B is available from a parts dealer. This kit includes: A stud remover, a 0.006" oversize reamer, and a 0.015" oversize reamer. For 0.010" oversize studs, use reamer T66P-6A527B. To press in replacement studs, use stud replacer T69P-6049-D.

Broken or damaged rocker arm studs can be replaced with standard studs. Loose studs in the head may be replaced with 0.006", 0.0 10", or 0.00 15" oversize studs which are available. Standard and oversize studs can be identified by measuring the stud diameter 1-1/8 inch or less from the pilot end of the stud. Stud diameters are:

Standard	0.37 14-0.3721
0.006" oversize	0.3774-0.7781
0.010" oversize	0.3814-0.3821
0.0 15" oversize	0.3864-0.387 1

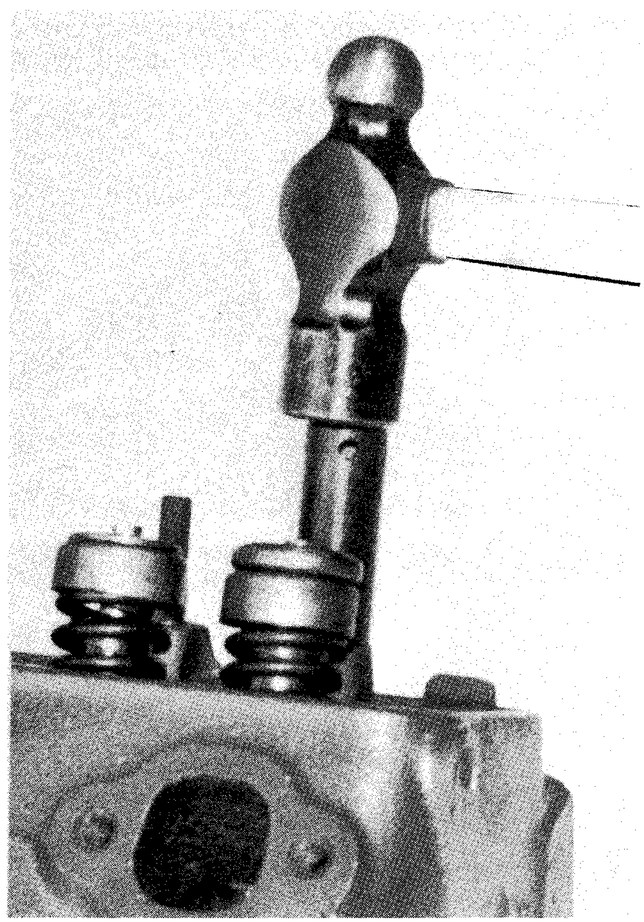


A pressed-in valve rocker arm stud can be removed using tool J-5802.

Any time you replace a standard size rocker arm stud with a 0.010" or 0.015" oversize stud, **ALWAYS USE** the 0.006" oversize reamer **BEFORE** finish-reaming with the 0.010" or 0.015" oversize reamer.

To remove a broken stud, position the sleeve of the rocker arm stud remover (Tool T62F-6A527-B) over the stud with the bearing end down. The stud puller is designed for 3/8-inch studs and it will not grip the 5/16-inch thread on a 302 CID engine. Therefore, when working on a 302 CID engine cylinder head, cut the threaded part of the stud off with a hacksaw. Thread the puller into the sleeve and over the stud until it is fully bottomed. Hold the sleeve with a wrench, and at the same time, rotate the puller clockwise and remove the damaged stud.

If a loose rocker arm stud is being replaced, ream the stud bore using the proper reamer (or reamers in sequence) for the required oversize stud. **TAKE EXTRA CARE** to be sure metal particles do not enter the valve area.



Before driving the new rocker arm stud into place with an installer tool, ALWAYS coat the parts with hypoid axle lubricant.

Coat the end of the new stud with Lubriplate or equivalent. Align the stud and installer T69P-6049-D with the stud bore. Next, tap the sliding driver until it bottoms. After the installer makes contact with the stud boss, the stud is installed to its correct height.

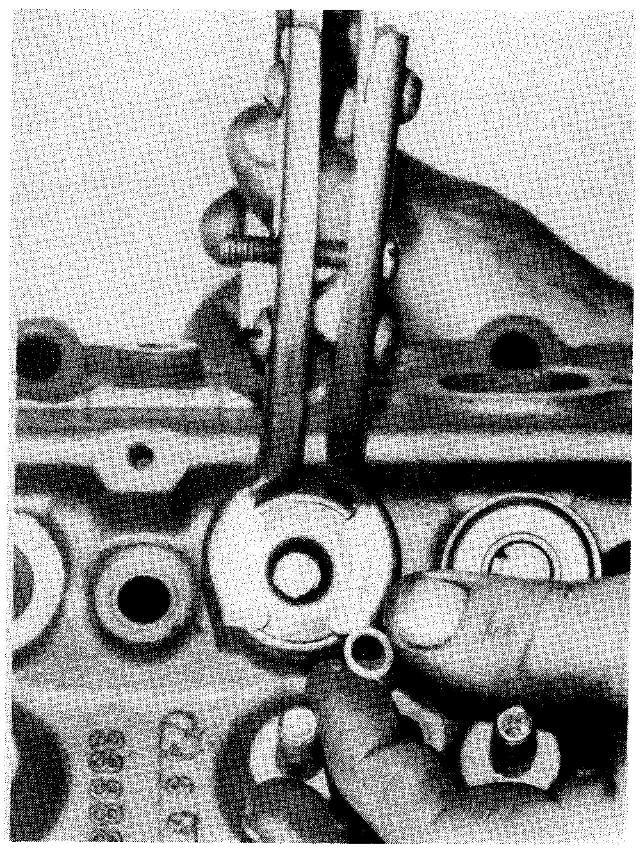
CYLINDER HEAD ASSEMBLING

Coat the valves, valve stems, and valve guides with a liberal coating of engine oil. Apply Lubriplate to the valve tips before installation. Install each valve into the same port from which is was removed.

Install the valve stem seal and valve. Install the spring retainer. Compress the spring and install the sleeve and retainer locks.

Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer.

If the assembled height is greater than amount given in the Specifications in the Appendix, it will be necessary to install enough 0.0030" spacers between the cylinder head spring pad and the valve spring until the assembled height is up to specification. **NEVER** install spacers unless it is necessary because the spacers will overstress the valve spring and exert an extra load on the camshaft lobe. This extra strain could lead to a worn lobe or possibly cause the spring to break.



Installing the valves into the cylinder head.

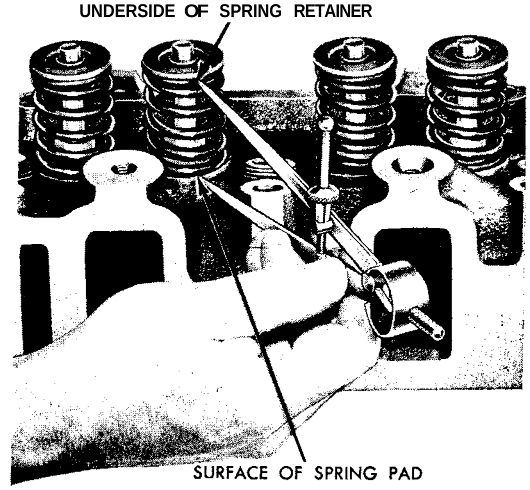
CYLINDER HEAD INSTALLATION

Place a new cylinder head gasket over the cylinder dowels on the block. **ALWAYS** use marine head gaskets to minimize salt water corrosion. Dowels in the block will hold the gaskets in place. **USE CARE** when handling the gaskets to prevent kinking or damaging the surfaces. **DO NOT** use any sealing compound on head gaskets, because they are coated with a special lacquer to provide a -good seal, once the parts have warmed to operating temperature.

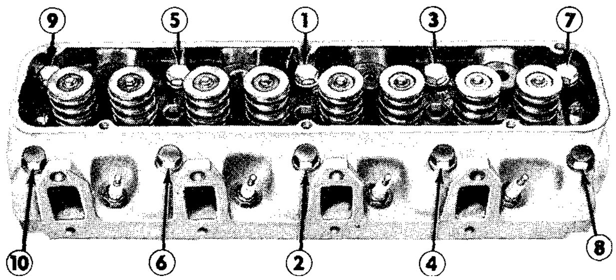
Carefully lower the head into place on the block, and then start the head bolts. After all of the bolts have been started, tighten them in the sequence shown in the accompanying illustration to a torque value of **50ft-lbs.** on the first round for the **302** CID engine and **85ft-lbs.** for the **351** CID engine. **BEAR IN MIND,** uneven tightening of the head bolts can distort the cylinder bores, causing compression loss and excessive oil consumption.

Make a second round in the same sequence and bring the bolts on the **302** CID engine up to a torque value of **60ft-lbs.** and on the **351** CID engine to **95ft-lbs.**

Make a final third round and tighten the bolts to the torque value given in the Specifications in the Appendix.



Measuring the height of the installed valve spring. Compare this measurement with the Specifications in the Appendix.



Head bolt tightening sequence for the Ford V-8 engine.

Install the exhaust manifolds; see Section 3-37.

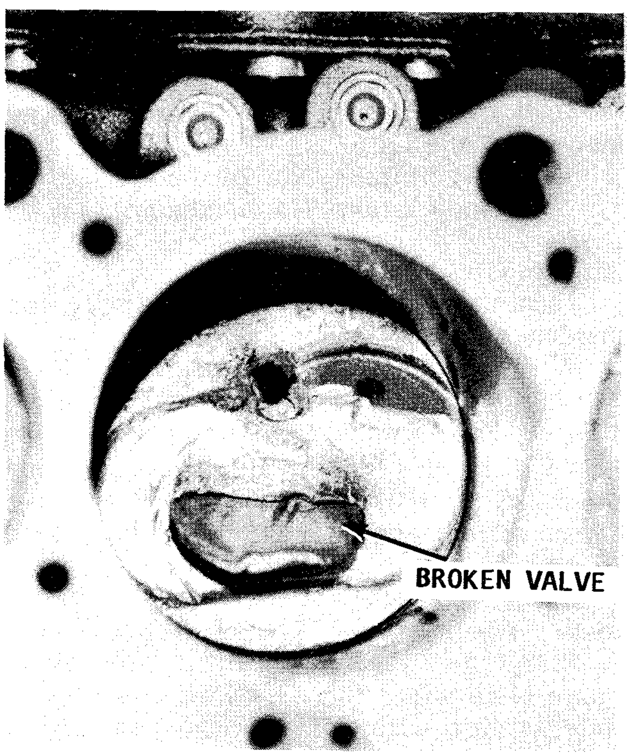
Apply Lubriplate, or equivalent, to both ends of the push rods. Install the push rods in the same position from which they were removed, see Section 3-39.

Apply a coating of Lubriplate or equivalent to the valve stem tips. Install the rocker arms and adjust the valve lash; see Section 3-40.

Connect the exhaust manifolds at the exhaust housing, see Section 3-37.

Install the alternator attaching bracket and the alternator. Adjust the drive belt tension.

Clean the valve rocker arm covers. Place the valve rocker arm cover gaskets in each cover. **ALWAYS** use new gaskets. **Check** to be sure the tabs of the gasket engage the notches in the cover. Install the valve rocker arm covers, and then tighten



Improper installation techniques caused this valve to drop out and strike the piston.

them in two stages. First, tighten the bolts to a torque value of 3 to 5ft-lbs. After about five minutes, tighten them again to the same torque value.

Clean the mating surfaces of the intake manifold, the cylinder heads, and the cylinder block with solvent. Apply a bead of silicone rubber sealer on the cylinder head at four places as shown in the accompanying illustration. Sealer will set up in 15 **MINUTES.** Therefore, keep moving along with the assembly work.

Place new seals on the cylinder block and new gaskets on the cylinder heads, with the gaskets interlocked with the seal tabs. **CHECK** to be sure the holes in the gaskets are properly aligned with the holes in the cylinder heads.

Install the intake manifold; see Section 3-38.

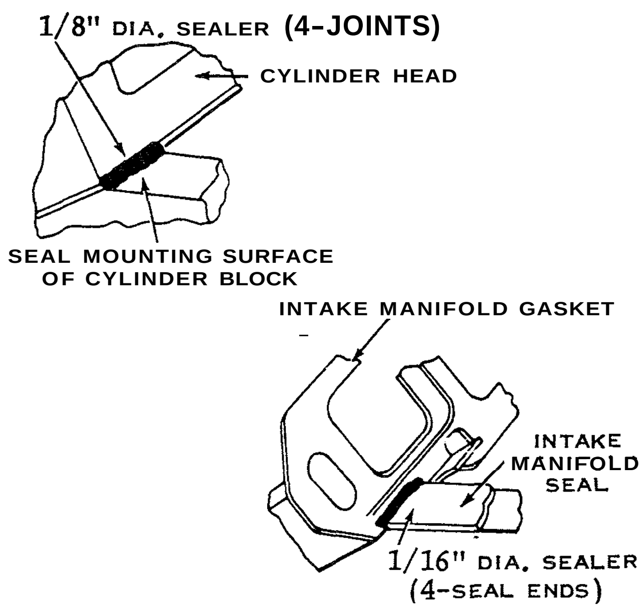
Close the water drain valves.

Start the engine and check for leaks.

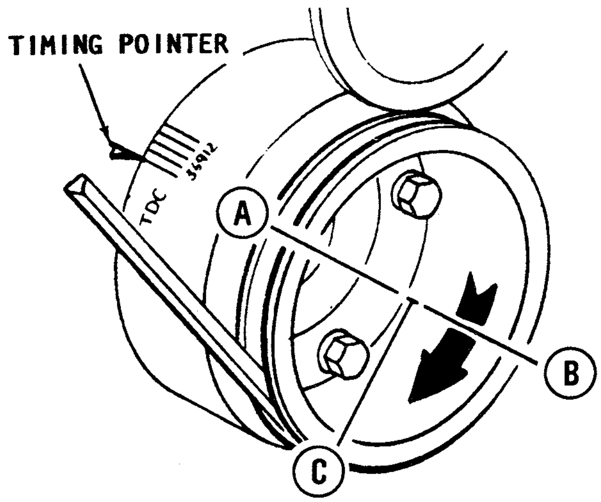
CAUTION: **Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.**

3-40 CHECKING THE HYDRAULIC LIFTER COLLAPSED CLEARANCE

Anytime the valves and the seats have been ground, or if you detect noise in the valve train that is not due to a collapsed lifter, the valve clearance **MUST** be checked. The valves are not adjustable. How-



Places to apply manifold sealer to minimize oil and air leaks.

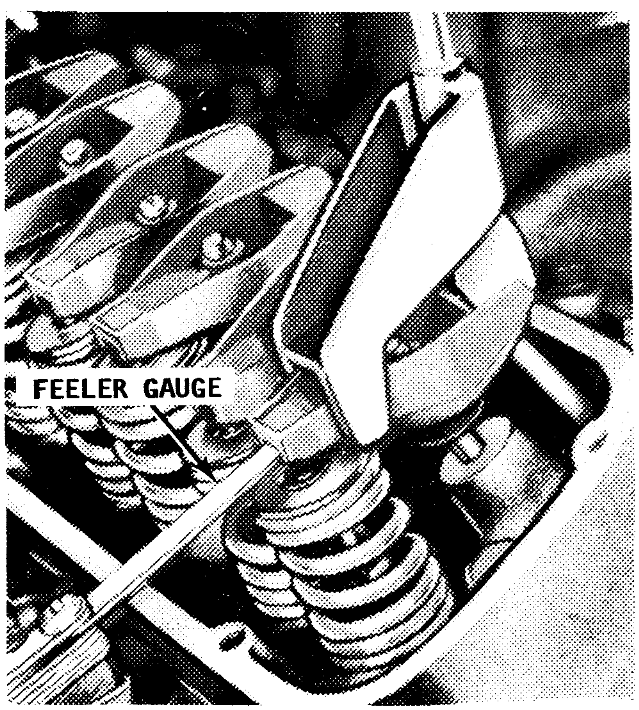


Crankshaft position for checking the valve lash. The No. 1 piston is at TDC at the end of the compres sion stroke for the "A" position. A chalk mark is then made 90° apart for points "B" and "C".

ever, 0.030" shorter push rods, or 0.030" longer rods are available.

Check the accompanying diagram on this page and notice that three crankshaft positions are designated by the letters A, B, and C.

The collapsed lifter clearance is checked by first turning the crankshaft to each of the three positions indicated in the diagram, and then checking the valve clearances at each position as follows:



Using a feeler gauge to check the collapsed hydraulic lifter lash. To keep the clearance between 0.090" and 0.190", shorter or longer push rods may be installed.

For the Ford 302 & 351 CID 190 hp & 235 hp

Position A

With the No. I piston at TDC, at the end of the compression stroke, check the following valves:

No. 1 intake, No. 1 exhaust
No. 4 intake, No. 3 exhaust
No. 8 intake, No. 7 exhaust

Position B

Turn the crankshaft to Position B, and then check the following valves:

No. 3 intake, No. 2 exhaust
No. 7 intake, No. 6 exhaust

Position C

Turn the crankshaft to Position C, and then check-the following valves:

No. 2 intake, No. 4 exhaust
No. 5 intake, No. 5 exhaust
No. 6 intake, No. 8 exhaust

For the Ford 302 CID 175 hp

Position A

With the No. 1 piston at TDC, at the end of the compression stroke, check the following valves:

No. 1 intake, No. 1 exhaust
No. 7 intake, No. 5 exhaust
No. 8 intake, No. 4 exhaust

Position B

Turn the crankshaft to Position B, and then check-the following valves:

No. 5 intake, No. 2 exhaust
No. 4 intake, No. 6 exhaust

Position C

Turn the crankshaft to Position C, and then check the following valves:

No. 2 intake, No. 7 exhaust
No. 3 intake, No. 3 exhaust
No. 6 intake, No. 8 exhaust

To make the actual valve lash clearance check, first apply -pressure on the valve lifter with Tool T711A-6513AC to bleed down the lifter plunger until it is fully collapsed, and then check the clearance with a feeler gauge. The clearance should be 0.083" to 0.183". BE **SURE** the feeler gauge is no wider than 3/8". If the clearance is not within the prescribed limits, replace the push rod with a longer or shorter one as required.

3-41 PISTON, RING, AND ROD SERVICE

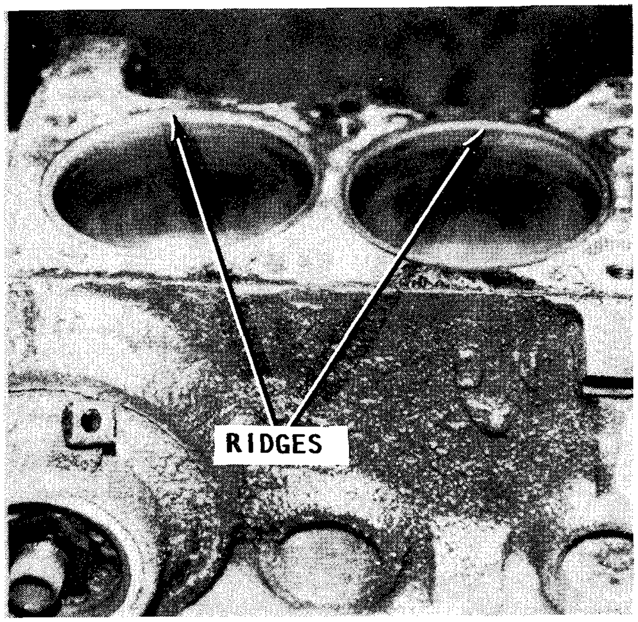
This section provides detailed procedures for removing, disassembling, cleaning, inspecting, assembling, and installing the complete piston-rod assembly. All parts **MUST** be kept together because if the old pistons are serviceable, they **MUST** be installed on the rods from which they were removed and installed in the same bore.

REMOVAL

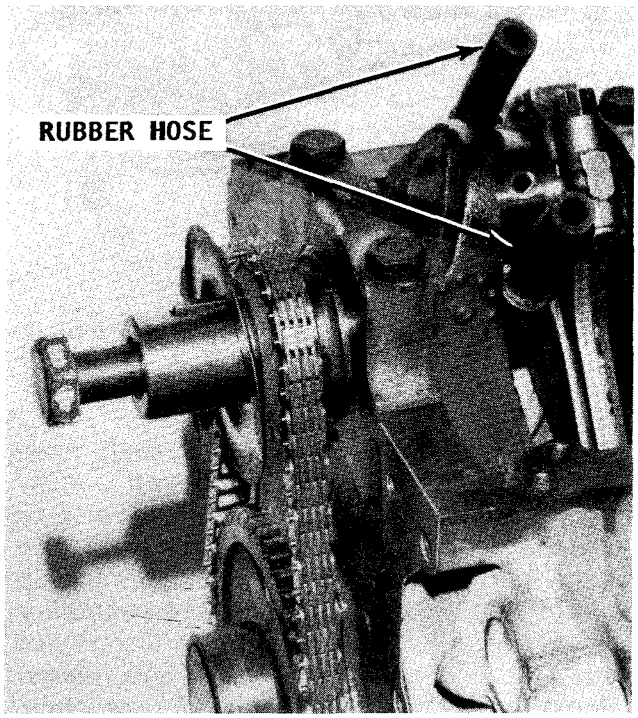
Remove the engine; see Section 3-34.
Remove the intake manifold; see Section 3-38.
Remove the cylinder heads; see Section 3-39.
Remove the oil pan; see Section 3-35.
Remove the oil pump; see Section 3-36.

If a shoulder or ridge exists in the cylinder bores above the ring travel, it must be removed with a ridge reamer or the rings may be damaged or the ring lands cracked during removal.

Before using the reamer, turn the crankshaft until the piston is at the bottom of its stroke, and then place a cloth on top of the piston to collect the cuttings. After the ridge is removed, turn the crankshaft until the piston is at the top of its stroke to remove the cloth and cuttings.

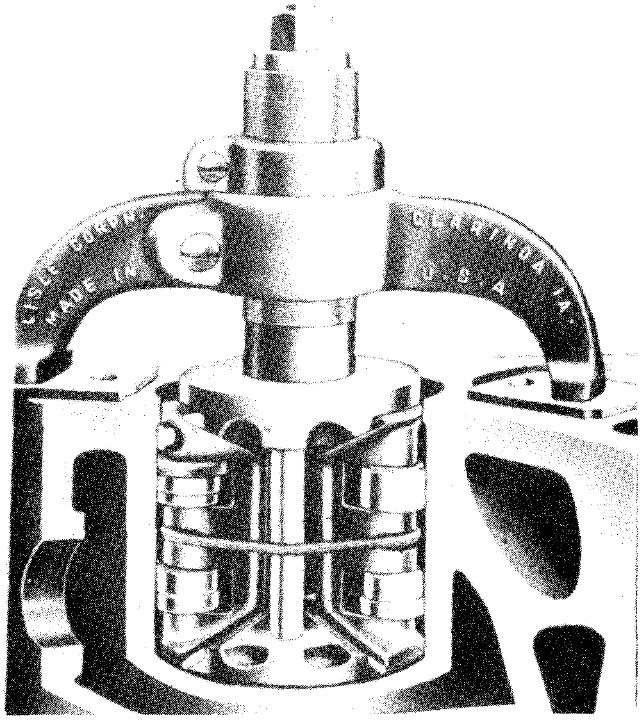


*Due to borderline lubrication conditions, the cylinder walls wear the most at the top. All measurements **MUST** be made in this worn area. This cylinder bore has been surfaced with a fine hone to remove the glaze for better piston ring seating.*

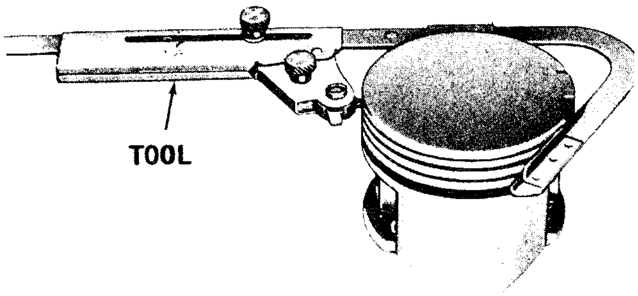


The rod bolt threads must always be covered with a piece of rubber hose to prevent damage to the bearing surface by the rod threads scraping as the piston assembly is removed.

Identify each piston, connecting rod, and cap with a quick drying paint or silver pencil to ensure each part will be replaced in the exact position from which it was removed.



A ridge remover MUST be used to cut the ridge from the top of the cylinder walls. The stop under the blade prevents cutting into the walls too deeply. NEVER cut more than 1/32" below the bottom of the ridge.



The ring grooves must be thoroughly cleaned to permit the new rings to seat properly. ***TAKE CARE*** *not to nick the sealing surfaces, or the ring will leak compression.*

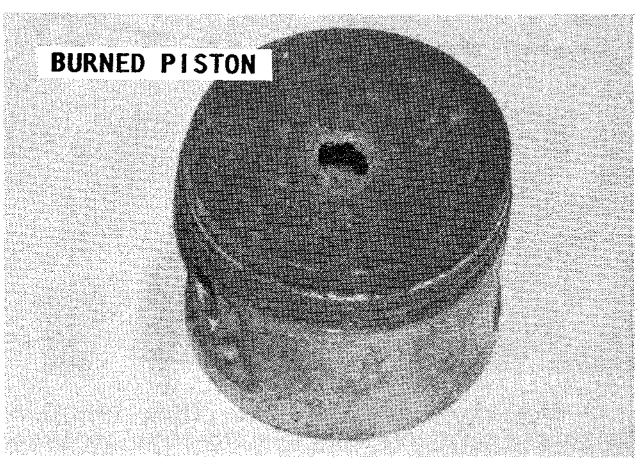
Remove the cap and bearing shell from No. 1 connecting rod, then install a connecting rod bolt guide hose on the bolts to hold the upper half of the bearing shell in place. Push the piston and rod assembly up and out of the cylinder. It will be necessary to turn the crankshaft slightly to disconnect some of the connecting rod and piston assemblies and to push them out of their cylinders. Remove the guides and install the bearing shells and cap on the rod.

Continue in a similar manner until all of the piston and rod assemblies have been removed, partially reassembled to keep the parts matched, and the assemblies hung or placed in order.

CLEANING AND INSPECTING

If the engine has over 750 hours of service, or if the piston and rod assembly has been removed, it is considered good shop practice to replace the piston pins. Loose piston pins, coupled with tight rings, will cause piston pin noi'ses. These noises may disappear as the engine loosens.

Most mechanics have the piston pin work done by a machine shop with the necessary equipment and trained people to perform a precision job. If done in a machine shop, the connecting rods will be aligned so the pistons and rings will run true with the cylinder walls.



Preignition caused this piston crown to melt.

CYLINDER BORES

Inspect the cylinder walls for scoring, roughness, or ridges which indicate excessive wear. Check the cylinder gauge at the top, middle, and bottom of the bore, both parallel and at right angles to the centerline of the engine.

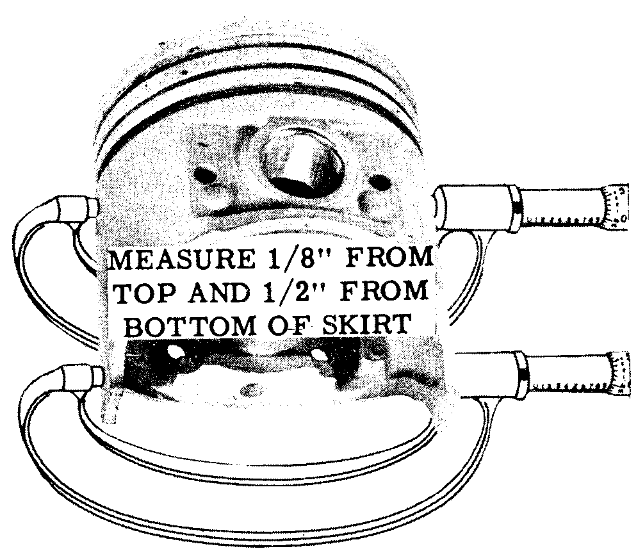
A cylinder bore which is tapered 0.005" or more, or is out-of-round 0.003" or more, must be reconditioned.

ROD BOLTS AND NUTS

Check the rod bolts and nuts for defects in the threads. Inspect the inside of the rod bearing bore for evidence of galling, which indicates the insert is loose enough to move around. Check the parting cheeks to be sure the cap or rod has not been filed. Replace any defective rods.

PISTONS AND FINS

Remove the compression rings with a ring expander. Remove the oil ring by removing the two rails and the spacer-expander, which are separate pieces in each piston's third groove.

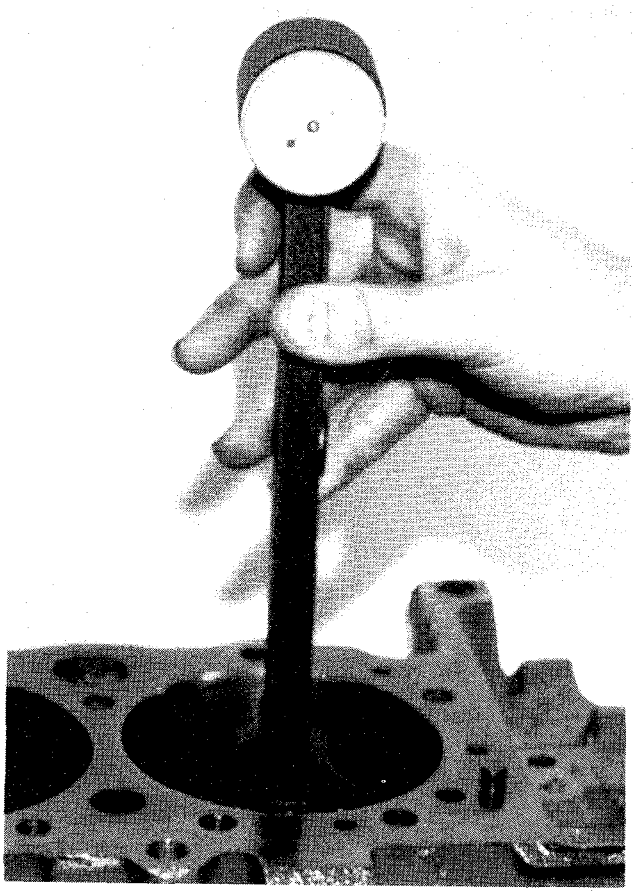


Proper measurement of the piston is made with a micrometer 1/8" from the crown and 1/2" from the bottom of the skirt.

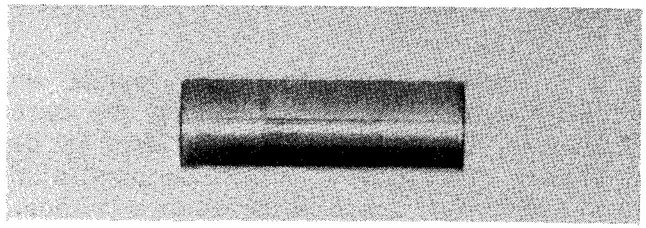
Use a cleaning solvent to remove the varnish from the piston skirts and pins. **NEVER** use a wire-brush on any part of the piston. Clean the ring grooves with a groove cleaner and make sure the oil ring holes and slots are clean. Inspect the pistons for cracked ring lands, skirts, or pin bosses; wavy or worn ring lands; scuffed or damaged skirts; and eroded areas at the top of the pistons.

Replace any piston that is damaged or shows signs of excessive wear. Inspect the grooves for nicks or burrs that might cause the rings to hang-up. Measure the piston skirt (across the centerline of the piston pin) and check the clearance in the cylinder bore. Compare your measurement with the limits given in the Specifications in the Appendix.

The pistons are cam-ground, which means the diameter at a right angle to the piston pin is more than the diameter parallel to the piston pin. When a piston is checked for size, it must be measured with micrometers applied to the skirt at points 90° to the piston pin. The piston should be measured for fitting purposes 1/4" below the bottom of the oil ring groove.



Cylinder wall taper and wear measured with a bore gauge indicator.

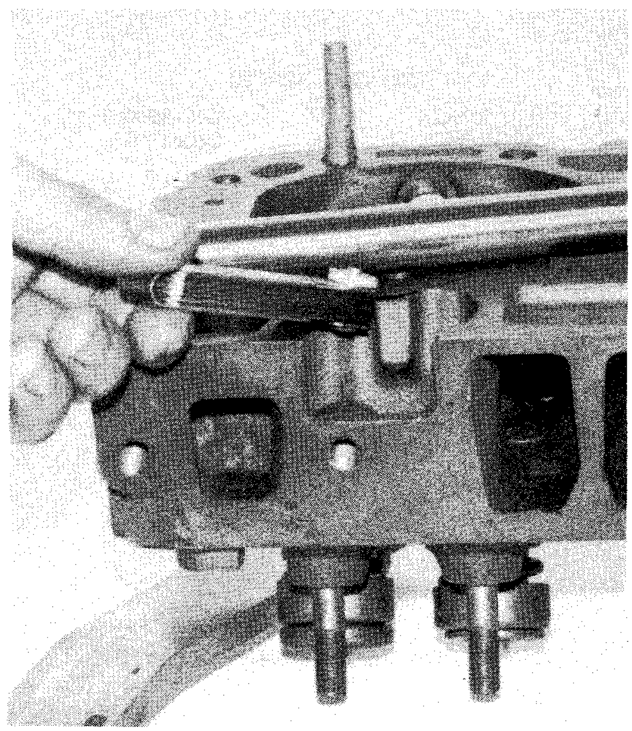


Three measurements with a micrometer should be made to determine piston pin wear. One, on the unworn section (center), the second and third, on both ends. Comparing any difference will indicate the amount of wear.

Inspect the piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured with a dial bore gauge or an inside-micrometer. If the clearance is greater than 0.0001", the piston and/or piston pin should be replaced.

Inspect the bearing surfaces of the piston pins. Use a micrometer to check for wear by measuring the worn and unworn surfaces. Rough or worn pins **MUST** be replaced. Test the fit of each pin with its piston boss. If the boss is warn out-of-round, the piston and pin assembly **MUST** be replaced.

The pistons are locked in the rod by a press fit and the pins turn in the pistons.



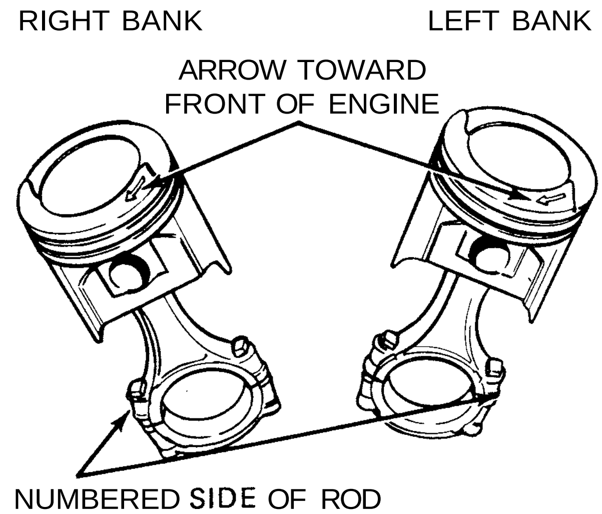
The cylinder head gasket surface must be checked for any uneven condition. Surface irregularities MUST NOT exceed 0.003" in any six-inch space.

RINGS

The glazed cylinder walls should be slightly dulled without increasing the bore diameter, if new piston rings are to be installed. This glazing is best accomplished using the finest grade of stones of a cylinder hone. The cylinder bores and piston grooves must be clean, dry, and free of any carbon deposits or burrs. New piston rings must be checked for clearance in the piston grooves and for end gap in the cylinder bores.

Compression rings in all engines are the deep section twist type. This type of compression ring takes its name from the fact that after it is installed, it is cocked or twisted slightly. These rings maintain this position for the life of the ring because the upper edge of its diameter is beveled making the ring unbalanced in cross-section.

The oil-control rings consist of two segments (rails) and a spacer. Piston rings are furnished in standard sizes and 0.010", 0.020", 0.030", and 0.040" oversize. To check the end gap of compression rings, first place each ring in the cylinder into which it will be used. Next, square the ring in the bore using the upper end sf a piston. Now measure the gap with a feeler gauge. Compare your measurement for each ring gap with the clearances given in the Appendix. If the gap is less than specified, the ends of the ring can be filed carefully with a fine. file until the proper gap is reached.



View looking AFT to indicate piston and rod location for both banks-of a Ford V8 engine.

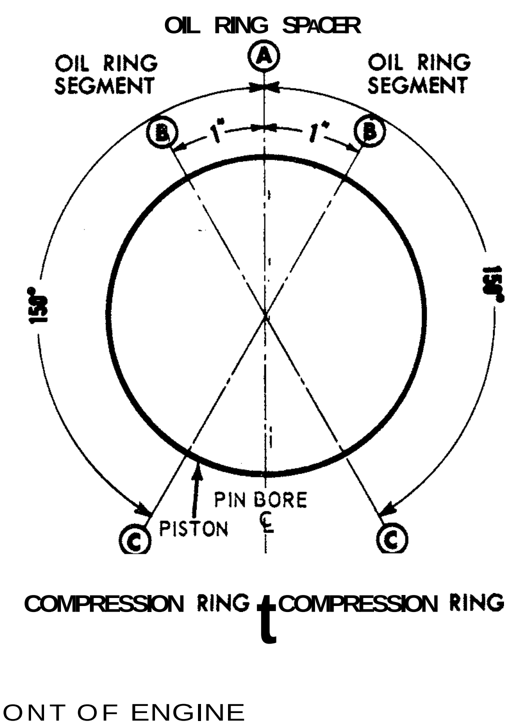
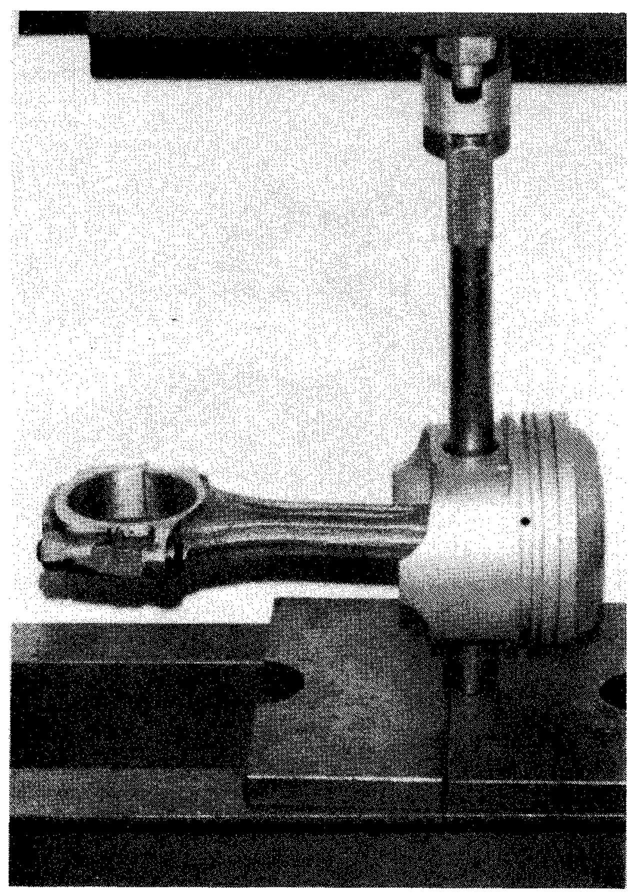


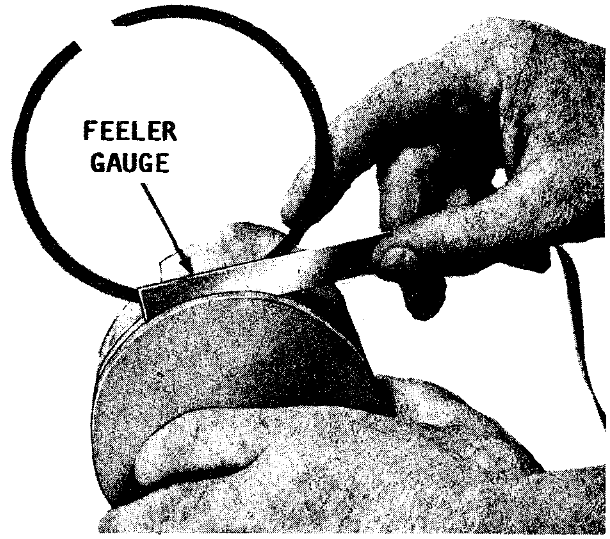
Diagram of piston ring spacing.



An arbor press and special tool should be used to press the pin through the piston.

After the rings are installed on the piston, the clearance in the grooves needs to be checked with a feeler gauge. Check the clearance between the ring and the upper land and compare your measurement with the Specifications. Ring wear forms a step at the inner portion of the upper land. If the piston grooves have worn to the extent to cause high steps on the upper land, the step will interfere with the operation of new rings and the ring clearance will be too much. Therefore, if steps exist in any of the upper lands, the piston should be replaced.

If new rings are installed on new pistons, the end gap should be checked and compared with specifications. If the ring gap is less or greater than the specified limits, try another ring set.

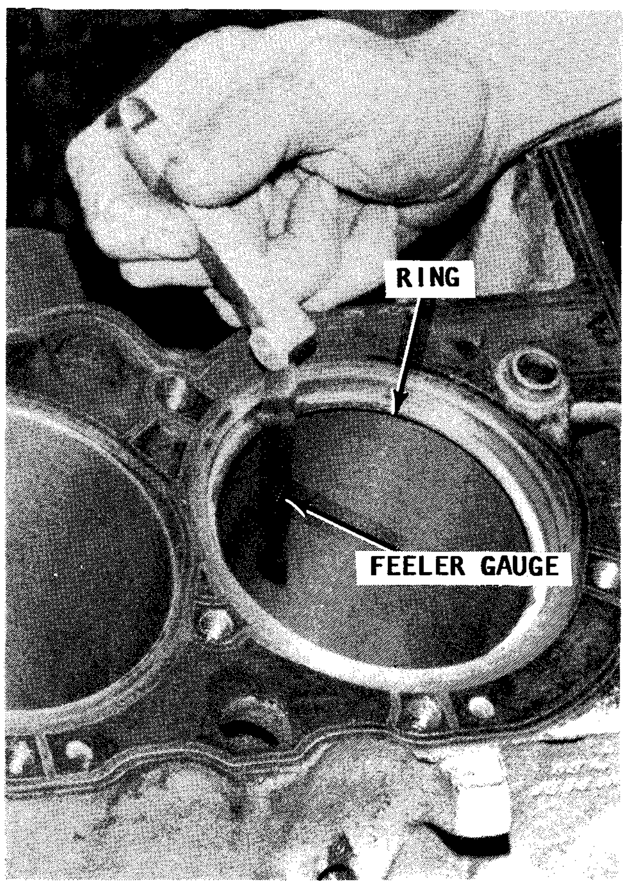


The piston ring side clearance ***MUST NOT*** *exceed 0.004".*

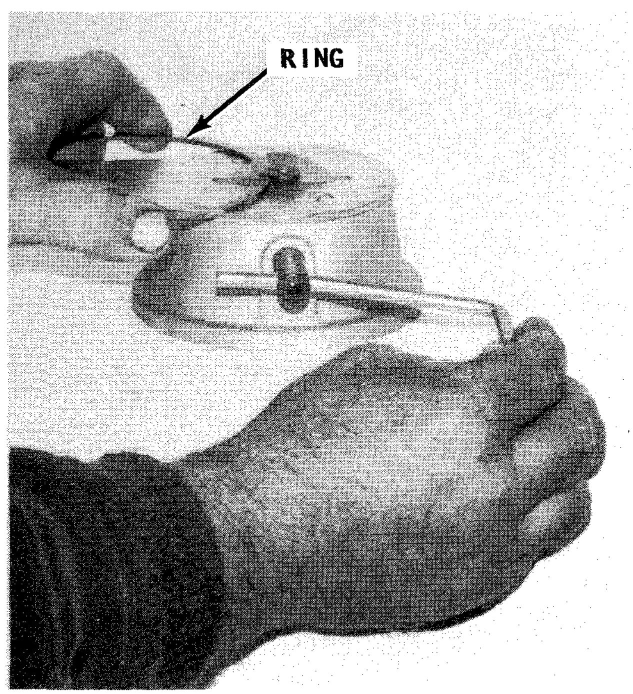
PISTON ASSEMBLING

Begin, by assembling the piston pin, rod, and piston. Lubricate the piston pin holes in the piston and connecting rod as an aid to the pin sliding into position. Insert the connecting rod in the piston with the numbered side of the rod facing outboard and the arrow on the piston facing forward when installed in the block, as shown in the illustration, previous page. Press the pin into place, and then keep the assembly in order to ensure it will be installed in the correct bank of the block.

If new piston rings are to be installed, remove the cylinder wall glaze with a cylinder hone. **TAKE EXTRA CARE** to remove all traces of abrasives as a prevention against excessive wear.



Check the piston ring end gap with a feeler gauge, as shown.



Grinding ring ends to obtain proper end gap, if another ring set with the desired gap cannot be found.

Slide the outer surface of each ring into the piston ring groove, and then roll the ring completely around the piston to be sure the ring is free and does not bind in the groove at any point. The side clearance is the distance between the ring and the upper land of the piston. Check the side clearance of each ring on each piston and compare the measurement with the limits given in the Specifications in the Appendix.

Install the oil ring spacer in the oil ring groove and position the gap in line with the piston pin hole. Hold the spacer ends butted, and install a steel rail on the top side of the spacer. Rotate the rail until the gap is at least 1-inch to the left of the spacer gap. Install the second rail on the lower side of the spacer. Rotate the rail until the gap is at least 1-inch to the right of the spacer gap. Rotate the oil ring group in its groove to be sure the ring is free and does not bind in the groove at any one point.

PISTON INSTALLATION

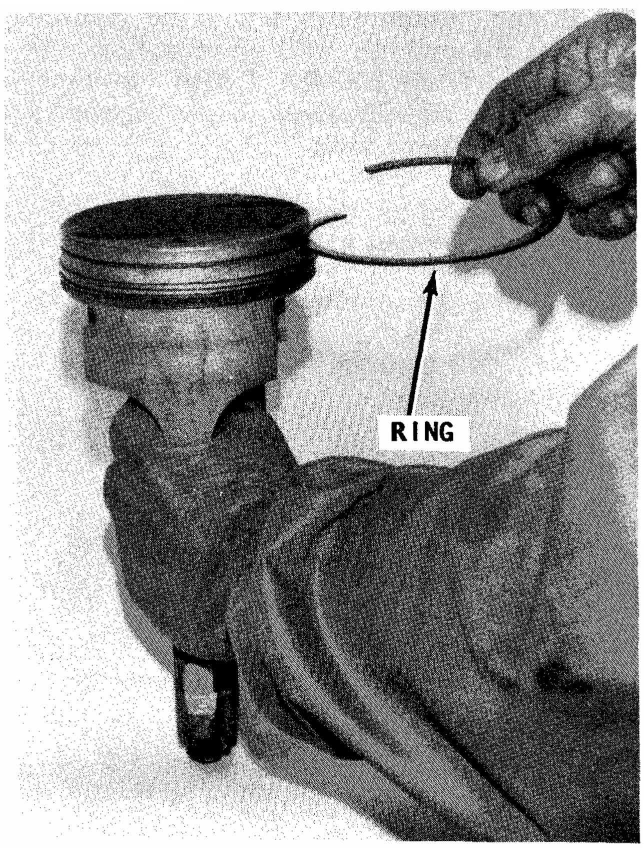
Apply a liberal amount of light engine oil to the piston rings, pistons, and cylinder walls. TAKE TIME to check the position of the ring gaps to be sure they are properly spaced around the circumference of the piston according to the previous paragraphs.

Compress the rings with a ring compressor. STOP at this point. Four areas call for SPECIAL ATTENTION.

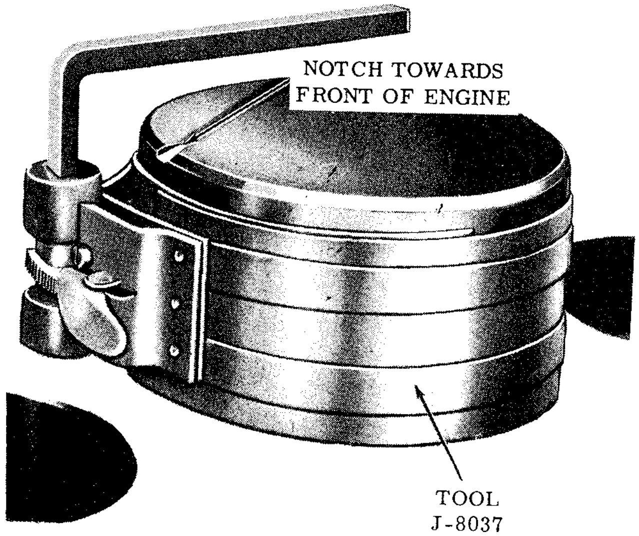
ONE, be sure the arrow on the top of the piston is facing forward. **TWO,** verify that each used assembly is being installed in the same cylinder from which it was removed. THREE, the numbers on the connecting rods and the bearing caps must be on the outboard side when the rod is installed in the cylinder bore. FOUR, take care to guide the connecting rods during the piston installation to prevent damaging the crankshaft journals.

Push the piston into the cylinder with a hammer handle. Continue pushing the piston into place until the top of the piston is slightly below the surface of the block.

Rotate the crankshaft until the throw for the piston being installed is at the bottom of its stroke. Now, push the piston all the way down until the connecting rod



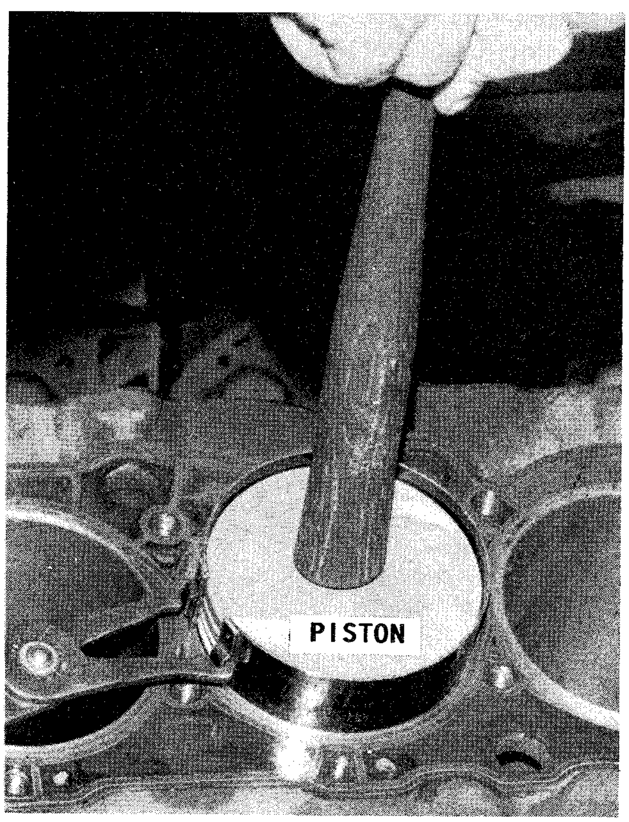
Proper installation of a new ring into the piston ring groove. Notice how the ring is bent slightly upward (left). After the ring is started, the ring is rotated around and over the top of the piston (right). The ring will feed into the groove and the end will finally snap into place.



A piston ring expanding tool must ALWAYS be used when installing the rings onto the piston. If such a tool is not used, the ring may be distorted and bind in the ring groove.

bearing seats on the crankshaft journal. Install the connecting rod cap. Tighten the cap nuts to the torque value given in the Specifications in the Appendix.

After all of the piston assemblies have been installed and the connecting rod cap



Installation of a well-lubricated piston and ring assembly into its proper cylinder. NEVER hammer on the piston head because a ring may have popped out of its groove and be broken.

nuts tightened to the required torque value, check the side clearance between the connecting rods on each crankshaft journal. Compare your measurement with the limits given in the Specifications.

Install the oil pump; see Section 3-36. **BE SURE** to prime the oil pump prior to installation.

Install the cylinder heads; see Section 3-39.

Install the intake manifold; see Section 3-38.

Install the exhaust manifolds; see Section 3-37.

Install the engine; see Section 3-34.

Fill the crankcase with the proper weight oil.

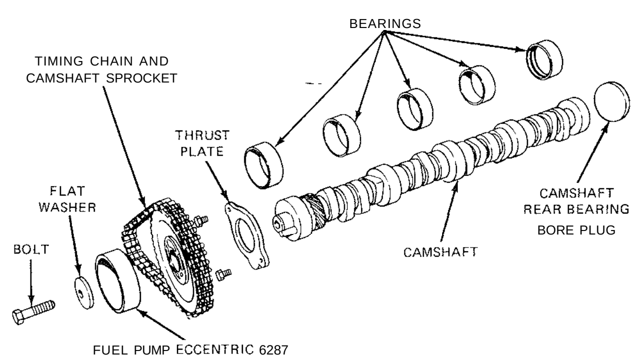
Start the engine and check for leaks.

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.

After the engine temperature has stabilized, adjust the engine idle speed and idle fuel mixture, see Chapter 4.

3-42 CAMSHAFT SERVICE

If the engine is to perform properly, the valves must open and close at a predetermined precise moment. On the power stroke, the exhaust valve must open just before bottom dead center in order to permit the exhaust gases to leave the combustion chamber under the remaining pressure (blowdown). On the exhaust stroke, the intake valve must open just before top dead center in order to permit the air-fuel mixture to enter the combustion chamber. The movement of the valves is a function of the camshaft design and the valve timing. Therefore, excessive wear of any camshaft part will affect engine performance.



Camshaft and associated parts.

CAMSHAFT LOBE LIFT TEST PROCEDURE

The camshaft lobe lift measurement is made to determine if the camshaft lobe is worn and the camshaft and the lifter operating on the worn lobe must be replaced.

Remove the valve rocker arm covers. Remove the rocker arm stud nut, fulcrum seat and rocker arm. Use the adapter for the ball-end push rods. Remove the pedestal mounted rocker arms. **MAKE SURE** the push rod is in the valve lifter socket. Install a dial indicator in such a manner as to have the ball socket adapter of the indicator on the end of the push rod and in the same plane as the push rod movement.

Connect an auxiliary starter switch in the the starting circuit. Crank the engine with the ignition switch OFF. Turn the crankshaft over in small amounts until the tappet or lifter is on the base circle of the camshaft lobe. At this point, the push rod will be in its lowest position.

Set the dial indicator at **Zero.** Rotate the crankshaft slowly until the push rod is in the fully raised position, as determined when the dial indicator is at the highest reading. Now, compare the total lift recorded on the indicator with the Specifications in the Appendix.

To double check the accuracy of your reading, continue to rotate the crankshaft until the dial indicator is back to Zero. If the lift on any lobe is below specified wear limits, the camshaft and the valve lifter(s) operating on the worn lobe(s) **MUST** be replaced.

Remove the dial indicator and the auxiliary starter switch. Install the rocker arms. After the rocker arms have been installed DO **NOT** rotate the crankshaft until the hydraulic valve lifters have had enough time to bleed down, or serious damage may be caused to the valve.

Install the rocker arm covers.

Start the engine and check for leaks.

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,

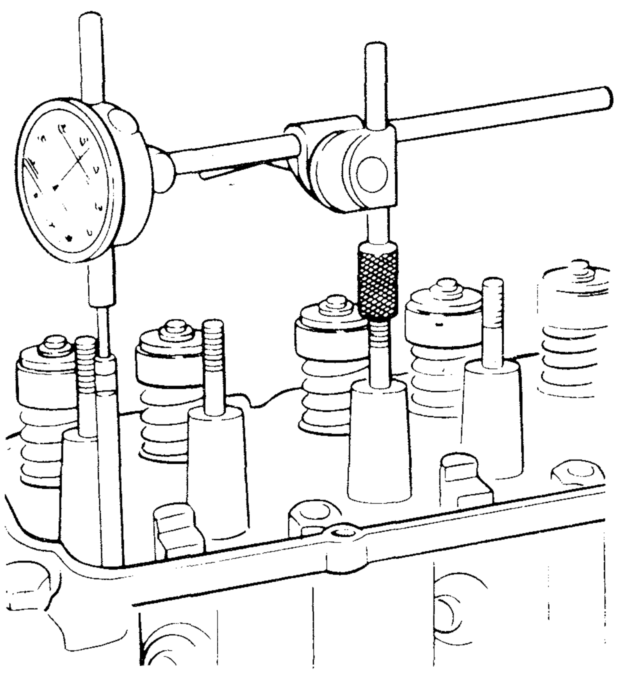
CAMSHAFT REMOVAL

Remove the intake manifold; see Section 3-38.

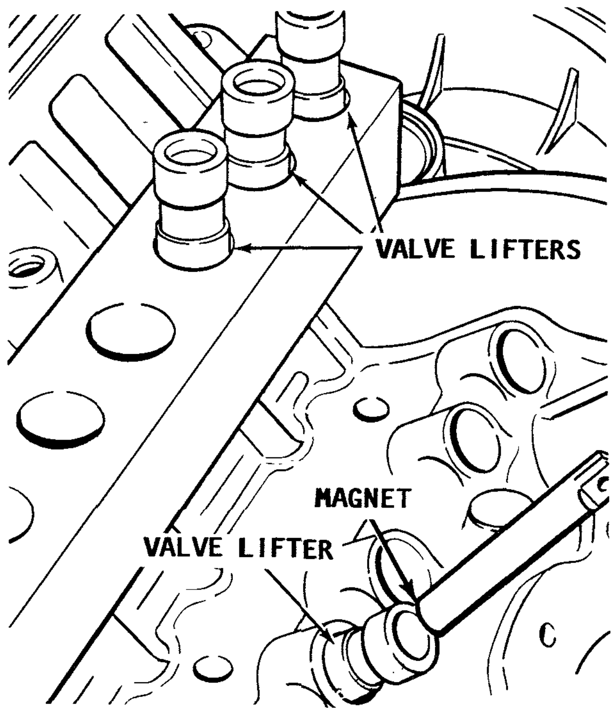
Remove the timing chain and camshaft sprocket; see Section 3-45.

Pull the spark plug wires from the brackets on the rocker arm covers. Remove the spark plug wires from the spark plugs.

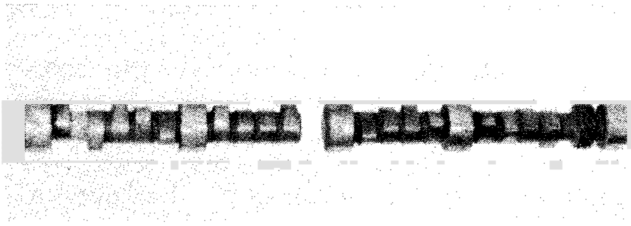
Remove the rocker arm covers. Loosen the rocker arm nuts, and then turn the rocker arms aside.



Checking the cam shaft lift using a special tool inserted through the push rod hole in the head.



Remove the valve lifter with a magnet.



***ALWAYS** handle the camshaft carefully to prevent damage to the bearings or the lobes.*

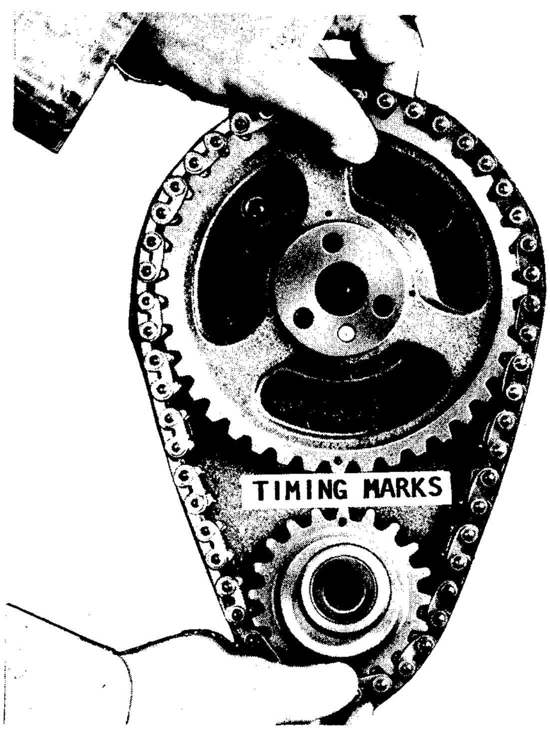
Set up some kind of system to hold the push rods, and then remove each one in order so they will be installed back in the identical hole from which they were removed.

TAKE CARE not to get any dirt into the engine paticularily into the valve lifters. Use cloths and compressed air to clean the cylinder heads and adjacent parts.

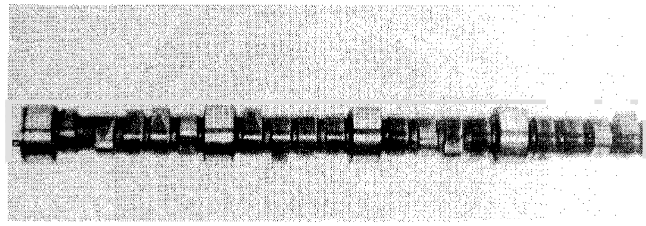
Remove the valve lifters with a magnet and keep them in order. Each MUST be installed into the same valve guide from which it was removed. If a valve lifter is stuck in its bore by excessive varnish or gum, a plier-type tool or a claw-type tool may be necessary in order to get it out. Rotate the lifter back-and-forth to loosen it from the varnish or gum.

Remove the fuel pump and push rod.

CAUTION: Be **sure to plug the fuel line** to **prevent fuel from siphoning out of the fuel tank.**



Removing the crankshaft sprocket, camshaft sprocket, and timing chain together as an assembly.



Example of damaged cam lobes.

After all of the lifters have been removed and placed in order, remove the camshaft thrust plate. CAREFULLY remove the camshaft by pulling it straight out the front of the engine.

CLEANING

Clean the camshaft with solvent and wipe the journals dry with a lint-free cloth. ALWAYS handle the shaft CAREFULLY to avoid damaging the highly finished journal surfaces. Blow out all of the oil passages with compressed air.

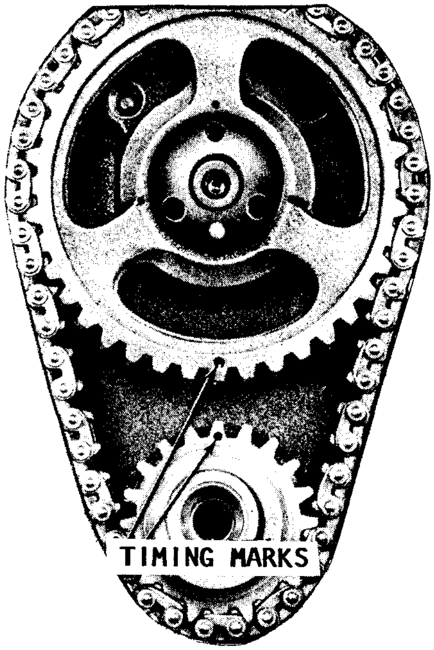
Clean the gasket surfaces on the block and crankcase front cover. Check the diameter of the five camshaft bearings with a micrometer for out-of-round condition, taper, and wear. If the journals are out-of-round more than 0.00 1", the camshaft should be replaced.

Inspect the camshaft lobes for scoring and signs of abnormal wear. Normal lobe wear may result in pitting in the general area of the lobe toe. This pitting is not detrimental to the operation of the cam shaft; therefore the camshaft need not be replaced unless the lobe lift loss has exceeded 0.005". The camshaft lobe lift can be checked with a dial indicator and the results compared with the specifications given in the Appendix.

Check the camshaft for alignment. This is best done using "V" blocks and a dial indicator. The dial indicator will indicate the exact amount the camshaft is out of true. If it is out more than 0.002" dial indicator reading, the camshaft should be replaced. When using the dial indicator in this manner the high reading indicates the high point of the shaft.

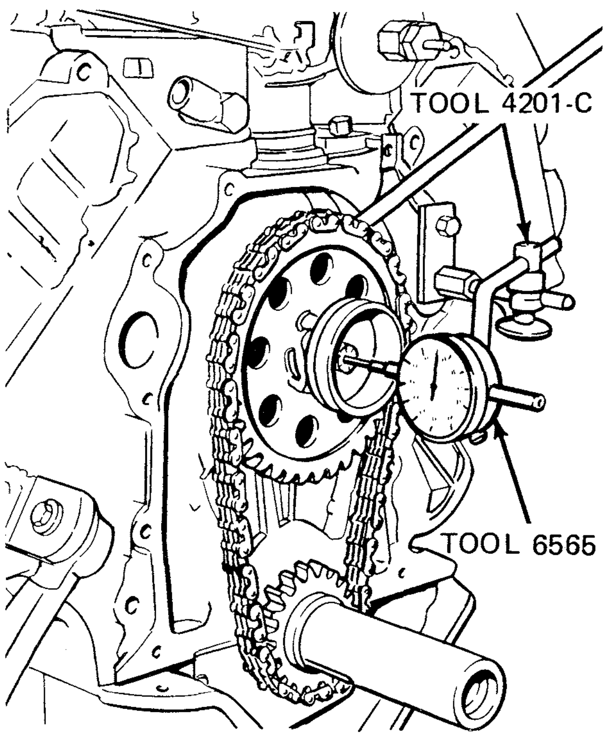
Remove any light scuffs, scores, or nicks from the camshaft machined surfaces with a smooth oil stone.

Check the cam shaft bearings. If any one needs to be replaced, replace ALL FIVE, never just one.



Align the timing marks through the centers of the camshaft and the crankshaft.

Check the distributor drive gear for broken or chipped teeth and replace the camshaft if the gear is damaged.



Checking end play on the camshaft.

CAMSHAFT BEARING SERVICE

Removal and replacement of the camshaft bearings should be performed by qualified mechanics in a shop equipped to handle such work. However, in most cases the block bores for the bearings can be bored to a larger size and oversize bearings installed. **BE SURE** to check with your local marine dealer for oversize bearings available.

CAMSHAFT INSTALLATION

Cover the camshaft journals with a coating of heavy engine oil and apply Lubriplate or equivalent to the camshaft lobes. If a new camshaft is being installed, coat the cam lobes with engine oil supplement, and then add the rest of the can's contents to the crankcase oil. **CAREFULLY** move the camshaft through the bearings into position. Install the camshaft thrust plate with the groove towards the cylinder block.

Check the camshaft end play by first pushing the camshaft towards the rear of the engine. Next, install a dial indicator in such a manner that the indicator point is on the camshaft sprocket attaching screw. Set the dial indicator at zero. Now, place a large screwdriver between the camshaft sprocket and the block. Finally, pull the camshaft forward and release it. Compare the dial indicator reading with the Specifications in the Appendix. If the end play is excessive, replace the thrust plate. Remove the dial indicator.

Lubricate the lifters and bores with heavy engine oil. Install the valve lifters **PAYING ATTENTION** that each one is replaced in the exact position from which it was removed.

Apply Lubriplate or equivalent to each end of the push rods and install the rods into the same guides from which they were removed. Coat the valve stem tips with Lubriplate, and then the rocker arms and fulcrum seats with heavy engine ail. Position the rocker arms over the push rods.

Install the intake manifold; see Section 3-38.

Install the timing gear cover; see Section 3-45.

Rotate the crankshaft until the No. 1 piston is at TDC at the end of the compression stroke, and then position the distributor in the block with the rotor at the No. 1 firing position and with the points just open. Install the hold down clamp.

Adjust the valve clearance; see Section 3-40.

Install the valve covers with NEW gaskets and tighten the attaching screws to the torque value given in the Specifications in the Appendix.

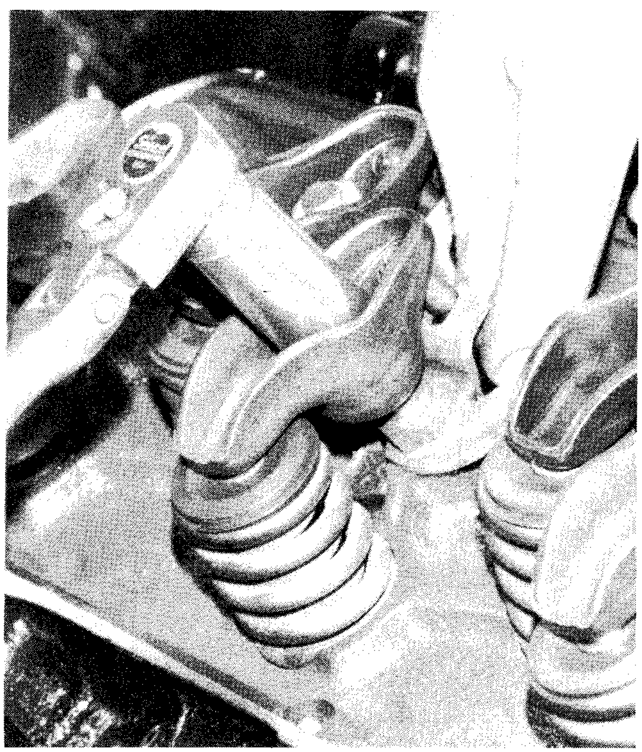
Start the engine and check for leaks.

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.

3-43 CRANKSHAFT AND MAIN BEARING SERVICE

Service work affecting the crankshaft or the crankshaft bearings may also affect the connecting rod bearings. Therefore, it is highly recommended that the rod bearings be carefully inspected as they are removed; see Section 3-30.

If the crankpins are worn to the extent that the crankshaft should be replaced or reground, then this work should be done in a qualified shop. Attempting to save time and money by merely replacing the crankshaft bearings will not give satisfactory engine performance.



Making the valve lash adjustment, as described in the text, see Section 3-40. There are three crankshaft positions for checking the valves, Page 3-102.

CRANKSHAFT REMOVAL

Remove the engine; see Section 3-34.

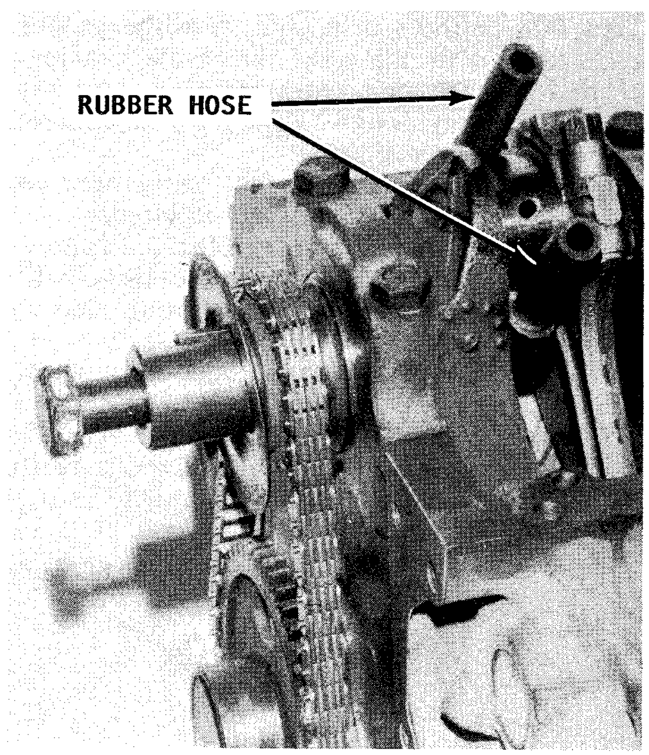
Remove the oil pan; see Section 3-35.

Remove the oil pump; see Section 3-36.

Remove the flywheel and coupler.

Remove each rod bearing cap; clean and inspect the lower bearing shell; and identify the cap plainly to ensure it will be installed onto the the same rod from which it was removed. Inspect each rod bearing journal surface. If the journal surface is scored or ridged, the crankshaft must be replaced or reground to ensure satisfactory service with the new bearings. A slight roughness may be polished out with fine-grit polishing cloth thoroughly wetted with engine oil. Burrs may be honed off with a fine stone.

Remove and inspect the main bearing caps and journals for signs of excessive wear. Identify each bearing cap to ensure it will be replaced in the same position from which it was removed. **CAREFULLY** remove the crankshaft from the block and support it on **"V"** blocks at the No. 1 and No. 4 main bearing journals.



Short pieces of a rubber hose should ALWAYS be used on the rod bolt threads to prevent damage to the bearing surface as the piston assembly is removed.

CLEANING

Clean the crankshaft with solvent and wipe the journals dry with a lint-free cloth. Inspect the main and connecting rod journals for cracks, scratches, grooves, or scores. Inspect the crankshaft oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or that might cause premature seal wear. **ALWAYS** handle the crankshaft carefully to avoid damaging the highly finished journal surfaces. Blow out all oil passages with compressed air. The oil passageway leads from the rod to the main bearing journal. **TAKE CARE** not to blow dirt into the main bearing journal bore.

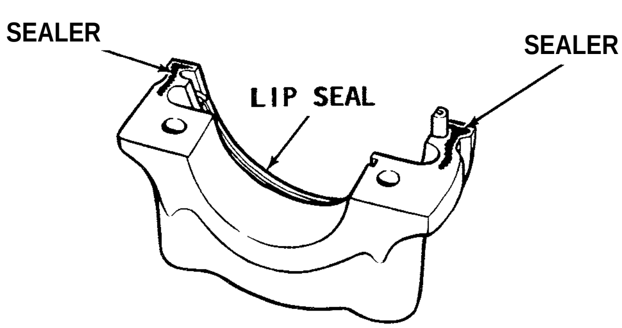
Measure the diameter sf each journal at four places to determine the out-of-round, taper, and wear. The out-of-round limit is 0,001"; the taper must not exceed 0.001"; and the wear limit is 0.0035". If any of these limits is exceeded, the crankshaft must be reground to an undersize, and undersized bearing inserts must be installed.

Dress minor scores with an oil stone. If the journals are severely marred or exceed the wear limit, they should be refinished to size for the next undersize bearing.

Refinish the journals to give the proper clearance with the next undersize bearing. If the journal will not clean up to the maximum undersize bearing available, replace the crankshaft.

ALWAYS reproduce the same journal shoulder radius that existed originally. A radius too small will result in fatigue failure of the crankshaft. A radius too large will result in bearing failure due to radius ride of the bearing.

After the journals have been refinished, bevel (chamfer) the oil holes, and then polish the journal with fine grit, No. 320, polishing cloth and engine oil. Crocus cloth may also be used as a polishing agent.



Places to apply sealer to the main bearing cap and the block to minimize the possibility of an oil leak.

CRANKSHAFT INSTALLATION

Remove the rear journal oil seal from the block. Remove the rear main bearing cap. Remove the main bearing inserts from the block and from the bearing caps.

Remove the connecting rod bearing inserts from the connecting rods and caps.

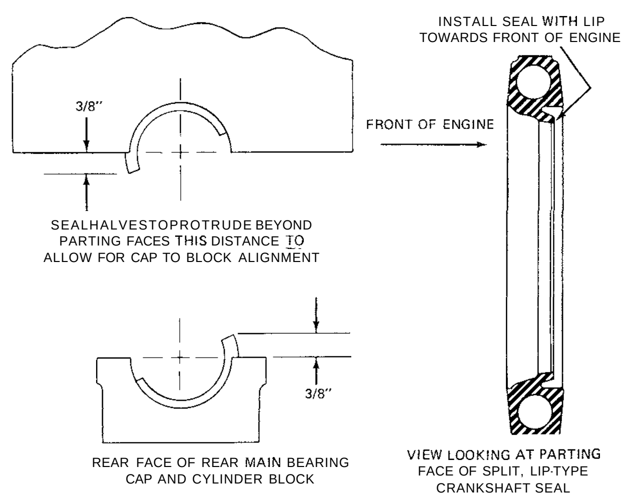
If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. BE **SURE** the bearing inserts and the bearing bores are clean. A very small amount of foreign material under the inserts could distort the bearing and cause a failure.

Place the upper main bearing inserts in position in the bores. **CHECK TO BE SURE** the tang indexes in the slot. Install the lower main bearing inserts in the bearing caps.

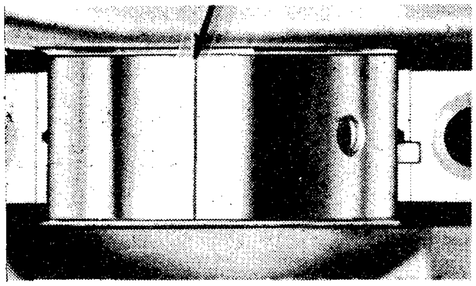
Clean the rear journal oil seal groove and the mating surfaces of the block and rear main bearing cap. Remove the oil seal retainer pin from the rear main bearing seal groove if one is installed. The retainer pin is not used with a split lip seal. Dip the lip seal halves in clean engine oil. Carefully install the seal halves in the block and in the rear main bearing cap with the **UNDERCUT** sides of the seal toward the **FRONT** of the engine and with approximately 3/8 inch protruding above the partial surface.

CAREFULLY lower the crankshaft into place. Be careful not to damage the highly finished journal surfaces.

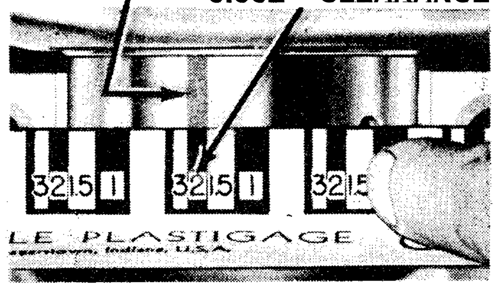
Plastigage is soluble in oil, therefore, clean the crankshaft journal thoroughly of all traces of oil, and then turn the crank-shaft until the oil hole is down away from



Details of the crankshaft rear oil seal installation.



INSTALLING PLASTIGAGE



MEASURING PLASTIGAGE

After the connecting rod cap has been properly tightened, and then removed, the flattened Plastigage can be compared with the scale on the side of the package and the amount of clearance accurately determined.

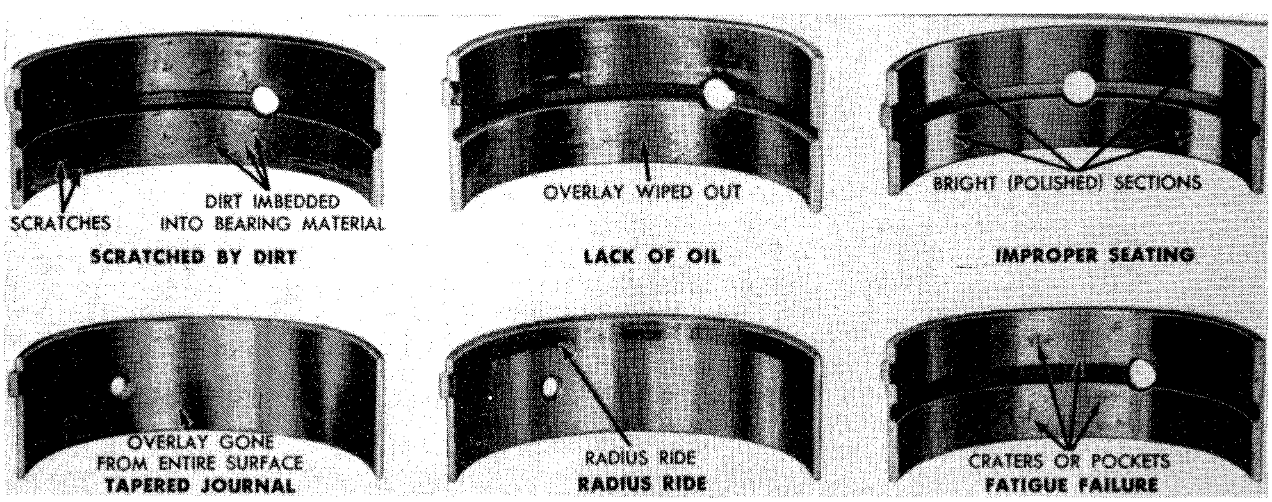
the cap to prevent getting any oil on the Plastigage. Whenever you turn the crankshaft with the rear bearing cap removed, hold the oil seal to prevent it from rotating out of position in the crankcase.

Place a piece of Plastigage on the bearing surface across the full width of the bearing cap and about 1/4 inch off center. Install the bearing cap, and then tighten the bolts to the torque value given in the Specifications in the Appendix. DO **NOT** turn the crankshaft while the Plastigage is in place.

Remove the bearing cap and measure the flattened Plastigage at its widest point using the scale printed on the Plastigage envelope. The number within the graduation which most closely corresponds to the width of the Plastigage indicates the bearing clearance in thousands of an inch. The widest point of the Plastigage is the minimum clearance and the narrowest point is the maximum clearance The difference between the readings indicates the taper of the journals. Compare your measurements with the Specificiations given in the Appendix.

If the clearance exceeds the limits given, try 0.001" or 0.002" undersize bearings in combination with the standard bearings. Bearing clearance must be within the specified limits. If 0.002" undersize main bearings are used on more than one journal, BE SURE they are all installed in the cylinder block side of the bearing. If standard and 0.002" undersize bearings do not bring the clearance within the specified limits, refinish the crankshaft journal, then install undersize bearings.

After the bearing has been fitted, apply a light coat of engine oil to the journal and the bearing. Install the cap and tighten the bolts to the torque value given in the Specifications in the Appendix.



Examples of various wear patterns on bearing halves, including possible reasons for the condition.

Repeat the procedure for the rear main bearing cap, and then for the remaining bearings except for No. 3 bearing, which is the thrust bearing. **CHECK TO BE SURE** each bearing cap has been installed in its original position and all of the cap bolts have been tightened to the required torque value.

Install the thrust, No. 3, bearing cap with the bolts finger tight. Pry the crankshaft forward with a large screwdriver against the thrust surface of the upper bearing half. Hold the crankshaft forward and at the same time, pry the thrust bearing cap to the rear. These movements will align the thrust surfaces of both halves of the bearings. Retain the forward pressure on the crankshaft, and tighten the cap bolts to the required torque value.

Force the crankshaft toward the rear of the engine. Install a dial indicator in such a position that the contact point rests against the crankshaft flange and the indicator axis is parallel to the crankshaft axis. Set the indicator to zero, and then push the crankshaft forward and note the reading. The reading will indicate the crankshaft end play. Compare your measurement with the limit given in the Specifications.

If the end play is less than the minimum limit, inspect both faces of the thrust bearing for scratches, burrs, nicks, or possible dirt.

If the thrust bearing faces are clean and not damaged, the problem of not enough end play is due to not having the thrust bearing properly aligned. Loosen the cap bolts and repeat the thrust bearing installation procedure. Check the end play again with the dial indicator.

After the main bearings have been properly installed and tightened to the required torque value, install the connecting rod caps; see Section 3-41. **TAKE TIME** to check the clearance of each rod bearing with Plastigage in the same manner as checking the main bearing clearance described earlier in this section. Compare your results with the Specifications. Oil the connecting rod bearings and crankshaft journals, then install the caps again and tighten the nuts to the required torque value.

Check the clearance between each connecting rod and its crankshaft journal and compare your measurement with the Specifications in-the Appendix.

Install the timing chain and sprockets, the cylinder front cover, and the crankshaft pulley and adapter; see Section 3-45.

Coat the threads of the flywheel attaching bolts with oil-resistant sealer. Position the flywheel on the crankshaft flange. Install and tighten the bolts to the required torque value given in the Specifications.

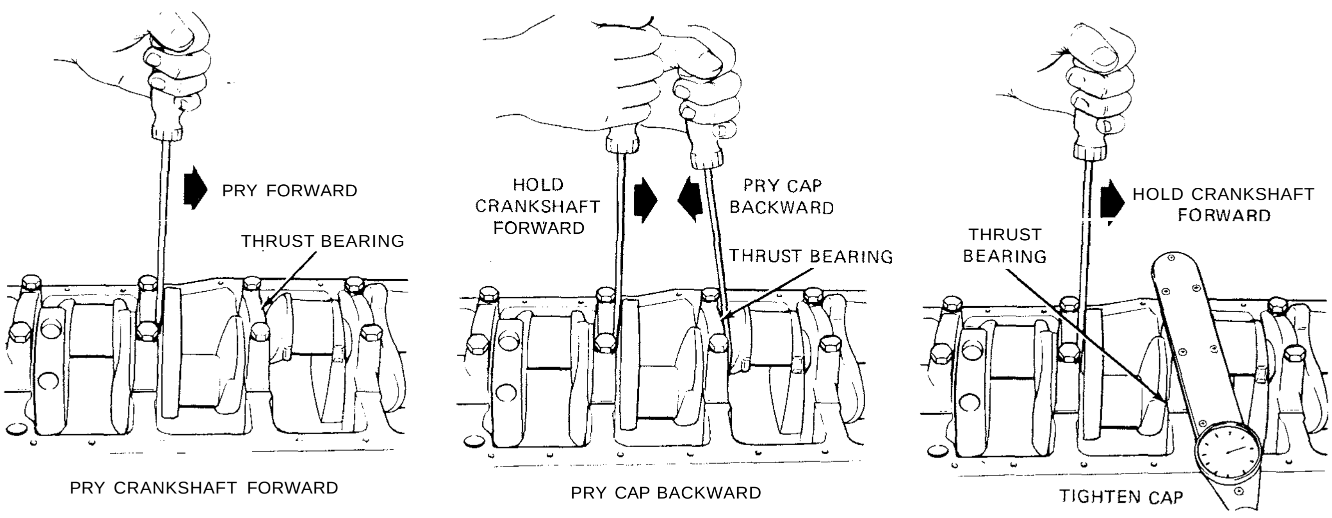
Install the oil pump; see Section 3-36. **BE SURE** to prime the oil pump.

Install the oil pan; see Section 3-35.

Install the oil filter and the fuel pump.

Install the engine; see Section 3-34.

Fill the crankcase with the proper weight oil.



The thrust bearing MUST be aligned properly before it is tightened. Alignment is accomplished by first prying the crankshaft forward, then prying the main bearing cap backward, and finally tightening the bolts to the torque value given in the Specifications in the Appendix.

Start the engine and check for leaks.

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.

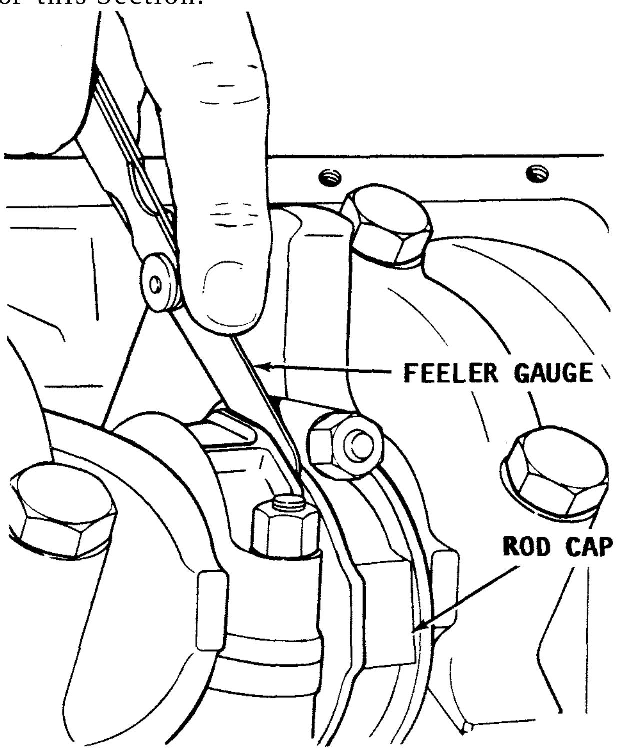
3-44 SERVICING MAIN BEARINGS AND/OR SEALS

REMOVAL

Remove the engine; see Section 3-34.
Remove the oil pan; see Section 3-35.
Remove the oil pump; see Section 3-36.

Remove the main bearing cap to which new bearings are to be installed. Work on **ONE** bearing at a time. Do not move on to the next, until the bearing cap bolts have been tightened to the torque value given in the Appendix.

Insert the upper bearing removal tool (Tool 6331) in the oil hole in the crankshaft. If the tool is not available, a cotter pin may be bent as required to do the job. Rotate the crankshaft clockwise as viewed from the front of the engine to roll the upper bearing out of the block. If you have difficulty removing the bearing, it may be necessary to remove the crankshaft; see the first part of this Section.



The connecting side clearance should be between. 0.010" to 0.020".

Clean the crankshaft journal with solvent and wipe it dry with a lint-free cloth. Inspect the journals and thrust faces (thrust bearing) for nicks, burrs, or bearing particles that would cause bearing wear.

If the rear main bearing is being replaced, remove and discard the rear oil seal from the bearing cap. In order to remove the block half of the rear oil seal, it will be necessary to loosen all of the main bearing cap bolts, and then to raise the crankshaft just a hair (not over 1/32 inch).

The oil seal in the cylinder block may be removed with a seal removal tool or by inserting a metal screw into one end of the seal and then pulling on the screw to remove the seal. **USE EXTRA CARE** when working around the journals not to scratch or damage the highly finished surfaces in any way.

Remove the oil seal retaining pin from the bearing cap, if one is installed. The retaining pin is not used with a split-tip seal.

INSTALLATION

Installation of upper **No.** 1, 2, and 4 main bearings. Place the plain end of the bearing over the shaft on the locking tang side of the block. Partially install the bearing to permit Tool 6331 to be inserted into the oil hole in the crankshaft. Insert the tool, and then rotate the crankshaft counterclockwise (when viewed from the front of the engine) until the bearing seats in position. Remove the tool. Apply a light coating of oil to the journal and bearing cap. Install the bearing cap and tighten the cap bolts to the torque value given in the Specifications in the Appendix.

Installation of the **No. 3,** thrust bearing: Apply a coating of engine oil to the journal and the bearing cap. Install the bearing cap, but bring the cap bolts up just **FINGER-TIGHT.**

Now, **RELEASE** the pressure on the other bearing caps to approximately **ONE-HALF** the required torque value. Pry the crankshaft forward against the thrust surface of the upper half of the bearing. Hold the forward pressure on the crankshaft and at the same time tighten the thrust bearing cap bolts to the specified torque value.

Installation of the **REAR MAIN BEARING:** First, clean the oil seal groove with a brush and lacquer thinner. If the bearing cap is equipped with a retaining pin, remove the pin. The pin is not used with a split lip seal.

Next, install the lower seal in the rear main bearing cap with the **UNDERCUT SIDE** of the seal toward the **FRONT** of the engine. Permit the seal to extend about 3/8 inch above the parting surface in order for it to mate with the upper seal when the cap is installed.

Dip both halves of the split lip-type seal in engine oil. Install the upper seal into its groove in the cylinder block with the **UNDERCUT SIDE** of the seal toward the **FRONT** of the engine. This is accomplished by rotating it on the seal journal of the crankshaft until about 3/8 inch extends below the parting surface. Check to be sure **NO RUBBER** has been shaved from the outside diameter of the seal by the bottom edge of the groove. DO **NOT** allow oil to get on the sealer area.

Tighten the cap bolts to the specified torque value.

Install the oil pump, see Section 3-36. **BE SURE** to prime the pump.

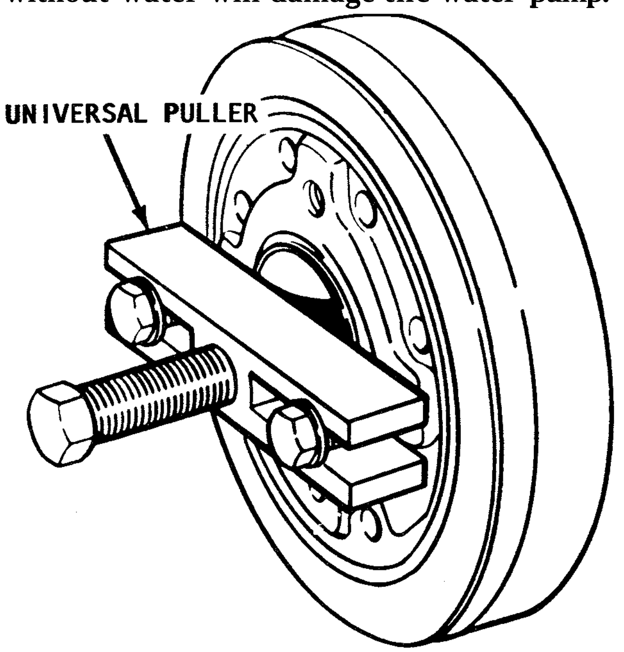
Install the oil pan; see Section 3-35.

Install the engine; see Section 3-34.

Fill the crankcase with the proper weight oil.

Start the engine and check for leaks.

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.



Using a puller to remove the crankshaft vibration damper.

3-45 TIMING CHAIN

The camshaft is driven at half-engine speed by a single-row chain and a sprocket on the crankshaft. Timing chains are subject to stretching after prolonged use, and, therefore, require replacement. Access to the chain is gained by first removing the timing chain cover.

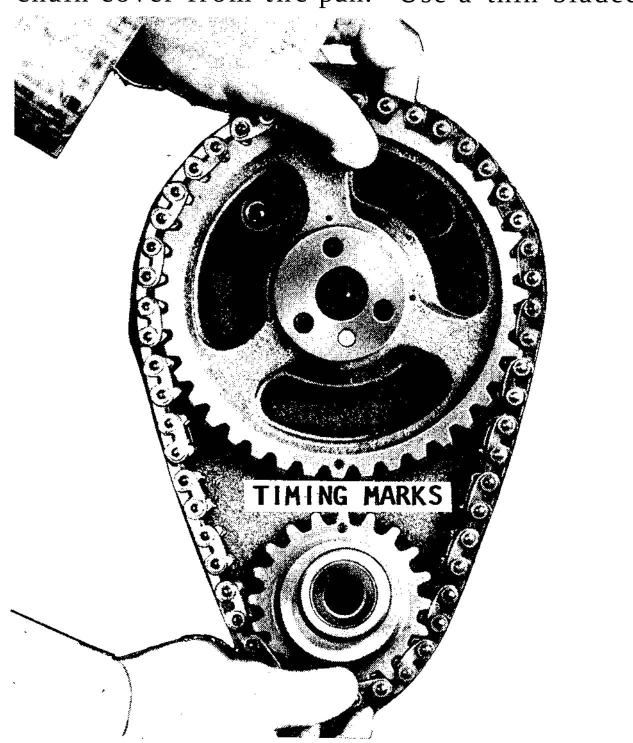
REMOVAL

Drain the water from the block. Remove the alternator drive belt. Remove all accessory brackets attached to the water pump. Remove the water pump pulley. Disconnect the water hoses from the water pump. Remove the bolts attaching the pump to the timing chain cover.

Drain the crankcase. Remove the crankshaft pulley from the crankshaft vibration damper. Remove the bolt and washer attaching the damper to the crankshaft. Install a puller onto the damper, and then remove the damper.

Disconnect the outlet line from the fuel pump. Remove the bolts attaching the fuel pump, and then move the fuel pump to one side out of the way with the inlet line still connected.

Remove the bolts attaching the timing chain cover from the pan. Use a thin bladed

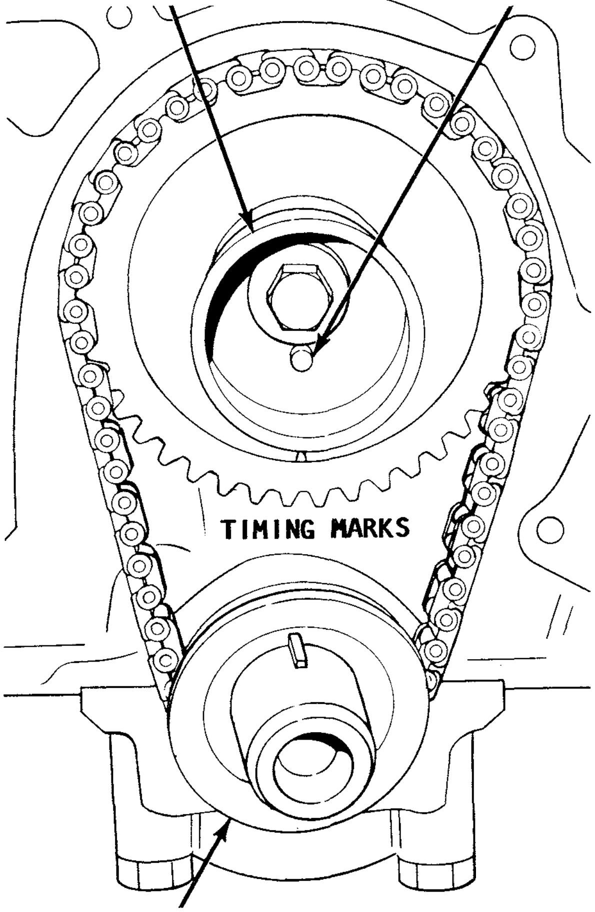


Align the timing marks on both sprockets through the center of the shafts.

knife to cut the oil pan gasket flush with the block face **BEFORE** separating the cover from the block. Cutting the pan gasket at this time means you do not have to remove the pan in order to replace the front part of the pan gasket when installing the timing chain cover. Remove the timing chain cover and the water pump together as an assembly. Discard the cover gasket. Remove the crankshaft front oil slinger.

Reinstall the damper attaching bolt into the crankshaft. Remove the spark plugs from both banks. With a socket wrench on the damper bolt head, rotate the crankshaft clockwise until the timing mark on the camshaft sprocket aligns with the timing mark on the crankshaft sprocket, as shown in the accompanying illustration.

Remove the camshaft sprocket cap screw, washers, and the fuel pump eccentric. Slide both sprockets forward and clear of the shafts with the chain still engaged.



Alignment of the timing marks through the centers of the crankshaft and the camshaft.

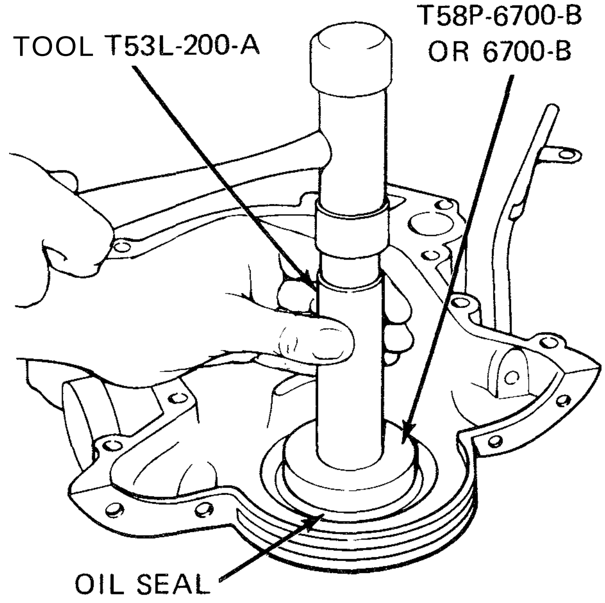
INSTALLATION

Position the key in the keyway of the crankshaft. Lay out the camshaft sprocket and the crankshaft sprocket with the timing marks aligned opposite each other, as shown. Now, engage the chain onto both sprockets, then slide both sprockets onto their shafts with the timing marks still aligned through the center of the shafts and the keyway of the crankshaft sprocket aligned with the key. Continue pushing both sprockets at the same time until they are fully seated. **NEVER** try to drive the sprocket onto the camshaft because the **WELSH** PLUG at the rear of the engine will be dislodged.

Install the fuel pump eccentric, washers, and camshaft sprocket cap screw. Tighten the cap screw to the torque value given in the Specifications in the Appendix. Install the crankshaft front oil slinger.

Clean the gasket surfaces of the timing chain cover, the oil pan, and the engine block. Install a new oil seal in the timing chain cover. **ALWAYS** use a new oil seal. Attempting to use the old seal is just asking for an oil leak and you will probably get one.

Apply a coating of engine oil to the timing chain. Lay down a bead of sealer onto the gasket surface of the oil pan. Cut, and then position the required section of a new gasket onto the oil pan. Lay down a second bead of sealer on top of the pan



Installation of a new oil seal in the timing case. A new seal should ALWAYS be installed or an oil leak at this point will surely develop.

gasket section. Now, coat the gasket surface of the timing chain cover and the mating surface of the block with sealer. Place a new gasket in position on the block.

CAREFULLY place the timing chain cover in position on the block, without damaging the seal or allowing the gasket to slip out of alignment.

Install a timing chain cover alignment tool. This tool is **NECESSARY** to ensure the seal makes even contact all around the crankshaft to prevent the possibility of an oil leak at this point.

Push downward on the cover, and while holding the cover in this position, install the pan-to-cover attaching bolts. Coat the cover-to-block attaching bolts with oil-resistant sealer, and then install the bolts. Tighten all of the bolts to the required torque value given in the Specifications in the Appendix. Remove the alignment tool.

Apply a coating of Lubriplate or equivalent to the oil seal rubbing surface of the inner hub of the vibration damper, to prevent damage to the seal. Cover the crankshaft with a coating of engine oil. Align the crankshaft vibration damper keyway with the key on the crankshaft, and then slide the damper onto the crankshaft. Install the cap screw and washer. Tighten the cap screw to the required torque value given in the Specifications.

Install the fuel pump with a **NEW** gasket. Connect the fuel outlet line to the fuel pump.

Remove any old gasket material from the water pump and mating surface of the timing chain cover. Coat both sides of a **NEW** gasket with sealer. Lay a bead of sealer onto the mating surfaces of the water pump and the timing chain cover. Install the water pump and tighten the attaching bolts to the required torque value given in the Specifications.

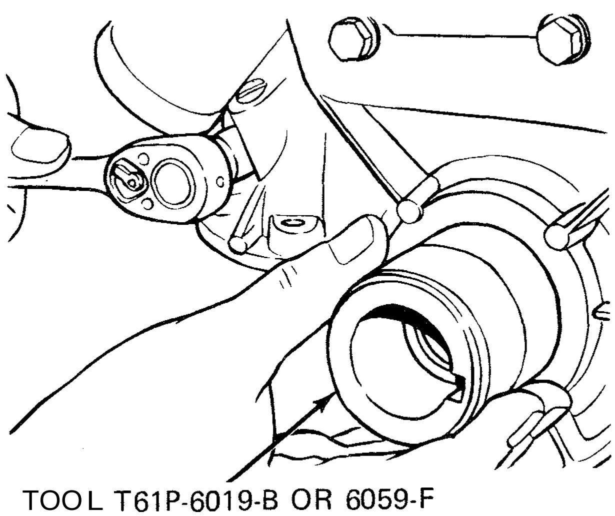
Connect the water hoses to the water pump. Install any accessory brackets which were removed from the water pump. Install the water pump pulley on the water pump shaft. Install the alternator, and the drive belt. Adjust the drive belts for proper tension.

Fill the crankcase with the proper weight oil.

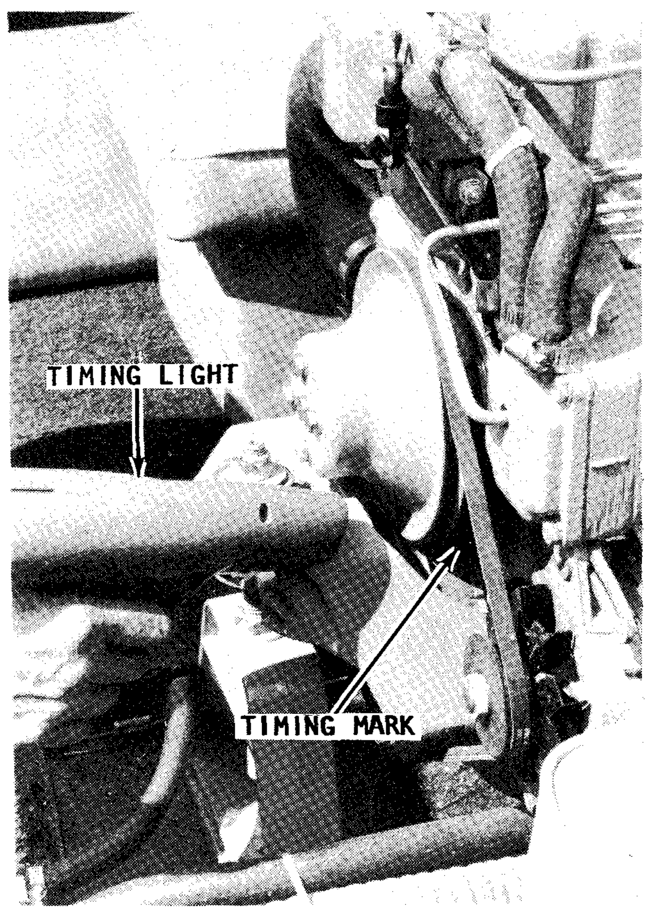
Close the water drain valves.

Start the engine and check for leaks.

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 centering gauge **MUST** be used to install the front cover to ensure the seal makes even contact around the crankshaft. If the seal is not installed properly, an oil leak will develop at this point.*



Using a timing light to accurately adjust the ignition timing to the manufacturer's specifications. Performance and fuel consumption are both directly dependent on precise timing.

4 FUEL

The fuel system includes the fuel tank, fuel pump, fuel filters, carburetor, connecting lines, and the parts associated with these items. Regular maintenance of this system, as an aid to satisfactory performance from the engine, is limited to changing the fuel filter and cleaning the flame arrester at regular interval$.

If a sudden increase in gas consumption is noticed, or if the engine does not perform properly, and if the flame arrester has been checked and found to be clean, then an overhaul, including boil-out, of the carburetor, or replacement of the fuel pump may be in order.

FUEL SYSTEM TROUBLESHOOTING

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.

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. Would you believe, a good majority of starting troubles which are traced to the fuel system are the result of an empty fuel tank and to aged fuel.

Fuel will begin to sour in three to four months and will cause engine starting problems. A fuel additive such as Sta-Bil may be used to prevent gum from forming during storage or prolonged idle periods.

If the automatic choke should stick in the open position, the engine would have trouble starting. This condition can be quickly corrected by rapid movement of the accelerator which will discharge fuel into the intake manifold and the engine will start.

If the automatic choke should stick in the closed position, the engine will flood making it very difficult to start. To correct this condition, move the fast idle or warm up lever to the wide-open position as the engine is cranked. This action will activate the unloader linkage to open the choke valve and help the flooded engine to start.

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. All carburetors are vented to allow this pressure to escape to the atmosphere. However, some of the fuel may percolate over the high-speed nozzle and overflow into the intake manifold.

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 open the throttle as wide as possible and to crank the engine until enough air is drawn in to provide the proper mixture for the engine to start. **NEVER** move the throttle lever back-and-forth in an attempt to start a hot engine. This action will only compound the problem by adding more fuel to an already too-rich mixture.

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 or 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 compartment during this test. Therefore, guard against fire by grounding the high-tension wire to prevent it from sparking.

The high tension wire between the coil and the distributor can be grounded by either pulling it out of the distributor cap and graunding it, or by connecting a jumper wire from the primary (distributor) side of the ignition coil to a good ground.

Disconnect the fuel line at the carburetor. Place a suitable container over the end of the fuel line to catch the fuel discharged, and then crank the engine. If the fuel pump is operating properly, a healthy stream of fuel should pulse out of the line.

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.

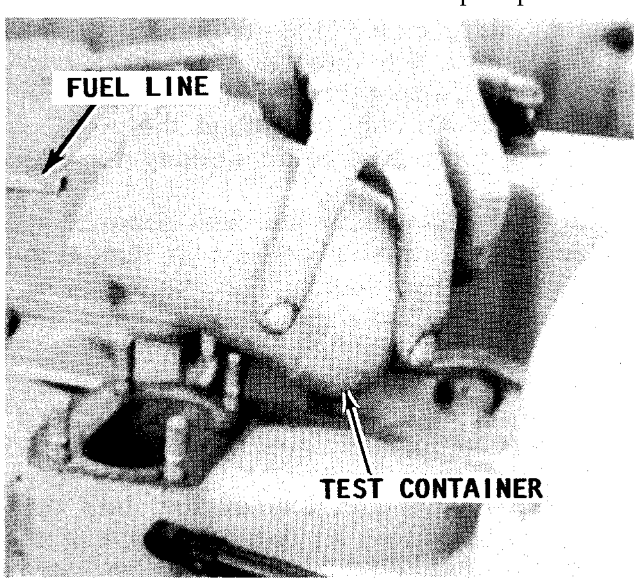
Continue cranking the engine and catching the fuel for about 15 pulses to determine if the amount of fuel decreases with each pulse or maintains a constant amount. A decrease in the discharge indicates a restriction in the line. If the fuel line is plugged, the fuel stream may stop. If there is fuel in the fuel tank but no fuel flows out of the fuel line while the engine is being cranked, the problem may be in one of three areas:

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 or the line may be leaking air.

The following test explores these possibilities.



Test setup to check fuel pump volume.

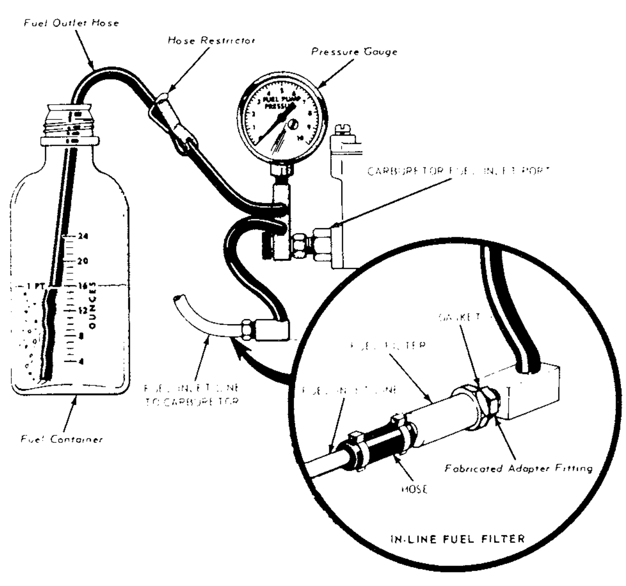
FUEL LINE TEST

Before spending time and effort checking the fuel system, make a careful survey to ensure some object such as a tackle box, etc. is not resting on the fuel line and restricting the flow of fuel.

The fuel line from the tank to the fuel pump can be quickly tested by disconnecting the existing fuel line at the fuel pump and connecting a six-gallon portable tank and fuel line. This simple substitution eliminates the fuel tank and fuel lines in the boat. Now, start the engine and check the performance.

If the problem has been corrected, the fuel system between the fuel pump inlet and the fuel tank, including the fuel tank is at fault. This area includes the fuel line, the fuel pickup in the tank, the fuel filter, anti-siphon valve, the fuel tank vent, excessive foreign matter in the fuel tank, and loose fuel fittings sucking air into the system. Improper size fuel fittings can also restrict fuel flow.

Another possible cause of fuel line problems may be deterioration of the inside lining of the fuel line which rnay cause some



Arrangement of pressure gauge and container to test fuel pump pressure.

of the lining to develop a blockage similar to the action of a check valve. Therefore, if the fuel line appears the least bit questionable, replace the entire line.

Begin at the fuel tank and check each area carefully and in a logical sequence.

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.

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 valves.

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; a dirty flame arrestor; 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 a leak. 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 sucking 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 ajusted, then the problem most likely is in the carburetor and an overhaul is in order. Check the power valve and the needle valve and seat for leaking. Use extra care when making any adjustments affecting the fuel consumption, such as the float level, automatic choke, vacuum-control, and the power valve. Any time the automatic choke is checked, **BE SURE** the heat tube is open and the vacuum system is operating properly.

The flame arrester should be cleaned at regular intervals.

ENGINE SURGE

If the engine operates as if the load on the boat were being constantly increased and .decreased even though you are attempting to maintain a constant engine speed, the problem can most likely be attributed to the fuel pump.

The next few paragraphs briefly describe operation of the fuel pump. This description is followed by detailed procedures for testing the pressure; testing the volume; removing; and installing the fuel pump.

SINGLE-DIAPHRAGM FUEL PUMP

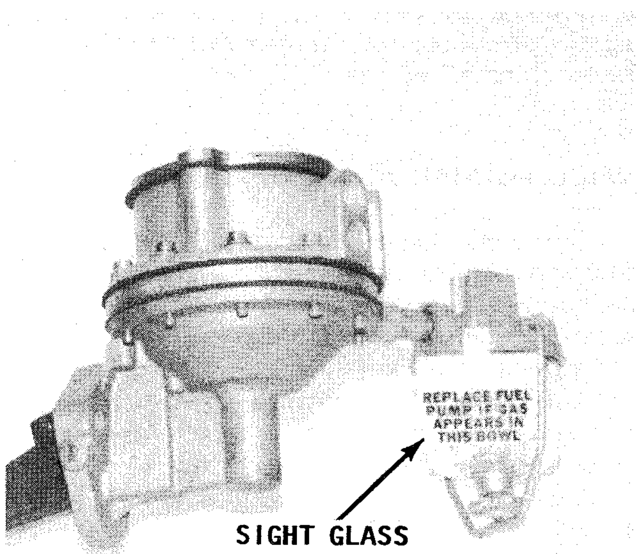
The fuel pump sucks gasoline from the fuel tank and delivers it to the carburetor in sufficient quantities, under pressure, to satisfy engine demands under all operating conditions.

The pump is operated by a two-part rocker arm. The outer part rides on a eccentric on the camshaft and is held in constant contact with the camshaft by a strong return spring. The inner part is connected to the fuel pump diaphragm by a short connecting rod. As the camshaft rotates, the rocker arm moves up and down. As the outer part of the rocker arm moves downward, the inner part moves upward, pulling the fuel diaphragm upward. This upward movement compresses the diaphragm spring and creates a vacuum in the fuel chamber below the diaphragm. The vacuum causes the outlet valve to close and permits fuel from the gas tank to enter the chamber by way of the fuel filter and the inlet valve.

Now, as the eccentric on the camshaft allows the outer part of the rocker arm to move upward, the inner part moves downward, releasing its hold on the connecting rod. The compressed diaphragm spring then exerts pressure on the diaphragm, which closes the inlet valve and forces fuel out through the outlet valve to the carburetor.

Because the fuel pump diaphragm is moved downward only by the diaphragm spring, the pump delivers fuel to the carburetor only when the pressure in the outlet line is less than the pressure exerted by the diaphragm spring. This lower pressure condition exists when the carburetor float needle valve is unseated and the fuel passages from the pump into the carburetor float chamber are open.

When the needle valve is closed and held in place by the pressure of the fuel on the float, the pump builds up pressure in the fuel chamber until it overcomes the pressure of the diaphragm spring. This pressure almost stops movement of the diaphragm until more fuel is needed in the carburetor float bowl.



Fuel in the sight glass indicates a ruptured diaphragm and the fuel pump ***MUST*** *be replaced.*

From this description and the accompanying illustration, you can appreciate why the the fuel pump diaphragm and the carburetor float must be in good condition at all times for proper engine performance.

DUAL-DIAPHRAGM FUEL PUMP

Some fuel pumps have two diaphragms and a sight bowl attached on the outside of the pump. The diaphragms are separated by a metal spacer. This type of fuel pump has four important safety features:

I- If the primary diaphragm fails, the pump continues to function with the second diaphragm.

2- Fuel cannot leak outward from the pump. The only possible place it can leak to is into the space between the diaphragms.

3- Fuel observed in the sight bowl indicates a faulty pump.

4- The possibility of both diaphragms failing at the same time is extremely remote because they are made of different materials and are shaped differently.

No maintenance is required or possible on the dual-diaphragm pump. If fuel is detected in the sight bowl replace the pump.

SERVICE PROCEDURES

Most fuel pumps on late-model engines are of the sealed-type and cannot be repaired. The cost of a new pump is nominal, therefore, even if the pump is not sealed, it is usually more practical to replace the pump instead of attempting to repair it. For your safety, the new pump must be a Coast Guard approved marine-type unit.

Proper fuel pressure and volume are both necessary for proper engine performance. If the pressure is not adequate, the fuel level in the float bowl of the carburetor will be low and result in a-lean mixture and fuel starvation at high speeds. If the pressure is too high the fuel level in the float bowl will rise and result in a rich mixture and flooding.

If the volume is not adequate, the engine will be starved at high speeds.

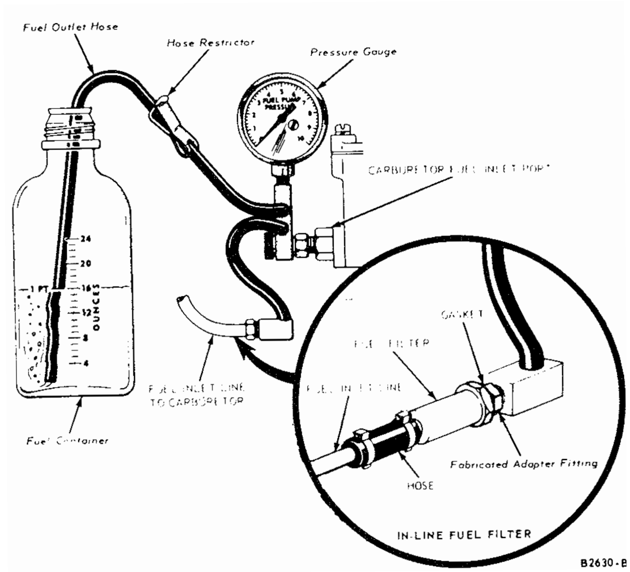
Service instructions consist of checking the output pressure of the pump and the volume delivered to the carburetor.

FUEL PUMP PRESSURE TEST

Remove the flame arrester. Disconnect the fuel line at the carburetor. **TAKE CARE** not to spill fuel on a hot engine because it may **IGNITE.**

ALWAYS have a fire extinguisher handy when working on any part of the fuel system. **REMEMBER,** a very small amount of fuel vapor in the bilge, has the potential explosive power of one stick of **DYNAMITE.**

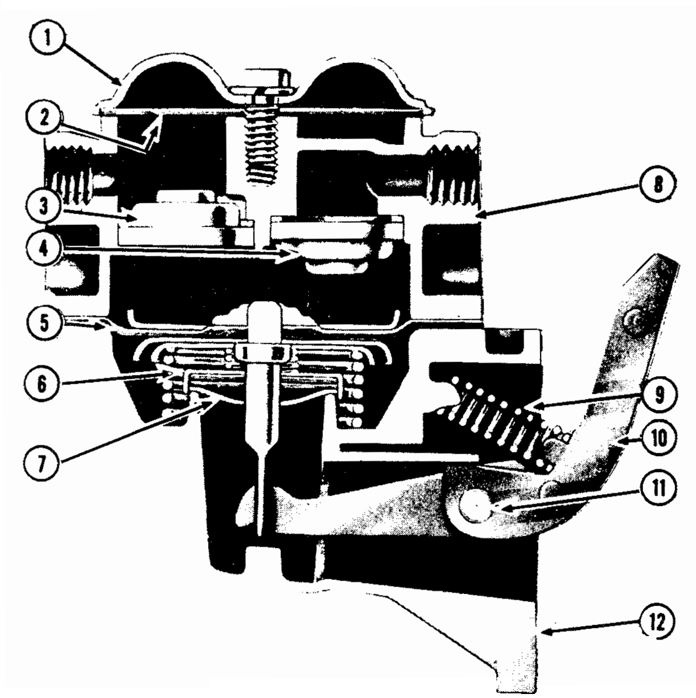
Connect a pressure gauge, restrictor, container, and flexible hose between the fuel filter and the carburetor. Start the engine. With the engine idling, vent the outlet hose into the container by opening the hose restrictor momentarily. Close the hose restrictor and allow the pressure to stabilize. The pressure reading should be between 3.5 and 5.5 psi.



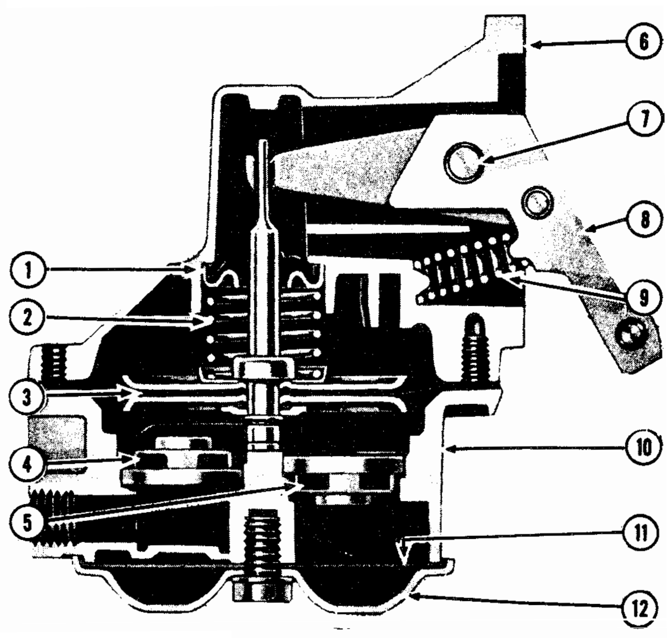
Arrangement of pressure gauge and container to test fuel pump pressure and volume.

FUEL PUMP VOLUME TEST

If the fuel pump pressure is within the 3.5 to 5.5 psi range, test the volume by opening the hose restrictor with the engine



FOUR AND SIX CYLINDER



V-8

1	Pulsator Cover	7	Oil Seat
2	Pulsator Diaphragm	8	Fuel Cover
3	Outlet Valve	9	Rocker Arm Return Spring
4	Inlet Valve	10	Rocker Arm and Lever Assembly
5	Diaphragm Assembly	11	Pivot Pin
6	Diaphragm Spring	12	Pump Body

1	Oil Seal and Retainer	7	Pivot Pin
2	Diaphragm Spring	8	Rocker Arm and Lever Assembly
3	Diaphram Assembly	9	Rocker Arm Return Spring
4	Inlet Valve	10	Fuel Cover
5	Outlet Valve	11	Pulsator Diaphragm
6	Pump Body	12	Pulsator Cover

Cutaway views of two fuel pumps.

idling and collect the fuel discharged into the graduated container. The fuel pump should discharge a pint of fuel in 30 seconds for a six-cylinder engine and in 20 seconds for a V8 engine.

FUEL PUMP REMOVAL

Disconnect the fuel inlet and outlet lines from the fuel pump. **ALWAYS USE** two wrenches when disconnecting or connecting the outlet line fitting to avoid damaging the fuel pump.

Be **sure to plug the fuel line to prevent fuel from siphoning out of the fuel tank.**

Remove the fuel pump mounting bolts, and then the pump and gasket. If you are working on a V8 engine and the push rod is to be removed, remove the pipe plug, push rod, and the fuel pump adaptor.

FUEL PUMP INSTALLATION

If working on a V8 engine, install the fuel pump push rod and pipe fitting or the adaptor. Lay down a bead of Permatex, Form-A-Gasket, or equivalent, on the gasket and pipe fitting.

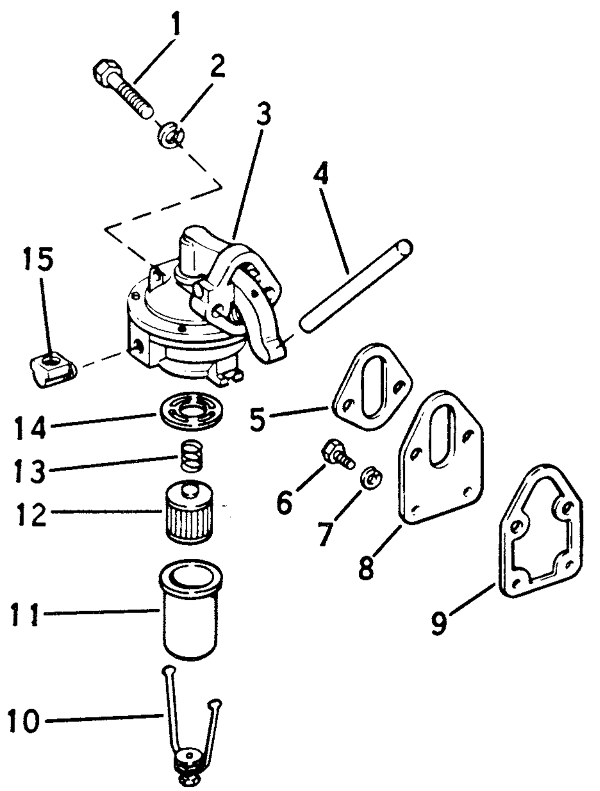
Install the fuel pump and a **NEW** gasket. Use sealer on the mounting bolt threads. Tighten the bolts securely.

On V8 engines, a pair of mechanical fingers can be used to hold the fuel pump push rod up while installing the pump.

Connect the fuel lines to the pump.

Start the engine and check for leaks.

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.



Exploded view of a Carter fuel pump. A fuel pump repair kit is available which consists of all moving or wearing parts except the rocker arm. If the rocker arm or a casting is damaged, it is advisable to replace the pump rather than attempting to repair it. (1) screw, (2) lockwasher, (3) fuel pump assembly, (4) push rod, (5) gasket, (6) screw, (7) lockwasher, (8) plate, (9) gasket, (10) yoke, (11) bowl, (12) filter element, (13) spring, (14) gasket, (15) fitting.

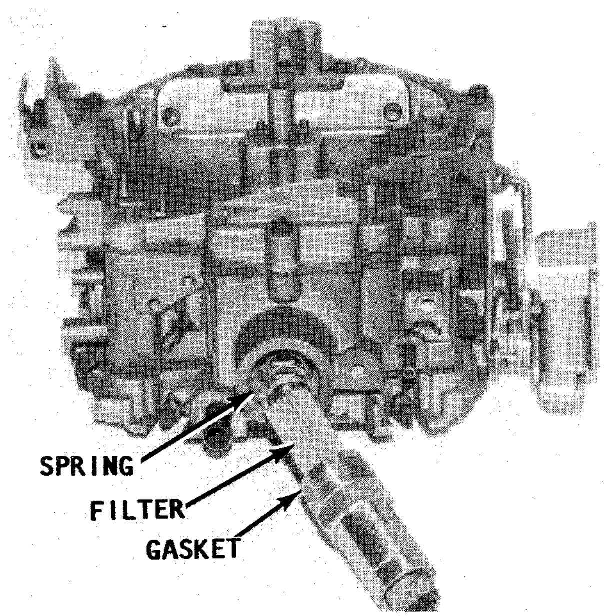
Arrangement of parts for mounting a fuel pump on late-model Chevrolet engines.

FUEL FILTER REPLACEMENT

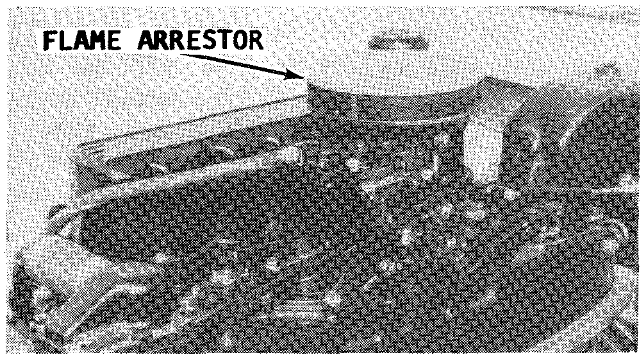
Most marine engines have some type of in-line fuel filter. This filter should be replaced every 100 hours of operation or sooner if you suspect it may be clogged.

To replace the in-line filter element, first remove the flame arrestor. Next, loosen the retaining clamps securing the hoses to the fuel filter. Disconnect the fuel filter from the hoses and discard the retaining clamps.

Install **NEW** clamps on the hoses. Connect the hoses to the new filter. Tighten the filter, and then position the fuel line hose clamps in place and crimp them securely. Start the engine and check for leaks.



Arrangement of fuel filter parts at the carburetor.



Clean flame arrestor every 50 hours of operation.

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.

FLAME ARRESTOR CLEANING

The flame arrestor should be removed and cleaned every 50 hours. It is not necessary to replace the arrestor unless it is damaged and will not seat properly on the carburetor.

Remove and clean the arrestor with solvent and blow it dry with compressed air. Replace it on the carburetor.

CARBURETORS

In the simplest terms, a carburetor is merely a metering device which mixes the proper amount of fuel and air for delivery to the cylinders under all operating conditions.

When the engine is idling, the mixture is roughly 10 parts air to 1 part fuel. At high speed or under heavy load, the mixture is about 12 parts air to 1 part fuel.

The fuel is held in reserve in the float chamber of the carburetor. A float valve in this chamber admits fuel from the fuel pump to replace the fuel leaving the chamber and burned by the engine. Metering jets extend from the fuel chamber into the carburetor throat.

The downward movement of a piston creates a suction that draws air into the carburetor throat. There is a restriction in the throat called a venturi. This venturi reduces air pressure at this point by increasing the air velocity.

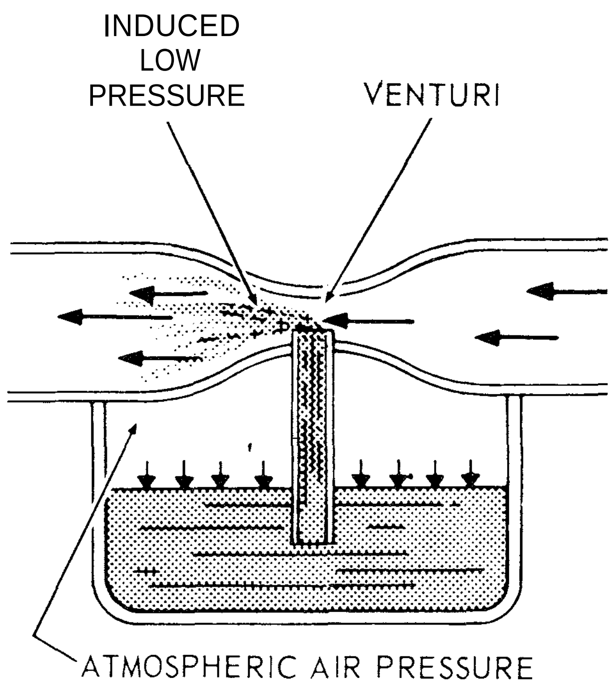
The difference between the air pressure in the float chamber and the pressure in the carburetor throat causes the fuel to be forced through the metering jets and into the air stream. This mixture of fuel and air is then burned in the engine cylinders.

From this description, you can appreciate why the jets must be clean, free of gum, and adjusted properly for satisfactory engine performance.

The low-speed jet has an adjustable needle to compensate for changing atmospheric conditions. The high-speed jet is a fixed orifice.

The volume of the fuel-air mixture drawn into the engine to regulate engine speed, is controlled by a throttle valve. An extra amount of fuel is required to start a cold engine- This extra fuel is delivered by a choke valve installed ahead of the metering jets and the venturi or venturis as the case may be. After the engine starts and warms to operating temperature, the choke is gradually opened to restore the normal air-fuel mixture.

The throat of a carburetor is usually referred to as a "barrel". Single, double, or four barrel carburetors have a metering jet, needle valve, throttle, and choke plate for each barrel or pair of barrels.



Air flow principle for a modern carburetor.

The information is presented with respect to the number of barrels in the carburetor, beginning with the single-barrel Rochester BC, Section 4-1, and Carter RBS, Section 4-2.

The 2GV and the 2GC, Section 4-3, are two-barrel Rochester carburetors. The only difference between these two models is in the choke and the mounting base.

The four-barrel carburetor section outlines procedures for work on the Rochester 4MV, Section 4-4.

The Holley two- and four-barrel carburetors are covered in the last section, 4-5.

Each section is identified by a number and these numbers are referenced in other Chapters.

"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.

A gasoline stabilizer and conditioner may be used to prevent fuel from "souring" for up to twelve full months.

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 preventative maintenance possible. In most cases, this old gas can be used without harmful effects in an automobile using regular gasoline.

The gasoline preservative additive STA-BIL, shown below, 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.

LEADED GASOLINE AND GASOHOL

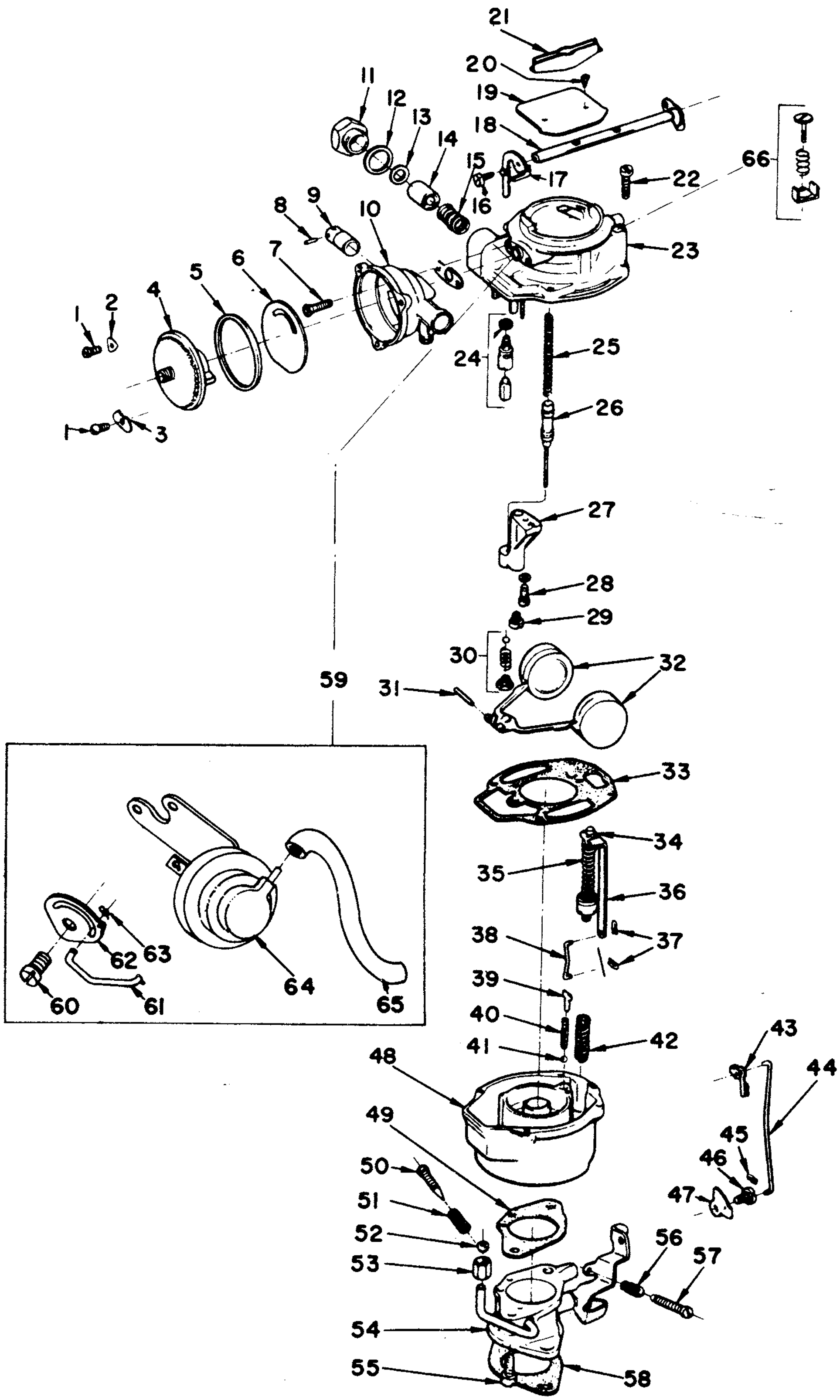
In the United States, the environmental Protection Agency (EPA), has enacted regulations nation-wide phasing-out the use of leaded fuels, "Regular" gasoline since 1988. Lead in gasoline boosts the octane rating (energy). Therefore, if the lead is removed, it must be replaced with another agent. Unknown 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 he affected.

Since 1980, OMC has 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 recotnmended 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.



1. Screw—Stat Cover
2. Retainer—Plain
3. Retainer—Toothed
4. Stat Cover & Coil Assembly
5. Gasket—Stat Cover
6. Baffle Plate
7. Screw—Choke Housing
8. Pin—Choke Piston
9. Choke Piston
10. Choke Housing
11. Fitting—Fuel Inlet
12. Gasket—Fuel Inlet
13. Gasket—Fuel Inlet Filter
14. Fuel Filter
15. Spring—Fuel Filter
16. Screw—Choke Lever
17. Piston Lever & Link Assembly
18. Choke Shaft Assembly
19. Choke Valve
20. Screw—Choke Valve
21. Support—Air Cleaner
22. Screw—Air Horn
23. Air Horn Assembly
24. Needle and Seat Assembly
25. Spring—Power Piston
26. Piston—Power
27. Support—Main Well
28. Screw—Main Well Support
29. Main Metering Jet
30. Power Valve Assembly
31. Pin—Float Hinge
32. Float Assembly
33. Gasket—Air Horn
34. Retainer—Pump Assembly
35. Spring—Pump Duration
36. Pump Plunger Assembly
37. Retainer Pin
38. Link—Pump
39. Guide—Pump Discharge
40. Spring—Pump Discharge
41. Ball—Pump Discharge
42. Spring—Pump Return
43. Clip—Choke Rod
44. Choke Rod
45. Pin—Choke Rod
46. Screw—Cam Attaching
47. Cam—Fast Idle
48. Float Bowl Assembly
49. Gasket—Throttle Body
50. Idle Needle
51. Spring—Idle Needle
52. Packing—Choke Tube
53. Nut—Choke Tube
54. Throttle Body Assembly
55. Screw—Throttle Body
56. Spring—Idle Stop Screw
57. Screw—Idle Stop
58. Gasket—Throttle Body
59. Vacuum Break Diaphragm Assembly (Model BV)
60. Screw
61. Link
62. Lever—Choke Shaft
63. Retainer Pin
64. Vacuum Break Assembly
65. Hose—Vacuum
66. Idle Vent Valve Assembly

Exploded view of the Rochester B, BC, and BV carburetor with principle parts identified.

4-1 ROCHESTER BC CARBURETOR

This single-barrel carburetor was used on early model four- and six-cylinder engines and was replaced by the Rochester 2GC model.

A couple features of this carburetor include:

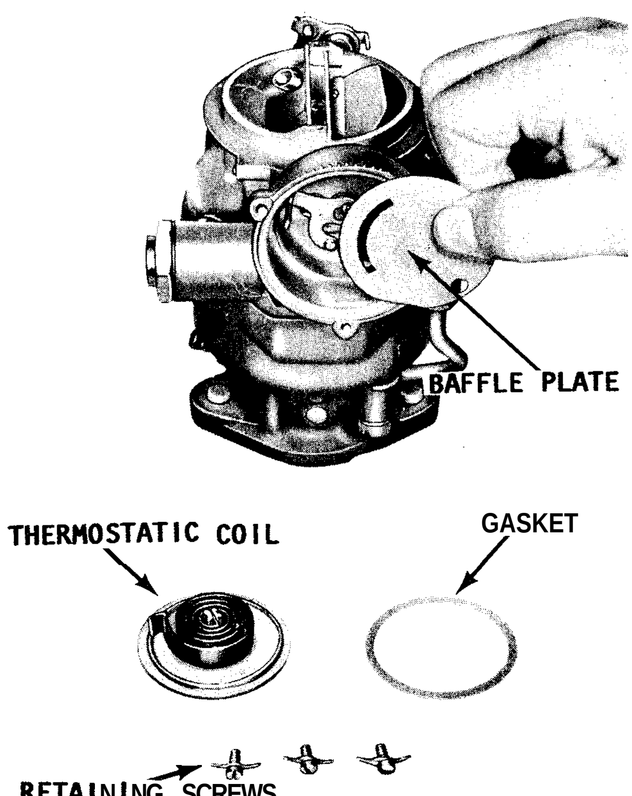
A concentric-type float bowl allowing fuel to surround the main carburetor bore and venturi. This design, plus the centrally located main fuel discharge nozzle, prevents fuel spill-over during sharp turns, quick starts, and sudden stops.

This assembly contains the main metering parts of the carburetor and is easily removed for inspection and service. It is attached to the air horn and suspended in the fuel in the float chamber. This arrangement insulates the main assembly from heat that may be transmitted from the engine directly to the bottom of the float bowl. This design helps maintain more accurate fuel rnetering because less fuel vapors enter the main metering parts of the assembly when the engine is hot.

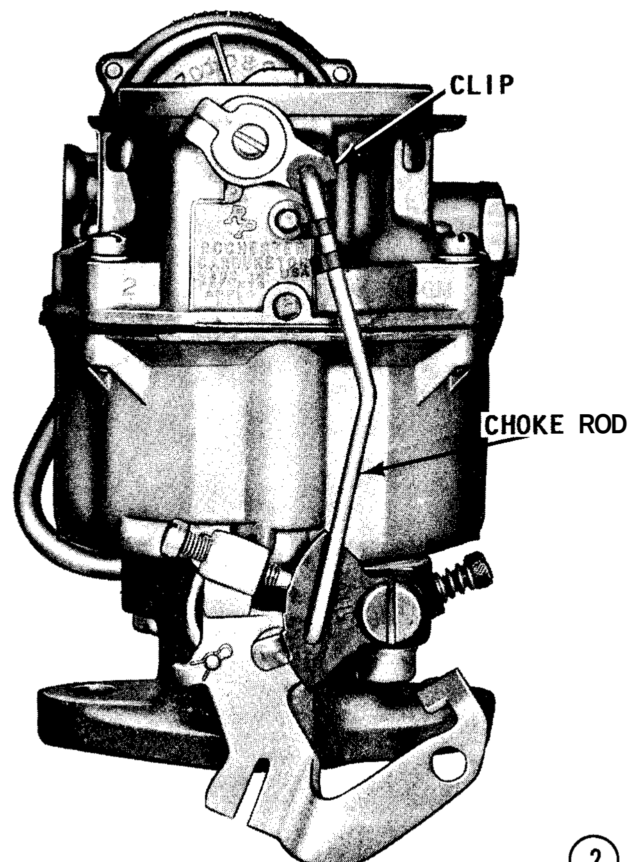
REMOVAL

1- Remove the choke cover attaching screws and retainers. Remove the choke cover and thermostatic coil assembly from the choke housing. Remove the choke cover gasket and baffle plate. Remove the fuel filter inlet nut, gaskets, fuel filter, and spring. The choke valve and shaft **SHOULD MOT** be removed unless the shaft is binding or the valve is damaged. To repair this type of damage, file the choke valve screw staked ends level with the choke shaft. Remove the choke valve plate retaining screws from the shaft. Lift out the plate, and then slide the shaft out of the air horn. The shaft is removed by first rotating the shaft to remove the piston and pin from the choke housing. Remove the choke housing from the bowl cover by removing the attaching screws and gasket.

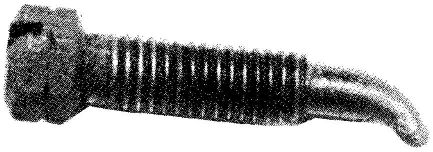
2- Remove the choke rod retaining spring clip and rod from the choke shaft lever. Unscrew the vacuum tube connector nut from the choke housing. Remove the bowl cover screws, and then the return spring bracket. Lift the cover **STRAIGHT** UP to prevent damage to the floats.



1



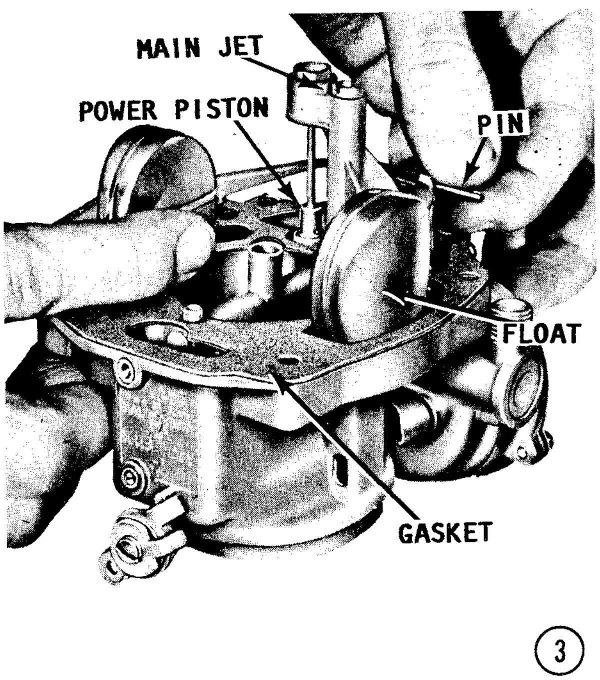
2



Tip of an idle mixture adjusting needle bent from being forced into its seat and against the closed throttle plate.

3- With the cover up-ended, remove the float hinge pin, the floats, and the float needle. Remove the float seat and gasket. Remove the main well support, vacuum power piston, and spring, Separate the gasket from the cover. Remove the main metering jet and power valve retainer. Take out the spring and ball from the main well support.

4- Use a pair of needle nose pliers to remove the pump discharge guide. Hold the accelerating pump plunger all the way down, and at the same time remove the hairpin retainers and the pump link from the throttle lever and pump arm. Remove the pump assembly from the bowl. Emerse the plunger in gasoline or kerosene to prevent the leather from drying. Remove the pump return spring from the pump well. Turn the bowl upside down and carefully remove the pump discharge spring and ball. While the bowl is still upside down, remove the throttle body attaching screws and gasket. Remove the idle mixture needle adjusting screw and spring from the throttle body.



CLEANING AND INSPECTING THE ROCHESTER BC

Place all of the metal parts in a screen-type tray and dip them in carburetor solvent until they appear completely clean, then blow them dry with compressed air.

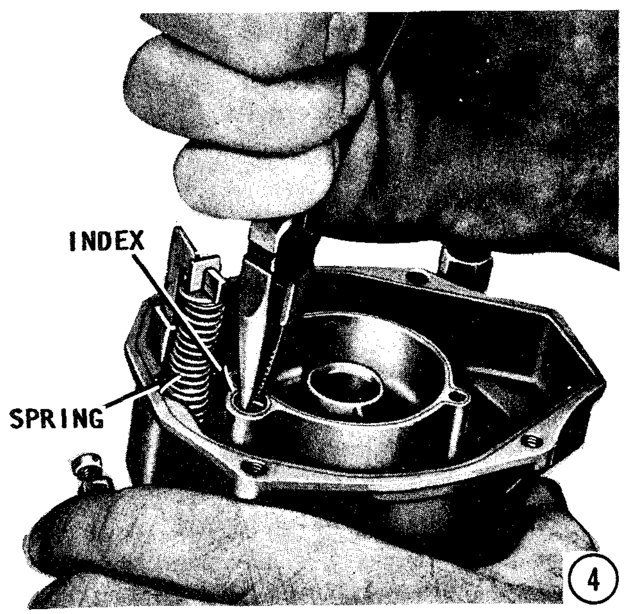
Check all of the parts and passages to be sure they are not clogged or contain any deposits. Blow out all of the passages. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Inspect the pump plunger. If the leather or its garter expanding spring is damaged in any way, replace the plunger assembly. Verify the bypass ball check inside the assembly is free by shaking the plunger and listening for-the ball movement.

Inspect the floats for dents and wear on the lip and hinge pin. Check the cover for wear in the hinge pin holes. If the float needle shows any wear, replace the float needle-and-seat assembly. This assembly consists of a matched and tested needle and seat, plus a new fiber washer.

Check the movement of the piston in the cover bore. The piston should move freely without any binding. If binding is felt, check the piston for burrs or other damage.

Check the complete throttle body assembly. If there is any evidence of abnormal wear or lcoseness, the entire assembly should be replaced, because of the close tolerance of the throttle valve and because the spark advance ports are drilled in relation to a properly fitted valve.



Check operation of the choke valve when it is assembled in the cover.

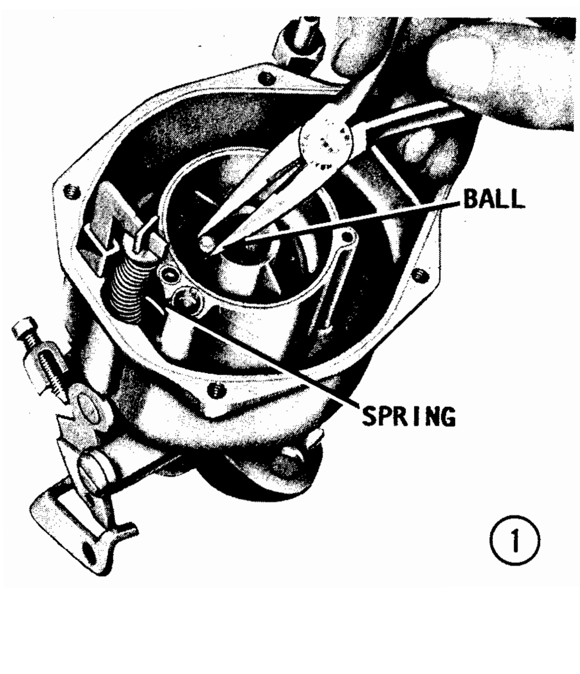
ALWAYS replace the fuel filter when making a carburetor overhaul.

The fuel pump system can be checked in the following manner: First, pour about 1-1/2" of gasoline into the carburetor bowl. Next, slide the pump plunger from the can of gasoline into the pump cylinder. Position the discharge check ball into the body. Now, raise the plunger and press lightly on the shaft to expel air from the pump passage. Hold the discharge ball down firmly in its seat with a small, clean brass rod. Raise the plunger again and press downward. The fuel should not flow past the discharge ball or back through the inlet ball in the pump assembly. If the pump plunger depresses easily, it could mean that either dirt is present or that the check balls are damaged. Clean the passage and repeat the test. If leakage is still indicated, replace the check ball or the pump plunger assembly.

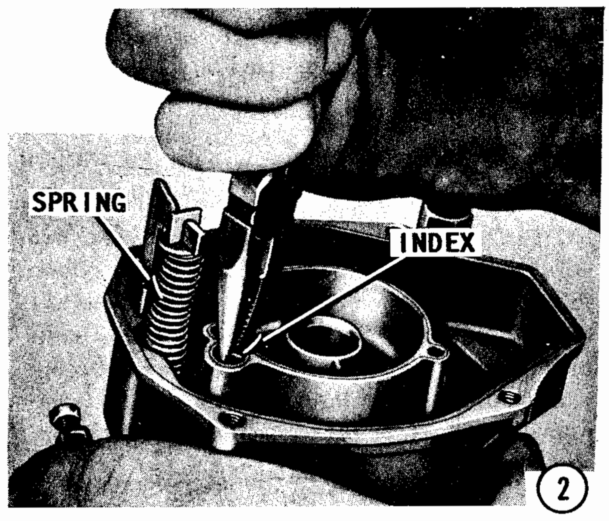
Most of the parts that should be replaced during a carburetor overhaul, including a new matched fuel inlet needle valve-and-seat assembly, are found in a carburetor kit available from the local marine dealer.

ASSEMBLING THE ROCHESTER BC

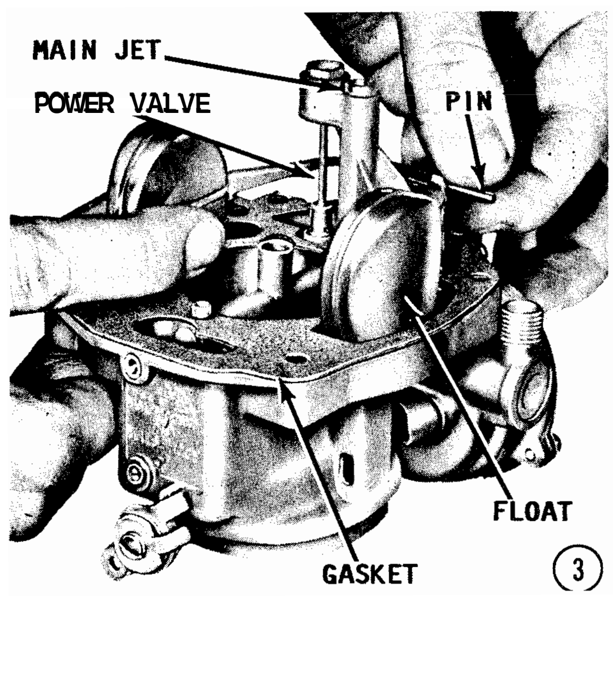
1- Place a NEW throttle body gasket in position, and then attach the bowl to the body with the 2 screws and lockwashers. Tighten the screws evenly. Place the pump return spring into the pump well, and then center it by depressing the spring with one finger. Install the pump plunger assembly. **USE CARE** and insert the leather part into the bowl and connect the pump link to the throttle lever and pump arm. Now, install the hairpin retainers at both the upper and lower ends of the link. Drop the large steel ball into the pump discharge cavity of the bowl and position the spring on top of the ball.



2- Insert the index end of the pump discharge guide into the spring and press the guide down until it is flush with the surface of the bowl.

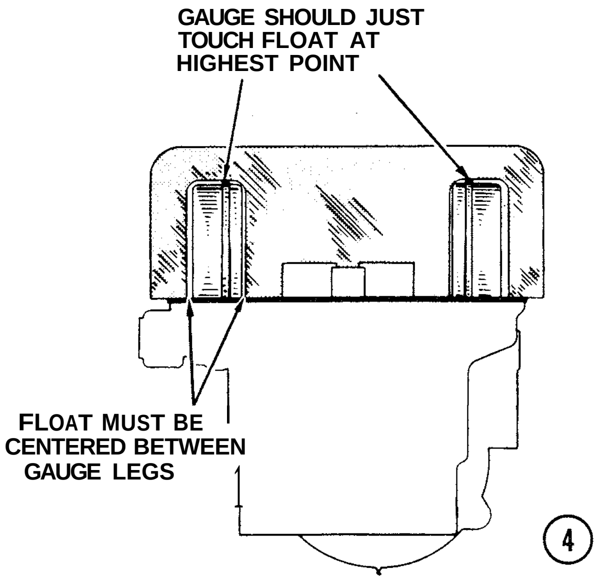


3- Place a new gasket in position on the air horn. Insert the power piston spring and the power piston into the air horn cavity, and then attach the main well support to the cover with a screw and lockwasher. Install the main metering jet and tighten it securely. Hold the power piston stem down, and at



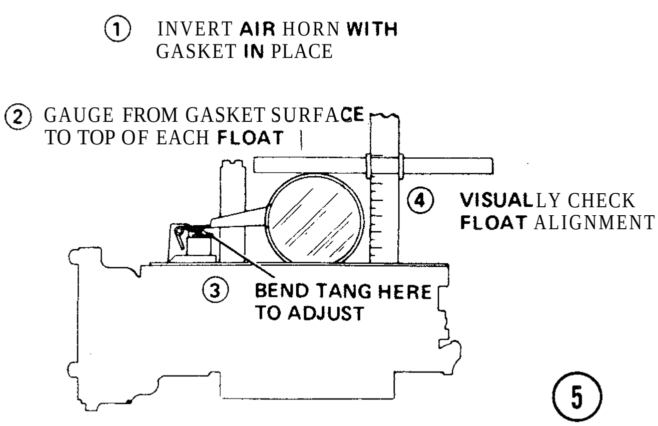
the same time, install the power ball, spring, and plug. Tighten the plug securely. Install a new fiber washer in the float needle seat well, and then install the seat and float needle. Attach the float and hinge pin with the float tang **FACING** the **COVER.** At this point, the float level and the float drop adjustments **MUST** be made.

4- Float Level Check: Place the proper gauge over the floats with the gasket in position. The floats should be equally cent- ered in the float gauge cutouts and they should just touch at their highest point.



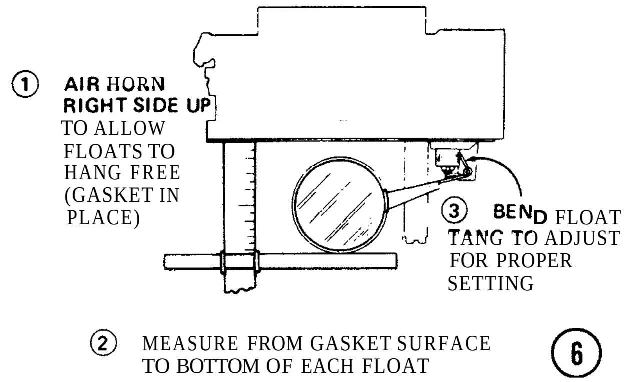
4

5- Float Level Adjustment: Bend the float arm until the distance from the air horn gasket to the top of each float is 1-9/32".



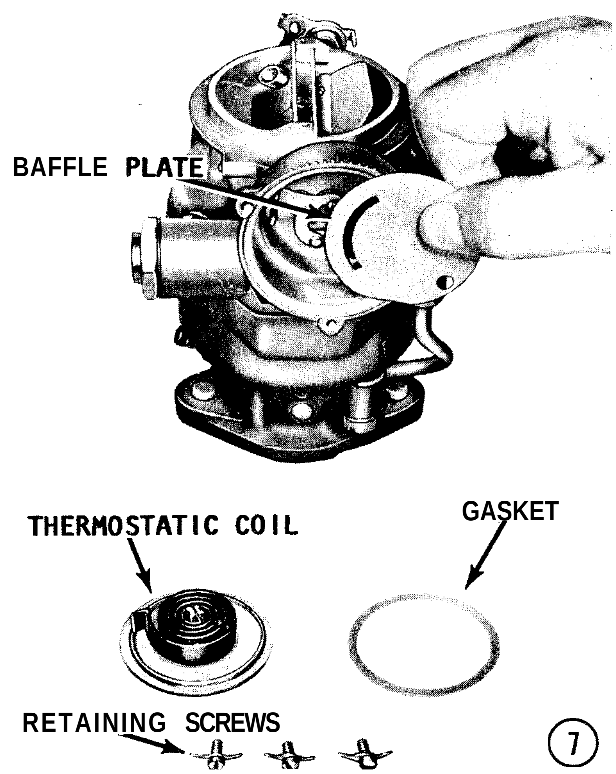
5

6- Float Drop Check: Measure the distance from the bottom sf the float to the air horn gasket, as shown. Bend the float tang until this distance is 1-3/4".



6

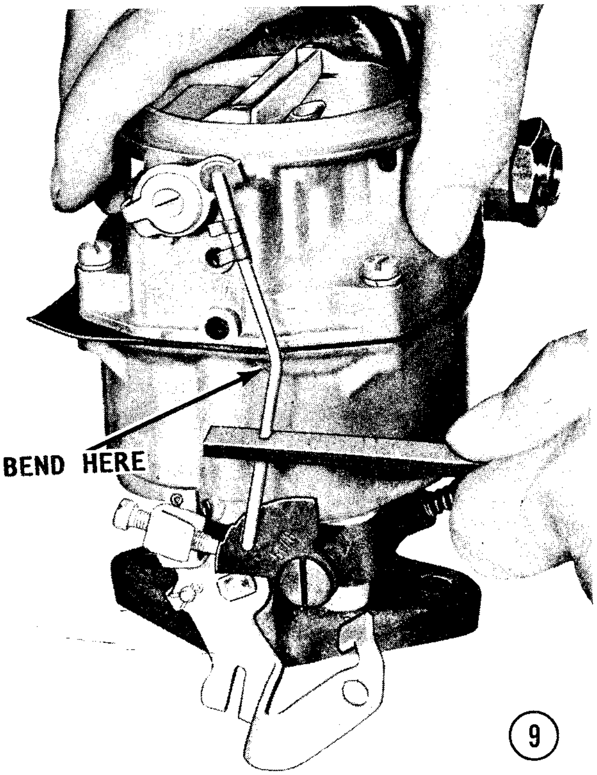
7- CAREFULLY place the assembled air horn onto the main body. Install and tighten the retaining screws. Tighten the 1/2" brass fitting on the choke suction tube. Assemble the choke piston to the shaft and slide the assembly into the choke housing bore. Ro- tate the choke shaft counterclockwise until the piston enters its cylinder. Install the choke valve with the letters **RP** facing **UPWARD.** Be sure to center the valve before tightening the two screws. Check to be sure the valve operates freely. Install the choke baffle plate, the choke housing gasket, and the thermostatic coil cover.



7

Rotate the cover clockwise until the index marks on the cover and the housing are aligned, Check the specifications in the Appendix. Tighten the three screws and retainers securely. The choke valve should touch the bore of the air horn lightly at room temperature. Install the idle mixture adjusting needle. Turn it in **GENTLY** until it seats, then back it out 2 turns. This position will give a rough adjustment at this time.

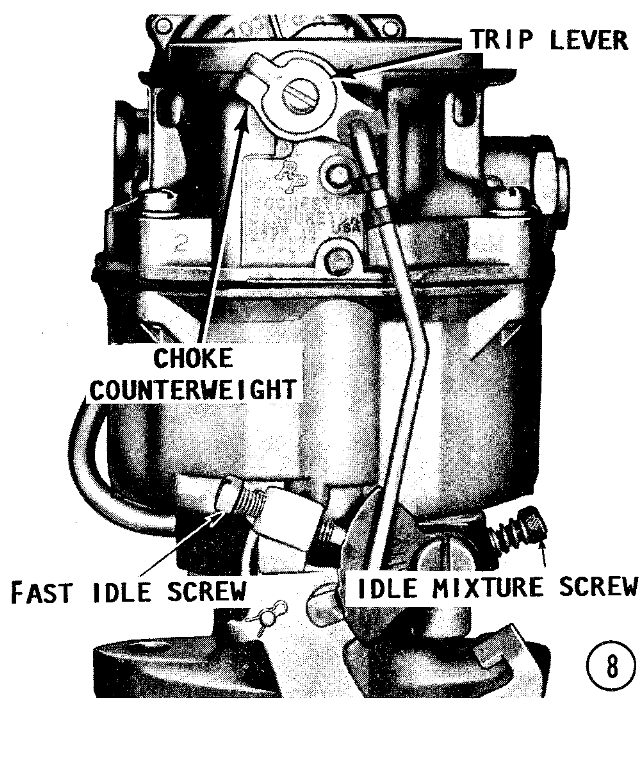
8- Place the choke counterweight on the end of the choke shaft, with the **TANG** facing the choke **HOUSING.** Install the spacing washer and trip lever in such a position that the tang of the trip lever will be on top of the counterweight tang when the choke is fully open. Attach one end of the choke rod to the counterweight and the other end of the rod to the fast-idle cam. The dog leg of the rod **MUST** FACE the idle adjusting needle. Install the pin spring and the end clip which will secure the choke rod.

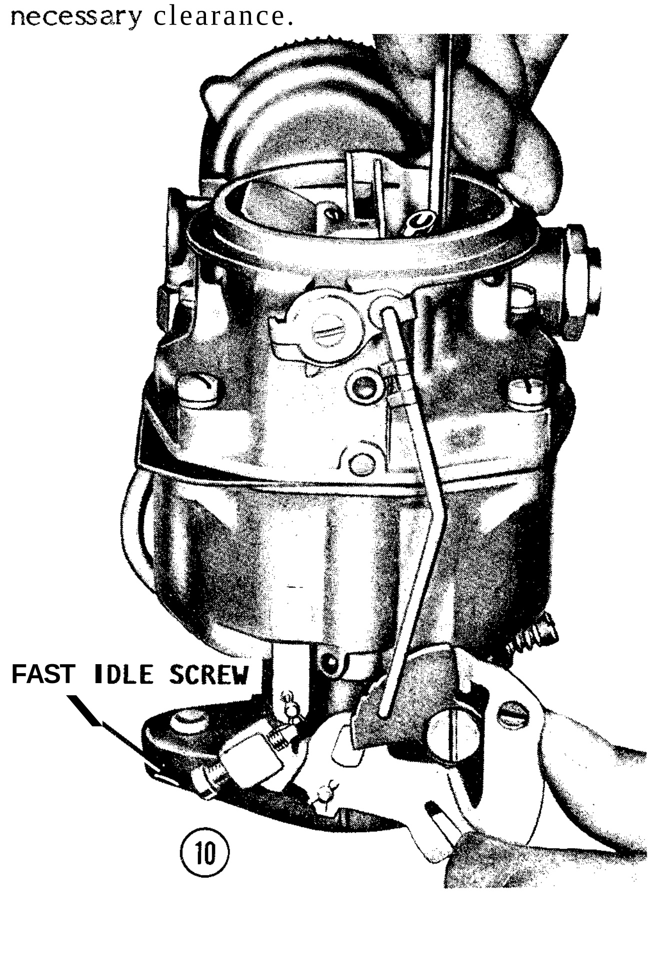


ROCHESTER BC ADJUSTMENTS

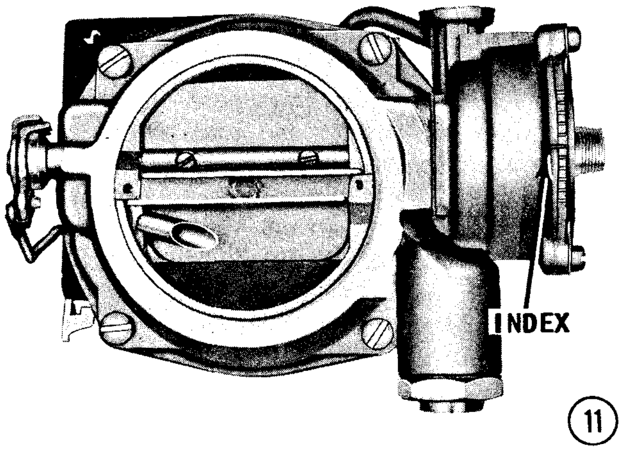
9- Choke Rod Adjustment: Check to be sure the idle screw contacts the fast-idle cam when the choke valve is completely open or completely closed. If the screw drops off the cam in either choke position, bend the choke rod until the cam is positioned correctly.

10- Unloader Adjustment: With the throttle in the wide-open position, Lase Tool J-9580, or measure 0.230" to 0.270", to verify the small end slides freely between the lower end of the choke valve and the bore of the carburetor. Bend the tang on the throttle lever as required to obtain the necessary clearance.





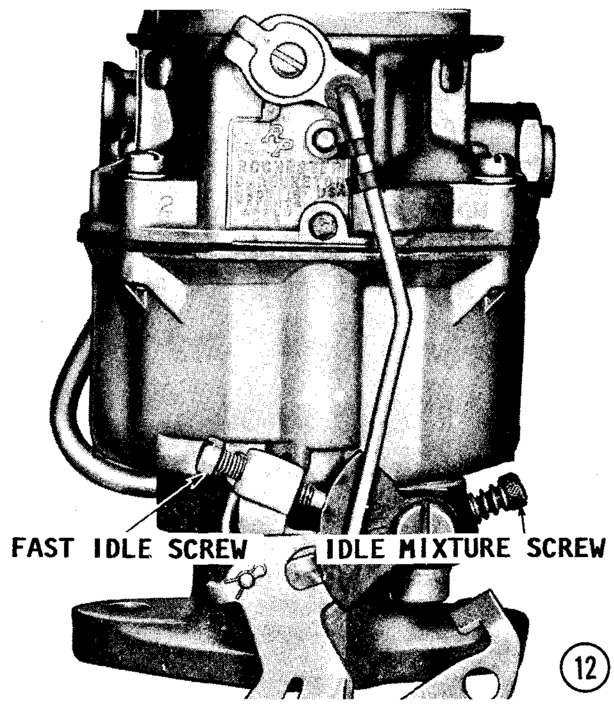
11– Automatic Choke Adjustment: Loosen the three screws that secure the choke cover, and then turn the cover until the scribe line on the cover aligns with the index mark on the choke housing. Tighten the cover screws.

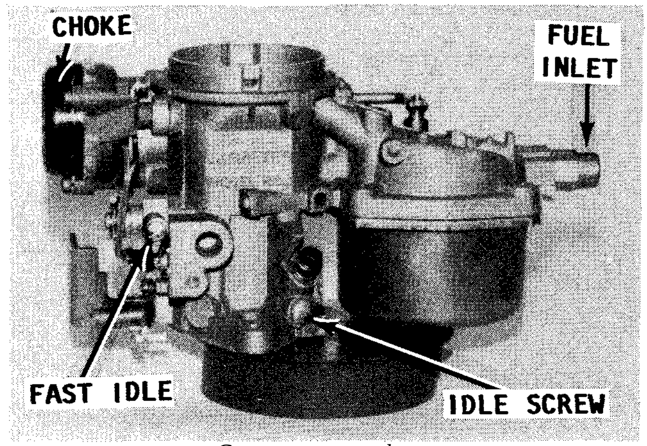


12– Idle Mixture and **Speed Adjustment:** Start the engine and allow it to warm to operating temperature, until the choke is wide open.

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.

Adjust the idle speed screw until the engine speed is 500 rpm, then adjust the mixture adjusting screw until the highest steady idle speed is obtained. A clean flame arrester **MUST** be installed when these adjustments are made.





The *Carter RBS carburetor.*

4-2 CARTER RBS CARBURETOR

DESCRIPTION AND OPERATION

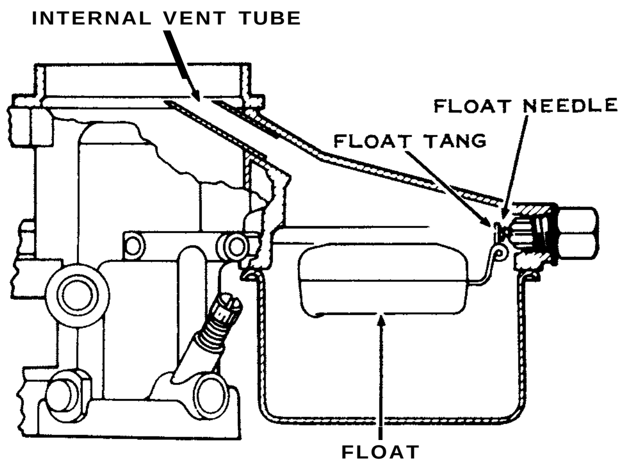
The following paragraphs will give you a general description of the Carter RBS carburetor including an explanation of how the various systems operate and their influence on engine performance.

The RBS carburetor is built with a single light-weight aluminum casting with a pressed-steel fuel bowl. Most of the calibration points are located in the central casting making it easy to service and adjust because the adjustment points are readily accessible. The fuel pick-ups are located near the centerline of the carburetor bore to gain the benefits of a concentric float bowl carburetor, but they are located so engine heat being radiated through the carburetor bore and casting are not easily conducted to the fuel bowl. A vacuum-controlled diaphragm step-up rod assembly provides instant response to varying engine demands.

FLOAT SYSTEM

The float system maintains an adequate supply of fuel at the proper level in the fuel bowl for use by all of the other systems. The float assembly is compact for rigidity, and assures little or no change in the fuel level setting due to heat or vibration.

The float is made of a cellular nitro rubber material which is impervious to denting under normal handling conditions and it is not susceptible to punctures. These features assure a constant bouyancy factor and long service life. The single float extends around the metering portion of the casting to produce the effect of having twin floats.



Details of the Carter RBS carburetor. The fuel level ***MUST*** *be properly adjusted to allow the correct amount of fuel to be delivered to the other systems at all speeds. Because the bowl is vented to atmospheric pressure, the pressure difference between the area on top of the fuel in the bowl and the pressure in the venturi area forces the fuel through the various systems.*

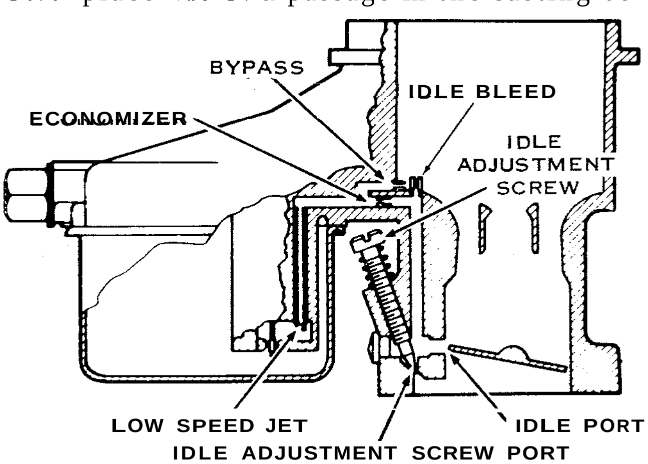
The needle seat is resilient and has the unique ability to "digest" small foreign particles in the fuel, thereby minimizing leakage of fuel or flooding under extreme conditions. This resilient seal reduces wear and extends the life of the fuel intake needle. The fuel bowl is vented to the inside of the air horn to provide a balance between air horn pressure and fuel bowl pressure.

IDLE SYSTEM

Fuel for idling and early part-throttle operation is metered through the idle, low-speed, system. The low-speed jet is pressed into place within a passage in the casting to prevent damage. It cannot be removed, but it can be cleaned by blowing compressed air through the step-up rod jet or through either of the idle passaage air bleeds located in the carburetor bore. Fuel from the bowl is metered as it enters the lower end of the jet and flows up through the tube where air which has been metered through the by-pass mixes with the fuel.

Both fuel and air then pass through the economizer and on to the idle bleed where more air, which has been metered, is introduced. This air-fuel mixture is discharged into the intake manifold through the idle port and the idle adjustment screw port.

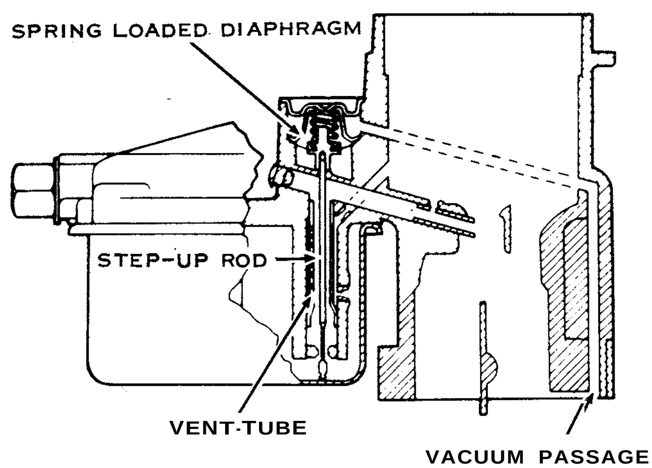
The idle adjustment screw controls the amount of air-fuel mixture admitted to the intake manifold. Backing the screw out increases the amount of mixture; turning the screw in decreases the mixture. At idle speed, only a small amount of idle port is exposed to intake manifold vacuum. As the throttle is opened, rnore of the idle port is exposed to allow an increase in the amount of air-fuel mixture admitted to the engine. The idle jet, economizer, and both air bleeds are calibrated and pressed into place.



Details of the idle system. The air-fuel mixture at idle is adjusted with the idle adjustment screw. This system furnishes the proper air-fuel mixture at low speed when the throttle valve is almost closed and the high speed system is ineffective,due to the low velocity of air through the venturi.

HIGH-SPEED SYSTEM

Fuel for part throttle and for full-throttle operation is supplied through the high-speed system. During part-throttle operation, the relatively high intake manifold



Details of the Carter ***RBS*** *high-speed system. When the throttle is opened, this system supplies the proper air-fuel mixture. The air velocity passing the venturi sucks fuel out of the high-speed nozzle. If the throttle is partially opened, vacuum transferred to the diaphragm of the step-up rod lifts the rod. The larger part of the rod is then in the jet to provide an economical air-fuel mixture. As the throttle is opened more, intake manifold vacuum drops, and the step-up rod is lowered into the jet to provide the richer mixture required* ***by*** *the additional power demand.*

vacuum is transferred through a passage in the manifold casting up to the upper surface of the spring-loaded diaphragm to which the step-up rod is attached. The manifold vacuum, exerting an opposing force to the calibrated spring, provides an economical air-fuel mixture to the engine under all conditions, except when full power is required. When the diaphragm is up, vacuum is high, the larger diameter (lower end) of the step-up rod is in the jet to provide the economy mixture.

When the throttle is opened, the manifold vacuum decreases. Once the difference in pressure applied to the two sides of the diaphragm is not great enough to offset the downward pressure of the calibrated spring, the diaphragm moves downward and the step-up rod, attached to the diaphragm, is lowered in the jet. The smaller diameter of the rod permits the metered increase in fuel flow to satisfy additional power demands. Additional fuel for these power requirements is fed through the constant-feed bushing as well as through the step-up rod jet.

Under an acceleration condition, the same action takes place to enrich the fuel mixture for the additional power needs. However, the step-up rod is raised in the jet just as soon as terminal acceleration is reached when engine load, and manifold vacuum, indicates the need for a less rich fuel mixture.

A vent tube is pressed into place within the high-speed well around the step-up rod. This tube has calibrated side holes. A metered amount of air is admitted from the bore of the carburetor to the ring around the vent tube. This air passes through the side holes in the vent tube to mix with the fuel before it flows through the nozzle into the air stream. This air-fuel mixture is known as an emulsion and it permits the fuel to vaporize immediately as it emerges from the tip of the nozzle and to assure equal distribution of the fuel to each cylinder. This action is further benefited by the additional air bleed located in the center of the nozzle.

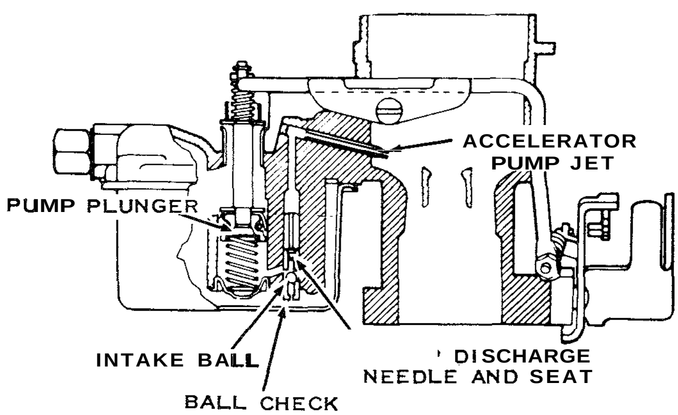
During idle operation, or with the engine shut off with hot fuel on an extremely hot day, fuel sometimes boils in the fuel bowl and the various passages of the carburetor. When these vapor bubbles in the high-speed passageway force fuel out the nozzle, the carburetor is said to be percolating. The design of the RBS carburetor prevents this action as the fuel level in the high-speed well is far below the nozzle cross-over passage and only vapors can be emitted through the nozzle, not raw fuel.

ACCELERATION SYSTEM

The accelerating pump system supplies the necessary amount of measured fuel to ensure smooth engine performance during low speed acceleration. As the throttle is closed, the pump plunger is raised in the pump cylinder and the fuel from the bowl flows into the cylinder through the intake ball check. This ball check is located next to the pump cylinder. Air is prevented from entering the cylinder due to the sealing action of the pump discharge needle being on its seat during the intake stroke. When the throttle is opened, mechanical action, transmitted through the pump arm, pushes the plunger downward in the cylinder. Fuel is forced past the discharge needle and out through the metered pump jet and into the air stream. During the discharge stroke, the intake ball is on its seat to prevent fuel from flowing back into the bowl. The spring on the connector link and the size of the pump jet provide a pump discharge of the required amount and for the proper length of time.

CHOKE SYSTEM

The Carter Climatic Control choke on the RBS carburetor provides the correct mixture necessary for quick cold engine starting and proper warm-up performance.



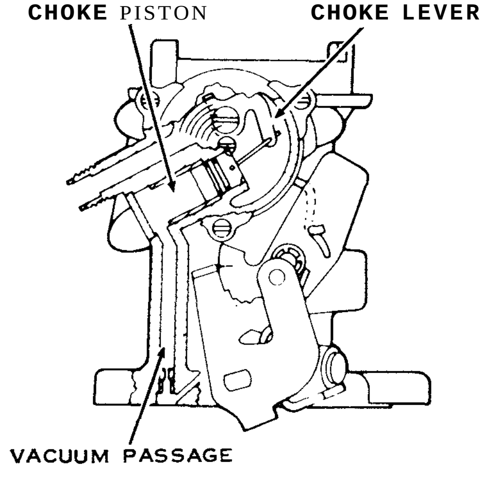
Details of the Carter RBS acceleration system. On demand during acceleration, the pump plunger is activated to force fuel past the discharge needle and out through the metered pump jet, as shown.

On a dual carburetor installation, the choke system operates only on the forward carburetor. The thermostatic coil housing assembly on the rear carburetor is set to the index mark plus 1-1/4 turns clockwise. At this setting, the choke valve in the rear carburetor is always in the open position.

When the engine is cold, tension of the thermostatic coil spring holds the choke valve closed. As the engine is cranked, air pressure against the offset choke valve causes the choke valve to open slightly against the spring tension of the thermostatic coil. Intake manifold vacuum applied to the underside of the choke piston also tends to pull the choke valve open.

When the engine starts, the choke valve assumes a position where the tension of the thermostatic coil spring is balanced by the pull of the manifold vacuum on the choke piston **AND** the force of the air stream against the offset choke valve.

After the engine starts and the choke piston moves down in the choke piston cylinder, slots located in the sides of the cylinder are uncovered. The uncovered slots allow intake manifold vacuum to draw warm air, heated by the exhaust manifold, through the thermostatic coil housing assembly. This warm air causes the thermostatic coil spring to lose its tension gradually until the choke valve is in the wide-open position.



Details of the Carter RBS choke system. This system provides the necessary air-fuel mixture for starting a cold engine. The flow of air through the carburetor is restricted because of the tension on a thermostatic spring holding the choke valve closed. After the engine starts, intake manifold vacuum, applied to the underside of the choke piston helps to open the choke valve to admit more air. On a dual carburetor installation, the choke system only operates on the forward carburetor.

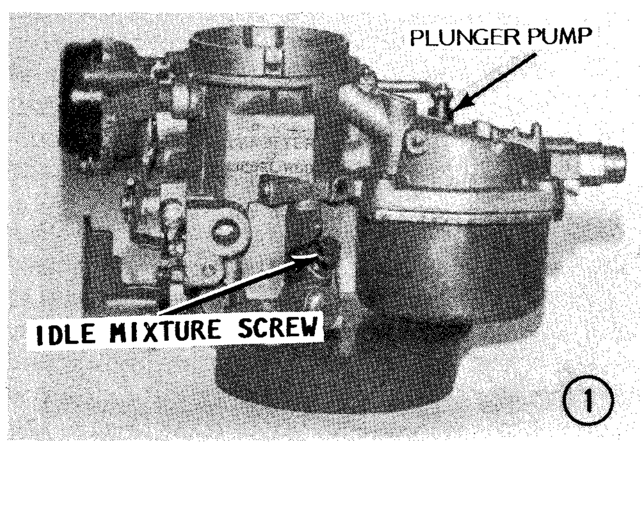
If the engine should be accelerated during the warm-up period, the drop in manifold vacuum allows the thermostatic coil spring to close the choke valve for just a moment which provides the necessary richer mixture.

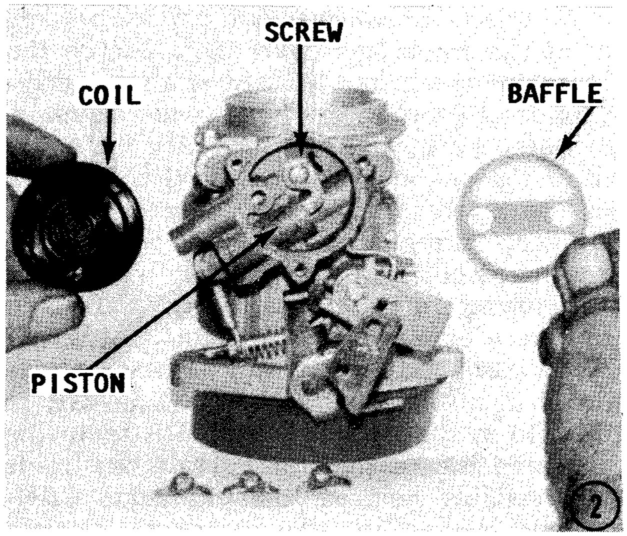
If the engine becomes flooded during the starting period, the choke valve can be opened manually to clean out the excessive fuel in the intake manifold. This is accomplished by moving the throttle to the wide-open position while the engine is being cranked. Opening the throttle causes a projection on the throttle lever to contact a cam, which in turn, opens the choke valve to a predetermined position. This is known as the unloader.

DISASSEMBLING THE CARTER RBS

1- Remove the pump rod retainer from the top of the pump plunger shaft. Remove the pump arm connector link nut from the end of the connector link, and then remove the spring and retainer from the connector link by pushing the pump plunger downward. **LEAVE** the connector dink in place. It cannot be removed unless the throttle shaft and lever assembly is removed. Remove the pump arm retaining screw, retainer, pump arm, upper pump spring, bushing, and washer.

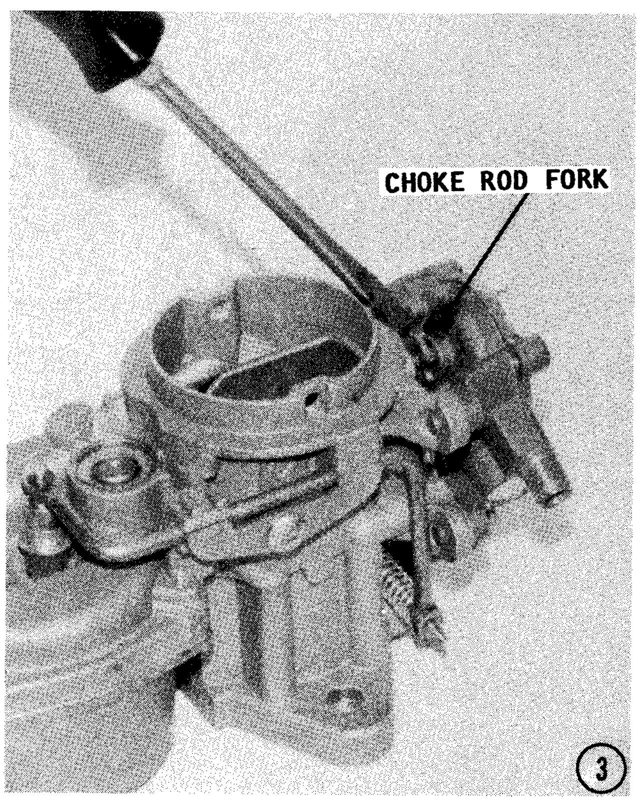
2- Remove the thermostatic coil housing, retainers, and gasket. If two carburetors are used, MARK the thermostatic coil assembly to identify the front and rear carburetor housing. When two carburetors are used, the rear thermostatic coil assembly, which is under extreme tension to maintain the choke in the open position, becomes stretched and loses its ability to properly operate the choke.

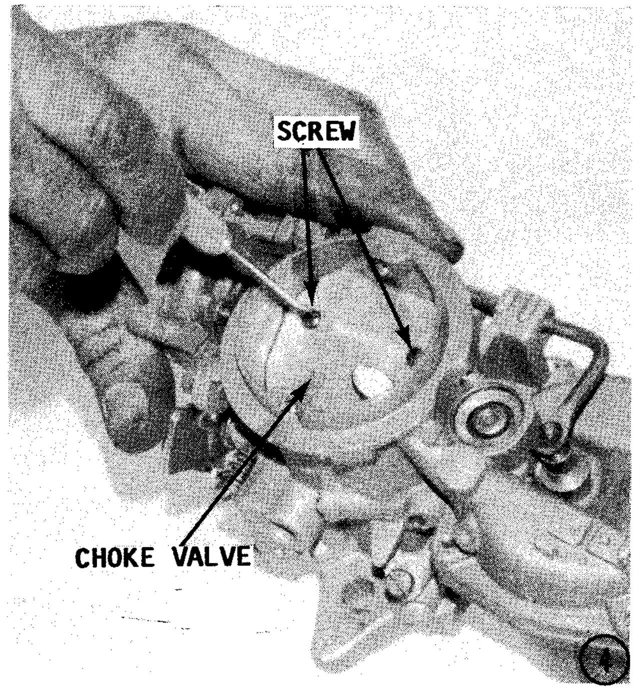




Remove the choke piston lever screw and the choke piston lever. Slide the choke piston out of the cylinder and disconnect the choke piston link by removing the piston pin.

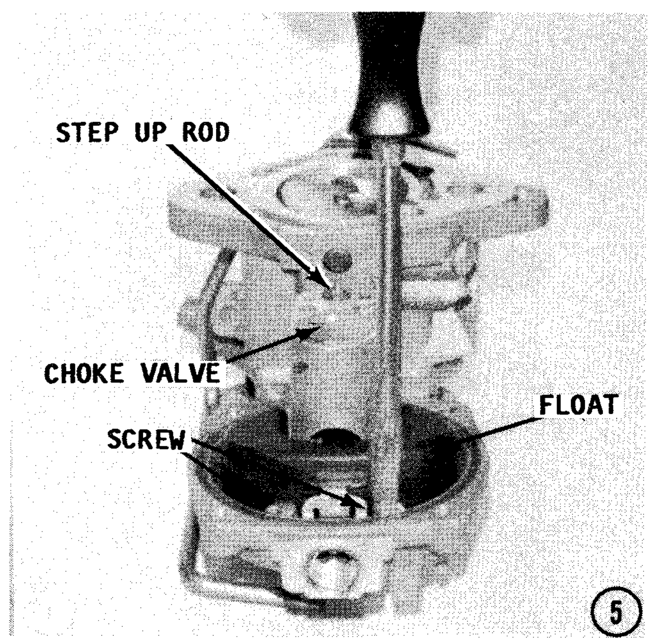
3- Under normal conditions, the choke valve and shaft do not need to be removed. However, if the choke valve and shaft are worn remove the cam retainer, lift the cam collar, and disengage it from the connector rod. Use a screwdriver and spread the fork end of the choke lever. This lever is located on the choke shaft between the choke housing and the body casting. Now, slide the choke lever from the shaft and disengage it from the connector rod.

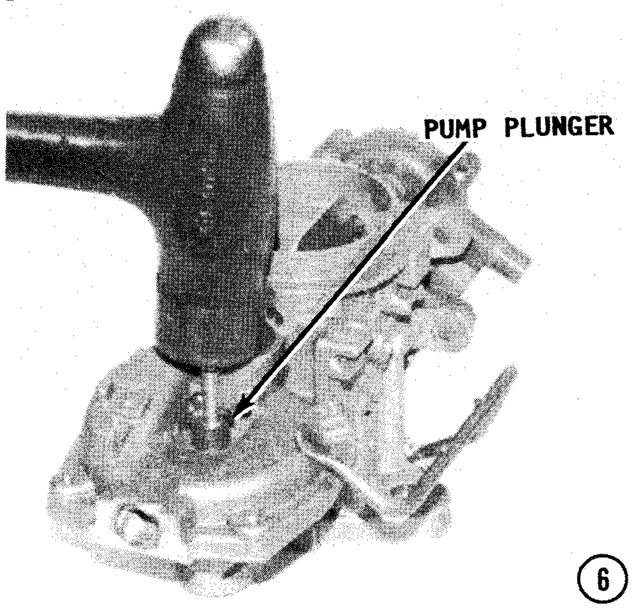




4- File off the upset ends of the choke valve attaching screws, and then remove the choke valve. Remove the idle adjustment screw and spring. Screw in the throttle adjusting screw until the throttle valve seats in the bore of the carburetor. Remove the choke valve and slide the choke shaft out of the casting.

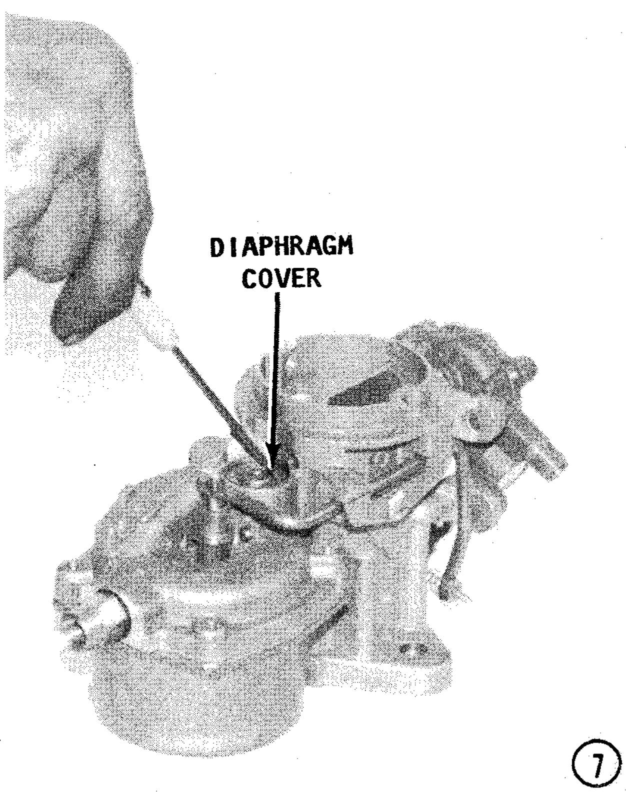
5- Turn the carburetor upside down and remove the float bowl attaching screws, float bowl, and the bowl ring gasket. Remove the float pin attaching screws and the float. Remove the pin from the float. Remove the needle and seat assembly.





6

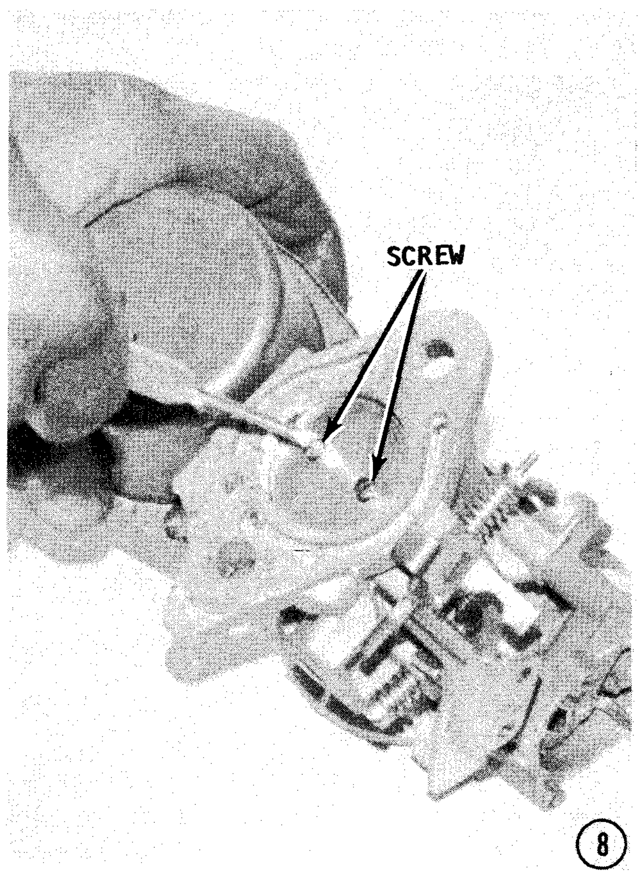
6- Turn the carburetor rightside up and place the float bowl under the lower portion of the pump cylinder to catch parts. Press the pump plunger down until it bottoms. Hold the plunger down and at the same time tap the upper end of the plunger shaft with a light hammer. and then remove the pump cylinder retainer, which is pressed on, and the spring.



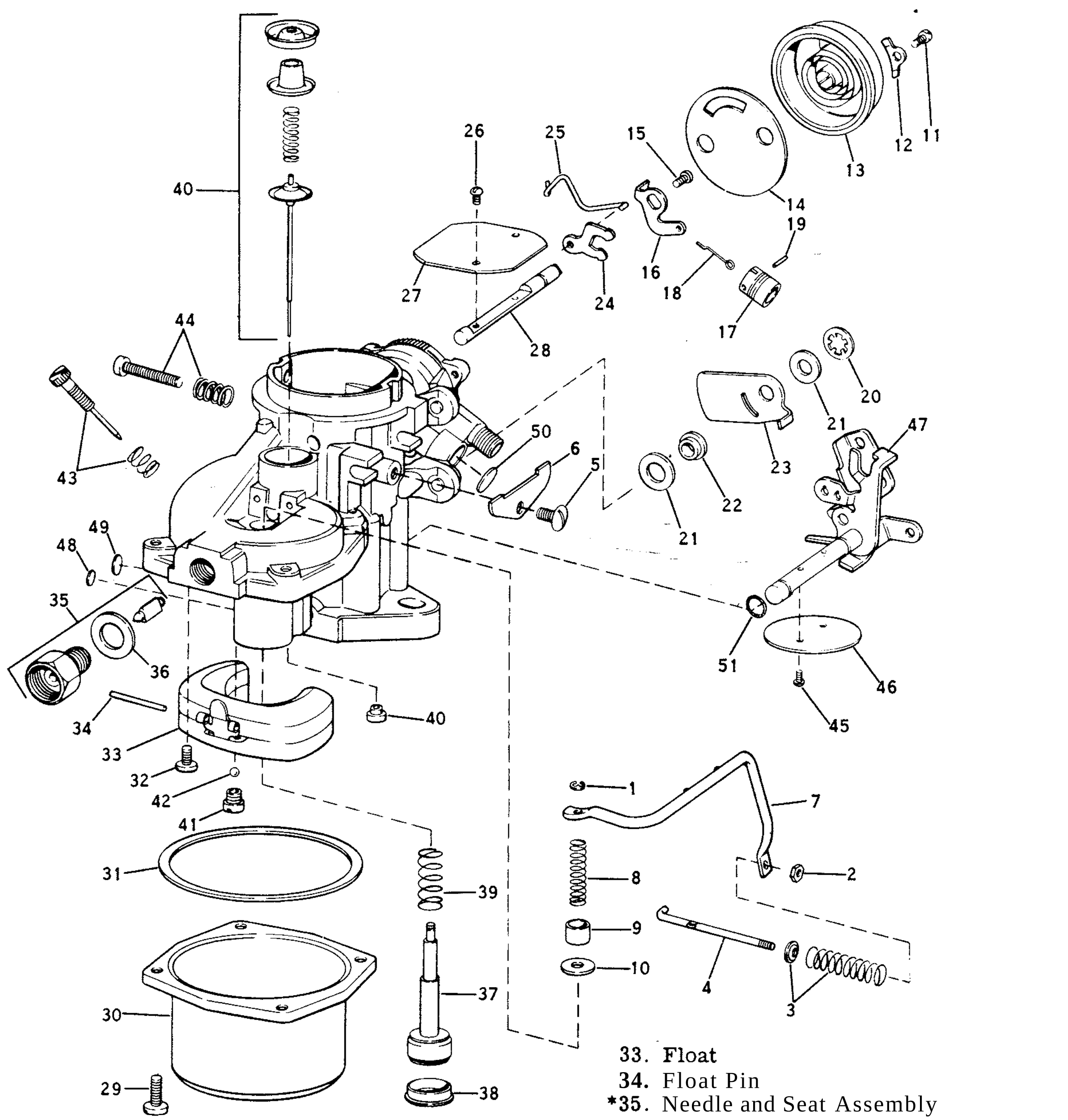
7

7- Use a screwdriver and pry the washer out of the diaphragm cover cap. Pierce the diaphragm cover cap by driving a screwdriver blade or a punch into the cover. Remove the pump plunger and spring. Pry the cover out of the casting using the bowl cover vent boss as a fulcrum. Remove the diaphragm retainer, spring, and step-up rod-and-diaphragm assembly. Remove the intake ball check using a suitable tool **ONLY** if there have been acceleration problems. **ALWAYS** pry upward and **AVOID** any excessive side thrust in the seat to prevent **DAMAGE** to the hole in the casting. **BEFORE** removing the pump intake seat, be certain new parts are available because the old parts **CANNOT** be used. Turn the carburetor upright and remove the pump intake ball. **NEVER** attempt to remove the pump discharge needle if new needles are not available.

8- If the throttle shaft needs to be replaced, remove the throttle valve attaching screws by first filing off the upset ends. Remove the throttle valve, and then slide the throttle shaft from the casting. **PAY ATTENTION** to the location of the connector link in the throttle lever as an aid during assembling.



8



* 1. Pump Rod Retainer
2. Connector Link Nut
3. Spring and Retainer
4. Connector Link
5. Pump Arm Retainer Screw
6. Pump Arm Retainer
7. Pump Arm
* 8. Upper Pump Spring
9. Bushing
10. Washer
11. Coil Housing Screw
12. Coil Housing Retainer
13. Thermostatic Coil and Housing
*14. Coil Housing Gasket
15. Lever Screw
16. Choke Piston Lever
17. Choke Piston
18. Choke Piston Link
19. Piston Pin
20. Cam Retainer
21. Washers
22. Cam Collar
23. Cam
24. Choke Lever
25. Connector Rod
26. Choke Valve Screw
27. Choke Valve
28. Choke Shaft
29. Bowl Attaching Screws
30. Float Bowl
*31. Bowl Ring Gasket
32. Float Pin Screw
33. Float
34. Float Pin
*35. Needle and Seat Assembly
36. Needle Seat Gasket
*37. Pump Plunger Assembly
*38. Pump Cylinder Retainer
39. Lower Pump Spring
*40. Step-up Rod and Diaphragm Assembly
*41. Intake Ball Check
*42. Intake Check Ball
43. Idle Adjustment Screw and Spring
44. Throttle Adjusting Screw and Spring
45. Throttle Valve Screw
46. Throttle Valve
47. Throttle Shaft
48. Fuel Well Welsh Plug
49. Idle Port Plug
50. Choke Piston Welsh Plug
51. "O"-Ring
* Repair Kit Parts

Exploded view of the Carter RBS carburetor with principle parts identified.

The needle and seat receive more wear than any other part of the carburetor. For this reason, they must be replaced regularly in order to maintain the correct fuel level for delivery to all systems. The needle and its seat MUST ALWAYS be replaced as a set.

CLEANING AND INSPECTING THE CARTER RBS

NEVER dip rubber parts, plastic parts, diaphragms, or pump plungers in carburetor cleaner.

Place all of the metal parts in a screen-type tray and dip them in carburetor solvent until they appear completely clean, then blow them dry with compressed air. The air horn has a plastic vent valve guide and a cranking enrichment valve. Both will withstand normal cleaning in carburetor cleaner.

Blow out all of the 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.

Inspect the idle mixture needle for any type of damage. Carefully check the float needle and seat assembly for wear. Good shop practice is to always install a new factory matched set to avoid leaks.

Inspect the holes in the levers for wear, especially for an out-of-round condition. Replace any leva-s or rods if they are worn. Check the throttle and choke levers and the valve plates for binding and damage. Inspect the fast idle cam for wear or damage.

Check the springs to be sure they have not become distorted or have lost their tension. If in doubt, compare them with a new one, if possible.

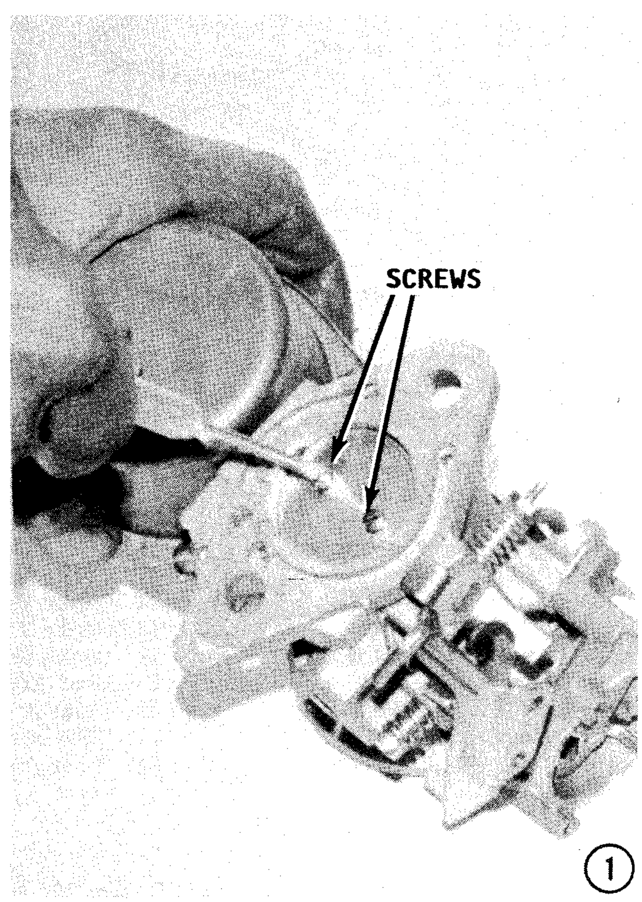
Inspect the sealing surfaces of the casting for damage.

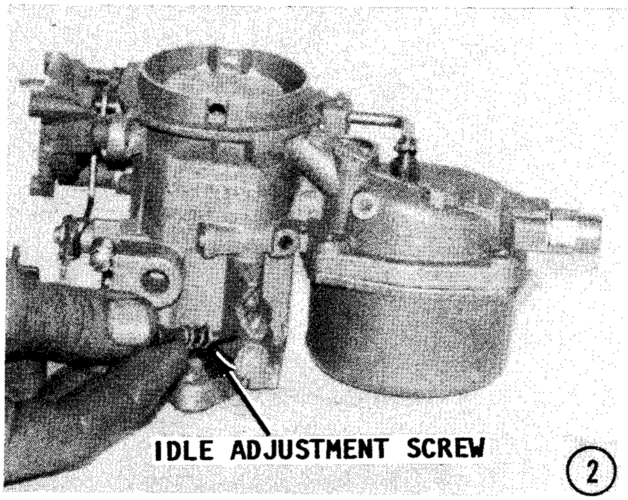
Most of the parts that should be replaced during a carburetor overhaul are included in an overhaul kit available from the local marine dealer.

Tip of an idle mixture adjusting needle bent from being forced into its seat and against the closed throttle plate.

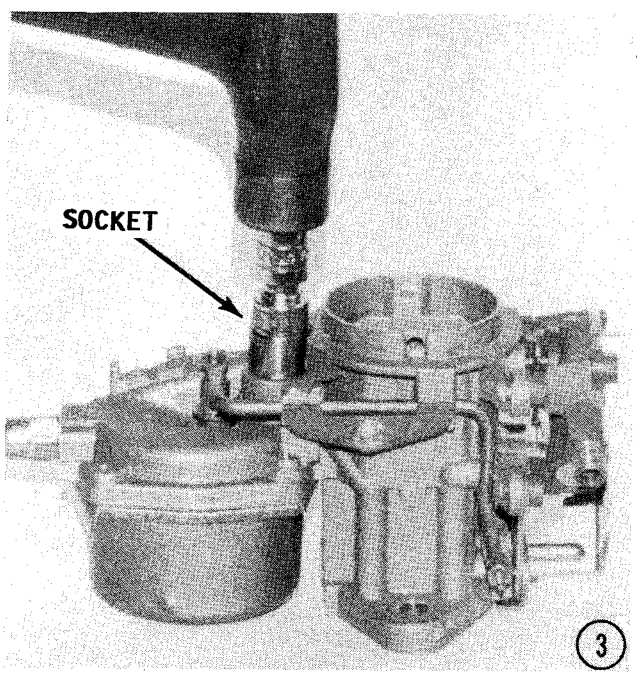
ASSEMBLING THE CARTER RBS

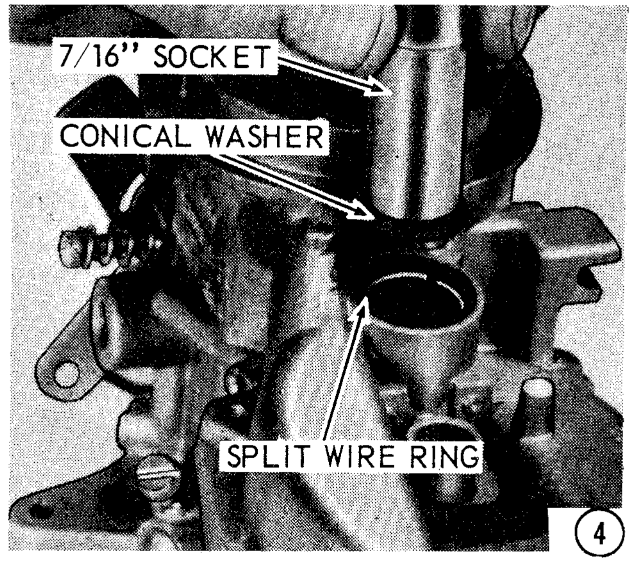
1– If the throttle shaft was removed, insert the pump arm connector link into the outside hole of the throttle lever and insert the shaft. Use **NEW** attaching screws and install the throttle valve with the trade mark **"C"** stamped on the throttle valve extending **TOWARD** the idle port when viewed from the manifold flange side. With the throttle valve attaching screws loose, tap the throttle valve lightly with a screwdriver to center the valve in the bore. Use your finger to hold the valve in place and at the same time tighten the screws. After the screws have been tightened, rough-up the ends to prevent the screws from backing out, and **TAKE CARE** not to bend the throttle shaft in the process.





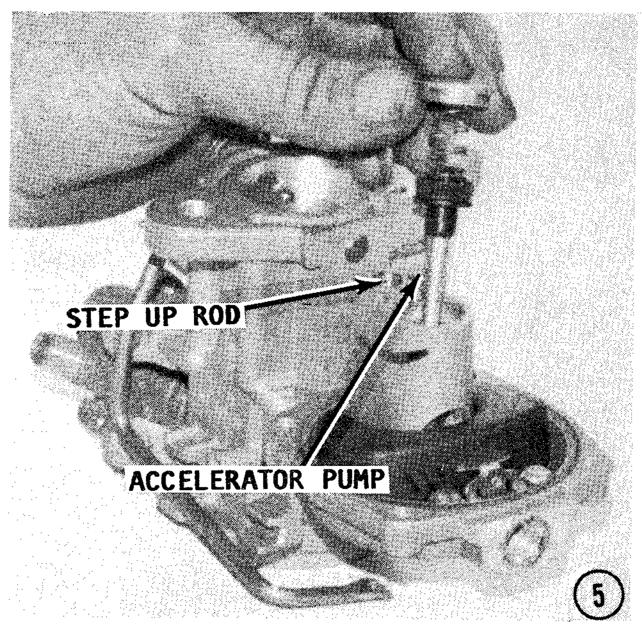
2- Install the idle adjustment screw and spring. Seat the screw LIGHTLY, and then back it out about 1-1/2 turns as a rough adjustment at this time. If the pump intake seat and ball were removed, install a NEW ball in the passage, and then install a new seat by driving it in place with a brass drift. Set the carburetor in the upright position, and place the step-up rod and diaphragm assembly in place. Turn the carburetor upside down and use the upper stem of the diaphragm to guide the step-up rod through the pressed-in metering jet. Place the brim of the hat-shaped retainer, without the spring, on top of the diaphragm, and then use it as a tool to press the diaphragm firmly against the gasket ledge in the casting. Remove the hat-shaped retainer and check the diaphragm assembly to be sure it is installed evenly.

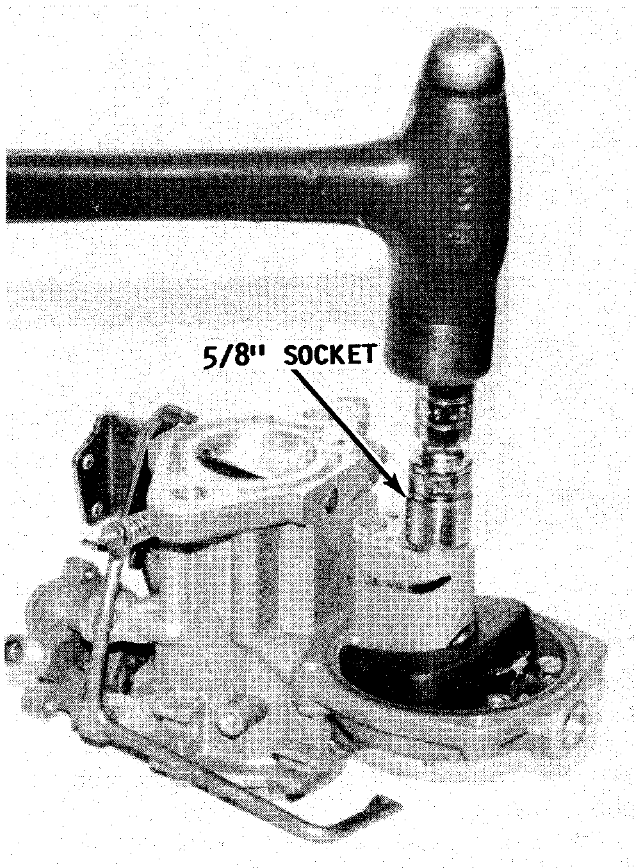




3- Insert the step-up rod spring into the cup-shaped plate on top of the diaphragm. Place the hat-shaped retainer with the brim **DOWN** on top of the spring. Place a new diaphragm cover cap in position. Now, use a 5/8" socket as a seating tool, and LIGHTLY tap the socket until the cover cap seats in the housing.

4- Place the split-wire ring inside the diaphragm over the cap. Place the conical washer with the SMALL end of the cone pointing UP over the split-wire ring. Now, place a 7/16" socket over the inside diameter of the conical washer and LIGHTLY tap it into place until the washer is flat. **NEVER** use a smaller tool when installing the conical washer because it may enter the cover cap or strike the center portion of the cover. **DO NOT** drive the washer beyond the flat position.



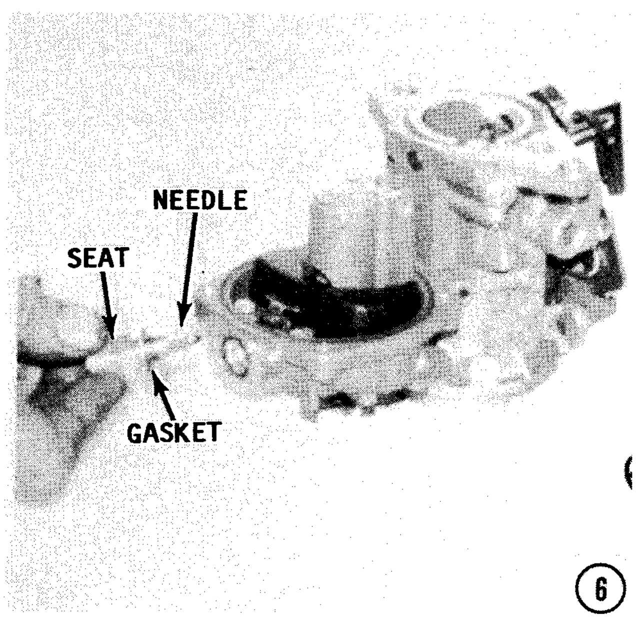


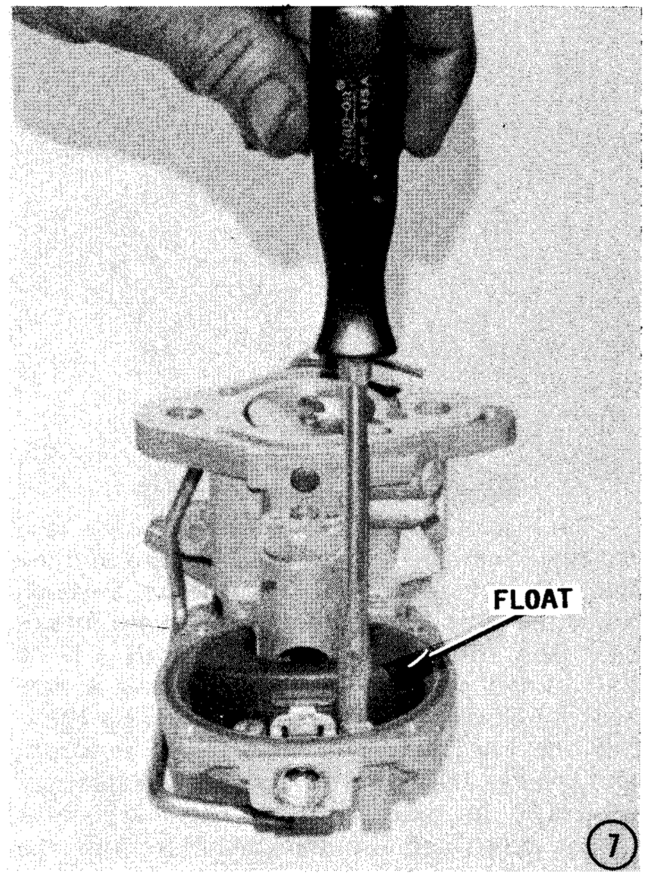
Installing the diaphragm cover onto the step up rod.

5- Invert the carburetor and install a **NEW** accelerator pump plunger and spring. Install and seat a **NEW** pump retianer.

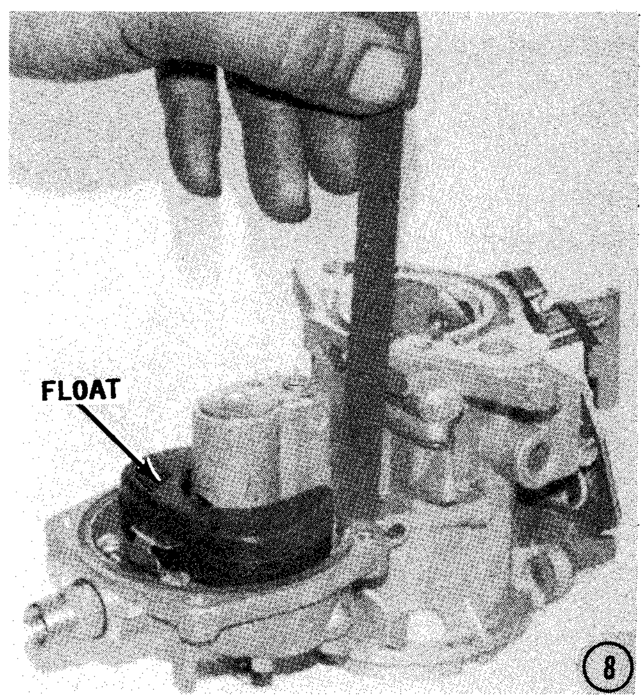
6- Install a **NEW** needle and seat assembly in the casting. **ALWAYS** use a new one as a precaution against leaks.

7- Insert the float pin in the float bracket and slide the float into place.





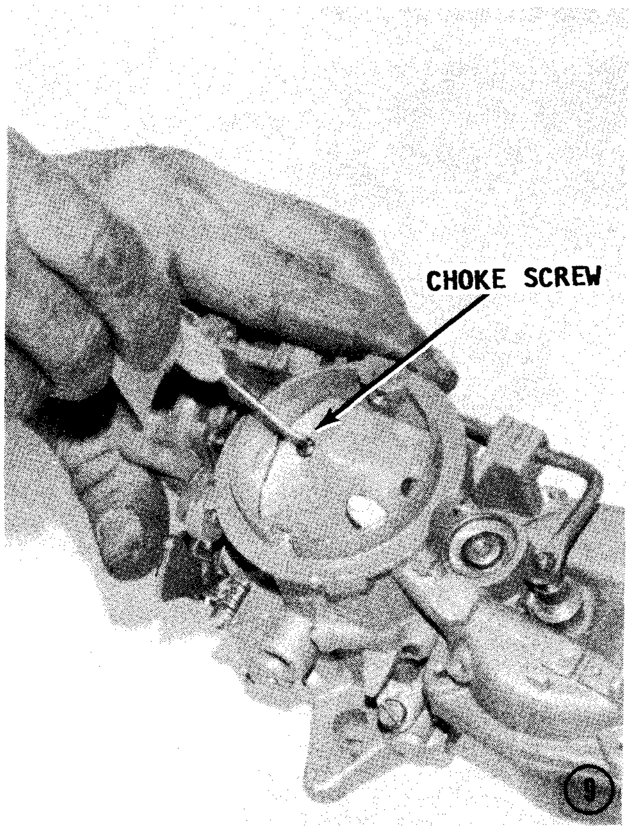
8- Float Level Measurement: Turn the carburetor upside down. Now, with only the weight of the float seating the needle, measure the vertical distance from the machined casting to the small "bump" at the outer end of the float. Measure the distance at both ends of the float. This distance should

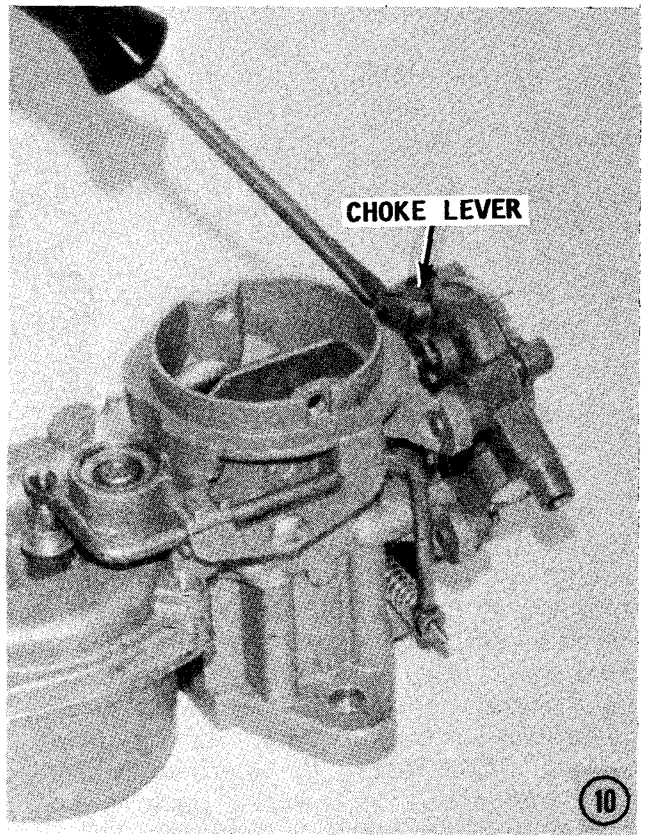


be 15/32". **TAKE EXTRA CARE** to ensure the needle is not pressed into the seat, because this carburetor has a resilient seat and pressing the needle would cause the seat material to take a "temporary set" which would result in an incorrect fuel level when the "set" is relieved. Adjustment: Hold the lip end of the float bracket with a pair of needle-nose pliers and bend the bracket at its narrowest point. Install the fuel bowl and a NEW bowl ring gasket using the attaching screws.

9- If the choke was completely disassembled, install the choke shaft in the casting. Attach the choke valve to the shaft with NEW screws. **DO NOT TIGHTEN** the screws at this time. Center the choke valve in the bore by tapping it lightly with a screwdriver. Hold the choke valve in place with your finger and at the same time tighten the screws. After the screws are tight, rough-up the ends to prevent the screws from backing out.

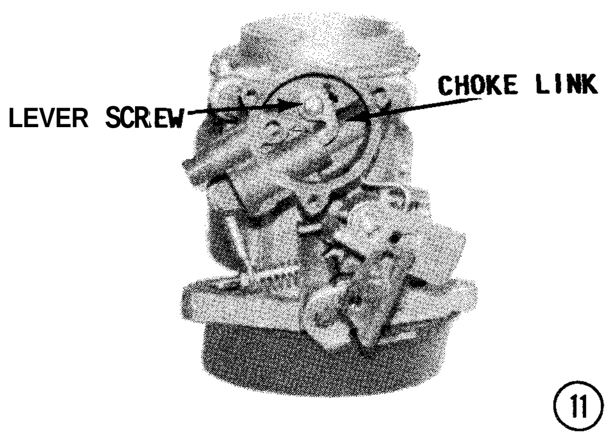
10- Attach the connector rod to the choke lever, and then install the lever on the choke shaft. Secure it in place by crimping the forked ends of the lever with pliers. Attach the cam to the lower end of the connector rod and attach the cam, collar, and retainer to the pivot shaft.



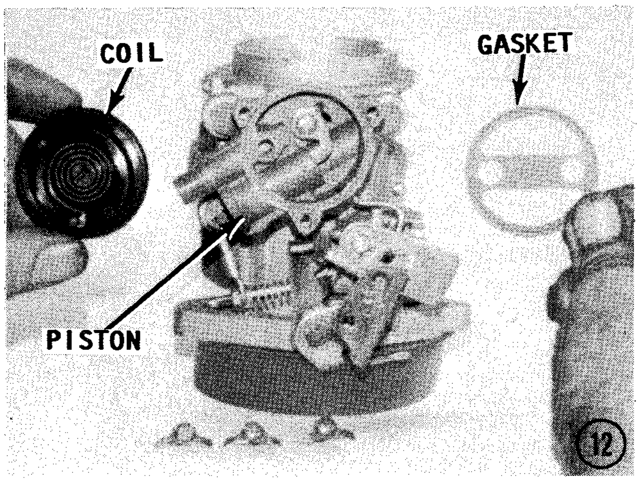


11- Assemble the choke piston and link using the choke piston ring. Attach the piston and link assembly to the choke lever, then slide the piston into the cylinder. Position the choke lever on the end of the choke shaft and attach it to the shaft using the lever screw. Check to be sure the choke linkage moves freely without binding.

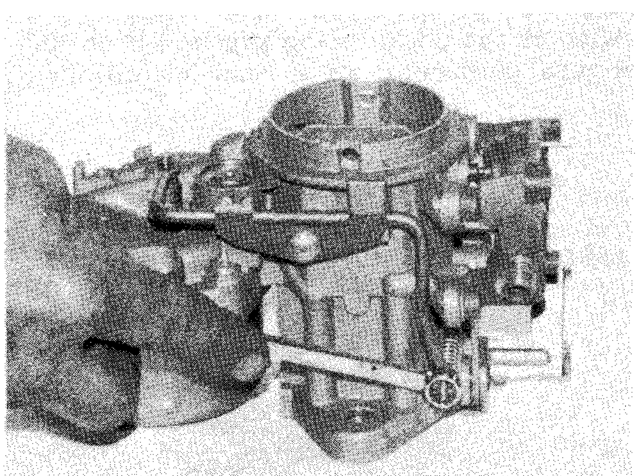
12- Place the coil housing gasket in place, and then install the coil housing with the retainers and JUST **START** the screws. Check to be sure the hook engages the lever. If the choke being adjusted is on the forward carburetor of a dual installation,



11



set the choke on the index mark, and then tighten the cover screws. The choke valve should now be spring-loaded in the closed position. If the choke being adjusted is on the rear carburetor, set the choke on the index mark, then turn it 1-1/4 turns clockwise. Now, tighten the cover screws. The choke valve should now be lightly spring-loaded. **REMEMBER,** the thermostatic coil assemblies **MUST** be installed back in their original location because the rear coil assembly is under tension to maintain the choke in the open position and this causes the coil to lose its ability to operate a choke properly. Place the carburetor in the upright position. Install the washer, bushing, and spring on the accelerator plunger shaft. Place the end of the pump arm over the plunger shaft and secure it with a retainer. Install the retainer washer on the throttle shaft connector link. Install the spring on the connector link through the lower hole of the pump arm and attach it with a nut.



The plunger must start its downward movement as soon as the throttle valve starts to open. If it does not, make the adjustment with a box-end wrench, as shown.

Align the pump arm so it fits in the groove in the carburetor casting and secure it with a retainer and screw. Check to be sure the pump arm moves freely.

BENCH ADJUSTMENTS FOR THE CARTER RBS

Pump

A pump adjustment **MUST** be made each time the carburetor is disassembled, and **MUST** be made **BEFORE** the unloader adjustment.

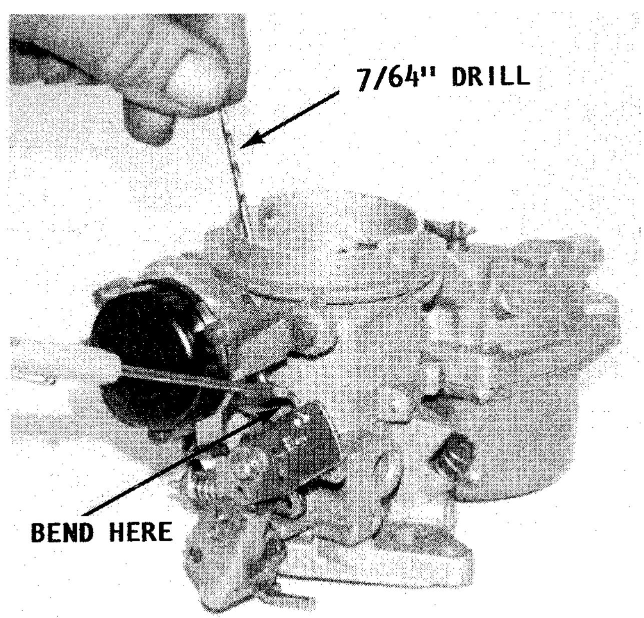
Back out the throttle adjusting screw and hold the choke valve wide open so the throttle valve seats in the bore of the carburetor.

With the throttle valve tightly closed, adjust the connector rod nut until there is no lag between the downward movement of the pump plunger and the opening of the throttle valve.

The plunger **MUST START** its downward movement as soon as the throttle valve starts to open.

Unloader, Forward Carburetor Only

Hold the throttle valve in the wide open position, and adjust the tang on the throttle lever until the clearance between the upper edge of the choke valve and the inner wall of the air horn is 7/64".



Adjusting the unloader at the forward carburetor using a 7/64" drill. The screwdriver points to the tab which is bent with a pair of pliers to make the adjustment.

SYNCHRONIZING DUAL CARBURETORS

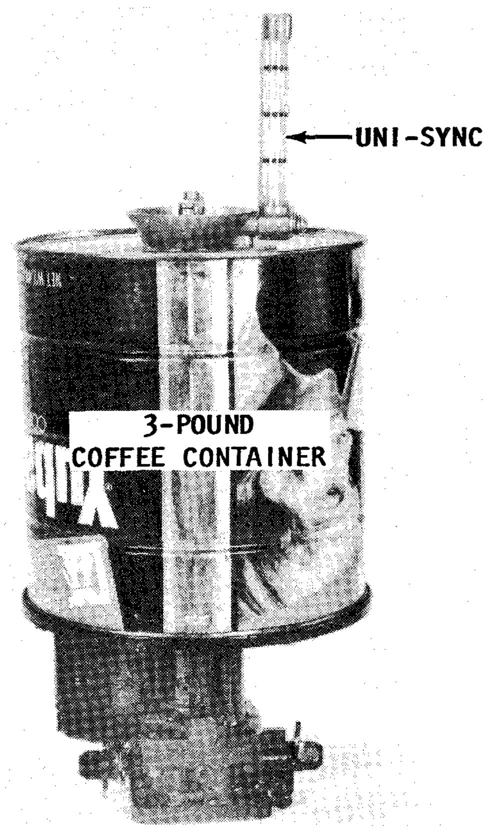
SPECIAL WORDS

Your goal is to be sure both carburetors are drawing air and fuel equally, at idle speed. While adjusting, MAKE SURE that when the throttle is advanced, both carburetors open at the same time.

As an aid to adjusting multiple carburetors, a three-pound coffee container can be adapted to hold a Uni-Sync vacuum measuring device, as shown in the accompanying illustration. This arrangement will prove to be an excellent tool. The coffee can inverted will fit on the top base of each carburetor. The vacuum of the carburetor can be accurately measured and adjustments made until both carburetors are pulling equally.

Turn the idle mixture screws on both carburetors in until they seat, then back them out 1-1/2 turns. Disconnect the forward ball joint link. Back out both idle stop screws fully until both throttles are fully closed in the bores. Next, adjust the forward ball joint link until both throttles begin to open at the same time.

Operate the throttle by pushing on the throttle connector pin where the remote control attaches. Adjust the rear idle stop screw until it contacts the throttle arm, and then turn it in 1-1/2 turns to open the throttle slightly.



A coffee container and Uni-Sync vacuum measuring device used when synchronizing multiple carburetors.

Start the engine.

CAUTION: Water must circulate through the lower unit to the engine.

Adjust the speed to between 500 and 600 rpm in gear, and using only the rear idle stop screw to make the adjustment.

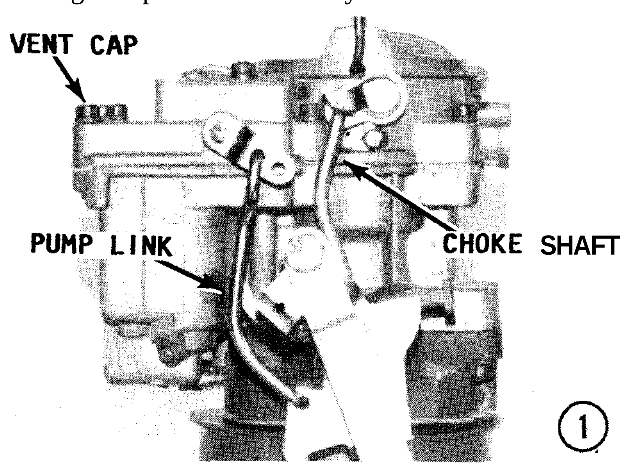
Adjust both idle mixture screws until the engine runs smoothly. Reset the idle rpm, if necessary, but use only the rear idle stop screw.

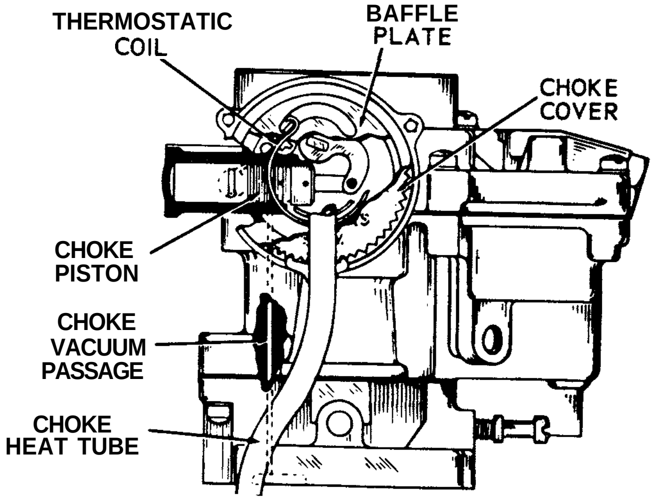
Finally, bring the forward idle stop screw up until it just touches the throttle arm.

4-3 ROCHESTER MODEL 2GC

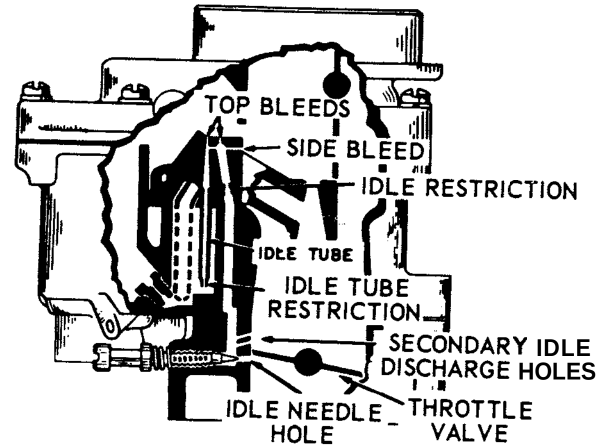
This current two-barrel carburetor is available in two different models: 2GC and 2GV. The Model 2GV has an automatic choke with the thermostatic coil installed on the engine manifold. The coil is then connected to the choke valve through linkage. This model has a vacuum-break diaphragm on the carburetor instead of the conventional choke housing on the air horn. The Model 2GC has the automatic choke as a part of the carburetor.

1- Remove the idle vent valve and the pump link. Remove the screw at the end of the choke shaft and the fast-idle cam attaching screw, then remove the fast-idle linkage as an assembly. Remove the air horn attaching screws and lift the air horn straight up from the body.

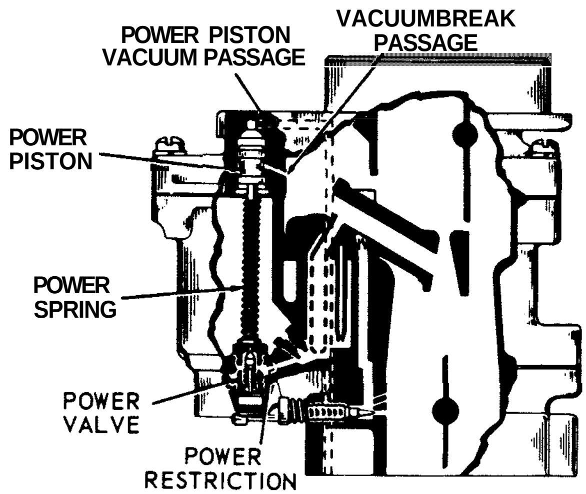




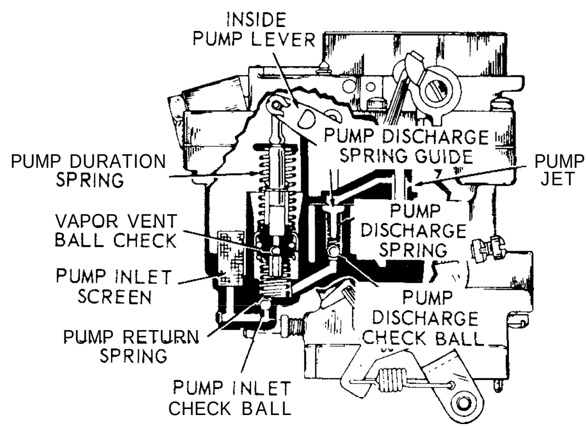
CHOKE SYSTEM



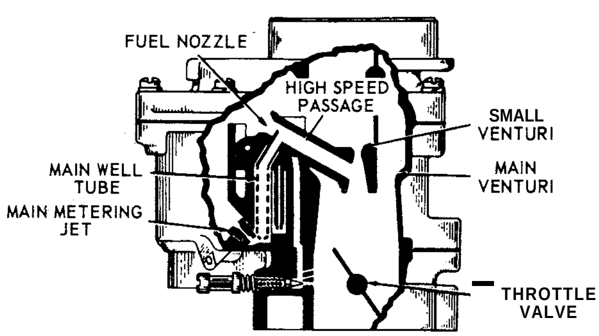
POWER SYSTEM



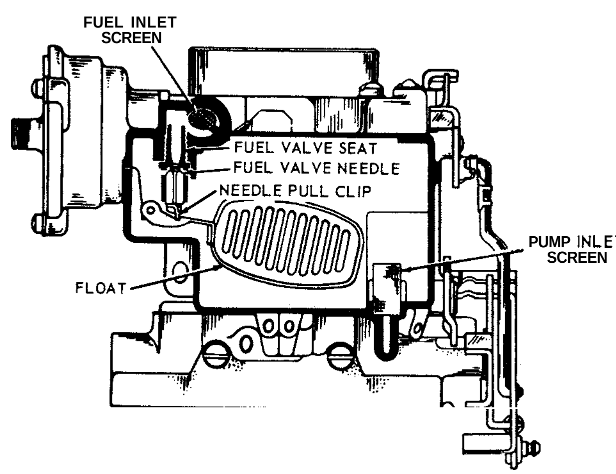
IDLE SYSTEM



POWER SYSTEM

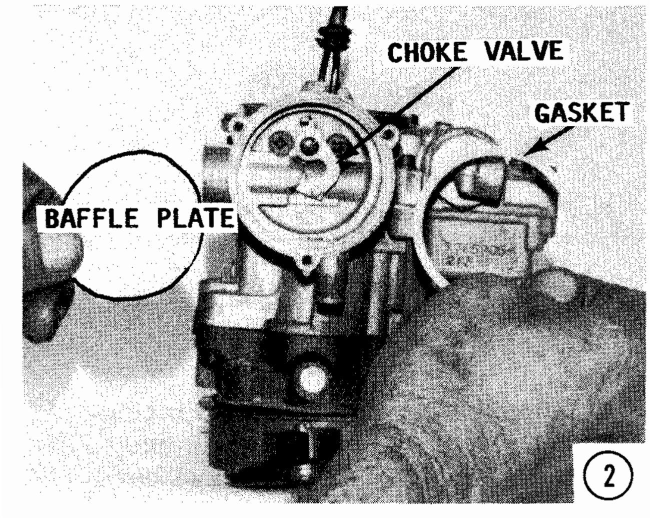


MAIN METERING SYSTEM



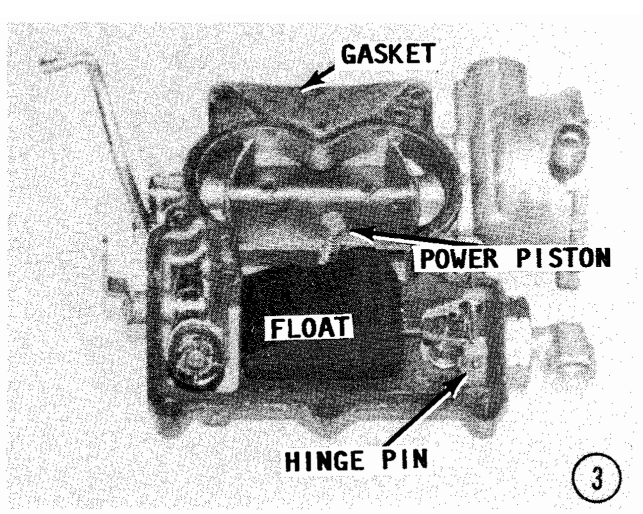
FLOAT SYSTEM

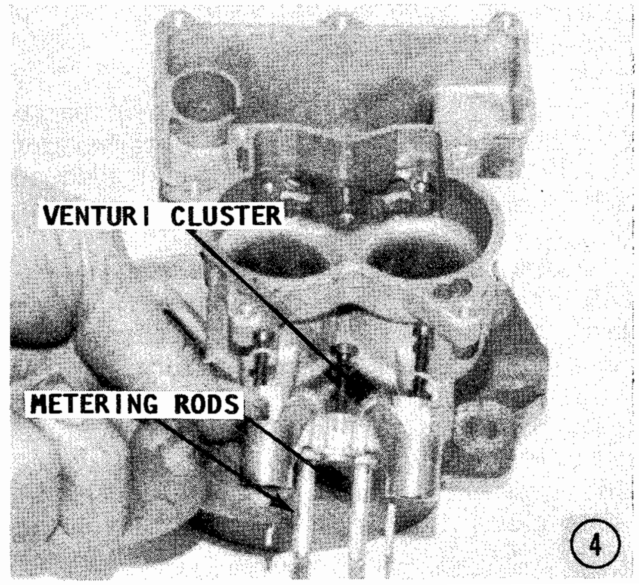
Details of the various systems of the Rochester 2G carburetor, for study purposes.



2- Disassemble the automatic choke by first removing the two choke valve retaining, screws. However, under normal conditions, the choke shaft is not removed. You may have to file the staked ends of the screws in order to remove them. Lift out the choke valve. Remove the choke cover, with the thermostatic coil attached, the gasket and the baffle plate. Now, rotate the choke shaft counterclockwise to guide the piston from its bore. Remove the shaft and piston assembly.

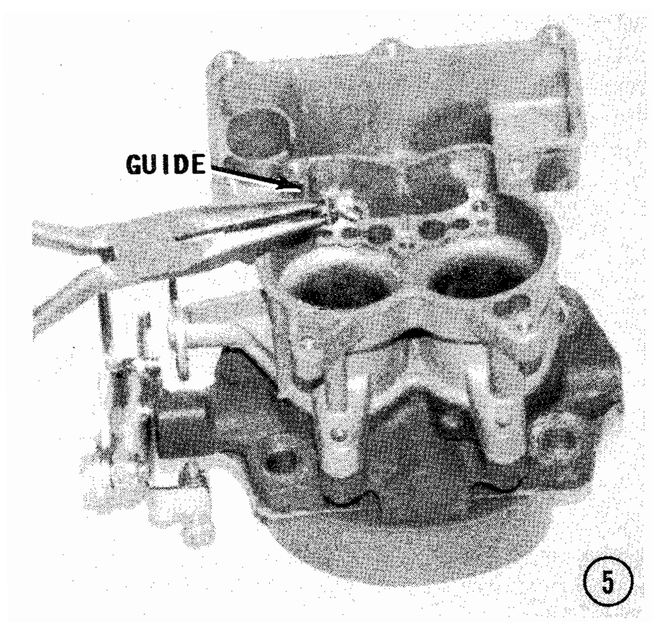
3- Turn the air horn upside down and remove the float hinge pin. Lift off the float, and remove the float needle. Depress the power piston shaft which will allow the spring to snap and in turn will force the piston from the casting and allow the power piston to be removed. Remove the accelerator pump plunger and the pump lever and shaft assembly. Remove the two choke housing-to-air horn attaching screws and lift off the choke housing. Discard the gasket.





4- Remove the pump plunger, return spring, main-metering jets, and power valve from the main body. Some models have an aluminum inlet ball in the bottom of the pump well. This ball will fall out when the carburetor is turned over. Remove the venturi cluster by removing the attaching screws.

5- Use a pair of needle-nosed pliers to remove the discharge ball spring T-shaped retainer. Now, take out the pump discharge spring and the steel discharge ball. Turn the carburetor over and remove the three throttle body-to-bowl attaching screws. Lift off the throttle body. DO NOT disassemble the throttle body. Replacement parts are NOT available because of the close relationships between the throttle plates and the idle ports.



CLEANING AND INSPECTING THE ROCHESTER 2G

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 of the 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.

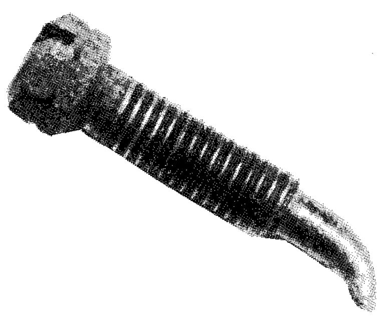
Move the throttle shaft back-and-forth to check for wear. If the shaft appears to be too loose, replace the complete throttle body because individual replacement parts are not available.

Inspect the main body, air horn, and venturi cluster gasket surfaces for cracks and burrs which might cause a leak.

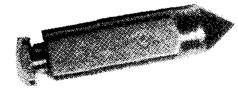
Shake the float to determine if there is any liquid inside, and if there is, replace the float. Check the float arm needle contacting surface and replace the float if this surface has a groove worn in it.

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.



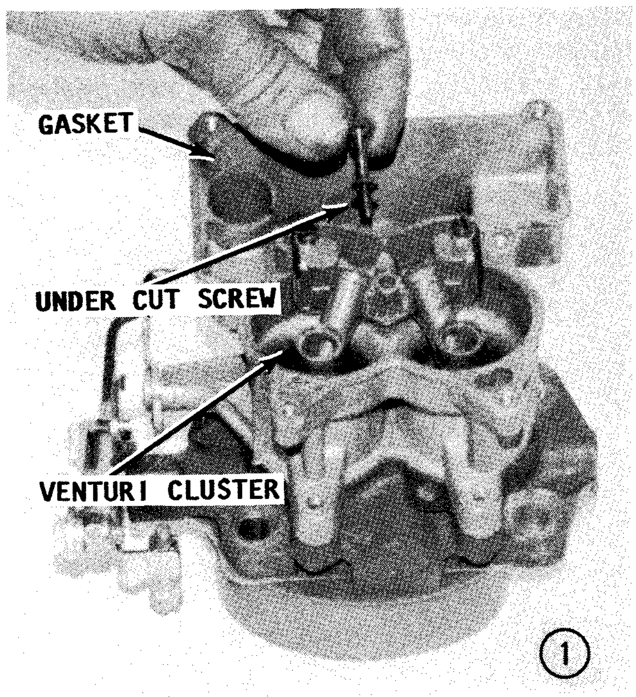
Tip of an idle mixture adjusting needle bent from being forced into its seat and against the closed throttle plate.



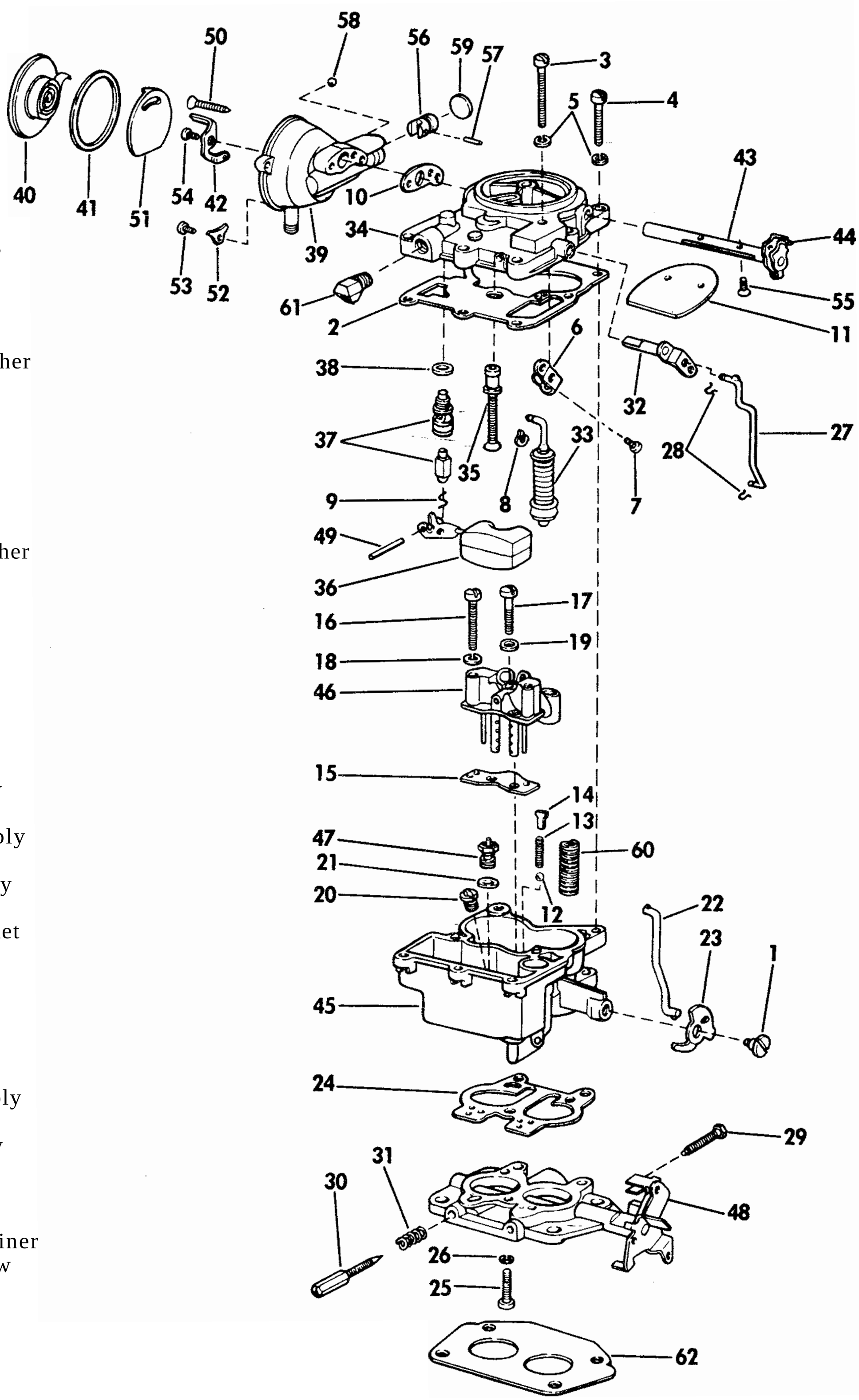
*Fuel inlet needle with a worn ridge. The set **MUST** be replaced to prevent a leak and carburetor flooding.*

ASSEMBLING THE ROCHESTER 2G

1- Install the idle mixture adjusting needles and springs into the throttle body **FINGERTIGHT.** Now, back the screws out 1-1/2 turns as a rough adjustment at this time. Use a **NEW** gasket and assemble the throttle body onto the bowl. A **NON-VENT** gasket **MUST** be used because during hot-engine operation, the fuel in the carburetor tends to "percolate" due to engine heat. If a vented, automotive-type gasket is used, these fuel vapors will be vented directly into the atmosphere. A genuine replacement gasket will prevent these fuel vapors from venting. Insert the pump discharge check steel ball, spring, and T-shaped retainer into the top of the main body. Use a **NEW** gasket and install the venturi cluster. **BE SURE** the undercut screw has a gasket and is placed in the center hole. Install the main metering jets and the power valve, with a **NEW** gasket. Install the pump return spring in the pump well and the pump inlet screen in the bottom of the bowl.



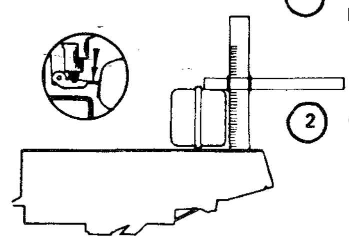
1. Idle Stop Lever Screw
2. Air Horn Gasket
3. Long Air Horn Screw
4. Short Air Horn Screw
5. Air Horn Lockwasher
6. Pump Lever
7. Pump Screw
8. Pump Clip
9. Pull Clip
10. Choke Gasket
11. Choke Valve
12. Pump Discharge Ball
13. Pump Discharge Spring
14. Pump Spring Guide
15. Venturi Gasket
16. Outer Venturi Screw
17. Center Venturi Screw
18. Outer Venturi Lockwasher
19. Center Venturi Gasket
20. Main Metering Jet
21. Power Valve Gasket
22. Choke Rod
23. Idle Speed Stop Lever
24. Throttle Body Gasket
25. Throttle Body Screw
26. Throttle Body Lockwasher
27. Pump Rod
28. Pump Rod Clip
29. Idle Stop Screw
30. Idle Adjusting Needle
31. Idle Needle Spring
32. Pump Shaft and Lever Assembly
33. Pump Assembly
34. Air Horn Assembly
35. Power Piston Assembly
36. Float Assembly
37. Needle and Seat Assembly
38. Needle Seat Gasket
39. Choke Housing Assembly
40. Thermostat Cover
41. Thermostat Cover Gasket
42. Choke Lever and Link Assembly
43. Choke Shaft Assembly
44. Choke Lever and Collar Assembly
45. Float Bowl Assembly
46. Venturi Cluster Assembly
47. Power Valve Assembly
48. Throttle Body Assembly
49. Float Hinge Pin
50. Choke Housing Screw
51. Baffle Plate
52. Thermostat Cover Retainer
53. Thermostat Cover Screw
54. Choke Lever Screw
55. Choke Valve Screw
56. Choke Piston
57. Choke Piston Pin
58. Lead Ball Plug
59. Expansion Plug
60. Pump Return Spring
61. Fuel Line Fitting



Exploded view showing all parts of the Rochester 2G carburetor.

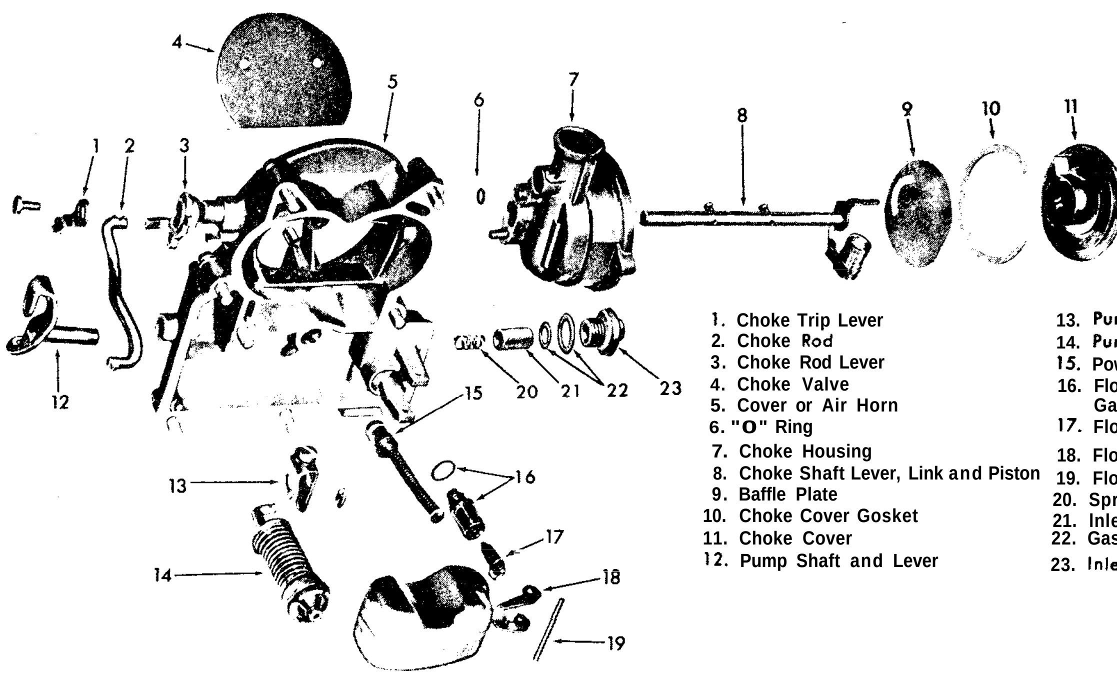
2- The following referenced part numbers in this step will be found on the accompanying exploded drawing. Place a new gasket in position and install the choke housing (7). Secure the housing with the two attaching screws, if the choke shaft was removed. Assemble the choke piston to the choke shaft and link (8). The piston pin and flat section on the side of the choke piston **MUST** face **OUTWARD** toward the air horn. Push the choke shaft into the air horn, and rotate the shaft until the piston enters the housing bore. Place the choke valve (4) on the choke shaft with the letters RP facing up. Install the two choke valve retaining screws just **FINGER-TIGHT.** Place the choke rod lever (3) and the trip lever (1) on the end of the choke shaft. Center the choke valve to obtain 0.020" clearance between the choke lever and the air horn casting. Now, tighten and then roueh the ends of the choke valve retaining screws to prevent them from backing out. Install the baffle plate (9) gasket (10), and thermostatic cover (11). Rotate the cover until the index marks align according to specifications. Install and tighten the three cover retainers and retaining screws. Install the outer pump lever (12) in the air horn. Assemble the inner pump arm (13) and tighten the screw . Attach the pump plunger (14) to the inner arm (13), with the pump shaft pointing **INWARD.** Install the horseshoe retainer. Position the screen on the float needle seat (16) and screw the assembly into the air horn. Install the power piston (15) into the vacuum cavity. Check to be sure the piston moves **FREELY.** Stake the retainer lightly to hold it in place. Install the air horn gasket and attach the needle (17) to the float (18). **CAREFULLY** insert the needle into the float needle seat while guiding the float between the bosses. Insert the hinge pin (19) to finish the air horn assembling.

Two float adjustments **MUST** be made at this time: The float level, and the float drop.



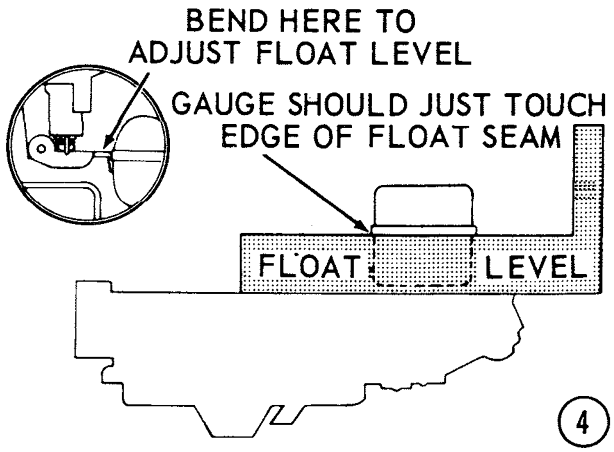
3

3- Float Level Adjustment on models with a **VERTICAL** seam in the float: Measure the distance from the top of the float to the air horn, with the gasket in place. Compare your measurement with the Specifications in the Appendix. **CAREFULLY** bend the float arm at the rear of the float as shown in the accompanying illustration, until the required measurement is reached.

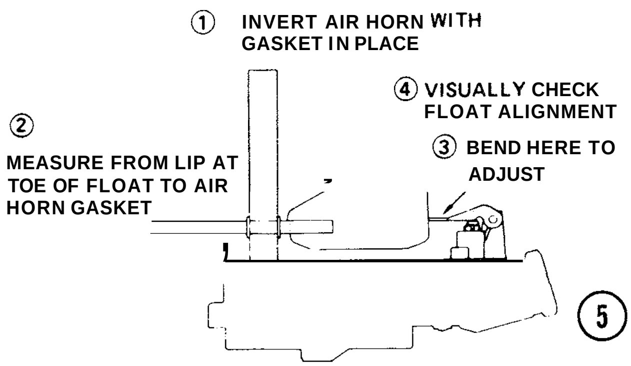


1. Choke Trip Lever
2. Choke Rod
3. Choke Rod Lever
4. Choke Valve
5. Cover or Air Horn
6. "O" Ring
7. Choke Housing
8. Choke Shaft Lever, Link and Piston
9. Baffle Plate
10. Choke Cover Gosket
11. Choke Cover
12. Pump Shaft and Lever
13. Pump Inside Lever
14. Pump Plunger and Rod
15. Power Valve Piston
16. Floot Valve Seat and Gasket
17. Float Needle Valve
18. Float Assembly
19. Float Hinge Pin
20. Spring
21. Inlet Filter
22. Gaskets
23. Inlet Nu!

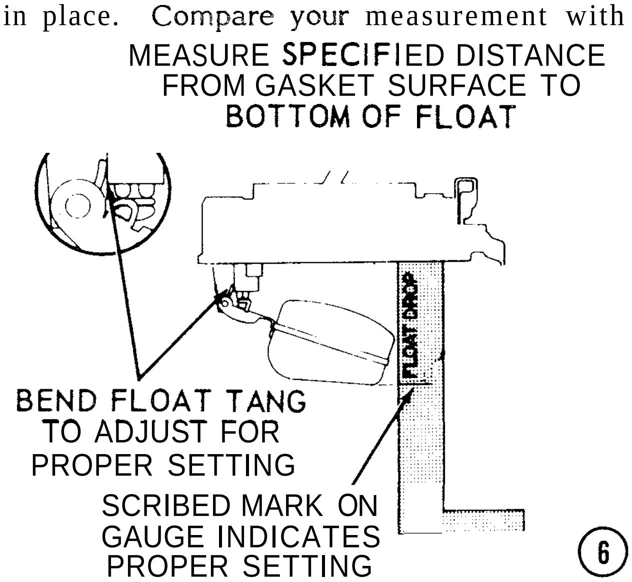
2



4- Float Level Adjustment on models with a **HORIZONTAL** seam in the float: Measure the distance from the lower edge of the seam to the air horn, with the gasket in place. Compare your measuremen with the Specifications. **CAREFULLY** bend the float arm at the rear of the float as shown in the accompanying illustration.



5- Float Level Adjustment on models with a **NITROPHYL-TYPE** (hollow) float: Measure the distance from the lip at the toe of the float to the air horn, with the gasket in place. Compare your measurement with the Specifications. **CAREFULLY** bend the float arm at the rear of the float, as shown in the accompanying illustration, until the required measurement is reached.

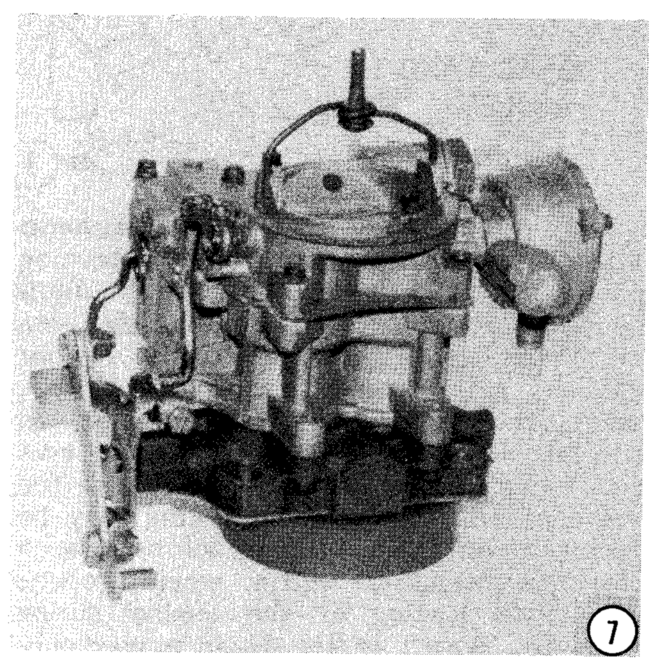


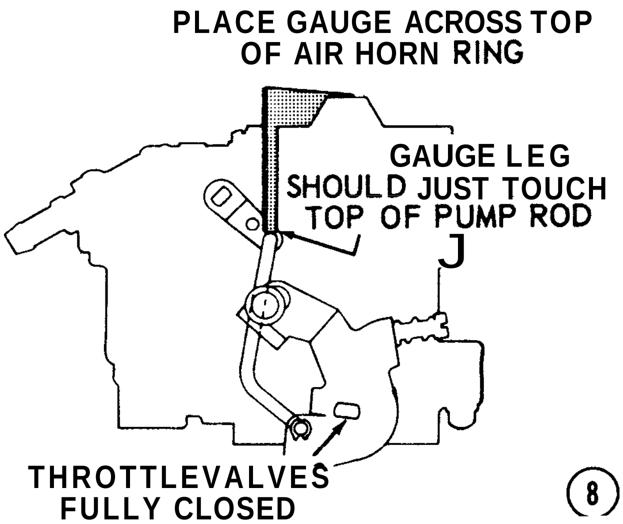
6- Float Drop Adjustment: Turn the air horn right side up to allow the float to move to the wide-open position. Now, measure the distance from the air horn gasket to the bottom of the float. Compare your measurement with those given in the Specifications. **CAREFULLY** bend the float tang until the required measurement is reached, as shown in the accompanying illustration.

7- Replace the assembled air horn onto the bowl and guide the accelerator pump plunger into its well. Install and tighten the cover screws. Install the idle needle into the spring, then into the throttle body. Install the pump rod, fast-idle rod, the fast-idle cam, and screw.

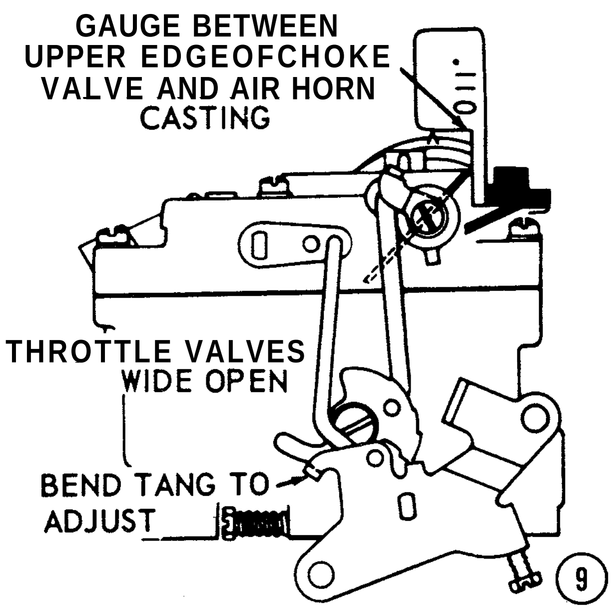
BENCH ADJUSTMENTS FOR THE ROCHESTER *2GC*

8- Back out the idle stop screw and completely close the throttle valves in their bores. Place a pump gauge across the top of the carburetor air horn ring, as shown, with the 1-5/32" leg of the gauge pointing downward towards the top of the pump rod. The lower edge of the gauge leg should just touch the top of the pump rod. **CAREFULLY** bend the pump rod, as required to obtain the proper setting.

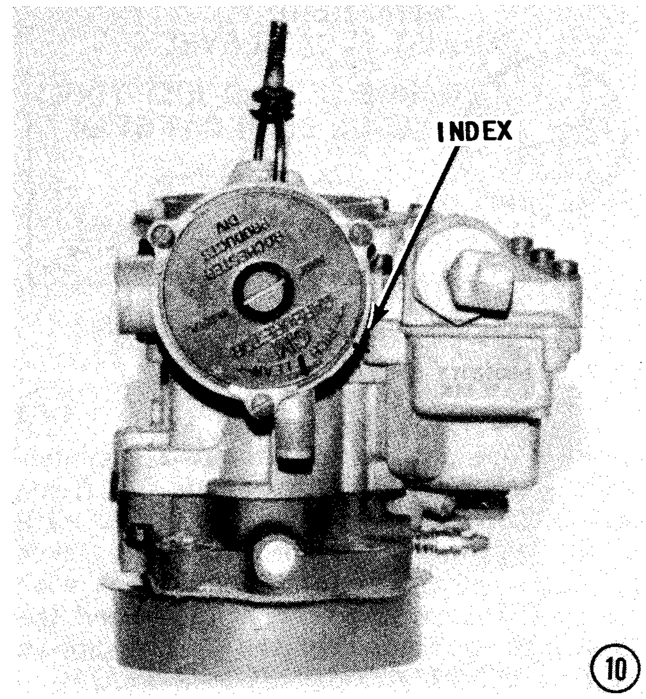




9- Unloader Adjustment: Open the throttle valves wide. The choke valve should open only enough to allow the specified gauge between the upper end of the valve and the inner air horn wall. **CAREFULLY** bend the tang on the throttle lever until the proper adjustment is reached.



10- Automatic Choke Adjustment: Loosen the thermostat cover attaching screws and rotate the cover until the mark on the cover is aligned with the index line on the housing. Tighten the screws. Do not use any setting except the standard one, unless the engine is usually operated on special blends of fuel which do not give satisfactory warm-up performance with the standard setting. A lean setting may be required with high octane fuel because a standard thermostat setting would produce too much loading of the engine during warm-up. A rich setting should be used only



if a lot of spitting occurs during engine warm-up with the standard setting. Whenever the setting is changed for either richer or leaner operation, the cover should be moved just one point at-a-time, and the results tested with the engine cold.

11- Idle Speed and Mixture Adjustments: Install a clean flame arrestor. Start the engine and allow it to run until it has warmed to operating temperature and the choke has moved to the full open position.

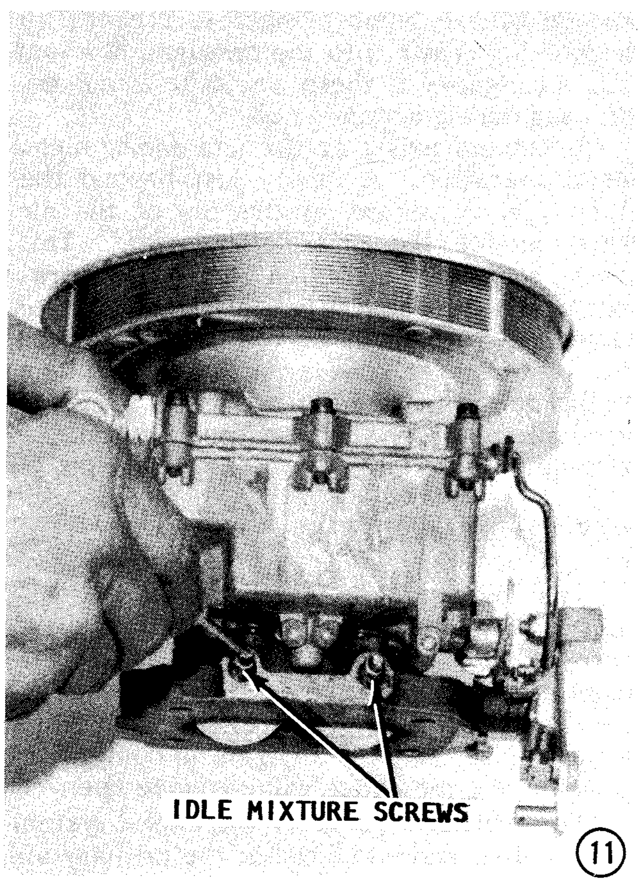
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Stop the engine and disconnect the throttle cable from the throttle lever. Now, turn the idle mixture adjusting screws in until they just barely make contact with their seats, then back out 1-1/4 turns as a rough adjustment. **TAKE CARE** not to turn the screws in tightly against the seats or the needles and seats will be **DAMAGED.**

With water running through the engine and outdrive, start the engine again and shift the drive unit into forward gear and run at idle rpm. Adjust the idle mixture needle for the highest and steadiest manifold vacuum reading. If a vacuum gauge is not available, obtain the smoothest running, maximum idle speed by first turning the idle adjusting needle in until the engine rpm begins to drop slightly. From this point, back the needle out over the "high spot" until the engine rpm again begins to drop. Now, set the idle adjusting needle halfway between the two points for a proper idle mixture. If these adjustments result in an increase in idle rpm, reset the idle speed adjusting screw to obtain the specified idle rpm and again adjust the idle mixture adjusting needle. Shift the drive unit into neutral.

Stop the engine and install the throttle cable. Check to be sure the throttle valves are fully open when the remote control is in the full forward position. **ALWAYS** have a helper turn the propeller when shifting without the engine running in order to engage the shift dog.

The engine **MUST NOT BE RUNNING** to make the following test. With the throttle valves fully open, turn the wide-open throttle stop adjusting screw clockwise until the screw just makes contact with the throttle lever. Tighten the set nut securely to prevent the adjustment screw from turning. Now, return the shift control lever to the neutral position, idle, and check to see if the idle stop screw is against the stop. Shift into forward gear. Readjust the idle speed screw until the recommended idle rpm is reached.



4-4 ROCHESTER 4MV

DESCRIPTION

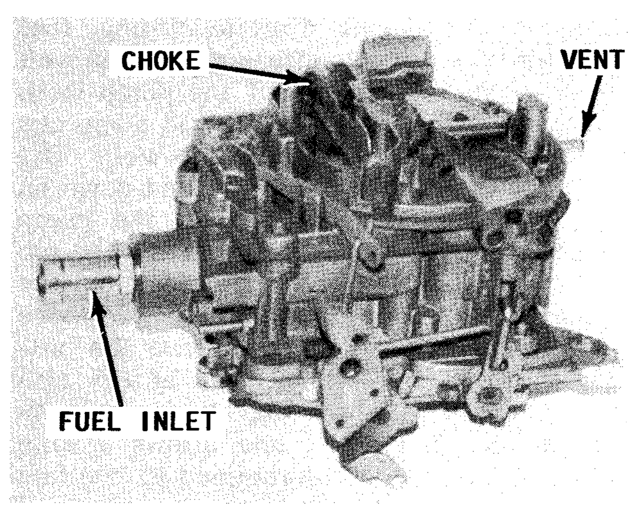
The 4MV Rochester carburetor is a four-barrel (Quadrajet) unit. The air-fuel mixture is controlled with a secondary-side air valve and tapered metering rods.

The Quadrajet carburetor has two stages. The primary (fuel inlet) side has small 1-3/8" bores with a triple venturi set-up equipped with plain-tube nozzles. The carburetor operates much the same as other carburetors using the venturi principle. The triple venturi, plus the small primary bores, makes for a more stable and finer fuel control during idle and partial throttle operation. When the throttle is partially open, the fuel metering is accomplished with tapered metering rods, positioned by a vacuum-responsive piston and operating in specially designed jets.

The secondary side has two large, 2-1/4", bores. These large bores, when added to the primary side bores, provide enough air capacity to meet most engine requirements. The air valve is used in the secondary side for metering control and backs-up the primary bores to meet air and fuel demands of the engine.

The secondary air valve operates the tapered metering rods. These rods move in orifice plates and thus control fuel flow from the secondary nozzles in direct relation to the air flowing through the secondary bores.

The float bowl is designed to avoid problems of fuel spillage during sharp turns of



The Rochester 4MV carburetor.

the boat which could result in engine cut-out and delayed fuel flow. The bowl reservoir is smaller than most four-barrel carburetors to reduce fuel evaporation during hot engine shut-down.

The float system has one pontoon float and fuel valve which makes servicing much easier than on some other model carburetors. A fuel filter is located in the float bowl ahead of the float needle valve This filter is easily removed for cleaning or replacement.

The throttle body is made of aluminum as part of a weight-reduction program and also to improve heat transfer away from the fuel bowl and prevent the fuel from "percolating" during hot engine shut-down. A heat insulator gasket is used between the throttle body and bowl to help prevent "percolating".

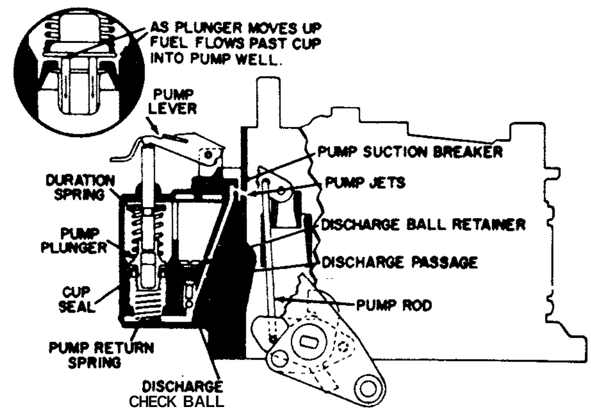
4MV ACCELERATING SYSTEM

When the throttle is opened suddenly during acceleration, the air flow and manifold vacuum change almost at the same time. The fuel, which is heavier, has a tendency to lag behind. This condition causes a lean mixture for just a moment. It is at this time, the accelerator pump comes into play by providing the extra fuel necessary to maintain the proper mixture.

The accelerator pump system is located in the primary side of the carburetor. The system consists of spring-loaded pump plunger and a return spring. The plunger is operated by a pump lever on the air horn which is connected to the throttle lever by a pump rod.

When the pump plunger moves upward in the pump well during throttle closing, fuel from the float bowl enters the pump well through a slot in the top of the pump well. This fuel flows past the synthetic pump cup seal into the bottom of the pump well. The pump cup floats and moves up and down on the pump plunger head. When the pump plunger is moved upward, the flat on the top of the cup unseats from the flat on the plunger head and allows fuel to move through the inside of the cup into the bottom of the pump well. This action also vents any vapors which may be in the bottom of the pump well and allows a solid charge of fuel to be maintanined in the fuel well beneath the plunger head.

When the primary throttle valves are opened, the connecting linkage forces the



ACCELERATING PUMP SYSTEM

pump plunger downward. The pump cup seats at once, and fuel is forced through the pump discharge check ball and passes on through the passage to the pump jets located in the air horn. From these jets, the fuel sprays into the venturi area of each primary bore. As mentioned earlier, the pump plunger is spring-loaded. The upper tine portion of the spring is balanced with the bottom pump return spring to permit a smooth sustained charge of fuel to be delivered during the acceleration period.

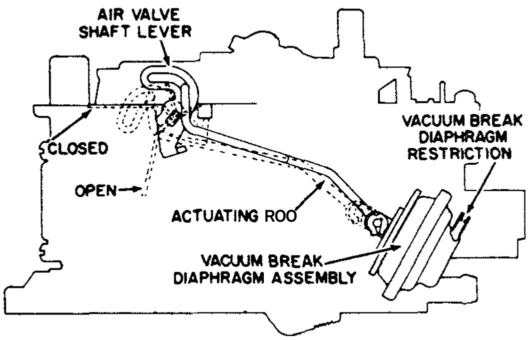
The pump discharge check ball seats in the pump discharge passage during upward motion of the pump plunger to prevent air from being drawn into the passage. Without this arrangement, there would be a momentary lag during acceleration.

A vacuum exists at the jets during high-speed operation. A cavity just beyond the pump jets is vented to the top of the air horn, outside the carburetor bores. This cavity serves as a suction breaker. Therefore, when the pump is not in operation, fuel cannot be pulled out of the pump jets into the venturi area, but ensures a full pump discharge when needed and still prevents any fuel spill over from the pump discharge passage.

4MV CHOKE SYSTEM

The choke valve is located in the primary side of the carburetor and provides the correct air-fuel mixture for quick cold-engine starting and until the engine reaches its operating temperature. The air valve is locked closed until the engine is completely warmed and the choke valve is wide open.

The principle parts of the choke system are a choke valve located in the primary air



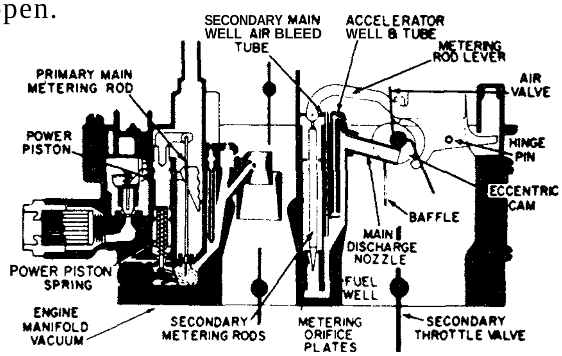
AIR VALVE DASHPOT OPERATION

horn bore, a vacuum diaphragm unit, fast-idle cam, connecting linkage, an air valve or secondary throttle valve lockout lever, and a thermostatic coil.

While the engine is being cranked, the tension of the thermostatic coil holds the choke valve closed. The closed choke valve restricts air flow through the carburetor to provide a richer mixture for starting.

After the engine starts, manifold vacuum applied to the vacuum diaphragm unit opens the choke valve the proper amount for the engine to run without loading or stalling.

Other conditions exist-after the engine starts: The cold-enrichment feed holes are no longer in a low-pressure area so they cease to feed fuel. These holes are then used as secondary main well air bleeds. The fast-idle cam follower lever on the end of the primary throttle shaft drops from the highest step on the fast-idle cam to a lower step when the throttle is opened. The lever in this position gives the engine enough fast idle and a correct fuel mixture for smooth operation until full operating temperature is reached. Once the engine has warmed-up, the thermostatic coil heats and eases its tension and allows the choke valve to open farther due to the intake air pushing on the off-set choke valve. The choke valve continues to open until the thermostatic coil is completely relaxed and the choke is fully open.



POWER SYSTEM

4MV POWER SYSTEM

The power system provides extra fuel to meet power demands during heavy engine loads and during high-speed operation. This richer mixture is supplied through the main metering systems in the primary and secondary sides of the carburetor.

The power system enriches the fuel mixture in the two primary bores. This system is made up of a vacuum-operated power piston and a spring located in a cylinder connected by a passage to intake manifold vacuum. The spring under the power piston operates against manifold vacuum and pushes the power piston upward.

During partial throttle and cruising ranges, the manifold vacuum is enough to hold the power piston down against spring tension so the larger diameter of the metering rod tip is held in the main metering jet orifice.

As engine load is increased until more fuel and a richer mixture is necessary, the power piston spring overcomes the vacuum pull on the power piston, and the tapered tips of the metering rods move upward in the main metering jet orifices. The smaller diameter of the metering rod tip permits more fuel to pass through the main metering jet and enriches the fuel mixture to meet the added power demands. When engine load decreases, the manifold vacuum rises and extra fuel and a richer mixture is no longer required. The higher vacuum pulls the power piston down against spring tension, and this action moves the larger diameter of the metering rod into the metering jet orifice, returning the fuel mixture to normal.

The primary side of the carburetor supplies enough air and fuel for low-speed operation. More air and fuel are required at higher speeds to meet engine demands and it is the secondary side of the carburetor that meets these requirements.

The secondary side of the 4MV has a separate and independent metering system. This system consists of two large throttle valves connected by a shaft and linkage to the primary throttle shaft. Fuel metering is controlled by spring-loaded air valves, metering orifice plates, secondary metering rods, main fuel wells with bleed tubes, fuel-discharge nozzles, accelerating wells, and tubes.

A lever on the primary throttle shaft, through a connecting link to the secondary throttle shaft, begins to open the secondary throttle valves when the engine reaches a point where the primary bores cannot deliver the quantity of air and fuel demanded by the engine. As the secondary throttle valves are opened, engine manifold vacuum (reduced pressure) is applied directly beneath the air valves. Atmospheric pressure on top of the air valves overcomes spring tension and forces them open, allowing metered air to pass through the secondary bores of the carburetor.

The secondary main discharge nozzles are located above the secondary throttle valves and just below the center of the air valves. There is one nozzle for each bore.

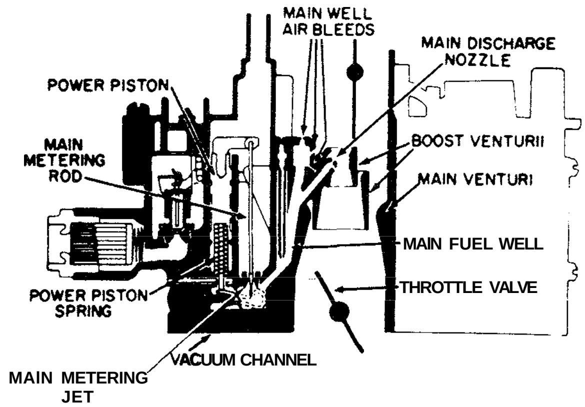
Because the valves are located in a low-pressure area, they feed fuel in the following manner:

When the secondary throttle valves are opened, atmospheric pressure opens the air valves. This action rotates a plastic cam attached to the center of the air-valve shaft. The cam movement lifts the secondary metering rods out of the secondary orifice plates through the metering rod lever. As the throttle valves are opened still farther and engine speed continues to increase, air flow through the secondary side increases and opens the air valve more. The opening valves lift the secondary metering rods farther out of the orifice plates. The metering rods are tapered. This design allows fuel flow through the secondary metering orifice plates in direct proportion to air flow through the secondary bores. This system allows correct air-fuel mixtures through the secondary bores to be controlled by the depth of the metering rods in the orifice plates.

The actual depth of the metering rods in the orifice plates is factory adjusted in relation to air-valve position and to meet air-fuel requirements for each engine. If an adjustment should become necessary due to replacement of parts, a service setting is possible.

4MV METERING SYSTEM

The main metering system supplies fuel to the engine from off-idle to wide-open throttle. The primary bores supply fuel and air during this range through plain-tube nozzles and the venturi principle. The main metering system starts to operate when air flow increases through the venturi system



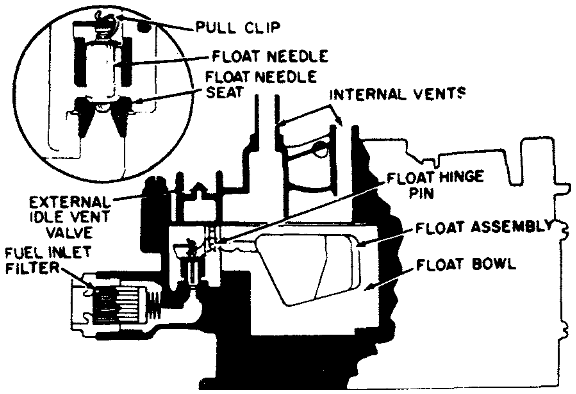
MAIN METERING SYSTEM

and more fuel is required to supply the correct air-fuel mixture to the engine. Fuel from the idle system gradually diminishes as the lower pressures are now in the venturi area.

The main metering system consists of the main .metering jets, vacuum-operated metering rods, main fuel wells, main well air bleeds, fuel discharge nozzles, and triple venturis.

When the primary throttle valves open beyond the off-idle ranee and allow more air to enter the engine intake manifold, air velocity increases In the carburetor venturi. The increased velocity causes a drop in pressure in the large venturi, which increases many times in the boast venturi. Because the low pressure (vacuum) is now in the smallest boost venturi, fuel flows from the main discharge nozzle in the following manner:

Fuel from the float bowl flows through the main metering jets into the main fuel wells. It passes upward in the main well and is fed with air by an air bleed located at the top of the well. The fuel is further fed air through calibrated air bleeds located near the top of the well in the carburetor bores. The fuel mixture then passes from the main well through the main discharge nozzles into the boost venturis where the fuel mixture then combines with the air entering the engine through the carburetor bores. It then passes as a combustible mixture through the intake manifold and on into the engine cylinders. The main metering system is calibrated by tapered and stepped metering rods operating in the main metering jets and also through the main well air bleeds.

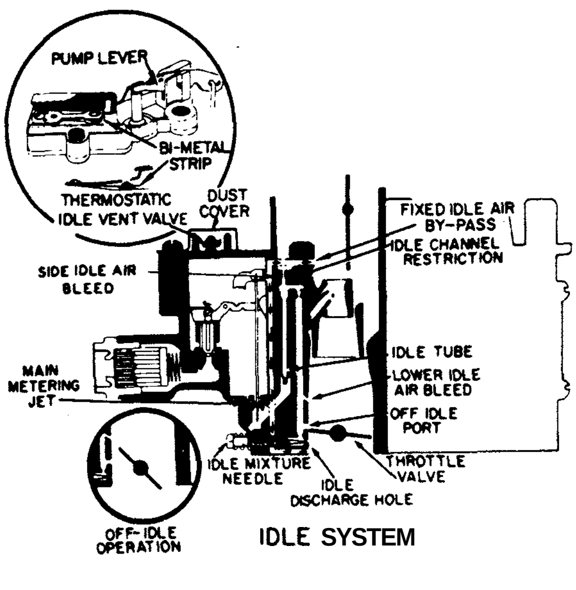


FLOAT SYSTEM

4MV FLOAT SYSTEM

The float bowl is located between the primary bores and adjacent to the secondary bores. This position assures an adequate fuel supply to all carburetor bores and does much to maintain excellent engine performance when the bow of the boat is high or during high-speed tight turns. The float pontoon is solid and made of a light plastic material. The combination of these two features gives added buoyancy to the float and allows the use of a single float to maintain a constant fuel level.

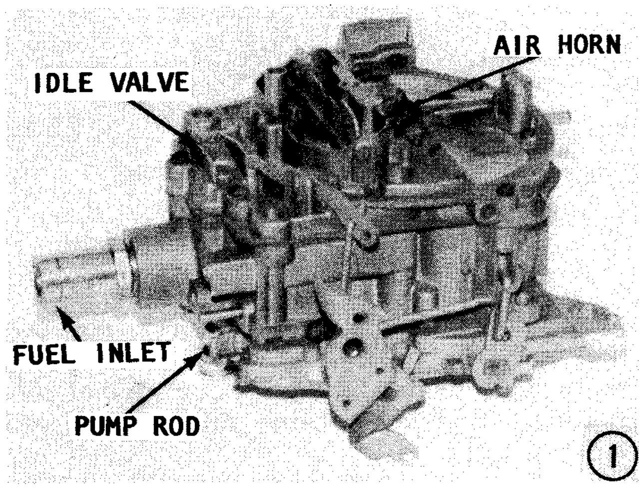
The parts of the float system include: The float bowl, a single pontoon float, float hinge pin-and-retainer combination, float valve and seat, and a slot valve pull clip. A plastic filler block is located in the top of the float chamber over the float valve to prevent fuel slosh into this area.



IDLE SYSTEM

4MV IDLE SYSTEM

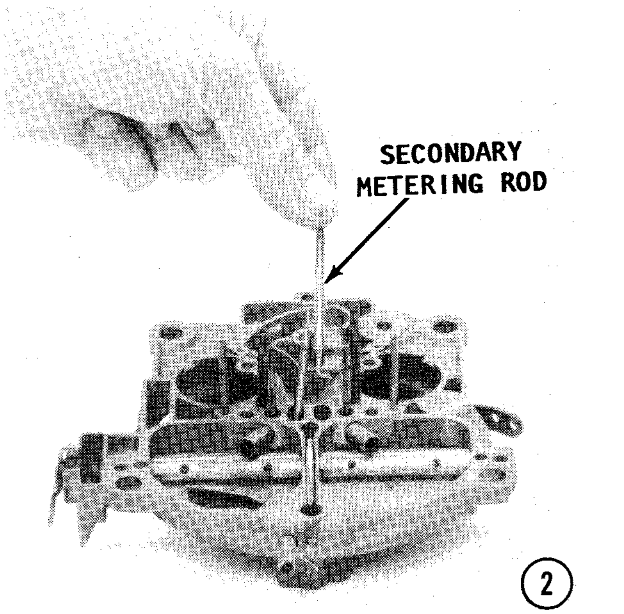
The idle system is located on the fuel inlet (primary) side of the carburetor to supply the correct air-fuel mixture during idle and off-idle operation. The idle system is used during this period because air flow through the carburetor venturi is not great enough to obtain good metering from the main disharge nozzles.



DISASSEMBLING THE ROCHESTER 4MV

1- Place the carburetor on the work bench in the upright position. Remove the idle vent valve attaching screw, and then remove the idle vent valve assembly. Remove the clips from the upper end of the choke rod, disconnect the choke rod from the upper choke shaft lever, and then remove the choke rod from the bowl. Detach the spring clip from the upper end of the pump rod, and then disconnect the pump rod from the pump lever. Remove the nine air horn-to-bowl attaching screws. Two screws are located next to the primary venturi. Lift straight up on the air horn and remove it. **TAKE CARE** not to bend the accelerating well and air bleed tubes sticking out from the air horn.

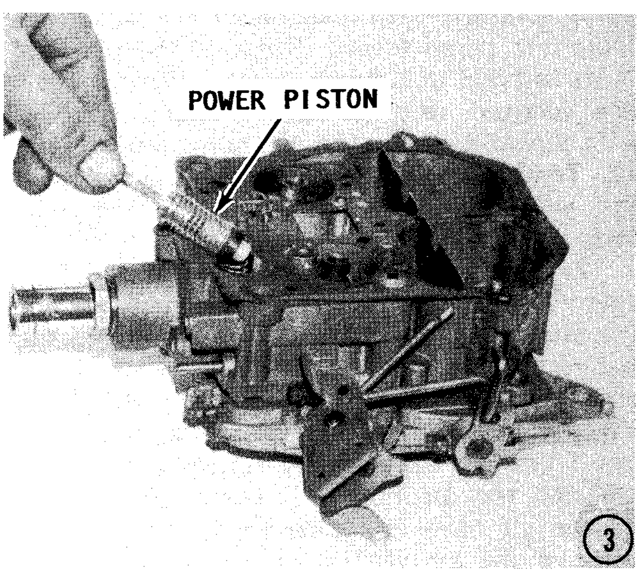
2- Mold the air valve wide open and then remove the secondary metering rods by tilting and sliding the rods from the holes in the hanger. Remove the dashpot piston from the air-valve link by rotating the bend through the hole, and then remove the dashpot from the air horn by rotating the bend through the air horn. Further disassembly of the air horn is not necessary. **DO NOT** remove the air valves, air valve shaft, and

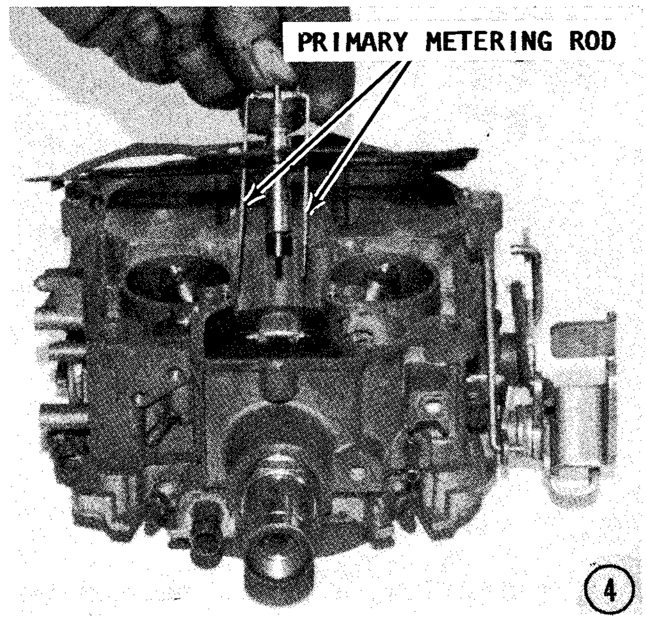


secondary metering rod hangers because they are calibrated. DO **NOT** attempt to remove the high-speed air bleeds and accelerating well tubes because they are pressed into position.

3- Remove the accelerating pump piston from the pump well. ele ease-the air horn gasket from the dowels on the secondary side of the bowl, and then pry the gasket from around the power piston and primary metering rods. Remove the pump return spring from the pump well.

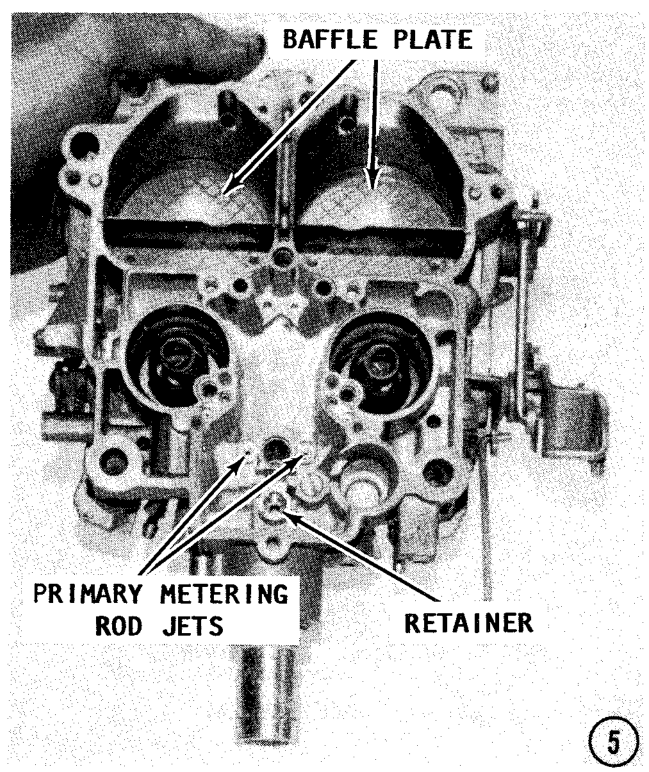
4- Remove the plastic filler from over the float valve. Use a pair of needle-nosed pliers and pull straight up on the metering rod hanger directly over the power piston and remove the power piston and the primary metering rods, Disconnect the tension spring from the top of each rod and then

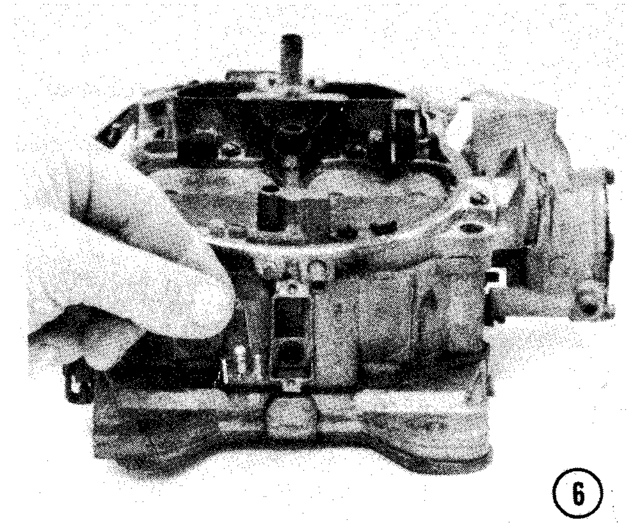




rotate the rod and remove the metering rods from the power piston. Pull up just a bit on the float assembly hinge pin until the pin can be removed by sliding it toward the pump well. Disengage the needle valve pull clip by sliding the float assembly toward the front of the bowl. **TAKE EXTRA CARE** not to distort the pull clip.

5- Remove the two screws from the float needle retainer, and then lift out the retainer and needle assembly. **NEVER** attempt to remove the needle seat because it is staked and tested at the factory. If the





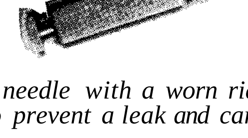
float assembly is damaged, replace the assembly. Remove both primary metering rod jets. Remove the pump discharge check ball retainer and the check ball. Remove the baffle plates from the secondary side of the bowl. Disconnect the vacuum hose from the tube connection on the bowl and from the vacuum break assembly. Remove the retaining screw, and then lift the assembly from the float bowl.

6– Remove the two screws from the hot-idle compensator cover. Lift the hot-idle compensator and O-ring from the float bowl. Remove the fuel inlet filter retaining nut, gasket, filter, and spring. Remove the throttle body by taking out the throttle body-to-bowl attaching screws, and then lift off the insulator gasket. Remove the idle mixture screws and springs. **TAKE CARE** not to damage the secondary throttle valves.

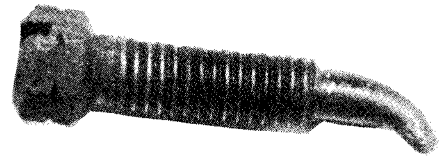
CLEANING AND INSPECTING THE ROCHESTER 4MV

NEVER dip rubber parts, plastic parts, diaphragms, pump plungers or the vacuum-break assembly in carburetor cleaner. Place all of the metal parts in a screen-type tray and dip them in carburetor solvent 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 of



Fuel inlet needle with a worn ridge. The set MUST be replaced to prevent a leak and carburetor flooding.



Tip of an idle mixture adjusting needle bent from being forced into its seat and against the closed throttle plate.

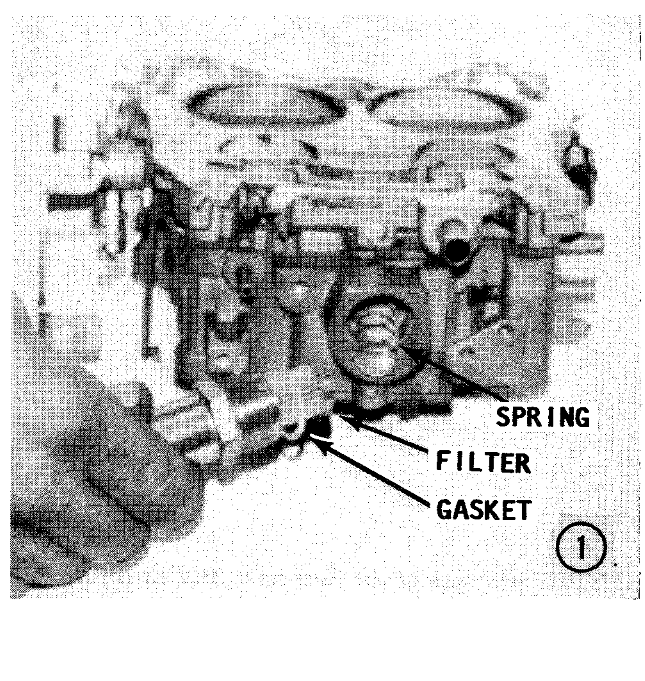
the parts and passages to be sure they are not clogged or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

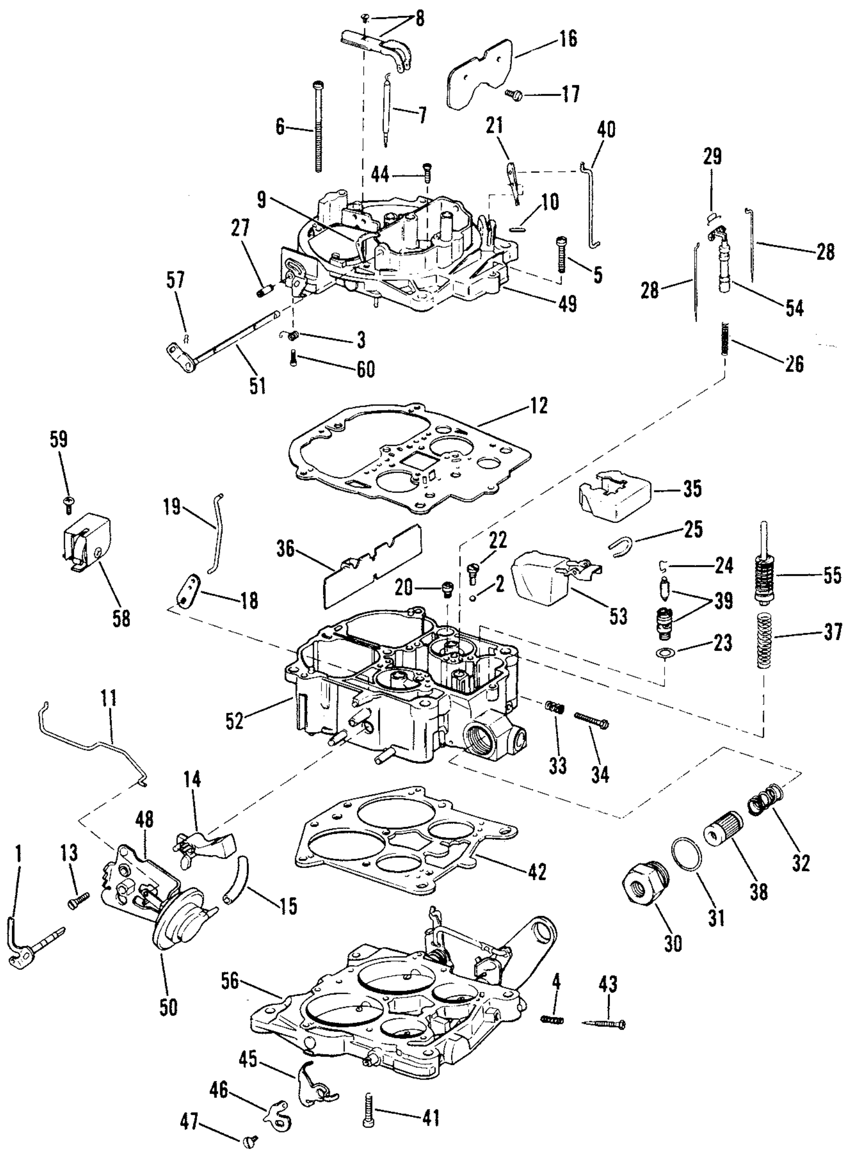
Inspect the idle mixture needles for damage. Check the float needle and diaphragm for wear. Inspect the upper and lower surfaces of the carburetor castings for damage. Inspect the holes in the levers for being out-of-round. Check the fast-idle cam for wear or damage. Check the air valve for binding. If the air valve is damaged, the complete air horn assembly must be replaced.

Most of the parts that should be replaced during a carburetor overhaul, including the latest updated parts, are found in a carburetor kit available at your local marine dealer. In addition to the parts, most kits include the latest specifications which are so important when making bench adjustments.

ASSEMBLING THE 4MV

1– Turn the idle mixture adjusting screws in until they are barely seated, and then back them out two turns as a rough adjustment at this time. **NEVER** turn the adjusting screws down tight into their seats





1. Vacuum break lever and shaft
2. Pump Discharge Ball
3. Secondary Air Valve Adjustment Spring
4. Idle Needle Spring
5. Air Horn Screw
6. Air Horn Screw
7. Secondary Metering Rod
8. Secondary Metering Rod Holder
9. Air Valve Lockout Lever
10. Roll Pin
11. Vacuum Break Rod
12. Air Horn Gasket
13. Control Attaching Screw
14. Fast Idle Cam
15. Vacuum Hose
16. Choke Valve
17. Choke Valve Screw
18. Intermediate Choke Lever
19. Choke Rod
20. Primary Jet
21. Pump Actuating Lever
22. Pump Discharge Ball Retainer
23. Needle Seat Gasket
24. Float Needle Pull Clip
25. Float Assembly Hinge Pin
26. Power Piston Spring
27. Secondary Air Valve Adjustment Shaft
28. Primary Metering Rod
29. Primary Metering Rod Spring
30. Fuel Inlet Filter Nut
31. Filter Nut Gasket
32. Fuel Filter Relief Spring
33. Idle Stop Screw Spring
34. Idle Screw
35. Float Bowl Insert
36. Secondary Baffle Plate
37. Pump Return Spring
38. Fuel Inlet Filter
39. Needle and Seat Assembly
40. Pump Rod
41. Throttle Body Screw
42. Throttle Body Gasket
43. Idle Needle
44. Air Horn Screw
45. Cam Lever
46. Fast Idle Lever
47. Idle Lever Screw
48. Vacuum Break Control Bracket
49. Air Horn Assembly
50. Vacuum Break Control Assembly
51. Choke Shaft & Lever Assembly
52. Float Bowl Assy
53. Float Assembly
54. Power Piston Assembly
55. Pump Assembly
56. Throttle Body Assembly
57. Choke Rod Clip
58. Choke Thermostat Assembly
59. Choke Screw
60. Set Screw

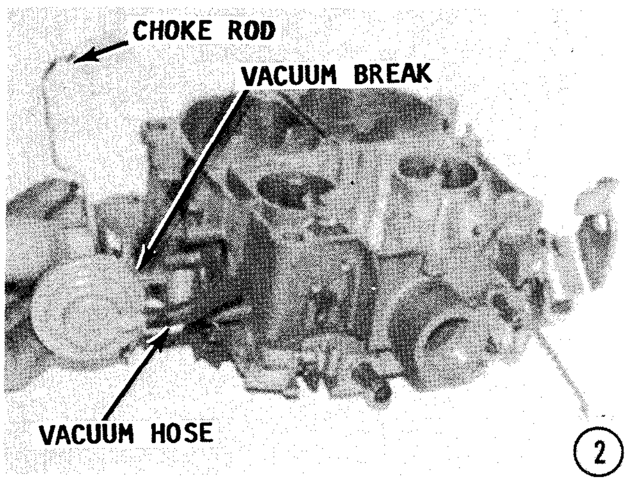
Exploded view of the Rochester 4MV carburetor installed on GMC V8 engines. Principle parts are identified.

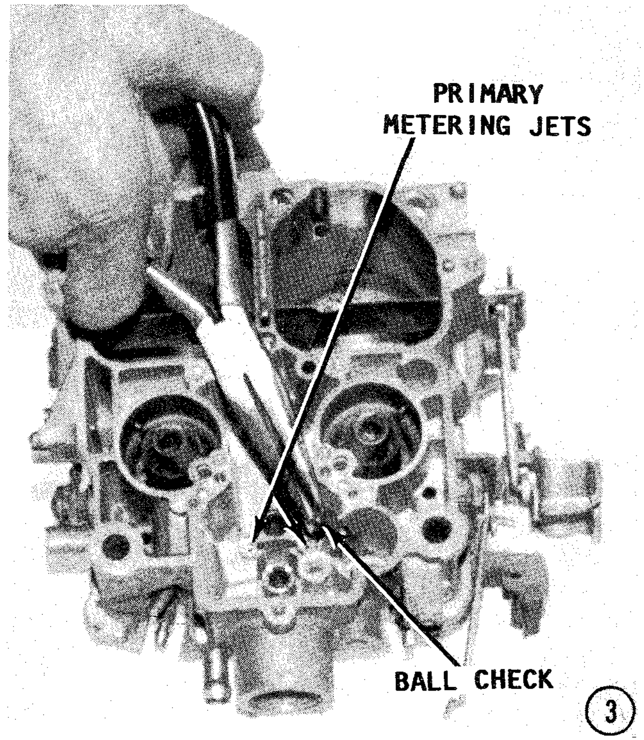
or they will be damaged. Install the pump rod in the lower hole of the throttle lever by rotating the rod. Place a new insulator gasket on the bowl with the holes in the gasket indexed over the two dowels. Install, and then tighten the throttle body-to-bowl screws evenly. Install the fuel inlet filter spring, filter, new gasket, and inlet nut. Tighten the nut. Position a NEW hot-idle compensator O-ring seal in the recess in the bowl, and then install the compensator.

2- Install the U-bend end of the vacuum-break rod in the diaphragm link, with the end toward the bracket, and then slide the grooved end of the rod into the hole of the actuating lever. Install the spring clip to retain the rod in the vacuum-break rod. Install the fast-idle cam on the choke housing assembly. Check to be sure the fast-idle cam actuating pin on the middle choke shaft is located in the cut-out area of the fast-idle cam. Connect the choke rod to the plain end of the choke rod actuating lever, and then hold the choke rod with the grooved end pointing inward and position the choke rod actuating lever in the well of the float bowl. Install the choke assembly, with the shaft engaged with the hole in the actuating lever. Install and tighten the retaining screw. Remove the choke rod from the lever. This rod will be installed later. Install and connect the vacuum hose.

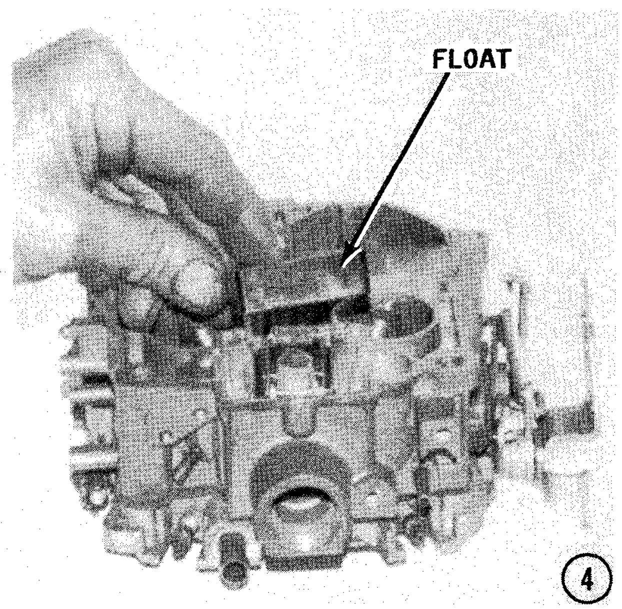
3- Install the baffle plates in the secondary side of the bowl with the notches facing up. Install the primary main metering jets. Install a NEW float needle seat. Install the pump discharge ball check and retainer in the passage next to the pump well.

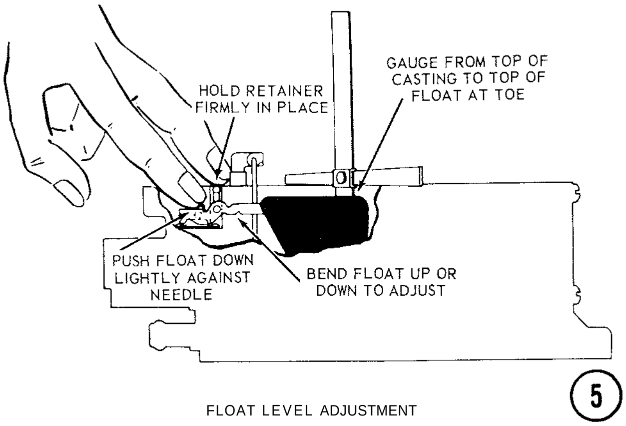
4- Install the pull clip on the needle with the open end toward the front of the bowl. Install the float by sliding the float lever under the pull clip from the front to the back. Hold the float assembly by the toe and with the float lever in the pull clip, install the retaining pin from the pump-well side. **TAKE CARE** not to distort the pull clip.





5- **Float** Level **Adjustment:** Measure the distance from the top of the float bowl gasket surface, with the gasket removed, to the top of the float at the toe end. **CHECK TO BE SURE** the retaining pin is held firmly in place and the tang of the float is seated on the float needle when making the measurement. Check your measurement



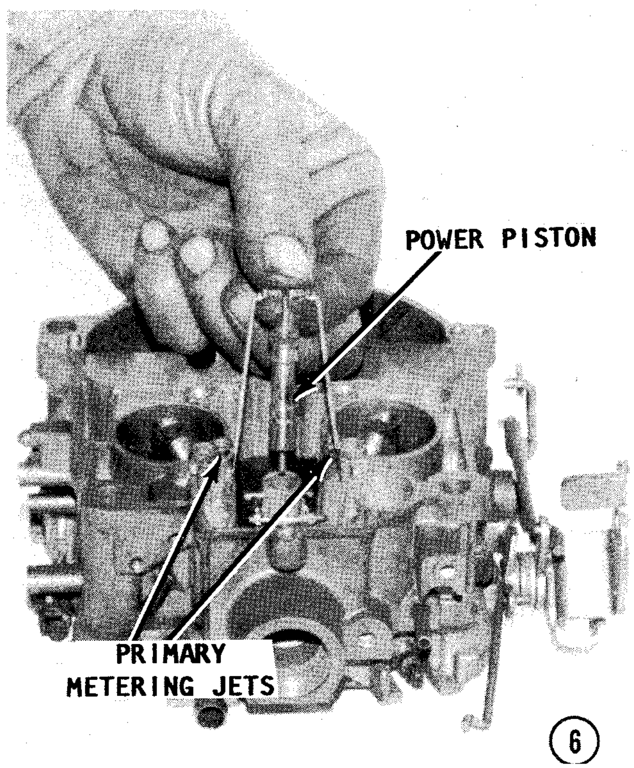


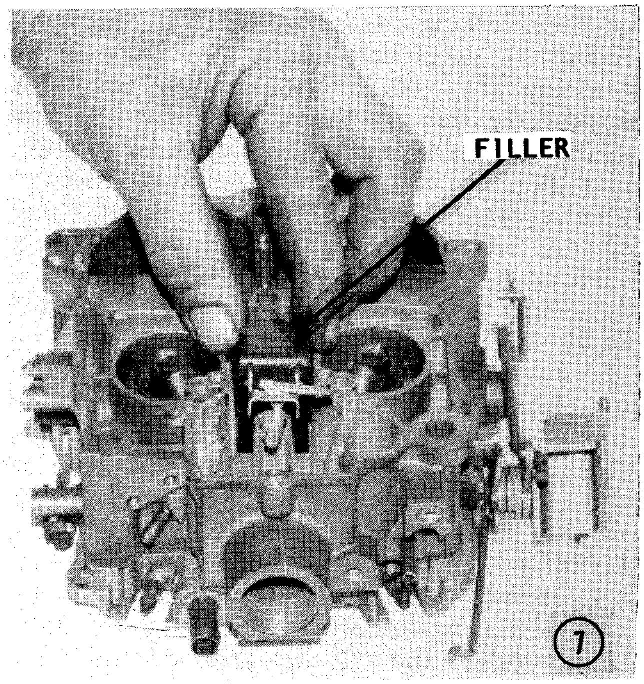
FLOAT LEVEL ADJUSTMENT

with the Specifications in the Appendix. CAREFULLY bend the float up or down until the correct measurement is reached.

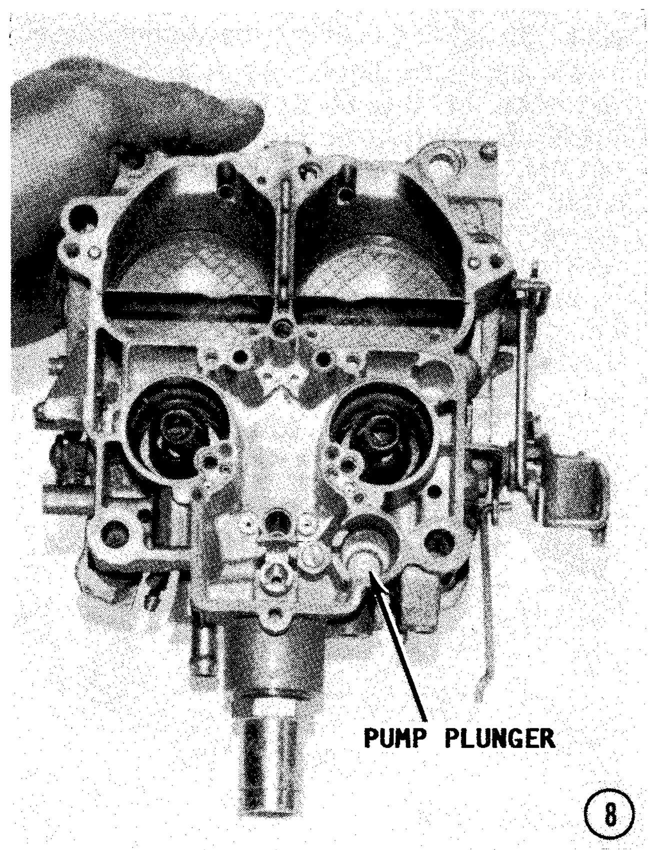
6- Install the power-pistop spring in the power-piston well. Install the primary metering rods, if they were removed during disassembly. Be sure the tension spring is connected to the top of each metering rod. Install the power-piston assembly in the well with the metering jets. On early models, it is necessary to press down on the power-piston to be sure the retaining pin is engaged with the hole in the throttle body gasket. On later models, a sleeve around the piston holds the piston in place during assembly.

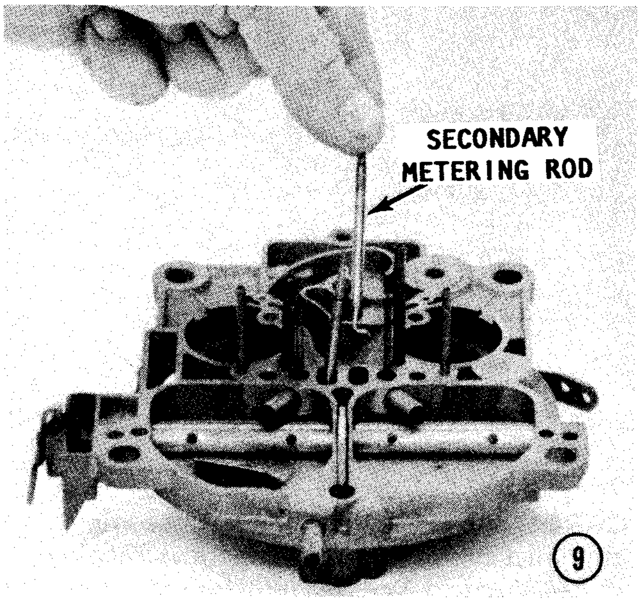
7- Install the plastic filler over the float needle. Press it down firmly until it is seated.

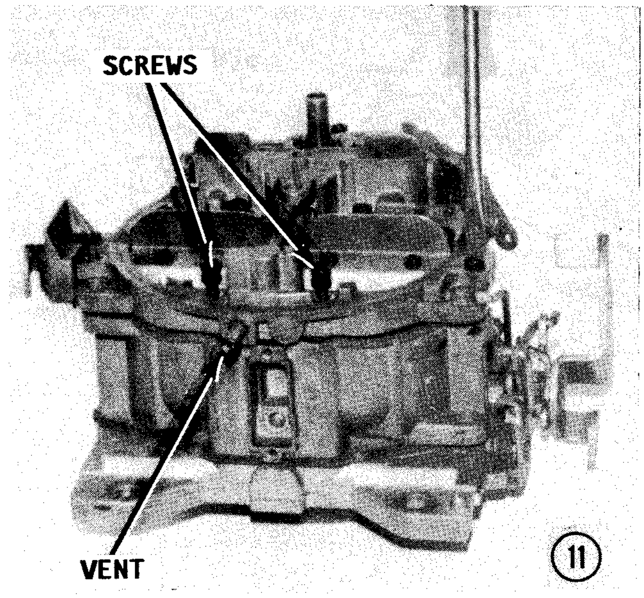




8- Place. the pump return spring in the pump well. Install the air horn gasket around the primary metering rods and piston. Install the gasket on the secondary side of the bowl with the holes in the gasket indexed over the two dowels. Install the accelerating pump plunger in the pump well.

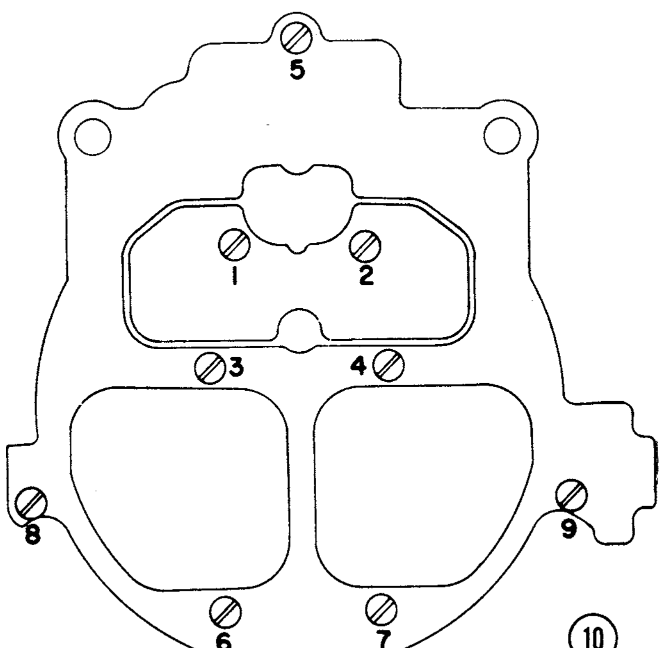






9– Install the secondary metering rods. Hold the air valve wide open and check to be sure the rods are positioned with their upper ends through the hanger holes and pointing toward each other.

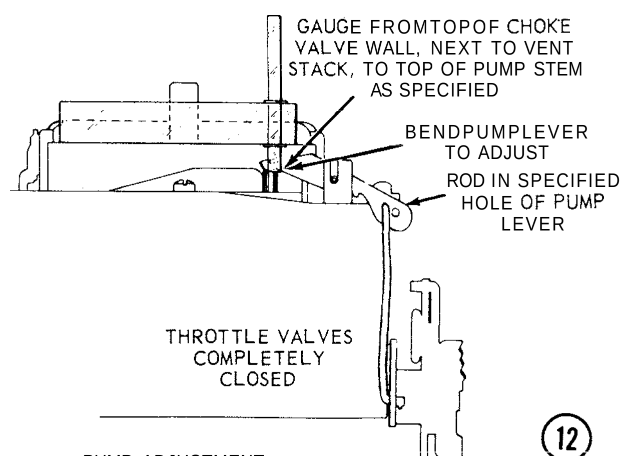
10– Slowly position the air horn assembly on the bowl and **CAREFULLY** insert the secondary metering rods, the high–speed air bleeds, and the accelerating well tubes through the holes of the air horn gasket. **NEVER** force the air horn assembly onto the float bowl because you may distort the secondary metering plates. If you move the air horn assembly slightly sideways it will center the metering rods in the metering plates. Install the attaching screws as follows: The-four long air horn screws around the secondary side; two short screws in the center section; one short screw above the fuel inlet; and the two countersunk screws in the primary venturi area. Tighten the screws evenly and in the sequence as shown in the accompanying illustration.



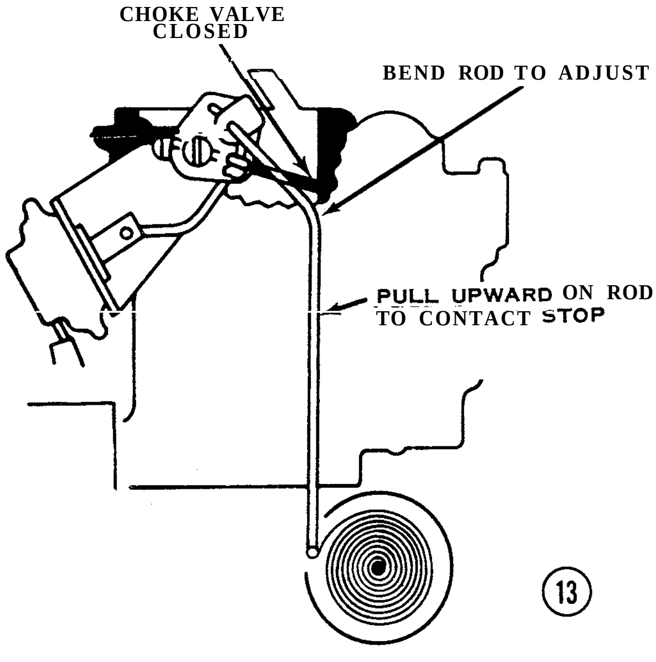
11– Install the idle vent actuating rod in the pump lever. Connect the pump rod to the inner hole of the pump lever and secure it with a spring clip. Connect the choke rod in the lower choke lever and secure it with a spring clip. Install the idle vent valve with the actuating rod engaged, and then tighten the attaching screws.

4MV BENCH ADJUSTMENTS

12– Pump Adjustment: Disconnect the secondary actuating link. Measure the distance from the top of the choke valve wall, next to the vent stack, to the top of the pump stem, with the throttle valves com–



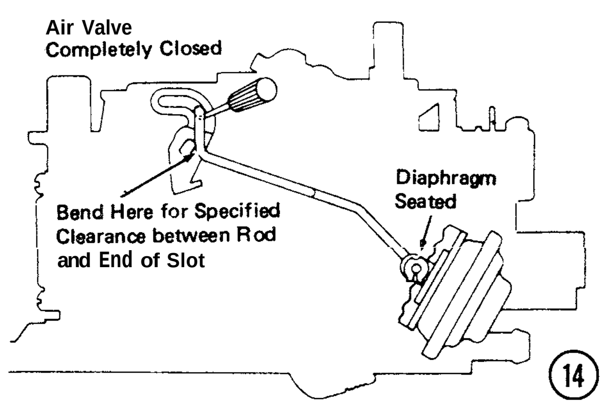
PUMP ADJUSTMENT

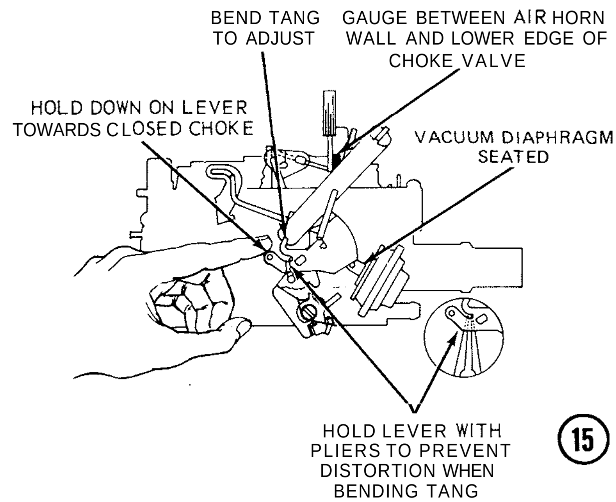


pletely closed and the pump rod in the specified hole in the lever. Compare your measurement with the Specifications. **CAREFULLY** bend the pump lever until the specified dimension is obtained. Connect the actuating link.

13– Choke Rod Adjustment: First, place the cam follower on the second step of the fast–idle cam and against the high step. Next, rotate the choke valve toward the closed position by pushing down **LIGHTLY** on the vacuum–break lever. Now, measure the distance between the lower edge of the choke valve and the air horn wall. Compare your measurement with the Specifications. **CAREFULLY** bend the choke rod until the proper measurement is obtained.

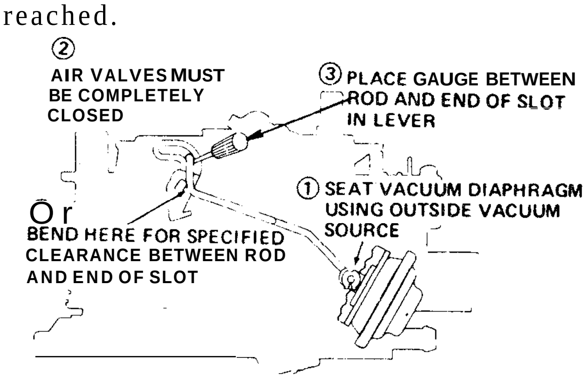
14–Air Valve Dashpot Adjustment: Push the vacuum–break stem in until the diaphragm is seated. Measure the distance between the dashpot rod and the end of the slot in the air valve lever. Compare your measurement with the Specifications.



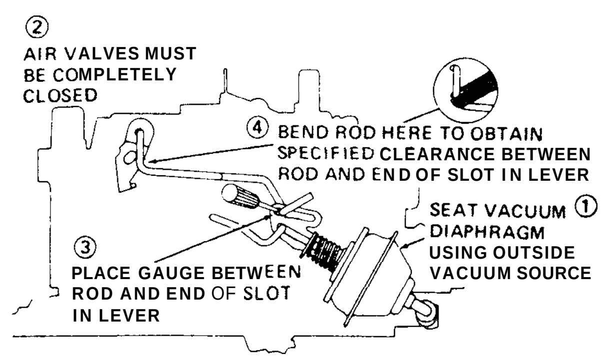


CAREFULLY bend the rod at the air valve end until the proper adjustment is reached.

15– Vacuum–Break Adjustment: Push the vacuum–break stem in until the diaphragm is seated. At the same time, hold the choke valve toward the closed position and measure the distance between the lower edge of the choke valve and the air horn wall. Compare your measurement with the Specifications. **CAREFULLY** bend the vacuum-break tang until the proper adjustment is reached.

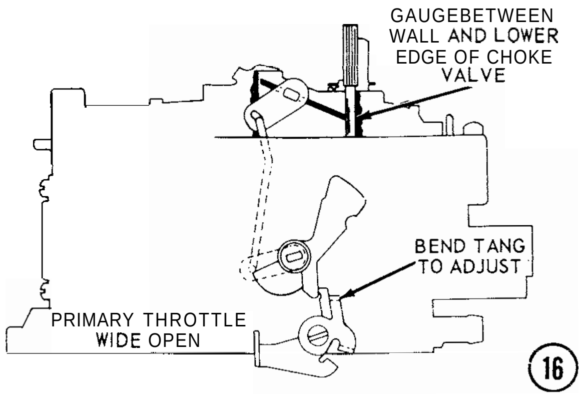


THROUGH 1971



SINCE 1972

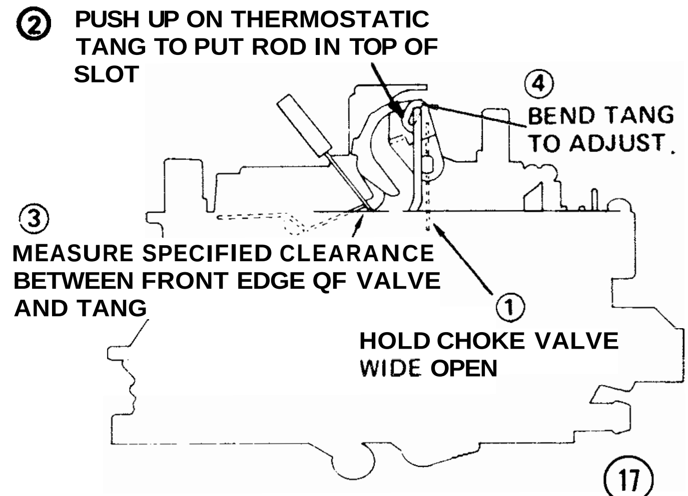
*Depending on the model, the air-valve dashpot on later models, is adjusted by inserting a **gauge** in the slot in the choke lever, or in the dashpot lever.*



UNLOADER ADJUSTMENT

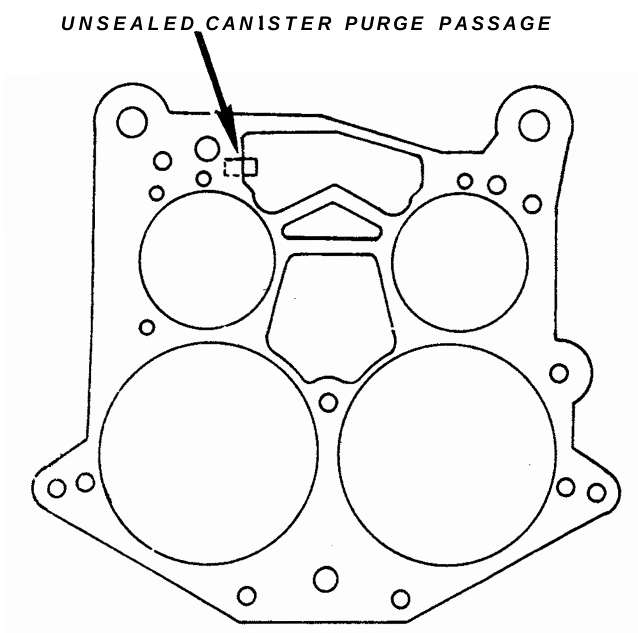
16- Unloader Adjustment: Secure a rubber band on the vacuum-break to hold the choke valve in the closed position. Move the primary throttle valves to the wide-open position and at the same time measure the distance between the edge of the choke valve and the air horn wall. Compare your measurement with the Specifications. **CAREFULLY** bend the fast-idle lever tang until the proper adjustment is reached.

17- Air-Valve Lockout Adjustment: With the choke valve wide open, force the thermostatic spring tang to move the choke rod to the top of the slot in the choke lever. Now, move the air valve toward the open

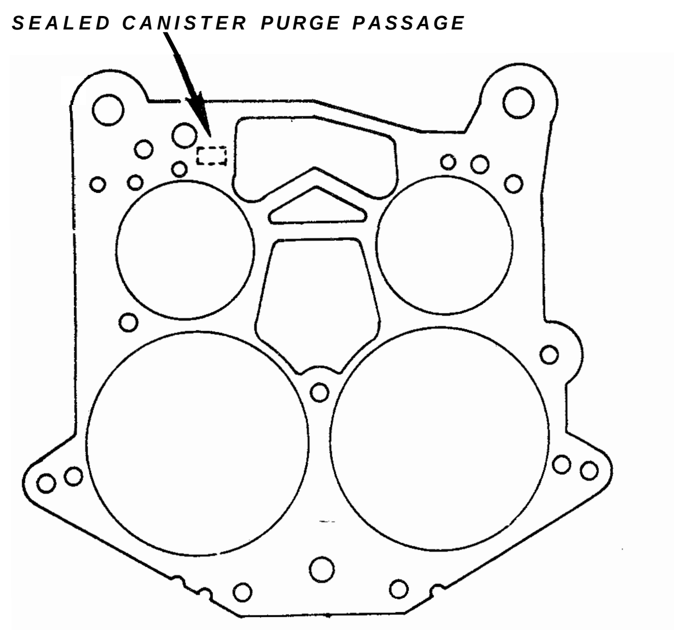


position. Measure the distance between the lockout tang and the front edge of the air valve, as shown in the accompanying illustration. **CAREFULLY** bend the upper end of the air valve lockout lever tang until the required adjustment is reached. Finally, open the choke valve to its wide-open position by applying force to the underside of the choke valve. BE **SURE** the choke rod is in the bottom of the slot in the choke lever, the air valve lockout tang holds the air valve closed.

18- Secondary Opening Adjustment: Open the primary throttle valves until the

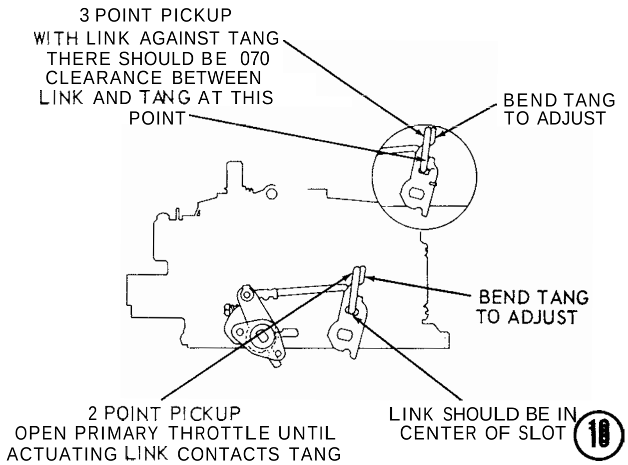


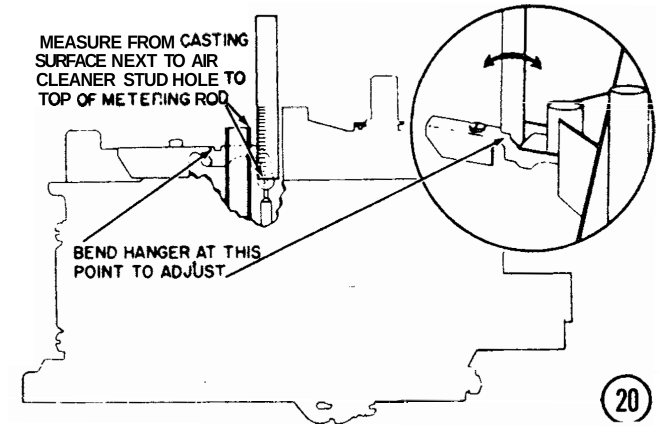
INCORRECT



CORRECT

The addition of a charcoal canister purge port on models since 1970 has resulted in a change in the gaskets used between the float bowl and the throttle body. A vacuum leak will result if the wrong gasket is used because air will bypass the primary throttle valves through the canister purge passageway (left) and the engine will not idle smoothly.





actuating link contacts the tang on the secondary lever, and then measure the distance between the link and the tang on the secondary lever, which should be 0.070". **CAREFULLY** bend the tang on the secondary lever until the proper adjustment is reached.

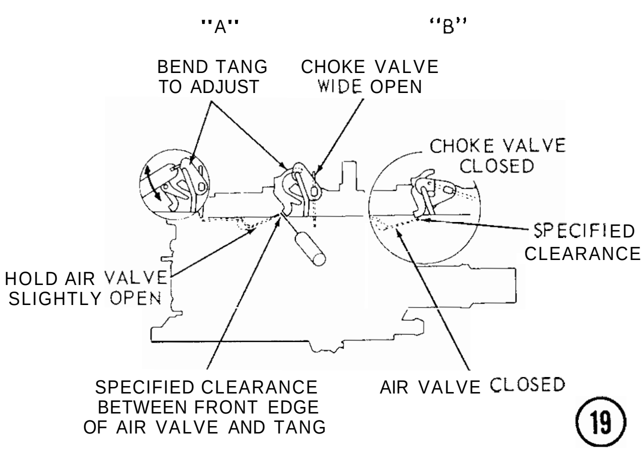
19- Secondary Closing Adjustment: After the idle speed has been adjusted and with the tang on the throttle lever against the actuating lever, measure the distance between the actuating link and the front of the slot in the secondary lever. Compare your measurement with the Specifications. **CAREFULLY** bend the tang on the throttle lever until the proper adjustment is reached.

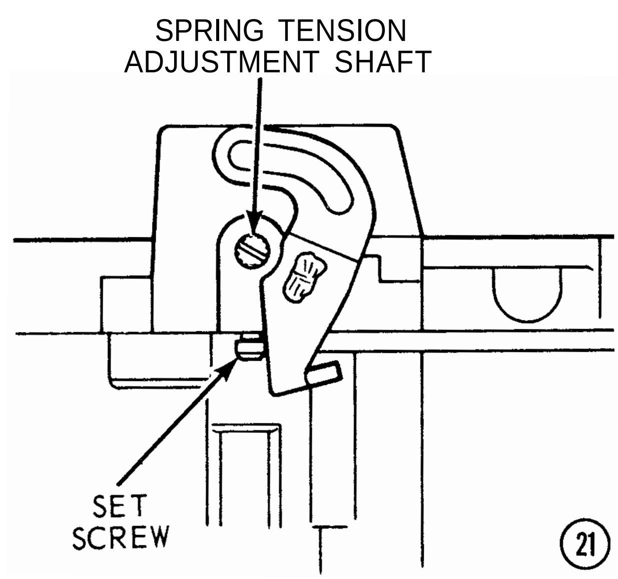
20- Secondary Metering Rod Adjusment Measure the distance from the top of the metering rod to the top of the air horn casting and also to the flame arrestor stud hole. Compare your measurement with the Specifications. **CAREFULLY** bend the metering rod hanger at the point shown in the accompanying illustration until the proper adjustment for both metering rods is reached. Both metering rods must be adjusted to the **SAME DIMENSION.**

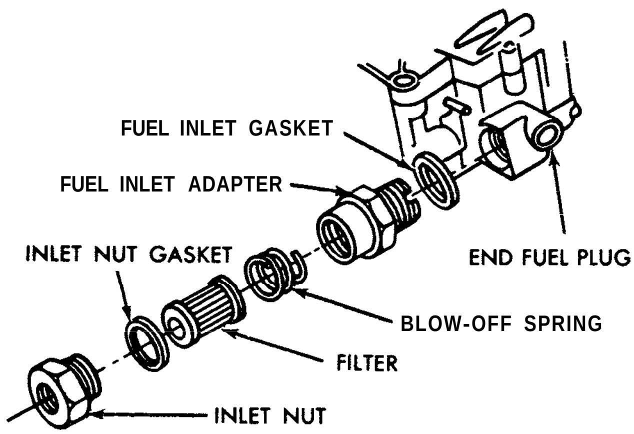
21- Air Valve Spring Adjustment: First, remove all of the tension on the spring by loosening the Allen-head lockscrew and turning the adjusting screw counterclockwise. Now, with the air valve closed, turn the adjusting screw clockwise until the torsion spring just contacts the pin on the shaft, and then 3/8 turn more. Hold the adjusting screw in this position, and tighten the lockscrew.

22- Choke Coil Rod Adjustment: Close the choke valve so the choke rod is at the bottom of the choke lever slot. Now, pull the choke coil rod up to the end of its travel. The top of the hole must be even with the bottom of the rod. **CAREFULLY** bend the choke coil rod until the proper adjustment is reached.

23- Idle Speed and Mixture Adjustments: Start the engine and allow it to warm to operating temperature with the flame arrestor in place.



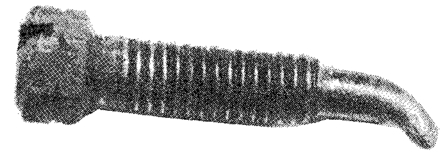




Arrangement of fuel filter parts including a self-tapping fuel inlet adapter which may be installed if the threads in the inlet hole of the carburetor are damaged. Use of the adapter will save considerable expense, because the carburetor does not have to be replaced.

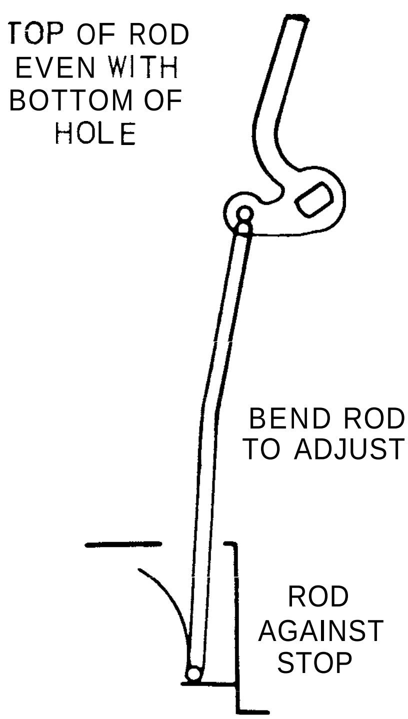
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Shut the engine down and disconnect the throttle cable. Turn the idle mixture adjusting screws in until they barely touch their seats, and then back them out one full

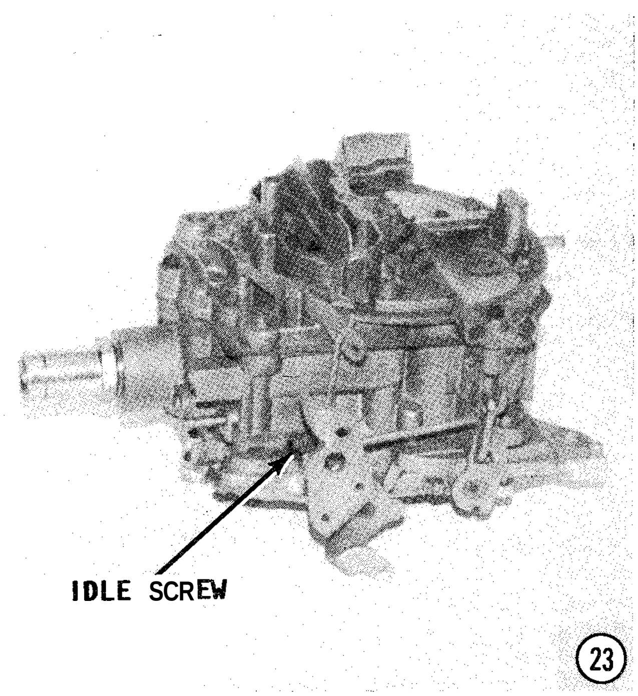


Tip of an idle mixture adjusting needle bent from being forced into its seat and against the closed throttle plate.

turn as a rough adjustment at this time. **NEVER** turn the adjusting needles in hard or the needle and seat will be DAMAGED. Start the engine and run it at idle speed. Adjust the idle mixture needle for the highest and steadiest manifold vacuum reading. If you do not have a vacuum gauge, obtain the smoothest running, maximum idle speed by turning the idle adjusting needle in until the engine rpm begins to drop off, then back the needle-off over the "high spot" until the engine rpm again begins to drop off. Set the idle adjusting needle halfway between the two points as an idle speed setting. Repeat the procedure with the other needle. If the adjustments result in an increase in idle rpm, reset the idle speed adjusting screw to obtain between *550* and *600* rpm. Again adjust the idle mixture adjusting needles. Stop the engine and install the throttle cable. Check to be sure the throttle valves are fully open when the remote control is in the full forward position. Shift the unit into forward gear and re-adjust the idle speed screw until the rpm is between *550* and *600* rpm.



(22)



(23)

4-5 HOLLEY CARBURETORS

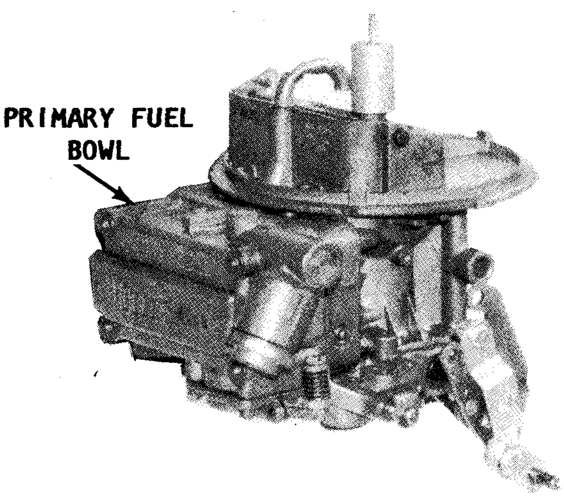
DESCRIPTION

The Holley two-barrel and four-barrel carburetors are designed and built very similarly. The four-barrel unit can be considered as dual two-barrel carburetors, mounted side-by-side, with each having its own fuel bowl and float system. Each side has its own metering body. The two primary bores have a single choke valve, and the primary side has a power valve, accelerating pump, and adjustable idle system. The throttles on the secondary side are controlled by a vacuum diaphragm. The secondary metering body has only fixed idle and high-speed metering systems.

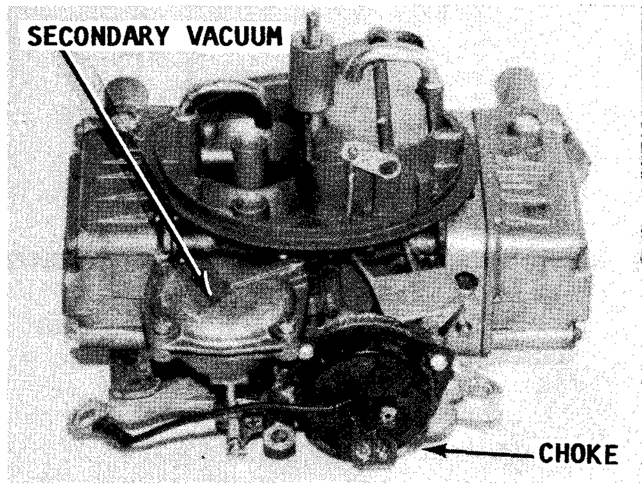
The two-barrel carburetor is basically the primary side of the four-barrel. Therefore, the overhaul procedures are the same for the two-barrel model as those provided in the following section for the four-barrel.

The four-barrel carburetors have a dual, high-speed system made up of primary and secondary circuits. The primary circuits are composed of the float, idle, acceleration, main metering, power, and choke circuits. The secondary circuit becomes operational when the engine demands extra power. Each circuit will be described under separate headings.

The illustrations accompanying this section are keyed by number to the paragraphs which describe the parts being shown.



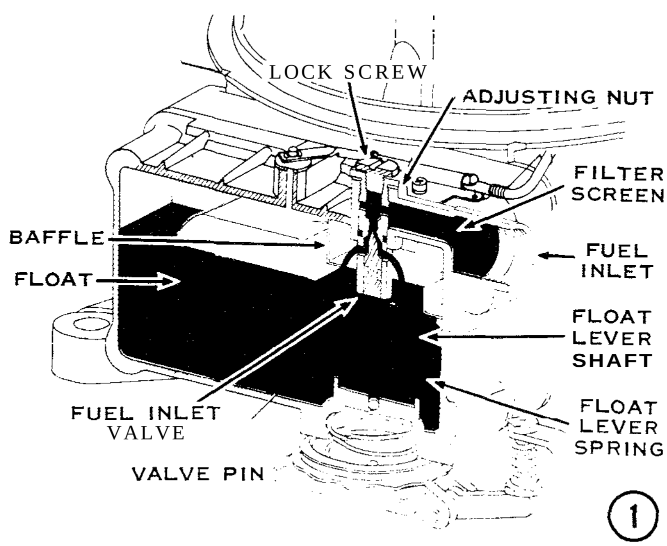
Holley two-barrel carburetor.



Holley four-barrel carburetor.

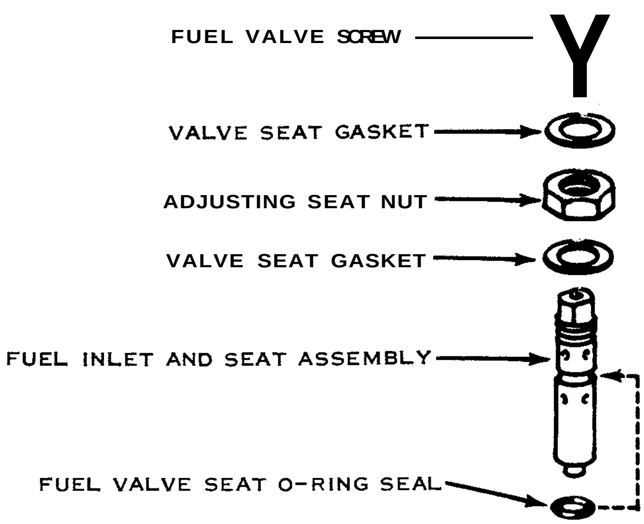
FLOAT CIRCUIT

1– Fuel-from the fuel pump line enters the fuel bowl through the inlet fitting, then passes through a filter, and finally into the fuel bowl through the needle and seat. The amount of fuel entering the fuel bowl is controlled by the fuel pump pressure, the size of the hole in the needle seat, and by the distance the needle is permitted to rise out of the seat as determined by the float drop. Therefore, the fuel level in the bowl is determined by the float level setting. As the fuel level drops, the float lowers, which allows more fuel to enter the bowl. When the level rises to the setting level, the float pushes the needle into the seat and thus shuts off the flow of fuel or at least restricts the amount entering the bowl. In this manner, the float rising and lowering allows only enough fuel to enter the bowl to replace the fuel used.

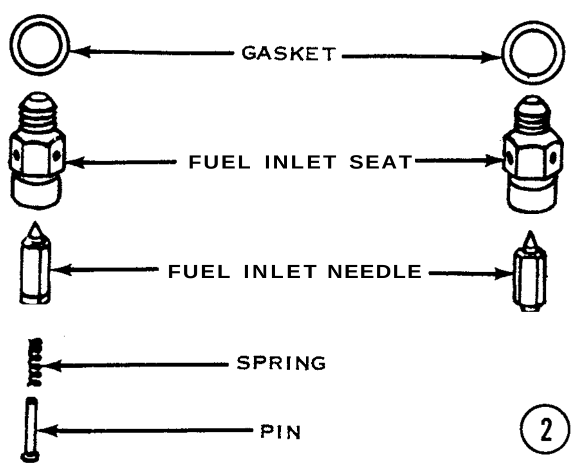


2- The Holley carburetors are equipped with one of three common types of needle and seat assemblies, as shown in the accompanying illustration: (1) spring loaded; (2) solid needle; and (3) externally adjustable.

To prevent dirt in the fuel from flooding, most of the needles have a special soft plastic tip. A spring under the float stabilizes and maintains a normal fuel level in most models. The proper fuel level is critical on any carburetor because all of the basic settings and calibrations of the other systems are based on the fuel level in the bowl. The float system is equipped with a vent valve in order to pressurize the fuel and to create a pressure differential. The reduced pressure in the venturi creates a pressure differential forcing the fuel to flow out of the fuel bowl to the discharge nozzle.

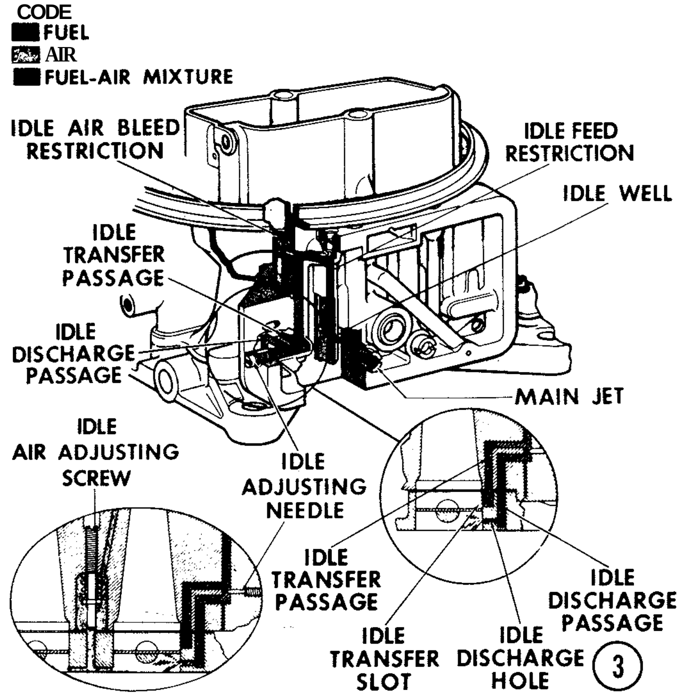


ADJUSTABLE



2

SPRING LOADED

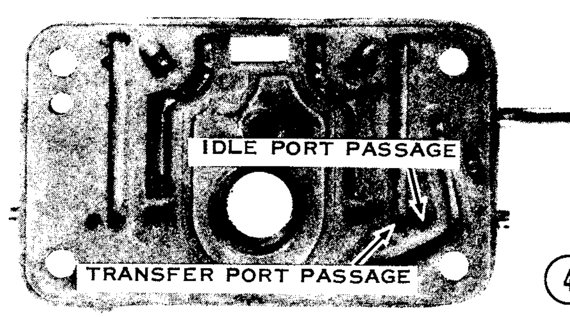


3

3- Fuel passes through the main metering jet to the vertical passageway. Near the top of this passageway is an idle feed restriction. This restriction performs the same function as an idle tube in other carburetors by metering the fuel for low-speed operation. From the restriction, the fuel moves horizontally across the carburetor to another vertical passageway, and then down the second passageway to the idle mixture screw port.

An idle air bleed is located in the low-speed fuel passageway, above the idle mixture adjustment screw. The idle air mixes with the fuel to form an emulsion that is easier to atomize when it is discharged. This air-fuel mixture moves much faster than solid fuel. The idle air bleed prevents fuel from syphoning from the fuel bowl when the engine is not running.

4- The fuel branches into two passageways at the idle mixture adjusting screw. One branch is controlled by the idle mixture needle. This branch exits below the throttle



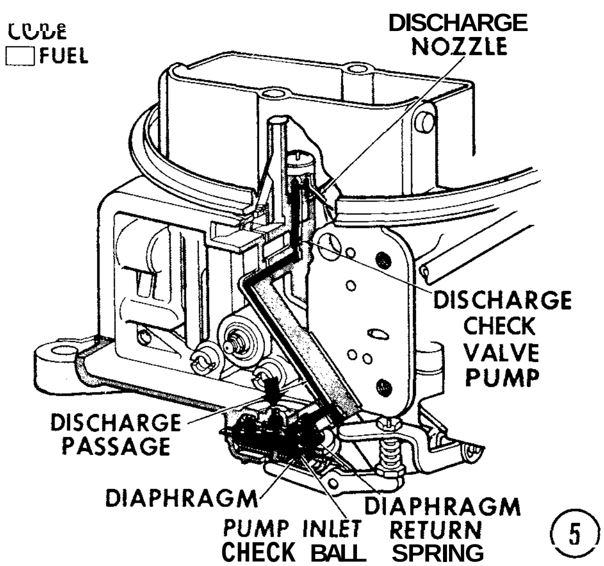
4

valve and supplies the fuel for the hot curb idle. The other branch exits above the throttle valve and supplies the fuel for the transfer from idle to the main metering stage. The mixture of air and fuel flows past the pointed tip of the adjusting needle. If the needle is backed out, the volume of the mixture is increased making it richer. If the needle is turned inward, the volume is decreased and the mixture becomes leaner. Fuel from the needle then moves through a passage and is discharged into the throttle bore below the throttle plate. When the throttle plates are opened above the idle position, more fuel is fed through the idle transfer passageway to supply the added demands of the engine.

If the throttle is opened wider, air speed in the venturi increases and the main metering system begins to function. As the flow increases in the main metering system, the idle transfer system tapers off to the point where its discharge stops. The discharge from the idle transfer system is stopped because of the loss of manifold vacuum due to the opening of the throttle valve and the loss of air velocity between the edge of the throttle valve and the transfer port.

HOLLEY ACCELERATION SYSTEM

5- During acceleration, the air flow thrsugh the carburetor responds almost immediately to the increased throttle opening. Since fuel is heavier than air, it has a slower response. The accelerator pump system mechanically supplies fuel until the other fuel metering systems can once again supply the proper mixture. The diaphragm-type



pump is located in the bottom of the primary fuel bowl. This location assures a more solid charge of fuel (fewer bubbles).

When the throttle is opened, the pump linkage, actuated by a cam on the throttle lever, forces the pump diaphragm up. As the diaphragm moves up, the pressure forces the pump inlet check ball or valve onto its seat, thereby preventing the fuel from flowing back into the fuel bowl.

The fuel passes through a short passage in the fuel bowl into the long diagonal passage in the metering body. It next flows into the main body passage and then into the pump discharge chamber. The pressure of the fuel causes the discharge valve to raise, and fuel is then discharged into the venturi.

The pump override spring is an important part of the .accelerator system. When the accelerator- is moved rapidly to the wide open position, the override spring is compressed and allows full pump travel. The spring applies pressure to maintain the pump discharge. Without the spring, the pump linkage would be bent or broken due to the resistance of the fuel which is not compressible.

As the throttle moves toward the closed position, the linkage returns to its original position and the diaphragm return spring forces the diaphragm down. The pump inlet check valve is moved off its seat and the diaphragm chamber is refilled with fuel from the fuel bowl.

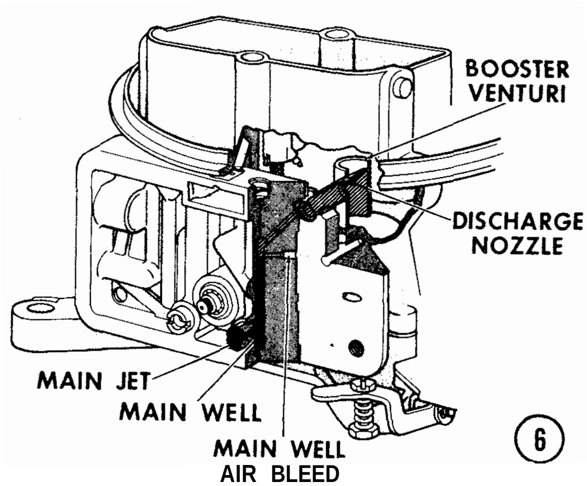
The accelerator pump delivery rate is controlled by the pump cam, linkage, the override spring, and the size of the discharge holes.

HOLLEY MAIN METERING

6- The main metering system on the two-barrel and four-barrel model is very similar.

At higher speeds the vacuum is increased at the main discharge nozzle in the center of the booster venturi.

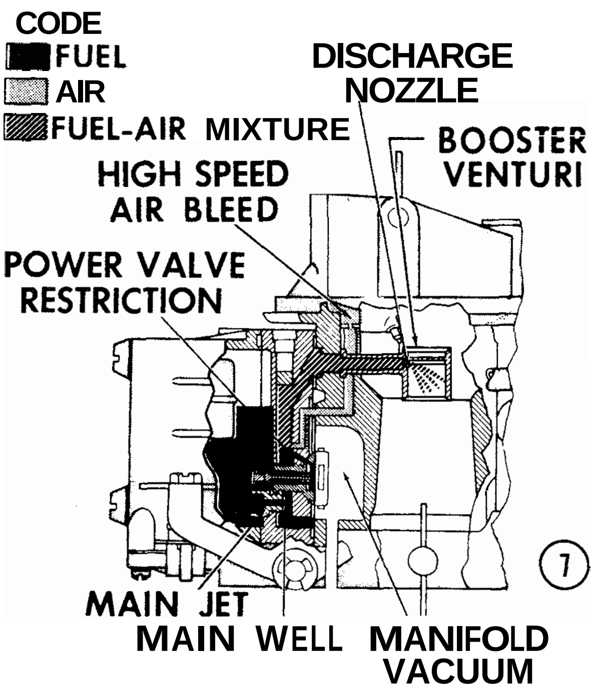
This vacuum or pressure differential causes fuel to flow through the main metering jet into the main well. The fuel moves up the main well past one or more air bleed holes from the main airwell. These air bleed holes are supplied with the filtered air from the "high speed" air bleeds in the air horn. The mixture of fuel and air moves up the main well and through a channel to the main discharge nozzle in the booster venturi.



POWER ENRICHMENT SYSTEM

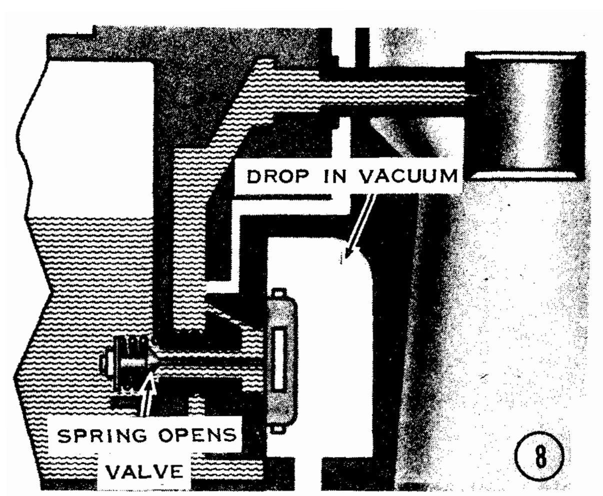
7- During high speed or heavy load operation, when manifold vacuum is low, the power system provides added fuel for power operation. A vacuum passage in the throttle body transmits vacuum to the power valve vacuum chamber in the main body. All of the power valves used in this series of carburetors are actuated by a vacuum diaphragm. Manifold vacuum is applied to the vacuum side of the diaphragm to hold it closed at idle and normal moderate load conditions.

When manifold vacuum drops below the power valve's calibration, the power valve spring opens the valve to admit additional fuel. This fuel is metered by the power valve channel restrictions into the main well and is added to the fuel flowing from the main metering jets.



HOLLEY AUTOMATIC CHOKE

8- The choke system has a bi-metal spring. When this spring cools, it closes the choke. An electric heating coil is installed in the choke spring cover. This heating element substitutes for the normal heat tube of other carburetors. The heating element is on whenever the ignition switch is turned on and provides the heat necessary to allow the bi-metal spring to open the choke. The time lapse between switch turn on until the choke opens is carefully calculated. For this reason, it is important that accessories such as bilge pumps, bilge blowers, etc, not be connected to the ignition circuit which would make it necessary to turn the ignition on for a period of time before starting the engine. Such an arrangement would open the choke before the engine starts and make starting difficult.

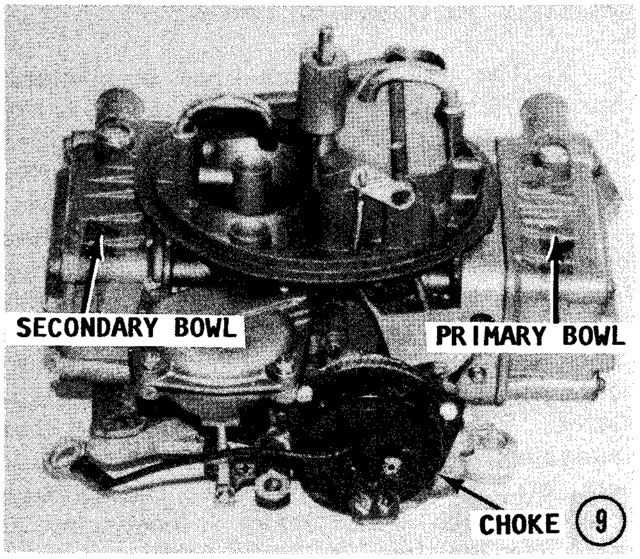


SECONDARY SYSTEMS

VACUUM SECONDARY OPERATION

9- At lower speeds the secondary throttle valves remain closed, allowing the engine to maintain proper air-fuel velocities and distribution for lower speed, light load operation. When engine demand increases to a point where additional breathing capacity is needed, the vacuum controlled secondary throttle valves begin to open automatically.

Vacuum from one of the primary venturi and one of the secondary venturi is channeled to the top of the secondary diaphragm. The bottom of the diaphragm is open to atmospheric pressure. At higher speeds and higher primary venturi vacuum, the diaphragm, operating through a rod and secon-



dary throttle lever, will start to open the secondary throttle valves. This action will start to compress the secondary diaphragm spring. As the secondary throttle valves open further, a vacuum signal is created in the secondary venturi. This additional vacuum assists in opening the secondary throttle valves to the maximum designed opening. The secondary opening rate is controlled by the diaphragm spring and the size of the vacuum restrictions in the venturi.

When the engine speed is reduced, venturi vacuum decreases and the diaphragm spring starts to push the diaphragm down to start closing the secondaries. Closing the primary throttle valves moves the secondary throttle connecting link.

Most production model carburetors have a ball check and bypass bleed installed in the diaphragm passage. The ball permits a smooth, even opening of the secondaries, but lifts off the inlet bleed to cause rapid closing of the secondaries when the primary throttle valves are closed.

SECONDARY FUEL METERING SECONDARY FLOAT CIRCUIT

10– The secondary system has a separate fuel bowl. Fuel is usually supplied to the secondary bowl by a transfer tube from the primary fuel inlet fitting.

The secondary fuel bowl is equipped with a fuel inlet valve and float assembly similar to the primary side. The specified fuel level on the secondary side is usually slightly lower than the primary side.

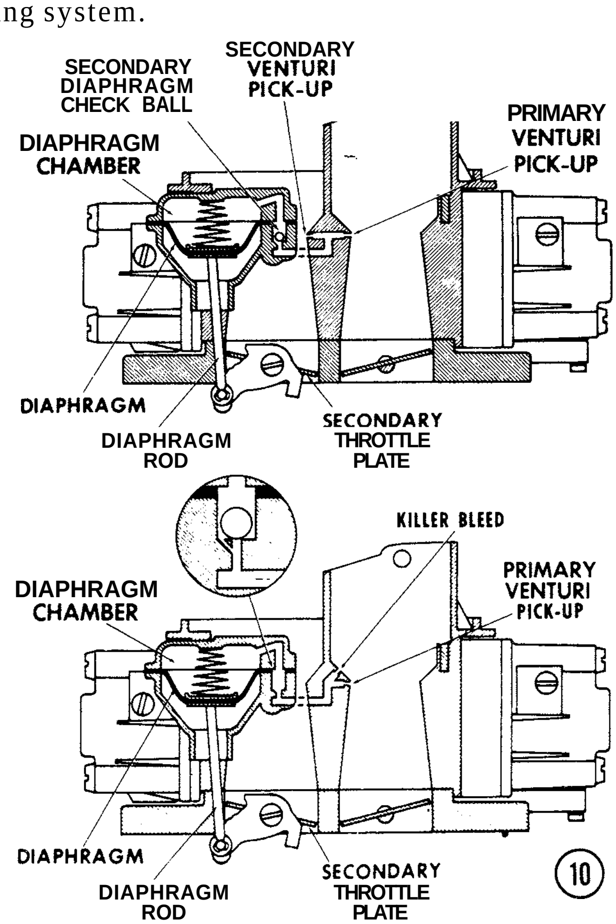
Many of the Holley carburetors use a fuel balance tube between the primary and secondary fuel bowls. This tube is made of brass and connects the bowls just above the fuel level to prevent flooding of the secondary fuel bowl.

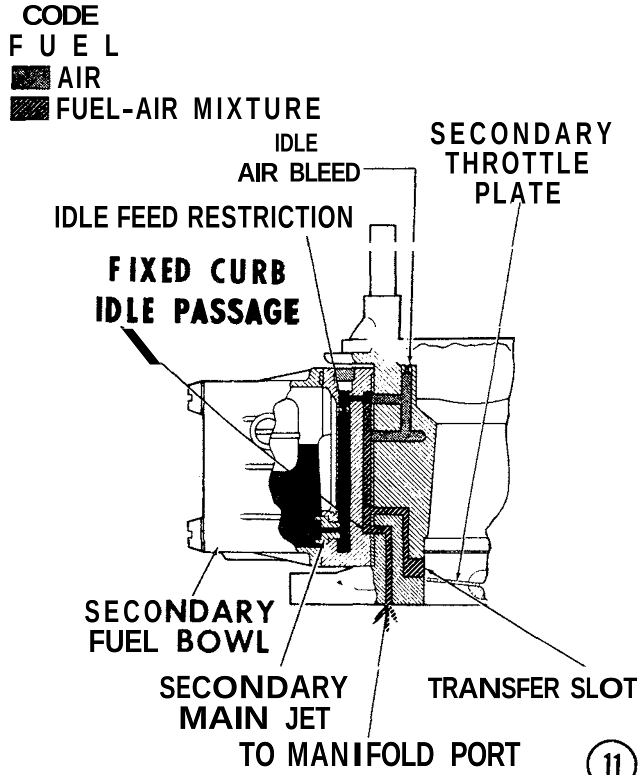
SECONDARY IDLE CIRCUIT

11– The secondary side of the carburetor is seldom used. Therefore, the fuel in the secondary fuel bowl could become stale and develop gum and varnish. To avoid this problem, a fixed idle is designed into the secondary side. Anytime the engine is running, some fuel is used from the secondary bowl and fresh fuel flows in to replace it. The secondary idle mixture is not adjustable. The transfer operates in the same manner as on the primary side.

SECONDARY MAIN METERING CIRCUIT

12– The basic principles sf the four-barrel carburetor are the same as on the two-barrel unit except for detailed construction differences. As the secondary throttle valves are opened further, air velocity increases in the boost venturi. This action allows fuel to flow through the main metering system.

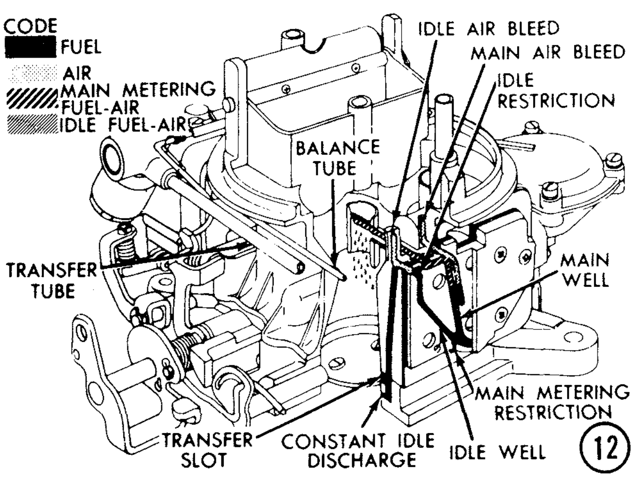


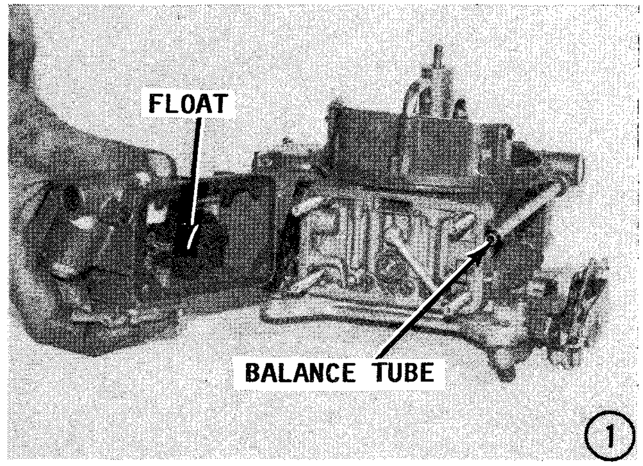


Fuel from the secondary fuel bowl enters the lower main metering holes in the metering body and then moves into the main well passageway. Air in the main well air bleed mixes with fuel that is still liquid at this point. The air-fuel mixture then moves horizontally through the discharge nozzle and into the boost venturi. The secondary circuit does not have a power circuit.

DISASSEMBLING THE HOLLEY TWO- OR FOUR-BARREL CARBURETOR

1- Remove the four primary fuel bowl retaining screws. Slide the bowl straight off. Discard the gaskets. Pull off the fuel transfer tube and discard the O-ring seals.

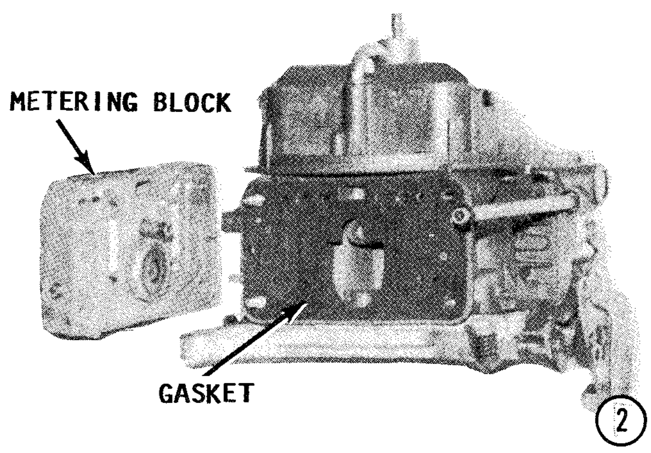


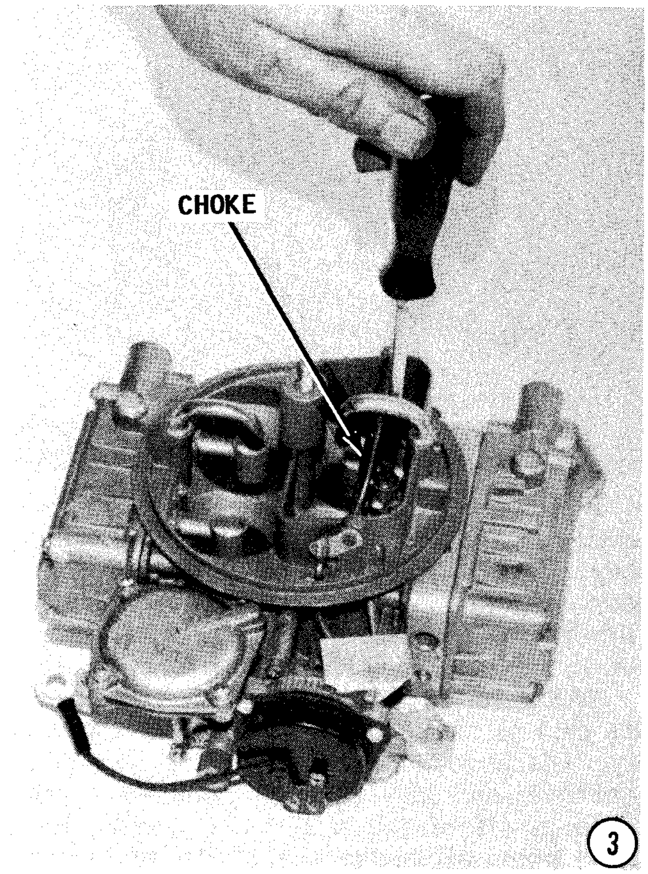


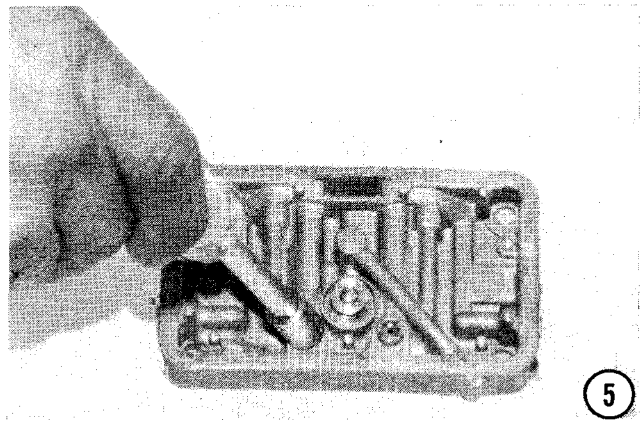
2- Remove the secondary fuel bowl assembly. Detach the secondary metering body. **TAKE CARE** and rernove the secondary metering body, plate, and gaskets. Slide the balance tube, washers, and-0-rings out of the main body from either end.

TAKE NOTE sf the position of the fast-idle can to the cam lever for proper assembly. Disconnect the link from the fast-idle cam lever and cam, and then slide the lever and cam off of the stub shaft, and at the same time, disengage the choke rod from the cam lever. Disconnect the secondary vacuum diaphragm assembly stem from the secondary stop lever, and then remove the assembly. Discard the gasket. Remove the choke plate retaining screws by first filing the backs of the screws to remove the stake marks. Remove the choke plate. Remove the choke shaft.

3- Remove the accelerator pump discharge nozzle by first removing the retaining screw. Discard both gaskets. Turn the carburetor over and catch the accelerating pump discharge needle as it falls out. Remove the six screws securing the throttle body and main body together and then separate the parts. Discard the gasket.

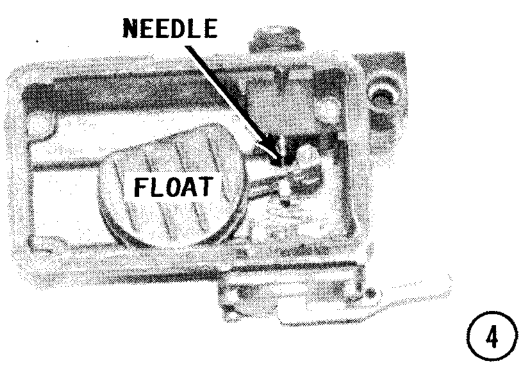






4- Remove the float retainer E-clip, and then slide out the float and spring. Remove the fuel inlet needle, and then take out the float baffle. Rewove the fuel inlet needle seat and gasket. Discard the gasket. Remove the fuel inlet fitting and discard the gasket. Remove the bowl vent valve assembly and accelerator pump cover on the primary fuel bowl. Remove the diaphragm and spring.

5- The power valve assembly should be replaced each time the carburetor is overhauled. This assembly should be removed from the primary metering body, using Tool No. 3747. The metering jets do not have to be removed because they can be cleaned with compressed air while they are still in place in the metering body. Remove the idle adjusting needles and gaskets. The secondary metering body does not have to be disassembled because the metering restrictions can be adequately cleaned with compressed air.



CLEANING AND INSPECTING THE HOLLEY

NEVER dip rubber parts, plastic parts, diaphragms, or pump plungers in carburetor cleaner. Place all of the metal parts in a screen-type tray and dip them in carburetor solvent until they appear completely clean, then blow them dry with compressed air.

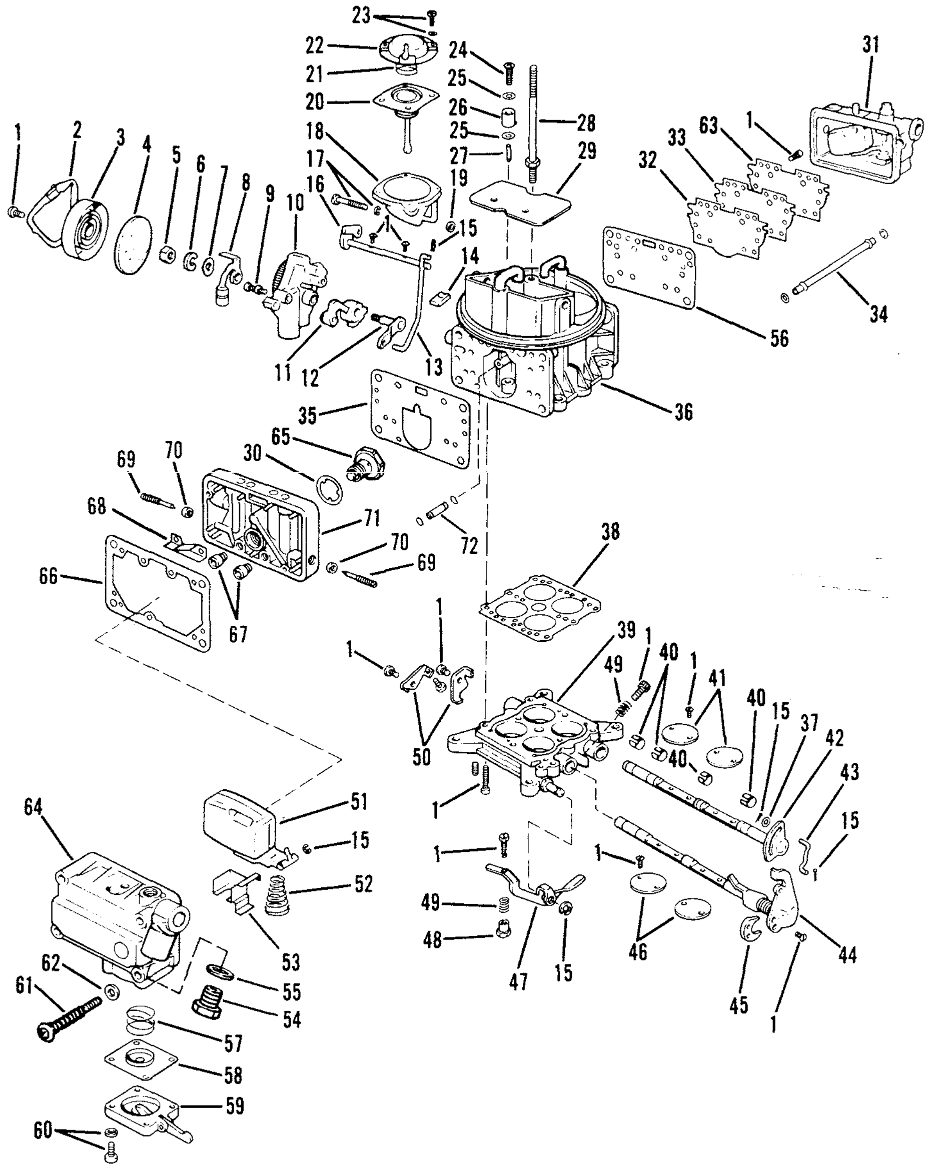
Blow out all of the passages in the castings with compressed air. Check all of the parts and passages to be sure they are not clogged or contain any deposits. **NEVER** use a piece of wire or any type of pointed instrument to clean drilled passages or calibrated holes in a carburetor.

Inspect the choke and throttle shafts for excessive wear and replace the complete carburetor if the throttle shaft is worn.

Check the floats for leaking by shaking them and listening for fluid movement inside. If a float contains fluid, it must be replaced. Inspect the arm needle contact surface and the float shaft and replace them if either has any grooves worn in it.

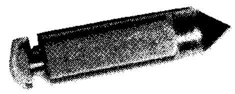
ALWAYS replace the needle valve-and-seat assemblies. These parts receive the most wear in the carburetor and the proper fuel level cannot be maintained if they are worn.

Check the choke vacuum diaphragm by first depressing the diaphragm stem, and then placing a finger over the vacuum fitting to seal the opening. Now, release the

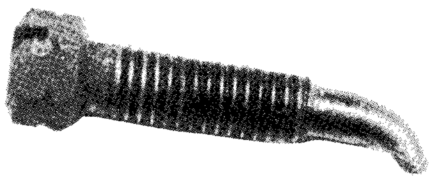


1. Screw
2. Choke Thermostat Housing Clamp
3. Choke Thermostat Housing and Spring
4. Choke Thermostat Housing Gasket
5. Nut
6. Lockwasher
7. Spacer
8. Choke Thermostat Lever Link and Piston Assembly
9. Screw and Washer
10. Choke Housing
11. Fast Idle Cam Assembly
12. Choke Housing Shaft and Lever
13. Choke Rod
14. Choke Rod Seal
15. Retainer
16. Choke Shaft
17. Screw and Washer
18. Secondary Housing
19. Gasket
20. Diaphragm Assembly
21. Diaphragm Spring
22. Cover
23. Screw and Washer
24. Screw
25. Gasket
26. Accelerating Pump Discharge Nozzle
27. Accelerating Pump Discharge Needle
28. Flame Arrestor Anchor Screw
29. Choke Plate
30. Power Valve Gasket
31. Secondary Fuel Bowl
32. Secondary Plate
33. Secondary Plate
34. Fuel Line
35. Primary Meter Block Gasket
36. Main Body
37. Washer
38. Throttle Body-to-main Body Gasket
39. Throttle Body
40. Shaft Bushings
41. Secondary Throttle Plates
42. Secondary Throttle Shaft
43. Throttle Connecting Rod
44. Primary Throttle Shaft Assembly
45. Accelerating Pump Cam
46. Primary Throttle Plates
47. Accelerating Pump Operating Lever
48. Sleeve Nut
49. Spring
50. Diaphragm Lever Assembly
51. Float
52. Float Spring
53. Baffle Plate
54. Fuel Inlet Fitting
55. Gasket
56. Gasket
57. Diaphragm Spring
58. Diaphragm Assembly
59. Accelerating Pump Cover
60. Retaining Screw and Lockwasher
61. Screw
62. Gasket
63. Secondary Metering Block
64. Primary Fuel Bowl
65. Power Valve
66. Primary Fuel Bowl Gasket
67. Main Jets
68. Baffle Plate
69. Idle Adjusting Needle
70. Seal
71. Primary Metering Block
72. Tube and O-Rings

Exploded view showing all parts of the Holley four-barrel carburetor.



Fuel inlet needle with a worn ridge. The set ***MUST*** *be replaced to prevent a leak and carburetor flooding.*



Tip of an idle mixture adjusting needle bent from being forced into its seat and against the closed throttle plate.

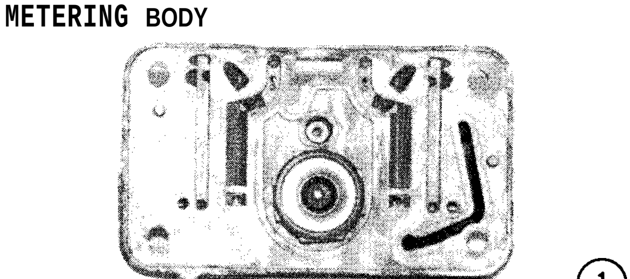
diaphragm stem. If the stern moves out more than 1/16" in ten seconds, the diaphragm has an internal leak and it should be replaced.

Most of the parts that should be replaced during a carburetor overhaul, including the latest updated parts are found in a carburetor kit available at your local marine dealer. In addition to the parts, most kits include the latest specifications which are so important when making adjustments.

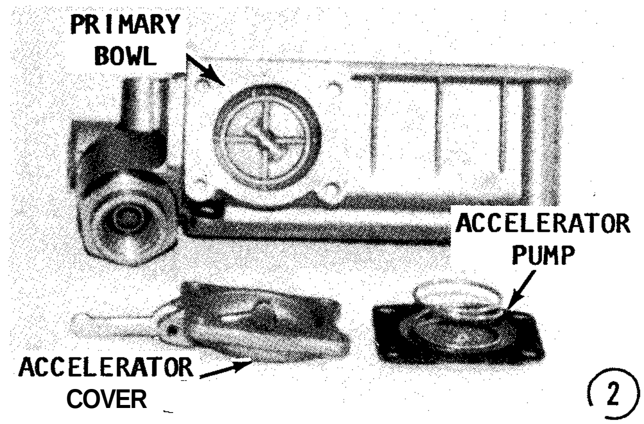
ASSEMBLING THE HOLLEY

1– Install a new power valve and gasket in the primary main metering body using Tool C-3747 to tighten it securely. Install the idle mixture adjusting needles and new gaskets. Tighten the needles **FINGERTIGHT,** then back each one out one full turn as a rough adjustment at this time. Install the main metering jets.

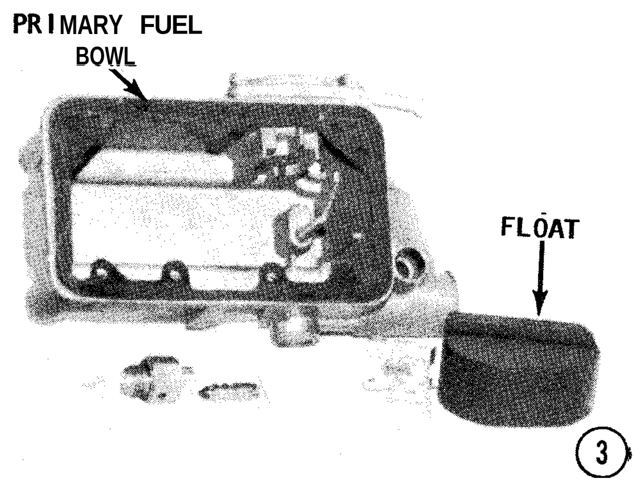
2– Assemble the parts to the primary fuel bowl by first placing the accelerator pump spring in position. Next place the diaphragm in position with the contact button facing the **PUMP LEVER** in the cover, as shown in the accompanying illustration. Place the cover over the diaphragm with the



pump lever **FACING** the **FUEL INLET** side, as shown. Start the attaching screws, then depress the pump lever to center the diaphragm, then tighten the screws. Install a new gasket over the fuel inlet fitting, then the fitting and tighten it securely.

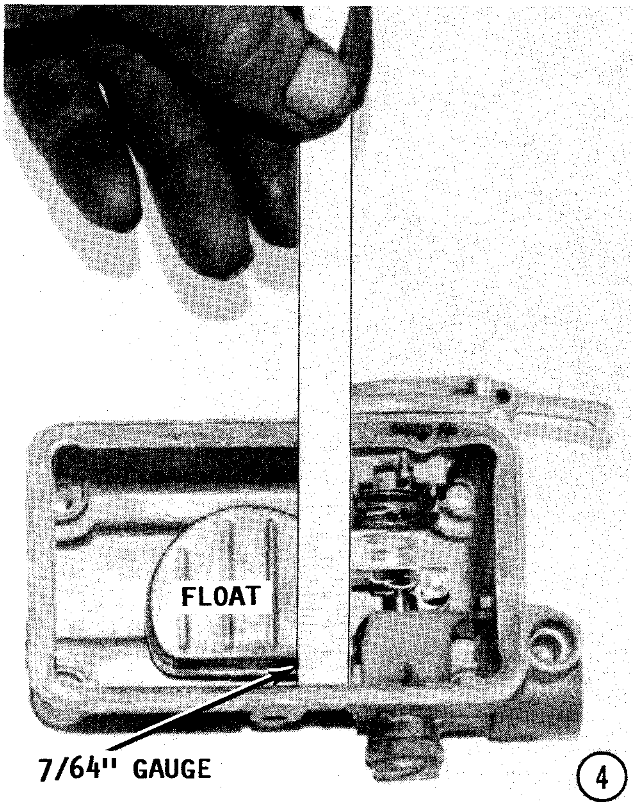


3– Install a **NEW** needle valve seat and gasket and tighten it securely. The needle valve and seat are a **MATCHED SET** and must be replaced in **PAIRS.** Slide the fuel inlet needle into its seat. Place the float baffle in position, then slide the float hinge over the pivot and secure it with an E-clip. Install the float spring. Repeat the procedures in this step for the secondary float bowl.



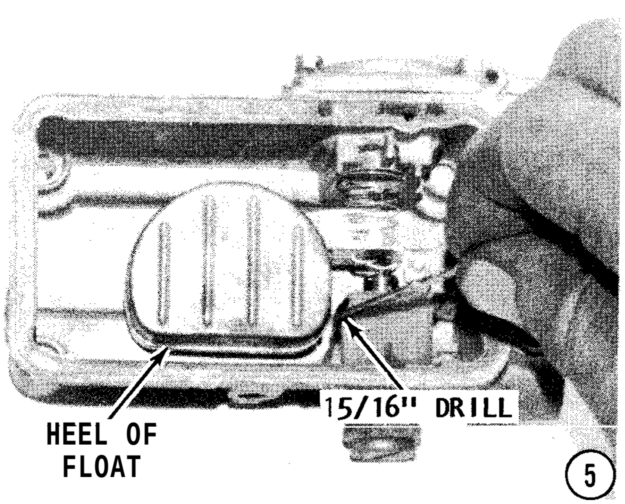
4– This step is only necessary if your bowl is not equipped with a float adjusting nut and screw. Turn the primary fuel bowl over and use a 7/64" gauge to measure the distance between the toe sf the float and the surface of the fuel bowl, as shown. **CAREFULLY** bend the float tang until the proper clearance is reached.

5– Turn the secondary fuel bowl over and use a 15/64" gauge to measure the

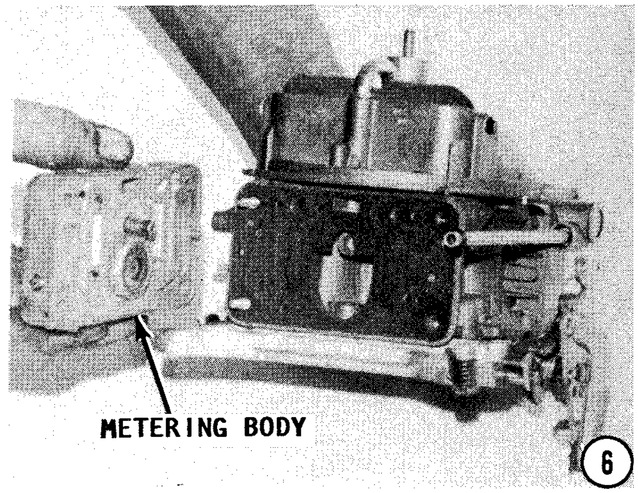


distance between the heel sf the float and the surface of the fuel bowl. **CAREFULLY** bend the float tane until the proper clearance is obtained.

6- Place a new gasket in position on the throttle body, and then lower the main body as you align the roll pin guides with the openings in the main body. The primary bores of the throttle body **MUST** be on the SAME side as the primary venturi. Fold the parts together, turn them over and install and tighten them securely. Push an O-ring seal into each recess, then install a flat washer at each end. Install a **NEW** gasket, then the plate, another **NEW** gasket, and

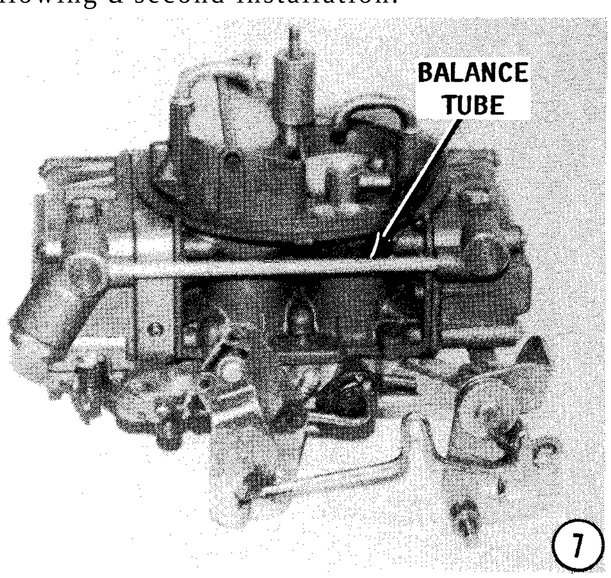


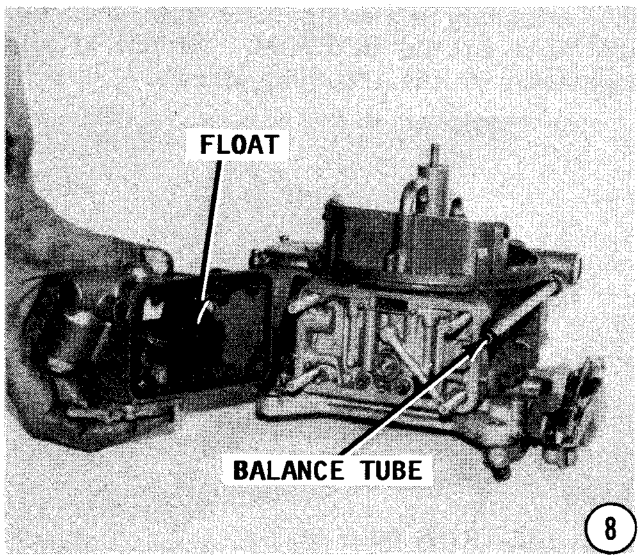
the secondary metering body with the restrictions at the **BOTTOM.** Secure it all together with the attaching screws.



7- Position the balance tube, if one is used, so one inch extends beyond the secondary metering body, as shown.

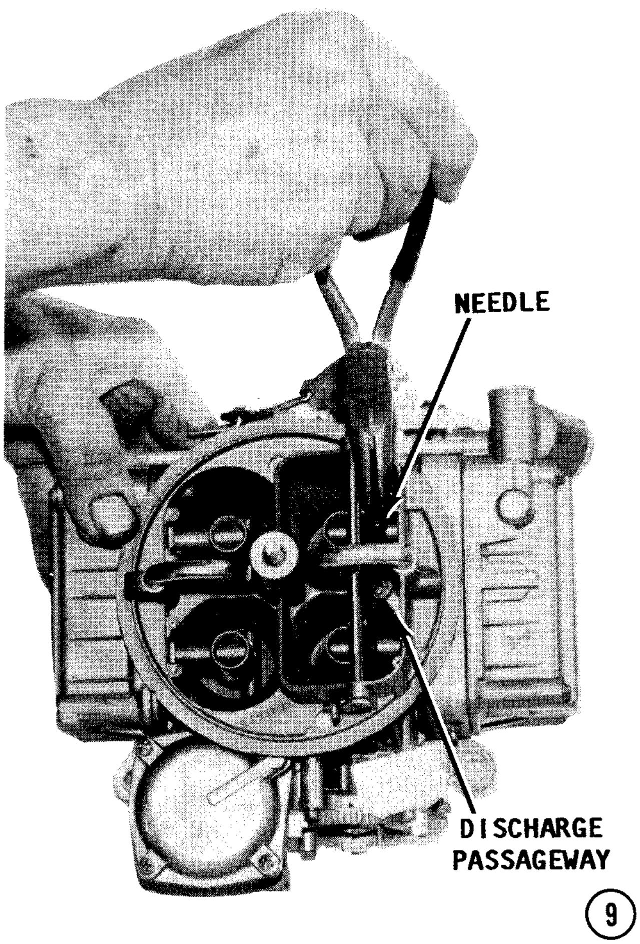
8- Slide the assembled secondary fuel bowl and a **NEW** gasket over the balance tube. Install and tighten the attaching screws. Slide a new O-ring seal on each end of the fuel transfer tube, and then press the tube into the opening in the secondary bowl. Place a **NEW** gasket over the primary metering body pin, then slide the body over the balance tube and into place on the main body. Slide a **NEW** gasket over the metering body, and then install the primary fuel bowl over the balance tube and down against the metering body. Slide **NEW** gaskets over the long fuel bowl mounting screws, then install and tighen them securely. **NEVER** use an old gasket because they will always leak following a second installation.

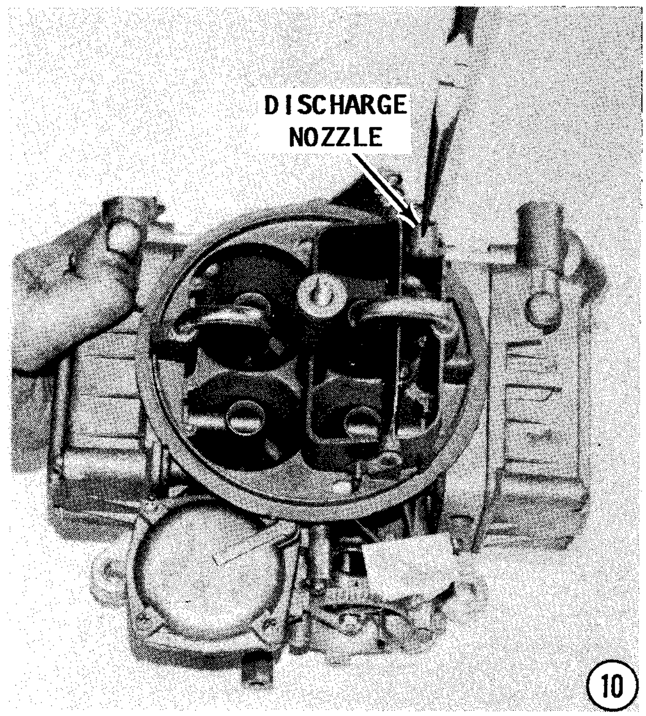




9- Install the accelerating pump discharge needle into the discharge passageway in the center of the primary venturi.

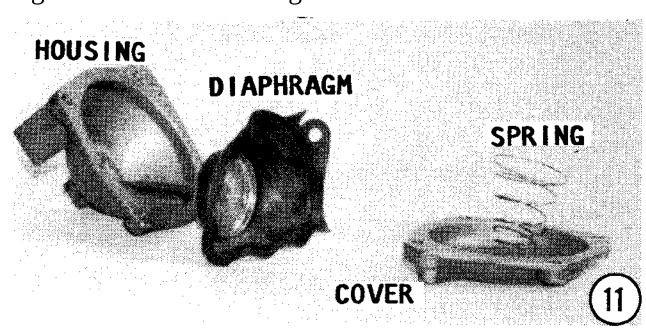
10- Install the pump discharge nozzle gasket, nozzle, mounting screw, and gasket. Align the notch in the rear of the nozzle with the projection on the boss of the casting. Install the choke valve and shaft.

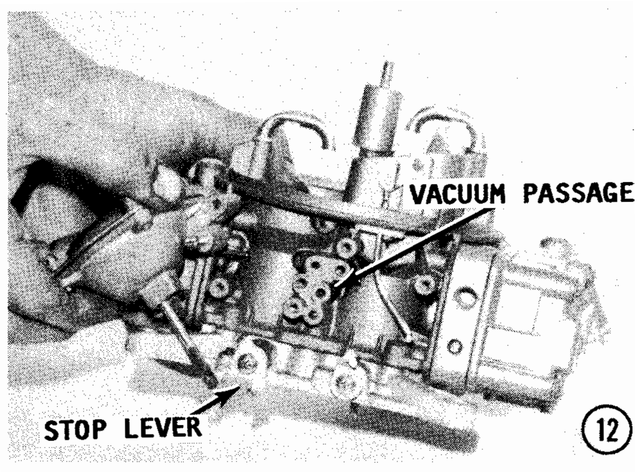




11- Assemble the secondary throttle-opening diaphragm by first sliding a new diaphragm into the housing. Next, place the diaphragm in position with the vacuum hole in the housing aligned with the vacuum hole in the diaphragm. Now, install the return spring with the coiled end snapped over the button in the cover. Lower the cover into position with the vacuum port in the cover aligned with the port in the housing. Keep the diaphragm flat while the cover is being installed. Install and tighten the attaching screws. Check the assembly for air leaks by depressing the diaphragm stem and then placing your finger over the port to seal it. If the diaphragm does not remain in the retracted position, there is an air leak.

12- Place a NEW gasket in the vacuum passageway recess in the diaphragm housing, then install the secondary diaphragm assembly and at the same time, engage the stem with the secondary stop lever. Install and tighten the attaching screws.





HOLLEY CARBURETOR ADJUSTMENTS

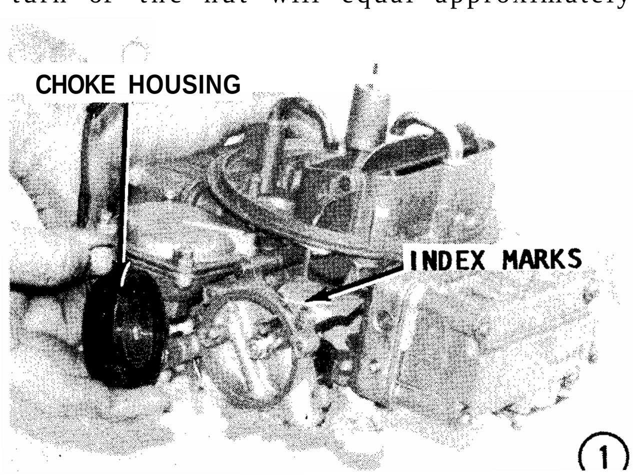
Carburetor adjustments MUST be performed in the sequence outlined in the following steps.

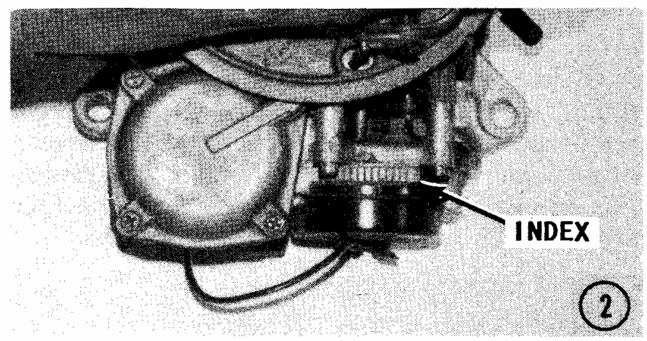
For best performance and economy results, follow the specifications included in the carburetor repair kit.

1– Automatic Choke Adjustment: The automatic choke is set at the factory to give maximum performance under all weather conditions. If necessary, the choke can be returned to its original position by aligning the index mark with the proper specification.

2– A richer or leaner mixture can be obtained for the warm-up period, if desired, by rotating the thermostat cover. **NEVER** set the index mark on the cover more than two marks from the specified setting.

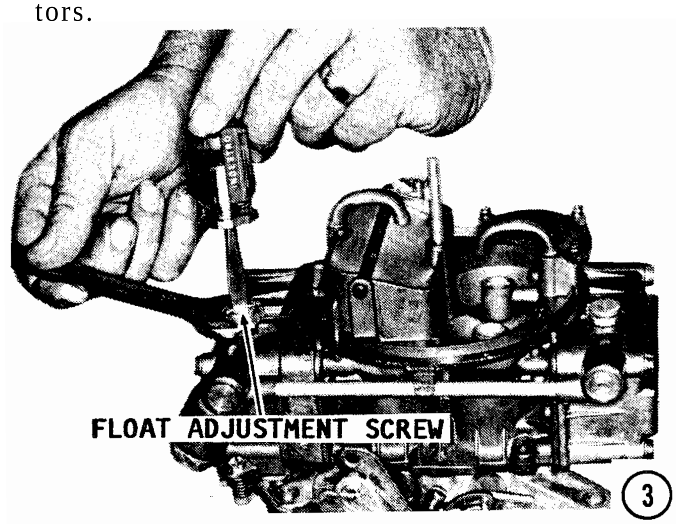
3– Fuel Level Adjustment: Loosen the lock screw and turn the adjusting nut clockwise to lower the fuel level and counterclockwise to raise the fuel level. A 1/16 turn of the nut will equal approximately

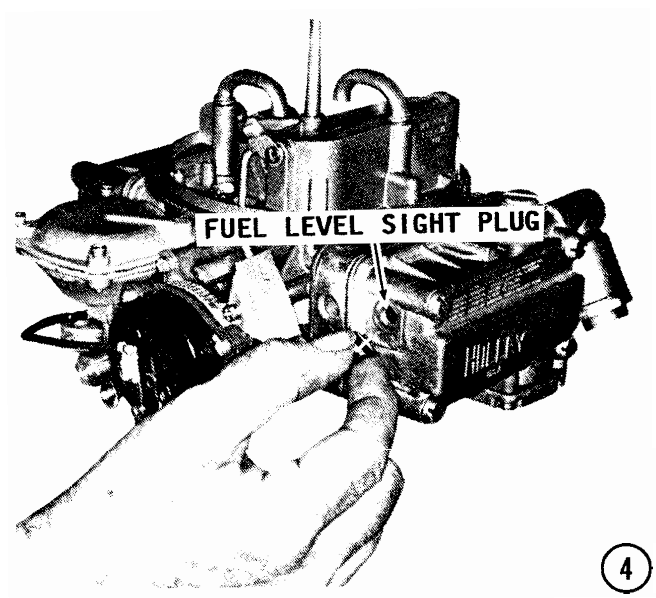




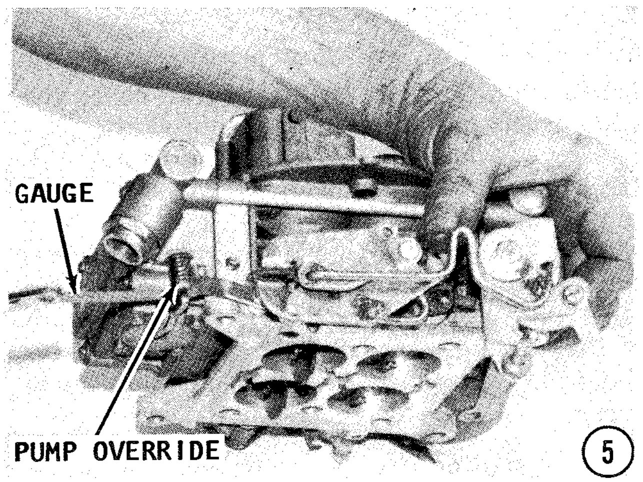
1/16 inch difference in fuel level. After the adjustment has been made, tighten the lock screw. On newer model carburetors, this adjustment can only be done with the bowl removed.

4– With the engine approximately level and the engine running, the fuel level in the sight plug must be in line with the threads at the bottom of the plug within 1/32". This sight plug is not used on late model carburetors.

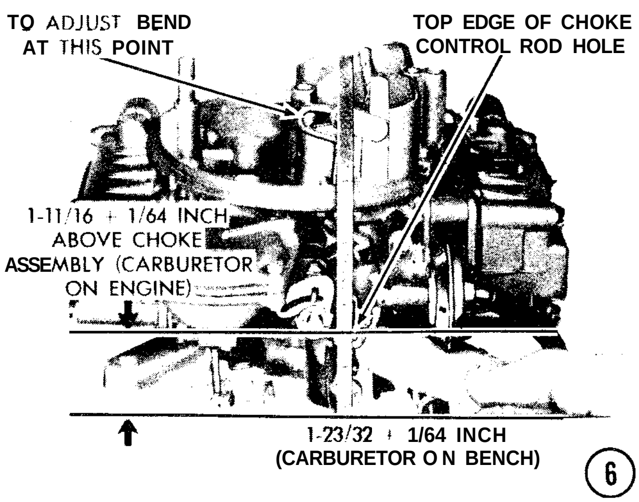


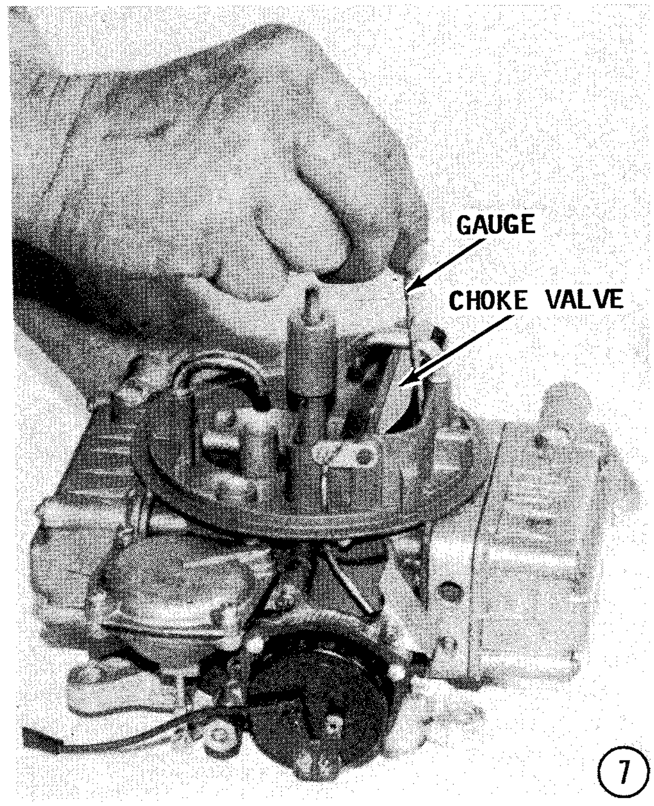


5- Accelerator Pump Lever Clearance: First, move the throttle to the wide-open position. Hold the pump lever down. You should be able to insert a 0.015" gauge between the adjusting nut and the lever. Rotate the pump override screw to obtain the correct clearance. There must be NO FREE **PLAY** with the pump lever at idle.

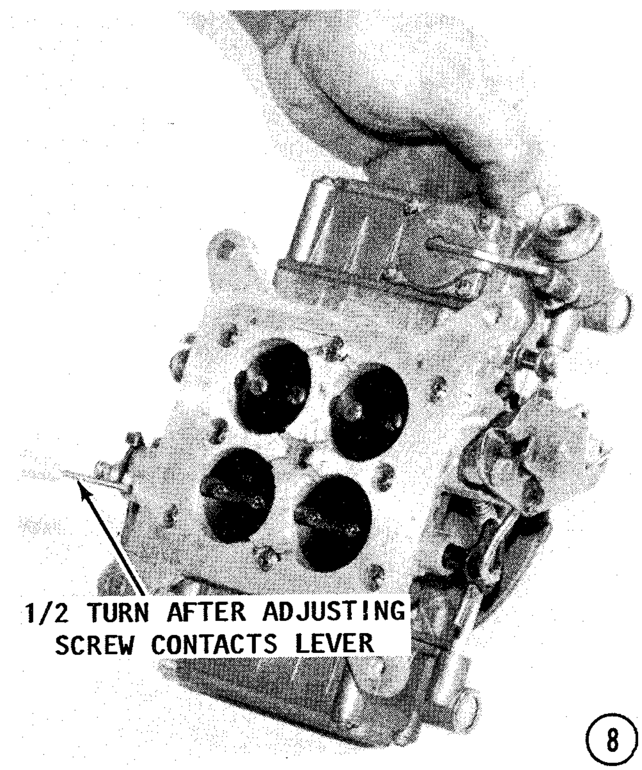


6- Choke Control Lever Adjustment: First, open the throttle to the midposition. Next, close the choke valve with a light pressure on the choke control lever. With the carburetor on the engine, measure the distance between the top of the choke rod hole in the control lever and the choke assembly and compare it with 1-11/16". CAREFULLY bend the choke shaft rod until the measurement is within 1/64" of the specification given. This adjustment is necessary to ensure a correct relationship between the choke valve, the thermostatic coil spring, and the fast-idle cam.





7- Choke Unloader Adjustment: Hold the throttle in the wide-open position and at the same time insert the specified gauge between the upper edge of the choke valve and the inner wall of the air horn. CARE-**FULLY** bend the indicated tang until the required measurement is obtained.



5
IGNITION

5-1 DESCRIPTION

Engine performance and efficiency are, to a large degree, governed by how fine the engine is tuned to factory specifications as determined by the designers. The service work outlined in this chapter must be performed in the sequence given and to the Specifications listed in the Appendix.

The ignition system consists of a primary and a secondary circuit. The low-voltage current of the ignition system is carried by the primary circuit. Parts of the primary circuit include the ignition switch, ballast resistor, neutral-safety switch, primary winding of the ignition coil, contact points in the distributor, condenser, and the low-tension wiring.

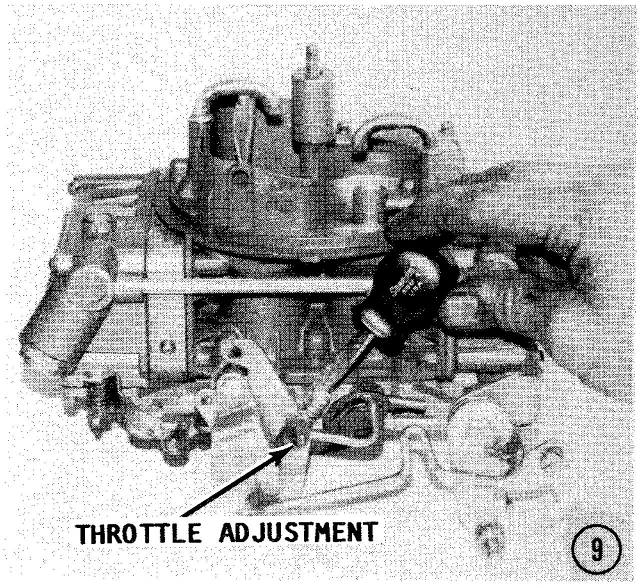
The secondary circuit carries the high-voltage surges from the ignition coil which result in a-high-voltage spark between the electrodes of each spark plug. The secondary circuit includes the secondary winding of the coil, coil-to-distributor high-tension lead, distributor rotor and cap, ignition cables, and the spark plugs.

When the contact points are closed and the ignition switch is on, current from the battery or from the alternator flows through the primary winding of the coil, through the contact points to ground. The current flowing through the primary winding of the coil creates a magnetic field around the coil windings and energy is stored in the coil. Now, when the contact points are opened by rotation of the distributor cam, the primary circuit is broken. The current attempts to surge across the gap as the points begin to open, but the condenser absorbs the current. In so doing, the condenser creates a sharp break in the current flow and a rapid collapse of the magnetic field in the coil. This sudden change in the strength of the magnetic field causes a voltage to be induced in each turn of the secondary windings in the coil.

The ratio of secondary windings to the primary windings in the coil increases the voltage to about 20,000 volts. This high voltage travels through a cable to the center of the distributor cap, through the rotor to an adjacent distributor cap contact point, and then on through one of the ignition wires to a spark plug.

When the high-voltage surge reaches the spark plug it jumps the gap between the

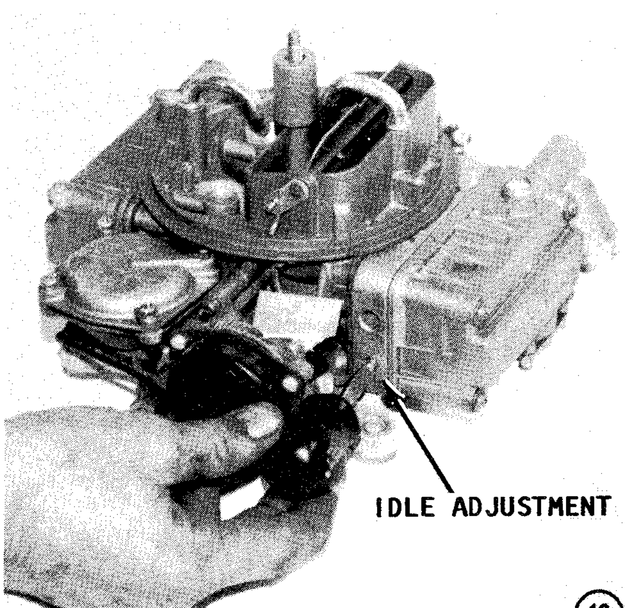
A fully charged battery, filled to the proper level with electrolyte, is the heart of the ignition system. Engine starting and efficient performance can never ***be*** *obtained if the battery is below its full charge rating.*

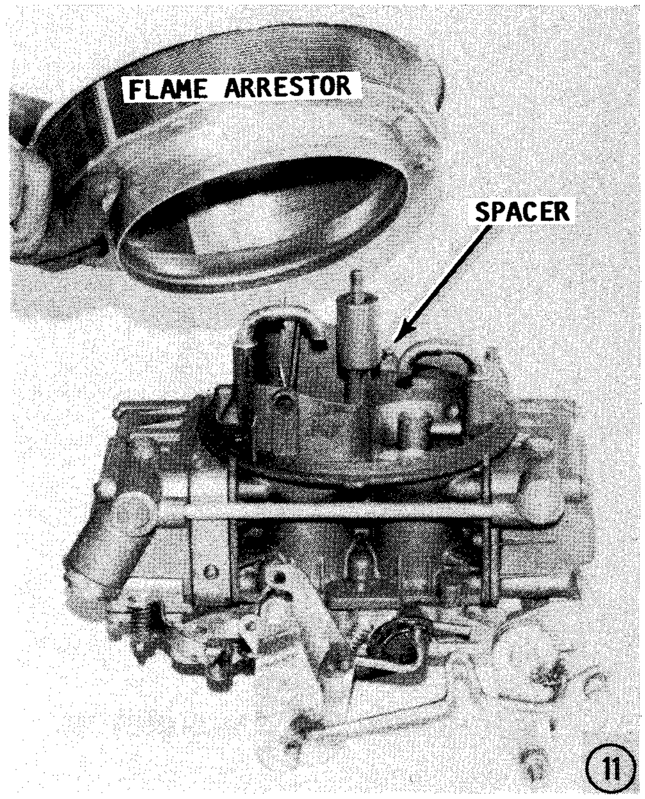


8- Secondary Throttle Valve Adjustment: First, back out the secondary throttle stop screw until the valves are fully closed. Next, turn the stop screw in until it barely contacts the secondary throttle stop lever. Now, turn the adjusting screw in 1/2 turn.

9- Fast Idle Adjustment: With the choke plate wide open, the fast-idle adjusting screw should just touch the lowest step of the fast-idle cam. This adjustment MUST be done **BEFORE** adjusting the idle needles.

10- Idle Speed and Mixture Adjustment: Turn each idle speed needle in until it barely seats, and then back it out one full turn. **TAKE CARE** not to seat the needles tightly because it would groove the tip sf the needle. If the needle should become grooved, a smooth idle cannot be obtained. Start



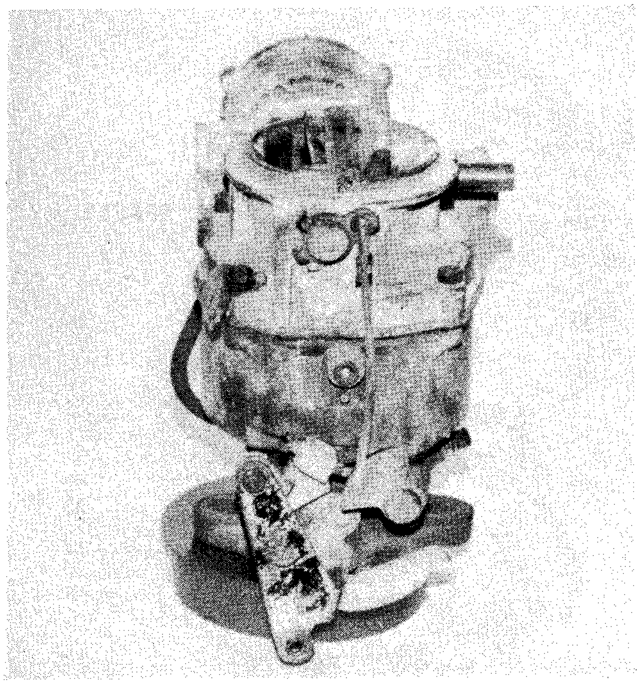


the engine and allow it to warm to full operating temperature.

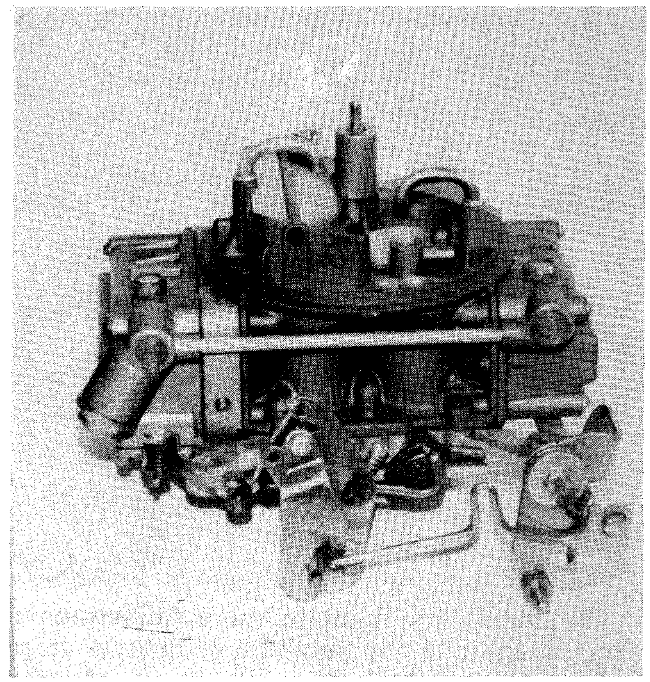
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump,

Adjust the idle-speed screw until the required rpm is reached as given in the Specifications in the Appendix. Now, set one of the two idle adjusting needles for the highest steady manifold vacuum reading. If a vacuum gauge is not available, turn the idle adjusting needle inward until the rpm begins to drop off, then back the needle out over the "highspot" until the rpm again drops off. Set the idle adjusting needle halfway between these two points as an idle speed setting. Repeat the procedure for the other needle. If these adjustments result in an increase in idle rpm, reset the idle speed screw to obtain the-required idle rpm, and then adjust the idle adjusting needles again.

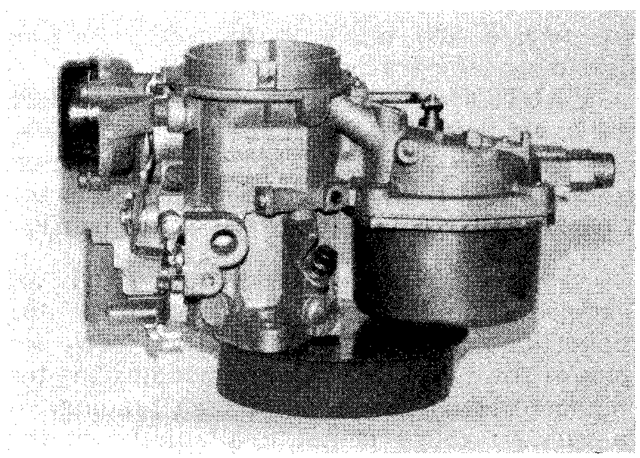
11- Position the sealing ring over the carburetor. The ring has three cutouts to make it fit easily. Install the spacer over the center screw, and then install the flame arrestor. **CHECK TO BE SURE** the flame arrestor is clean because a dirty one will consume too much fuel and cause the engine to run rough at high speeds.



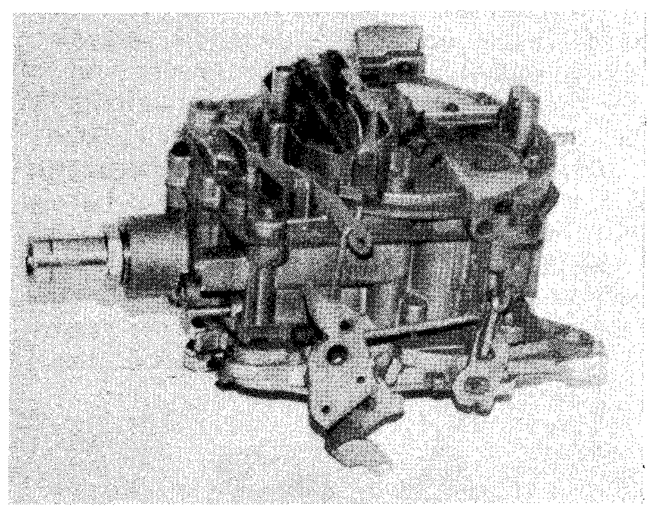
ROCHESTER BC CARBURETOR



HOLLEY CARBURETOR



CARTER RBS CARBURETOR



ROCHESTER 4MV CARBURETOR

insulated center electrode and the grounded side electrode. This high voltage jump across the electrodes produces the energy required to ignite the compressed air-fuel mixture in the cylinder.

The entire electrical build-up, breakdown, and transfer of voltage is repeated as each lobe of the distributor cam passes the rubbing block on the contact breaker arm, causing the contact points to open and close. At high engine rpm operation, the number of times this sequence of actions take place is staggering.

BALLAST RESISTOR

Beginning at the key switch, current flows to the ballast resistor and then to the positive side of the coil. When the resistor is cold its resistance is approximately one ohm. The resistance increases in proportion to the resistor's rise in temperature.

While the engine is operating at idle or slow speed, the cam on the distributor shaft revolves at a relatively slow rate. Therefore, the breaker points remain closed for a slightly longer period of time. Because the points remain closed longer, more current is allowed to flow and this currrent flow heats the ballast resistor and increases its resistance to cut down on current flow thereby reducing burning of the contact points.

During high rpm engine operation, the reduced current flow allows the resistor to cool enough to reduce resistance, thus increasing the current flow and effectiveness of the ignition system for high-speed performance.

The voltage drops about 25% during engine cranking due to the heavy current demands of the starter. These demands reduce the voltage available for the ignition system. In order to reduce the problem of less voltage, the ballast resistor is by-passed during cranking. This releases full battery voltage to the ignition system.

SHIFT CUTOUT SWITCH

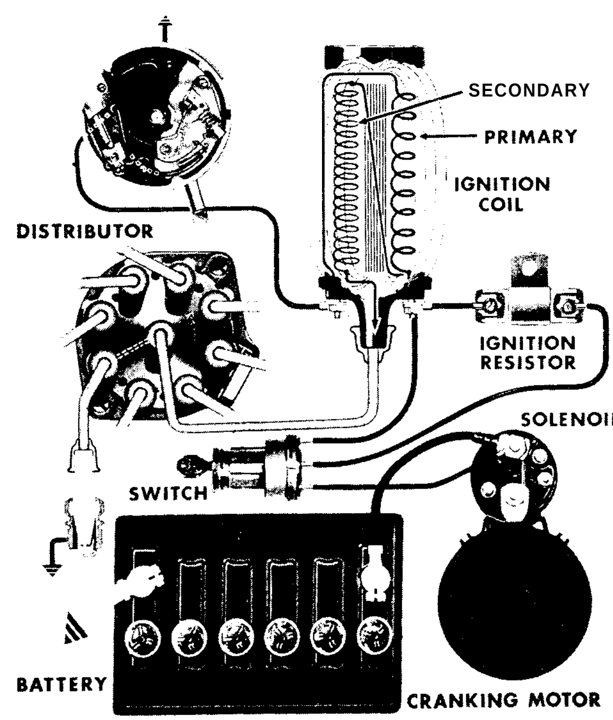
The shift cutout switch is connected between the primary side of the ignition coil and ground. This switch is normally open. The function of this switch is to ground the ignition system during a shift to neutral. By grounding the ignition system, gear pressure is released and the shift is made much easier. Obviously, if the ignition system is grounded, the cylinders will not fire during this period. In actual practice only a few cylinders fail to fire and it is usually not noticeable. The shift cutout switch is mounted on the transom and is activated by the remote-control shift cable.

TAKE NOTE: If this switch is not adjusted properly, or if it shorts out (is grounded) then the primary side of the ignition coil will be grounded and the engine will not start.

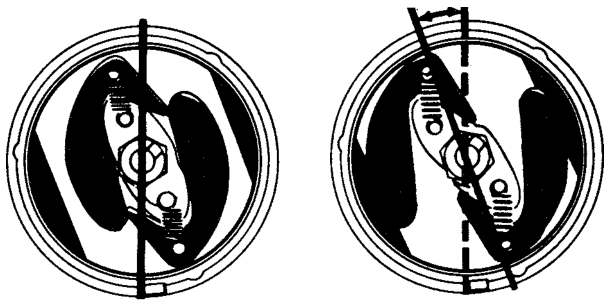
IGNITION TIMING

In order to obtain the maximum performance from the engine, the timing of the spark must vary to meet operating conditions. For-idle, the spark advance should be as low as possible. During high-speed operation, the spark must occur sooner, to give the air-fuel mixture enough time to ignite, burn, and deliver it's power to the piston for the power stroke.

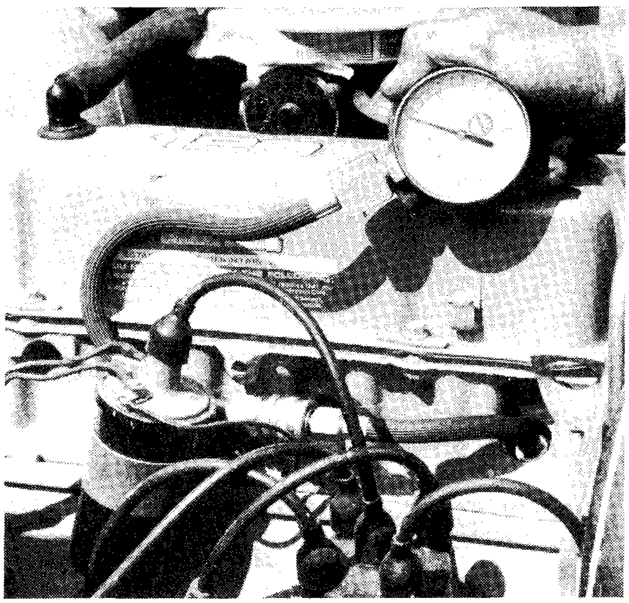
Manual setting and centrifugal advance are the two methods of obtaining the constantly changing demands of the engine. The manual setting is made at idle speed. This setting allows the contact points to open at a specified position of the piston



Functional diagram of the ignition system.



Movement of the centrifugal advance mechanism. All parts must be free to move properly or the ignition timing will not advance with engine speed and all phases of performance will suffer, as explained in the text.



Cylinder pressure should not vary between cylinders by more than 15 psi for the engine to run smoothly. Variation between the cylinders is much more important than the actual individual readings.

before Top Dead Center (TDC). The TDC position for the No. 1 cylinder is indicated by the timing mark on the crankshaft pulley.

The centrifugal advance is controlled entirely by engine speed. A pair of weights, two springs, and a weight base plate comprise the centrifugal advance mechanism. As engine speed increases, centrifugal force causes the weights to move outward and push against the cam ramps which in turn rotate the distributor cam ahead of the distributor shaft. This action causes the distributor cam lobes to open the contact points sooner and the timing of the spark is advanced.

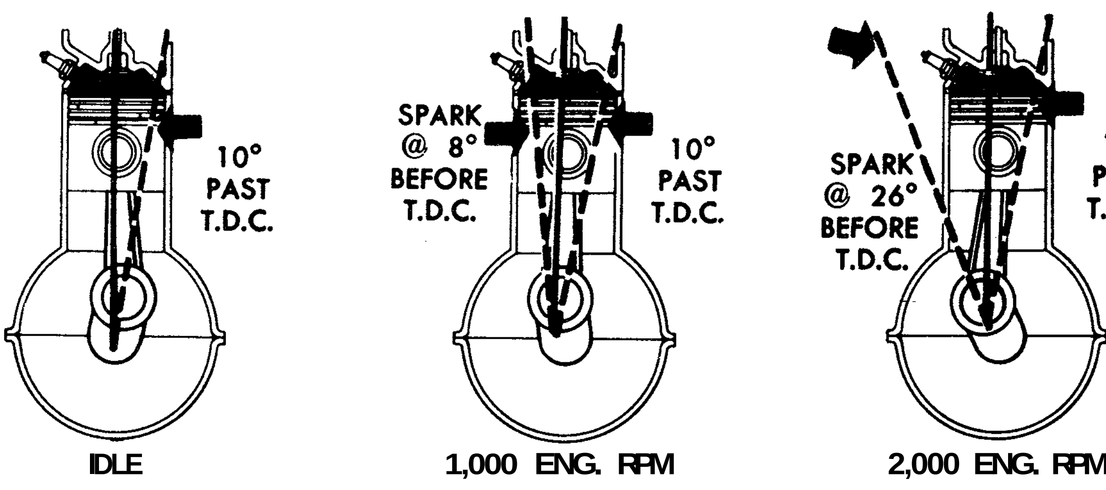
5-2 IGNITION TROUBLESHOOTING

COMPRESSION

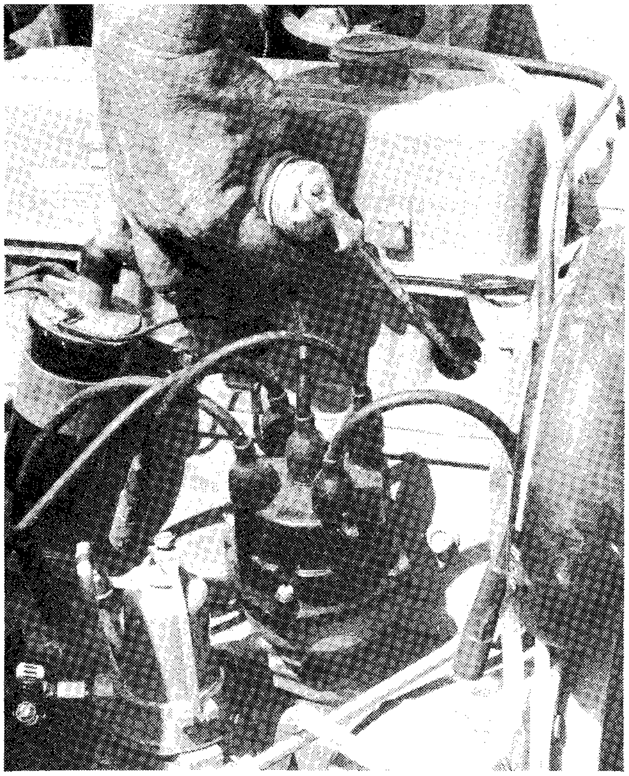
Before spending time and money seeking a problem in the ignition system, a compression check should be made of each cylinder. Without adequate compression, your efforts in the ignition system will not give the desired results.

Remove each spark plug in turn; insert a compression gauge in the hole; crank the engine several times; and note the reading. A variation between the cylinders is more important than the actual reading. A variation of more than 20 psi indicates either a ring or valve problem.

To determine which is defective, squirt about a teaspoonful of oil into the cylinder that has the low reading. Crank the engine



The mechanical spark advance mechanism advances ignition timing when engine speed increases, as shown in these three drawings. Maximum pressure must occur by 10° ATDC, at all speeds. Therefore, the spark must occur at TDC for idle speeds (left); at approximately 8° before TDC for 1,000 rpm (center); and at 26° before TDC for 2,000 rpm (right).



After taking the first pressure reading, a small amount of oil inserted into a low reading cylinder, followed by a second pressure reading will indicate whether the compression loss is past the rings or the valves.

a few times to distribute the oil. Now, recheck the compression and note the difference from the first reading. If the pressure increased, the compression loss is past the piston rings; if no change is noted, the loss is past a burned valve.

IGNITION SYSTEM TESTS

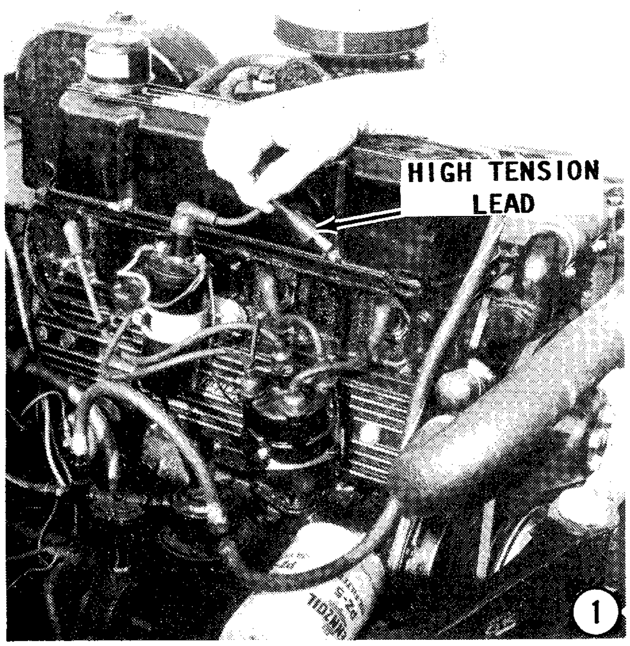
Any problem in the ignition system must first be localized to the primary or secondary circuit before the defective part can be identified.

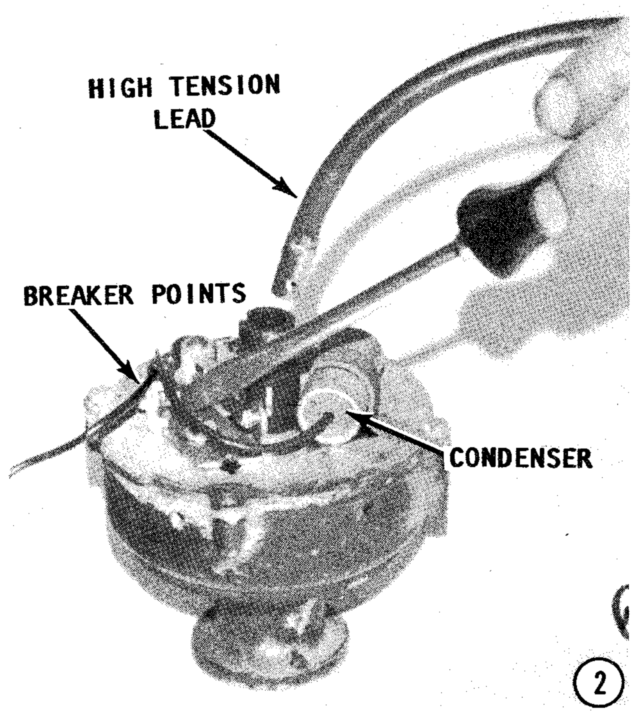
1- GENERAL TESTS

Disconnect the wire from the center of the distributor cap and hold it about 1/4" from a good ground. Turn the ignition switch to **START,** and crank the engine with the starter. If you observe a good spark, go to Test 5 (Secondary Circuit Test). If you do not have a good spark, go to Test **2** (Primary Circuit Test).

2- PRIMARY CIRCUIT TEST

Remove the distributor cap; lift off the rotor; and then turn the crankshaft until the contact points close. Turn the ignition switch on, and open and close the contact points using a small screwdriver or a non-metallic object. Hold the high-tension coil wire about 1/4" from a good ground. If you observe a good spark jump from the wire to the ground, the primary circuit checks out. Go to Test 5, (Secondary Circuit Test). If there is no spark, go to Test **3,** (Contact Point Test).





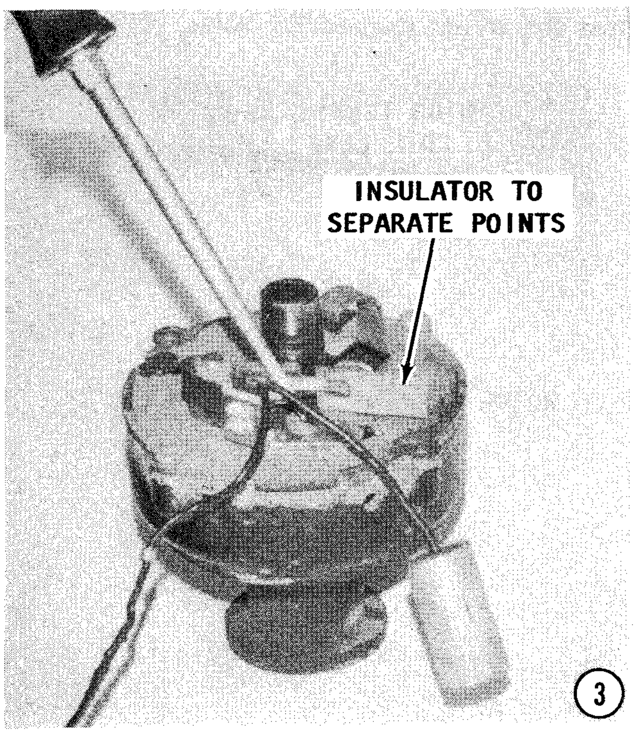
3- CONTACT POINT TEST

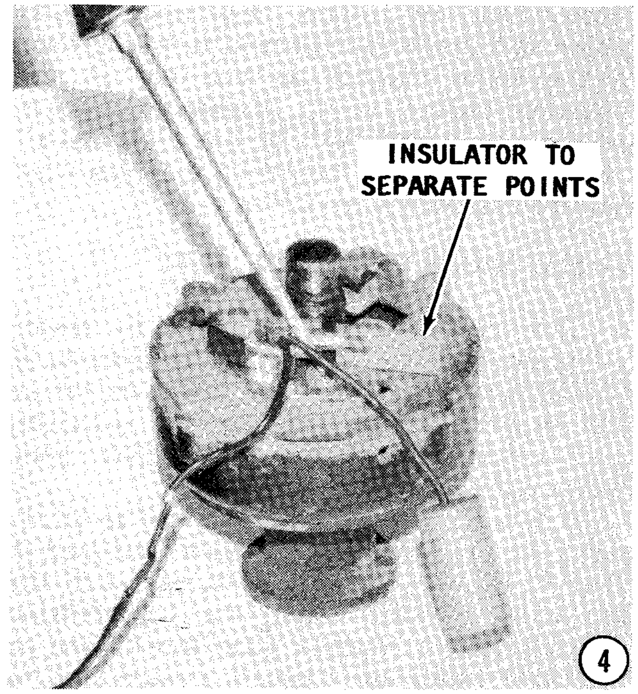
Remove the distributor cap and rotor. Turn the crankshaft until the points are open, and then insert some type of insulator between the points. Now, hold the high-tension coil wire about 1/4" from a good ground, and at the same time move a small screwdriver up and down with the screwdriver shaft touching the moveable point and the tip making intermittent contact with the contact point base plate. In this manner, you are using the screwdriver for a set of contact points. If you get a spark from the high-tension wire to ground, then the problem is in the contact points. Replace the set of points. If there is no spark from the high-tension wire to ground the problem is either a defective coil or condenser. To test the condenser, go to Test 4 (Condenser Test),

4- CONDENSER TEST

Condensers seldom cause a problem. However, there is always the possibility one may short out and ground the primary circuit. Before testing the condenser, check to be sure one of the primary wires or connections inside the distributor has not shorted out to ground.

The most accurate method of testing a condenser is with an instrument manufactured for that purpose. However, seldom is





one available, especially during an emergency. Therefore, the following procedure is outlined for emergency troubleshooting the condenser and the primary circuit insulation for a short.

First, remove the condenser from the system. **TAKE CARE** that the metallic case of the condenser does not touch any part of the distributor. Next, insert a piece of insulating material between the contact points. Now, move the blade of a small screwdriver up and down with the shaft of the screwdriver making contact with the moveable contact point and the tip making and breaking contact with the contact point base plate. Observe for a low-tension spark between the tip of the screwdriver and the contact point base plate as you make and break the contact with the screwdriver tip. You should observe a spark during this test and it will prove the prirnary circuit complete through the neutral-safety switch, the primary side of the ignition coil, the ballast resistor, the shift cutout switch, and the primary wiring inside the distributor are all functioning correctly. If you have a spark, reconnect the condenser and again make the same test with the screwdriver. If you do not get a spark, either the condenser is defective and should be replaced, or the shift control switch should be adjusted or replaced.

If you were unable to get a spark with the condenser disconnected, it means no current is flowing to this point, or there is a short circuit to ground. Use a continuity tester and check each part in turn to ground in the same manner as you did at the moveable contact point. If you get a spark, indicating current flow, at one terminal of the part, but not at the other, then you have isolated the defective unit.

5- SECONDARY CIRCUIT TEST

The secondary circuit cannot be tested using emergency troubleshooting procedures **UNLESS** the primary circuit has been tested and proven satisfactory, or any problems discovered in the primary cirucuit have been corrected.

If the primary circuit tests are satisfactory, use the same procedures as outlined in Test 2, Primary Circuit Test, to check the secondary circuit. Hold the high-tension wire about 1/4" from a good ground and at the same time, use a small screwdriver to open and close the contact points. A spark at the high-tension wire proves the ignition coil is good. However, if the engine still fails to start and the problem has been traced to the ignition system, then the defective part or the problem must be in the secondary circuit.

The distributor cap, the rotor, high-tension wires, or the plugs may require attention or replacement. To test the rotor, go to Test 6 (Rotor Test). If you were unable to observe a spark during the secondary circuit test just described, the ignition coil is defective and must be replaced.

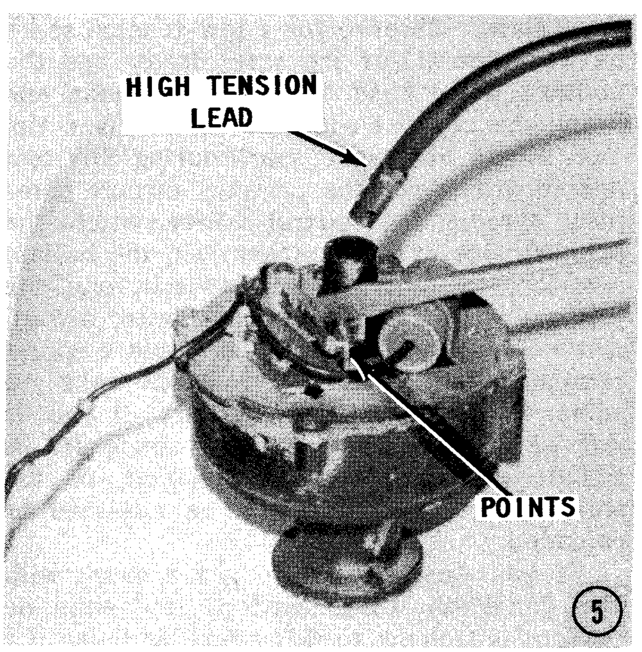
6- ROTOR TEST

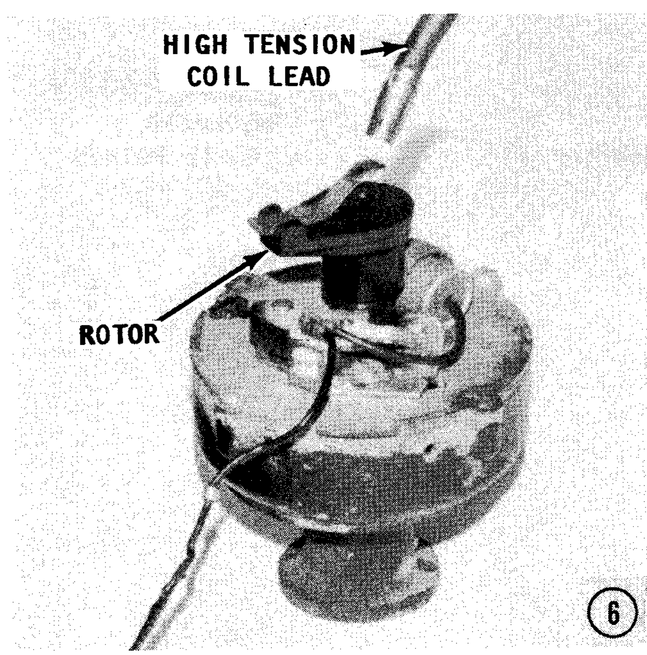
With the distributor cap removed and the rotor in place on the distributor shaft, hold the high-tension coil wire about 1/4" from the rotor contact spring, and at the same time crank the engine with the ignition switch turned **ON.** If a spark jumps to the rotor, it means the rotor is shorted to ground and must be replaced. If there is no spark to the rotor, it means the insulation is good and the problem is either in the distributor cap (check it for cracks), in the high-tension wires (check for poor insulation or replace it), or in the spark plugs (replace them).

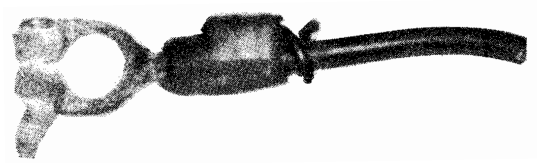
IGNITION VOLTAGE TESTS

Many times hard starting and misfiring problems are caused by defective or corroded connections. Such a condition can lower the available voltage to the ignition coil. Therefore, make voltage tests at critical points to isolate such a problem. Move the voltmeter test probes from point-to-point in the following order.

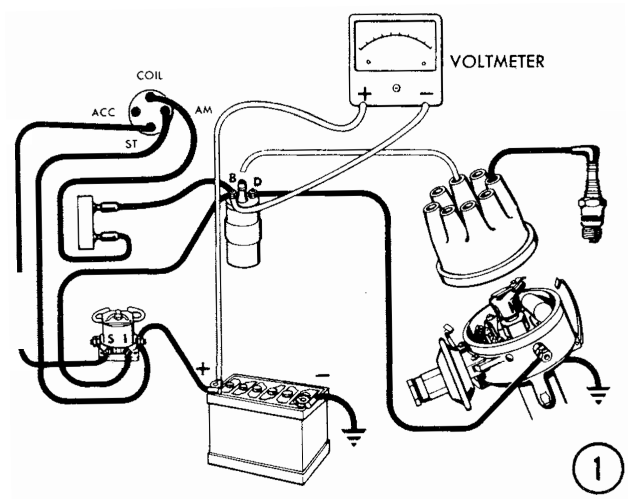
TEST 1 Voltage Loss Across Entire Ignition Circuit: Connect a voltmeter between the battery side of the ignition coil and the positive post of the battery, as shown in the Test 1 illustration. Crank the engine until the contact points are closed. Turn the ignition switch to ON. The voltage loss should not exceed 3.2 volts. This figure



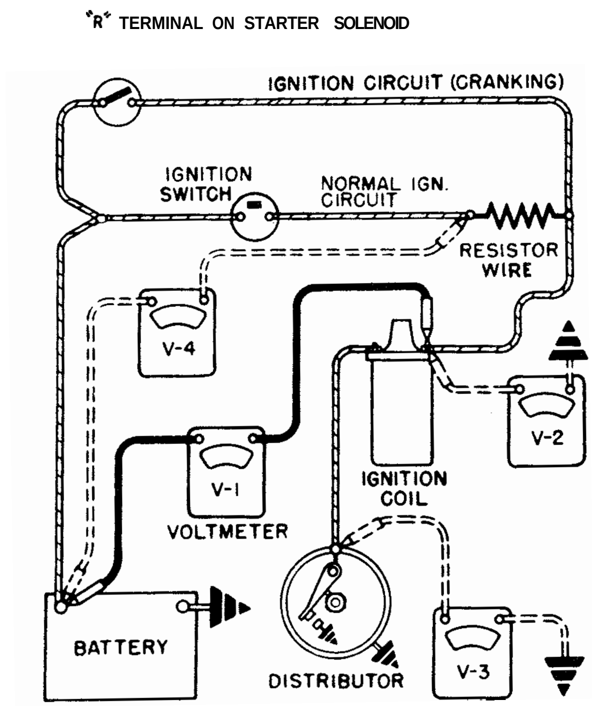




Many ignition system problems can be traced to a high-resistance connection caused by corroded battery posts and cables.

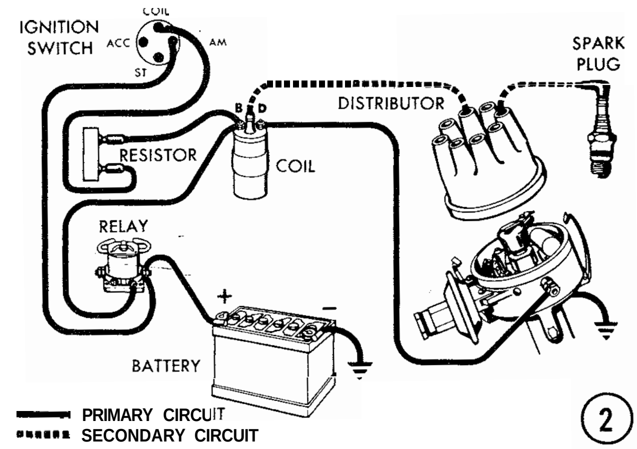


allows for a 0.2 loss across each of the connections in the circuit, plus a calibrated 2.4 volt drop through the ballast resistor. If the total voltage loss exceeds 3.2 volts, then it will be necessary to isolate the corroded connection in the circuit of the key resistor, the wiring, or at the battery.

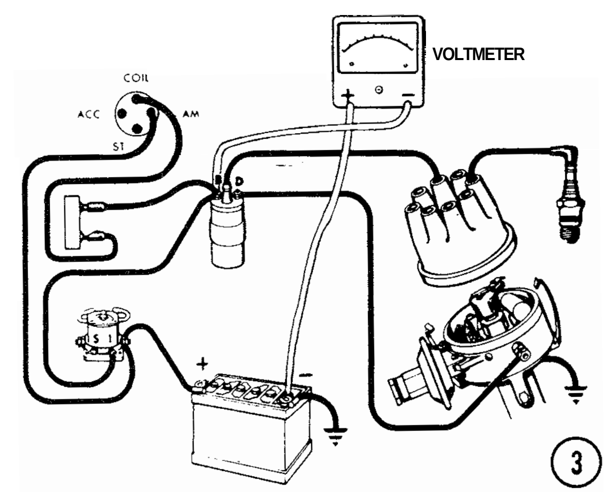


Functional diagram showing voltmeter hookups.

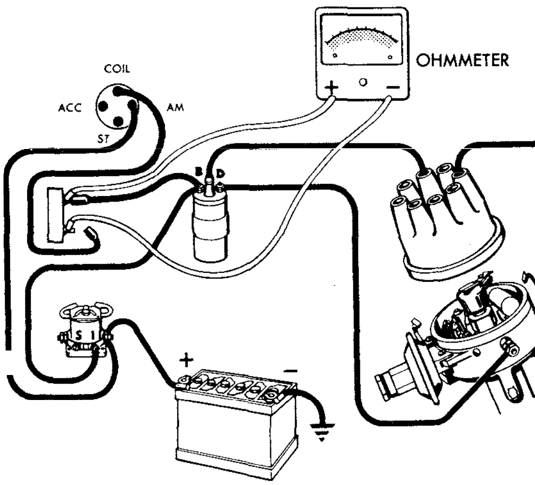
TEST 2 Cranking System: First disconnect the high-tension wire and ground it securely to minimize the danger of sparks and a possible fire. Next, connect a voltmeter between the battery side of the ignition coil and ground, as shown in Test 2 illustration. Now crank the engine and check the voltage. A normal system should have a reading of 8.0 volts. If the voltage is lower, the battery is not fully charged or the starter is drawing too much current.



TEST 3 Contact Points and Condenser: Measure the voltage between the distributor primary terminal and ground, as shown in Test 3 illustration. Crank the engine until the contact points are closed. Turn the ignition switch to the ON position. The voltage reading must be less than 0.2 volts. A higher reading indicates the contact points are oxidized and must be replaced. To check the condenser, crank the engine until the contact points are open, and then take a voltage reading. If the reading is not equal to the battery voltage, the condenser is shorted to ground. Check the condenser installation or replace the condenser.



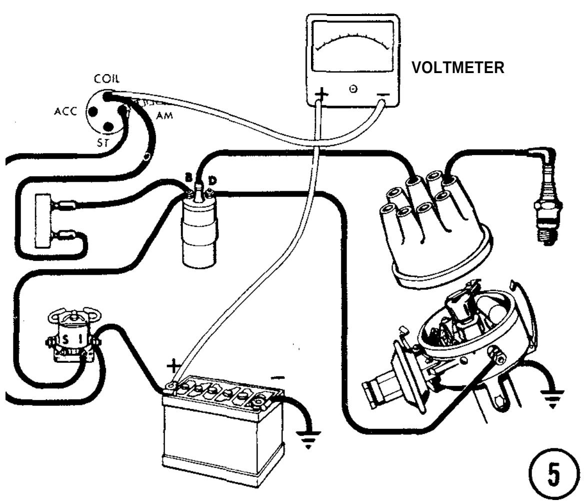
TEST 4 Primary Resistor: Disconnect the battery wire at the primary resistor to prevent damage to the ohmmeter. Connect an ohmmeter across the terminals of the resistor, as shown in Test 4 illustration. The specified resistance is between 1.3 and 1.4 ohms. If the reading does not fall within this range, replace the resistor.



4

TEST 5 Voltage Loss in the ignition switch, ammeter, and battery cable Crank the engine until the points are closed. Connect the voltmeter to the battery post (not the cable terminal) and to the load side of the ignition switch, as shown in Test 5 illustration. Now, turn the ignition switch to the ON position and note the voltage reading. The meter reading should not be more than 0.8 volts. A 0.2 volt drop across each of the connections is permitted.

If the voltage drop is more than 0.8 volts, move the test probe to the "hot" side of the ammeter. If the reading is 0.4 volts, the ignition switch is satisfactory. Once the corroded connection has been located, remove the nut, clean the wire terminal and connector, and then tighten the connection securely.



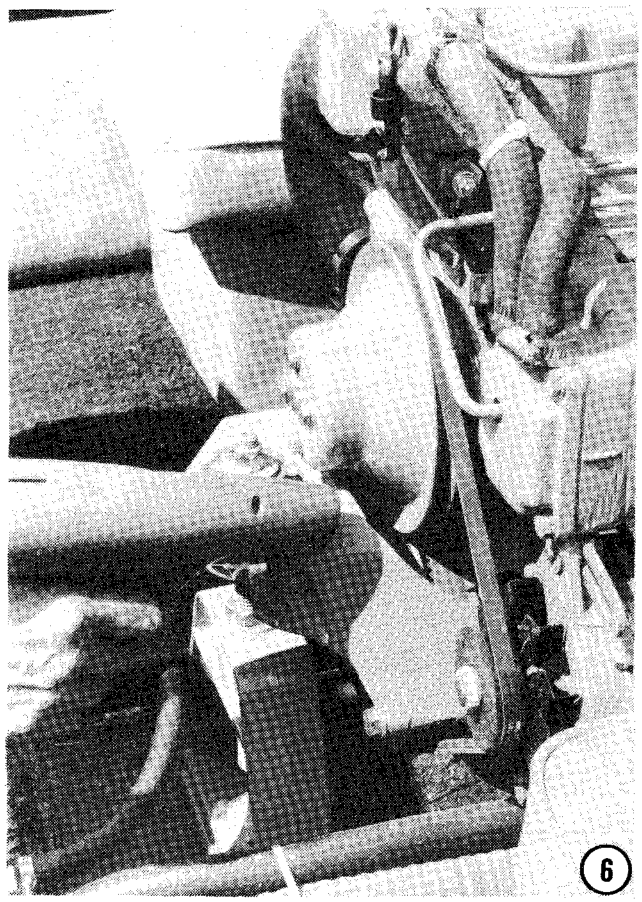
5

TEST 6 Distributor Condition: The condition of the distributor can be quickly and conveniently checked with a timing light.

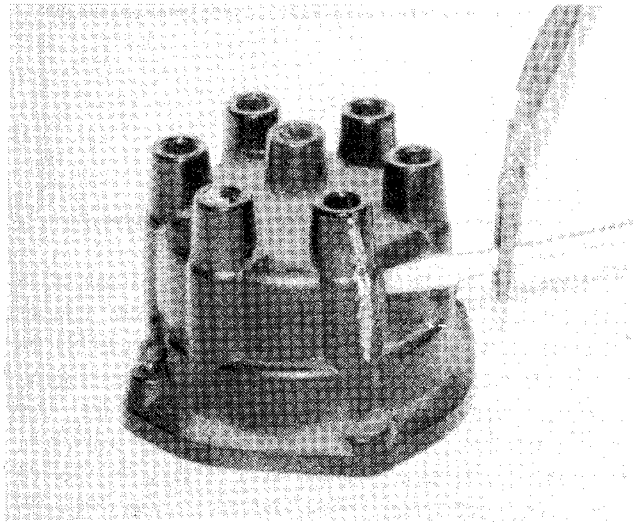
Under normal timing light procedures the trigger wire from the timing light is attached to the spark or plug wire of the No. 1 cylinder. In this test, connect the trigger wire to the third cylinder in the firing order of an in-line engine or to the fourth cylinder in the firing order of a V6, or to the fifth cylinder in the firing order of a V8 engine.

The timing mark and the pointer should line up in the same position as it did with the number one cylinder. If there is a variation of a few degrees, the distributor shaft bushings or cam lobes may be worn and the condition will have to be corrected.

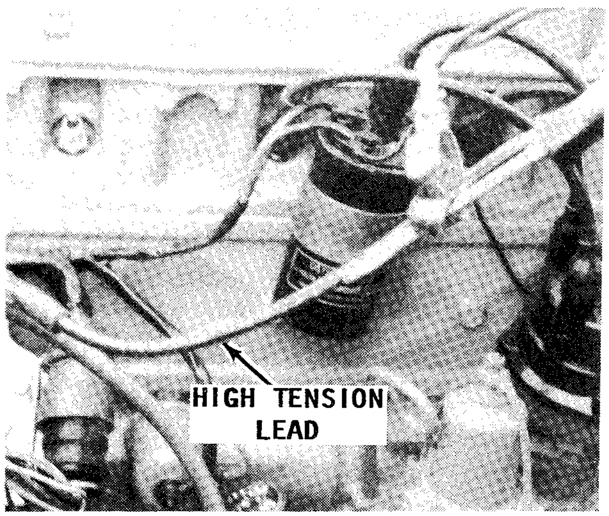
Before setting the timing, make sure the point dwell is correct. TAKE CARE to aim the timing light straight at the mark. Sighting from an angle may cause an error of two or three degrees.



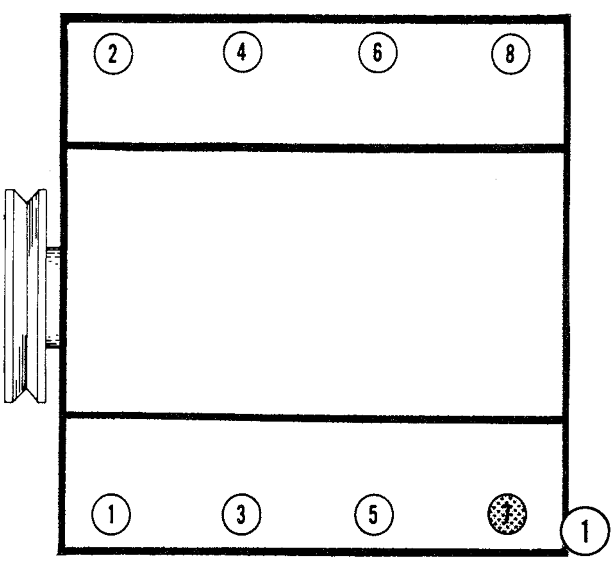
6

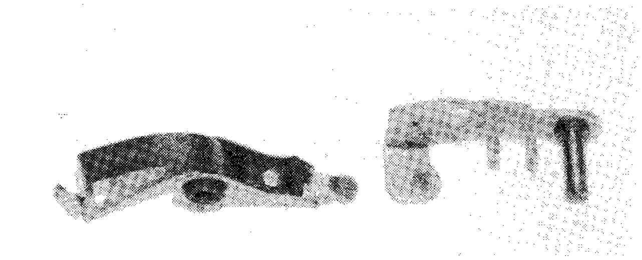


Using a grounded screwdriver blade and spark plug tester to test a cracked distributor cap.



Hook-up for making a voltage check of high-tension spark plug wires. One end of a jumper wire is clipped to the screwdriver; the other end is grounded; and the spark plug wire is disconnected from the plug. As a preventative measure against hard starting, the high tension wires (complete set) should be replaced every two years.





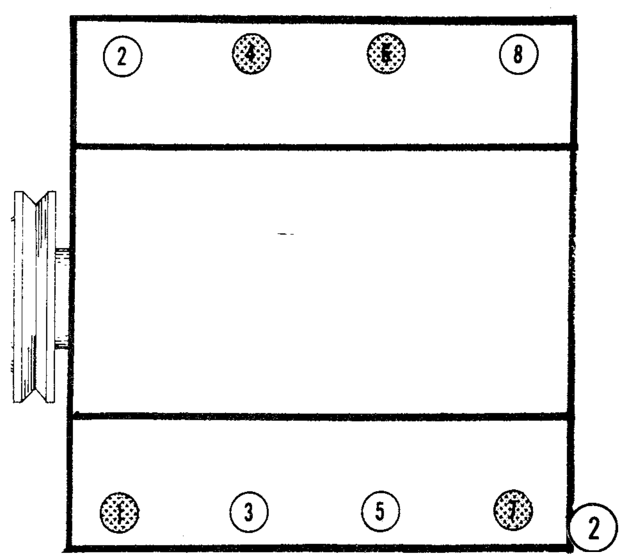
Oxidized GMC contact points which should be replaced for satisfactory performance.

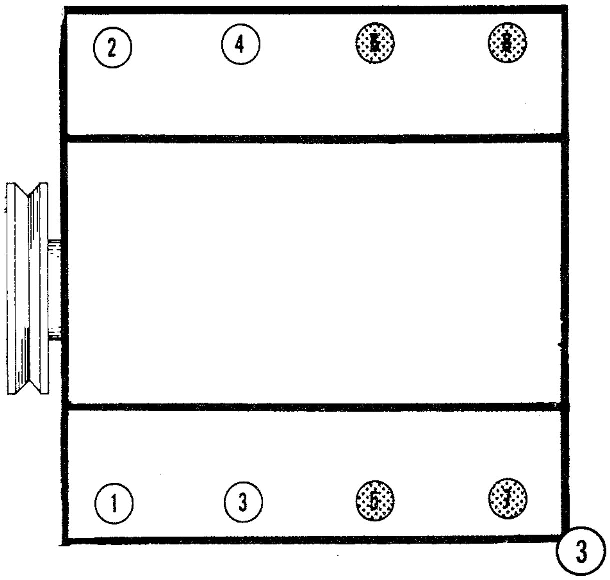
5-3 SPARK PLUG TROUBLESHOOTING

The following conditions are keyed to the illustrations with the same number. Refer to the illustration for a visual indication of which plugs are involved.

Condition 1: One spark is overheated. Check the firing order. If the burned plug is the second of two adjacent, and consecutive-firing plugs, the overheating may be the result of crossfire. If you found the spark plug of No. 7 cylinder was overheated, and the firing order is 1-8-4-3-6-5-7-2, the crossfire might result because cylinders No. 5 and No. 7 are adjacent to each other physically and No. 7 follows No. 5 in firing order. Separate the high-tension leads to these two plugs and the problem may be corrected.

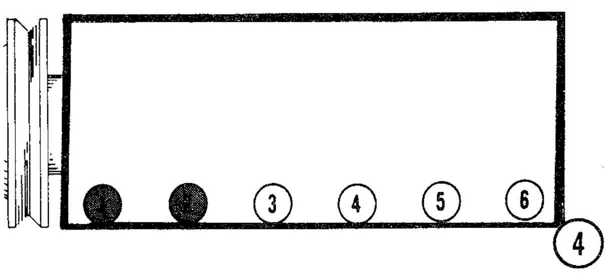
Condition 2: Four spark plugs are fouled in the unusual pattern shown in the No. 2 illustration. This pattern follows the usual fuel flow in a V8 engine. This condition may indicate one barrel of the carburetor is running too rich.

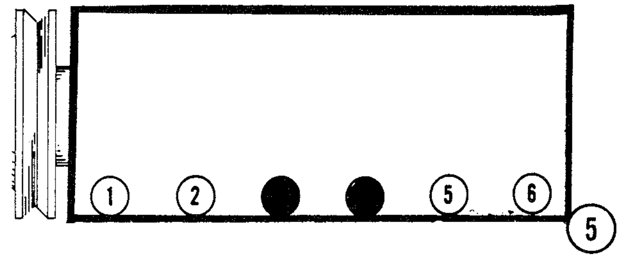




Condition 3: The four rear spark plugs are overheated. This condition indicates a problem in the cooling system. A reverse-flush of the engine may restore circulation to the rear of the cylinder heads.

Condition 4: Two adjacent plugs are fouled. Check the high-tension leads to the spark plugs to be sure they are connected in the proper sequence and leading to the correct plug for firing order. If the high-tension wires are all in good order and connected properly, then check for a blown cylinder head gasket, refer to Chapter 3.





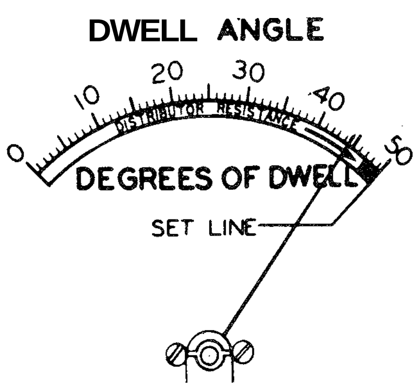
Condition 5: The two center plugs of a 6-cylinder engine are fouled. The cause may be raw fuel boiling out of the carburetor into the intake manifold after the engine is shut down. This condition can be the result of fuel percolating in the carburetor, a leaking intake valve and seat, a heavy float, or a too-high fuel level in the carburetor bowl. Refer to Chapter 4.

SPARK PLUG EVALUATION

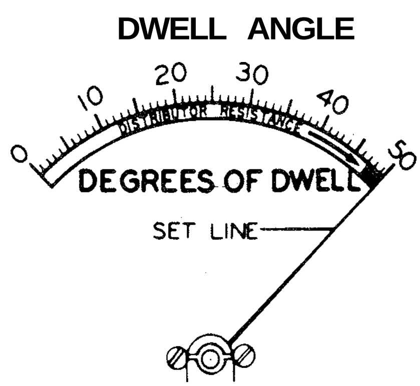
Removal: Remove the spark plug wires by pulling and twisting on only the molded cap. **NEVER** pull on the wire or the connection inside the cap may become separated or the boot damaged. Remove the spark plugs and keep them in order. **TAKE CARE** not to tilt the socket as you remove the plug or the insulator may be cracked.

Examine: Line the plugs in order of removal and carefully examine the firing end to determine the firing conditions in each cylinder.

Correct Color: A proper firing plug should be dry and powdery. Hard deposits inside the shell indicate the engine is starting to use some oil, but not enough to cause concern. The most important evidence is the light gray color of the porcelain, which is an indication this plug has been running at the correct temperature. This means the

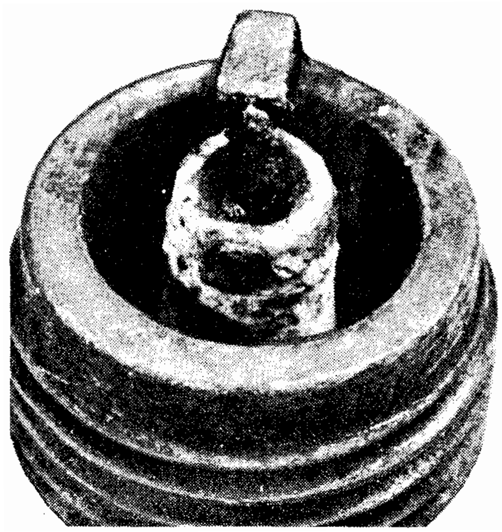


SATISFACTORY READING

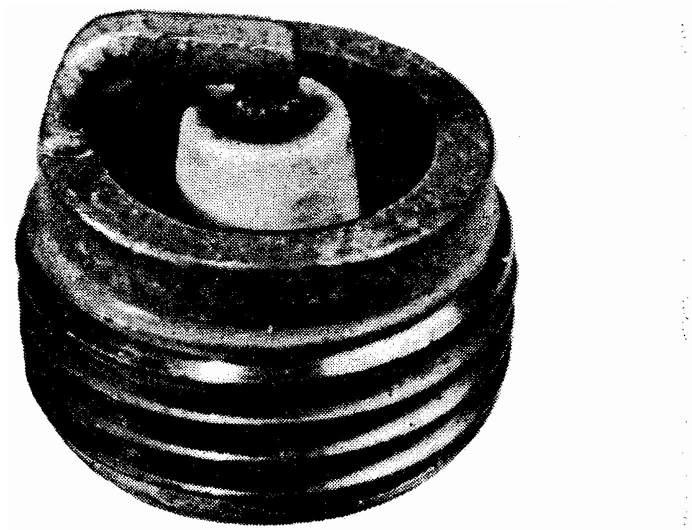


UNSATISFACTORY READING

Dwell meter reading with a satisfactory set of contact points (left) adjusted between 44 and 45 degrees. The same set of points with an unsatisfactory reading (right) at 50 degrees.



Example of excessive overheating.



Heavy oil consumption.

plug is one with the correct heat range and also that the air-fuel mixture is correct.

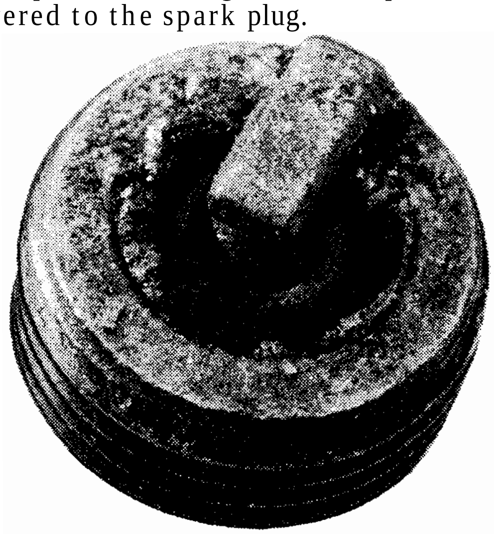
Overheating: A dead white or gray insulator, which is generally blistered, is an indication of overheating and pre-ignition. The electrode gap wear rate will be more than normal and in the case of pre-ignition, will actually cause the electrodes to melt as shown in this illustration. Overheating and pre-ignition are usually caused by overadvanced timing, detonation from using too-low an octane rating fuel, an excessively lean air-fuel mixture, or problems in the cooling system.

Fouled: A foulded 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 to be delivered to the spark plug.

Carbon Deposits: Heavy carbon-like deposits are an indication of excessive oil consumption. This condition may be the result of worn piston rings, worn valve guides, or from a valve seal that is either worn or was incorrectly installed.

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.

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.



Light oil fouling.

Plug with too cold a rating.

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.

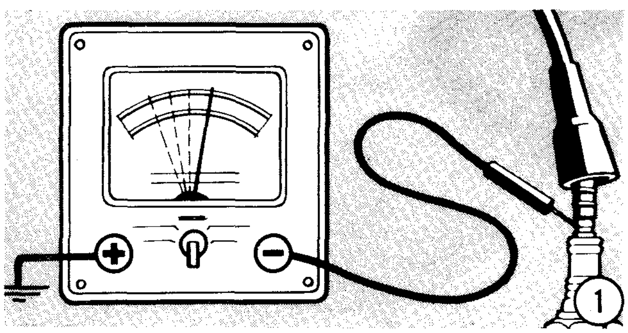
Electrode Wear: Electrode wear results in a wide gap and if the electrode becomes carbonized it will form a high-resistance path for the spark to jump across. Such a condition will cause the engine to misfire during acceleration. If all of the plugs are in this condition, it can cause an increase in 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 and gapped to specification.

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 because of an accumulation of scale or defective exhaust shutter. This condition **MUST** be corrected at the first opportunity. Refer to Chapter 9, Cooling System Service.

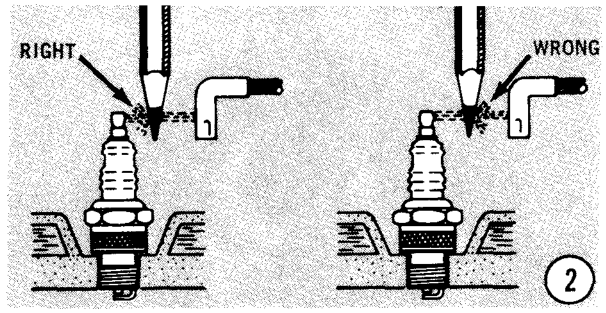
POLARITY CHECK

Coil polarity is extremely important for proper battery ignition system operation. If a coil is connected with reverse polarity, the spark plugs may demand from 30 to 40 percent more voltage to fire. Under such demand conditions, in a very short time the coil would be unable to supply enough voltage to fire the plugs. Any one of the following three methods may be used to quickly determine coil polarity.

1- The polarity of the coil can be checked using an ordinary D.C. voltmeter. Connect the positive lead to a good ground.



1



2

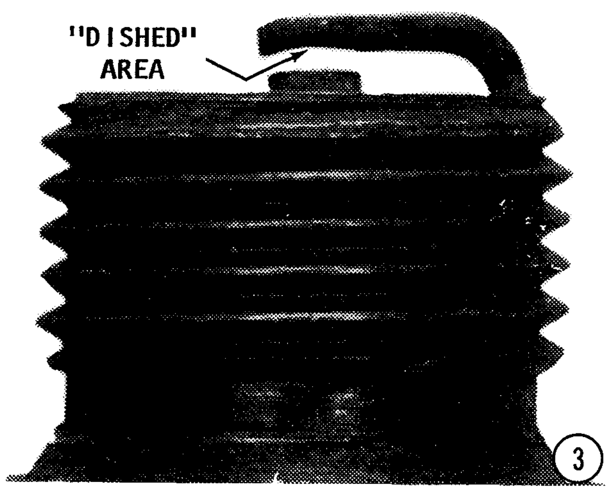
With the engine running, momentarily touch the negative lead to a spark plug terminal. The needle should swing upscale. If the needle swings downscale, the polarity is reversed.

2- If a voltmeter is not available, a pencil may be used in the following manner: Disconnect a spark plug wire and hold the metal connector at the end of the cable about 1/4" from the spark plug terminal. Now, insert an ordinary pencil tip between the terminal and the connector. Crank the engine with the ignition switch ON. If the spark feathers on the plug side and has a slight orange tinge, the polarity is correct. If the spark feathers on the cable connector side, the polarity is reversed.

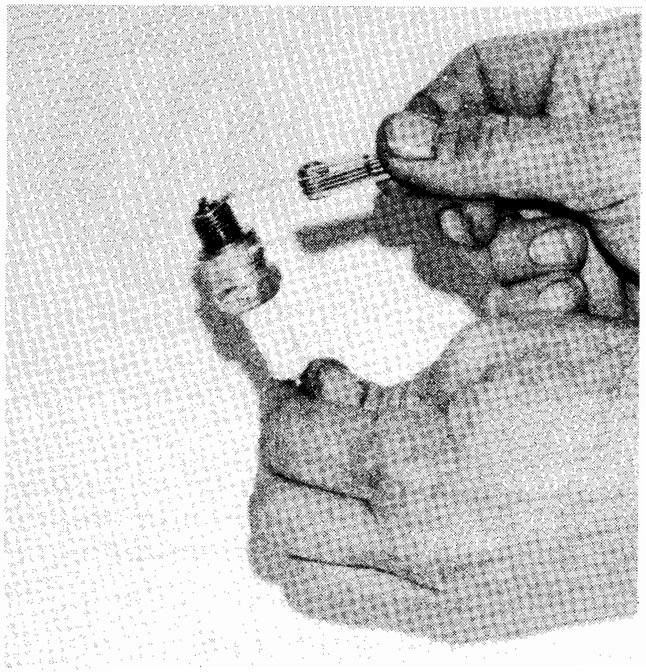
3- The firing end of a used spark plug can give a clue to coil polarity. If the ground electrode is "dished", it may mean polarity is reversed.

5-4 DISTRIBUTOR SERVICE

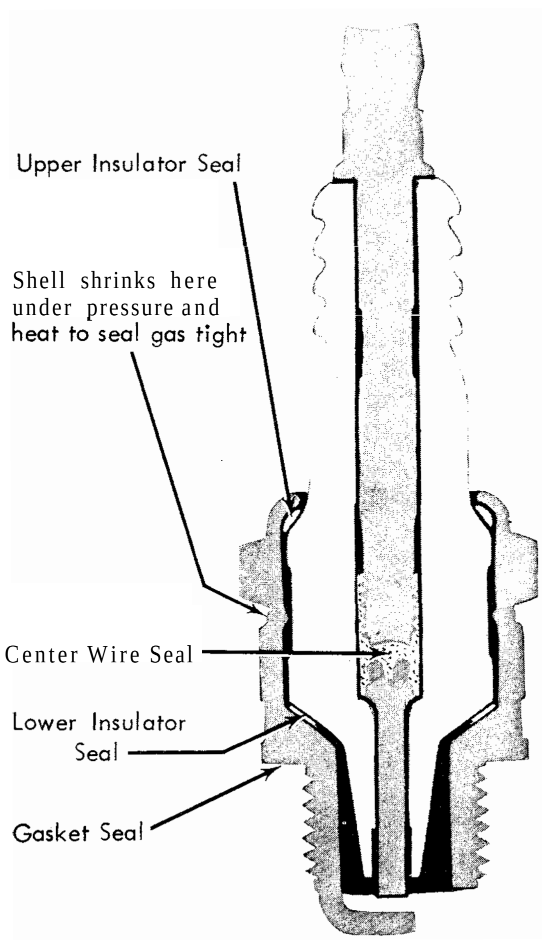
The four- and six-cylinder in-line engines all have a Delco-Remy distributor. The V8 engines may have one of several makes: A Delco-Remy, Mallory, or an Autolite/Prestolite.



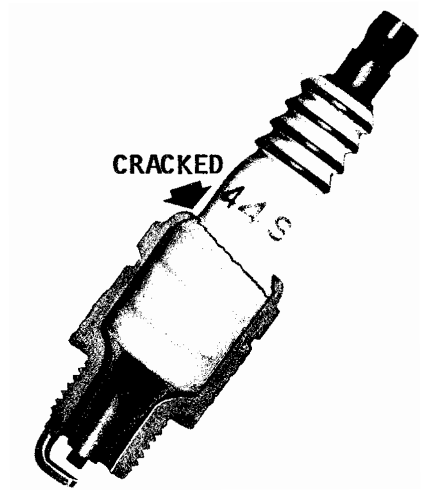
3



A rounded wire type feeler gauge should ALWAYS be used to check the spark plug gap. Bend the side electrode slightly to make an adjustment.



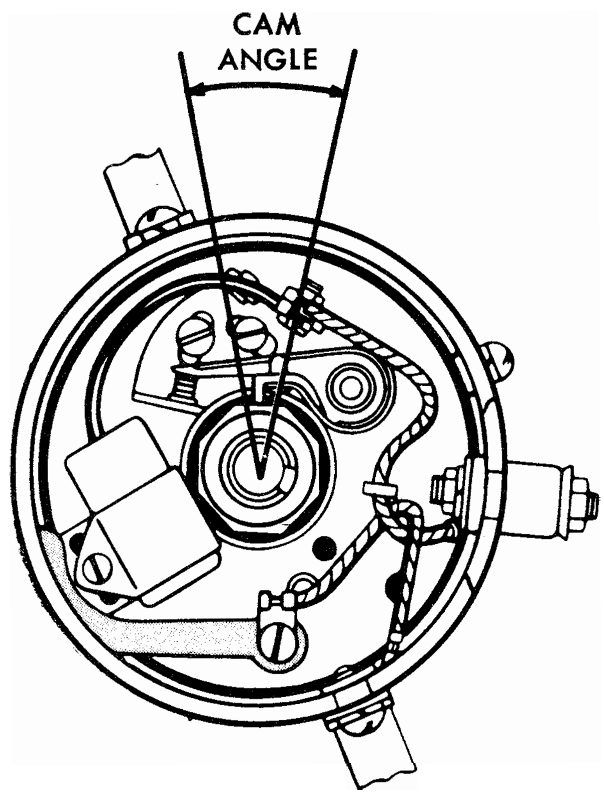
Cross section view of a spark plug.



A cracked insulator is always caused by tilting the socket during removal or installation.

Service procedures for these distributors will be given in the above listed order.

The distributor should be removed for any service including the installation and adjustment of the breaker points. New breaker points can be installed with the distributor in place but the position of the distributor usually makes it awkward to do a perfect job of aligning the points and making the point gap setting.



Cam angle of points closed.

DISTRIBUTOR REMOVAL

Remove the distributor cap by turning the cap retainer screws 90 degrees and then lifting off the cap. Some distributor caps have one retainer screw and others have two screws.

Turn the crankshaft until the rotor points to the front of the engine. Scribe a mark on the edge of the distributor housing and a matching one on the block as an aid during installation.

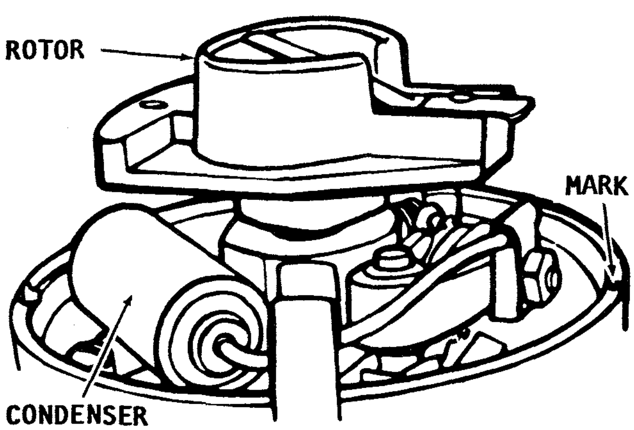
Loosen the retaining screw and disconnect the condenser and primary leads from the terminal. Remove the hold-down clamp bolt, and then remove the distributor from the block.

5-5 SERVICING A DELCO-REMY DISTRIBUTOR

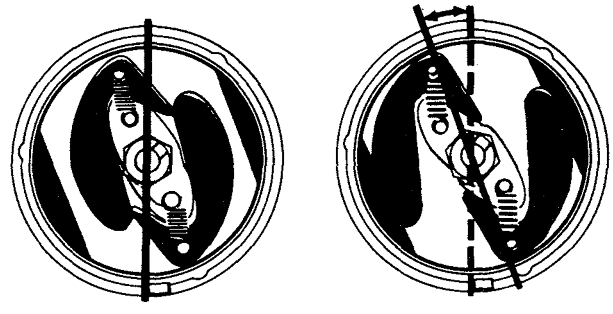
DISASSEMBLING FROM A 4- OR 6-CYLINDER ENGINE

Remove the rotor. Remove the breaker point set and the condenser by first disconnecting the primary and condenser leads from the contact point quick-disconnect terminal. Remove the attaching screws, and then remove the breaker plate. Further disassembly of the breaker plate is not necessary.

Remove the pin securing the main shaft drive gear, and then slide the gear off the shaft. Pull the mainshaft and cam out of the distributor housing. Disassemble the main shaft parts by removing the weight cover and stop-plate screws, and then removing the cover, weight springs, weights and cam assembly. Remove the main shaft bushing felt washer from the housing.



Scribe a mark on the distributor housing aligned with the rotor contact before removing the distributor, as an assist during installation.



Increased engine speed causes the centrifugal weights to be thrown outward to advance the ignition timing.

The main shaft bushings in the housing are not serviced individually. The housing and bushings **MUST** be serviced together as an assembly.

CLEANING AND INSPECTING

NEVER wash the distributor cap, rotor, condenser, or breaker plate assembly of a distributor in any type of cleaning solvent. Such compounds may damage the insulation of these parts or, in the case of the breaker plate assembly, saturate the lubricating felt.

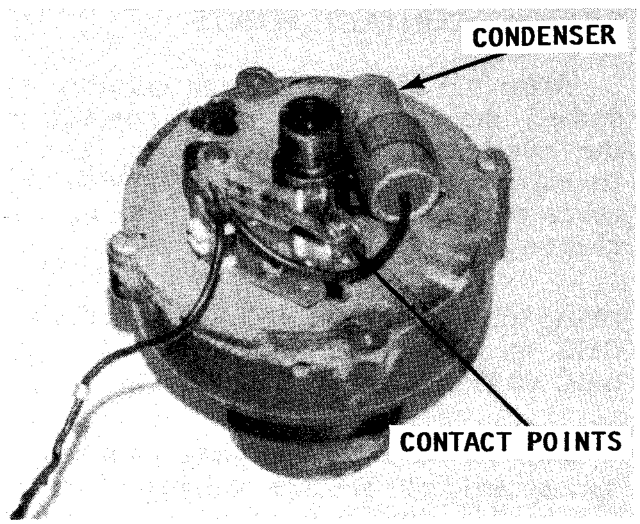
Check the shaft for wear and fit in the distributor body bushings. If either the shaft or the bushings are worn, replace the shaft and distributor body as an assembly. Use a set of V-blocks and check the shaft alignment with a dial gauge. If the run-out is more than 0.002", the shaft and body **MUST** be replaced.

Inspect the breaker plate assembly for damage and replace it if is there are signs of excessive wear.

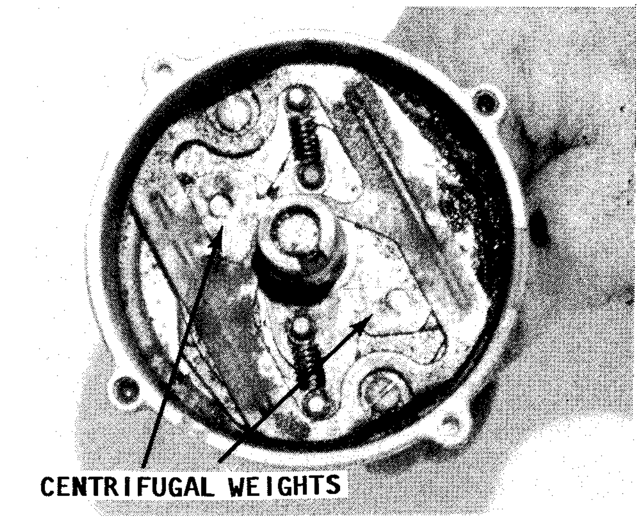
Check to be sure the governor weights fit free on their pins and do not have any burrs or signs of excessive wear. Check the cam fit on the end of the shaft. The cam should not fit loose but it should still be free without binding.

ALWAYS replace the points with a new set during a distriburor overhaul.

The condenser seldom gives trouble, but good shop practice a few years ago called for a new condenser with a new set of points. Some point sets still include a condenser in the package. If you have paid for a new condenser, you might as well install it and be free of concern over that part. Inspect the distributor cap for cracks or damage. Check the spark plug wires.

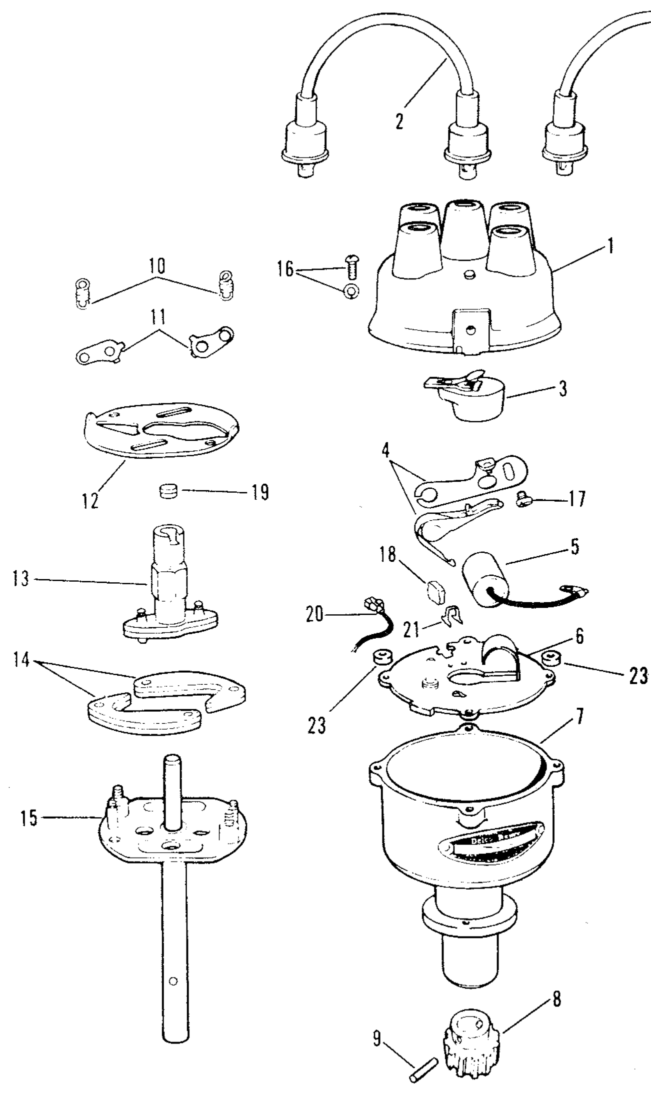


Breaker point parts of a G.M. in-line engine distributor.

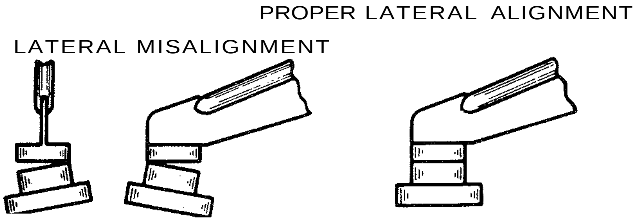


Centrifugal weights and the weight cover installed in the distributor housing.

1. Cap and Button Assy.
2. Lead - Coil
3. Rotor
4. Contact Points Set
5. Condenser
6. Breaker Plate
7. Housing
8. Gear
9. Pin
10. Spring, Weight
11. Lockwasher
12. Weight Hold Down
13. Cam Assembly
14. Weight
15. Main Shaft
16. Screw (#8-32)
    Screw (#lo-32)
17. Screw
18. Felt Lubricator
19. Grommet
20. Lead, Primary
21. Retainer
22. Lead - Spark Plug
23. Grommets



Breaker point parts of an in-line engine distributor.



New contact points must be aligned by bending the fixed contact support. *CAUTION: Never bend the breaker lever.*

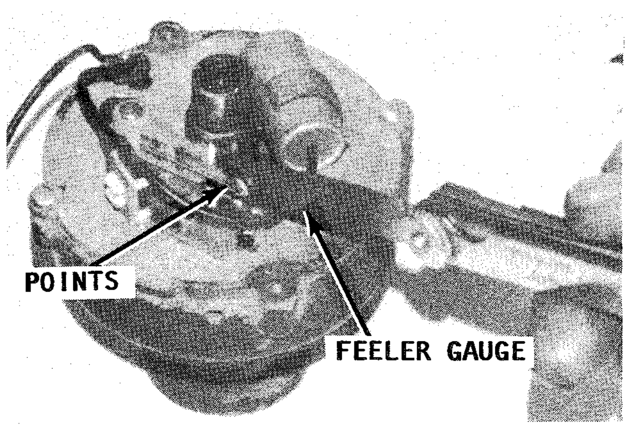
*Before setting the breaker point gap, the points must be properly aligned (right). ALWAYS bend the stationary point, **NEVER** the breaker lever. Attempting to adjust an old worn set of points is not practical, because oxidation and pitting of the points will always give a false reading.*

ASSEMBLING THE DELCO-REMY FROM A 4- OR 6-CYLINDER ENGINE

Begin, by placing the weights on their pivot pins and then install the weight springs. Next, install the weight cover and the stop plate.

Lubricate the main shaft with crankcase oil, and then install the shaft in the distributor housing. Slide the gear onto the shaft with the mark on the gear hub aligned with the rotor segment, and then secure it with the pin. Check to be sure the shaft turns freely.

Install the breaker plate assembly and secure it with the attaching screws. Install the condenser. Install the contact point set with the pilot indexed in the matching hole in the breaker plate. Secure the set in place with the attaching screws. Connect the primary and condenser leads to the quick-disconnect terminal.



Using a feeler gauge to measure the breaker point gap. Keep the feeler gauge blade clean. The slightest amount of oil film transferred from the blade to the points will cause oxidation and hard starting.

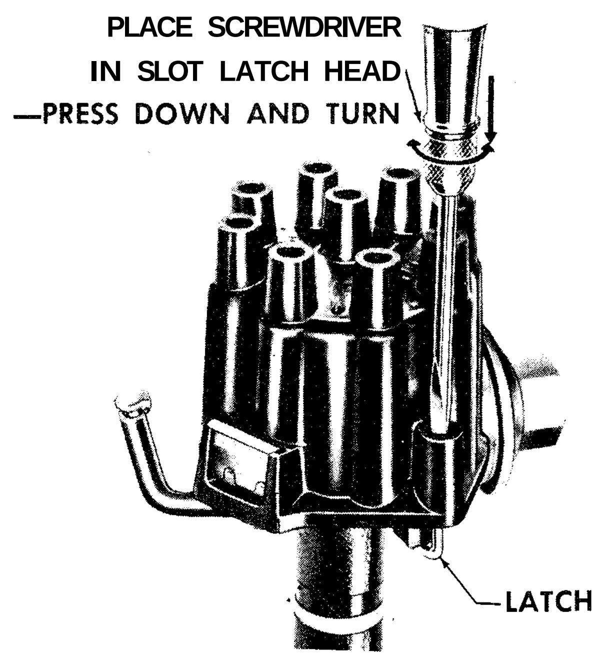
GAPPING CONTACT POINTS

After the points have been properly installed, the gap must be accurately set, or the dwell adjusted, and then the ignition timing set. These two adjustments are covered in detail in the last part of this chapter.

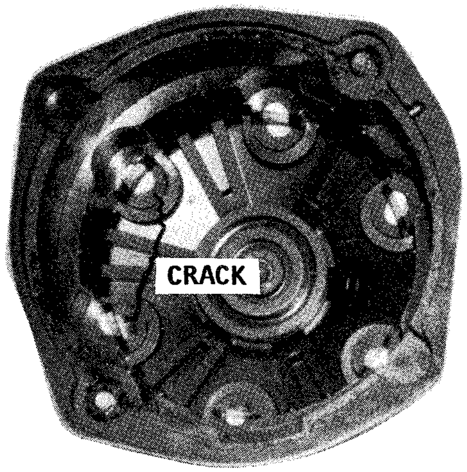
DISASSEMBLING THE DELCO-REMY GMC V6 1964-72 OR GMC V8 ENGINE

Pull off the rotor. Remove both weight springs and both advance weights. Remove the head of the gear pin with a file, and then drive the pin out of the distributor shaft. Remove the gear from the shaft. **BEFORE** removing the shaft from the housing, **REMOVE** ANY **BURRS** from around the pin hole in the shaft with a flat file. Failure to remove these burrs will damage the shoulder bushing when the shaft is removed. After the burrs are removed, pull the shaft-and-cam weight base assembly out of the housing. Remove the breaker cam-and-weight base assembly from the housing.

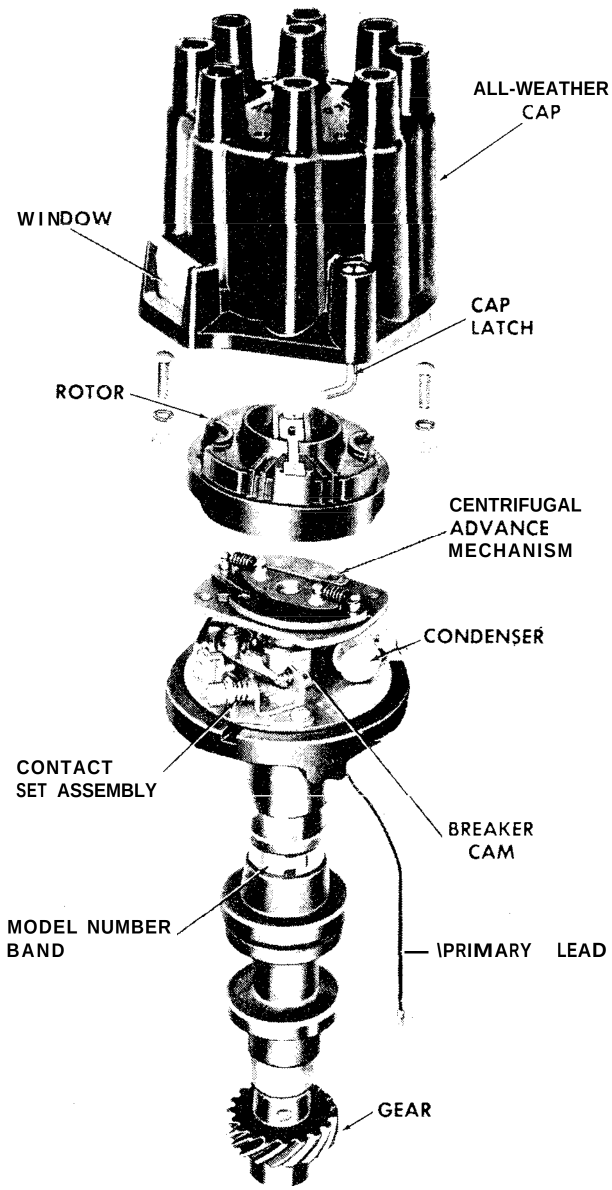
Remove the felt washer from around the bushing in the housing. Remove the gasket from the shaft housing.



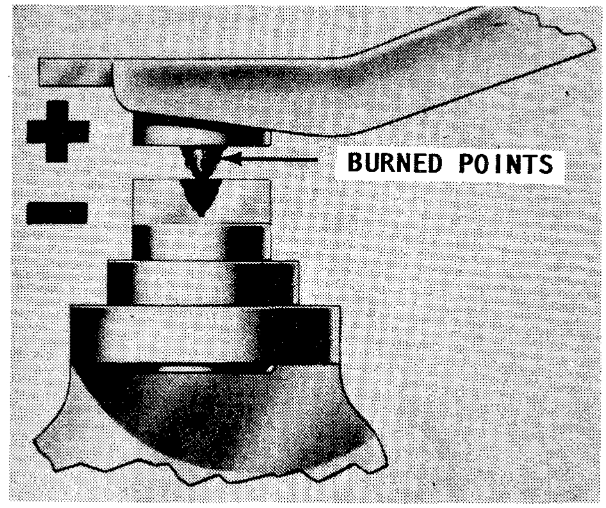
Two latch screws hold the distributor cap on GMC V8 engines in place. To release the cap, simply press down on each screw with a screwdriver and rotate the screw one-half turn.



A crack in the distributor cap will cause misfiring and hard starting.



The rotor is secured in place with two screws. Two attaching screws are then removed to release the contact point assembly.

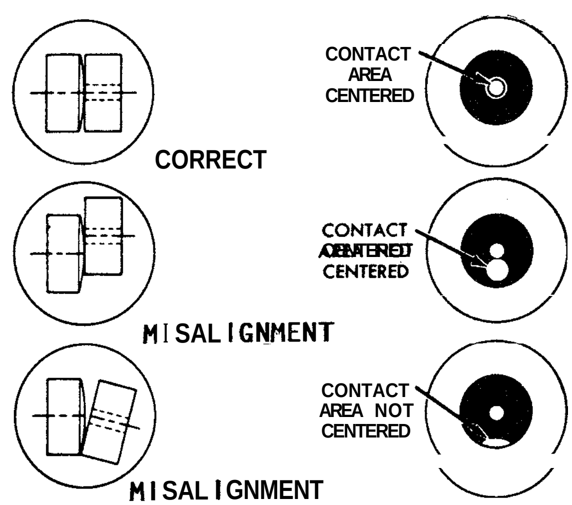


Defective contact points will cause misfire at high speed and hard starting.

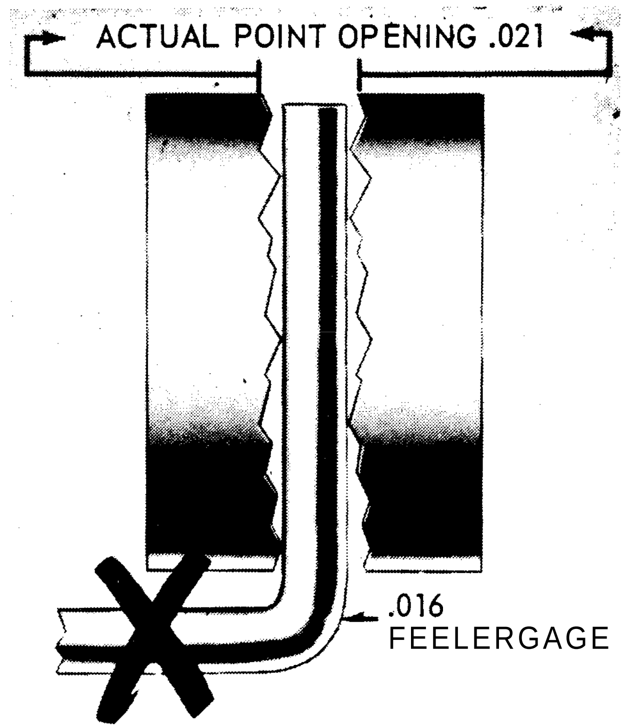
CLEANING- AND INSPECTING

NEVER wash the distributor cap, rotor, condenser, or breaker plate assembly of a distributor in any type of cleaning solvent. Such compounds may damage the insulation of these parts or, in the case of the breaker plate assembly, saturate the lubricating felt.

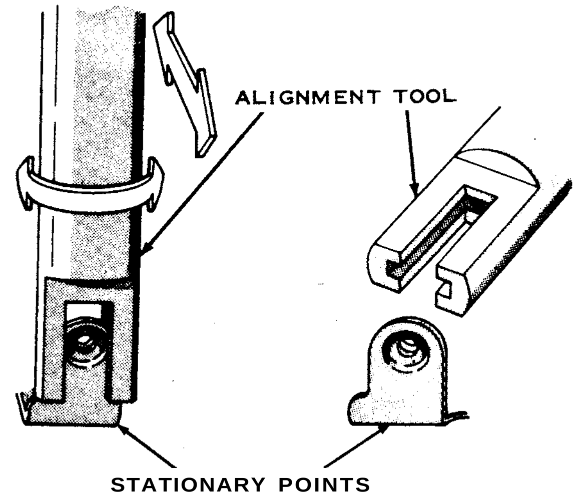
Check the shaft for wear and fit in the distributor body bushings. If either the shaft or the bushings are worn, replace the shaft and distributor body as an assembly. Use a set of V-blocks and check the shaft alignment with a dial gauge. If the run-out is more than 0.002", the shaft and body **MUST** be replaced.



Before setting the breaker point gap, the points must be properly aligned (top). ALWAYS bend the stationary point, NEVER the breaker lever. Attempting to adjust an old worn set of points is not practical, because oxidation and pitting of the points will always give a false reading.



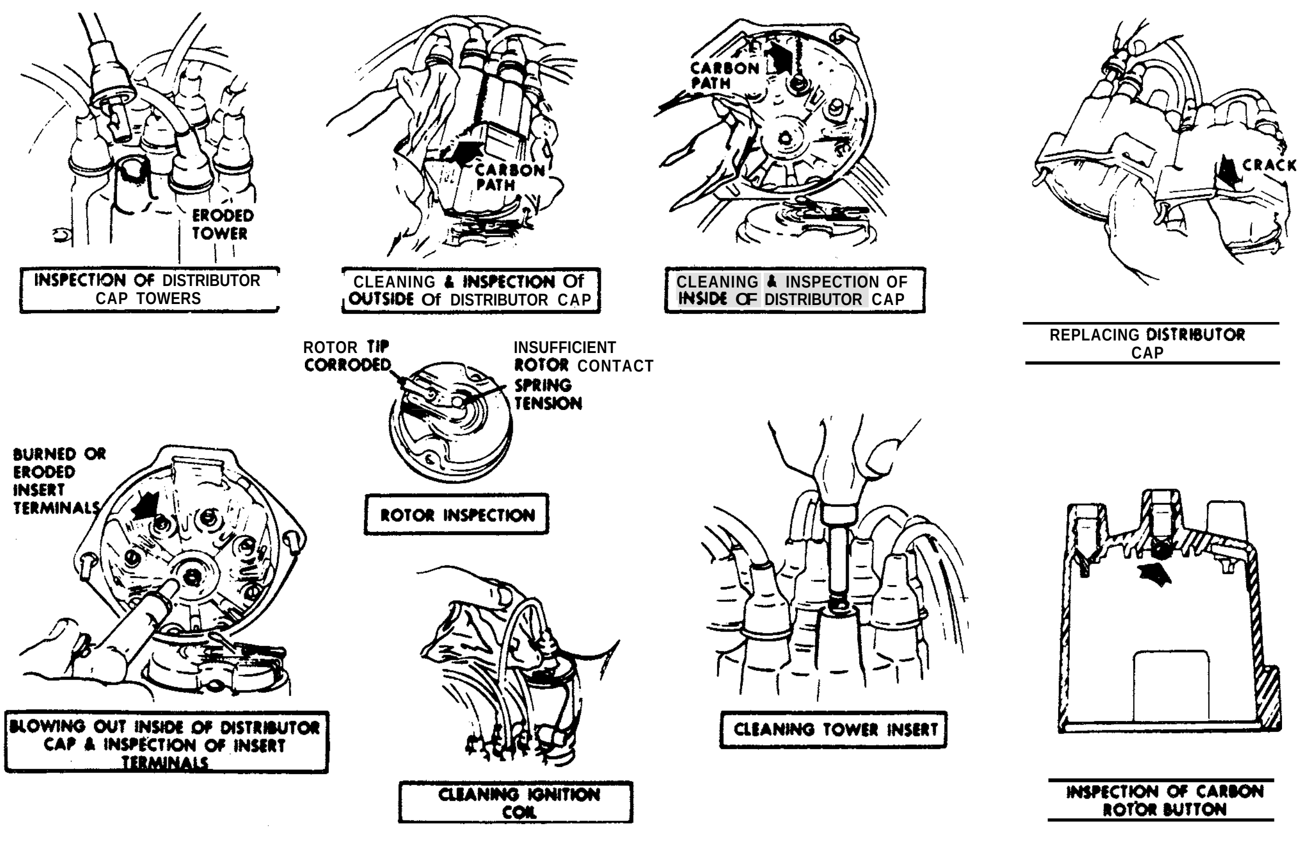
An exaggerated drawing to illustrate a set of burned points. Notice how the feeler gauge will only register the gap between the high section of the points. Naturally this gives a completely false reading. Therefore, a set of burned points should ***ALWAYS*** *be replaced instead of making an attempt to clean and adjust.*



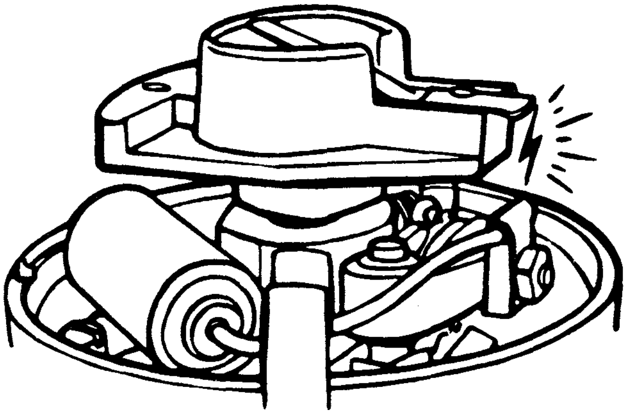
Method of bending the stationary point to align the contact points properly.

Inspect-the breaker plate assembly for damage and replace it if is there are signs of excessive wear.

Check to be sure the governor weights fit free on their pins and do not have any burrs or signs of excessive wear. Check the cam fit on the end of the shaft. The cam should not fit loose but it should still be free without binding.



Cleaning and inspecting the distributor cap.



If the primary leads are not properly insulated, a high-tension spark can jump from the rotor to the primary wires, as indicated.

ALWAYS replace the points with a new set during a distributor overhaul.

The condenser seldom gives trouble, but good shop practice a few years ago called for a new condenser with a new set of points. Some point sets still include a condenser in the package. If you have paid for a new condenser, you might as well install it and be free of concern over that part.

Inspect the distributor cap for cracks or damage. Check the spark plug wires.

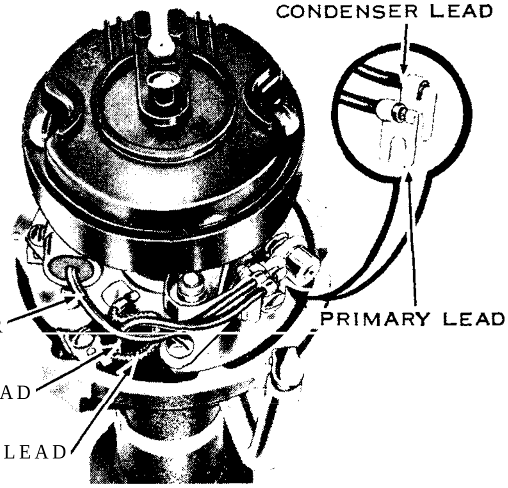
ASSEMBLING THE DELCO-REMY GMC V6 1964-72 OR GMC V8 ENGINE

Install the gasket into the shaft housing. Place the felt washer around the bushing in the housing.

Install the breaker plate in the housing, and then the spring retainer onto the upper bushing. Place the condenser in position and secure it with the attaching screw. Install the breaker point set and secure it with the attaching screws.

Place the cam-and-weight base assembly onto the shaft. If the lubrication in the grooves at the top of the shaft was cleaned out, use Plastilube No. 2 or the equivalent. Install the shaft-and-cam weight assembly in the distributor housing. Install the gear onto the shaft and secure it in place with the pin. Install the advance weights and springs.

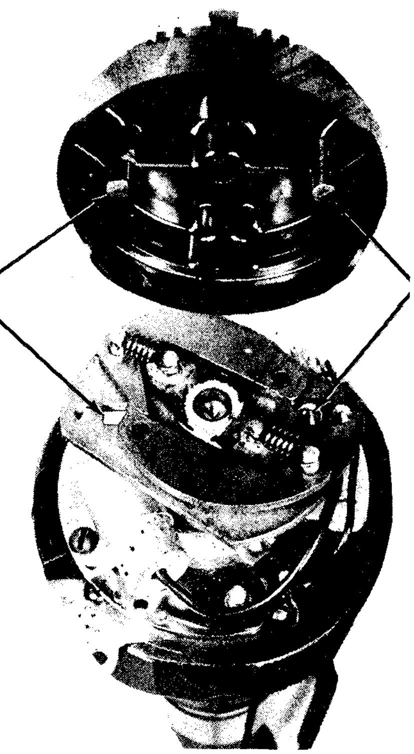
Install a new cam lubricator, and then the rotor.



*Arrangement of the condenser and primary leads. The leads **MUST** be properly insulated or the ignition system will be shorted out and the engine fail to start.*

GAPPING CONTACT POINTS

After the points have been properly installed, the gap must be accurately set, or the dwell adjusted, and then the ignition timing set. These two adjustments are covered in detail in the last part of this chapter.



***CHECK** to be sure the primary lead is properly connected and safely tucked back to prevent being pinched when the cap is installed. If the lead is pinched, the ignition system will be shorted out and the engine fail to start.*

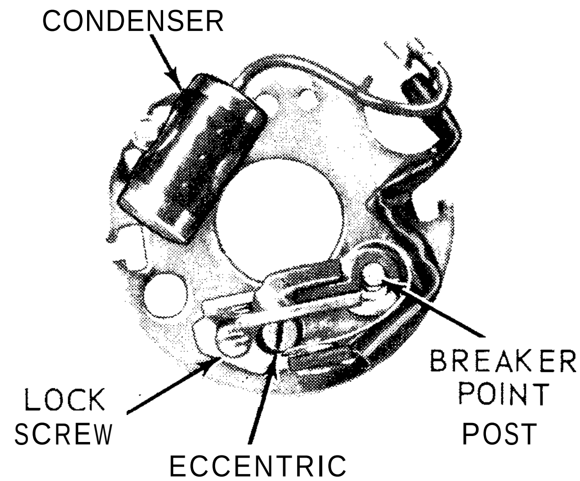
5-6 SERVICING A MALLORY DISTRIBUTOR!

REMOVAL AND DISASSEMBLY FROM A V8 OR V6 ENGINE

Remove the distributor cap and the cap gasket. Pull the rotor off of the distributor shaft.

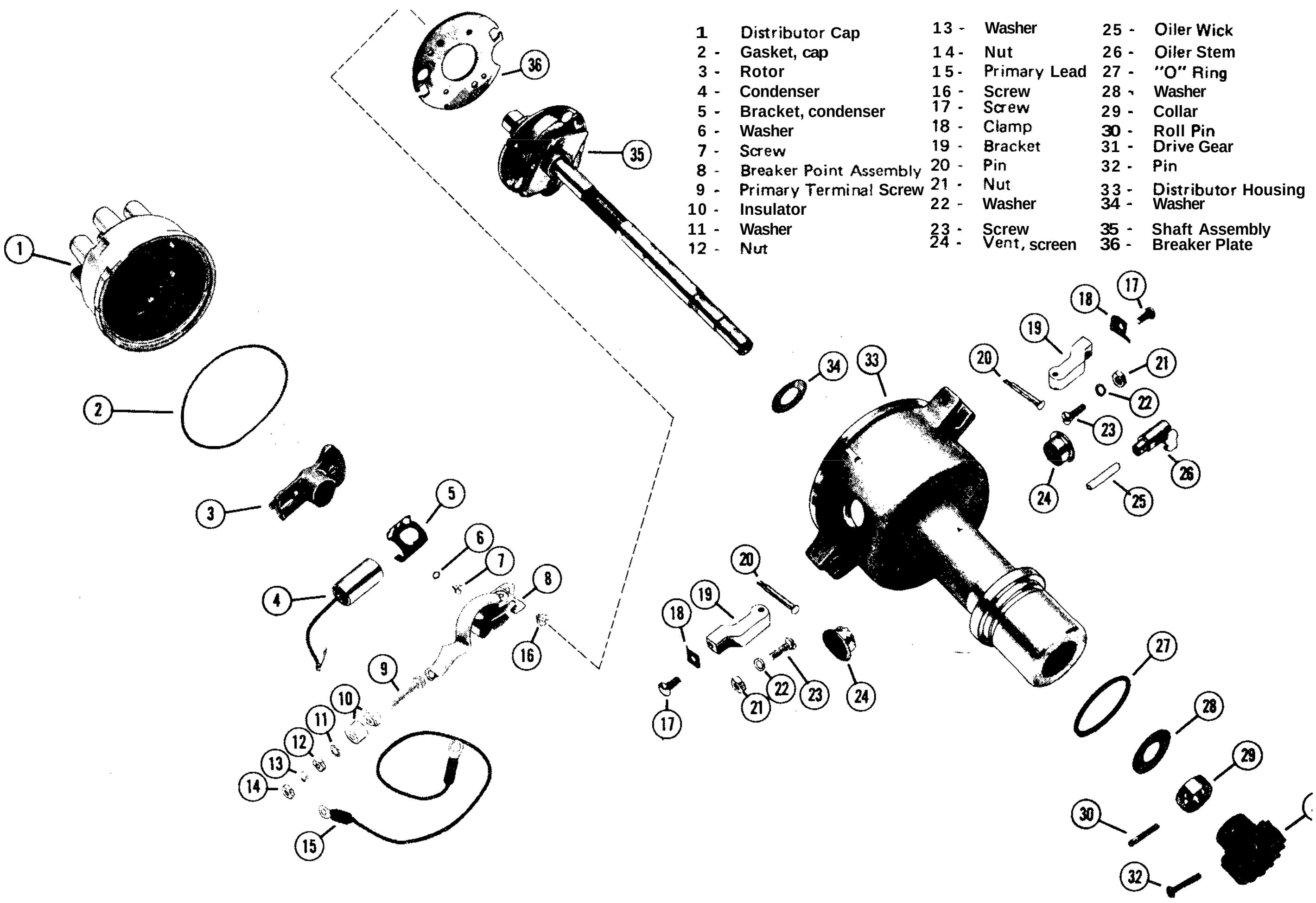
Remove the condenser and bracket by first disconnecting the condenser lead from the primary terminal, and then removing the retaining screw. Disconnect the breaker assembly lead from the primary terminal, and then remove the retaining screw and the breaker assembly. Scribe a mark on the housing to indicate the position of the breaker plate as an aid to installation. Remove the plate retaining screws, and then the plate. Remove the oiler wick. The oiler wick is a press fit in the housing and need not be removed.

DO **NOT** disassemble the distributor further because the oil seal may be damaged.



Arrangement of principle parts of a Ford V8 engine distributor.

Drive the retaining pin from the drive gear, and then remove the gear from the shaft. Drive the roll pin out of the distributor shaft collar. Remove the collar, washer, distributor housing, and washer. Remove the vent screen from the housing.



1	Distributor Cap	13 -	Washer	25 -	Oiler Wick
2 -	Gasket, cap	14 -	Nut	26 -	Oiler Stem
3 -	Rotor	15 -	Primary Lead	27 -	"O" Ring
4 -	Condenser	16 -	Screw	28 -	Washer
5 -	Bracket, condenser	17 -	Screw	29 -	Collar
6 -	Washer	18 -	Clamp	30 -	Roll Pin
7 -	Screw	19 -	Bracket	31 -	Drive Gear
8 -	Breaker Point Assembly	20 -	Pin	32 -	Pin
9 -	Primary Terminal Screw	21 -	Nut	33 -	Distributor Housing
10 -	Insulator	22 -	Washer	34 -	Washer
11 -	Washer	23 -	Screw	35 -	Shaft Assembly
12 -	Nut	24 -	Vent, screen	36 -	Breaker Plate

Exploded view showing all parts of a Mallory distributor.

CLEANING AND INSPECTING

NEVER wash the distributor cap, rotor, condenser, or breaker plate assembly of a distributor in any type of cleaning solvent. Such compounds may damage the insulation of these parts or, in the case of the breaker plate assembly, saturate the lubricating felt.

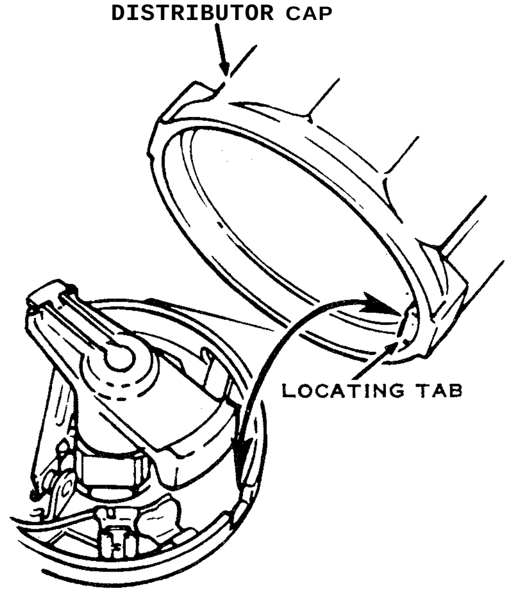
Check the shaft for wear and fit in the distributor body bushings. If either the shaft or the bushings are worn, replace the shaft and distributor body as an assembly. Use a set of V-blocks and check the shaft alignment with a dial gauge. If the run-out is more than 0.002", the shaft and body **MUST** be replaced.

Inspect the breaker plate assembly for damage and replace it if is there are signs of excessive wear.

Check to be sure the governor weights fit free on their pins and do not have any burrs or signs of excessive wear. Check the cam fit on the end of the shaft. The cam should not fit loose but it should still be free without binding.

ALWAYS replace the points with a new set during a distributor overhaul.

The condenser seldom gives trouble, but good shop practice a few years ago called for a new condenser with a new set of points. Some point sets still include a condenser in the package. If you have paid for a new condenser, you might as well install it and be free of concern over that part.



*Locating tab on the distributor cap and matching cutout in the rim of the distributor housing. The tab **MUST** index in the cutout or the tip of the rotor will strike one segment of the cap and crack it.*

Inspect the distributor cap for cracks or damage. Check the spark plug wires.

ASSEMBLING THE MALLORY FROM A V8 OR V6 ENGINE

Install the vent screen in the distributor housing vent hole. Secure the screen in place by crimping the inside flange.

Slide a washer onto the distributor shaft, and then install the shaft through the housing. Install the washer and collar on the shaft and secure the collar in place with a **NEW** pin. Check the shaft for end play which should be between 0.008" and 0.010". Install the drive gear on the distributor shaft with the shoulder going on first and secure the gear in place with a **NEW** pin through the shoulder and shaft. Peen both ends of the pin to prevent it from coming out.

Insert the oiler wick into the oiler stem. Install the breaker plate screws, the plate, washers, and nuts. **DO NOT** tighten the nuts at this time.

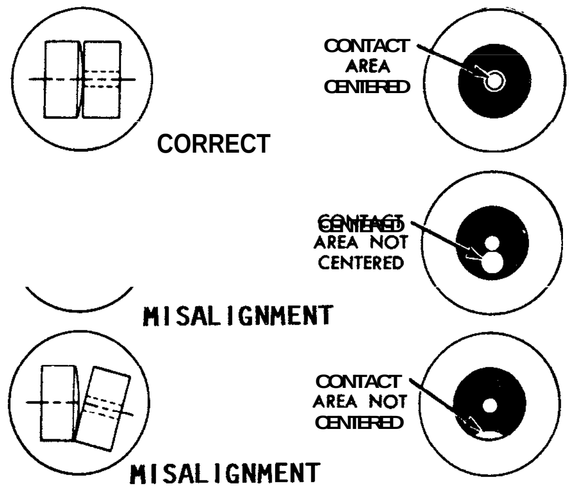
Install the breaker plate with the marks made during disassembly aligned, and then tighten the screws. Install the breaker assembly and connect the breaker assembly lead to the distributor primary terminal.

Install and secure the condenser with the bracket and attaching screw. Connect the condenser lead to the distributor primary terminal.

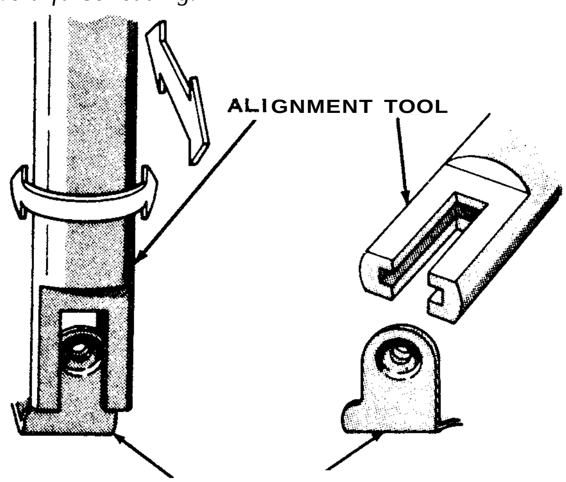
Slide the rotor onto the distributor shaft. Install a **NEW** gasket on the distributor cap with the notch in the cap aligned with the locating pin on the housing. Install the distributor cap with the tab on the inside rim of the cap aligned with the notch in the housing. If the cap is not properly positioned, as described, the rotor will strike one of the segments in the cap and crack it. Secure the cap in place by tightening the two screws.

GAPPING CONTACT POINTS

After the points have been properly installed, the gap must be accurately set, or the dwell adjusted, and then the ignition timing set. These two adjustments are covered in detail in the last part of this chapter.



Before setting the breaker point gap, the points must be properly aligned (top). ALWAYS bend the stationary point, NEVER the breaker lever. Attempting to adjust an old worn set of points is not practical, because oxidation and pitting of the points will always give a false reading.



*Before setting the breaker point gap, the points must be properly aligned (top). ALWAYS bend the stationary point, **NEVER** the breaker lever. Attempting to adjust an old worn set of points is not practical, because oxidation and pitting of the points will always give a false reading.*

5-7 SERVICING AN AUTOLITE/PRESTOLITE DISTRIBUTOR

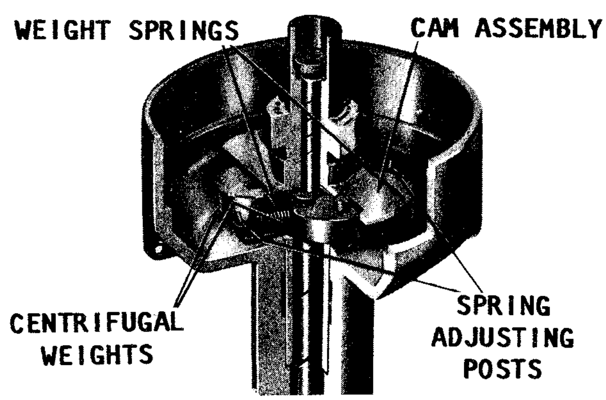
DISASSEMBLING FROM A FORD V8 ENGINE

Remove the distributor cap, and then remove the rotor.

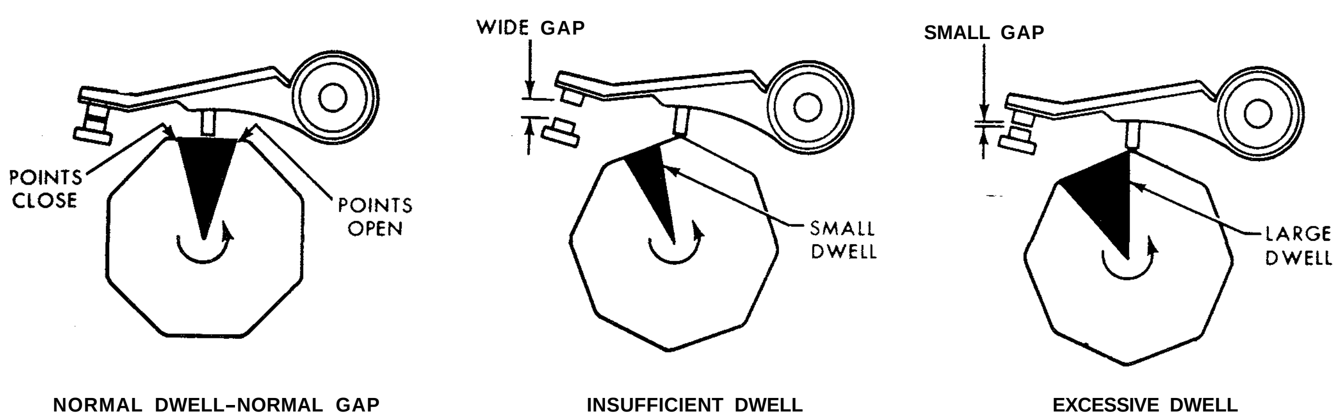
Disconnect the primary wire and the condenser lead from the breaker point assembly terminal. Remove the breaker point assembly by removing the two attaching screws. Remove the condenser attaching screw and the condenser.

Pull the primary lead through the opening in the housing. Remove the two breaker plate attaching screws, and then remove the breaker plate.

Identify one of the distributor weight springs and its bracket with a mark. Mark one of the weights and its pivot pin. **CAREFULLY** unhook and remove the weight springs. Pull the lubricating wick out of the cam assembly. Remove the cam assembly by first removing the retainer, and then lifting the assembly off the distributor shaft.



Cut-a-way view of an Autolite distributor showing the automatic advance mechanism.



Three different point gap/dwell angle conditions. A normal gap (and dwell angle) is shown in the left view. The center view illustrates an excessive gap with too small a dwell angle. The right illustration depicts too small a gap with the resulting dwell angle too great. If the gap is too small, the ignition timing is retarded, causing loss of power.

Remove the thrust washer installed only on counterclockwise rotating engines.

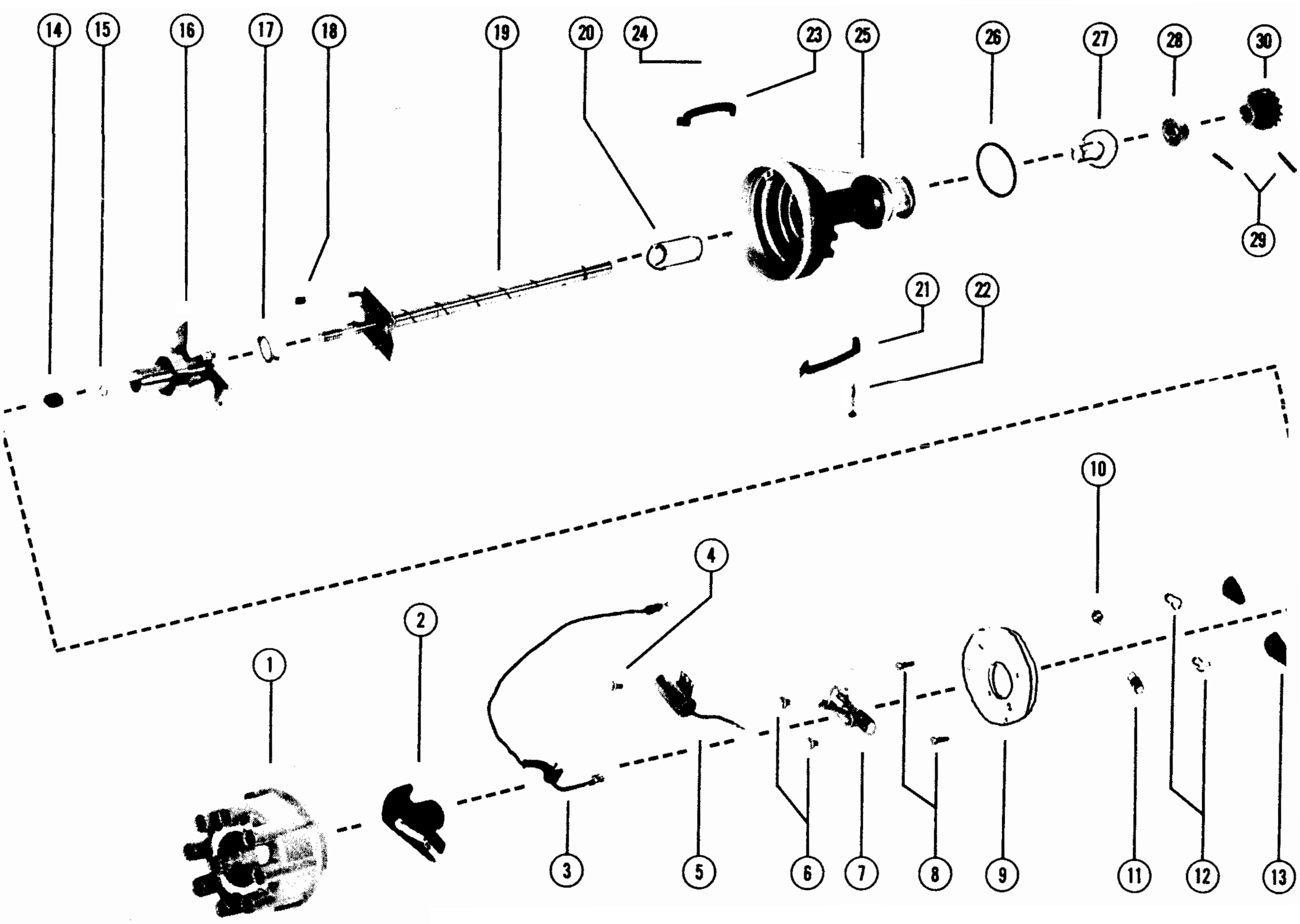
Remove the weight retainers, and then remove the weights.

Remove the distributor cap clamps. Scribe a mark on the gear and a matching mark on the distributor shaft as an aid in locating the pin holes during assembly. Place the distributor shaft in a V-block, and then use a drift punch to remove the roll pin. Remove the gear from the shaft. Remove the shaft collar roll pin.

CLEANING AND INSPECTING

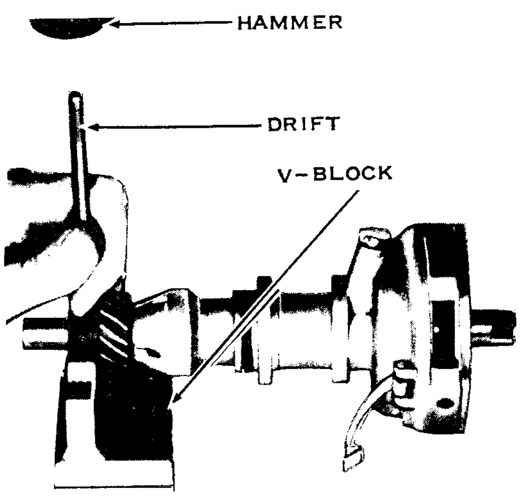
NEVER wash the distributor cap, rotor, condenser, or breaker plate assembly of a distributor in any type of cleaning solvent. Such compounds may damage the insulation of these parts or, in the case of the breaker plate assembly, saturate the lubricating felt.

Check the shaft for wear and fit in the distributor body bushings. If either the shaft or the bushings are worn, replace the shaft and distributor body as an assembly.



1 Cap, distributor
2 Rotor
3 Primary Wire
4 Screw
5 Condenser
6 Screws
7 Breaker Point Assembly
8 Screws
9 Breaker Plate
10 Spring
11 Spring
12 Weight Retainer
13 Weight
14 Lubricating Wick
15 Retainer
16 Cam Assembly
17 Thrust Washer
18 Bumper
19 Shaft
20 Upper Bushing
21 Clomp
22 Pin
23 Clamp
24 Pin
25 Housing
26 Oil Seal
27 Thrust Washer (not used on standard rotatior
28 Collar
29 Pin
30 Gear

Exploded drawing of an Autolite/Prestolite distributor.



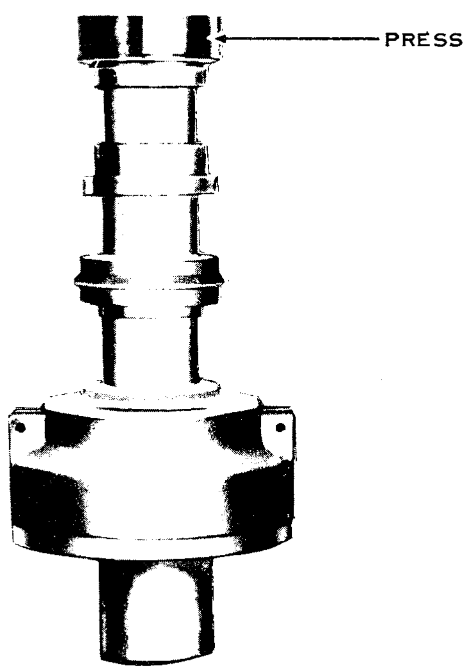
Setup to drive out the roll pin holding the distributor gear in place.

Use a set of V-blocks and check the shaft alignment with a dial gauge. If the run-out is more than 0.002", the shaft and body **MUST** be replaced.

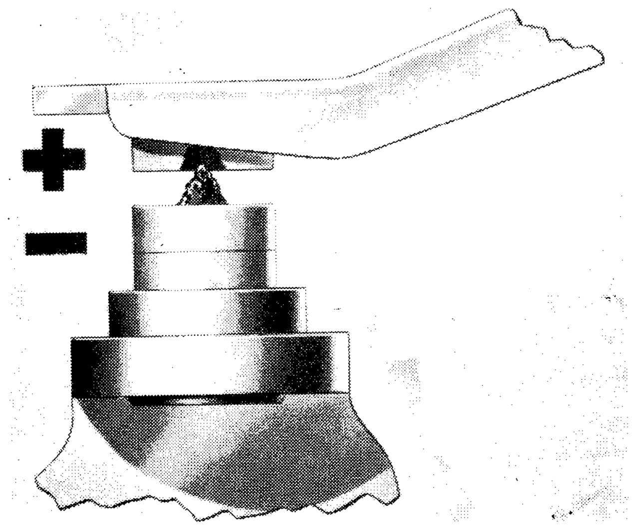
Inspect the breaker plate assembly for damage and replace it if there are signs of excessive wear.

Check to be sure the advance weights fit free on their pins and do not have any burrs or signs of excessive wear. Check the cam fit on the end of the shaft. The cam should not fit loose but it should still be free without binding.

ALWAYS replace the points with a new set during a distributor overhaul.



Setup to install a new upper bushing.



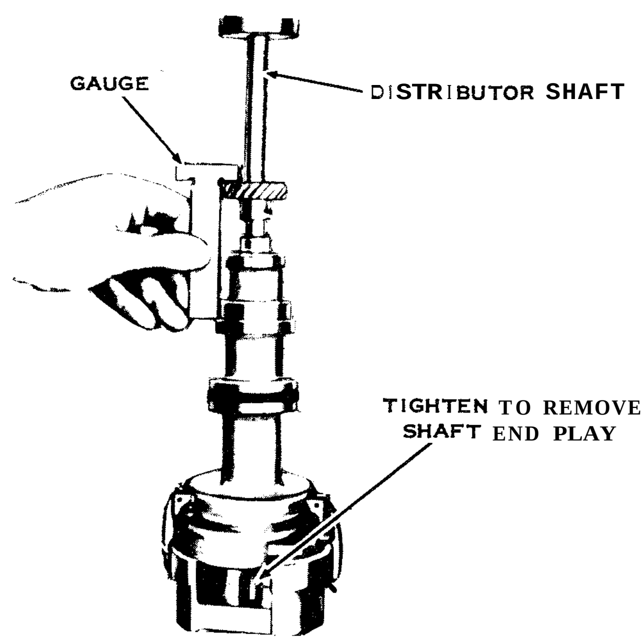
Oxidized contact points which should be replaced for satisfactory performance.

The condenser seldom gives trouble, but good shop-practice a few years ago called for a new condenser with a new set of points. Some point sets still include a condenser in the package. If you have paid for a new condenser, you might as well install it and be free of concern over that part.

Inspect the distributor cap for cracks or damage. Check the spark plug wires.

ASSEMBLING THE AUTOLITE/PRESTOLITE

Lubricate the distributor shaft with crankcase oil, and then slide it into the



Using a feeler gauge to check for end play as described in the text.

distributor body. Slide the collar onto the shaft; align the holes in the collar with the hole in the shaft; and then install a **NEW** pin.

Install the distributor cap clamps. Left-hand rotating engine distributor assemblies have an additional thrust washer between the collar and the base. Use a feeler gauge between the collar and the distributor base to check the shaft end play. The end play should be between 0.024" and 0.035"

Install the gear onto the shaft with the marks on the gear and the shaft you made during disassembly aligned. The holes through the gear and the shaft should be aligned after the gear is installed. Install the gear roll pin.

Fill the grooves in the weight pivot pins with distributor cam lubricant. Position the weights in the distributor with the weight you identified with a mark during disassembly matched with the marked pivot pin. Secure the weights in place with the retainers. Slide the thrust washer onto the shaft. Fill the upper distributor shaft grooves with distributor cam lubricant.

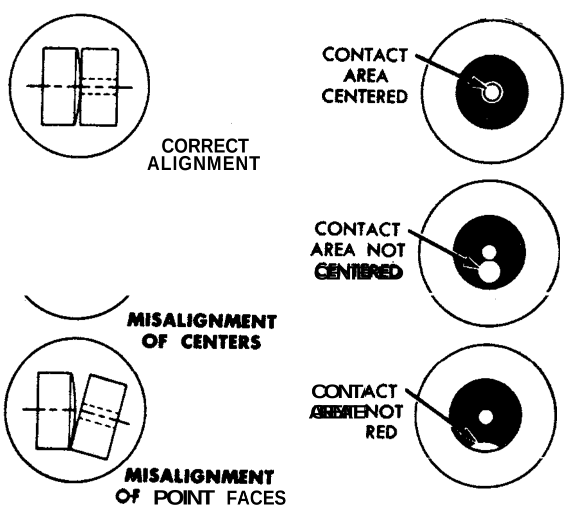
Install the cam assembly with the marked spring bracket near the marked spring bracket on the stop plate. If a new cam assembly is being installed, **TAKE CARE** to be sure the cam is installed with the hypalon-covered stop in the correct cam plate control slot. The proper slot can be determined by measuring the length of the slot used on the old cam, and then using the corresponding slot on the new cam. Some new cams will have the size of the slot stamped in degrees near the slot. If the **WRONG** slot is used, the maximum advance will not be correct.

Coat the distributor cam lobes with a light film of distributor cam lubricant. Install the retainer and wick. Use a few drops of SAE 10W engine oil on the wick. Install the weight springs with the spring and bracket you marked during disassembly matched.

Place the breaker plate in position, and then secure with the attached screws.

Push the primary wire through the opening in the distributor. Place the breaker point assembly and the condenser in position and secure them in place with the attaching screws. Connect the primary wire and the condenser lead to the breaker point primary terminal.

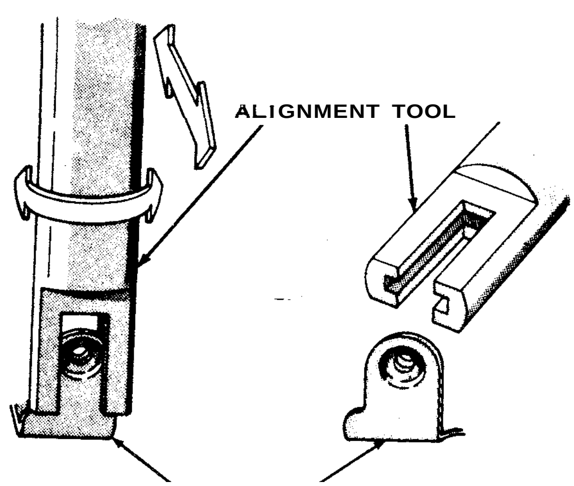
Adjust the point gap and dwell as outlined in the following procedures, then install the rotor and the distributor cap.



Before setting the breaker point gap, the points must be properly aligned (top). ALWAYS bend the stationary point, ***NEVER*** *the breaker lever. Attempting to adjust an old worn set of points is not practical, because oxidation and pitting of the points will always give a false reading.*

5-8 ADJUSTING THE POINT GAP ALL DISTRIBUTORS

A feeler gauge or a dwell meter may be used to adjust the contact points. However, due to the rough surface of used points, a feeler gauge will never provide an accurate setting. The feeler gauge can give satisfactory results if a new set of contact points is being adjusted or if a dwell meter is not available. The feeler gauge is used when the points are adjusted with the distributor out of the engine and the dwell meter when the distributor is installed and the engine is running.



Method of bending the stationary point to align the contact points properly.

USING A FEELER GAUGE

If the distributor is not installed, rotate the shaft until the fiber rubbing block is on the high point of the cam. If the distributor is installed, crank the engine until the rubbing block is on the high point of the cam. Adjust the gap to the specification given in the Appendix by turning the eccentric adjuster on the stationary contact point or moving the point with a screwdriver in the base slot. Rotate the distributor shaft until the points are closed. Check to see if the points are properly aligned, as shown in the accompanying illustration. If necessary, use a pair of needle-nose pliers, or a contact point alignment tool, to bend the **STATIONARY** point bracket until the points are aligned, as shown.

ALWAYS use a clean feeler gauge to make the final adjustment or you may leave a thin coating of oil on the points. Any oil on the points will oxidize in a short time and cause problems. TAKE CARE when making the gap measurement with the feeler gauge not to twist or cock the gauge. If the guage is not inserted square with the points, you will not get an accurate measurement.

Adjust the point gap about **0.003"** wider than the specification to allow for initial rubbing block wear. Keep the contact point retaining screw snug while making the adjustment to keep the gap from changing when the screw is finally tightened.

After the proper gap has been obtained, tighten the retaining screw, and then recheck the gap to be sure the setting has not changed.

Coat the distributor cam with a light film of heavy grease, and then turn the distributor shaft in the normal direction sf rotation to wipe the lubricant off against the back of the rubbing block. The lubricant will remain there as a reservoir while the rubbing block wears. Wipe any excess lubricant from the cam.

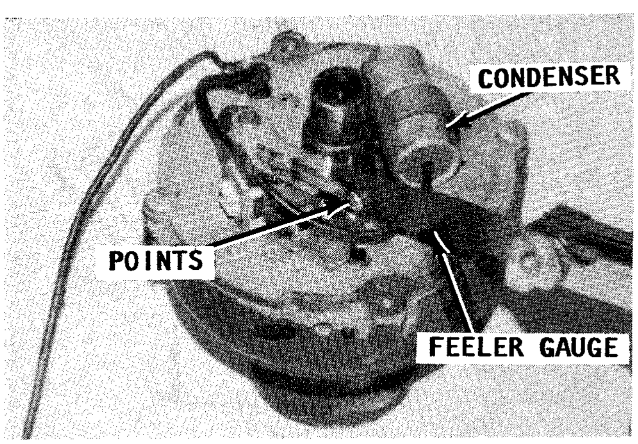
5-9 DISTRIBUTOR INSTALLATION

During removal you scribed a mark on the distributor housing and a matching one on the block as an aid to installation. Now, slide the distributor shaft into the block with the rotor pointing toward the front of the engine and with the marks you scribed during removal aligned as close as possible.

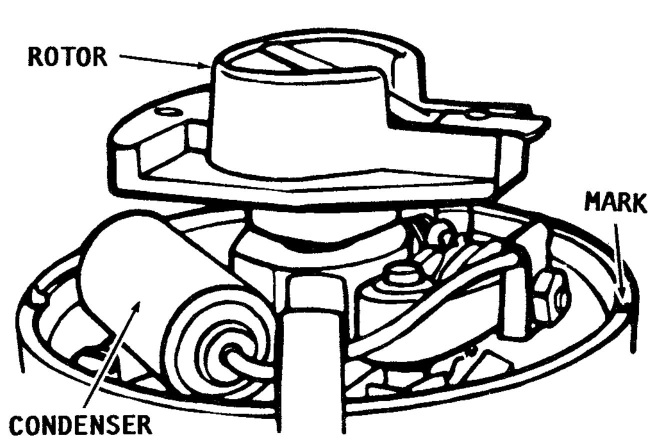
If the crankshaft was turned for any reason while the distributor was removed, the timing was lost and it will be necessary to retime the engine.

To time the engine, first remove the rocker arm cover. Next, rotate the crankshaft in the normal direction with a wrench on the harmonic balancer bolt until both valves for No. 1 cylinder are closed and the timing mark on the balancer is aligned with the "O" on the timing indicator. **NEVER** rotate the crankshaft in the opposite direction from the normal or the water pump in the stern drive will be damaged. Now, with both valves closed, and the timing mark aligned with the timing indicator, the No. 1 cylinder is in firing position.

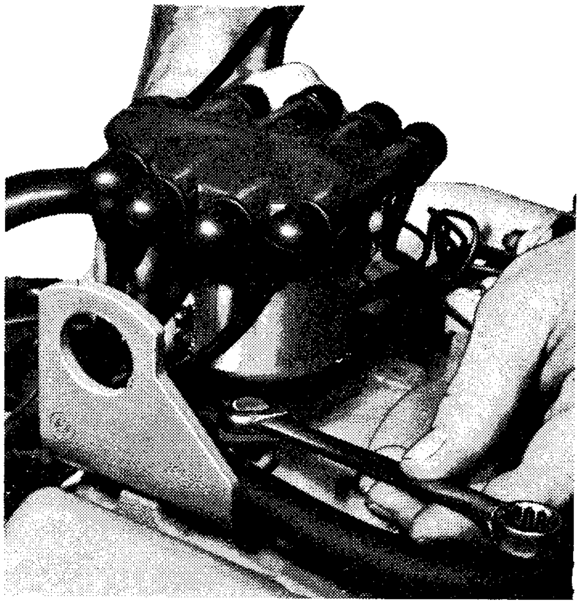
Align the rotor with the No. 1 cylinder wire terminal in the distributor cap, and then install the distributor in the block. If the distributor will not seat fully in the



Using a feeler gauge to measure the breaker point gap. Keep the feeler gauge blade clean. The slightest amount of oil film transferred from the blade to the points will cause oxidation and hard starting.



If the primary leads are not properly insulated, a high-tension spark can jump from the rotor to the primary wires, as indicated.



After the distributor is mounted and the engine properly timed, the lock bolt should be tightened securely -- Mallory distributor.

block, press down lightly on the housing while a partner turns the crankshaft slowly until the distributor tang snaps into the oil pump shaft slot and the distributor moves into its full seated position. Tighten the distributor hold-down bolt.

Ignition fine-tuning will be accomplished after the engine is running.

Wipe the distributor cap and the coil of any moisture to be sure it does not cause a leakage path.

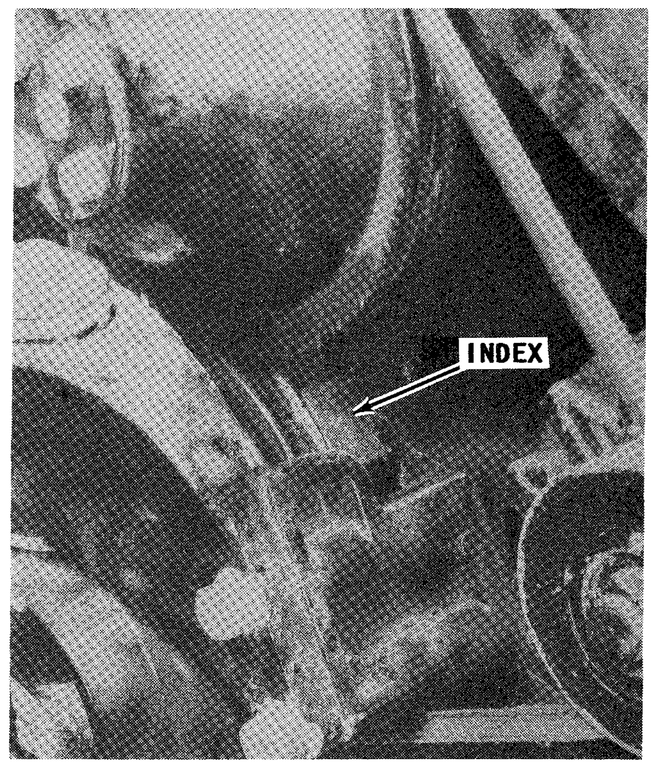
ADJUSTING THE DWELL

A dwell meter accurately measures the length of time the points are closed, as shown in the accompanying illustration. Connect one lead of the dwell meter to the negative side of the ignition coil and the other lead to a good ground. Start the engine and adjust the dwell to the Specifications in the Appendix.

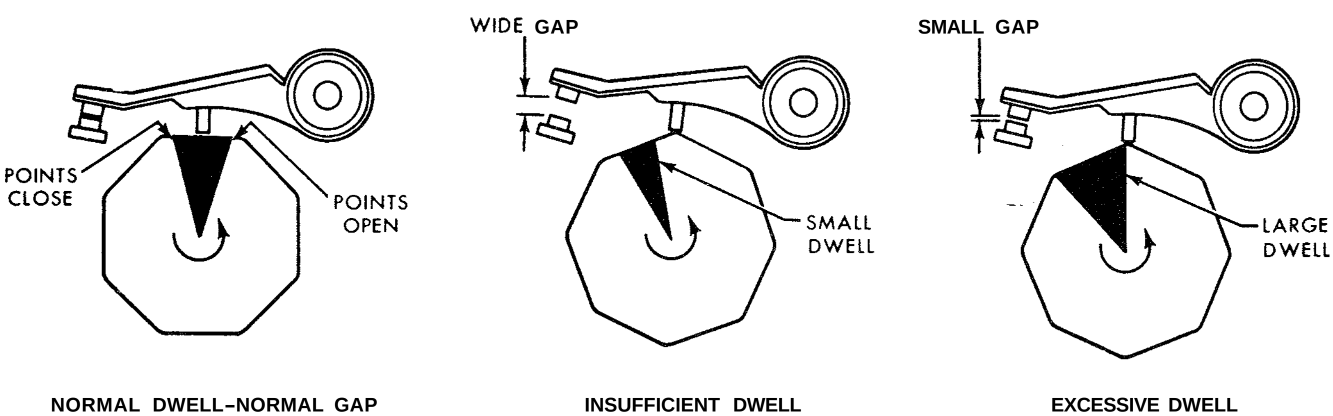
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

ADJUSTING IGNITION TIMING

The breaker point gap or the dwell must be accurately set before attempting to fine-tune the engine because the point gap directly affects the timing.



Timing mark on the harmonic balancer.



Three different point gap/dwell angle conditions. A normal gap (and dwell angle) is shown in the left view. The center view illustrates an excessive gap with too small a dwell angle. The right illustration depicts too small a gap with the resulting dwell angle too great. If the gap is too small, the ignition timing is retarded, causing loss of power.

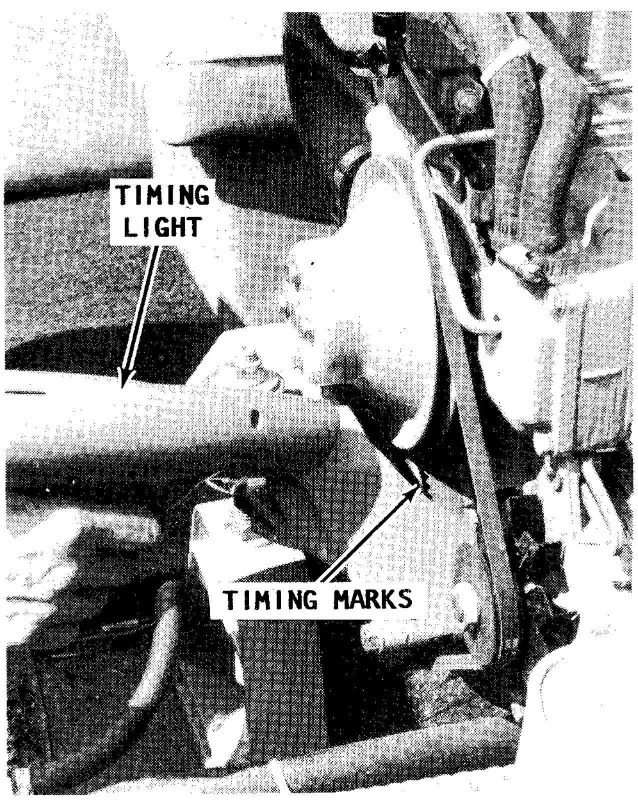
Check the timing mark on the balancer or pulley and the lines on the timing tab. If they are hard to see, mark them with paint or chalk. Connect a timing light to an adaptor for No. 1 spark plug. **NEVER** puncture the high-tension wire or you will damge the core.

Start the engine and adjust the idle speed to specification.

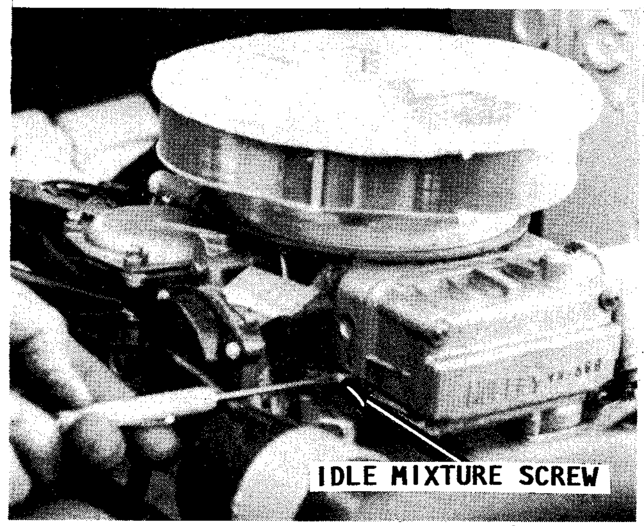
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

Now, aim the timing light at the timing mark on the pulley and the timing tab. **TAKE CARE** to aim the timing light straight at the mark. Sighting from an angle may cause an error. The specified timing mark should align with the pointer. If it does not, loosen the distributor hold-down bolt and rotate the distributor until it is aligned. Tighten the hold-down bolt, and then check the marks again with the light.

Check operation of the centrifugal advance mechanism by accelerating the engine and checking the position of the timing mark with the light. The mark should advance on the pulley if the advance mechanism is operating properly.



Use of the timing light to accurately adjust the timing.



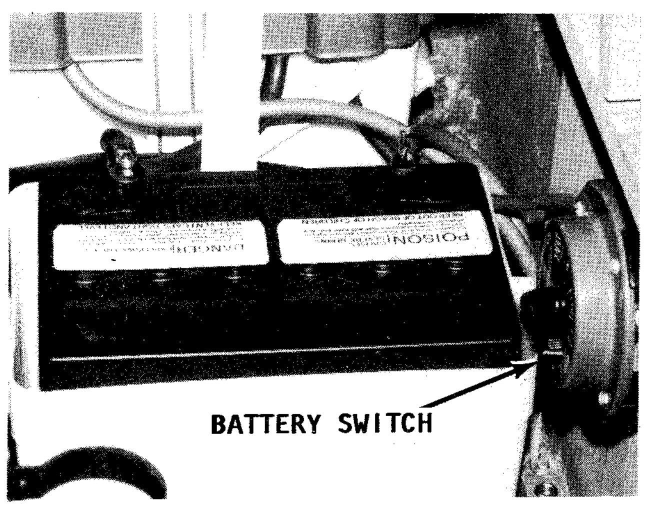
Adjusting the idle mixture needle and the fast idle.

5-10 ADJUSTING IDLE SPEED AND MIXTURE

Connect a tachometer, then start the engine and allow it to warm to normal 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.

Adjust the idle speed screw until the engine is running at idle specification given in the Appendix. Turn the idle mixture adjusting needles and observe the tachometer reading until the highest rpm is obtained. **ALWAYS** turn the needles very **SLOWLY** because there is a time lag until the engine responds to the new mixture and stablizes.



*The battery **MUST** be located near the engine in a well-ventialated area. It must be secured in such a manner that absolutely no movement is possible in any direction under the most violent action of the boat.*

6
ELECTRICAL

6-1 INTRODUCTION

The battery, gauges and 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.

6-2 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 if it should fail 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 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

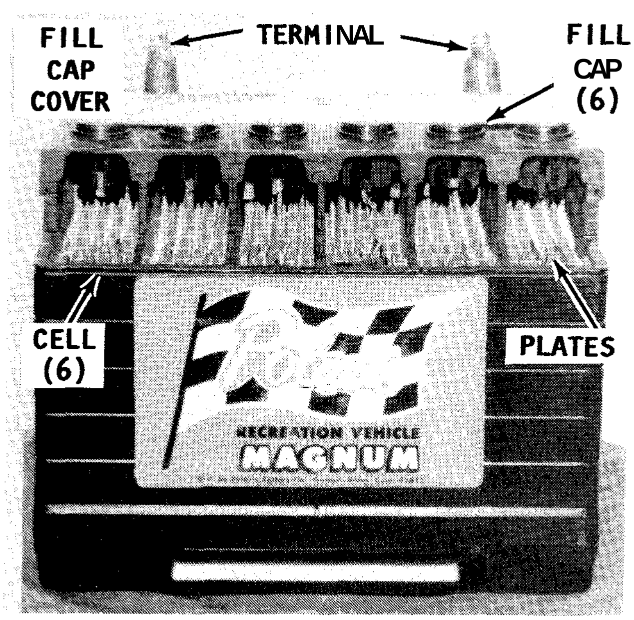
Because marine batteries are required to perform under much more rigorous conditions than automotive batteries. thev are constructed much differently than those used in automobiles or trucks. Therefore, a marine battery should always be the No. 1 unit for the boat and other types of batteries used only 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 much longer period of time than any type of automotive-type unit.



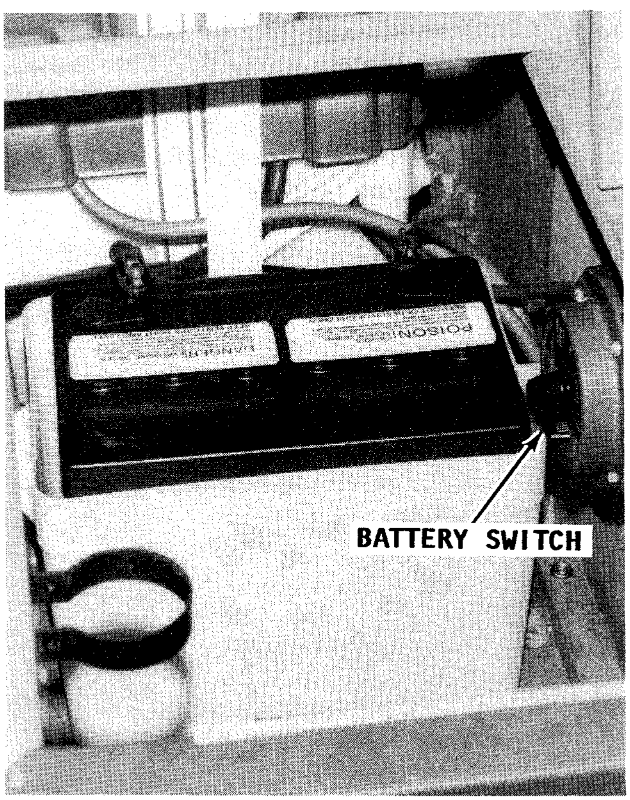
A fully charged battery, filled to the proper level with electrolyte, is the heart of the ignition and electrical systems. Engine cranking and efficient performance of electrical items depend on a full-rated battery.

BATTERY CONSTRUCTION

A battery consists of a number of positive and negative plates immersed in a solution of dilute 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 the 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 are connected to each other in a positive-to-negative manner with a heavy strap called the cell connector.

BATTERY RATINGS

Two ratings are used to classify batteries: One is a 20-hour rating at 80^{o}F and the other is a cold rating at 0^{o}F. This second figure indicates the cranking load capacity and is refered to as the Peak Watt Rating of a battery. This Peak Watt Raing (PWR) has been developed as a measure of the batteries cold-cranking ability. The numerical rating is embossed on each battery case at the base and is determined by multiplying the maximum current by the maximum voltage.



The battery MUST be located near the engine in a well-ventilated area. It must be secured in such a manner that absolutely no movement is possible in any direction under the most violent action of the boat.

The ampere-hour rating of a battery is its capacity to furnish a given amount of amperes over a period of time at a cell voltage of 1.5. Therefore, a battery with a capacity of maintaining 3 amperes for 20 hours at 1.5 volts would be classified as a 60-ampere hour battery.

Do not confuse the ampere-hour rating with the PWR because they are two unrelated figures used for different purposes.

A replacement battery should have a power rating equal or as close to the old unit as possible.

BATTERY LOCATION

Every battery installed in a boat must be secured in a well-protected ventilated area. If the battery area is not well ventilated, hydrogen gas which is given off during charging could become very explosive if the gas is concentrated and confined. Because of its size, weight, and acid content, the battery must be well-secured. If the battery should break loose during rough boat maneuvers, considerable damage could be done, including damage to the hull.

BATTERY SERVICE

The battery requires periodic servicing and a definite maintenance program will ensure extended life. If the battery should test satisfactorily, but still fail to perform properly, one of four 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 slipping fan belt, a defective voltage regulator, a faulty alternator, 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 excessive 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.

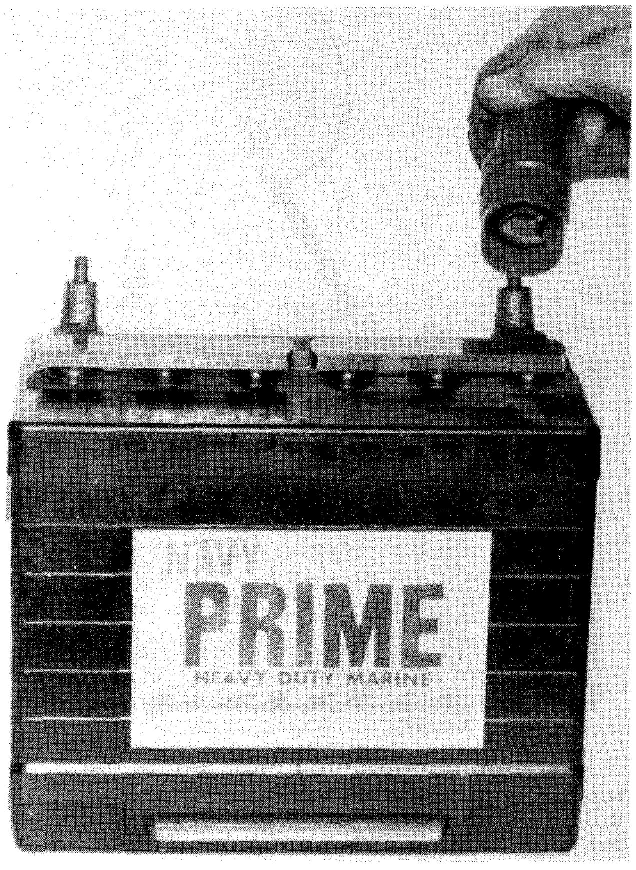
Some late-model batteries have an electrolyte-level indicator installed which operates in the following manner: A transparent rod extends through the center of one of the cell caps. The lower tip of the rod is immersed in the electrolyte when the level is correct. If the level should drop below normal, 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 colorless, odorless, drinking water to bring the level of electrolyte in each cell to the proper level. **TAKE CARE** not to overfill because it 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.

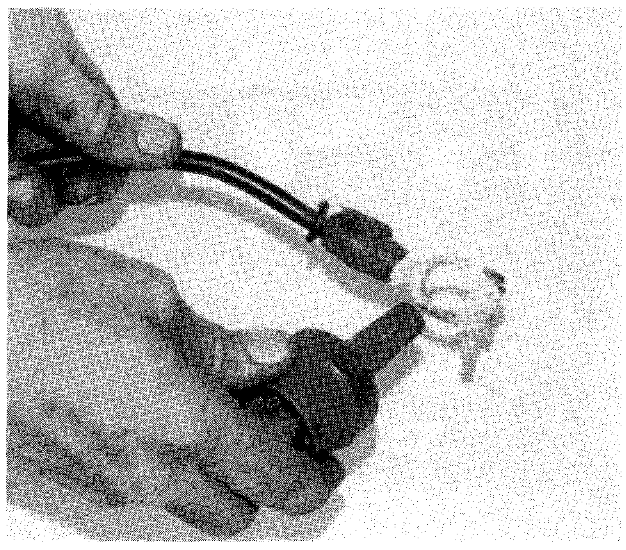
Cleaning

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.



One of the most effective means of cleaning the battery terminals is by using a wire brush with holder designed for this specific purpose.



An inexpensive brush can be purchased and used to clean the battery terminals to ensure a proper connection.

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. Clean the inside of the cable clamps to be sure they do not cause any resistance in the circuit.

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.

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 electro lyte with the new water and to cause vigorous gassing.

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.

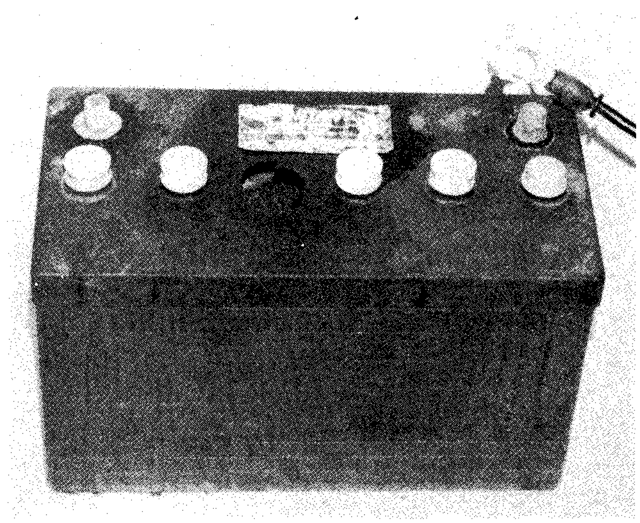
4- **BE SURE** to hold the hydrometer vertically and suck up liquid only until the float is free and floating.

5- **ALWAYS** hold the hydrometer at eye level and take the reading at the surface of the liquid with the float free and floating.

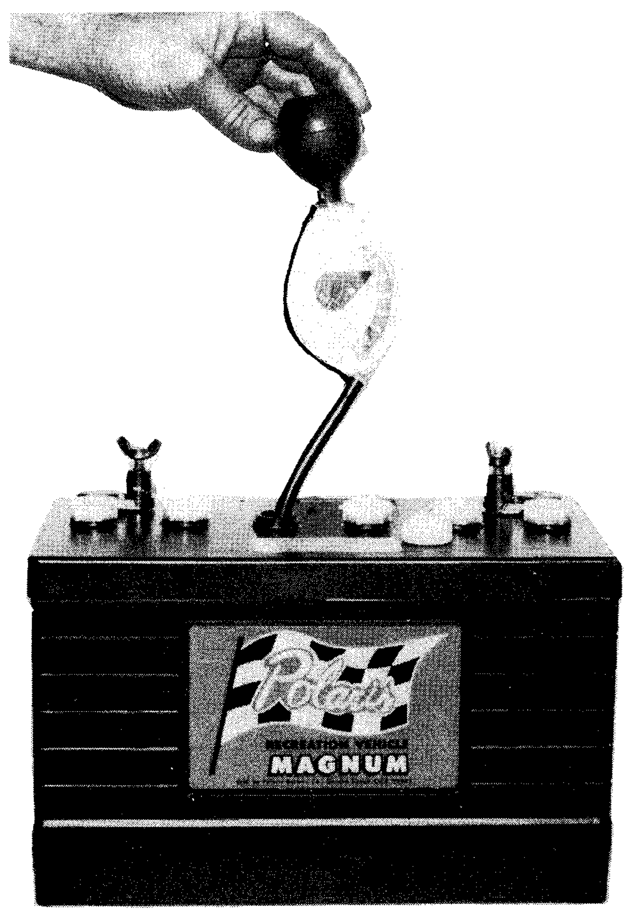
Disregard the light curvature appearing where the liquid rises against the float stem due to surface tension.

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 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, the condition of the battery is satisfactory. If the level is within the white



Corroded battery terminals such as these result in high resistance at the connections. Such corrosion places a strain on any and all electrically operated devices on the boat and causes hard engine starting.



A check of the electrolyte in the battery should be a regular part of the maintenance schedule on 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 needs to be charged. Observe the six points listed in the text when using a hydrometer.

band, the battery is in fair condition, and if the level is in the red band, it needs charging badly or is dead and should be replaced. If level fails to rise above the red band after charging, the only answer is to replace the battery.

JUMPER CABLES

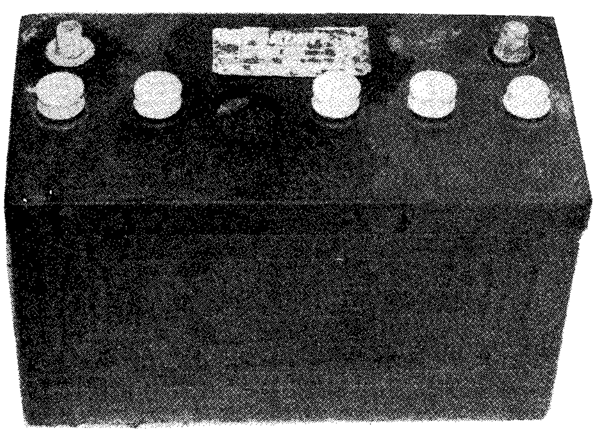
If booster batteries are used for starting an engine the jumper cables must be connected correctly and in the proper sequence to prevent damage to either battery, or to the alternator diodes.

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 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 alternator.

NEVER use a fast charger as a booster to start the engine because the diodes in the alternator will be **DAMAGED.**



An explosive hydrogen gas is released from the cells when the caps are removed. This battery exploded when the gas ignited from smoking in the area with the caps removed, or possibly from a spark at the terminal post.

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.

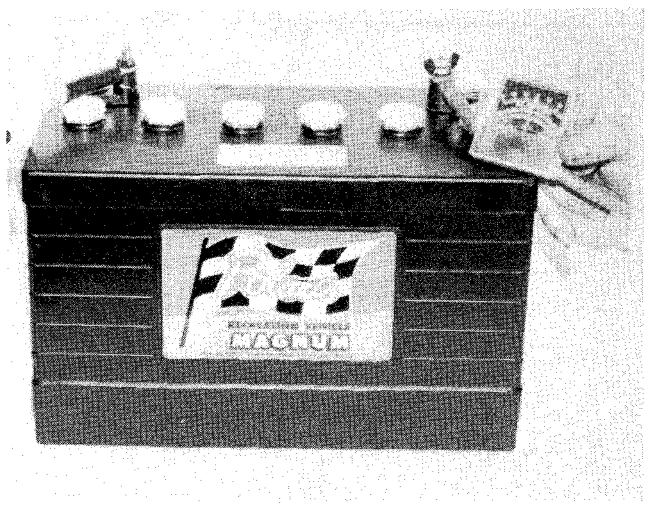
NEVER store the battery with anything on top of it or cover the battery in such a manner as to prevent air from circulating around the fillercaps. All batteries, both new and old, will discharge during periods of storage, more so if they are hot than if they remain cool. Therefore, the electrolyte level 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. 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.

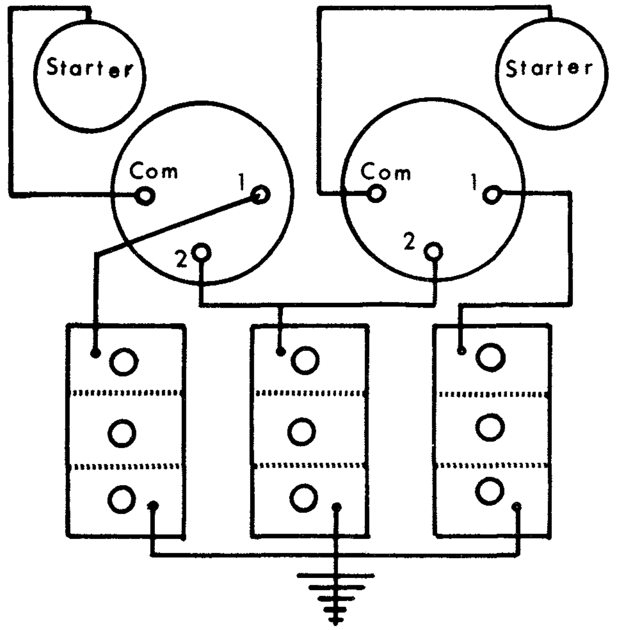
DUAL BATTERY INSTALLATION

Three methods are available for utilizing a dual-battery hook-up.

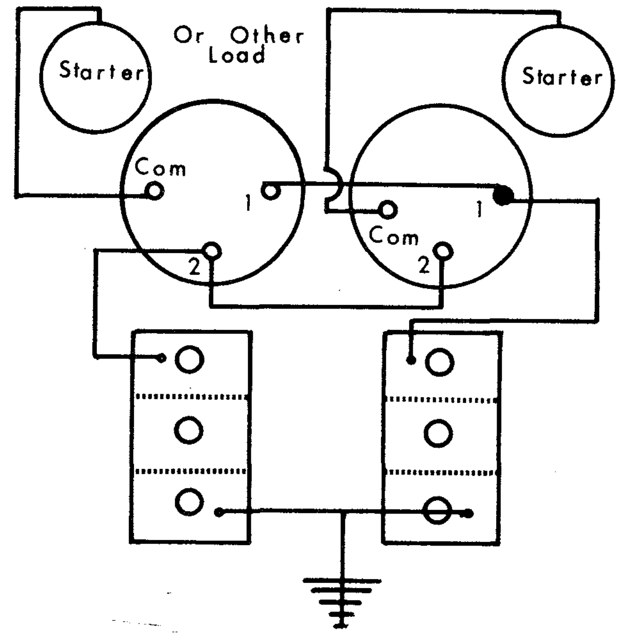
1- A high-capacity switch can be used to connect the two batteries. The accompanying illustration details the connections



The charging system output can be determined while the engine is running at a fast idle speed by holding an induction-type ammeter over the main wire.



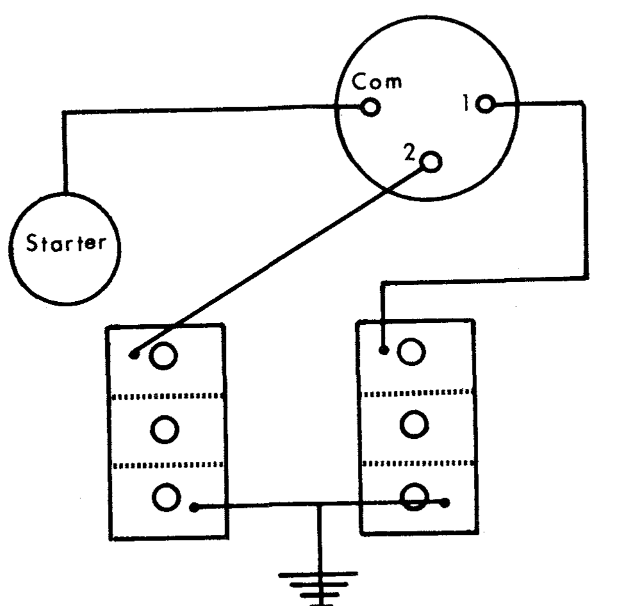
Schematic diagram for a three battery, two engine hookup.'



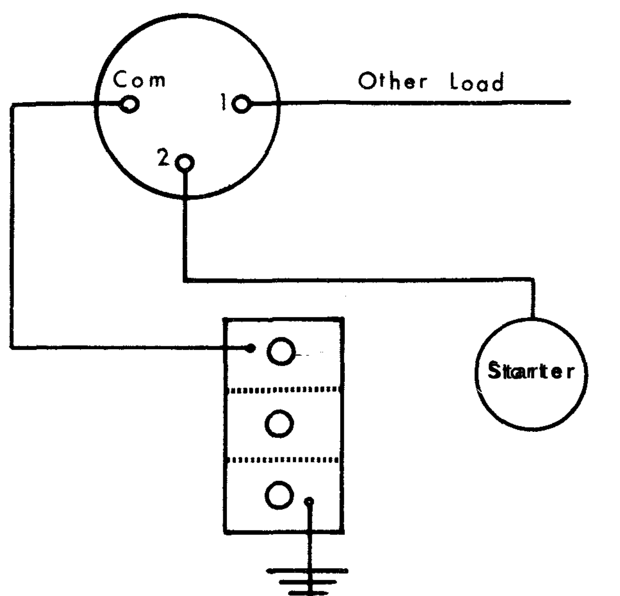
Schematic diagram for a two battery, two engine hookup.

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 forgotten in the closed position, it will let the convenience loads run down both batteries and the advantage of the dual installation is lost. However, 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



Schematic diagram for a two battery, one engine hookup.



Schematic diagram for a single battery, one engine hookup.

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 Amnerican Boat and Yacht Council, INC. or the Fire Protection Standard for Motor Craft, N.F.P.A. No. 302.

6-3 GAUGES AND LIGHTS

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 too 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. 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 sf 5 volts. This steady 5 volts ensures the gauges will read accurately under varying conditions from the electrical system.

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.

6-4 OIL AND TEMPERATURE GAUGES

The body of oil and 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.

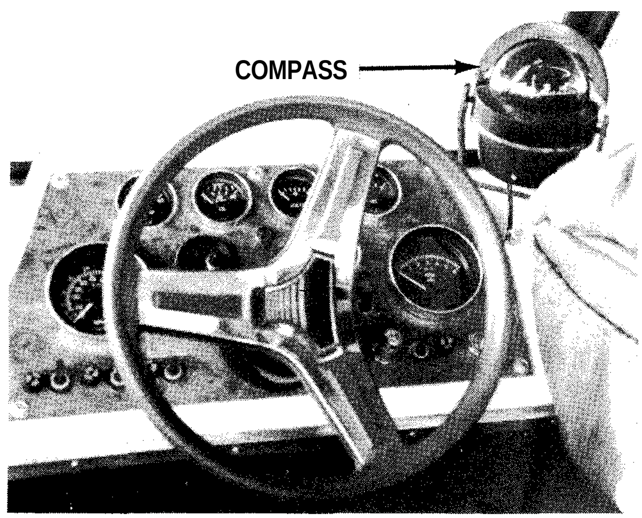
Ground the wire to the sending unit and the needle of the gauge should move to the full right position indicating the gauge is in serviceable condition.

Check Gauge Sender for a defective motor temperature warning system: Remove the sender from the engine. Connect the sender terminals to an ohmmeter. Submerge the sender in a container of oil with a thermometer. Heat the oil over a fireless heating element. Now, observe the meter and thermometer readings. The meter should read 450 ohms +5% at 220°F.

Check The Sender for a defective oil pressure warning system: Substitute a new sender unit of the correct value. Start the engine with the propeller in the water. Observe the gauge. If the reading is still unsatisfactory, replace the original gauge and test again. If the reading is still unsatisfactory, the problem may be in the engine lubrication system and due to worn bearings. **NEVER** attempt to interchange the sending unit from a system using a gauge with a unit from one using a warning light.

6-5 WARNING LIGHTS

If a problem arises on a boat equipped with water, temperature, and oil pressure



The indicator and control panel should be kept clean and protected from water spray, especially when operating in a salt water atmosphere.

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 or the oil pressure is too low, 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.

Check The Sender for a defective motor temperature warning system: Remove the sending unit from the engine and connect the terminals to an ohmmeter. Submerge the sender in a container of oil with a thermometer. Heat the oil over a fireless heating element. Observe the thermometer readings. The meter should indicate an open circuit until the temperature reaches 200+5°F. If the circuit does not close at the specified temperature, replace the unit.

Check The Sender for a defective oil pressure warning system: Disconnect the electrical lead at the sending unit. Connect an ohmmeter between the terminal and ground. Turn the ignition switch on and the meter should indicate a complete circuit. Start 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.

Increase engine rpm and the meter should then indicate an open circuit. If it does not, replace the sender. If a new sender still fails to open the circuit, the problem may be in the engine lubricating system or because of worn bearings.

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 about 3000 rpm.

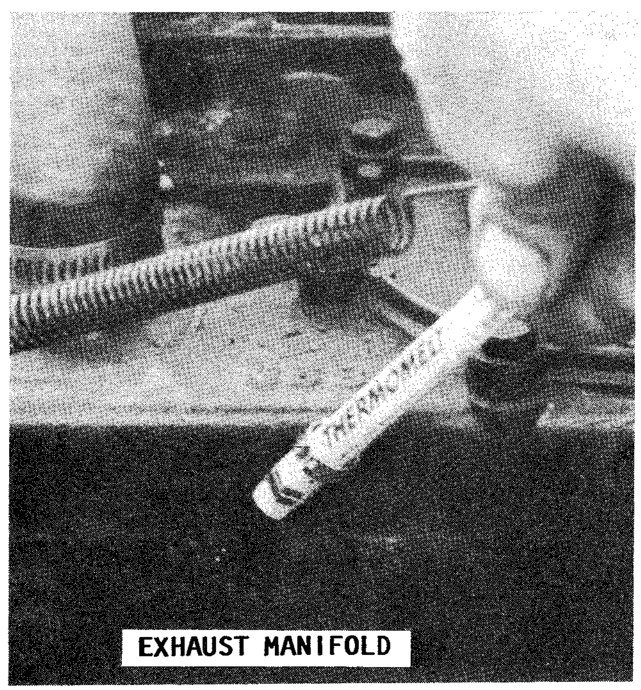
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

The 140 degree stick should melt when you touch it to the lower thermostat housing. 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 and it 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. For service procedures on the cooling system, see Chapter 9.

6-6 FUEL-GAUGES

The fuel gauge is intended to indicate the quantity of fuel in the tank. As the experienced boatman 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 and if the boat has a list to port or starboard.



*A Thermostick is a quick, simple, and fairly accurate method **to** determine engine running temperature.*

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 clear of 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.

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.

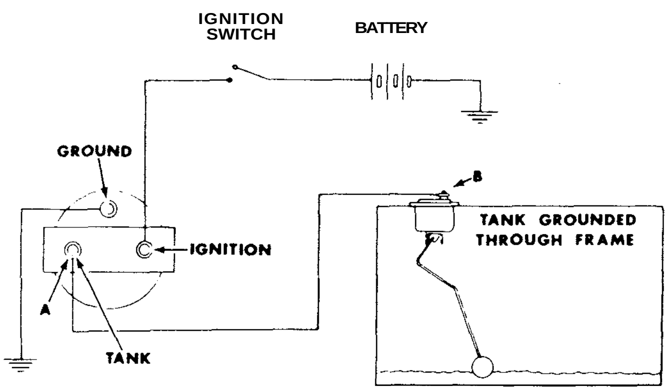
Pink -- insulated wire for the fuel gauge sending unit to the gauge.

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.



Schematic diagram for safe fuel tank hookup.

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 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 systern.

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 systern.

If the pointer remains at about 3/8 full, it indicates a 12-volt gauge is installed in a six-volt systern.

Erratic Fuel Gauge Readings

Inspect all of the wiring in the circuit for possible damage to the insulation or conductor. Carefully check:

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 trunk 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 grounding connection in the boat.

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 spare unit reads FULL, the original unit is shorted and must be replaced.

2- A reading of EMPTY indicate 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 ground thru a variable resistor or thru a spare tank unit.

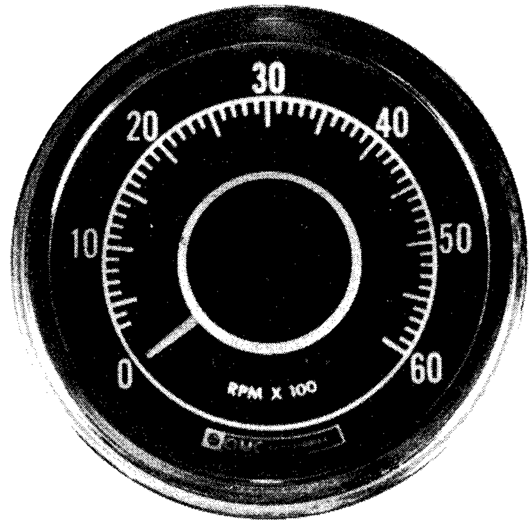
2- Observe the dash gauge reading. The reading should be FULL when resistance is increased to about 90 ohms. This resistance would simulate a full tank.

3- If the check indicates the dash gauge is operating properly, the the trouble is either in the tank sending unit rheostat being shorter, or the float is binding. The arm could be bent, or the tank may be deformed. Inspect and correct the problem.

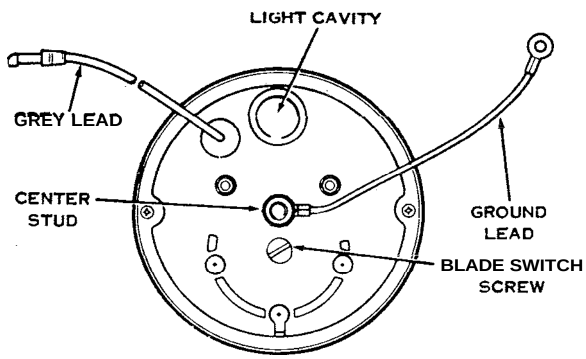
6-7 TACHOMETER

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 ciruits 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.



Maximum engine performance can only be obtoined through proper tuning using a tachometer.



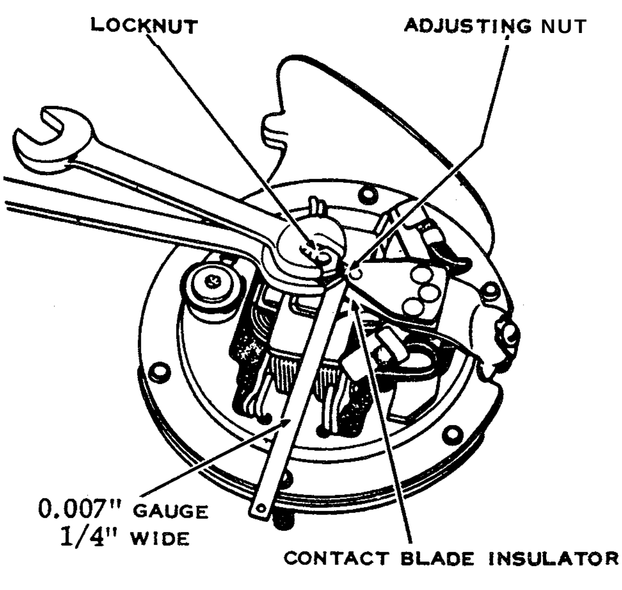
A blade-type tachometer can be installed for use with a four, six, or eight cylinder engine. Simply shift the blade to the connector matching the number of engine cylinders.

6-8 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 The 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.



*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.*

Before replacing the horn however, connect a second jumper wire from the horn frame to ground to check the ground connection.

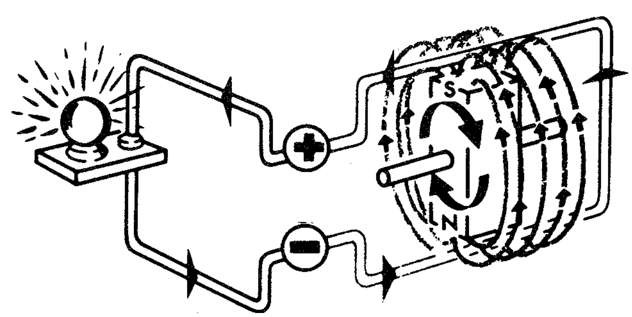
Test the winding for an open circuit, faulty insulation, or poor ground. Check the resistor with an ohmmeter, or test the condenser for capacity, ground, and leakage. Inspect the diaphragm for cracks.

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" 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.

6-9 CHARGING SYSTEM

The alternator, regulator, battery, ammeter, and the necessary wiring to connect it all together comprise the charging system.

Before the alternator is blamed for battery problems, consider other areas which may be the cause:



*Simplified drawing to illustrate voltage generation in its most basic form. The stator has many coils of wire, shown here as a single loop. The rotor spins; cuts the magnetic field; an electrical voltage is produced in the loop; the voltage moves out of the loop and into **the** system. Higher revolutions per minute of the loop generates more voltage.*

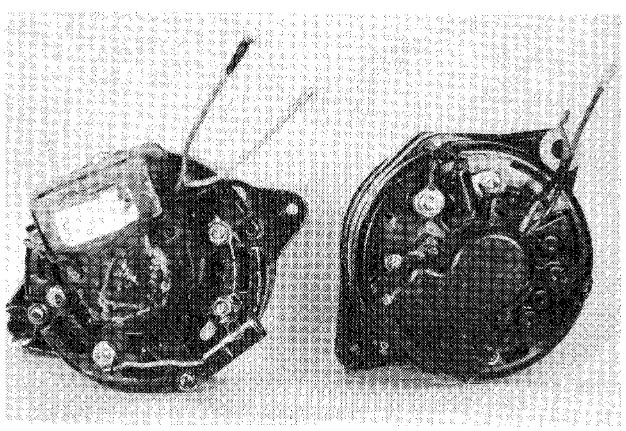
1- Excessive use of lights and accessories while the engine is shut down or operating at low speed for short periods.
2- Voltage losses and the cause.
3- Corroded battery cables, connectors, and terminals.
4- Low electrolyte level in the battery cells.
5- Prolonged disuse of the battery causing a self-discharged condition.

6-10 ALTERNATOR DESCRIPTION AND OPERATION

An alternator is an AC generator replacing the conventional DC generator. The alternator has four distinct advantages over the generator:

1- A higher charging rate.
2- A lower cut-in charging speed.
3- A lighter weight.
4- Longer trouble-free service.

The alternator operates on a different principle from the conventional generator. The armature of the alternator is the stationary part and is called the **STATOR;** and the field is the rotating part and is called the **ROTOR.** With this arrangement, the higher current carried by the stator is conducted to the external circuit through fixed leads. This method results in trouble-free operation of a small current supplied to the fields to be conducted through small brushes and rotating slip rings. This is in contrast to the DC generator where the current is carried through a rotating commutator and brushes.



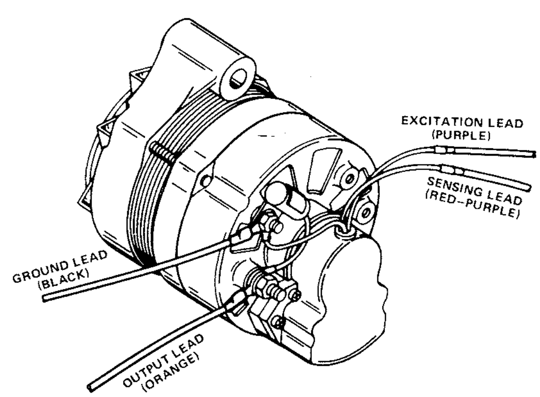
The Mando alternator (right), looks very much like the Motorola (left), but is tested like a Delco-Remy.

The alternator has a three-phase stator winding. The windings are phased electrically 120° apart. The rotor consists of a field coil encased between two four- or six-pole, interleaved sections. This arrangement produces an eight- or twelve-pole magnetic field, with alternate north and south poles. As the rotor turns inside the stator an alternating current (AC) is induced in the stator windings. This current is changed into DC (rectified) by silicon diodes and then sent to the output terminals of the alternator.

Consider the silicon diode rectifiers as electrical one-way valves. Three of the diodes are polarized one way and are pressed into an aluminum heat sink which is grounded to the slip ring end head. The other three diodes are polarized the opposite way and are pressed into a similar heat sink, which is insulated from the end head and connected to the alternator output terminal. Since a diode has high resistance to the flow of electricity in one direction and passes current with very little resistance in the opposite direction, it is connected in a manner which allows current to flow from the alternator to the battery in a low-resistance direction.

The high resistance in the opposite direction prevents battery current from flowing to the alternator, therefore, no circuit breaker (cutout) is required between the alternator and the battery.

The magnetism left in the rotor field poles is negligible. Thus, the field must be excited by an external source, the battery. The battery is connected to the field winding through the ignition switch and the voltage regulator. The alternator charging voltage is regulated by varying the field strength. This is controlled by the voltage



Wire identification for a Mando alternator.

regulator. No current regulator is required since the alternator has self-limiting current characteristics.

ALTERNATOR PROTECTION DURING SERVICE

The alternator is an important and expensive piece of equipment on the boat. Unless certain precautions are taken before and during servicing, parts of the alternator or the charging circuit may be damaged. **TAKE TIME** to review the following points **BEFORE** servicing or troubleshooting the charging system.

1- If the battery connections are reversed, the diodes in the alternator will be damaged. Check the battery polarity with a voltmeter before making any connections to be sure the connections correspond to the battery ground polarity.

2- The field circuit between the alternator and the regulator **MUST NEVER BE GROUNDED.** If this circuit is grounded the regulator will be damaged.

3- **NEVER** ground the alternator ouput terminal while the engine is running or shut down because no circuit breaker is used, and battery current is applied to the alternator output terminal at all times.

4- **NEVER** operate the alternator on an open circuit with the field winding energized, or the unit will be **DAMAGED.**

5- **NEVER** attempt to polarize the alternator because it is never necessary. Any attempt to polarize the alternator will result in **DAMAGE** to the alternator, the regulator, and the wiring.

6- **NEVER** short the bending tool to the regulator base while adjusting the voltage, or the unit will be **DAMAGED.** The bending tool should be **INSULATED** with tape or an insulating plastic sleeve while making the adjustment.

7- **ALWAYS** disconnect the battery ground strap before replacing an alternator or connecting any meter to it.

8- 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.

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 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.

9- 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 alternator.

10- **NEVER** use a fast charger as a booster to start the engine because the diodes in the alternator will be **DAMAGED.**

CHARGING SYSTEM TROUBLESHOOTING

The following symptoms and possible corrective actions will be helpful in restoring a faulty charging system to proper operation.

Alternator Fails To Charge

1- Drive belt loose or broken. Replace and/or adjust.

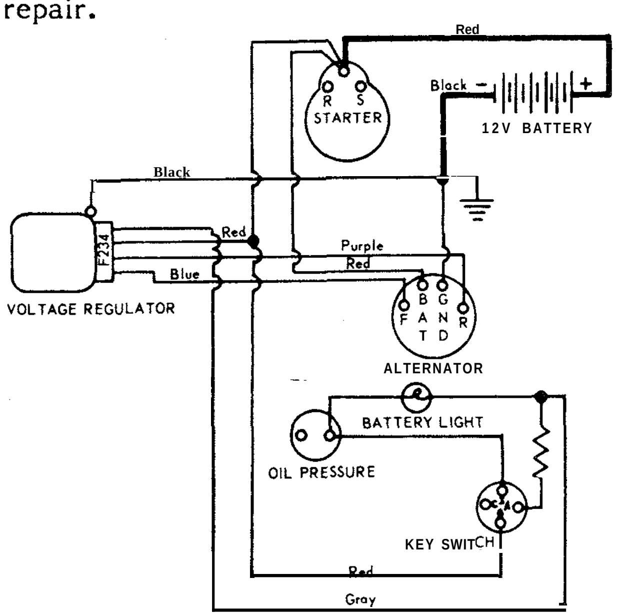
2- Corroded or loose wires or connection in the charging circuit. Inspect, clean, and tighten.

3- Worn brushes or slip rings. Replace as required.

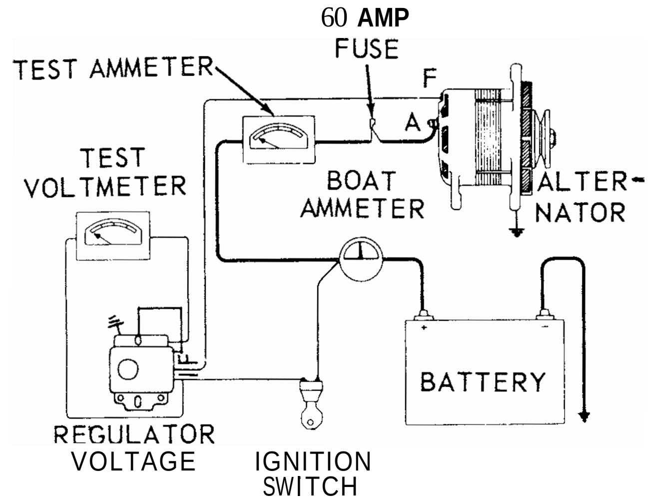
4- Sticking brushes.

5- Open field circuit. Trace and repair.

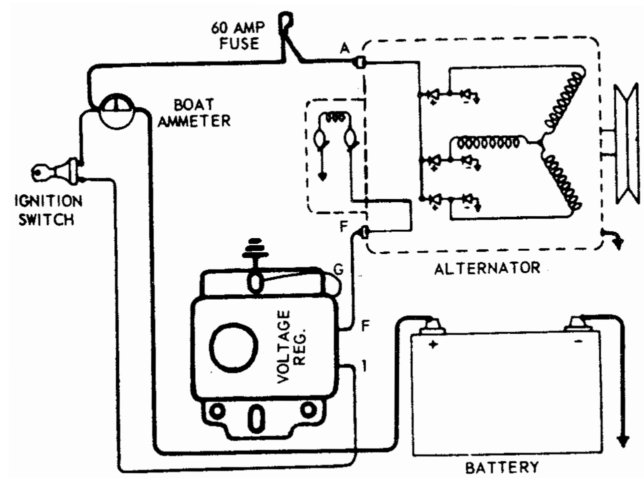
6- Open charging circuit. Trace and repair.



Schematic diagram for a charging system with an indicator light on the dashboard and a relay-type voltage regulator installed.



Functional diagram for hookup to test the electrical generating system.



Schematic diagram of the Prestolite charging system installed on OMC stem drive engines.

7– Open circuit in the stator windings.
8– Open rectifier. Replace the unit.
9– Defective regulator. Replace the unit.

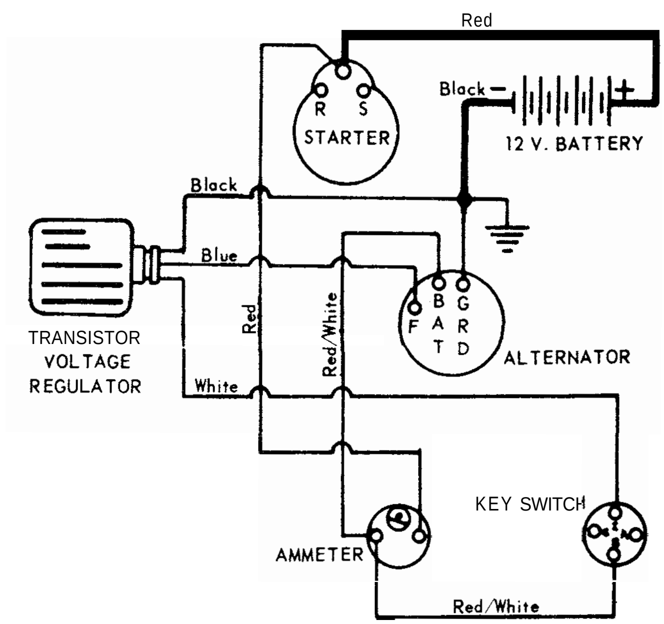
Alternator Charges Low or Unsteady

1– Drive belt loose or broken. Replace and/or adjust.
2– Battery charge too low. Charge or replace the battery.
3– Defective regulator. Replace the unit.
4– High resistance at the battery terminals. Remove cables, clean connectors and battery posts, replace and tighten.

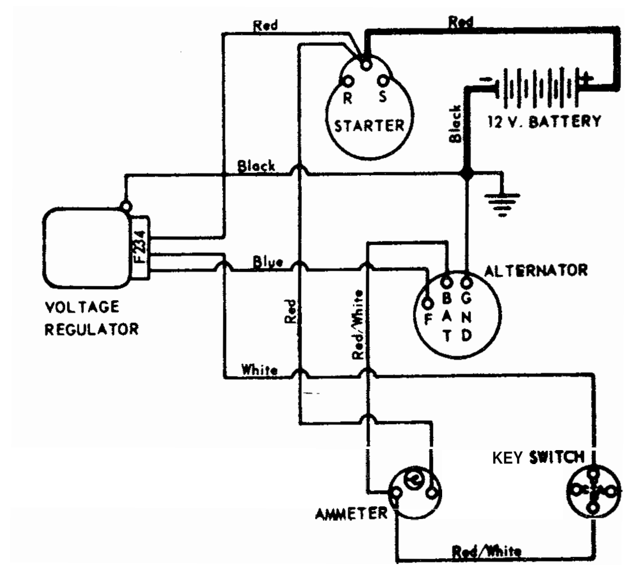
5– High resistance in the charging circuit. Trace and repair.
6– Open stator winding. Replace alternator.
7– High resistance in body-to-ground lead. Trace and repair.

Alternator Output Low and a Low Battery

1– Drive belt slipping. Adjust.
2– High resistance in the charging circuit. Trace and repair.
3– Shorted or open-circuited rectifier. Replace rectifier.
4– Grounded stator windings. Replace alternator.



Schematic diagram for a charging system with an ammeter on the dashboard and a relay-type voltage regulator installed.



Schematic diagram for a charging system with an ammeter on the dashboard and a transistor-type regulator installed.

Alternator Output Too High – Battery Overcharged

1– Faulty voltage regulator. Replace.

2– Regulator base not grounded properly. Correct condition to make good ground.

3– Faulty ignition switch. Replace.

Alternator Too Noisy

1– Worn, loose, or frayed drive belt. Replace belt and adjust properly.

2– Alternator mounting loose. Tighten all mounting hardware securely.

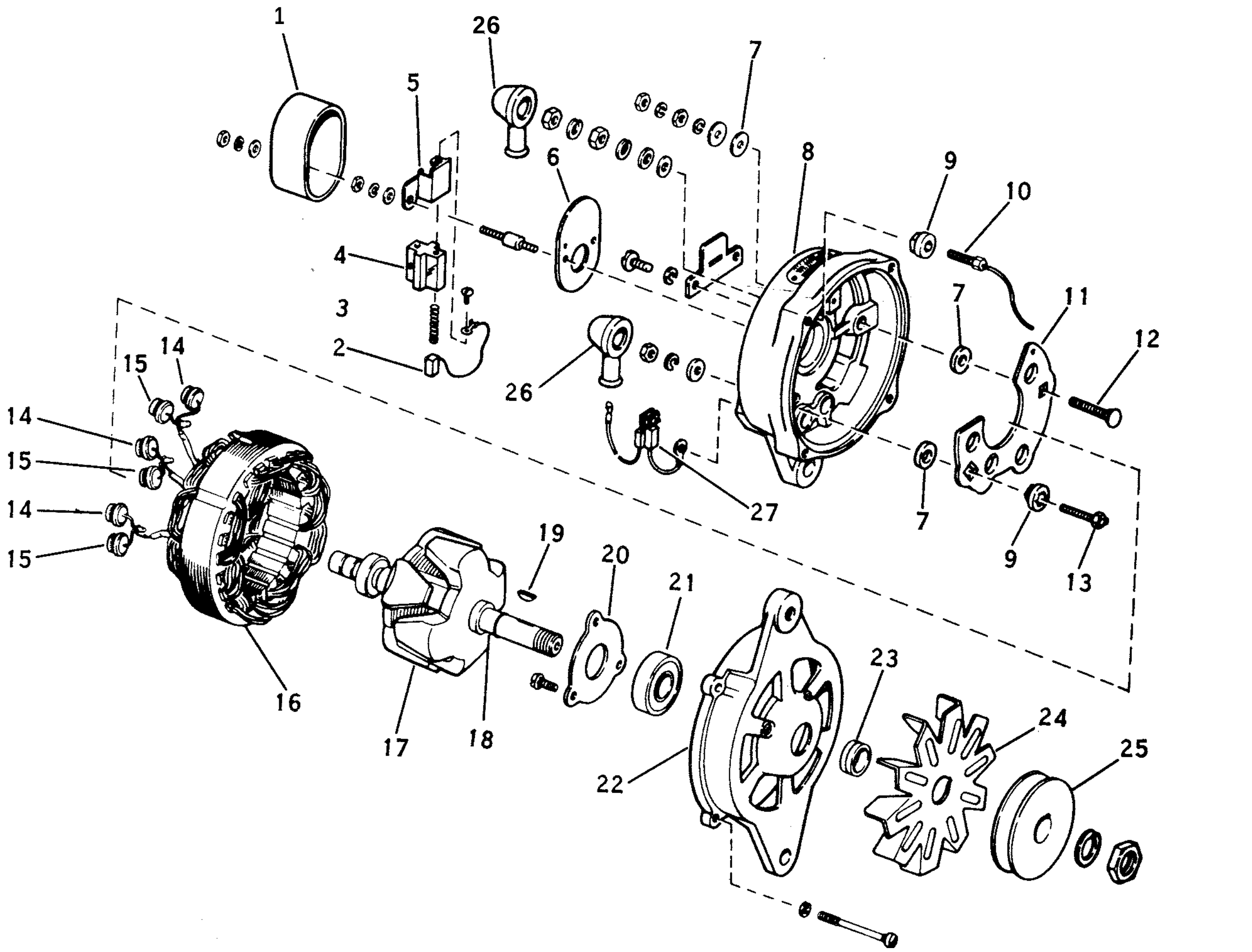
3– Worn alternator bearings. Replace.

4– Interference between rotor fan and stator leads or rectifier. Check and correct.

5– Rotor or fan damaged. Replace.

6– Open or shorted rectifier. Replace.

7– Qpen or shorted winding in stator. Replace.



1. Slip Ring Cover
2. Brush Set
3. Spring
4. Brush Holder
5. Brush Holder Cover
6. Back-up Plate
7. Insulating Washer
8. Slip Ring End Head
9. Insulating Bushing
10. Field Terminal Wire and Stud
11. Rectifier Plate
12. Battery Terminal Stud
13. Stud
14. Negative Rectifiers
15. Positive Rectifiers
16. Stator
17. Rotor and Bearing
18. Retaining Ring
19. Key
20. Retainer Plate
21. Bearing
22. Drive End Head
23. Spacer
24. Fan
25. Pulley
26. Cover
27. Fuse and Lead (Shown without Potting Material)

Prestolite alternator with major parts identified.

Ammeter Fluctuates Constantly

High resistance connection in the alternator or voltage regulator circuit. Trace and repair.

6-11 SERVICING CHARGING SYSTEM WITH SEPARATE REGULATOR

Trouble between the alternator and the regulator may be isolated as follows:

First, connect one end of a jumper wire to the **BAT** terminal and the other end to the F (field) terminal.

If the charging system works with the jumper wire in place, but not without it, then the regulator is at fault and must be replaced.

If the charging system does not operate with the jumper in place, then the alternator is at fault and must be replaced. The **REGULATOR MUST** be replaced any time the alternator is replaced, because the regulator will also be defective as evidenced by its failure to control the alternator output properly.

Regulator trouble is often caused by high resistance in the charging circuit at the ammeter or at the battery. Check both of these areas, and if corrosion is discovered, the connection must be disassembled, cleaned, and then tightened securely to prevent recurrence of the problem.

DISASSEMBLING

Remove the nuts, washers, and cover from the top of the brush holder. Remove the studs and the brush-and-spring assemblies. Remove the screws securing the brush holder to the end frame, and then remove the brush holder.

Scribe a mark on both end frames and matching marks on the stator as an aid to properly assembling the parts.

Remove the four through-bolts. Separate the drive end frame and rotor assembly from the stator by **CAREFULLY** prying with a screwdriver at the slot in the stator frame. **NEVER** pry anywhere except at the slot or the castings will be damaged.

Cover both sides of the bearing on the end frame and the bearing surface with tape as a prevention from damaging them.

CLEANING AND TESTING

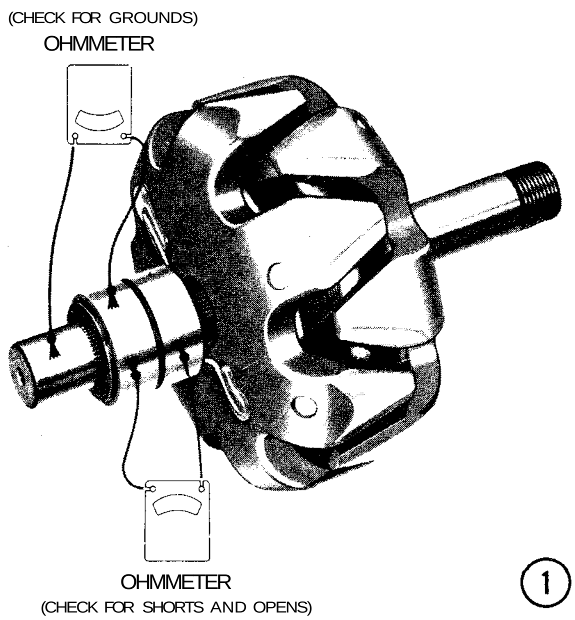
The following procedures are keyed by number to matching illustrations as an aid in performing the work.

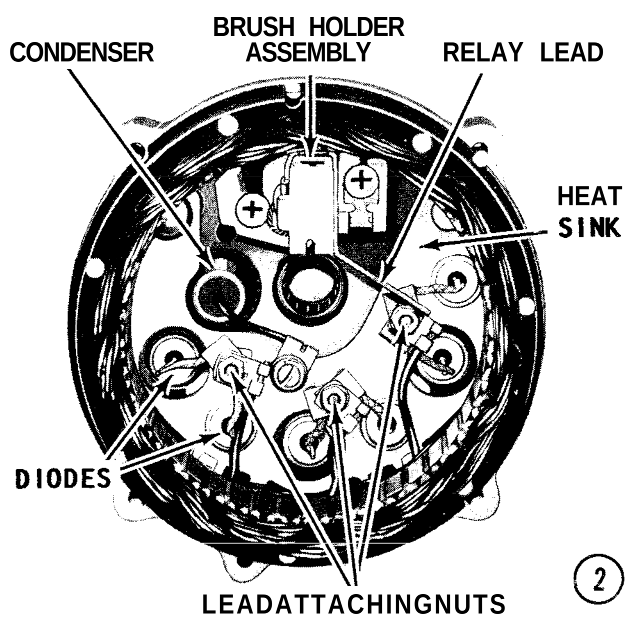
ROTOR

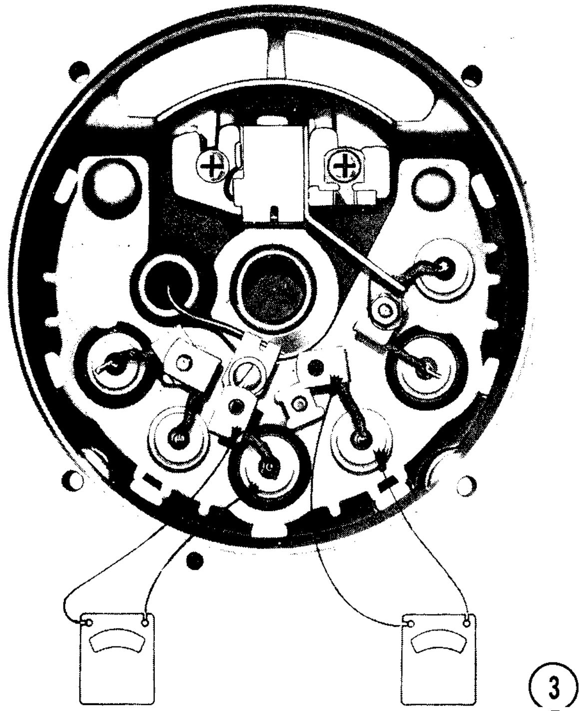
1- Check the rotor windings for a short or ground: Connect an ohmmeter between one brush slip ring and the shaft. The meter must indicate an open circuit on the R-100 scale. Check the rotor windings for continuity: Connect the ohmmeter between the two slip rings, and the reading should be 6 ohms for a 42-ampere alternator rotor, or 4.5 ohms for a 32-ampere rotor.

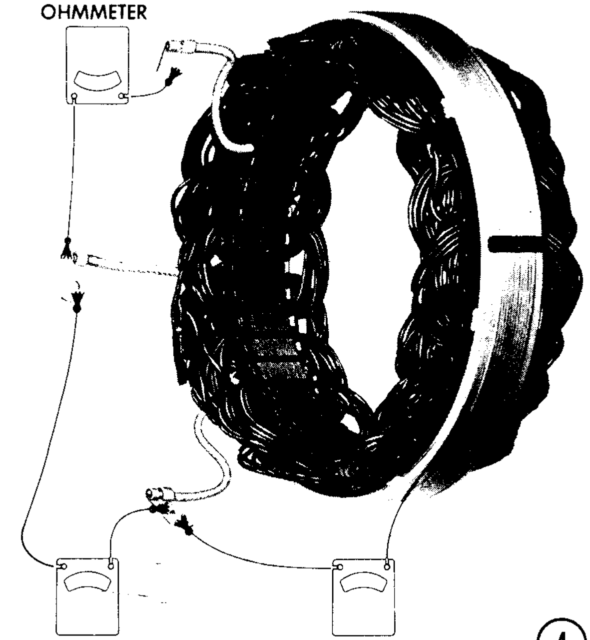
DIODES

2- Each diode must be tested to be sure it is not open or shorted. Check the three diodes in the heat sink: Disconnect the









stator leads and test each diode with one ohmmeter probe on the heat sink and the other on the disconnected diode terminal. Note the reading, and then reverse the test leads and again note the reading. If one reading is high and the other low, the diode is satisfactory. If both readings are zero or infinity, the diode is defective and must be replaced.

3– Check the three diodes in the end frame: Connect the ohmmeter in the same manner as for the previous test EXCEPT connect one test lead to the end frame instead of the heat sink. Note the reading, then reverse the leads and again note the reading. The results should be the same as the previous test.

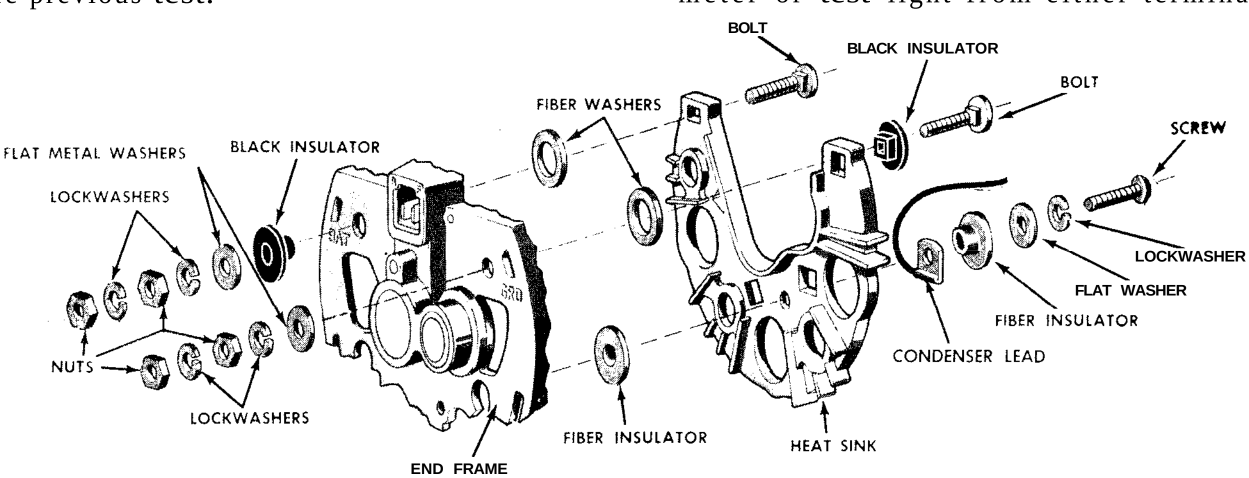
STATOR

4– The stator is not checked for shorts due to the very low resistance of the windings. Neither are checks of the delta stator for opens because the windings are connected in parallel.

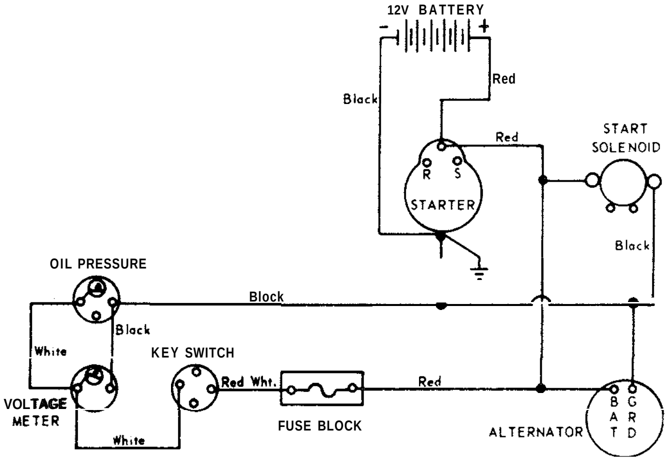
Checks that are made on the stator must be made with all of the diodes disconnected from the stator.

Check the Y-connected stator for open circuits: Connect an ohmmeter or test light across any two pair of terminals. If the ohmmeter reading is high, or if the test light fails to come on, there is an open in the winding.

Both types of stator winding can be checked for grounds by connecting an ohmmeter or test light from either terminal to



Exploded view showing all parts of the heat sink.



Schematic diagram of an alternator with an integral regulator and a harness length over 20 feet.

the stator frame. If the ohmmeter reads low or if the lamp comes on, the windings are grounded.

If all of the tests check out satisfactorily, but the alternator still fails to meet its rated output, a shorted Y-connected or delta stator winding, or an open delta winding, may be the cause.

6-12 SERVICING CHARGING SYSTEM WITH INTEGRAL REGULATOR

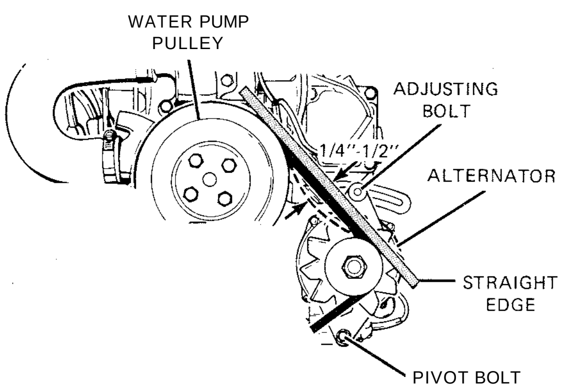
Alternators with an integral solid-state regulator installed are easily identified by an explosion-resistant screen at each end frame.

Trouble between the alternator and the regulator may be isolated as follows:

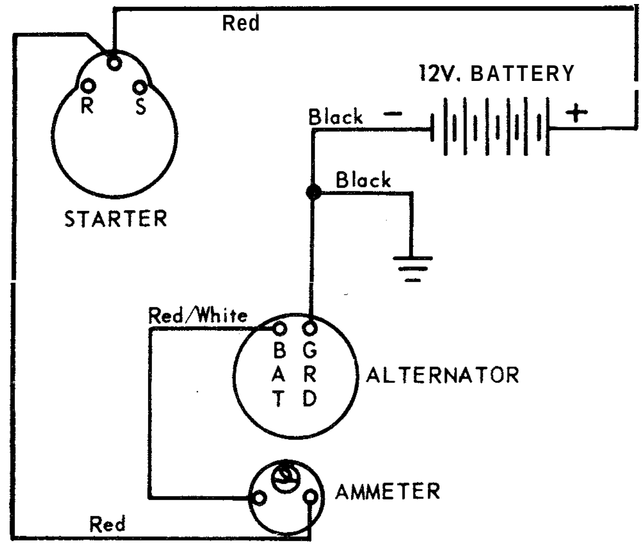
Start the engine.

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.

Now, with the engine running, **CAREFULLY AND SLOWLY** insert a small bladed



Checking for proper drive belt tension.

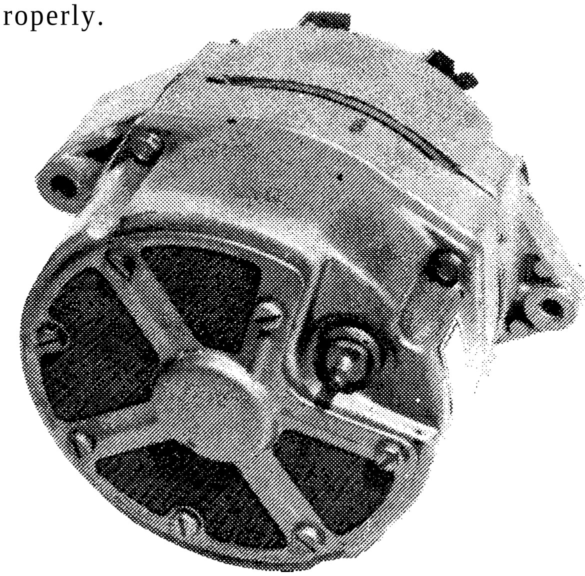


Schematic diagram of an alternator with an integral regulator and a harness length less than 20 feet.

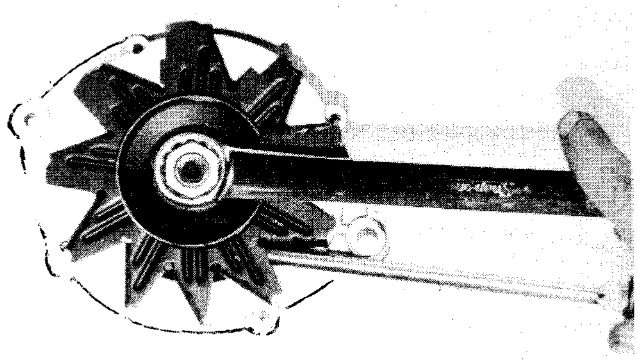
screwdriver **NO MORE THAN ONE-INCH** into the test hole in the slip ring end frame. **NEVER** insert the screwdriver more than 1", because you will contact the rotor and **DESTROY THE ALTERNATOR.**

With the screwdriver in place, the field winding is grounded and the regulator is bypassed. If the alternator charges with the screwdriver in place, the regulator is defective and must be replaced. If the alternator does not charge with the screwdriver in place, then the alternator is defective and must be repaired or replaced.

WHENEVER the alternator is repaired or replaced, the regulator must be replaced because it is also defective, as evidenced by its failure to control the alternator output properly.



Exterior view of an alternator with an integral regulator.



Removing the alternator pulley.

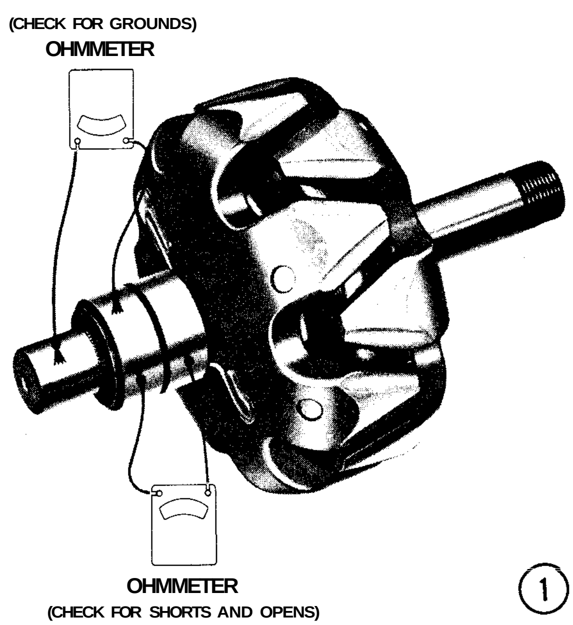
Many times, the cause of a defective regulator is a high resistance connection in the charging circuit, at the ammeter, or at the battery. Each of these areas should be checked and serviced thoroughly to prevent repetition of the trouble. Disassemble the connection, clean, and then tighten it.

DISASSEMBLING

Remove the four through-bolts, and then take off the cover. Secure a 5/16" Allen wrench in a vise, as shown in the accompanying illustration.

Now, slide the alternator shaft over the exposed end of the Allen wrench. Use a 15/16" box-end wrench to loosen, and then remove the end nut, washer, pulley, fan, collar, drive-end frame, and collar from the rotor shaft.

CAREFULLY pull the rotor assembly from the slip-ring end frame, and **TAKE CARE** not to lose the brush springs. Cover the slip-ring end frame with tape to keep dirt out of the bearing. Cover the slip rings with tape also as a precaution against scaring them. **NEVER** use friction tape, which leaves a gummy deposit which is very difficult to remove.



CLEANING AND TESTING

The following procedures are keyed by number to matching illustrations as an aid in performing the work.

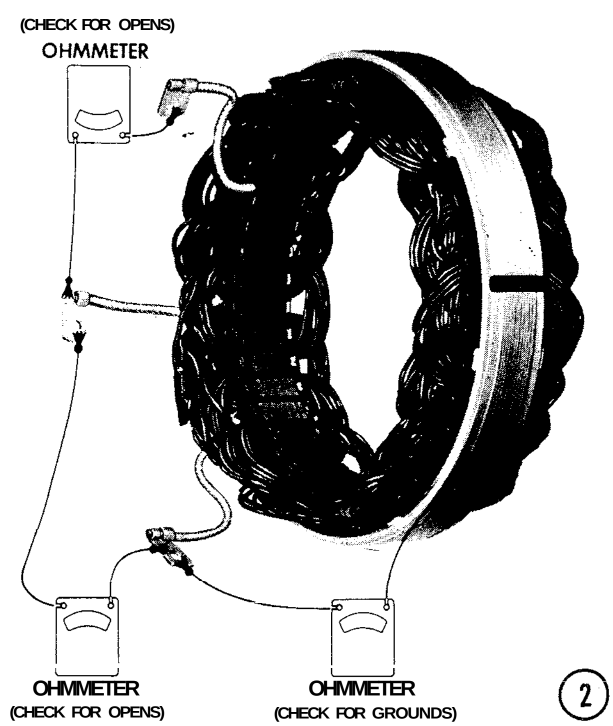
ROTOR

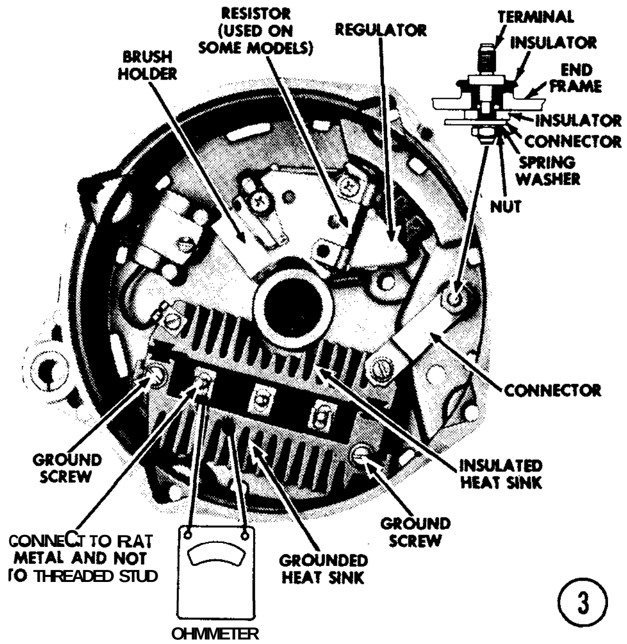
1- Check the rotor windings for a short or ground: Connect an ohmmeter between one brush slip ring and the shaft. If the meter does not show an open circuit on the R-100 scale there is a short in the rotor windings. Check the rotor windings for continuity: Connect the ohmmeter between the two slip rings, and a normal reading of 2.6 ohms will indicate the rotor coil is serviceable.

STATOR

2- The stator is not checked for shorts due to the very low resistance of the windings. Neither are checks of the delta stator for opens because the windings are connected in parallel.

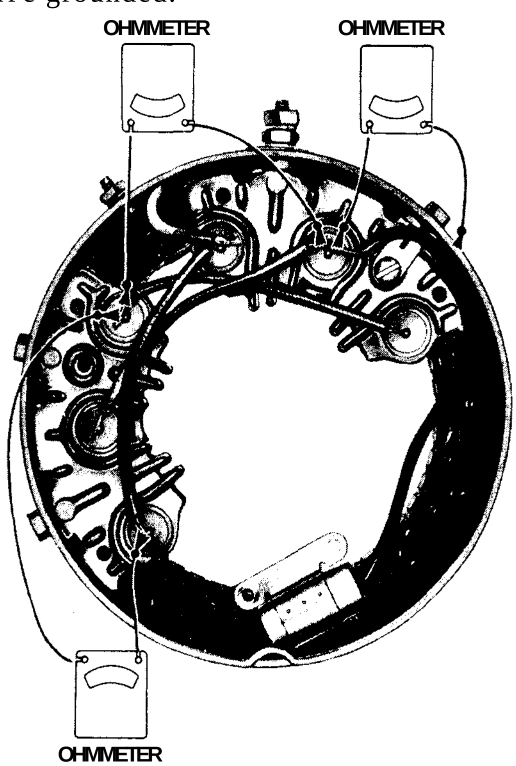
Checks that are made on the stator must be made with all of the diodes disconnected from the stator.





Check the Y-connected stator for open circuits: Connect an ohmmeter or test light across any two pair of terminals. If the ohmmeter reading is high, or if the test light fails to come on, there is an open in the winding.

Both types of stator winding can be checked for grounds by connecting an ohmmeter or test light from either terminal to the stator frame. If the ohmmeter reads low or if the lamp comes on, the windings are grounded.



Ohmmeter hookups for testing.

If all of the tests check out satisfactorily, but the alternator still fails to meet its rated output, a shorted Y-connected or delta stator winding, or an open delta winding, may be the cause.

RECTIFIER BRIDGE

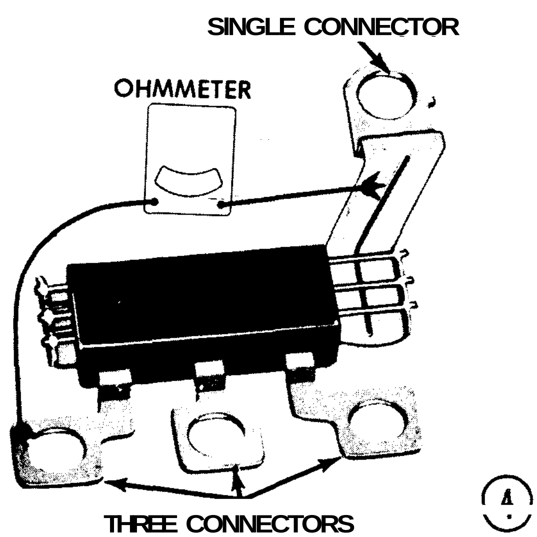
3- First, set the ohmmeter scale to R-100. Next, connect one test lead to the grounded heat sink and the other test lead to one of the three terminals. Now, note the reading on the scale. Reverse the test leads, and again note the reading. If both readings are zero or very high, the rectifier bridge is defective. If one of the readings is high and the other low, the rectifier checks out for service.

Repeat the tests between the grounded heat sink and the other two terminals, and then between the insulated heat sink and each of the three terminals. When you are finished, you should have made a total of six tests, with two readings during each test.

DIODE TRIO

4- Remove the diode trio by removing the attaching bolts and nuts. Set the ohmmeter scale to R-100. Check each diode for a short or open by first connecting one test lead to a single connector, of the three connectors, and then noting the reading on the scale. Now, reverse the test leads, and again note the reading. If both readings are zero or very high, the diode is defective. If one reading is low and the other is high, the diode checks out for service.

Repeat each test for each of the other two connectors, taking two readings during each test for a total of six readings. Replace the diode trio if any one diode fails to check out.



6-13 CRANKING SYSTEM

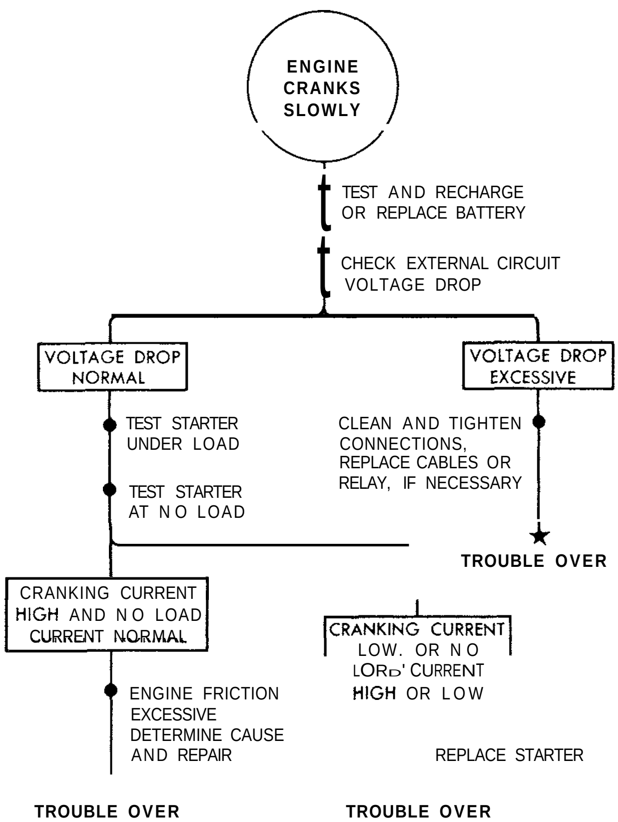
The cranking system includes the starter and drive, battery, solenoid, ignition switch, and the required cables and wires to connect the parts for efficient operation. A neutral-start switch to prevent operation of the starter unless the shift selector lever is in the **NEUTRAL** position, is installed in the shift box on all boats.

The Delco-Remy, Autolite, and Prestolite cranking motors (starters) are used on most marine engine installations. The Delco-Remy starter has a solenoid mounted on the field coil housing. The Autolite and Prestolite units have separate solenoids.

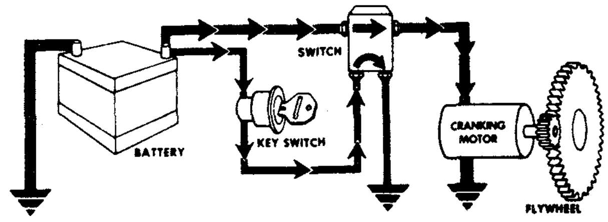
Detailed, illustrated service procedures are given in the following sections for each starter.

6-14 CRANKING SYSTEM TROUBLESHOOTING

Regardless of how or where the solenoid is mounted, the basic circuits of the starting system on all makes of cranking motors are the same and similar tests apply. In the following testing and troubleshooting procedures, the differences are noted.



Engine Cranks Slowly



Functional diagram of a typical cranking circuit.

ALWAYS TAKE TIME TO VENT THE BILGE WHEN MAKING ANY OF THE TESTS AS A PREVENTION AGAINST IGNITING ANY FUMES ACCUMULATED IN THAT AREA. AS A FURTHER PRECAUTION, REMOVE THE HIGH-TENSION WIRE FROM THE CENTER OF THE DISTRIBUTOR CAP AND GROUND IT SECURELY TO PREVENT SPARKS.

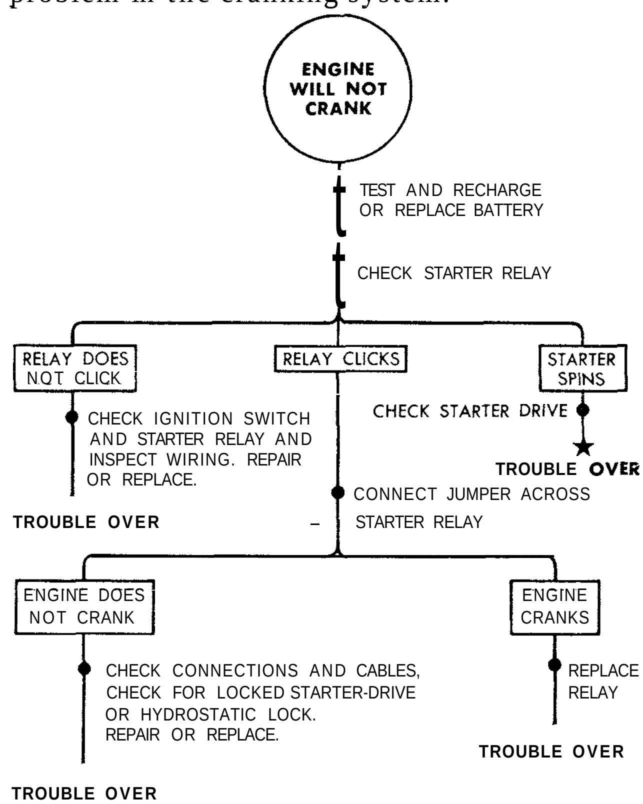
All starter problems fall into one of three problem areas:

1- The starter fails to turn.

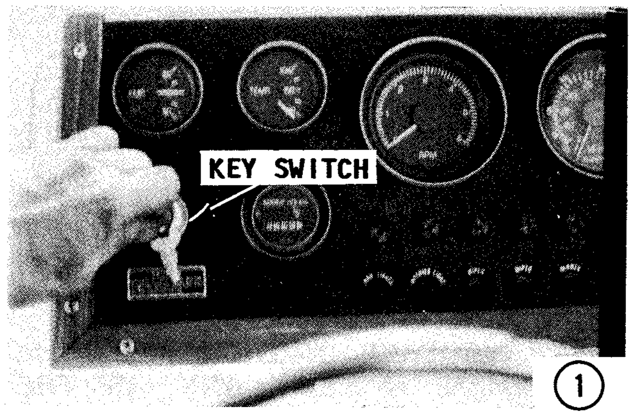
2- The starter spins rapidly, but does not crank the engine.

3- The starter cranks the engine, but too slowly.

The following paragraphs provide a logical sequence of tests designed to isolate a problem in the cranking system.



Engine Will Not Crank



1

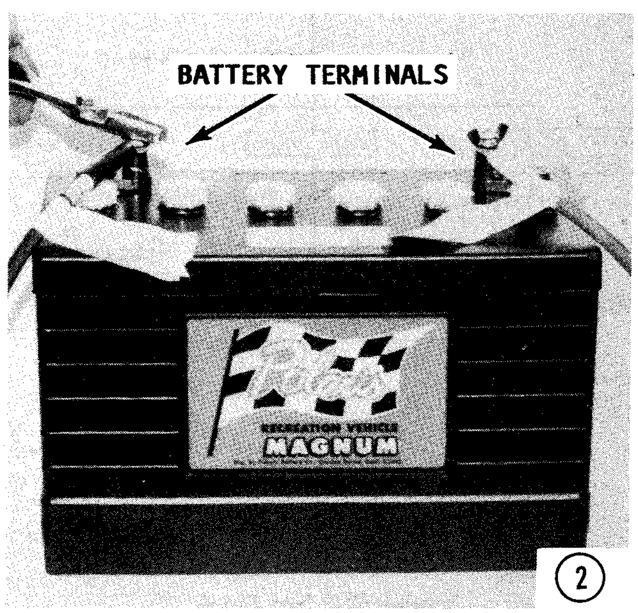
The procedures are keyed by number to matching numbered illustrations as an aid in performing the work.

BATTERY TEST

1- Turn on several of the cabin lights. Now, turn the ignition switch to the **START** position and note the reaction to the brightness of the lights.

With a normal electrical system, the light will dim slightly and the starter will crank the engine at a reasonable rate. If the lights dim considerably and the engine does not turn over, one of several causes may be at fault.

a- If the lights go out completely, or dim considerably, the battery charge is low or almost dead. The obvious remedy is to charge the battery; switch over to a secondary battery if one is available; or to replace it with a known fully charged one.



2

b- If the starting relay clicks, sounding similar to a machine gun firing, the battery charge is too low to keep the starting relay engaged when the starter load is brought into the circuit.

c- If the starter spins without cranking the engine, the drive is broken. The starter will have to be removed for repairs.

d- If the lights do not dim, and the starter does not operate, then there is an open circuit. Proceed to Test 2, Cable Connection Test.

CABLE CONNECTION TEST

2- If the starter fails to operate and the lights do not dim when the ignition switch is turned to **START,** the first area to check is the connections at the battery, starting relay, starter, and neutral-safety switch.

First, remove the cables at the battery; clean the connectors and posts; replace the cables; and tighten them securely.

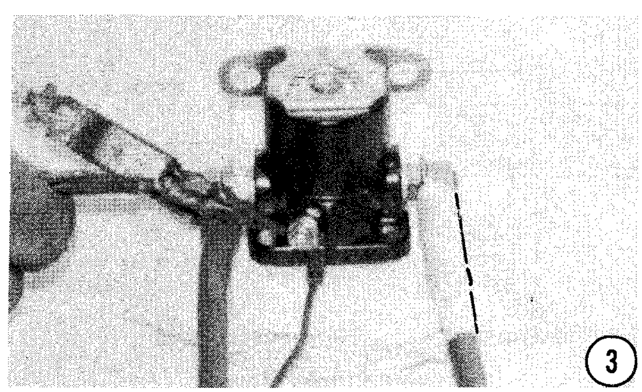
Now, try the starter. If it still fails to crank the engine, try moving the shift box selector lever from **NEUTRAL** to **FORWARD** to determine if the neutral-safety switch is out of adjustment or the electrical connections need attention.

Sometimes, after working the shift lever back-and-forth and perhaps a bit sideways, the neutral-switch connections may be temporarily restored and the engine can be started. Disconnect the leads; clean the connectors and terminals on the switch; replace the leads; and tighten them securely at the first opportunity.

If the starter still fails to crank the engine, move on to Test **3,** Solenoid Test.

SOLENOID TEST

3- The solenoid, commonly called the starting relay, is checked by directly bridging between the terminal from the battery (the large heavy one) to the terminal from the ignition switch.


3

TAKE EVERY PRECAUTION TO ENSURE THERE ARE NO GASOLINE FUMES IN THE BILGE BEFORE MAKING THESE TESTS.

If a bilge blower is installed, operate it for at least five minutes to clear any fumes accumulated in the bilge.

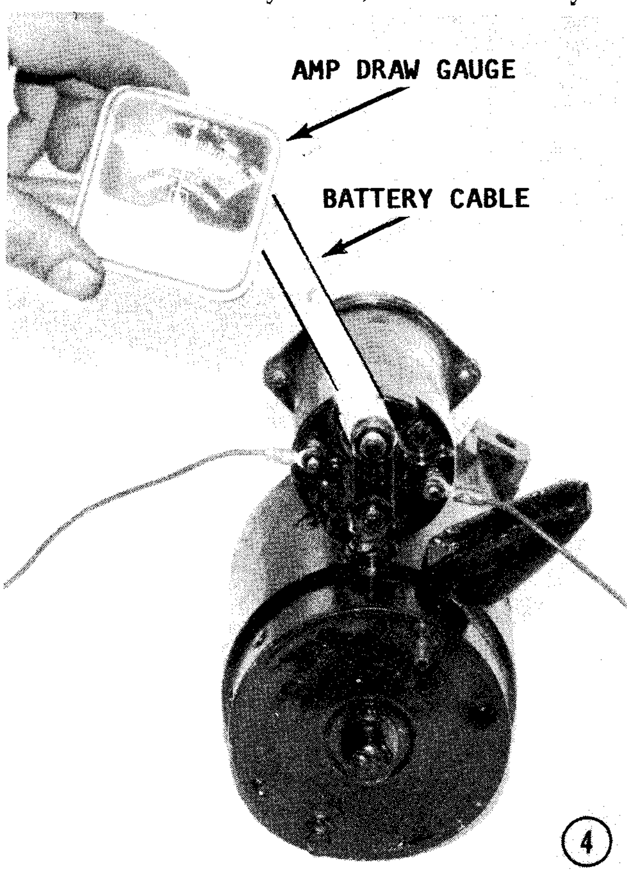
Turn the ignition switch to the **START** position. Now, bridge between the battery lead terminal and the ignition lead terminal with a very heavy piece of wire. If the relay operates, the trouble is in the circuit to the ignition switch. If the starter still fails to operate, continue with Test 4, Current Draw Test.

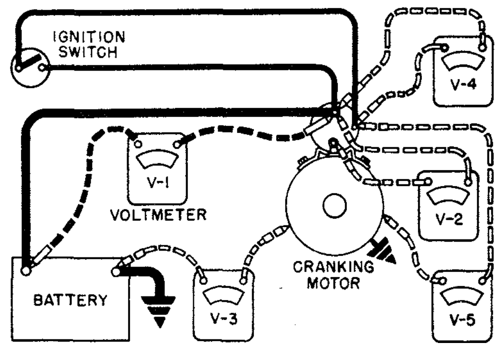
CURRENT DRAW TEST

4- Lay an amperage gauge on the cable between the battery and the starter. Attempt to crank the engine and note the current draw reading of the amperage gauge under load. The current draw should not excced 190 amperes.

CHECKING CRANKING CIRCUIT RESISTANCE

If the starter turns very slowly or not at all, or if the solenoid fails to engage the starter with the flywheel, the cause may be





Functional diagram of hookup for various voltage tests outlined in the text.

excessive resistance in the cranking circuit.

The following checks can be performed with the starter installed on the engine in the boat.

Test the battery and bring it up to a full charge, if necessary. **GROUND** the distributor primary lead to prevent the engine from firing during the following checks.

1- Measure the voltage drop during cranking between the positive battery post and the battery lead terminal of the solenoid.

2- Measure the voltage drop during cranking between the battery lead terminal of the solenoid and the motor lead terminal of the solenoid.

3- Measure the voltage drop during cranking between the negative battery post and the starter motor frame.

If the voltage drop during any of the previous three tests is more than 0.2 volt, excessive resistance is indicated in the circuit being checked. Trace and correct the cause of the resistance.

4- If the solenoid fails to pull in, the problem may be due to excessive high voltage drop in the solenoid circuit. To check voltage drop in this circuit, measure the voltage drop during cranking, between the battery terminal of the solenoid and the switch terminal of the solenoid. If the voltage drop is more than 2.5 volts, the resistance is excessive in the solenoid circuit.

5- If the voltage drop is not more than 2.5 volts and the solenoid does not pull in, measure the voltage available between the switch terminal of the solenoid and the starter motor frame (ground). The solenoid should pull in with 8.0 volts at temperatures up to 200°F. If it does not pull in, remove the starter motor and test the solenoid.

AUTOLITE AND PRESTOLITE CRANKING SYSTEM VOLTAGE TESTS

Even though the starter cannot be tested accurately while it is mounted on the engine, several tests can be made for excessive resistance in the cranking system circuits. The following four tests are designed to isolate excessive resistance with the system under load.

TAKE EVERY PRECAUTION TO ENSURE THERE ARE NO GASOLINE FUMES IN THE BILGE BEFORE MAKING THESE TESTS.

If a bilge blower is installed, operate it for at least five minutes to clear any fumes accumulated in the bilge.

REMOVE THE HIGH-TENSION WIRE FROM THE CENTER OF THE DISTRIBUTOR AND GROUND IT BEFORE MAKING ANY OF THE FOLOWING TESTS.

The circled numbers on the accompanying illustration are keyed to the tests and indicate the connection for the voltmeter leads.

TEST 1

Voltage Drop Across the Battery Terminal Cable and Post:

Connect the positive lead of the voltmeter to the positive post of the battery and the negative lead of the voltmeter to the battery terminal of the starter. Have a partner turn the ignition switch to **START** and note the reading of the voltmeter. If a partner is not available, connect a remote starter cable switch between the **S** and battery terminals of the starter relay.

If the reading is more the 0.5 volt, there is a high-resistance connection between the battery post and the cable. The battery post is the first place for corrosion to form due to the high corrosive nature of the battery electrolyte (acid).

Remove both battery cable connectors; clean the connectors and the battery posts thoroughly; replace the connectors; and tighten them securely.

TEST 2

Voltage Drop In the Battery Cable to Starter Relay:

Leave the positive lead of the voltmeter connected to the positive post of the battery. Connect the negative lead of the voltmeter to the battery terminal of the starter relay. Do not connect it to the cable, but directly to the terminal.

Attempt to crank the engine as described in Test 1, and note the voltage drop. If the voltage drops more than 0.1 volt, the starter is drawing too much current because the cable is too thin, or the connection at the relay is corroded. Clean and tighten the connection or replace the cable.

TEST 3

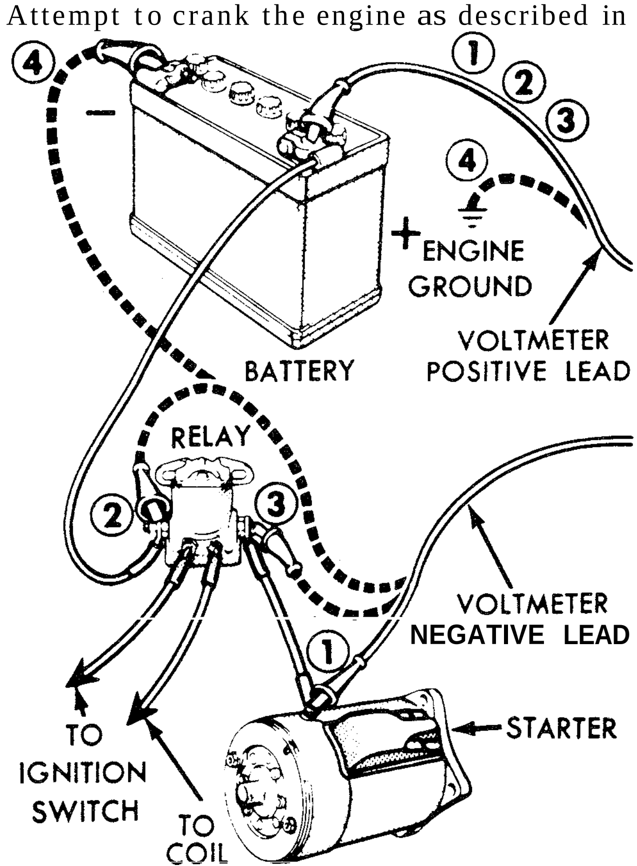
Voltage Drop Across the Contacts Inside the Starter Relay:

Leave the positive lead of the voltmeter connected to the positive battery post. Connect the negative lead of the voltmeter to the starter terminal of the starter relay, as shown. Attempt to crank the engine as described in Test I and note the voltage drop. If the voltage drop is more than 0.3 volt, the starter relay must be replaced because the contacts are burned.

TEST 4

Voltage Drop Between the Negative Battery Post and the **Engine Ground:**

Connect the positive lead of the voltmeter to a **GOOD** engine ground. Do not attempt to obtain a good ground on a painted surface. Connect the negative lead of the voltmeter to the negative battery post. Attempt to crank the engine as described in



Functional diagram of hookup for various tests of an Autolite or Prestolite starting system. The numbers are identified in the text.

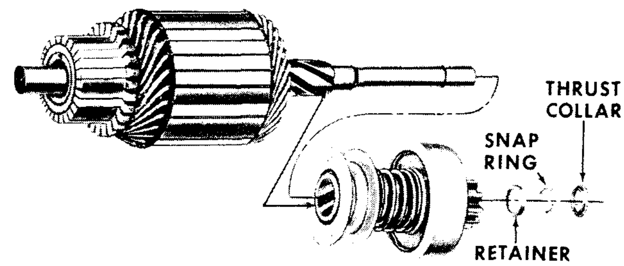
Test 1 and note the voltage drop. If the voltage drop is more than 0.1 volt, the negative battery post or the cable connector is corroded and must be cleaned and the connector tightened securely. One other possibility is paint between the engine and the cable. Remove the cable, scrape the paint away to bare metal, connect the cable again and repeat the test.

6-15 DELCO-REMY STARTER DESCRIPTION AND OPERATION

Delco-Remy starters consist of a set of field coils positioned over pole pieces, which are attached to the inside of a heavy iron frame. An armature, an overrunning clutch drive mechanism, and a solenoid are included inside the iron frame.

The armature consists of a series of iron laminations placed over a steel shaft, a commutator, and the armature winding. The windings are heavy copper ribbons assembled into slots in the iron laminations. The ends of the windings are soldered or welded to the commutator bars. These bars are electrically insulated from each other and from the iron shaft.

An overrunning clutch drive arrangement is installed near one end of the starter shaft. This clutch drive assembly contains a pinion which is made to move along the

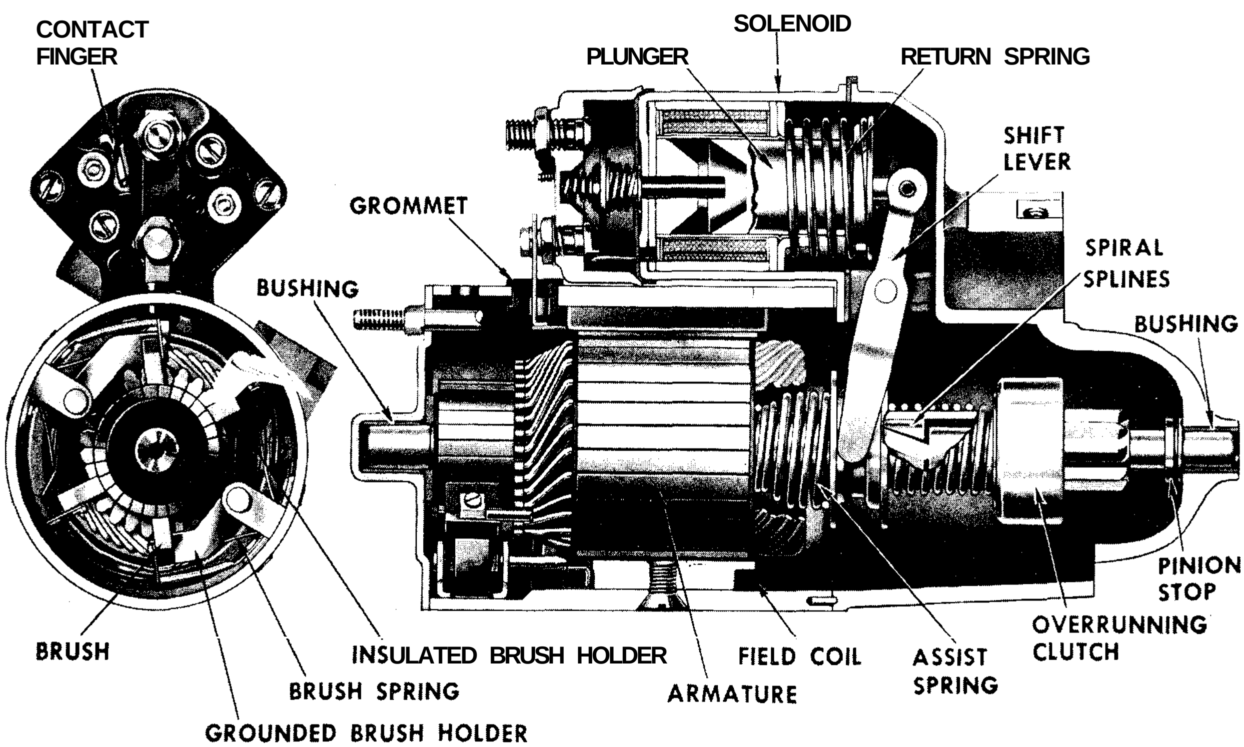


Starter armature and clutch assembly.

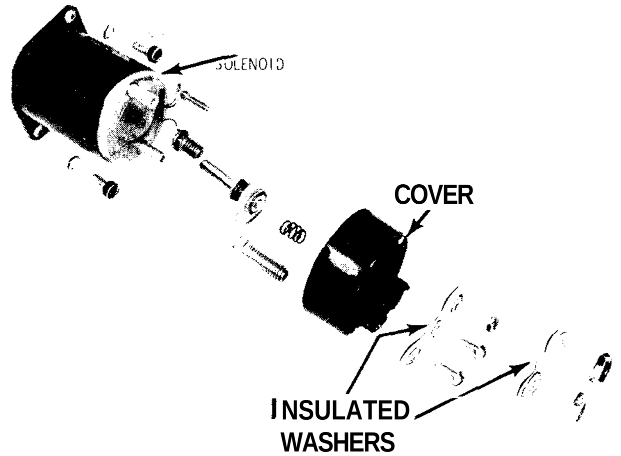
shaft by means of a shift lever to engage the engine ring gear for cranking. The relationship between the pinion gear and the ring gear on the engine flywheel provides sufficient gear reduction to ,meet cranking requirement speed for starting.

The overrunning clutch drive has a shell and sleeve assembly, which is splined internally to match the spiral splines on the armature shaft. The pinion is located inside the shell. Spring-loaded rollers are also inside the shell and they are wedged against the pinion and a taper inside the shell. Some starters use helical springs and others use accordion type springs. Four rollers are used. A collar and spring, located over a sleeve completes the major parts of the clutch mechanism.

When the solenoid is energized and the shift lever operates, it moves the collar endwise along the shaft. The spring assists



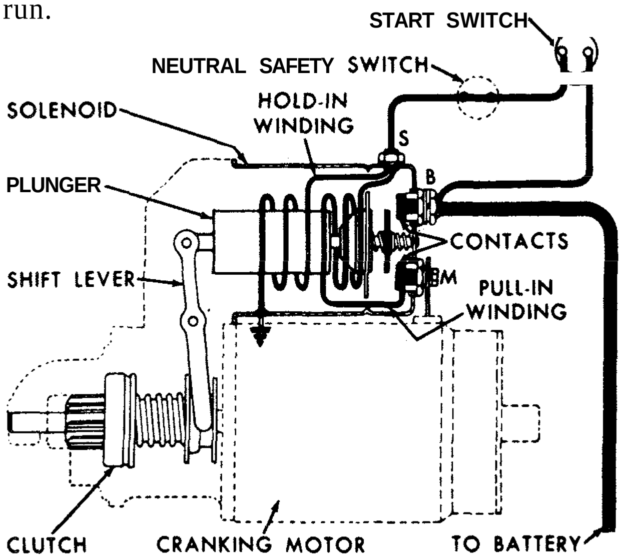
Cross-section view of a cranking motor.



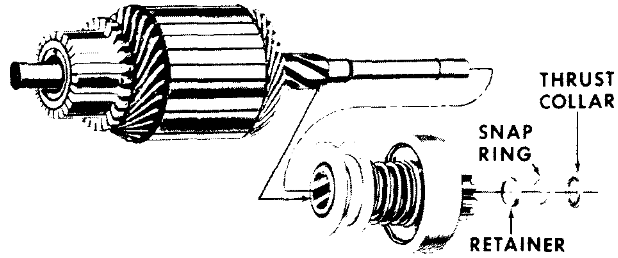
Arrangement of external parts of a starter solenoid.

movement of the pinion into mesh with the ring gear on the flywheel. If the teeth on the pinion fail to mesh for just an instant with the teeth on the ring gear, the spring compresses until the solenoid switch is closed; current flows to the armature; the armature rotates; the spring is still pushing on the pinion; the pinion teeth mesh with the ring gear; and cranking begins.

Torque is transfered from the shell to the pinion by the rollers, which are wedged tightly between the pinion and the taper cut into the the inside of the shell. When the engine starts, the ring gear drives the pinion faster than the armature; the rollers move away from the taper; the pinion overruns the shell; the return spring moves the shift lever back; the solenoid switch is opened; current is cutoff to the armature; the pinion moves out of mesh with the ring gear; and the cranking cycle is completed. The start switch should be opened immediately when the engine starts to prevent prolonged over-run.



Functional diagram of the starter solenoid circuit.



Principle parts of the starter armature and clutch assembly. ***NEVER*** *wash the clutch assembly in solvent or the lubricant will dissolve causing the unit to seize.*

SERVICING DELCO-REMY STARTERS

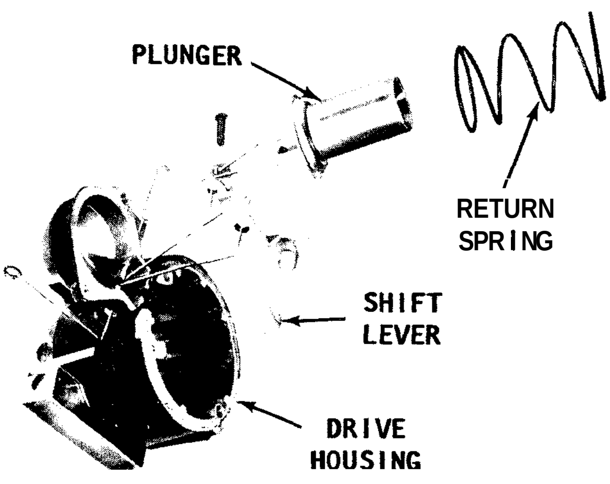
The starter is usually installed in an inaccessible location. For this reason the starter drive-end bushing receives little or no lubrication. For lack of lubrication, the drive-end bushing wears; the armature drops down and rubs against the field pole pieces; internal drag is created; and the output torque of the starter is reduced.

The commutator-end bushing is more accessible and therefore, may receive too much lubrication. The commutator becomes covered with oil; this oil insulates the commutator from the brushes; resistance is increased; and the efficiency of the cranking system is reduced.

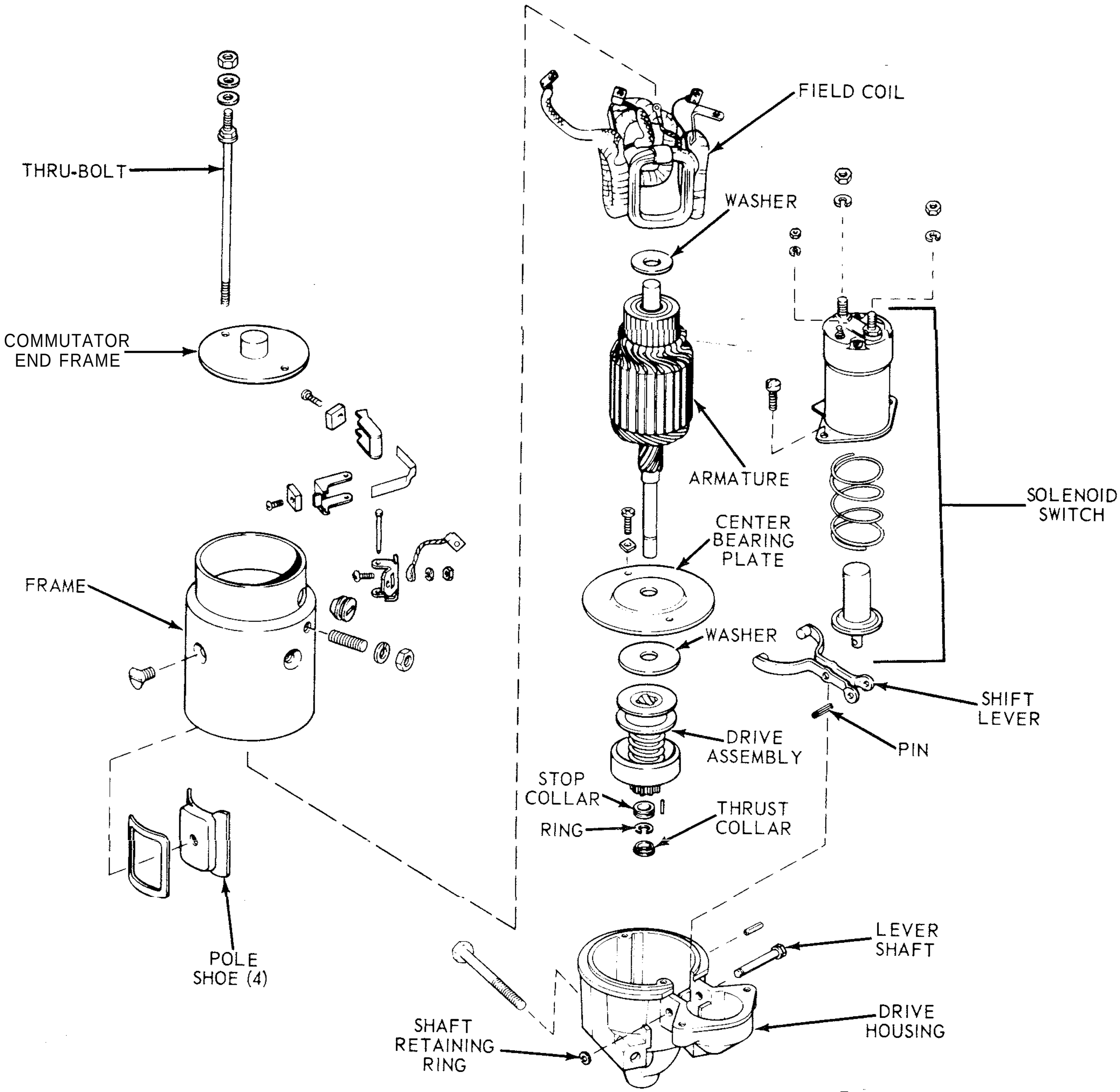
Service on the starter consists of replacing defective switches, bushings, brushes, and turning the commutator to make it true.

TESTING DELCO-REMY STARTERS

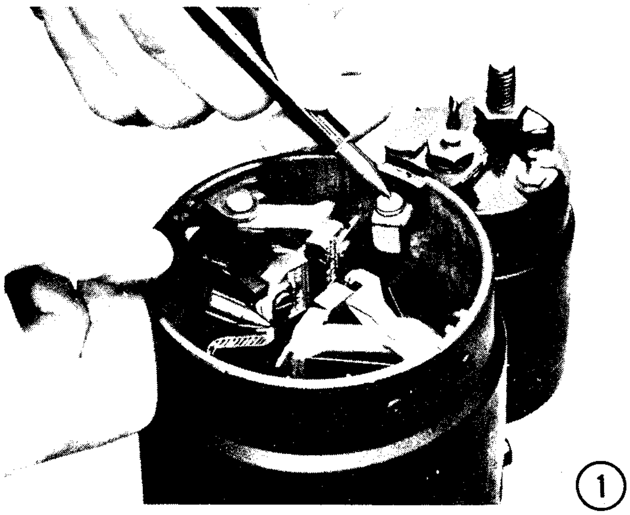
The following paragraphs provide a logical sequence of tests designed to isolate a defective part in the starter.

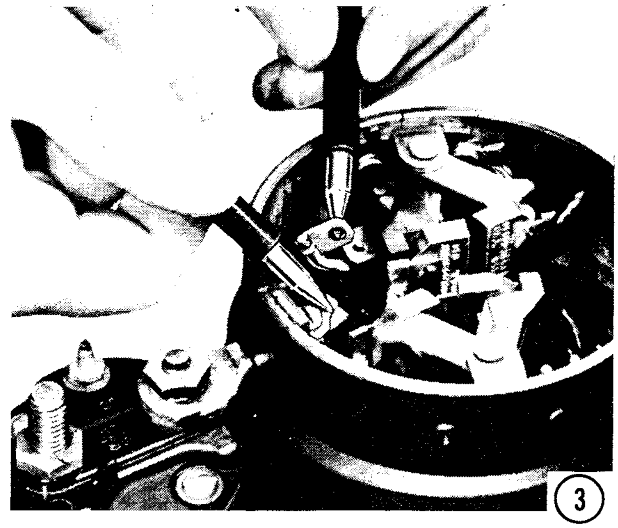


Arrangement of the drive housing and related parts.



Exploded view of the Delco-Remy starter with principle parts identified.





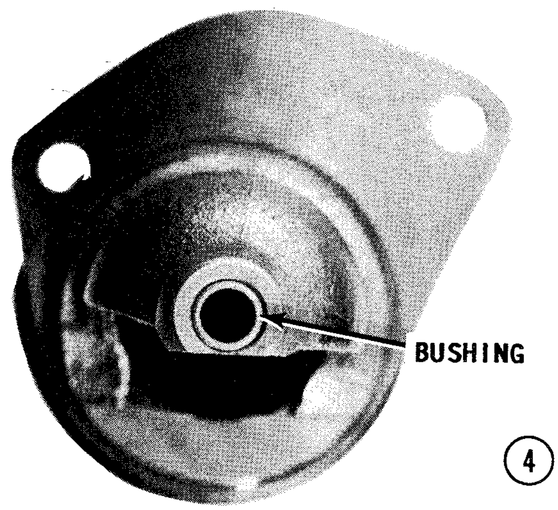
The procedures and suggestions are keyed by number to matching numbered illustrations as an aid in performing the work.

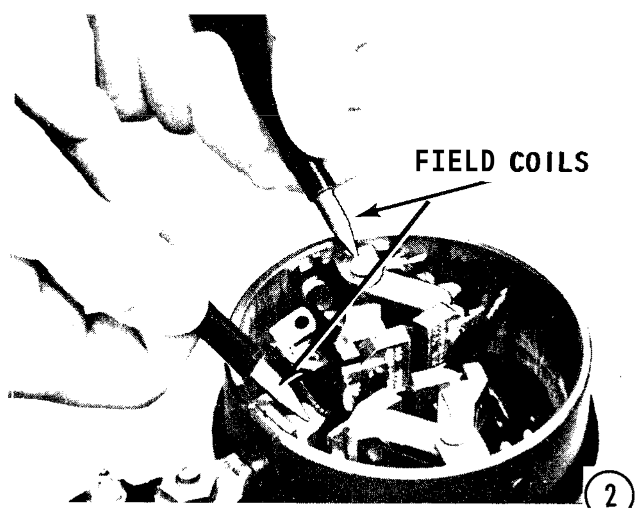
1– Make contact with one probe of a test light on each end of the field coils connected in series. If the test light fails to come on, there is an open in the field coils and repair or replacement is required.

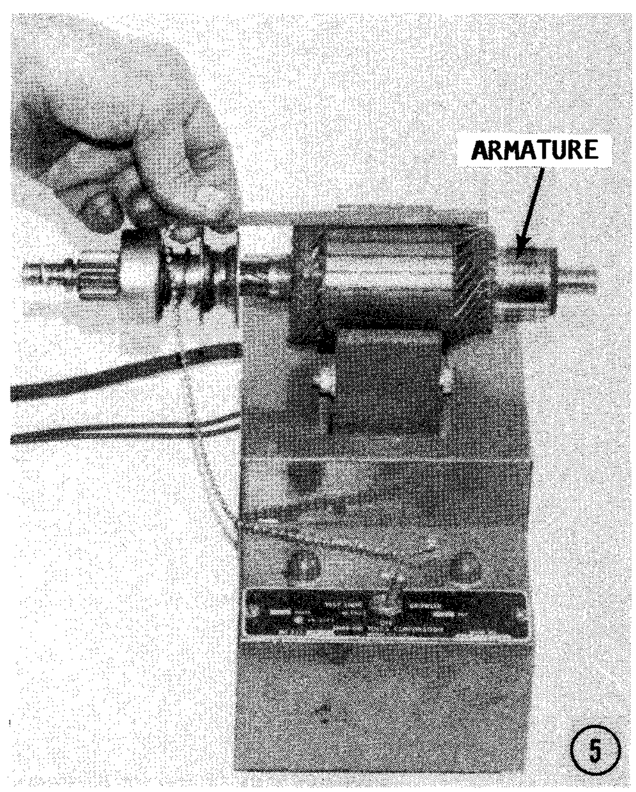
2– Disconnect the shunt coil or coil ground. Make contact with one probe of the test light on the connector strap and on the field frame with the other probe. If the test light comes on, the field coils are grounded and the defective coils must be repaired or replaced.

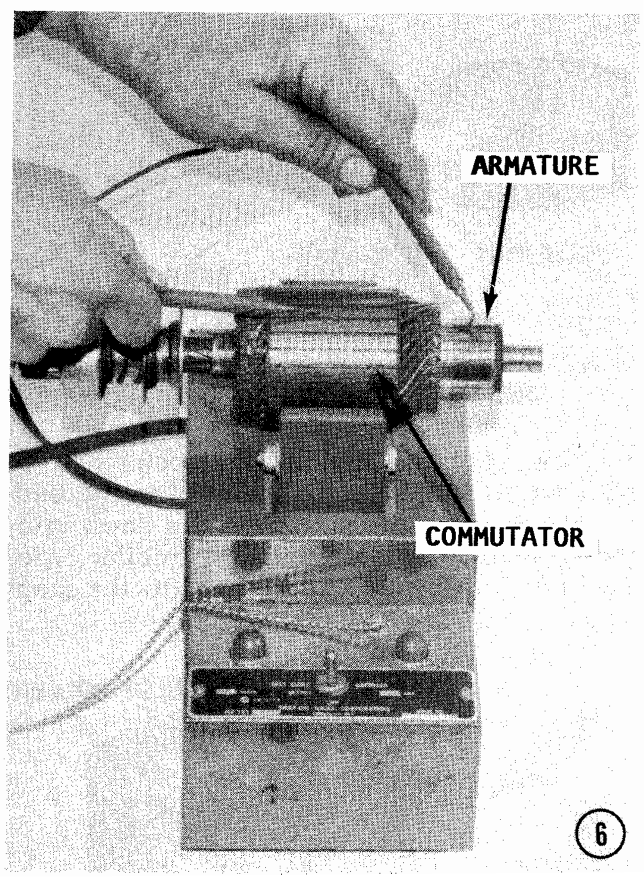
3– Disconnect the shunt coil grounds. Make contact with one probe of the test light on each end of the shunt coil, or coils. If the light fails to come on, the shunt coil is open and must be repaired or replaced.

4– ALWAYS replace the drive-end bushing during a starter overhaul.

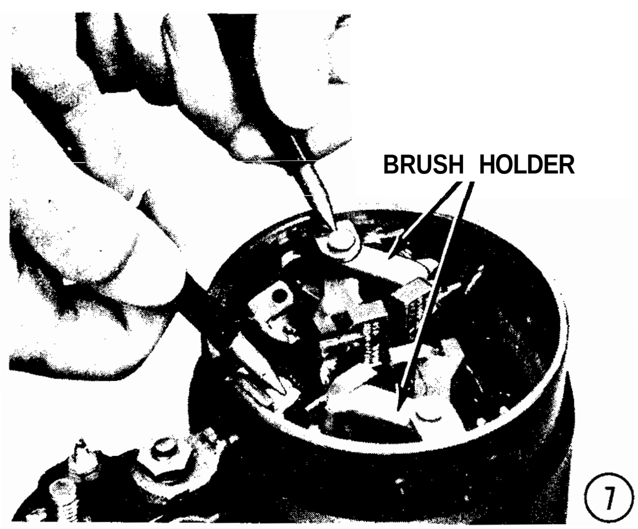


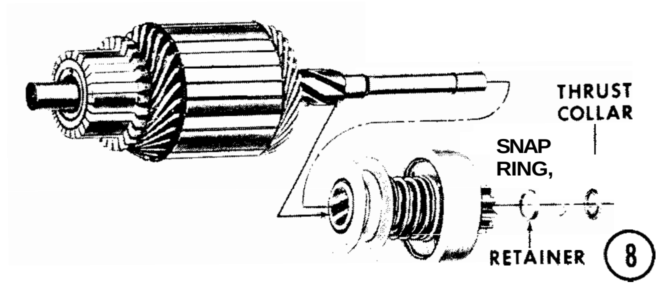






5- True the commutator, if necessary, in a lathe. **NEVER** undercut the mica because the brushes are harder than the insulation. Check the armature for a short circuit by placing it on a growler and holding a hack saw blade over the armature core while the armature is rotated. If the saw blade vibrates, the armature is shorted. Clean between the commutator bars, and then check again on the growler. If the saw blade still vibrates, the armature must be replaced.



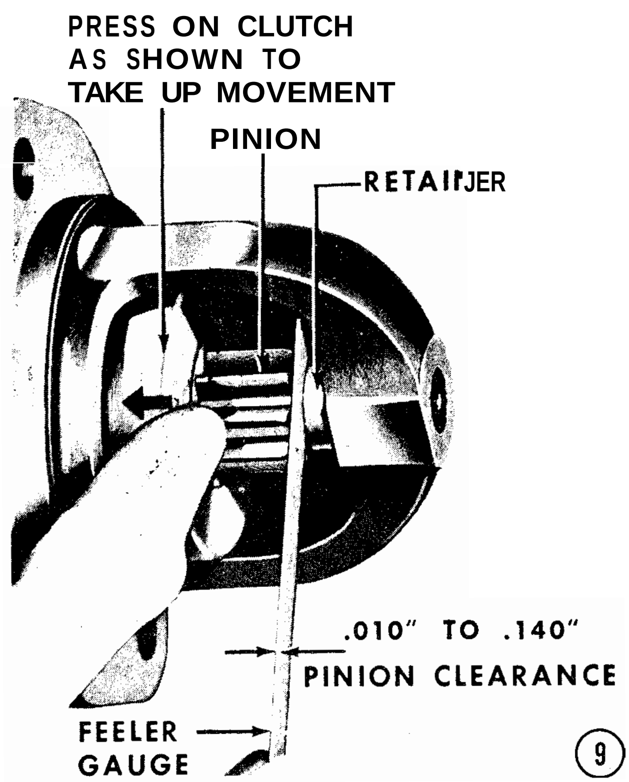


6- Make contact with one probe of the test light on the armature core or shaft and the other probe on the commutator. If the light comes on, the armature is grounded and must be replaced.

7- Wash the brush holder in solvent, and then blow it dry with compressed air. Use the test light to verify two of the brush holders are grounded and two are insulated.

8- The overrunning clutch is secured to the armature by a snap ring. This ring may be removed if the clutch requires replacement. **NEVER** wash an overrrunning clutch in solvent or the lubricant will be disolved; the clutch will fail; the engine will drive the cranking motor armature at high speed; the windings will be thrown out by centrifugal force; and the armature will be destroyed.

9- Check the clearance between the pinion and the retainer. **NEVER** use a 12-volt battery while making this check or the armature will turn. Using a **6-VOLT** battery, energize the solenoid coil; push the

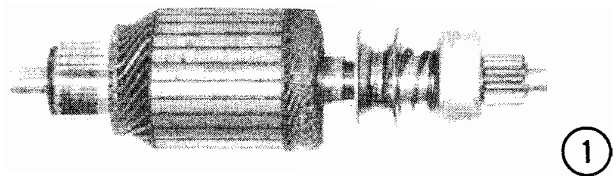


pinion back to take up the slack; and measure the clearance with a feeler gauge. If the clearance is not between 0.010" and 0.140", the solenoid is not properly installed, or the linkage is worn.

ASSEMBLING A DELCO REMY

After all parts have been cleaned, tested, and replacements obtained, the starter is ready to be assembled.

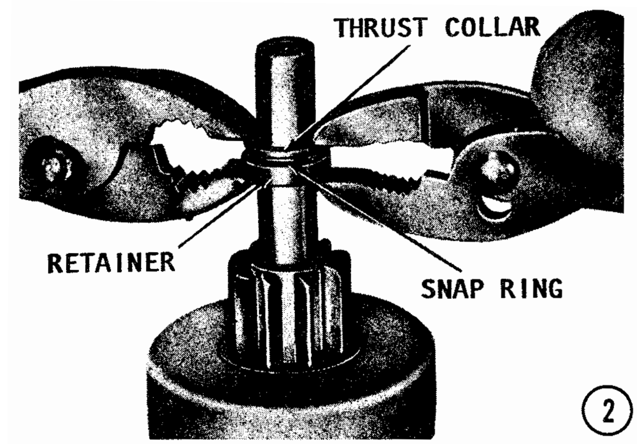
The following instructions are numbered and matched to numbered illustrations as an aid in performing the work.



1

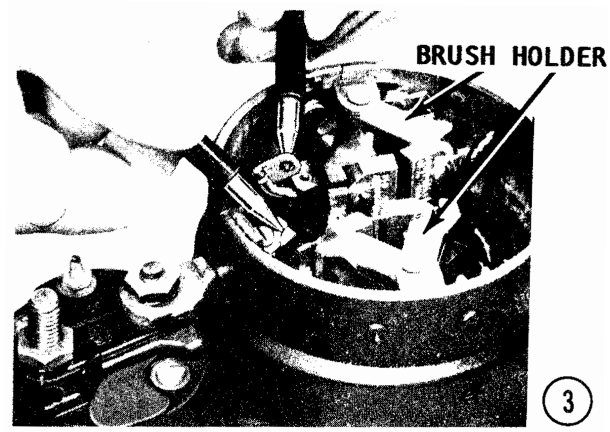
1– Lubricate the drive end of the armature shaft with a thin coating of silicone lubricant. Slide the clutch assembly onto the armature shaft with the pinion facing outward. Slide the retainer onto the shaft with the cupped surface facing the end of the shaft (away from the pinion).

2– Stand the armature on end on a wooden surface with the commutator down. Position the snap ring on the upper end of the shaft and hold it in place with a block of wood.

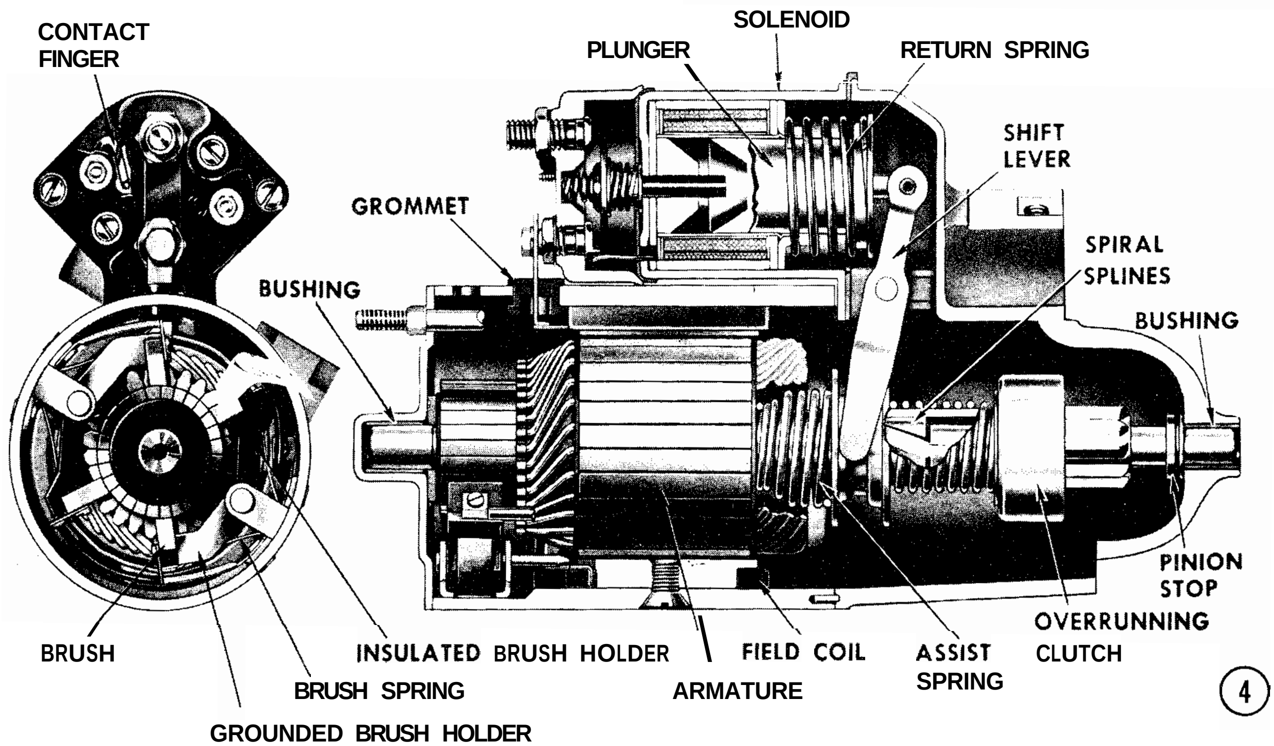


2

Now, tap on the wood block with a hammer to force the snap ring over the end of the shaft. Slide the snap ring down into the groove. Assemble the thrust collar onto the shaft with the shoulder next to the snap ring.



3



4

Place the armature flat on the work bench, and then position the retainer and thrust collar next to the snap ring. Next, using two pair of pliers at the same time (one pair on each side of the shaft), grip the retainer and thrust collar and squeeze until the snap ring is forced into the retainer.

Lubricate the drive housing bushing with a thin coating of silicone lubricant. **MAKE SURE** the thrust collar is in place against the snap ring and the retainer.

3- Install the brushes into the brush holders. Assemble the insulated and grounded brush holders together with the **"V"** spring and position them as a unit on the support pin. Push the holders and springs to the bottom of the support, then rotate the springs to engage the **"V"** in the support.

Attach the ground wire to the grounded brush and the field lead wire to the insulated brush.

4- Slide the armature and clutch assembly into place in the drive housing engaging the shift lever with the clutch.

Position the field frame over the armature and apply a thin coating of liquid neoprene (Gaco) between the frame and the solenoid case. Place the frame in position against the drive housing. **TAKE CARE** not to damage the brushes.

Apply a coating of silicone lubricant to the bushing in the commutator end frame. Place the leather brake washer onto the armature shaft and slide the commutator end frame onto the shaft. Connect the field coil connectors to the **MOTOR** solenoid terminal.

Pinion Clearance Check:

After the starter has been assembled, check the pinion clearance as follows:

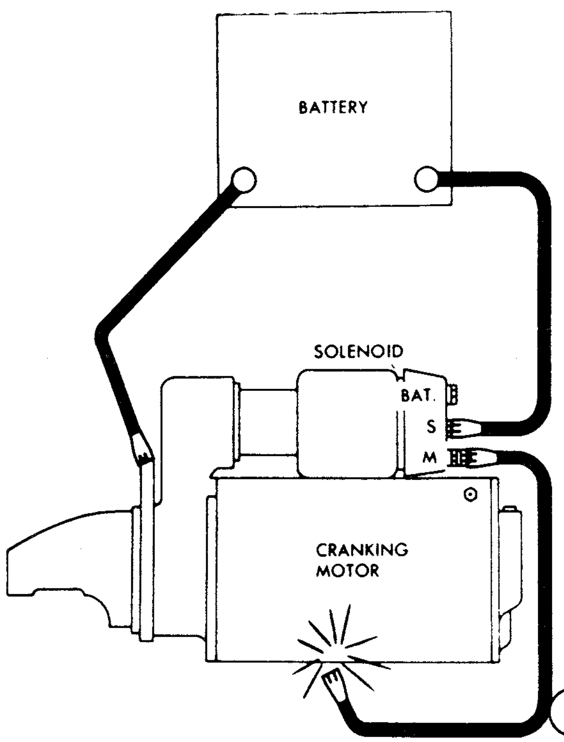
1- Connect a battery, of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame or ground terminal. **DISCONNECT** the motor field coil connector for the test.

Momentarily make contact with a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. The pinion will now shift into the cranking position and it will remain there until the battery is disconnected.

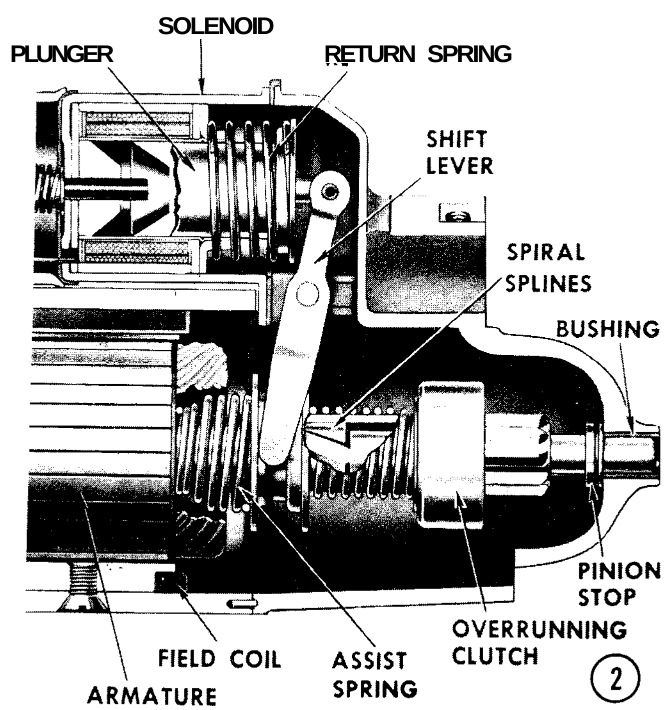
2- Push the pinion back towards the commutator end to eliminate any slack movement. Now, measure the distance between the pinion and the pinion stop with a feeler gauge. The clearance should be between 0.10" and 0.040". If the clearance is not within these limits, it may indicate excessive wear of the solenoid linkage shift lever yoke buttons or improper assembly of the shift lever mechanism. Any worn or defective parts should be replaced.

6-16 AUTOLITE CRANKING SYSTEM

The Autolite cranking system consists of the starter, relay, ignition switch, battery,

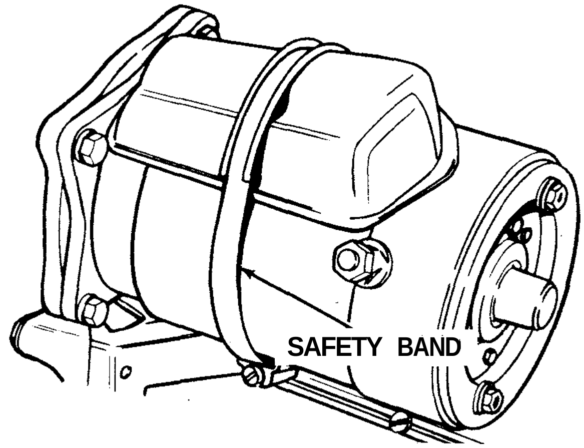


1



2

cables, and necessary wiring for efficient operation. The starter has a special moveable pole shoe within the field housing to engage the drive assembly. As on all marine installations, a neutral-start switch is installed in the shift box to permit operation of the starter only when the shift lever is in the **NEUTRAL** position.



A marine starter must have a clamp installed, as shown. The starter cap coming off during engine operation could cause a fire.

AUTOLITE STARTERS DESCRIPTION AND OPERATION

The starter has an integral, positive-engagement drive mechanism. The sequence of events in the cranking operation is as follows: The ignition key is turned to the **START** position; current flows to the relay; the relay makes contact through heavy-current type contacts; current is directed through the grounded field coil; the moveable pole shoe is activated; the special pole shoe is attached to the starter drive piunger lever which forces the drive (with the overrunning clutch) to engage the ring gear of the engine flywheel; after the shoe is fully seated, it opens the field coil grounding contacts; and the starter is in normal cranking operation. While the starter is turning the engine flywheel, a holding coil holds the moveable pole shoe in the fully seated position.

DISASSEMBLING AN AUTOLITE STARTER

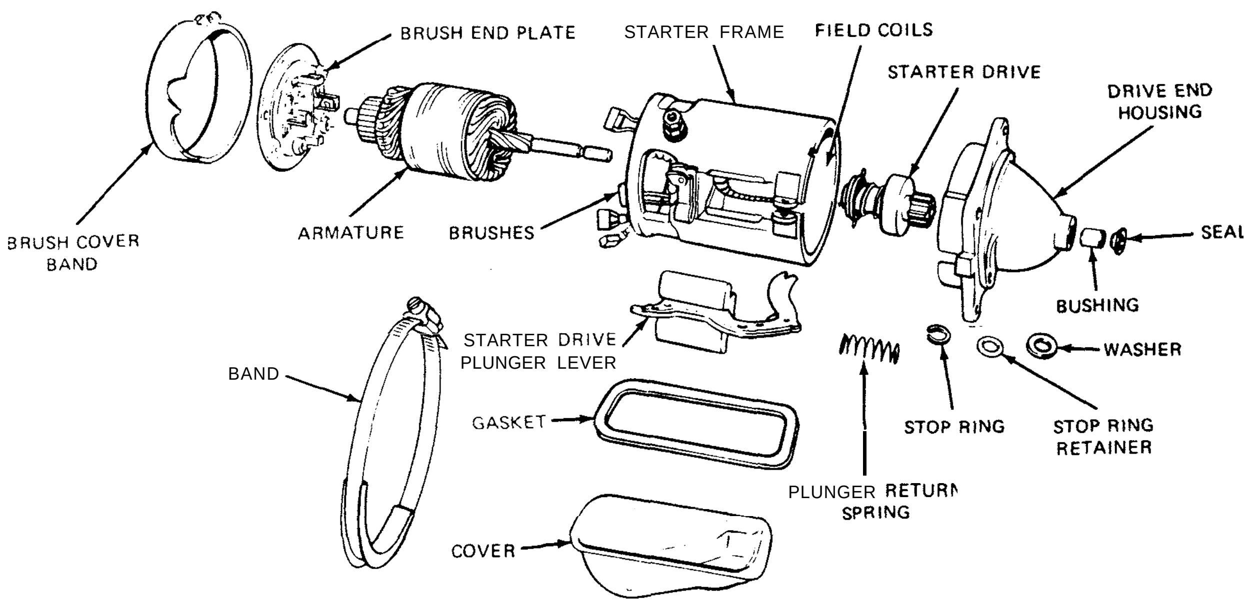
Loosen the retaining screw, and then slide the brush cover band off the starter. Remove the starter drive plunger cover and gasket. Take note of the lead position as an aid to assembling. Remove the commutator brushes from the brush holders.

Remove the long through bolts. Separate the drive end housing from the starter. Remove the plunger return spring. Drive out the pivot pin retaining the starter gear plunger lever, and then remove the lever and the armature.

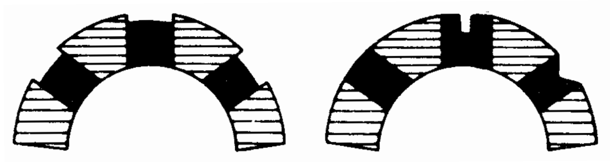
Remove the stop ring retainer from the shaft, and then remove and discard the stop ring. Slide the starter drive gear assembly off the shaft.

Remove the retaining screws, and then the brush end plate. Remove the screws retaining the ground brushes to the frame.

CAREFULLY bend the tab on the field coil retaining sleeve up, and then remove the sleeve.



Exploded view of an Autolite starter with principle parts identified.



Armature segments properly cleaned (left) and improperly cleaned (right).

CLEANING AND INSPECTING

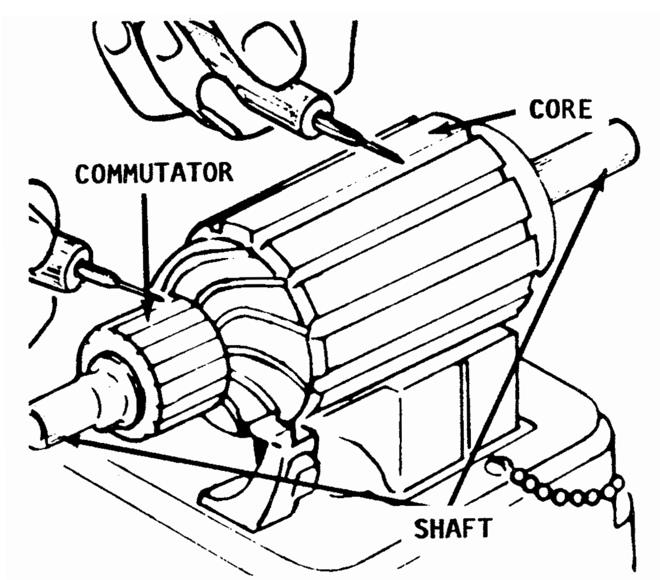
Clean the field coils, armature, commutator, brushes, and bushings with a brush or compressed air. Wash all other parts in solvent and blow them dry with compressed air. **NEVER** use a grease dissolving solvent to clean electrical parts and bushings, because the solvent would damage the insulation and remove the lubricating qualities from the bushings.

Perform electrical tests on any part suspected of defect, according to the procedures outlined in the Testing Sections of this Chapter.

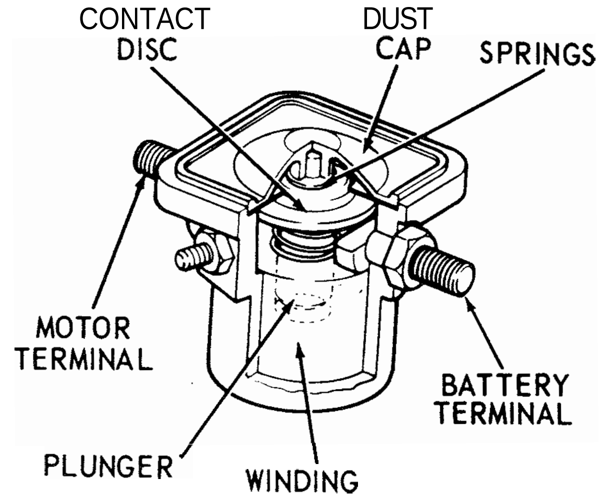
Check the commutator for run-out. Inspect the armature shaft and both bearings for scoring.

Turn the commutator in a lathe if it is out-of-round by more than 0.005".

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. Check the insulated brush holders for shorts to ground. If the brushes are worn down to 1/4" or less, they must be replaced.



Armature check for a short: one test light lead on each commutator segment, alternately, and the other lead on the armature core. No continuity.



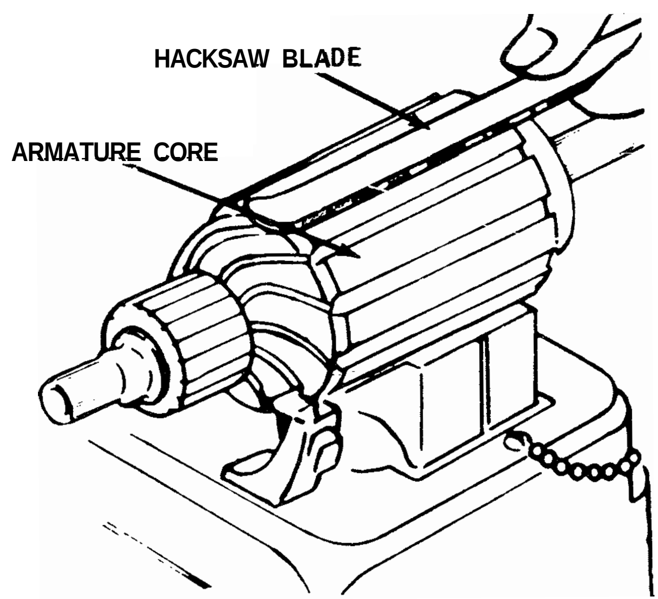
Cutaway view of a starter solenoid showing major parts.

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.

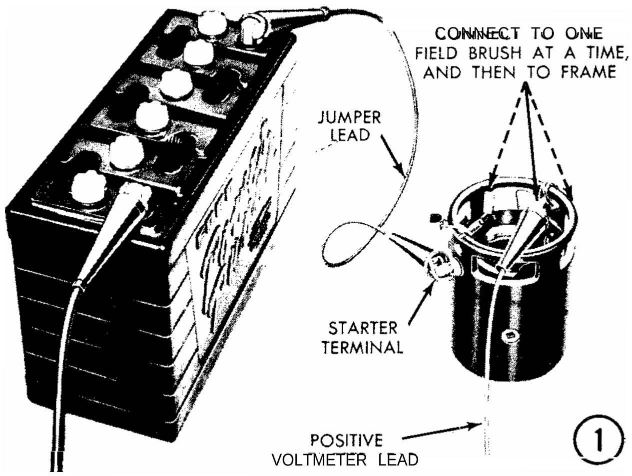
BENCH TESTING AUTOLITE STARTERS

The following paragraphs provide a logical sequence of bench tests designed to isolate a defective part in the starter.

The procedures and suggestions are keyed by number to matching numbered illustrations as an aid in performing the work.



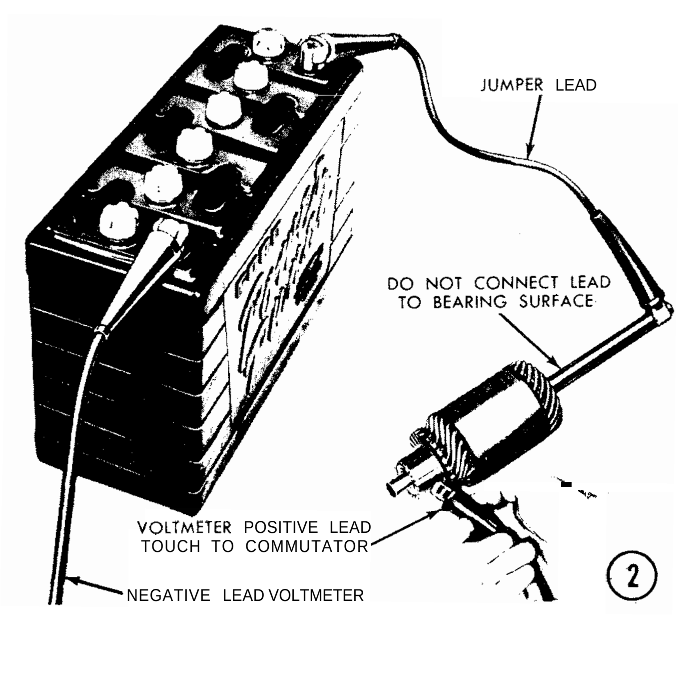
Method of testing the armature for a short circuit using a growler and hacksaw blade. If the blade vibrates, the mica must be cleaned out or the armature replaced.

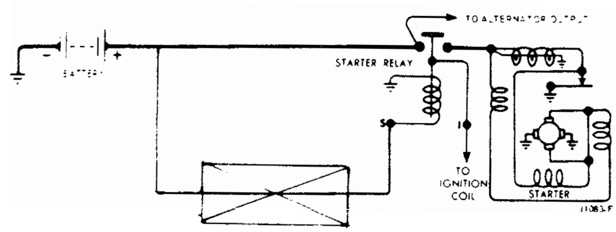


Armature and Field Open Circuit Test

1– Examine the commutator for any evidence of burning. A spot burned on the commutator is caused by an arc formed every time the commutator segment con nected to the open-circuit winding passes under a brush.

Connect a jumper wire from the positive terminal of a battery to the starter terminal. Connect the negative lead from a voltmeter to the negative battery terminal. Connect the positive voltmeter lead to one field brush, as shown. Since the starter has three field windings, it will be necesasary to check each of the windings separately. If the voltmeter fails to register, the coil is open and must be replaced.



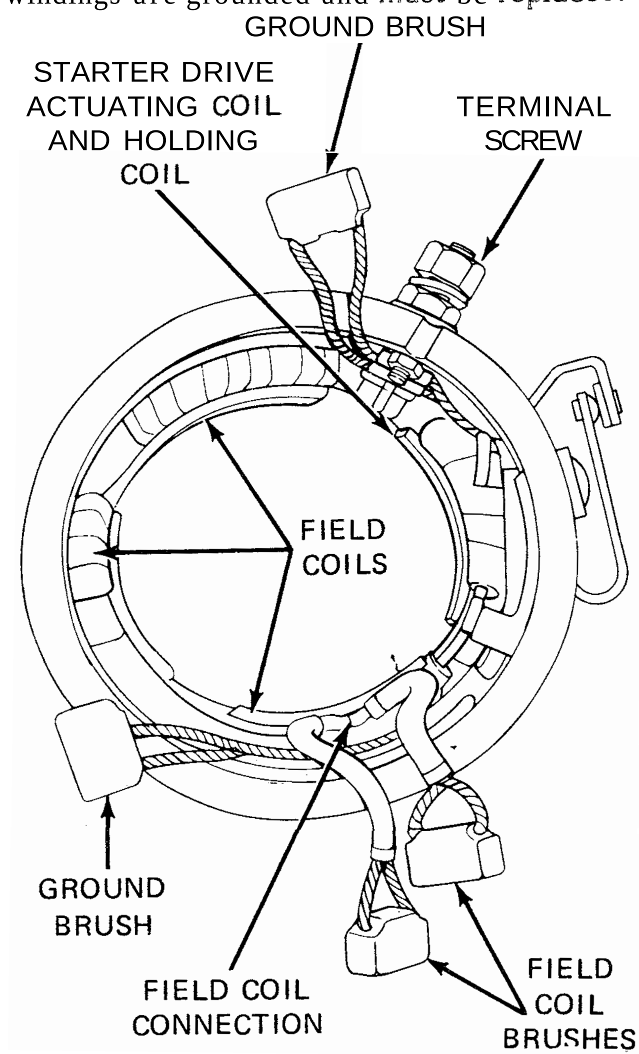


Schematic diagram of the Ford cranking system.

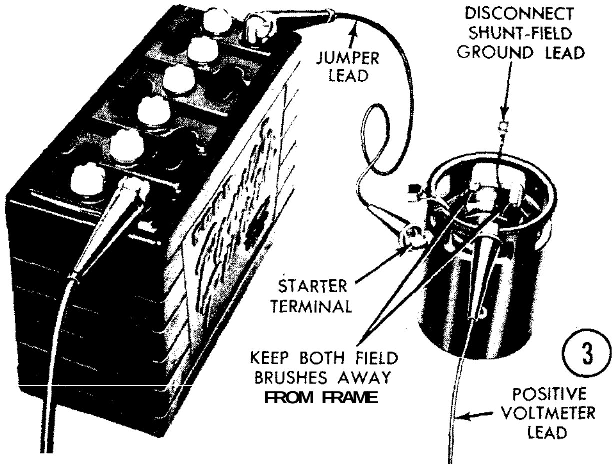
Armature Grounded Circuit Test

2– This test will determine if the winding insulation has failed, permitting a conductor to touch the frame or armature core.

Connect a jumper wire from the positive terminal of a battery to the end sf the starter shaft opposite the commutator, as shown. Connect the negative Bead from a voltmeter to the negative battery terminal. Make contact with the positive voltmeter lead to the commutator and check for voltage. If the voltmeter fails to register, the windings are grounded and must be replaced.



Principle parts of the field coil and brushes.



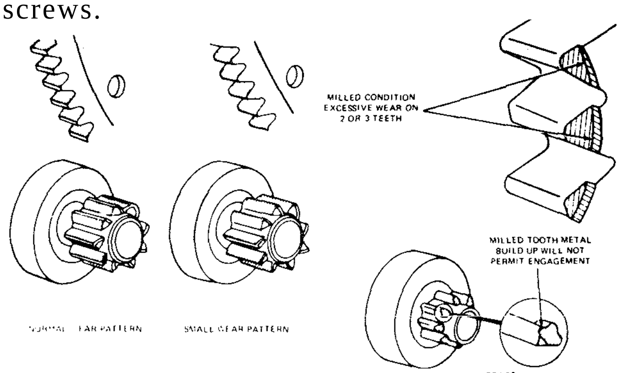
Field Ground Circuit **Test**

3– Grounded field windings can be detected using a voltmeter and battery. First, **DISCONNECT** the shunt–field ground lead. Next, connect a jumper lead from the positive lead of the battery to the starter terminal. Connect the negative lead from the voltmeter to the negative battery terminal. Now, keep both field brushes away from the starter frame, and make contact with the positive lead from the voltmeter to the starter frame, as shown. If the voltmeter indicates any voltage, the field windings are grounded and must be replaced.

ASSEMBLING AN AUTOLITE STARTER

Position the new insulated field brushes lead onto the field coil terminal and secure it with the clip. To ensure extended service, solder the lead, clip and terminal together, using resin core solder.

Place the solenoid coil ground terminal over the nearest ground screw hole. Place each ground brush in position to the starter frame and secure them with the retaining screws.



Wear pattern on a starter drive gear and on the flywheel ring gear.

Place the brush end plate into position on the starter frame with the boss on the plate indexed in the slot on the frame.

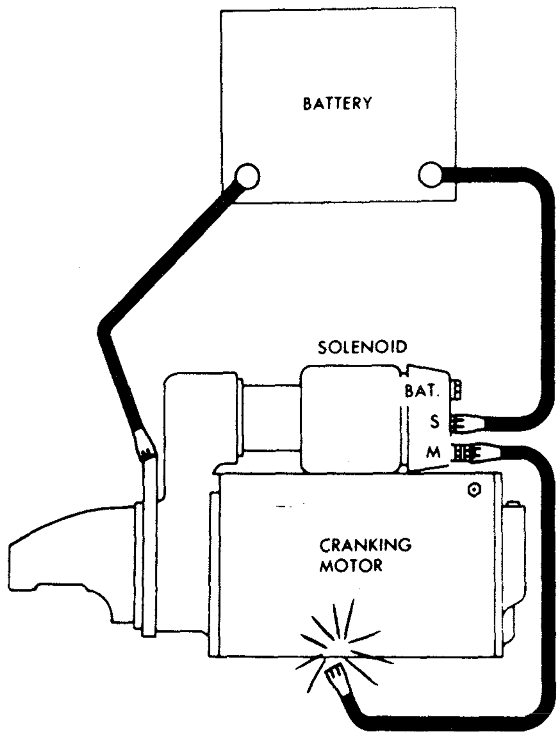
Coat the armature shaft splines with a thin layer of Lubriplate. Slide the starter drive assembly onto the armature shaft, and secure it in place with a **NEW** stop ring and stop–ring retainer.

Slide the fiber thrust washer onto the commutator end of the shaft, then insert the armature shaft into the starter frame. (The thrust washer is not used with molded commutator armatures.)

Place the drive gear plunger lever in position in the frame and the starter drive assembly, and then install the pivot pin.

Fill the drive–end housing bearing bore **ONLY 1/4 FULL** with lubrication. Insert the starter drive plunger lever return spring in position, and then mate the drive–end housing with the starter frame. Install and tighten the through bolts to a torque value of 55-75 in–lbs. **TAKE CARE** not to pinch the brush leads between the brush plate and the frame. **CHECK TO BE SURE** the stop ring retainer is properly seated in the drive housing.

Install the brushes in the brush holder with the **SPRINGS CENTERED** on the brushes.



Bench testing a starter.

Check the brush spring tension by pulling on a line with a scale. The line should be hooked under the brush spring near the brush and the pull should be parallel to the face of the brush. Take the reading just as the spring leaves the brush. The reading should be from 32 to 40 ozs.

Finally, position the gasket and drive gear plunger lever cover in place, then slide the brush cover band in place and secure it with the retaining screw.

If the engine should start, but fail to reach the predetermined rpm to disengage the detent pin, a ratchet-type clutch on the screw shaft allows the pinion to over-run the armature shaft and prevent damage to the starter. When this over-run occurs, a light buzzing sound is audible from the clutch ratcheting. When the engine is accelerated, the drive will release and the buzzing sound will stop.

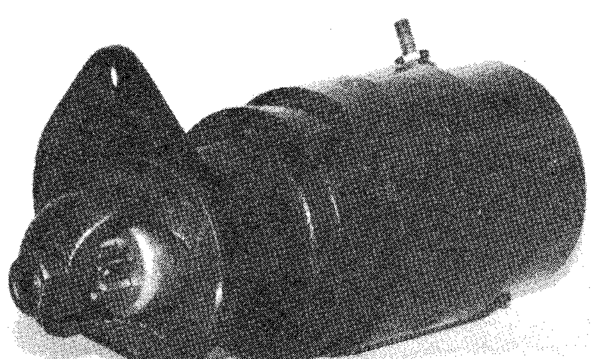
6-17 PRESTOLITE CRANKING SYSTEM

DESCRIPTION AND OPERATION

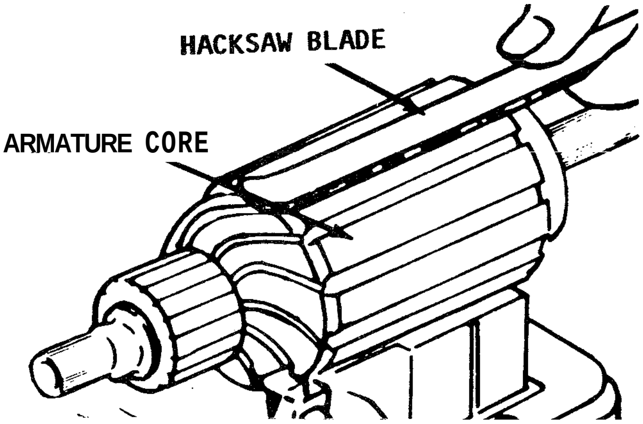
The Prestolite cranking system includes the starter, relay, ignition switch, battery, cables, wiring, and a special starter relay. As with all marine installations, a safety-start switch is installed in the shift box. This switch prevents operation of the cranking system unless the shift lever is in the **NEUTRAL** position.

The starter motor has a Bendix Folo-Thru type drive designed to overcome disengagement of the flywheel ring gear when engine speed has reached a predetermined rpm.

After the pinion engages the flywheel ring gear, a spring-loaded detent pin in the pinion gear assembly indexes in a notch in the screw shaft. The pinion then remains



Prestolite starter which may be installed on some OMC stern drive units.



Method of testing the armature for a short circuit using a growler and hacksaw blade. If the blade vibrates, the mica must be cleaned out or the armature replaced.

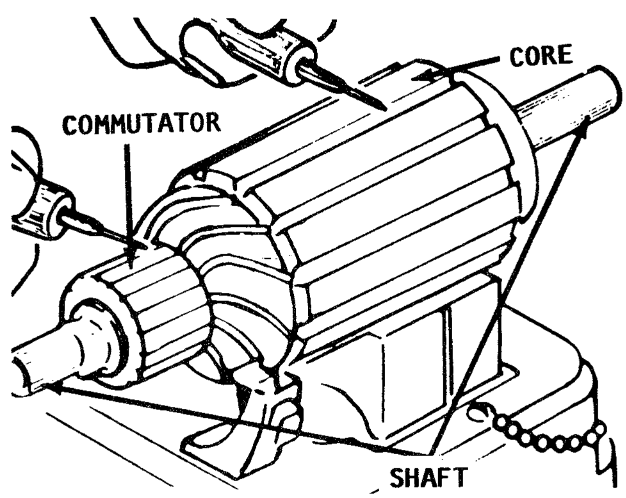
locked in the engaged position until the engine rpm reaches a predetermined speed. At that point, centrifugal force moves the detent pin out of the notch in the shaft and allows the pinion to disengage the flywheel.

If, during the starting operation, the engine fails to continue running, movement of the pinion in a disengaging direction is prevented by the pin indexed in the screw shaft. For this reason, if the starting motor is re-engaged while the engine kicks back, the starter will not be damaged.

DISASSEMBLING A PRESTOLITE STARTER

First, remove the two through-bolts, and then separate the cover assembly from the commutator end. Next, remove the starter housing from the armature and the end frame.

Now, remove the two screws securing the bearing assembly to the end frame, and then remove the end frame assembly.



Armature check for a short: one test light lead on each commutator segment, alternately, and the other lead on the armature core. No continuity.

Remove the pin and the Bendix drive. Remove the bearing assembly from the armature shaft. Remove the three attaching screws, and then the brush plate. Remove the springs and brushes.

If the field is to be removed, disconnect the field wire from the terminal stud; the four screws; field assmbly; and pole shoes.

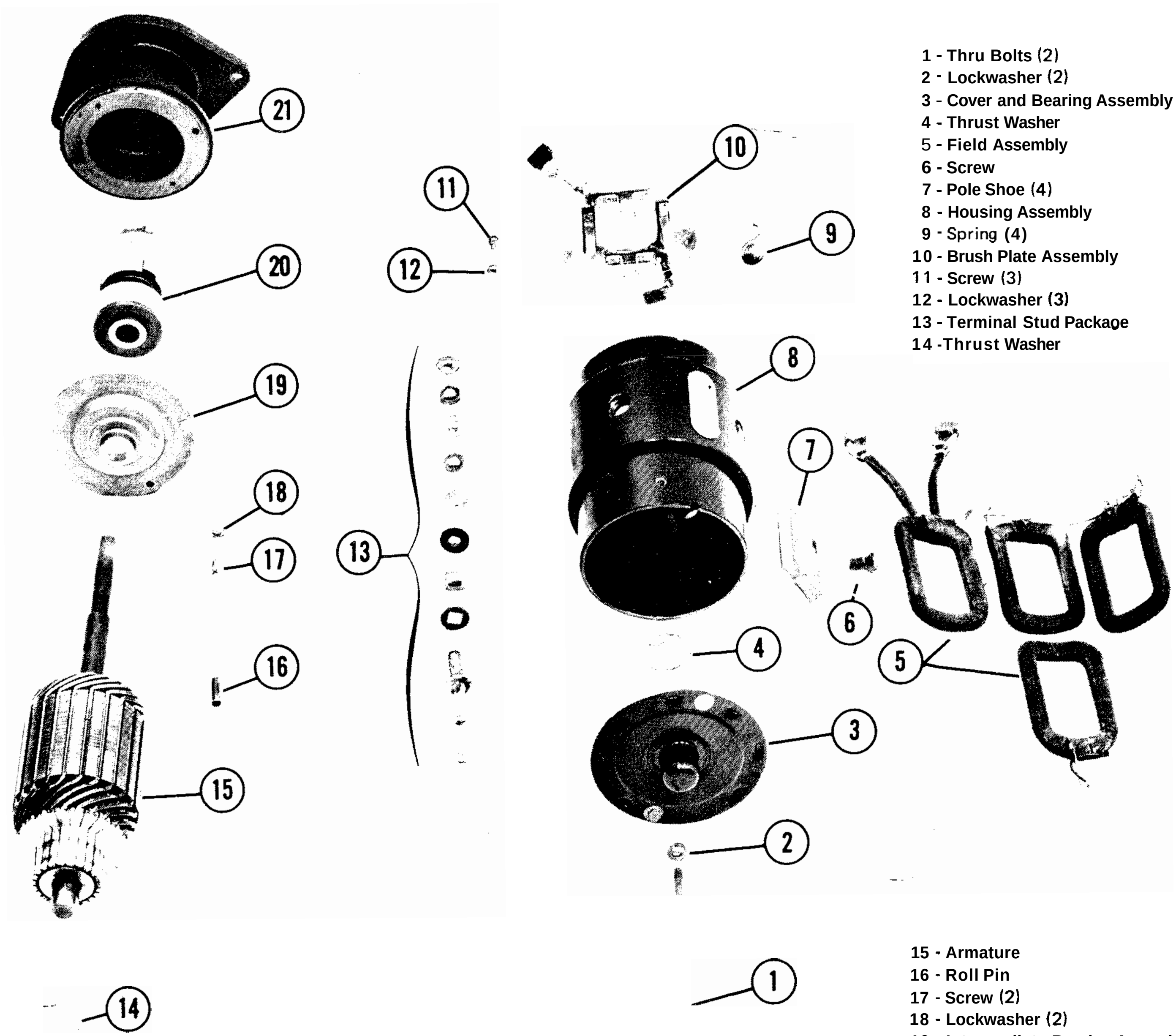
CLEANING AND INSPECTING

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 part suspected of defect, according to the procedures outlined in the Testing Sections of this Chapter.

Check the armature shaft to be sure it is not worn or bent. Check the other armature parts: Commutator worn; laminations core scored; or connections requiring attention.



1 - Thru Bolts (2)
2 - Lockwasher (2)
3 - Cover and Bearing Assembly
4 - Thrust Washer
5 - Field Assembly
6 - Screw
7 - Pole Shoe (4)
8 - Housing Assembly
9 - Spring (4)
10 - Brush Plate Assembly
11 - Screw (3)
12 - Lockwasher (3)
13 - Terminal Stud Package
14 - Thrust Washer
15 - Armature
16 - Roll Pin
17 - Screw (2)
18 - Lockwasher (2)
19 - Intermediate Bearing Assembly
20 - Bendix Drive Assembly
21 - End Frame Assembly

Exploded view of a Prestolite starter with principle parts identified.

Inspect the armature shaft and bearings for scoring or excessive wear. If the commutator is rough, burned, out-of-round, or has high mica on it, the commutator must be turned on a lathe. The out-of-round limit is 0.005".

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. Check the insulated brush holders for shorts to ground. If the brushes are worn down to 1/4" 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.

Inspect the drive teeth of the Bendix drive. The pinion teeth must engage the teeth on the engine flywheel ring gear by at least one-half the depth of the ring gear teeth. Any less engagement will cause excessive wear to the ring gear and finally, starter drive failure. Replace the drive gear or the ring gear if the teeth are pitted, broken, damaged, or show evidence they are not engaging properly.

ASSEMBLING A PRESTOLITE STARTER

Install a **NEW** terminal stud according to the sequence given on the package. Use a test light to verify the stud is insulated from the starter housing.

Place the field winding and pole shoes in the starter housing. Slide the four screws through the housing and into the poles. Tighten the screws firmly.

Position the brush plate assembly in place and install the three screws and lockwashers through the starter housing and into the plate assembly, then tighten them firmly*

Connect the shunt ground wire to the brush plate assembly and install the brush springs.

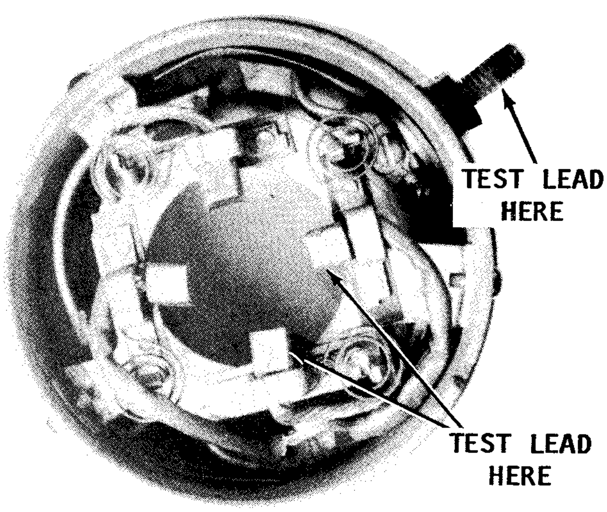
Apply a thin coating of lubricant to the bearing surface of the bearing assembly, and then slide the asembly into place on the armature shaft. Apply a thin coating of lubricant to the drive-end of the armature shaft. Slide the Bendix drive assembly onto the shaft, and then install a NEW roll pin.

Apply a thin coating of lubricant to the bearing in the end frame asesmbly, and then install the armature into the end frame. Install the two screws and lockwashers through the bearing assembly and into the end frame. Tighten the screws firmly. Position the armature assembly into the starter housing. Slide the required number of thrust washers onto the armature shaft to obtain an end play of 0.005" to 0.030".

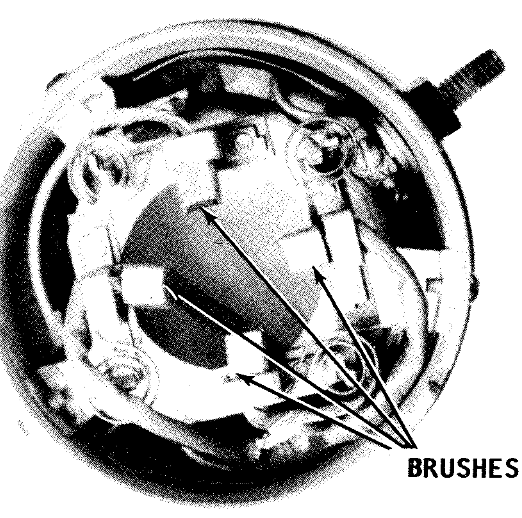
Check the brush spring tension by pulling on a line with a scale. The line should be hooked under the brush spring near the brush and the pull should be parallel to the face of the brush. Take the reading just as the spring leaves the brush. The reading should be from 32 to 40 ozs.

Apply lubricant to the bearing in the cover assembly, and then position the cover on the armature shaft and starter. Slide the through-bolts through the housing and tighten them securely.

Check the armature shaft end play again.



Points to attach test leads when testing a Prestolite starter.



Prestolite starter with the brushes installed.

7
REMOTE CONTROLS

7-1 INTRODUCTION

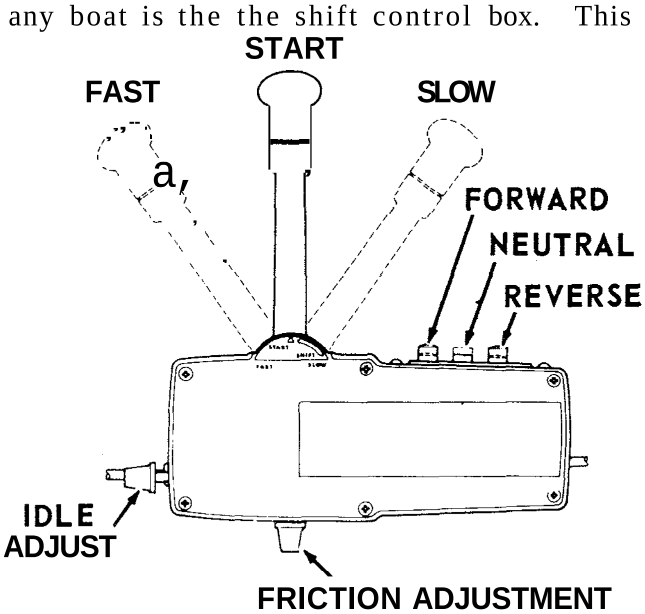
Boat accessories are seldom obtained from the original equipment manufacturer. Shift boxes, Selectrim, steering, bilge pumps, blowers, and other similar equipment may be added after the boat leaves the plant. Because of the wide assortment, styles, and price ranges of such accessories, the distributor, dealer, or customer has a wide selection from which to draw, when outfitting the boat.

Therefore, the procedures and suggestions in this chapter are general in nature in order to cover as many units as possible, but still specific and in enough detail to allow you to troubleshoot, repair, and adjust each of these accessories for maximum comfort, performance, and enjoyment.

7-2 SHIFT BOXES

Undoubtedly, the most used accessory on any boat is the the shift control box. This unit is a remote-control device for shifting the stern drive and at the same time controlling the throttle. The shift box on OMC equipped boats is considered an accessory, therefore many installations may have other than a factory installed unit. OMC equipped boats may have one of four different type shift boxes: The single lever, side mount, push button, or a binnacle mount unit.

Early model stern drive shift boxes used a switch for shifting into forward or reverse gear. Later models were equipped with a cut-out switch in the cranking system. This switch prevents the cranking system from operating unless the shift lever is in the **NEUTRAL** position. All shift box arrangements have a means of advancing the throttle without moving the shift lever into gear. This device is commonly known as the "warm-up" lever and may be adjusted for low and fast idle speeds.



One type of OMC shift box.

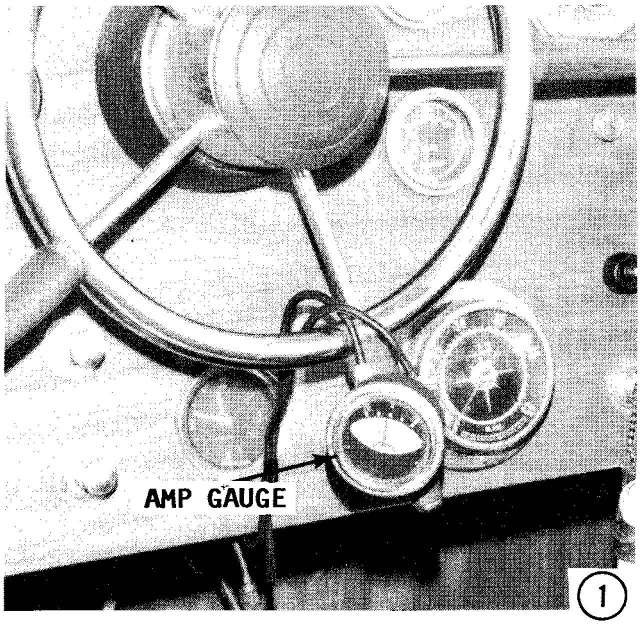
7-3 TROUBLESHOOTING GEAR BOXES

The following paragraphs provide a logical sequence of tests, checks, and adjustments, designed to isolate and correct a problem in the shift box operation.

The procedures and suggestions are keyed by number to matching numbered illustrations as an aid in performing the work.

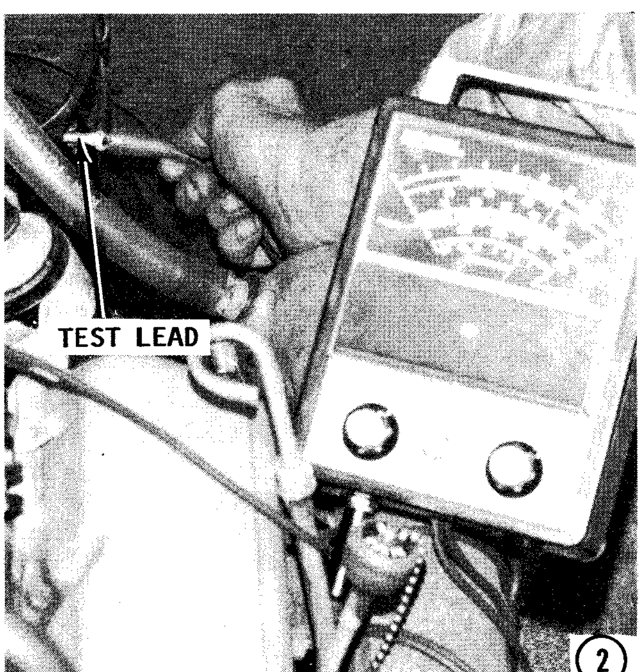
DIFFICULT SHIFT OPERATION

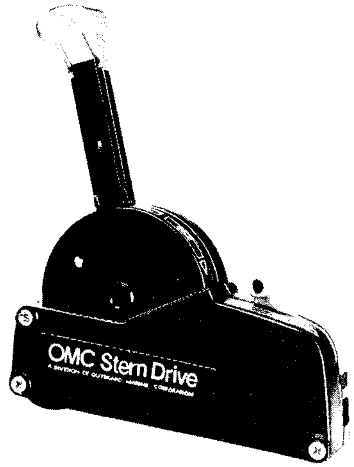
BE SURE to cycle the shift lever to the full position in both directions, when making any test on the shift box. The safety-neutral switch may have a dead spot and will not indicate the switch is defective unless the shift lever is fully cycled for each test.

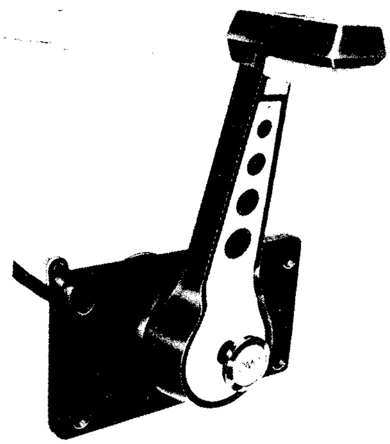


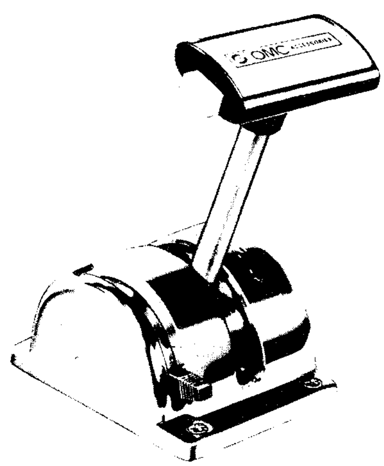
1- Turn the ignition switch to the ON position and note the ammeter reading. Now, operate the shift control lever to the **FORWARD** position, and then to the **REVERSE** position. Note how much the ammeter reading increased each time the shift lever was moved. If the reading was more than 2.5 amperes for either shift positions, continue with the following checks.

Disconnect the shift leads at the intermediate housing. Again operate the shift lever and note the current loss. If the current draw is still more than 2.5 amperes, then check for a short in the control box switch or wiring. If the current draw is









Three most popular OMC shift boxes.

normal with the leads disconnected from the intermedidate housing, then check for a short in the gear case coil(s) or wiring. If the coil leads are shorted to each other, both shift coils would be energized, stalling the engine or causing serious damage to the driveshaft.

2- Testing the shifting coils is accomplished by first disconnecting the wires on the port side of the engine, under the exhaust manifold, just above the tilt motor. Next, connect an ohmmeter first to one shift coil lead and ground, and then to the other in the same manner. A reading of more than 4.5 to 6.5 ohms indicates a short in the coil or lead. No reading at all indicates an open circuit. If the results of this test indicate a short in the cirucit, the gearcase must be disassembled and inspected. See Chapter 10, Stern Drive.

CRANKING SYSTEM INOPERATIVE

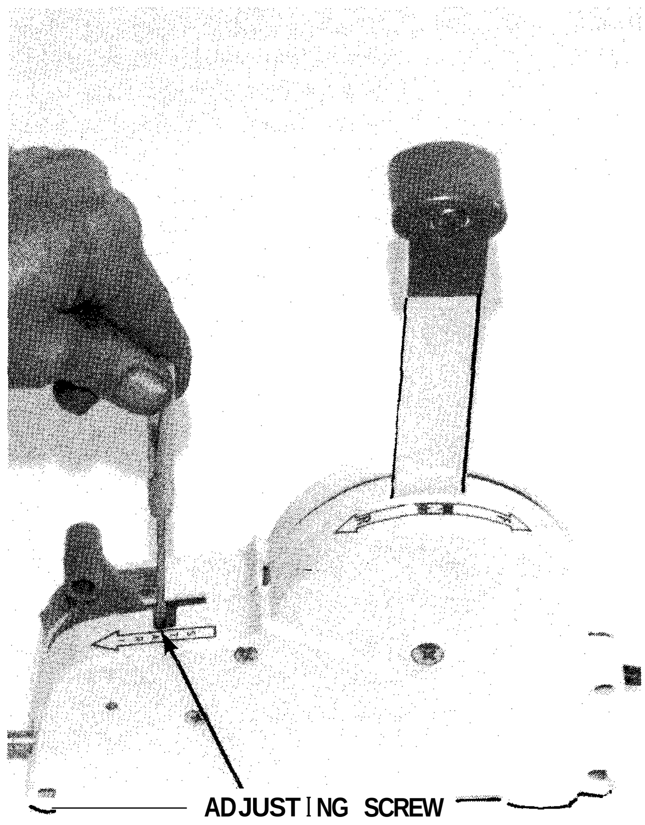
3- If the cranking system fails to operate the starter properly when the shift lever is in the **NEUTRAL** position, check the 20-ampere fuse between the ingition switch **BAT** terminal and the ammeter **GEN** terminal. **If** the fuse is not defective, check for continuity by making contact with one lead from a test light to the ST terminal of the ignition switch and the other probe to the starter solenoid.

If the starter operates in gear (which it should not do) and also in **NEUTRAL,** check for a short between the two white leads in the shift box wiring.

ADJUSTING STARTER LOCK-OUT

4- Move the shift lever to the **NEUTRAL** position and the warm-up lever to the **START** position. Now, turn the ignition switch to the **START** position in an attempt to crank the engine. If the starter fails to crank the engine, move the warm-up lever to the **IDLE** position, and then rotate the setscrew counterclockwise one-half turn. Move the auxiliary throttle to the **START** position, and then turn the ignition switch to the **START** position again. If the starter still fails to crank the engine with the warm-up lever in the full ADVANCE position, back off the warm-up lever to determine the point at which the starter ceases to operate. Make the adjustment sf the setscrew clockwise a half-turn at a time until the starter operates only with the warm-up lever in the full **START** position.

3



4

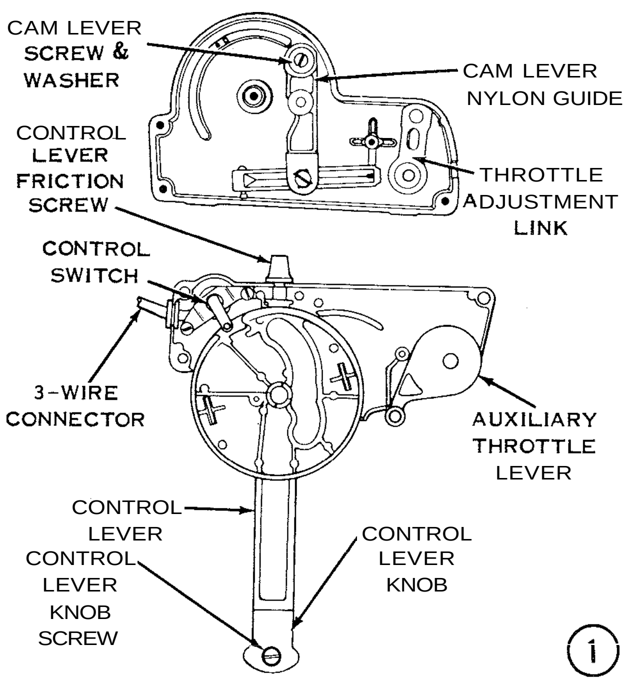
7-4 REMOVAL AND REPAIR OF SINGLE- AND SIDE-MOUNT SHIFT BOXES

1- Remove the attaching screws; pull the shift clear, and then disconnect the shift wire under the dash. Check the shift box for salt water corrosion, worn bushings, and general condition. Clean the box thoroughly inside and out with solvent and blow it dry with compressed air. Apply a thin coat of engine oil on all of the metal parts. The three-position switch installed in the gear box cannot be repaired. Therefore, if a problem is isolated to the swtich, it must be replaced.

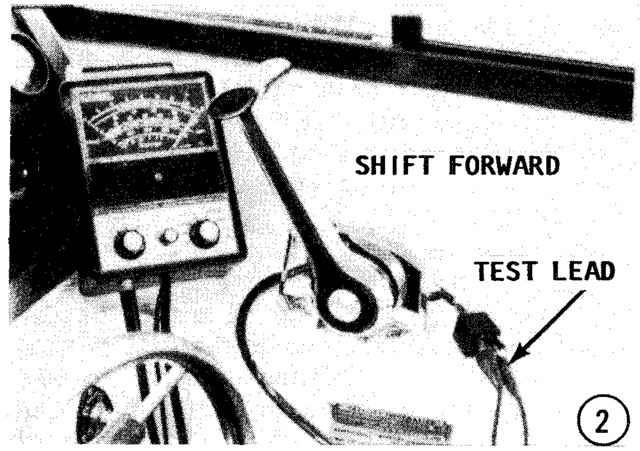
Testing The Shift Switch

The warm-up lever on single-mount type shift boxes is red and located at the rear of the box. The control on side-mount shift boxes is a knob which is operated by a pull/push action.

2- To test the switch for the FORWARD position, make contact with one probe of a test light, or continuity meter, to the ignition terminal (purple or red lead) and to 'the forward (green lead) terminal with the other probe. Now, move the shift lever to the FORWARD, NEUTRAL, and REVERSE positions. The test light should come on, or the meter indicate continuity, when the shift lever is in the FORWARD position and remain off, or indicate an open circuit, for the other two shift positions.



1



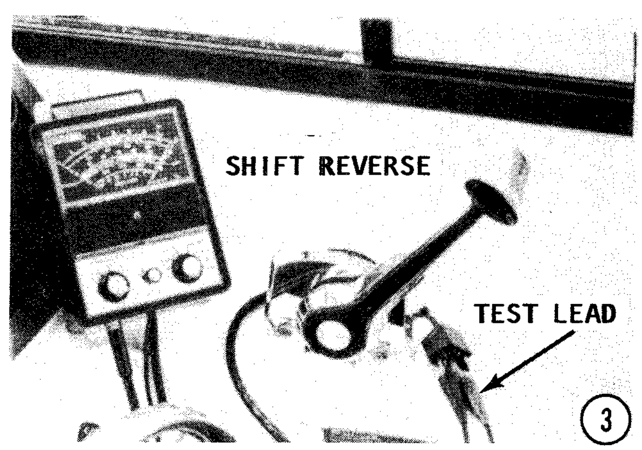
2

3- To test the shift switch for reverse, make contact with one probe of a test light, or continuity meter, to the ignition terminal (purple or red lead) and to the reverse terminal (blue lead) with the other probe. Again, move the shift lever to the FORWARD, NEUTRAL, and REVERSE positions. The light should come on, or the meter indicate continuity when the lever is in the reverse position and remain off, or indicate an open circuit, in the other two.

Testing The Cut-out Switch

4- Make contact with each probe of a test light, or continuity meter to each sf the NEUTRAL terminals (white leads). Move the control lever again to the FORWARD, NEUTRAL, and REVERSE positions. The test light should come on or the meter indicate continuity only when the shift lever is in the NEUTRAL position and remain off or indicate an spen circuit for the other two.

If the switch fails to check out, as described in the previous tests, the switch and cable assembly MUST be replaced. Early model shift lever boxes did not have this switch installed.

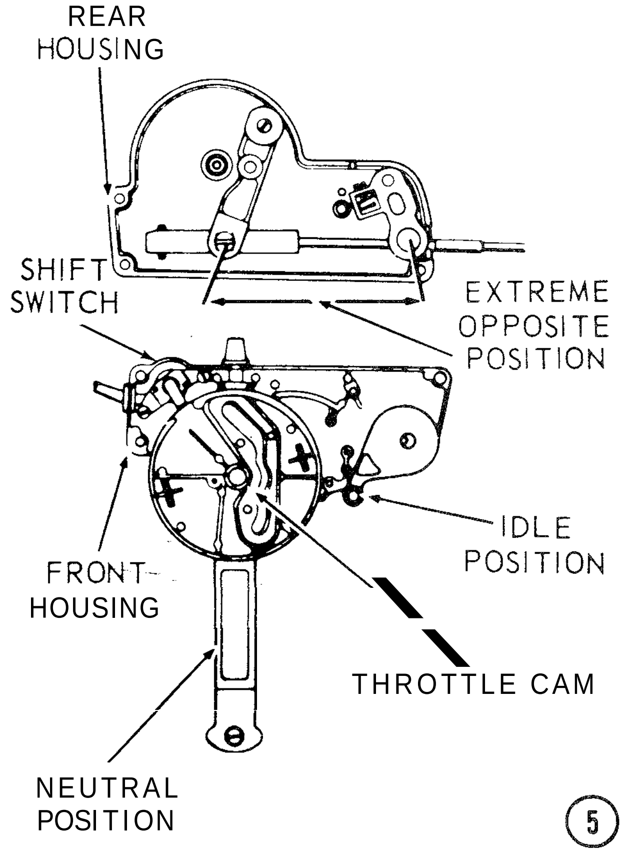


3

ASSEMBLING AND ADJUSTING

5- ALWAYS TAKE CARE when assembling the shift box, not to damage the remote-control unit. The arm on the switch **MUST** lay in the cut-out portion of the throttle cam. The idle adjustment is made by turning the thumbscrew in front of the shift box in or out. The tension of the throttle lever is adjusted by the friction knob under the shift box. Turn the knob clockwise to increase friction and counterclockwise to decrease friction.

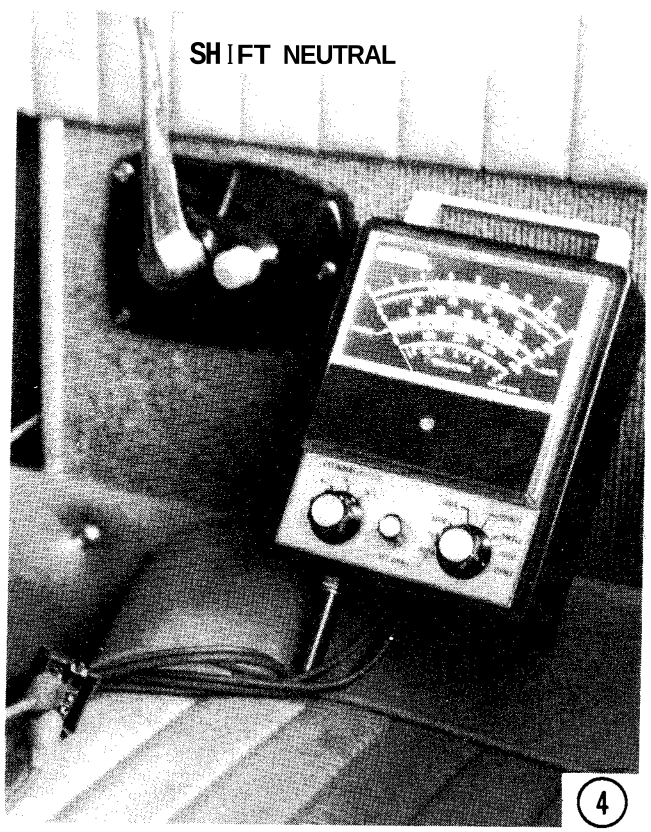
Connect the shift wire under the dash. Place the shift box in position and secure it with the attaching screws or bolts. Bolts with self-locking nuts **SHOULD ALWAYS BE USED** because a loose shift box during high speed operation could be extremely dangerous.



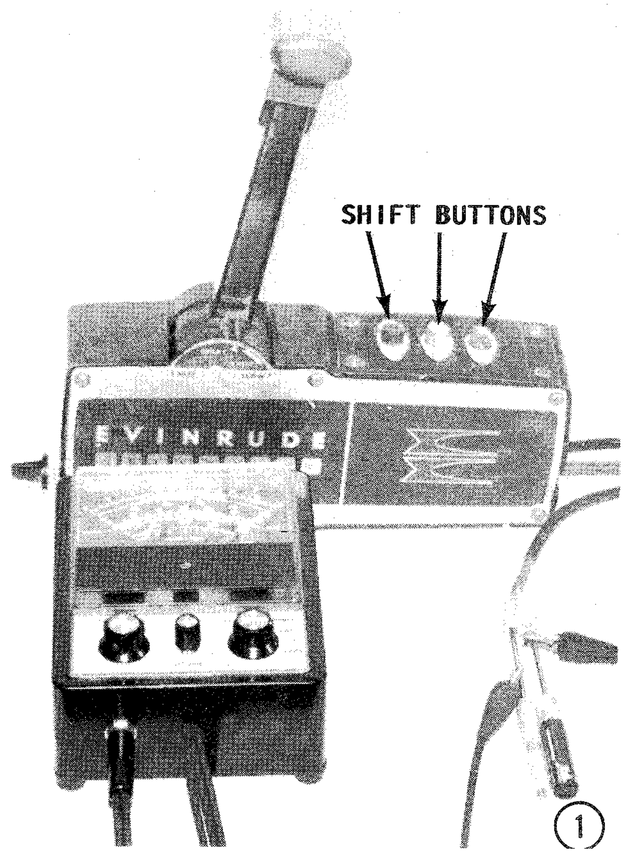
5

7-5 REMOVAL AND REPAIR OF PUSH BUTTON TYPE SHIFT BOX

1- To test the switch for the **FORWARD** position, make contact with one probe of a test light, or continuity meter, to the terminal on the bottom of the switch marked + and the other probe to the **F** teminal. Move the **FORWARD** button and the light must come on, or the meter indicate continuity.



4



1

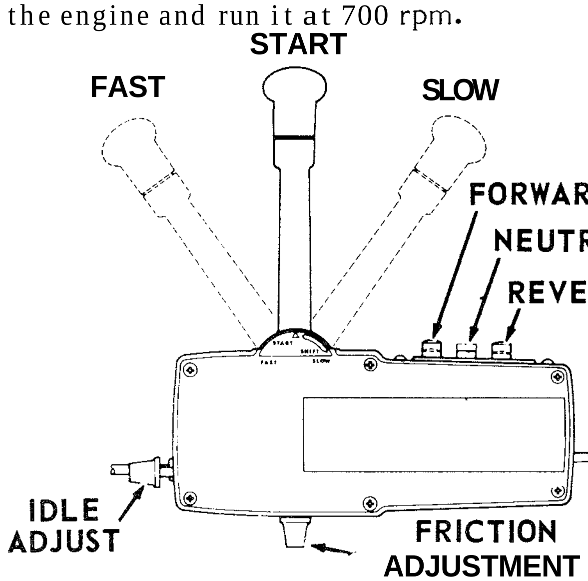
Leave the one probe contacting the + terminal and in turn make contact with the other probe to the **N** and **R** teminals. The light should not come on, or the meter should indicate an open circuit for both tests.

To test for the **REVERSE** position, make contact with one probe of the test light, or continuity meter, to the + terminal and to the R terminal with the other probe. Push the **REVERSE** button. The test light should come on, or the meter should indicate continuity.

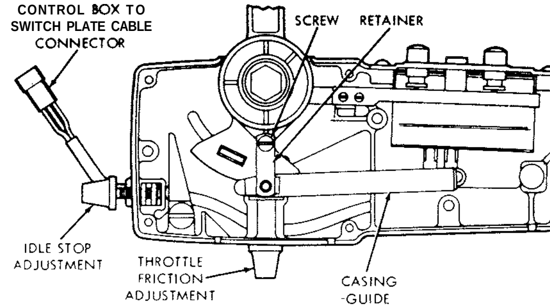
Leave the one probe contacting the + terminal and in turn make contact with the other probe to the **N** and **F** terminals. The light should not come on, or the meter should indicate an open ciruict for both tests.

2- Remove the screws on the side of the shift box. Working from inside the shift box, remove the attaching screws or bolts to the side panel. The switch assembly can be removed after taking out the cover plate attaching screws. Remove the yoke and selector bracket. Slide the switch box off and remove the wires. New buttons are not supplied with replacement switches. Therefore, **SAVE the THREE BUTTONS** for installation with the new switch.

3- The only adjustment of the shifting to throttle advancement is the slide yoke which is located under the cover plate. This yoke will slide back-and-forth locking the push bottons when the throttle is advanced. To assemble the shift box, first install the switch and hold-down bracket. Next, install the yoke slide and three buttons onto the switch. Now, install the cover plate. Start the engine and run it at 700 rpm.



2



3

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.

Now, adjust the slide yoke to allow the push buttons to be depressed at 700 rpm, but at 750 rpm , they cannot be depressed. To adjust the friction knob under the shift box, turn the knob clockwise to increase friction and coutnerclockwise to decrease friction.

7-6 OPERATION AND SERVICE OF A BINNACLE-MOUNTED SHIFT BOX

OPERATION

Operation of the binnacle-mounted shift box is more involved than for the other shift boxes detailed in this chapter.

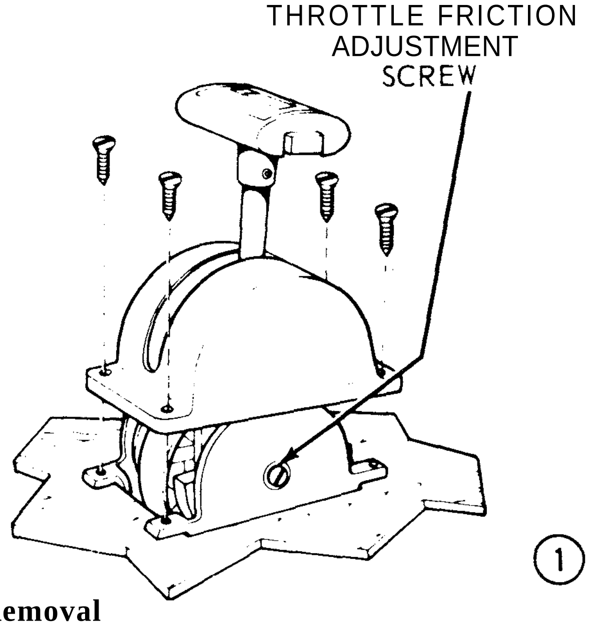
When the control lever is in the **NEUTRAL** position, the lever can be lifted up which will disengage the gearshift mechanism and allow the throttle advance required for starting. Once the engine starts, the control lever can then be retarded to the **NEUTRAL** position, and then pushed back down for normal gearshift and throttle operation.

To get underway, move the control lever toward **FORWARD** or **REVERSE.** If the reverse position is selected, the reverse lock-out push button must be depressed before the control lever can be moved into **REVERSE.**

If the engine is cold or not properly tuned and is running rough, the idle trim lever may be advanced in order to get underway.

To obtain at higher-than-normal idle speed, first advance the idle trim lever. Now, with the main control lever in the **START** (up) position, advance the lever to **PART THROTTLE,** and then return it to the **NEUTRAL** position. This action will reduce engine rpm by the control. From this point, adjust the idle to the desired level by moving the idle trim lever back.

ALWAYS reduce engine speed before shifting. **NEVER** attempt to shift if the engine speed is more than 700 rpm. Shifting at a high idle speed can result in **SERIOUS DAMAGE** to the gearcase.

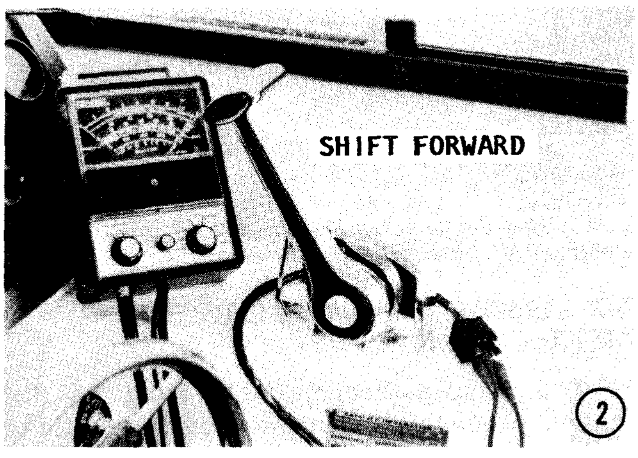


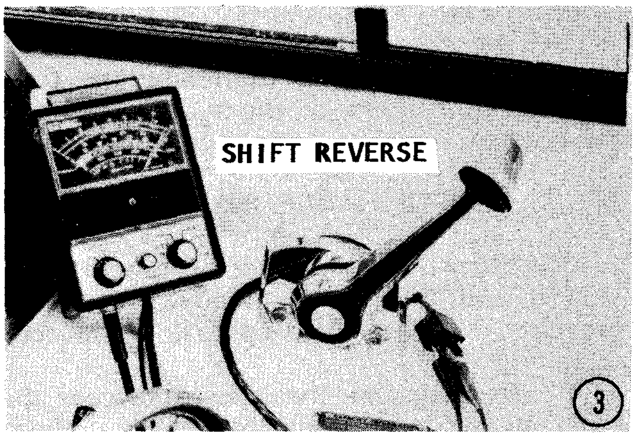
Removal

1– Remove the setscrew under the handle, and then remove the top handle. Remove the attaching screws, and then slide the cover off the shift handle.

Testing The Shift Switch

2– To test the switch for the **FORWARD** position, make contact with one probe from a test light or continuity meter, to the ignition terminal (purple wire) and the other probe to the **FORWARD** terminal (green wire). Move the shift control lever to the **FORWARD, NEUTRAL,** and **REVERSE** position. The light should come on, or the meter indicate continuity, only when the shift lever is in FORWARD, and remain off or indicate an open circuit for the other two.





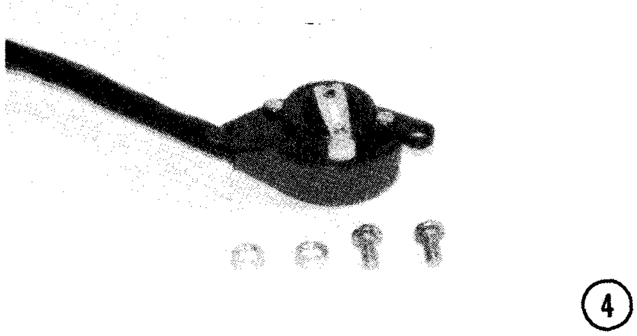
3– To test the switch for the **REVERSE** position, make contact with one probe from a test light, or continuity meter, to the ignition terminal (purple wire) and to the **REVERSE** terminal (blue wire) with the other probe. Again move the shift lever to the **FORWARD, NEUTRAL,** and **REVERSE** positions. The light should come on, or the meter indicate continuity, only when the shift lever is in **REVERSE,** and remain off or indicate an open circuit in the other two positions.

Installation

4– If a cadmium plated switch is being replaced with a black plastic housing, it MUST be spaced from the mounting bosses about 0.031" to prevent the switch arm from rubbing on the adjacent rib in the shift housing. The shift unit, switch, cables, and connectors are all matched and are **NOT** interchangeable, one model to another.

Model 1969 and later stern drives use part number 172122 Control unit; with part number 172124 switch and five-wire cable assembly; and part number 311741 connector.

Model 1968 and prior stern drives use control part number 171985; switch and three-wire cable assembly, part number 171988; and connector part number 310486.



Adjustments

5- Increase throttle friction by lifting the chrome cover, and tightening the friction adjusting screw on the starboard side of the control.

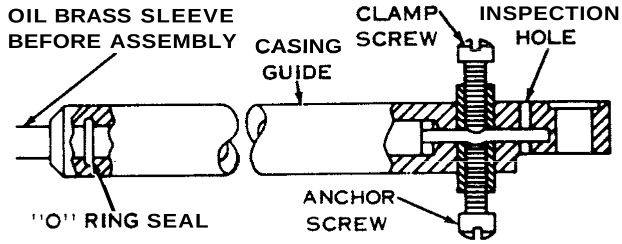
7-7 THROTTLE CABLE INSTALLATION

The throttle cable must be properly installed and both ends firmly secured to prevent loss of throttle operation and control.

Before installing the cable, lubricate the brass sleeve on the flexible cable. Next, slide the casing guide, with the cable clamp in place, onto the brass sleeve and control wire. **CHECK TO SURE** the O-ring is in place in the casing guide and the control wire passes through the small hole in the cable clamp, as shown in the accompanying illustration.

TAKE EXTRA CARE to avoid twisting the cable. The clamp and anchor screws **MUST** be horizontal to the deck of the boat after they are installed.

The control cable is held firmly in position by two screws, as shown. However, the wire **MUST** be kinked by the clamp screw to ensure it will not slip loose. To make this

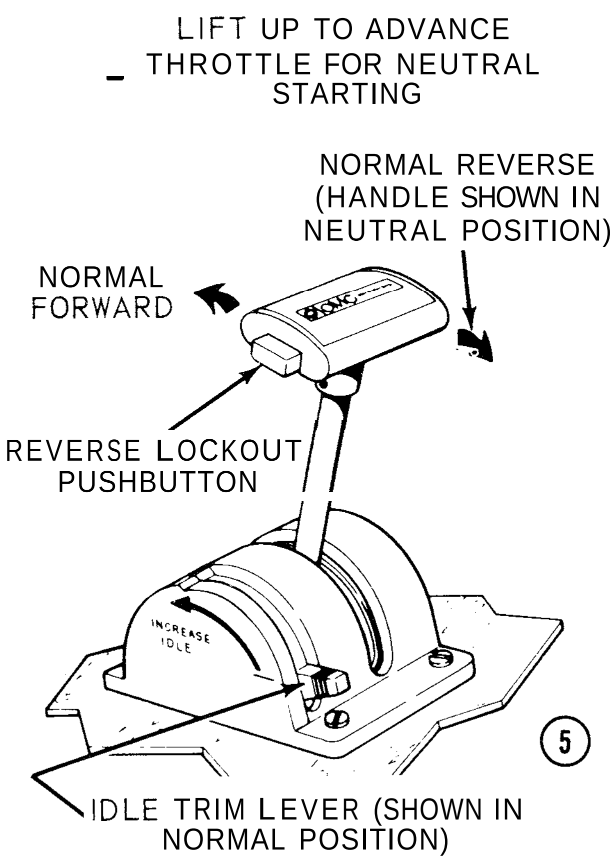


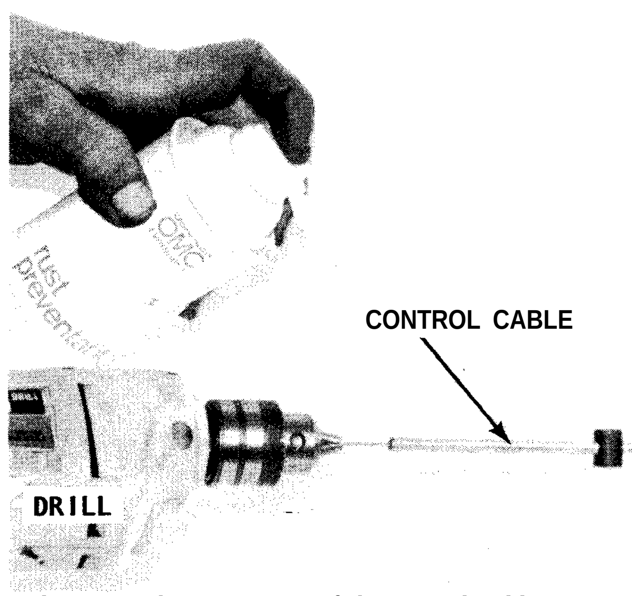
CASING GUIDE (MOTOR END)

Proper method of installing the clamp and anchor screw for the throttle cable.

kink in the wire, first check to be sure the wire is bottomed in the fitting. Draw the clamp screw and the anchor screw up until they both make contact with the wire, and then give the clamp screw one more complete turn. **EXERCISE CARE** not to tighten the clamp screw more than just described because if enough force is used, it is possible to shear the wire or at least to weaken its strength. These two screws are Allen-head on the 90 Series engines and fillister-head screws on the 120 and 150 Series engines.

To lubricate the inner wire, remove the casing guide from the cable at both ends. Attach an electric drill to one end of the wire. Turn the drill on and off to rotate the wire and at the same time allow lubricant to flow into the cable.





Lubricating the inner wire of the control cable using an electric drill, as described in the text.

7-8 REMOTE-CONTROL CABLE INSTALLATION

The remote-control cable must be installed properly for satisfactory operation.

The clamp nearest the shift box **MUST** be postioned correctly as follows:

First, move the warm-up lever on the shift box to full advance. Now, measure 36" (actually this measurement could range from 33" to 42") on the cable from the shift box. **BE SURE** there is no slack in the cable, and then secure the clamp to the boat at the measured position.

Next, place the warm-up lever in the slow position and observe the amount of slack in the cable between the shift box and the first clamp. The slack should not be more than 1/2 inch. **AVOID SHARP TURNS** in the cable. The radius of any bend **MUST** not be less than 5".

ALWAYS use the correct length of cable when replacing the assembly. Single-lever control units use cable part numbers 377372 through 377380. Binnacle-mounted controls use part numbers 377365 through 379850. Concealed side-mount controls use cable part numbers 380905 through 380950.

7-9 SELECTRIM FOR IN-LINE ENGINES

DESCRIPTION AND OPERATION

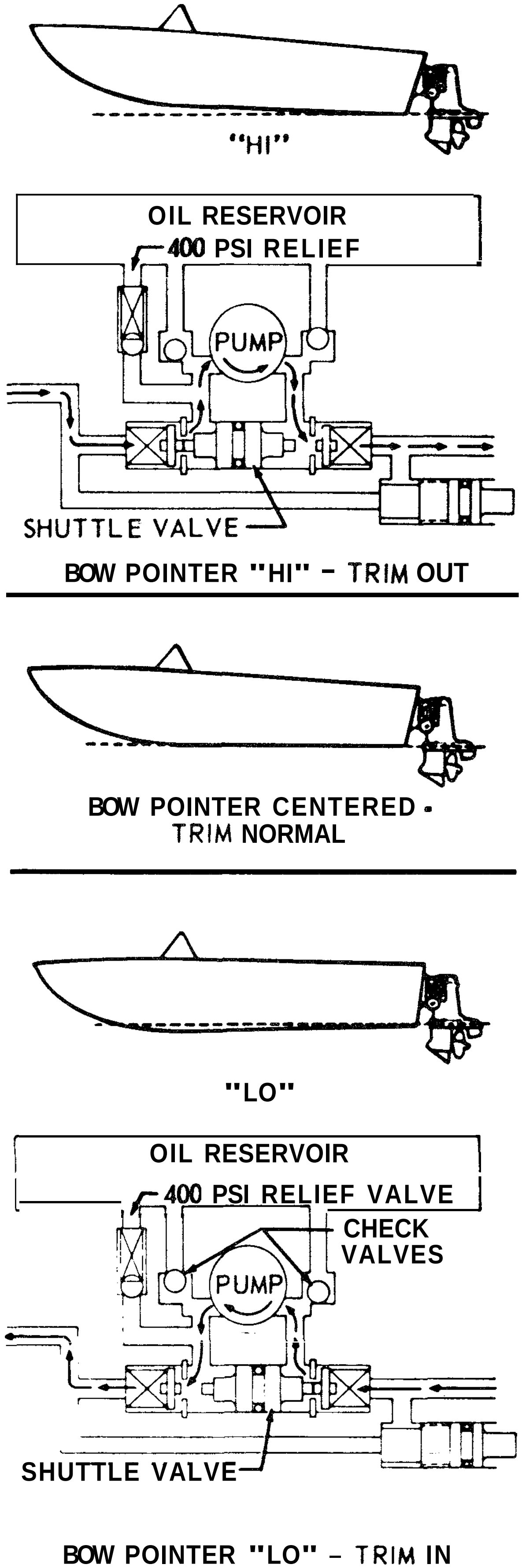
The Selectrim allows the angle of the vertical drive unit to be changed, with respect to the boat bottom. This angle change contributes to maximum boat attitude and performance for a given condition. The angle is changed, by raising or lowering the front of the engine by means of a power-operated jackscrew attached to the front engine mount.

The jackscrew is powered by an electric motor through a worm-and-wheel arrangement and is controlled by a spring-loaded toggle switch on the Selectrim dash panel.

When this switch is moved to the **HI** position, the vertical drive moves towards the transom and the bow of the boat is lowered. An indicator on the Selectrim dash panel displays the position of the bow. In this manner, the boat may be trimmed for maximum performance under various load distribution and speed conditions.

SELECTRIM SAFETY FACTORS

On some boats steering may become difficult or unstable when the Selectrim is moved to the full **HI** or **LO** positions. The helmsman may find steering is uncommonly



*SelecTrim controlling angle of the stern **drive.***

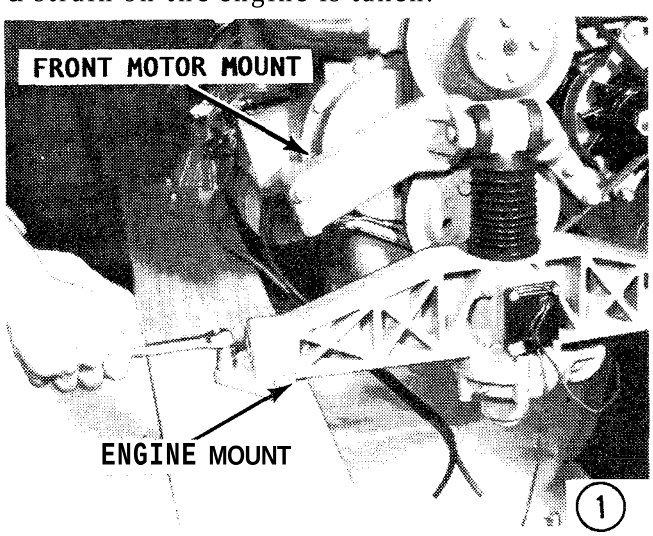
easy in one direction and more difficult than usual in the oppposite direction. This condition is caused by the increased steering torque reaction at the vertical drive created by the angle change.

Under such adverse steering conditions, safety of the boat and crew is in jeopardy. Therefore, the condition should be corrected as soon as possible. The total travel of the Selectrim unit is limited by an internal mechanical stop. The unit should NOT be bottomed against the stop for long periods of time to minimize the starting loads on the trim motor when trim operations are again activated.

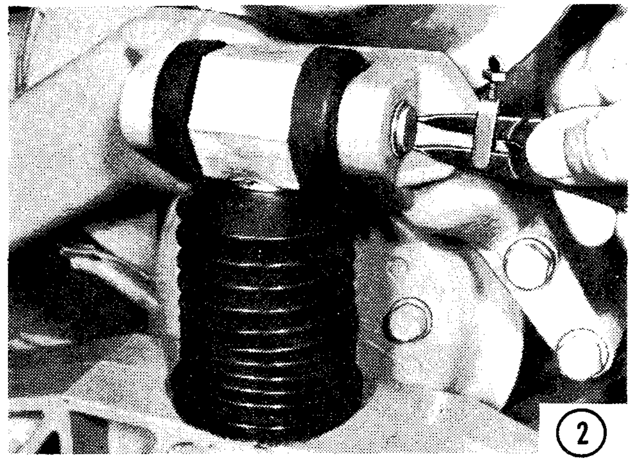
An internal circuit breaker protects the Selectrim motor from overload. If the Selectrim switch is held in the same direction after the unit has reached the end of its travel, the circuit breaker will trip. This is particularily true for the HI bow position. If the circuit breaker is tripped, allow the motor to cool for about 30 seconds. The circuit breaker will automatically reset itself and the Selectrim can again be operated.

REMOVAL

1- Before the Selectrim can be removed, the engine must be raised just enough to take the weight from the Selectrim unit. No big deal! The engine has two lifting brackets to be used with a length of chain. Run the chain through the holes in the lifting brackets, and then fasten the ends together with a bolt and nut. Attach the lifting device in the center of the chain, and then tie the chains together to prevent the lifting device from riding down the chain as a strain on the engine is taken.



1



2

After the lifting device is in place and ready, remove the lag bolts on the port and starboard front motor mounts. Take a strain on the lifting device until the engine weight has been removed from the trim assembly.

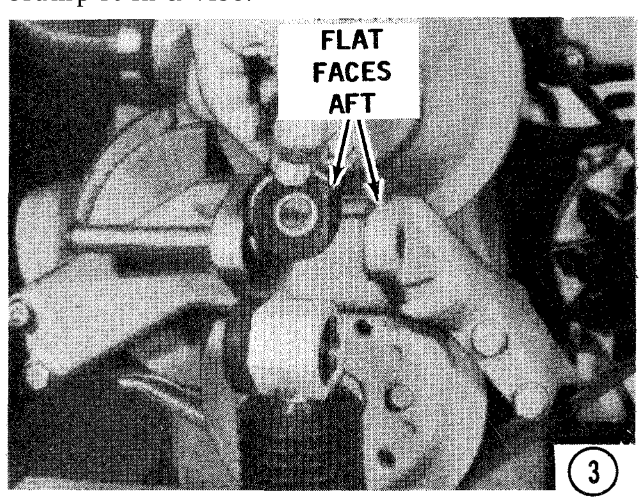
2- On the 165 hp engine installation, remove the snap ring from the end of the pivot shaft at the top of the jackscrew. Support the trim assembly and remove the pivot pin.

3- Remove the trim assembly and catch the grommets from each side of the jack screw. The grommets are cutout to clear the engine bracket.

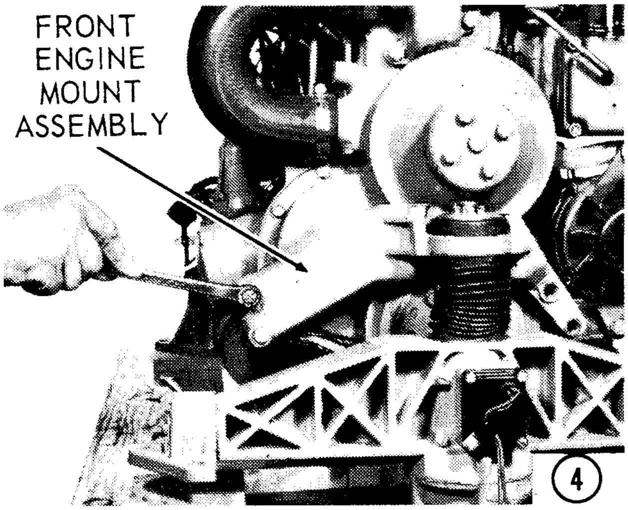
4- On 120 to 140 hp egnine installations, remove the four bolts to the engine mounting brackets. Remove the tie wrap from the bottom of the Selectrim boot.

DISASSEMBLY

5- Unscrew the jackscrew by turning the Selectrim engine mount counterclockwise to allow room to clamp the jackscrew in a vise. After the jackscrew has been turned enough, clamp it in a vise.



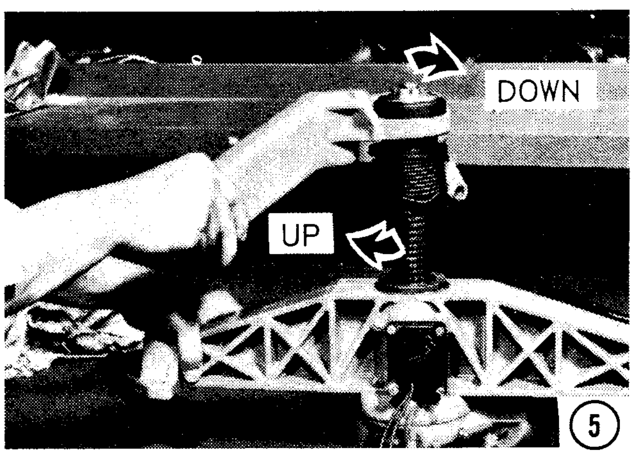
3



6- Drive the roll pin out of the top of the jackscrew using a drift punch and hammer.

7- Remove the nut from the top of the jackscrew with a 1-1/8" socket.

8- Lift the assembly from the vise, and then turn the Selectrim engine mount bracket counterclockwise and remove it from the jackscrew.

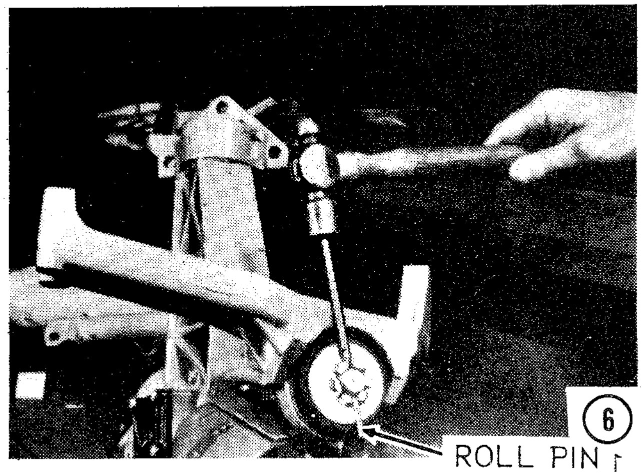


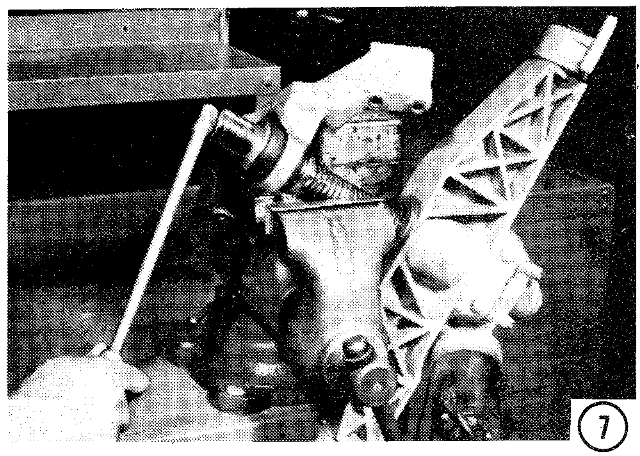
9- Remove the three self-tapping screws securing the boot, and then remove the boot. If necessary, use an arbor press to remove the rubber grommet from the engine mount assembly.

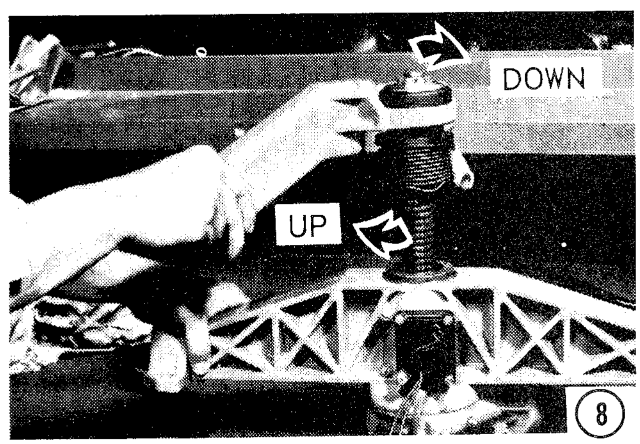
10- Remove the mount retainer from the threaded end of the jackscrew.

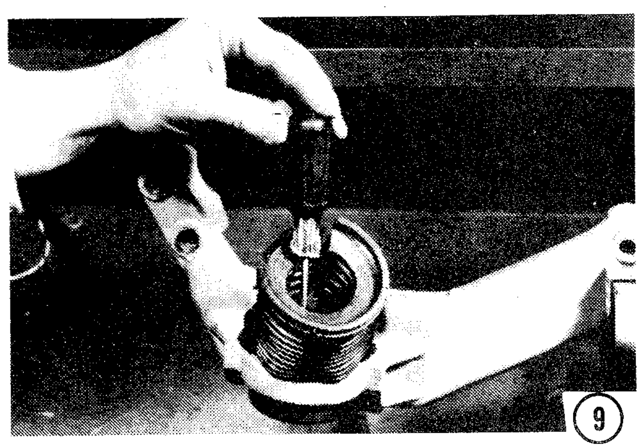
11- Remove the pillow blocks from each side of the front motor mount.

12- Remove the clamps and slide the trim motor rubber cover back to gain access to the motor mount through-bolts. Remove the through-bolts and NOTICE the lower bolt secures the motor ground wire. CAREFULLY remove the motor to avoid pulling



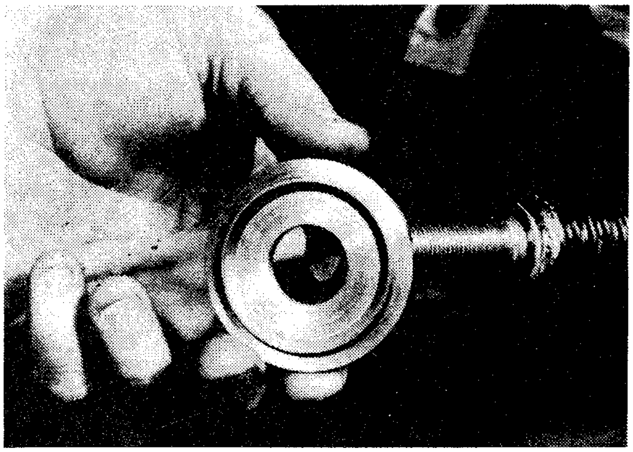




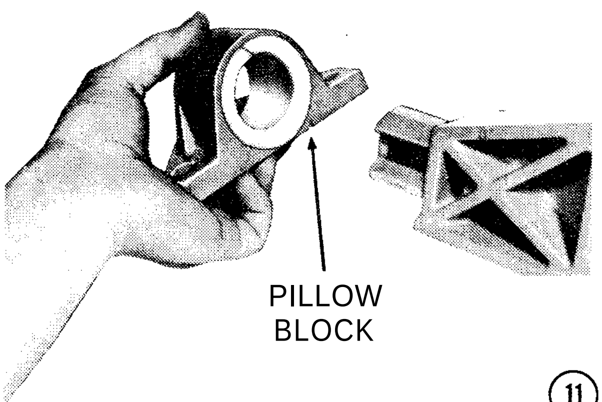


off the end caps. These caps are sealed to the frame.

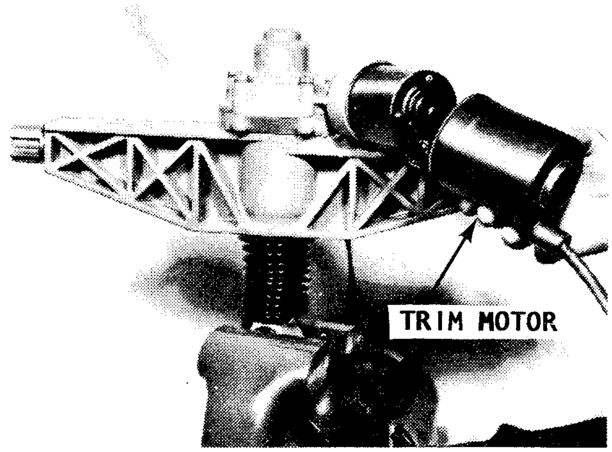
13- The roll pin, two thrust washers, and the bearing on the armature shaft are serviced as a unit with the motor.



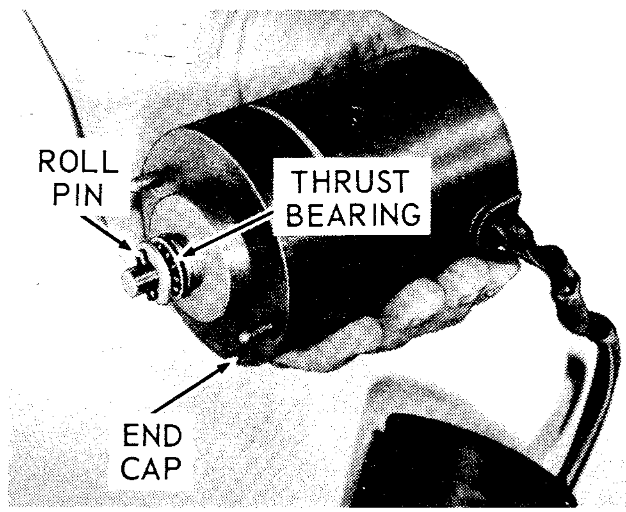
10



11



12



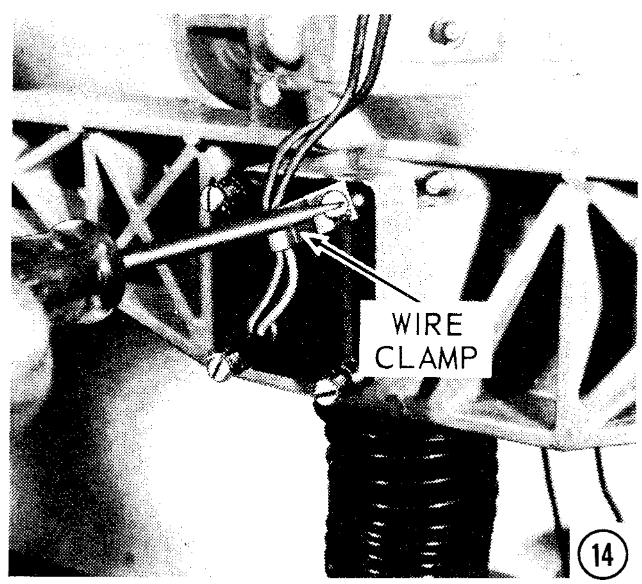
13

14- Clamp the motor mount in a vise, and then remove the Selectrim sender unit. Notice and remember the position of the wire clamp as an aid to assembly. The sending unit and cover are serviced as an assembly. **DO NOT** DISCARD the cover *O*-ring. If the ring is in good condition, it may be used again.

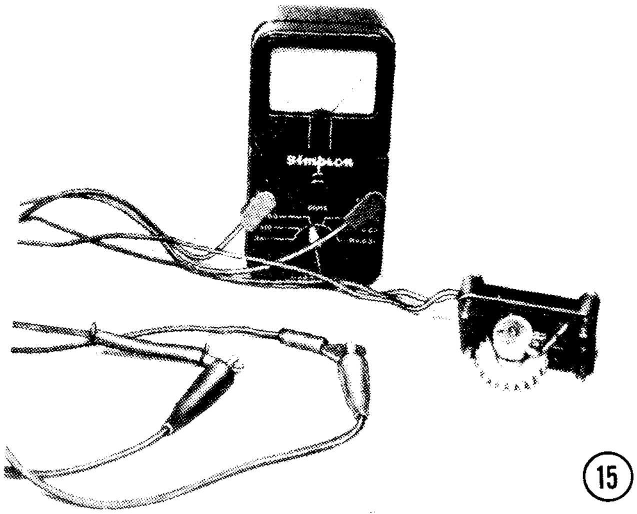
15- To test the sender unit, use an ohmmeter set to the RX-100 scale. The meter **MUST** indicate continuity with no resistance.

16- Remove the attaching screws from the worm wheel cover. Remove the thrust washer, bearing, a second thrust washer, and any shims, in that order. Slide the worm gear out of the cover.

17- Remove the bolt and washers from the end of the jackscrew. NOTICE the



14



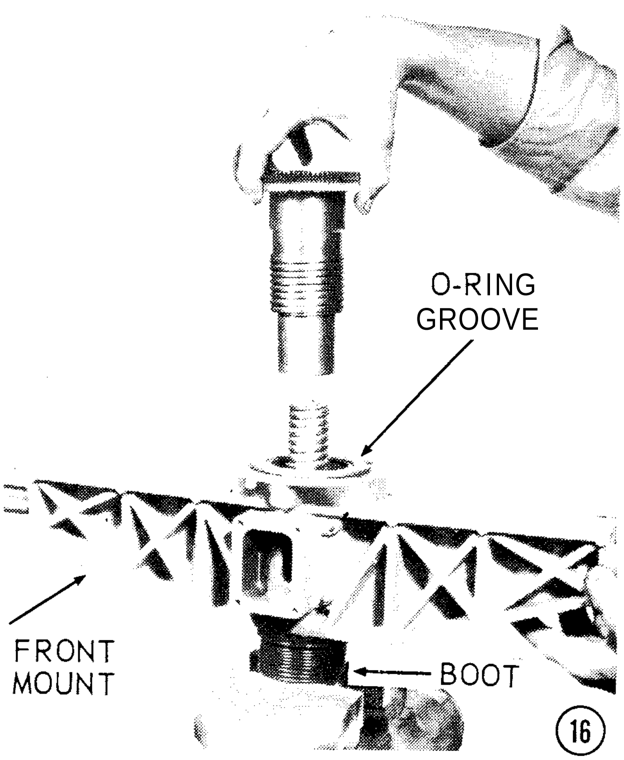
15

small spring washer between the two flat washers.

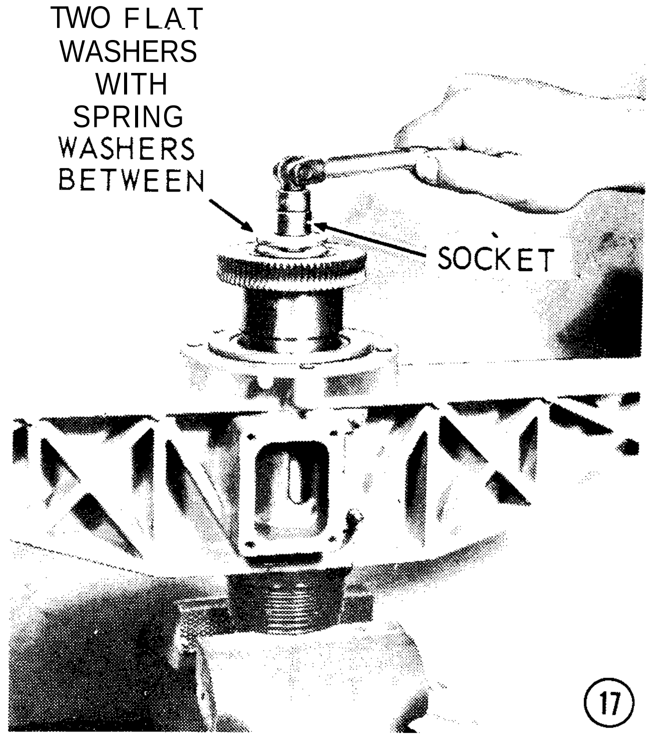
18- Remove the worm wheel from the mount by turning it counterclockwise. On the 165 hp engine installation only, disconnect the rubber boot tie. Lift the front mount from the jackscrew.

19- Using a slide hammer, remove the first bearing from inside the motor mount.

20- Remove the thrust washer, thrust bearing, a second thrust wasssher, any shims, and the O-ring from the motor mount bore. REMEMBER, they were removed in the order listed as an aid to assembly.



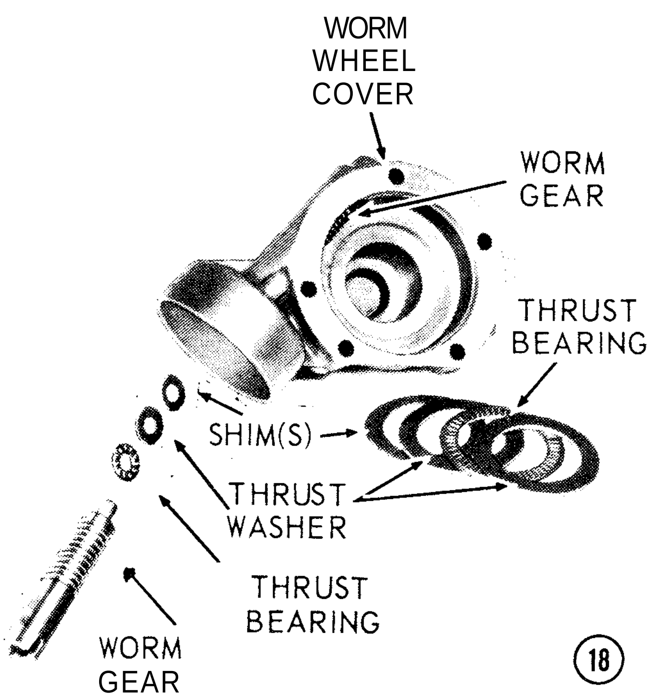
16



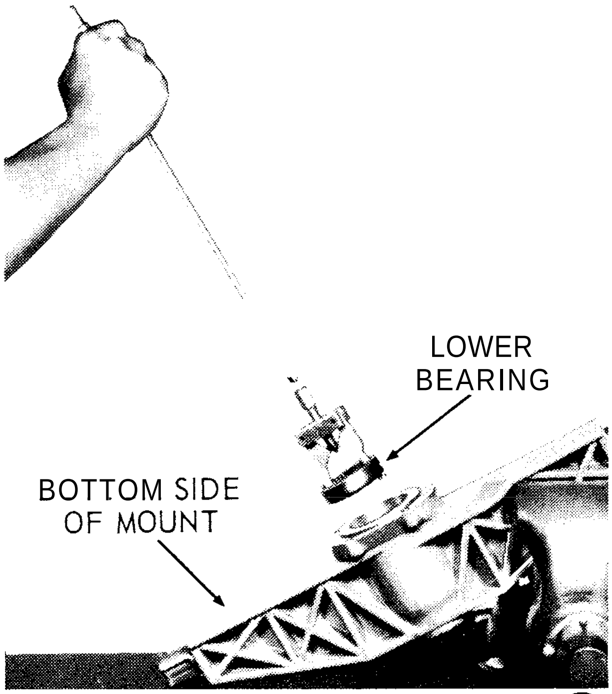
17

21- Notice how the upper bearing is positioned in the motor mount to provide clearance for the jaws of a bearing removal tool.

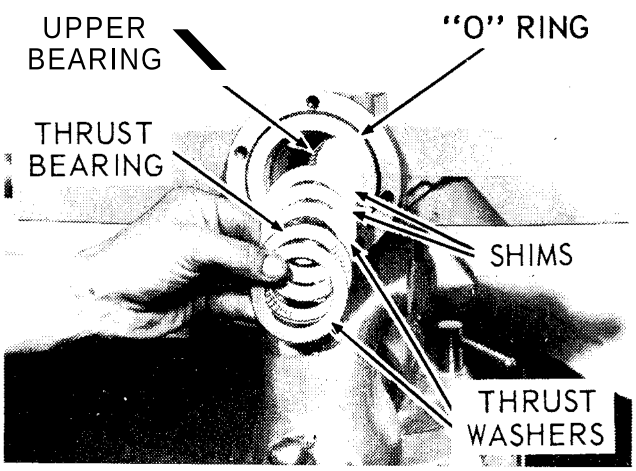
22- Install the puller properly, and then remove the bearing.



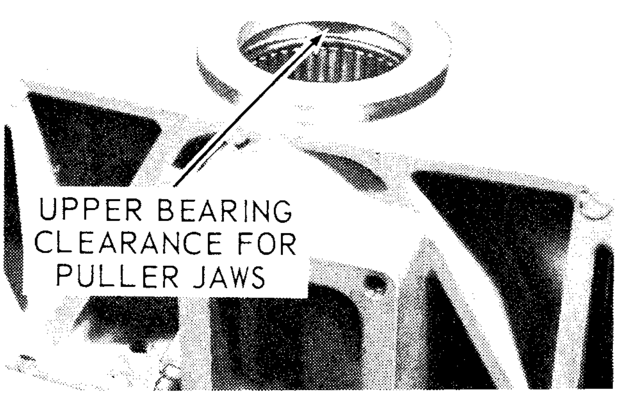
18



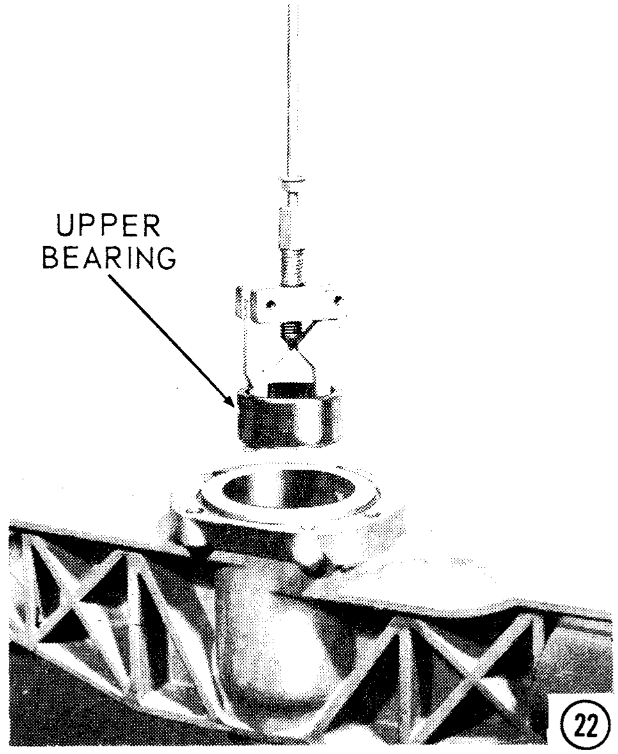
19



20



21

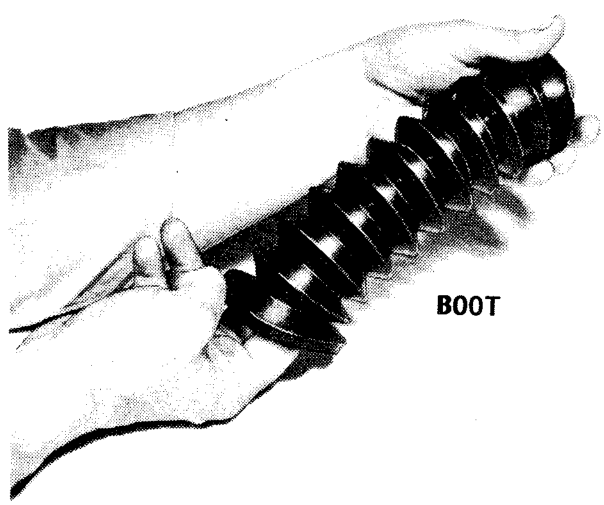


22

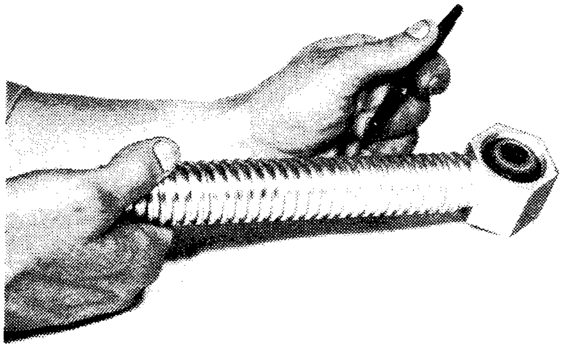
CLEANING AND INSPECTING

Clean all of the parts in solvent, and then blow them dry with compressed air. Replace any part that is badly corroded, worn, or damaged.

Replace the O–ring from the groove in the motor mount. Check the boot for cracks and wear. Inspect the gear, thrust bearing, thrust washer, shim, worm wheel, and shaft. Check the jackscrew for damage or corrosion.



Inspect the boot for cracks or other signs of damage.



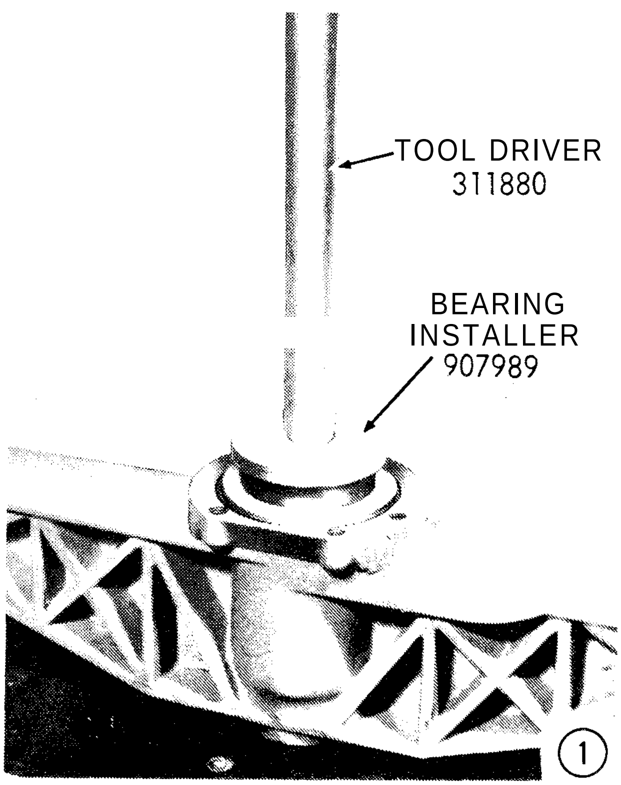
Inspect the screw threads for wear and distortion.

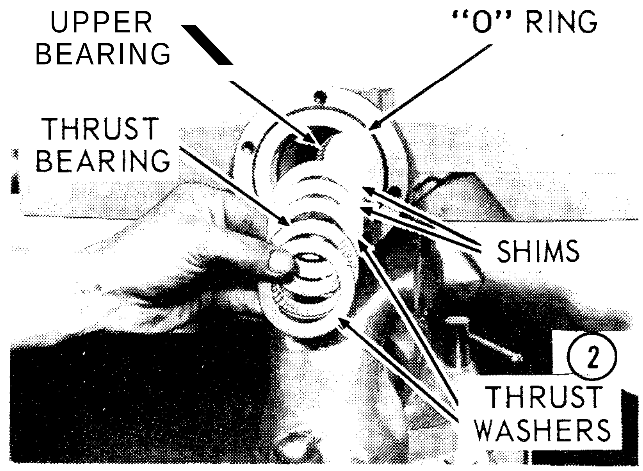
ASSEMBLING

1– Tool Drive No. 311880 and Bearing Installer No. 907990 are required to perform this bearing installation. The tool will seat the bearing the proper depth in the cavity. Drive the upper needle bearing into the motor mount upper bearing cavity with the letter side of the bearing facing up.

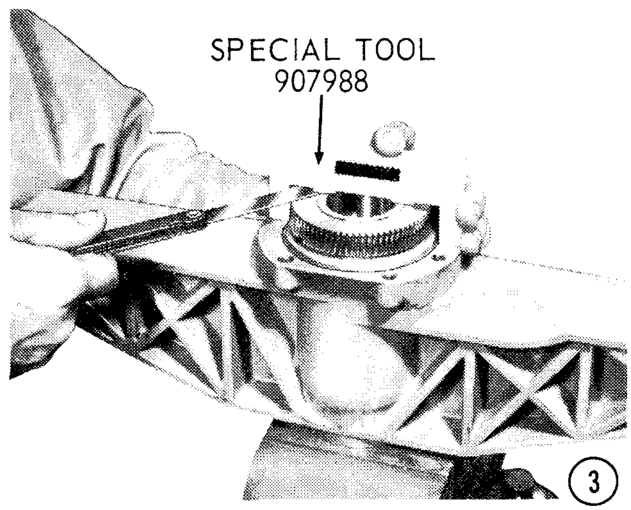
2– In this order, install the thrust washer, thrust bearing, second thrust washer, and the O–ring into the large bearing cavity in the motor mount.

3– Shims **MUST** be installed between the thrust washer and the seal in the motor mount to obtain **ZERO** end play of the worm wheel–and–shaft assembly in the motor mount.

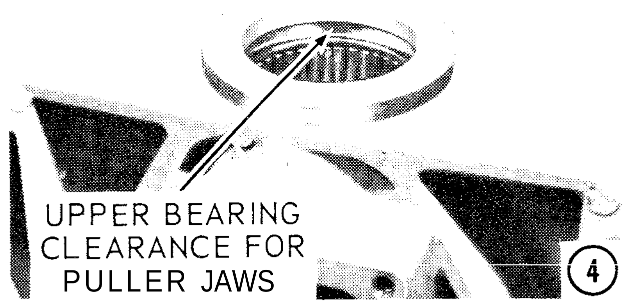


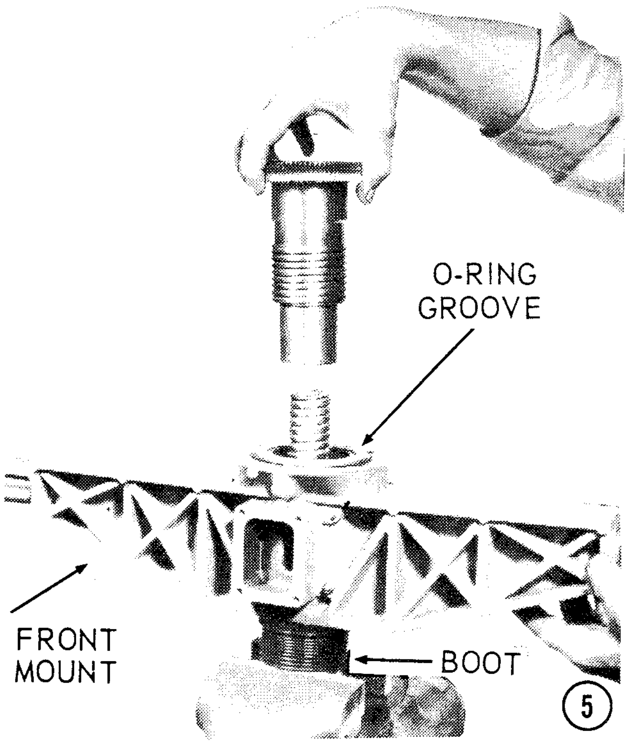


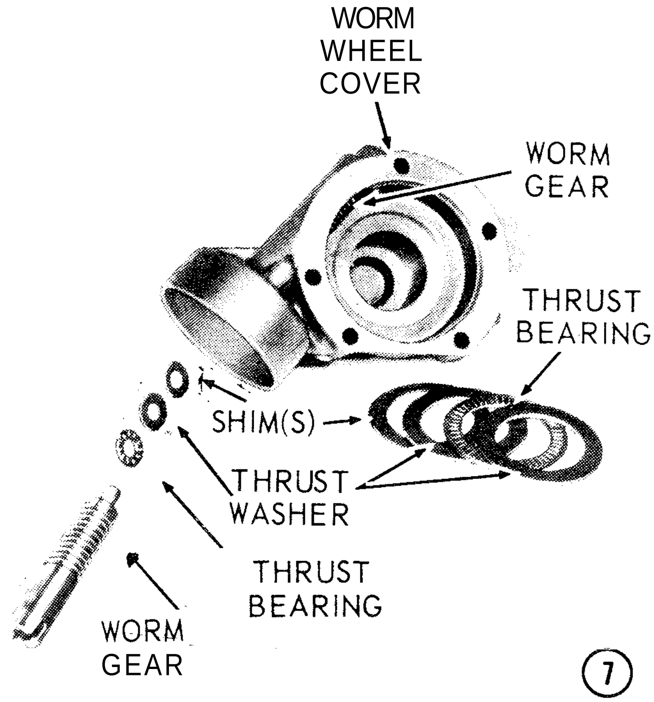
First, install the worm wheel–and–shaft assembly into place. Next, use a shim gauge, Special Tool No. 970988, to determine how much shimming is requied to obtain the **ZERO** end play. Once this is determined, remove the worm wheel–and–shaft asembly; and finally, add the required shims.



4– Special Bearing Installer Tool No. 907989 and Drive Handle No. 311880 are required to perform this bearing installation. **ALWAYS** press against the lettered side of the bearing during installation. Install the lower bearing with the lettered side of the bearing facing up.



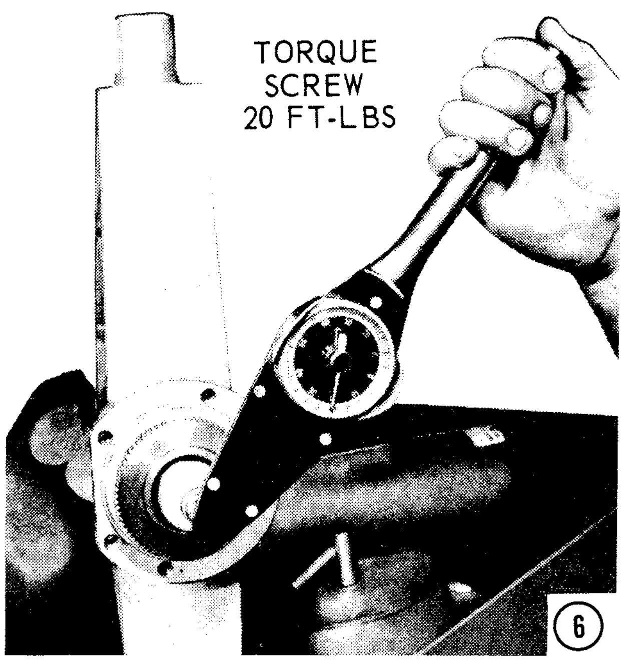




5- On units installed on 165 hp models only: Clamp the pivot jackscrew in a vise, and then slip the boot over the screw with the small end going on first.

On all models: Install the motor mount over the shaft, and then thread the worm wheel-and-shaft assembly onto the jacks-crew.

6- Rotate the jackscrew shaft down until you are able to install two flat washers with spring washers between them. Tighten the screw to a torque value of 20 ft-lbs.

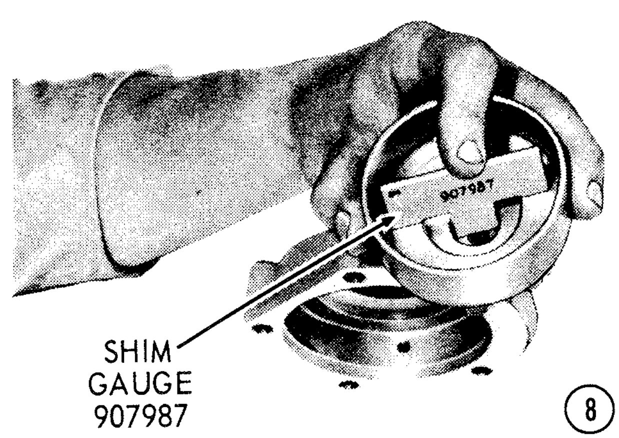


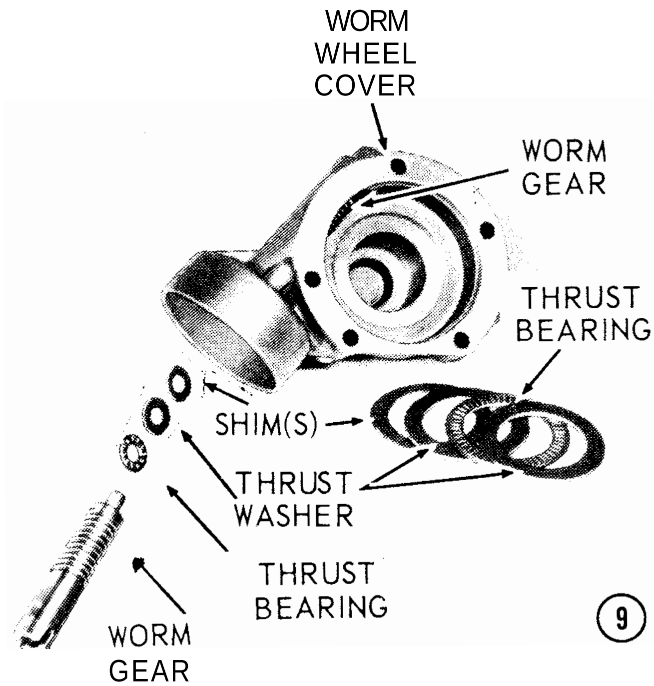
7- Install the shim(s), thrust washer, and thrust bearing in the worm gear bearing bore of the worm wheel cover.

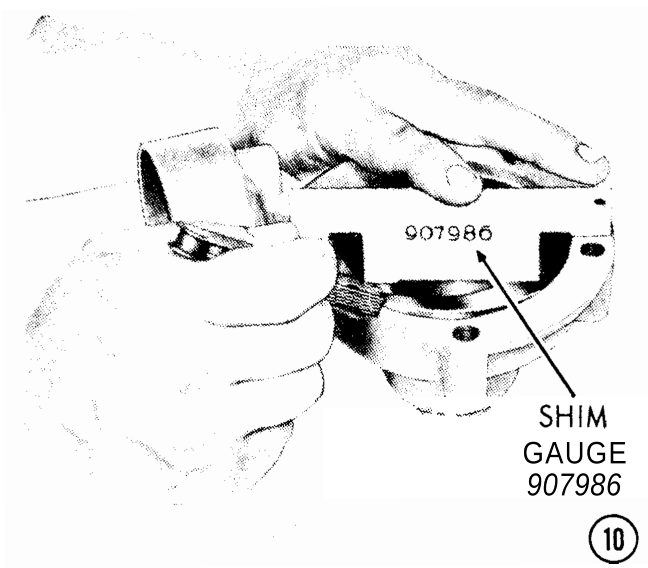
8- Shims **MUST** be installed to obtain **ZERO** end play between the worm gear and the housing. The worm gear **MUST** be installed with **ZERO** end play in the worm wheel housing.

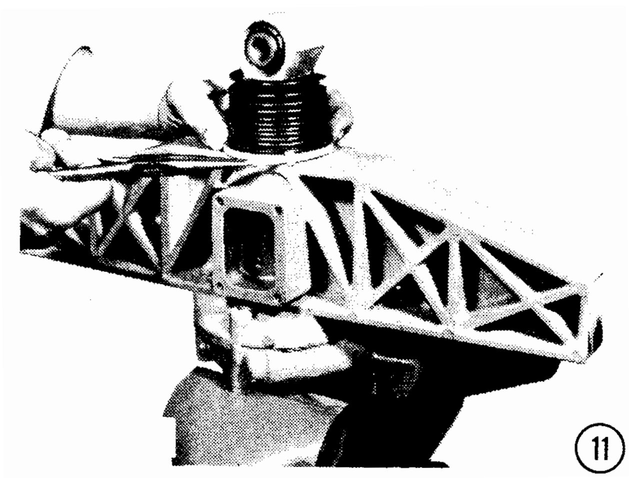
First, install the worm gear in the cover. Next, use Special Tool No. 907987 to determine the shimming requied to locate the gear for **ZERO** end play. Remove the worm gear and shim as required. The shim(s) **MUST** be placed between the seat in the worm wheel housing and the thrust washer.

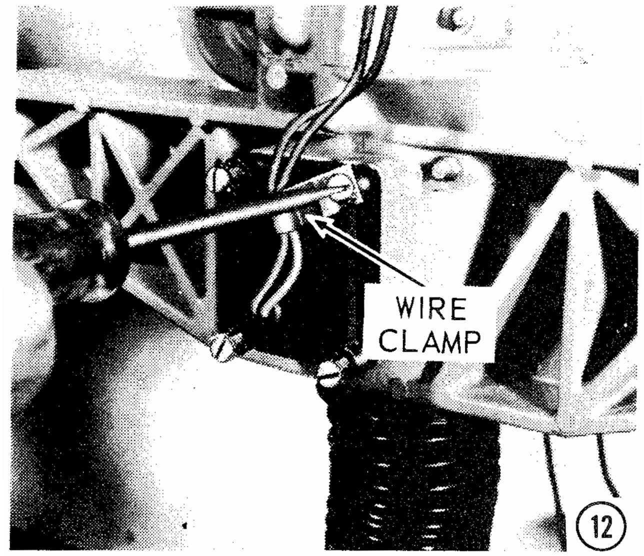
9- In this order, install the shim(s), thrust washer, thrust bearing, and second thrust washer in the worm wheel cover.











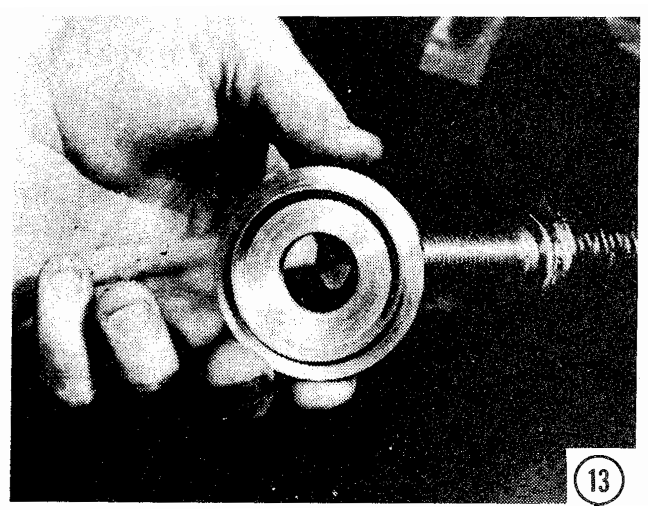
10- Special Tool No. 907986 is required to perform this step. Determine the shimming required to locate the worm wheel shaft properly when the cover is installed. Install the necessary shim(s). Position a new O-ring in the groove in the motor mount. Use heavy lubricant to hold the shim(s), thrust washer, and bearing in the cover. Install the cover on the motor mount. Tighten the bolts to a torque value of 18-20 ft-lbs.

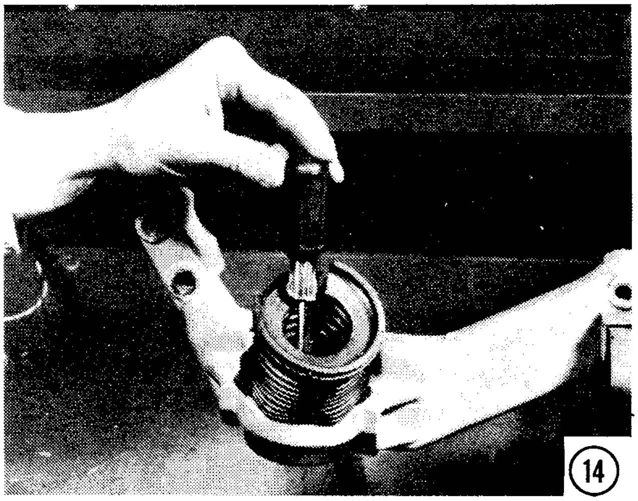
11- Install a **NEW** tie wrap around the jackscrew boot.

12- Position a **NEW** O-ring in the groove in the sender unit cover, and then install the cover.

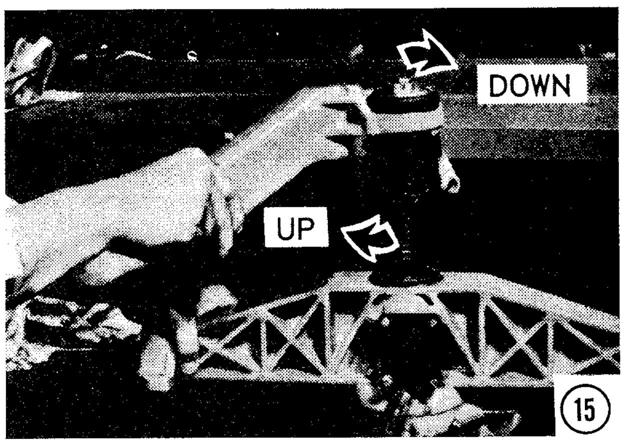
13- On units installed on 120-140 hp engines only: Install the motor retainer onto the threaded end of the jackscrew.

14- Press the rubber grommet into the engine mount assembly, if it was removed during disassembly. Install the boot onto the engine mount assembly.



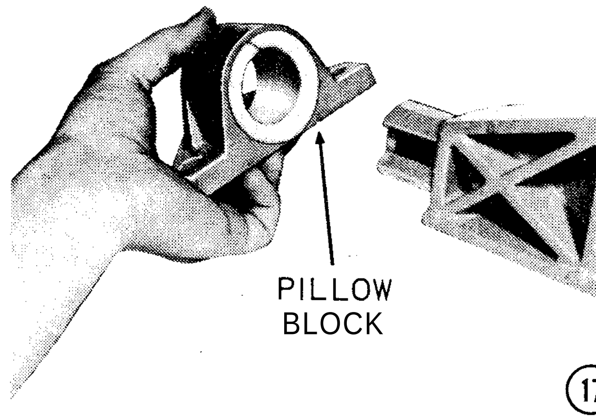


14



15

15– Install the engine mount assembly onto the jackscrew. The jackscrew goes on clockwise. Clamp the jackscrew in a soft-jawed vise, and then install the nut, and tighten it until the roll pin can be inserted. Remove the unit from the vise, and then turn the engine mount assembly clockwise until the jackscrew is about half way into the SelecTrim unit. Secure a tie wrap around the bottom of the SelecTrim boot.



17

16– On units installed on 120-140-165 hp engines only: Install the trim motor, and then slide the boot over the motor. Secure the boot with the clamp.

17– Install the pillow blocks.

INSTALLATION ON THE ENGINE

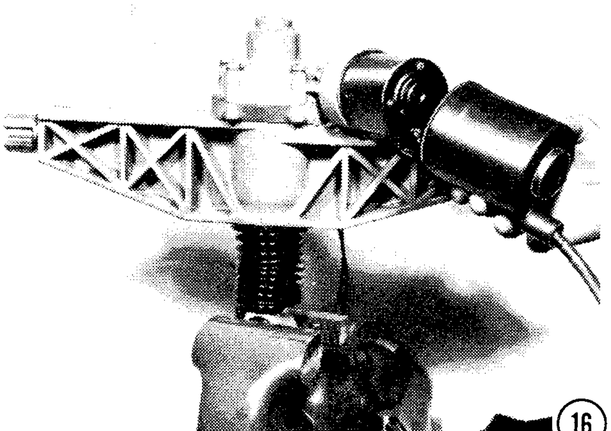
18– On 165 hp engine installations: Coat the pivot pin with Type "A" lubricant, and then assemble the SelecTrim onto the front of the engine. BE **SURE** the cutout portion of the grommet is positioned facing aft in order to clear the engine bracket.

19– On units installed on 120-140 hp engines: Install the SelecTrim engine mount onto the engine.

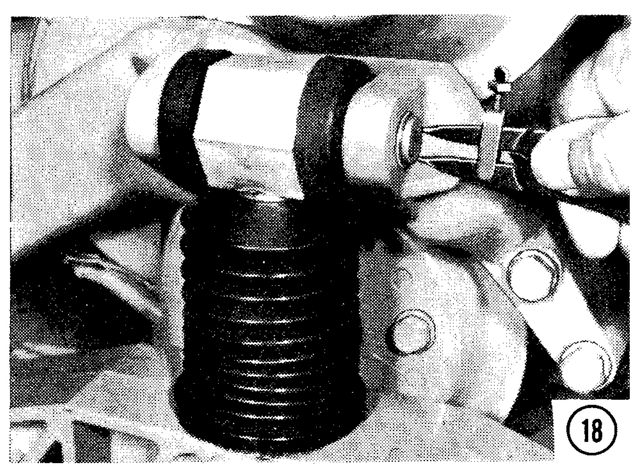
On units installed on 165 hp engines: Install the snap ring on the pivot shaft.

On all installations: Connect the Selec-Trim wiring. Operate the engine lifting device and lower the engine.

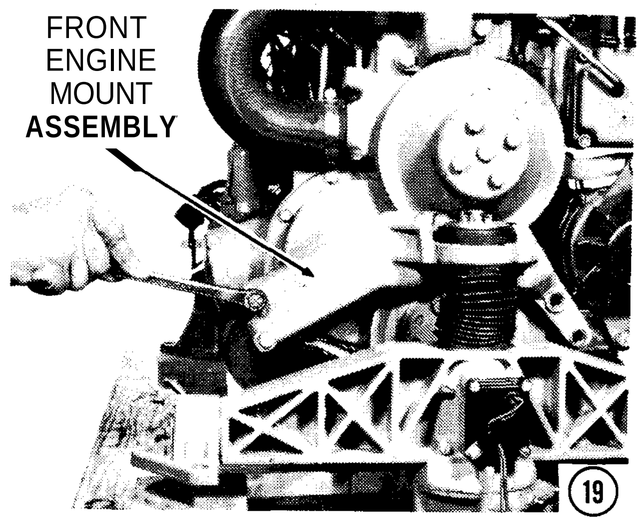
20– Align the lag bolt holes in the mount with the holes in the engine mounting stringers. Install the lag bolts.

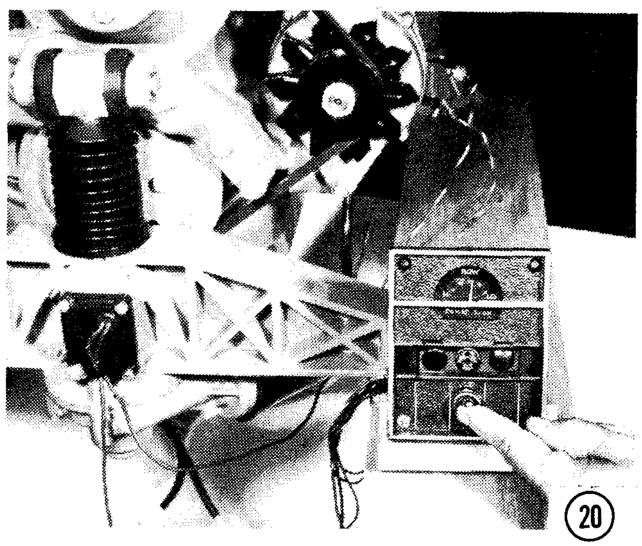


16



18





Lubricate the SelecTrim unit with Sunoplex EP 992 using a hand gun. Work the gun about five to eight good strokes at the bottom of the lube fitting.

To center the needle: Move the control lever to the **HI** and **LO** positions until the motor stops. The trim indicator is equipped with a slip-type clutch which will center the needle.

7-10 SELECTRIM FORD V8 ENGINES

DESCRIPTION AND OPERATION

The SelecTrim allows the angle of the vertical drive unit to be changed, with respect to the boat bottom. This angle change contributes to maximum boat attitude and performance for a given condition. The angle is changed by raising or lowering the front of the engine by an electro-hydraulic unit attached to the front motor mount.

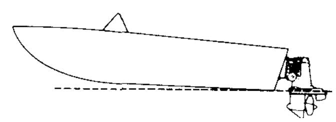
The unit consists of a hydraulic pump, reservoir, and electric motor. Two hydraulic actuators are located under the forward motor mounts. The electric motor is actuated by a selecTrim toggle switch on the dash panel. The electric motor powers the hydraulic pump which provides fluid pressure to the hydraulic actuators to raise or lower the front of the engine.

When the SelecTrim switch on the dash is moved to the HI position, the vertical drive moves away from the transom, and the bow of the boat is raised. Movement of the switch to the **LO** position causes the vertical drive to move in towards the transom and the bow is lowered.

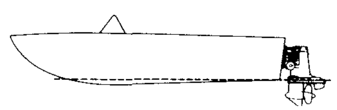
The boat is properly trimmed when the SelecTrim unit is adjusted to provide the most satisfactory bow position for maximum boat performance, under various speed and load conditions.

Changes in the bow position are displayed on an indicator gauge installed on the SelecTrim dash panel.

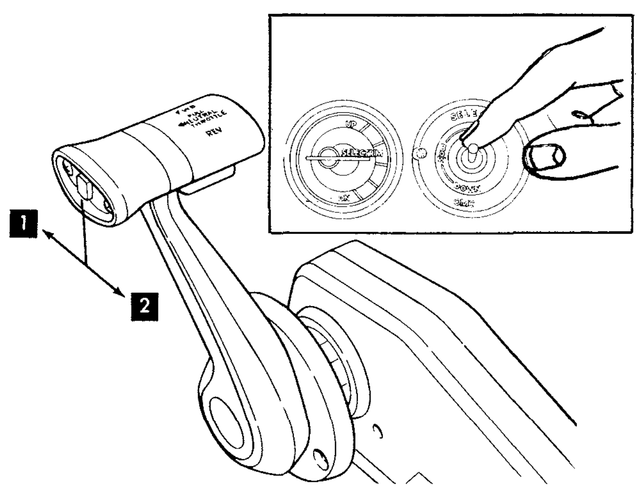
The SelecTrim motor is protected from overload by an internal circuit breaker, and a 100 amp in-line fuse located on the main post of the starter assist solenoid. This fuse



☐ TRIM OUT - BOW **UP**



2 TRIM IN - BOW DOWN



Operation of the OMC SelecTrim.

also protects the power tilt electrical system.

If the SelecTrim switch is held in the same direction after the unit has reached the end of its travel, the circuit breaker will trip. This is particularily true for the **HI** bow position. If the circuit breaker is tripped, allow the motor to cool for about 30 seconds. The circuit breaker will automatically reset itself and the SelecTrim can again be operated.

SELECTRIM SERVICE

The following sections provide step-by-step illustrated procedures for servicing the cylinder and hydraulic pump.

Replacement of the manual release valve; electrical checks for the system; and tests for the SelecTrim gauge and sender units are also included.

The sections are coded for easy reference when performing other work. The steps are keyed by number to the illustrations.

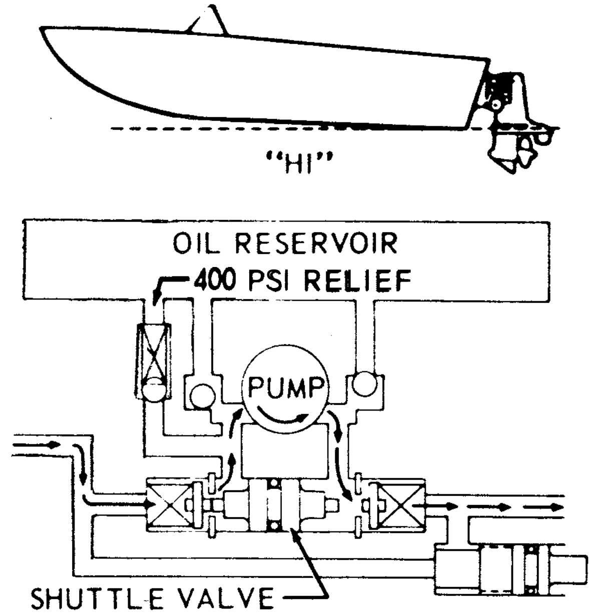
TRIM CYLINDER SERVICE

The following procedures outline detailed steps to remove, disassemble, clean, inspect, repair, assemble, and install the cylinder.

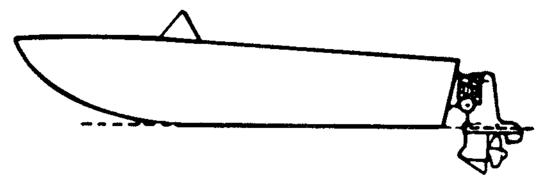
REMOVAL

1- Rotate the manual release valve on the hydraulic pump three to four turns counterclockwise to lower the engine. **ALWAYS** keep clear of the engine and the trim mechanism while operating the manual release valve. **NEVER** attempt to make any adjustments, to remove any part, or to attach any test instruments until the piston rods are fully retracted.

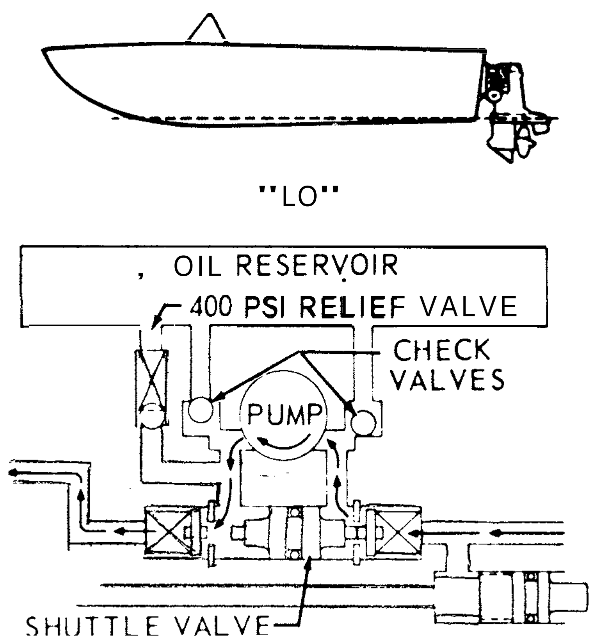
2- Before the cylinder can be removed, the engine must be raised just enough to take the weight from the SelecTrim unit. The engine has two lifting brackets to be used with a length of chain. Run the chain through the holes in the lifting brackets, and then fasten the ends together with a bolt and nut. Attach the lifting device in the center of the chain, and then tie the chains together to prevent the lifting device from riding down the chain as a strain on the engine is taken. Check to be sure clearance exists between the top rear of the interme-



BOW POINTER "HI" - TRIM OUT

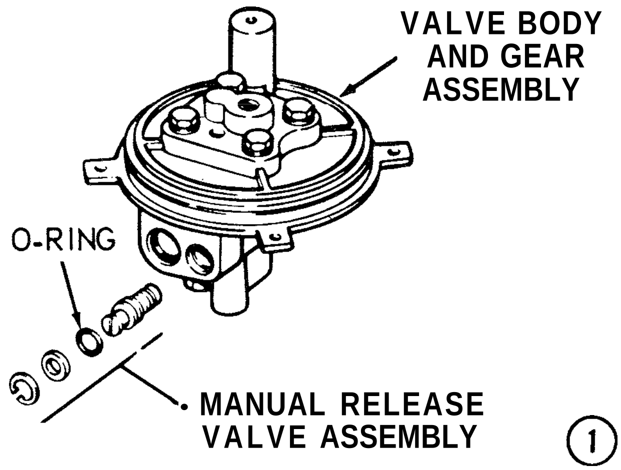


BOW POINTER CENTERED - TRIM NORMAL



BOW POINTER "LO" - TRIM IN

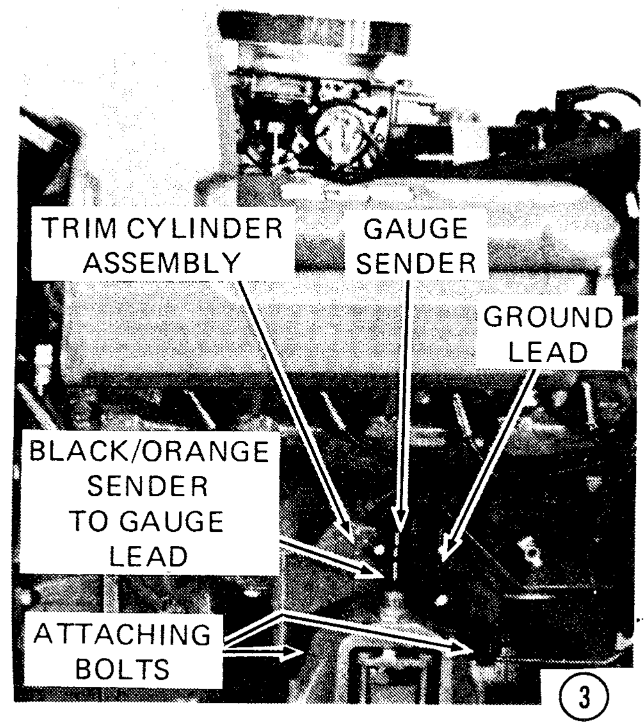
SelecTrim system controlling the bow position.



diate housing and the transom cut-out when moving the engine. After the lifting device is in place and ready, remove the lag bolts on the port and starboard front motor mounts. Take a strain on the lifting device until the engine weight has been removed from the trim assembly.

3- Disconnect the SelecTrim unit sender leads. The black/orange lead has a knife-type disconnect.

4- Be prepared to catch hydraulic fluid and disconnect the piston rod hydraulic lines at the pump unit. Remove the hydraulic line clamp from the front of the oil pan. Remove the two bolts, port and starboard, attaching the trim cylinders and motor mount assembly to the engine. Remove the assembly from the boat. TAKE CARE not to bend the hydraulic lines. The oil filter may have to be removed for additional clearance.

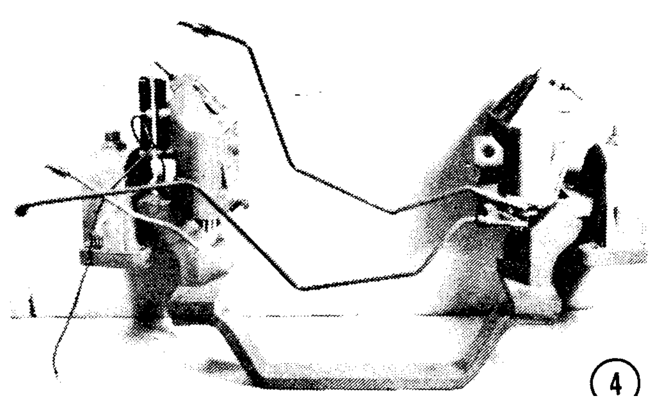


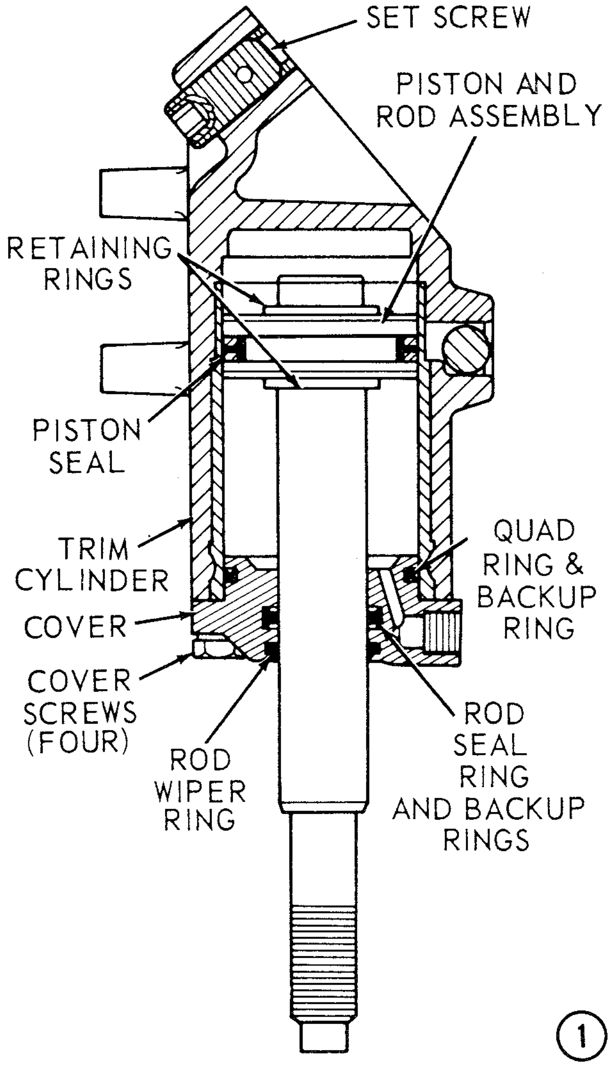
Because of the wide range of boat hull and bilge area designs, it may be necessary to remove the engine and SelecTrim unit together. See Chapter 3 for engine removal.

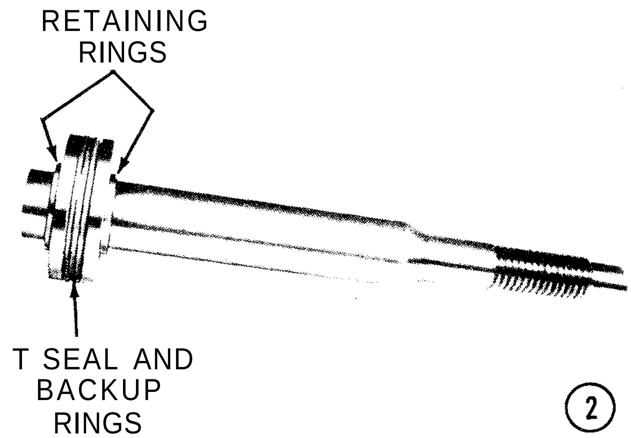
CYLINDER DISASSEMBLY

1- Remove the hydraulic lines from both cylinders. Remove the gauge sender unit from the port side cylinder. Bend the tabs out and remove the lock nuts, and then separate the piston cylinders from the tie bar and motor mounts.

2- Remove the four screws from the bottom of the cylinder. Pull the cover, piston, and rod assembly from the cylinder. Pull the cover of off the rod.







3- Remove and **DISCARD** the seal rings and wipers from the cover and piston. The cover has internal and external seal rings. The internal seal has two split backup rings installed on each side of the seal ring. The external seal has a single split backup ring installed. The piston and rod are serviced as an assembly. **NEVER** attempt to remove the piston from the rod.

CLEANING AND INSPECTING

Clean all metal parts in solvent and blow them dry with compressed air. Inspect the piston, rod, and cylinder bore for wear, scratches, and corrosion. The cylinder bores are microfinished. Therefore, any damage will cause by-passing of hydraulic fluid and damage to the seal rings and wipers.

Inspect the piston and rod retaining rings. If the upper or lower ring has been unseated from its groove, or if the piston has moved from its press fit on the rod, replace the piston, rod and ring assembly.

Inspect the trim cylinder covers for scratches, and wear in the rod bore. Replace the cover if it is worn.

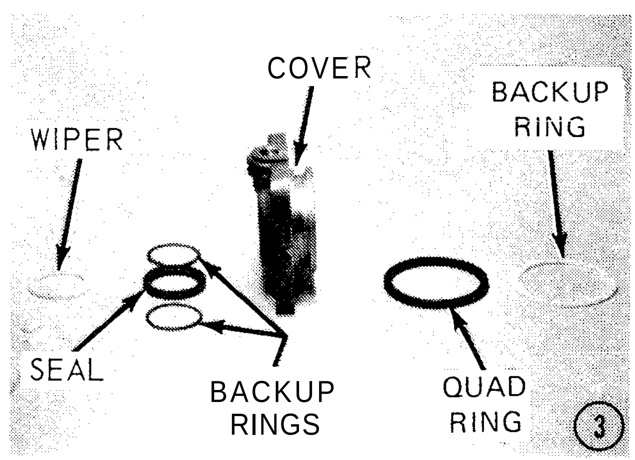
Inspect-the hydraulic line fittings, but **DO NOT** remove them unless they are damaged. If a fitting must be replaced, **TAKE CARE** to position and install the replacement in the same manner as the original. Coat the fitting threads with Loctite Hydraulic Sealant, or equivalent, before installation.

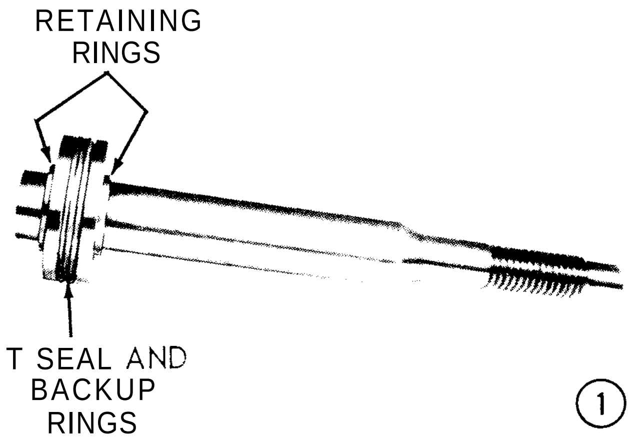
ASSEMBLING A TRIM CYLINDER

1- Lubricate the cylinder bore, rod, and piston with OMC Sea-Lube Premium Blend Gearcase Lube. Install a **NEW** seal ring on the piston.

2- Install a **NEW** seal ring and back-up ring on the trim cylinder cover. The slit in the backup ring **MUST** be properly aligned, as shown.

3- Install a **NEW** wiper in the cover bore with the lip facing out. Slide the covers onto the rod. Assemble the piston and cover to the cylinder with the hydraulic fitting



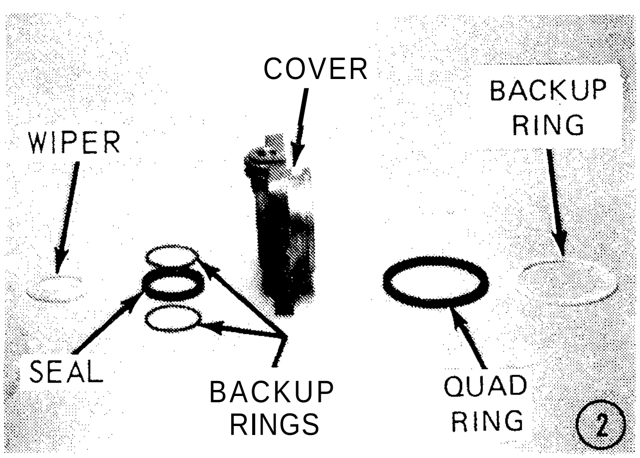


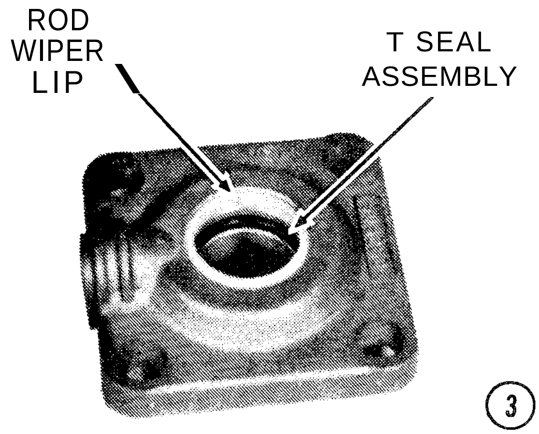
facing inward. Coat the cover screw with OMC Nut Lock prior to assembly. Attach the cover with the attaching screws and tighten them to a torque value of 33-38 ft-lbs.

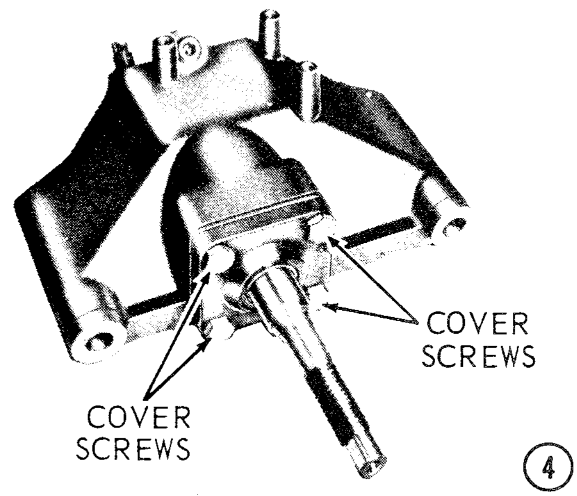
4- After both cylinders have been properly assembled, install them to the front motor mounts and tie bar with NEW lock nuts. Tighten the nuts to a torque value of 80-90 ft-lbs. Bend the locktabs over the nuts. Connect the hydraulic lines to the trim cylinders. Connect the trim gauge sender to the port side trim cylinder. Connect the ground lead under the aft screw.

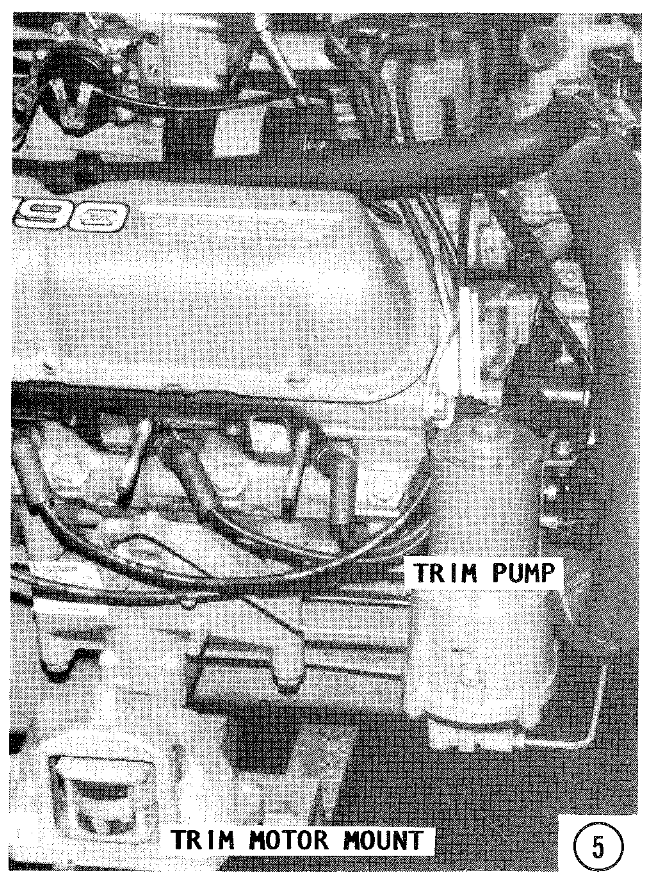
TRIM CYLINDER INSTALLATION

5- Place the motor mount and trim cylinder assembly in position under the engine. Attach the trim cylinders to the engine and tighten the screws to a torque value of *55-65* ft-lbs. Lower the engine onto the stringers, and then install the engine mount lag bolts. Connect the hydraulic lines to the hydraulic pump. Install the









hydraulic line clamp to the front of the engine.

Fill the hydraulic pump according to the procedures in the next section under Adding Fluid or Filling a Dry System Installed.

7-11 HYDRAULIC PUMP AND MOTOR SERVICE

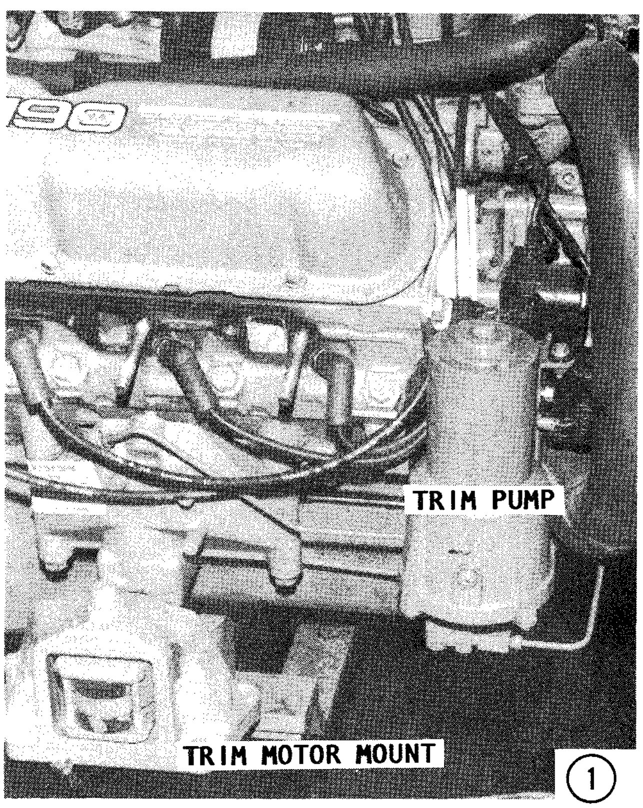
The hydraulic pump installed in the selecTrim assembly is a compact, high-pressure pump driven by an electric motor. The pump delivers pressurized fluid to the trim cylinders.

This section provides service instructions for the pump and the motor.

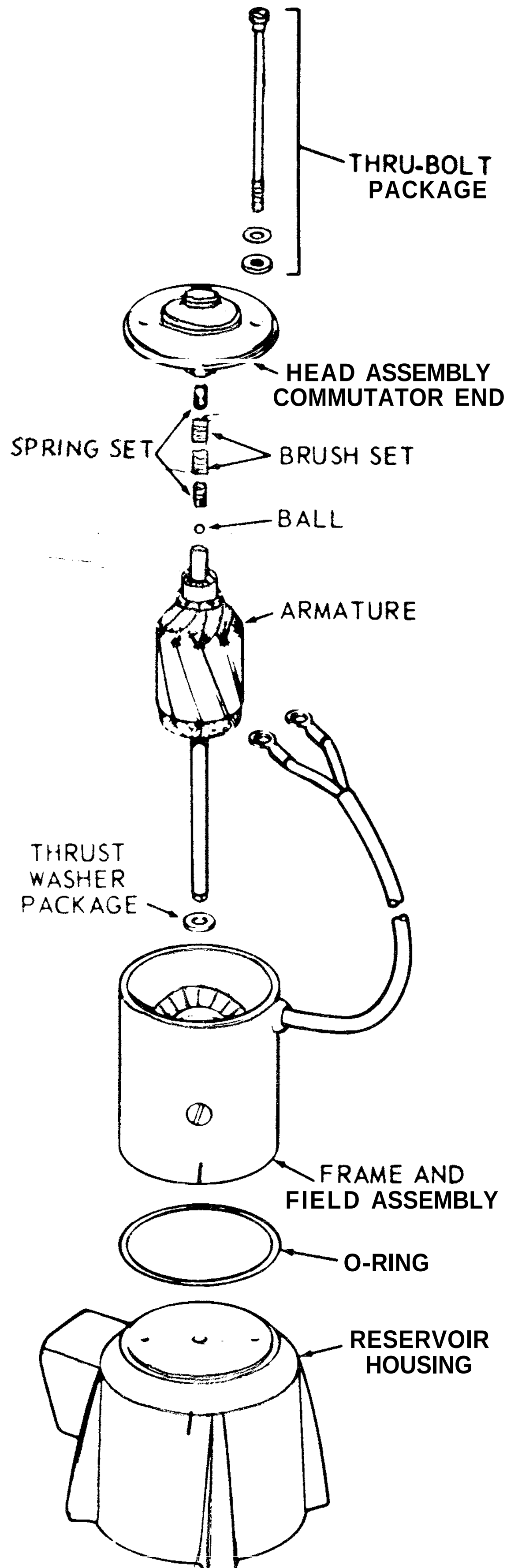
REMOVAL

1– Disconnect the red wire and the blue/orange and green/orange sending unit wires from the trim solenoids. Be prepared to catch hydraulic fluid and disconnect the hydraulic lines at the pump. Drain the hydraulic fluid from the reservoir. This is accomplished by removing the two allen head drain screws. One screw is located on the side of the pump and the other is on the bottom.

Remove the pump and sclenoids as an assembly from the engine.



1



2

DISASSEMBLY

2- Mark the reservoir, valve body, and motor body as an aid to alignment during assembly. Loosen the frame screws until the tapped holes in the reservoir are dis–engaged. **DO NOT** remove the screws.

Slide the end head, and the frame and field assembly off of the reservoir. The armature normally will remain in the frame and field assembly.

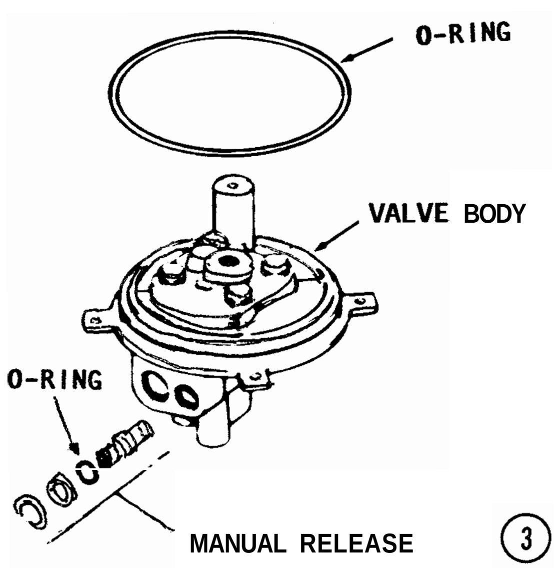
Pull the armature out of the frame and field assembly. **TAKE CARE** not to loose the ball bearing at the top end of the shaft and the washers on the lower end.

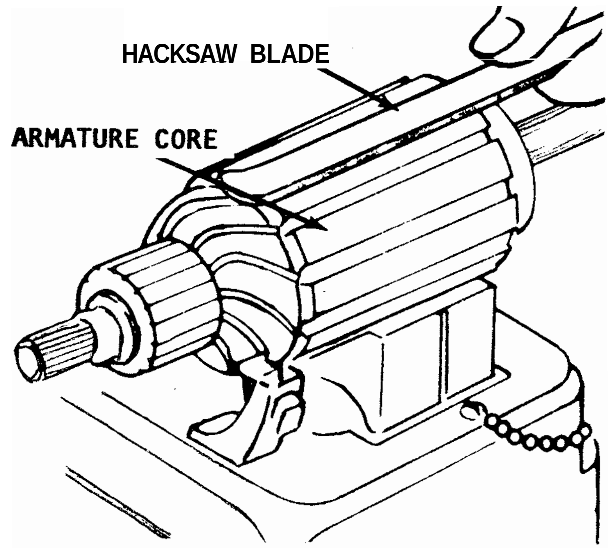
CAREFULLY slide the frame and field away from the end head in order to expose the wiring connections. **TAKE NOTICE** of the field lead connections to the end cap. Remove the frame screws, disconnect the leads, and then remove the end head.

3- Remove the screws securing the pump to the reservoir, and then remove the pump assembly. The manual release valve and the end O–ring are the only parts servic–ed in the pump assembly. If the internal valves are defective, the valve body and gear assembly **MUST** be replaced.

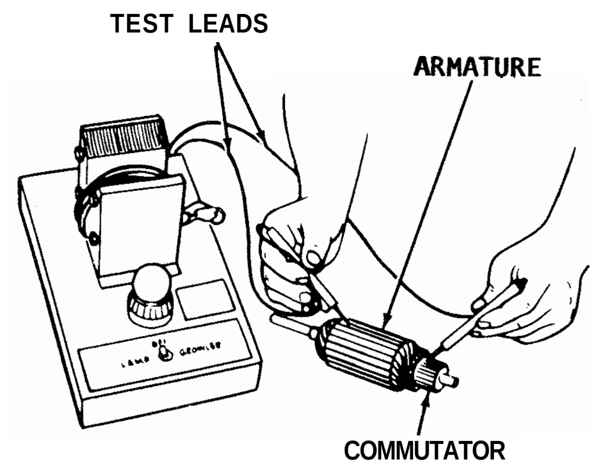
CLEANING AND INSPECTING

Inspect the brushes for wear and chipped corners. If the brushes are damaged, crack–ed, or worn half way down, they should be replaced. If the springs appear to be weak or take a set, if collapsed, they should be replaced. Clean the contact points of the circuit breaker but **TAKE CARE** not to spring the bi–metal strip. Polish the points





Testing an armature on a growler with a hacksaw blade.

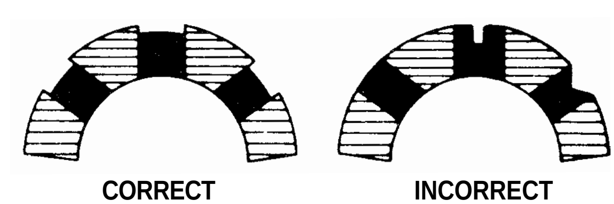


Armature check for a short: one test light lead on each commutator segment, alternately, and the other lead on the armature core. No continuity.

for continued long life with a strip of extra fine emery cloth. Check the armature thrust ball bearing for wear.

Wipe all parts clean and dry. **NEVER** use solvent because it may soften insulation on the armature. Clean the commutator with grade **00** sandpaper.

True the commutator, if necessary, in a lathe. **NEVER** undercut the mica because the brushes are harder than the insulation.



Armature segments properly cleaned (left) and improperly cleaned (right).

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 commutator bars, and then check again on the growler. If the saw blade still vibrates, the armature must be replaced.

Make contact with one probe of a test light on the armature core or shaft and the other probe on the commutator. If the light comes on, the armature is grounded and must be replaced.

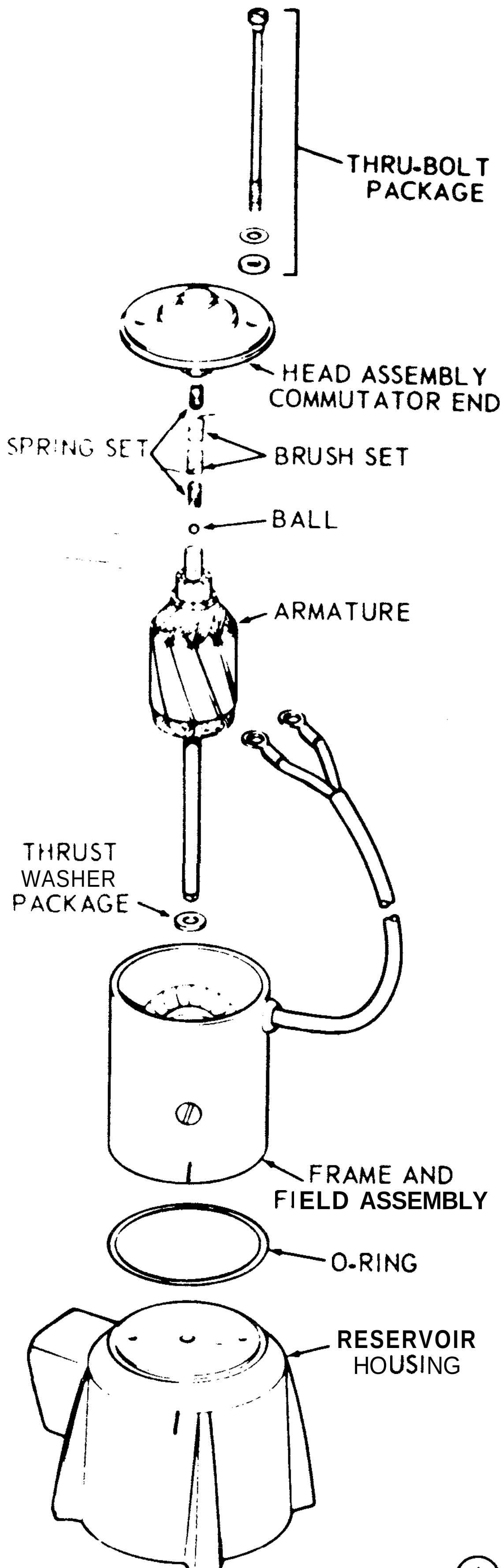
Visually inspect the insulation for indications of overheating and for damaged windings. Remove any deposits of carbon or foreign matter which could contribute to later failure of the windings.

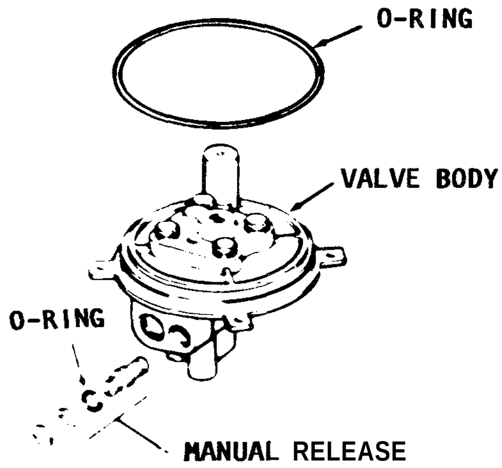
ASSEMBLING THE PUMP AND MOTOR

1– Assemble the brushes and the springs to the end head. Connect the field leads to the end head. Install the washers on the long shaft end of the armature. Slide the armature into the frame and field assembly. Install a **NEW** O–ring on the reservoir. Place the armature, frame, and field assembly in position on the reservoir. Place the ball bearing on the top end of the armature shaft. Position a **NEW** gasket on the frame and field assembly. Place the end cap and brush assembly in position on the frame and field assembly. Check to be sure the armature commutator does not disengage the brushes during assembly.

Attach the motor cable to the appropriate solenoid terminals and actuate the switch to check for proper motor operation in both directions. The motor current, when it is not assembled to the pump, should not be more than 20 amps for either direction. Install the assembled motor onto the reservoir housing. Observe and align the marks made during disassembly. Lightly tighten the frame screws.

2– Install the pump assembly with a NEW O–ring. **TAKE CARE** to align the pump shaft with the motor shaft for proper engagement. Tighten the pump assembly mounting screws to a torque value of 15–20 in.-lbs. Tighten the frame screws to 30–35 in.-lbs.

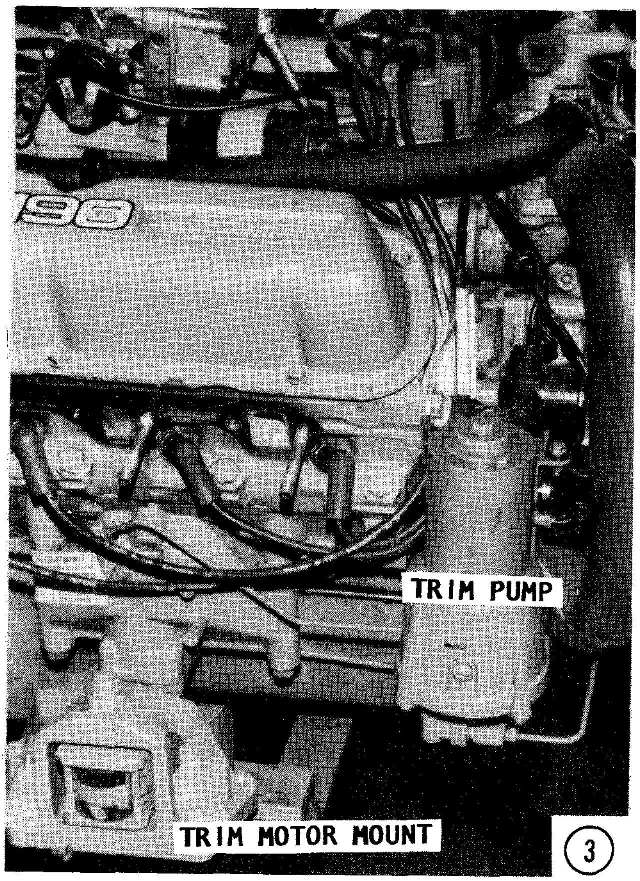




2

PUMP AND MOTOR INSTALLATION

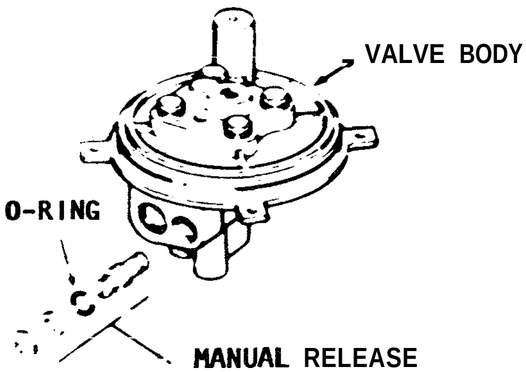
3– Install the pump on the engine. Connect the hydraulic lines. **ALWAYS** start the fitting with your fingers and be sure the connection has been made by a least a couple full turns before tightening it with a tool. Connect the electrical connectors. Fill the fluid reservoir and test the unit according to the procedures outlined in the this section, Adding Fluid.



3

MANUAL RELEASE VALVE REPLACEMENT

4– The manual release valve is located on the bottom of the pump. It is not necessary to remove the hydraulic pump from the engine in order to sevice this valve. To replace the valve, simply unscrew the valve and replace it with a new part. Tighten the valve to a torque value of 10–20 in.-lbs. After the valve has been replaced, check the hydraulic fluid level and bleed the system acccrding to the procedures outlined in the next section.



4

ADDING FLUID OR FILLING A DRY HYDRAULIC SYSTEM — INSTALLED

This procedure should be used if a substantial amount of fluid has been lost due to repair of the system or for any other reason. Total capacity of the system is 14 fluid oz. (1-3/4 cups). **NEVER** operate the pump without fluid in the reservoir. Fill or add to the system **ONLY** OMC Sea-Lube Premium Blend Gearcase Lube.

1– With both piston rods down and the fill plug removed, top off the reservoir with fluid.

2– Run the trim motor to extend the rods. **ADD** FLUID into the reservoir as the piston rods **EXTEND.**

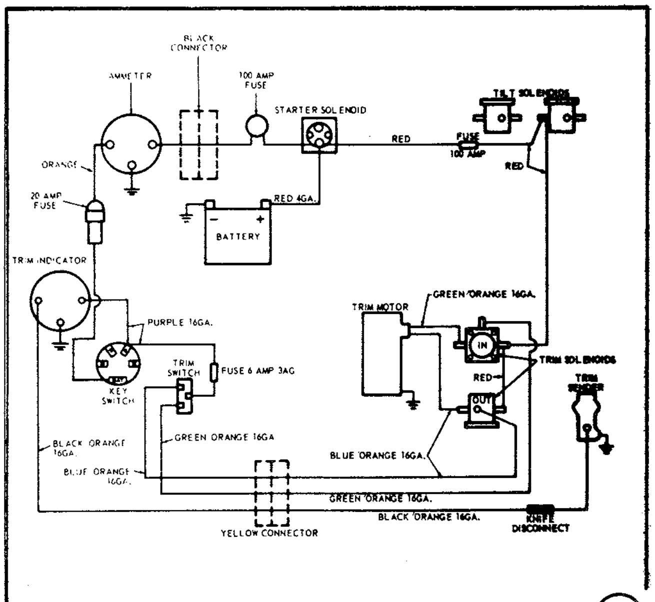
3– Replace the fill plug.

4– Operate the trim motor and retract both rods. Operate the motor until the rods are fully extended. Remove the fill plug, again top off the reservoir, and replace the plug.

5– Repeat step 4, until the reservoir requires no more fluid with the rods fully extended.

6– Check the boat's battery and bring it up to a full charge, if necessary.

7- Energize the pump to extend the rods. The engine should travel up thru the trim range (4 stern drive out to 3° in) in 9 to 13 seconds and require 25-30 amps at 12 volts (13.5 volts initial). In the down direction, current draw should be approximately 25-30 amps for 8.5 seconds at 12 volts (13.5 initial). Stall current should be about 60 amps minimum in the full down position. If the unit does not perform within the limits described, perform the checks in the following sections.



1

ELECTRICAL CHECKS

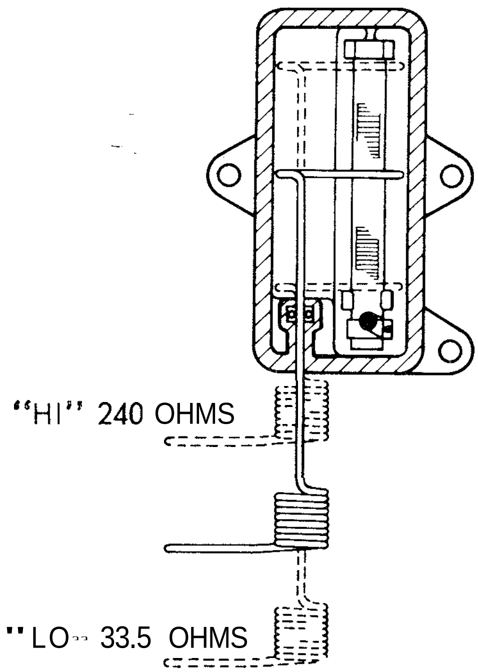
1- Check the voltage drop at the motor. Although a 12 volt potential is imposed at the battery connections, a voltage drop occurs thru the cable to the pump motor. If the voltage drop thru the cable exceeds 3 volts for the stern drive up and 1.5 volts down, the pump motor is not receiving the proper input power. Determine the voltage at the pump motor leads. Check to be sure the leads at the motor are properly connected.

Current draw over 50 amps while trimming, indicates a possible inefficient motor due to armature misalignment, blackened motor brushes, or corrosion of motor parts.

Excessive current draw may also be caused by a tight pump shaft. Check the shaft by first removing the valve body and gear assembly. The shaft should rotate without any indication of binding.

TESTING THE SENDER

2- Slide the rubber sleeve aside and disconnect the sender black/orange lead at the knife connection. Set the scale of an ohmmeter to the high ohms scale. Make contact with one probe of the meter to the sender lead and the other probe to a good ground. Activate the trim unit from the **HI** to **LO** position and note the reading. In the **LO** position the reading should be 33.5 ohms and in the **HI** position, 240 ohms. If the readings are not within these limits, or gives intermittent readings, replace the sender.



2

Conclusions: A continuous **LO** reading on the gauge indicates an open, or broken sending unit wire. A continuous **HI** reading on the gauge indicates a shorted wire from the sending unit to the gauge.

7-12 TRU-COURSE STEERING

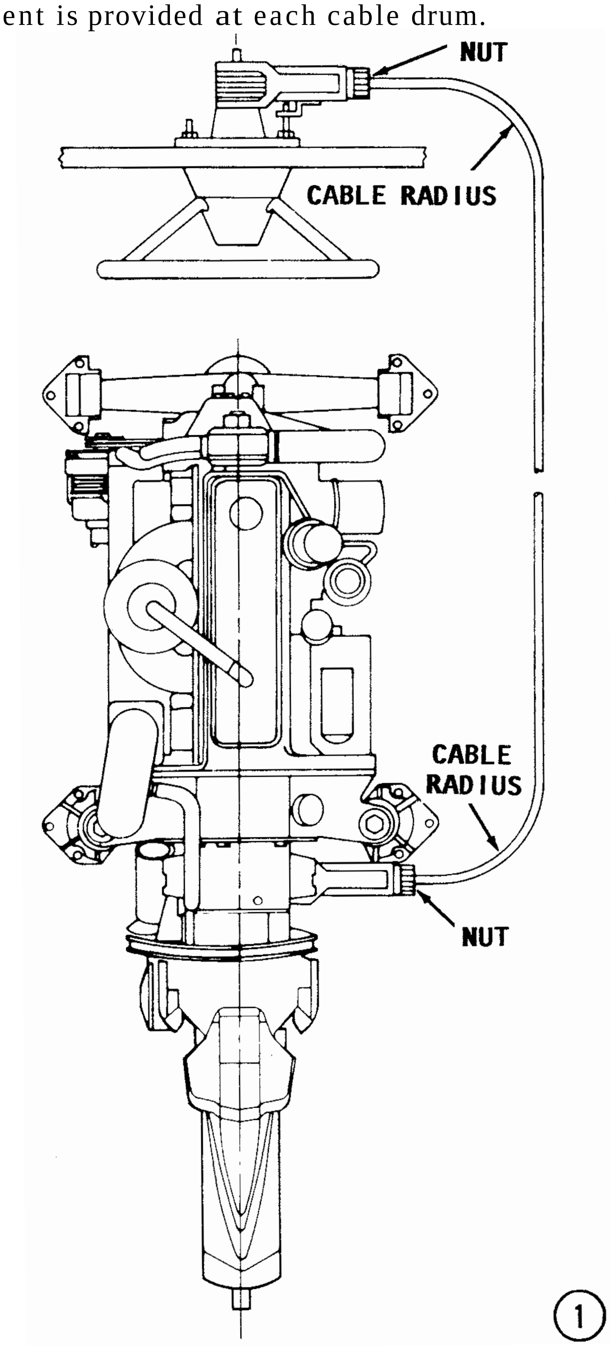
DESCRIPTION AND OPERATION

Tru-Course Steering is an OMC mechanical, non-reversing steering system for single station installations. This system was developed to meet the demands of today's boaters desiring a non-reversing feature and one insensitive to changing trim characteristics.

As the name inplies, the Tru-Course system will hold the boat on course. The system will point in a sharp turn as well as on a dead-ahead bearing, and is more positive at high speeds because steering loads are constant. The system does not have reduced steering efforts at low speeds.

Because it will turn the stern drive a full 90°, the full travel from hard-over in one direction to hard-over in the opposite direction is almost equal to the stern drive travel.

The Tru-Course system consists of the helm assembly, a preassembled steering cable, and a drum-and-bracket assembly. Two cables are secured to the drum assemblies at each end and are encased inside a one-piece housing. Cable tension adjustment is provided at each cable drum.

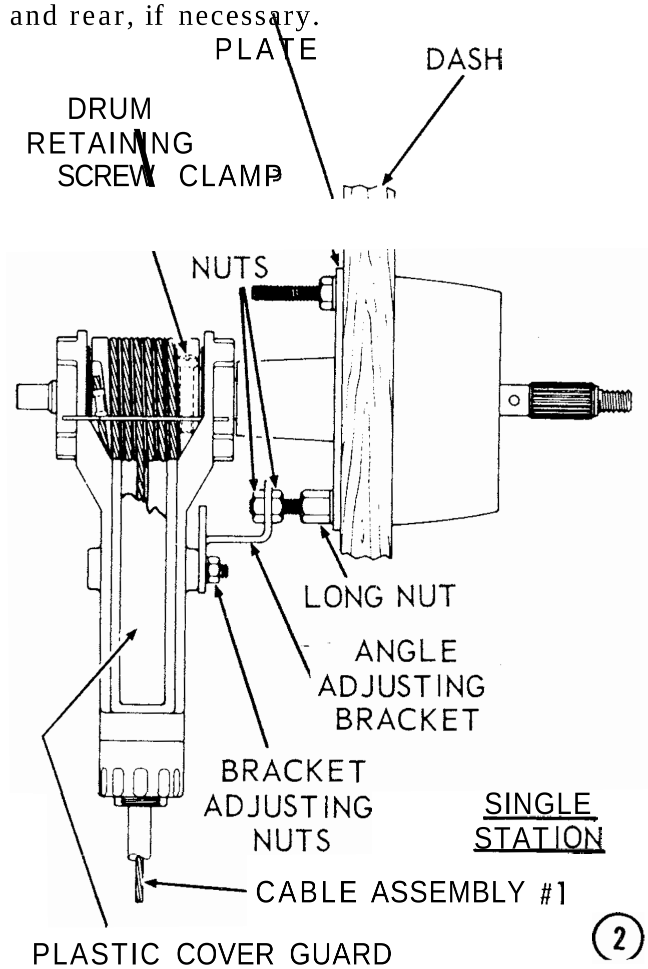


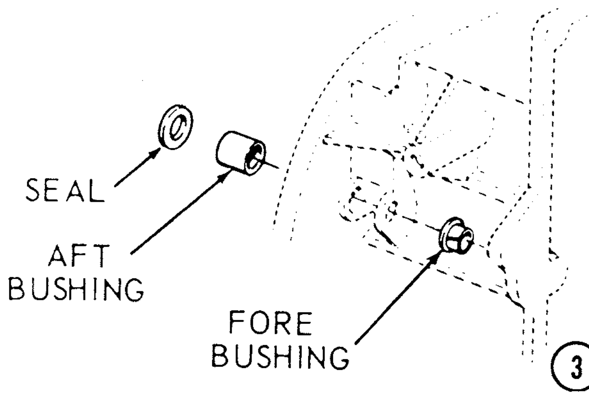
DISASSEMBLING

1- Center the wheel and vertical drive for a dead-ahead course if the system is operative. Remove the steering cable drum-and-bracket assembly from the helm by first removing the retaining screw from the drum, and then take off the clamp nut. Next, slide the assembly off the helm shaft. On some installations, it may be necessary to remove the helm assembly at the same time for the required clearance. This would be true for a binnacle installation.

2- Remove the cable and drum-and-bracket assembly from the intermediate housing by first removing the vertical drive unit as outlined in Chapter 10, Stern Drive. Next, remove the support bracket-to-intermediate housing screw. Remove the steering drum-to-gear shaft retaining screw. **STANDY BY** to catch the cable drum-and-bracket assembly, spring washer, and the spacer. Now, pull the spur gear-and-shaft assembly out of the intermediate housing. The aft washer on the gear shaft may remain on the shaft as it is pulled out.

3- Remove the bushings from the front and rear, if necessary.



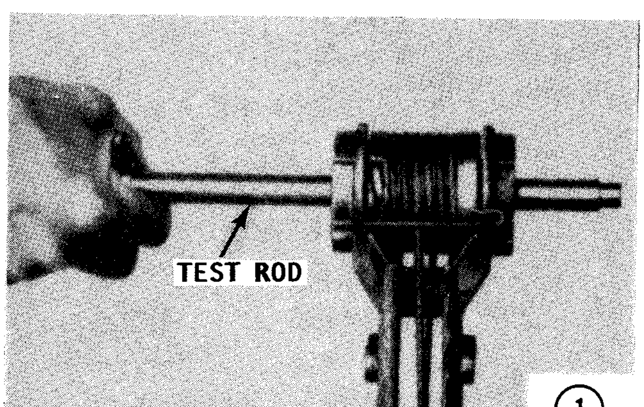


3

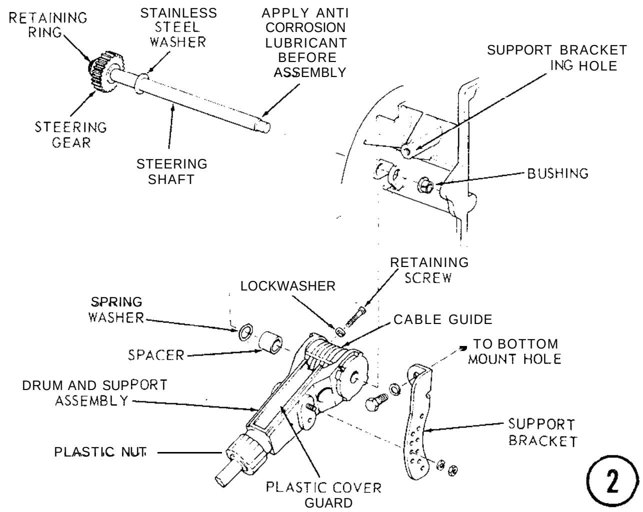
ASSEMBLING

1- The cable and drum-and-bracket assembly are preassembled and have retaining screw holes in both cable drums. These holes **MUST** be aligned with holes in the helm shaft and the intermediate housing cable drum shaft. If the cable assembly has been disturbed, the cable-and-drum assembly **MUST** be **CENTERED.** First, insert the gear shaft through the cable drum-and-bracket assembly and secure it with a retaining screw. Next, turn the gear-and-shaft assembly in either direction until it stops, and then back the other way three full turns. Remove the steering drum-to-gear shaft screw and take out the shaft. The assembly is now properly centered and ready to be installed.

2- Slide a washer and a **NEW** O-ring onto the gear shaft. Insert the fore and aft bushings into the intermediate housing. Slide the gear shaft through the aft bushing and slightly beyond, the forward side of the web in the intermediate housing. Place the spring washer and spacer on the shaft.

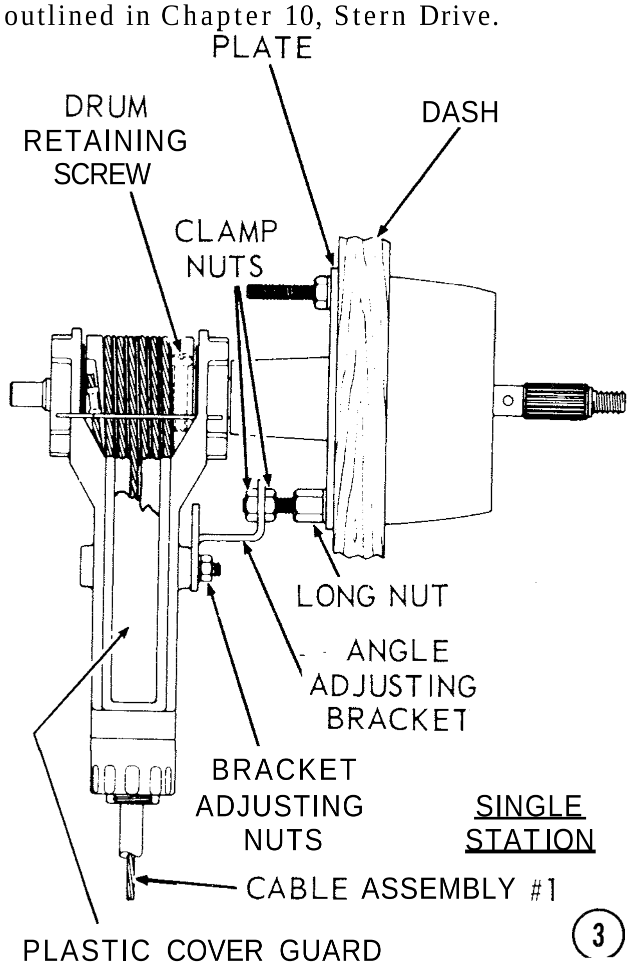


1



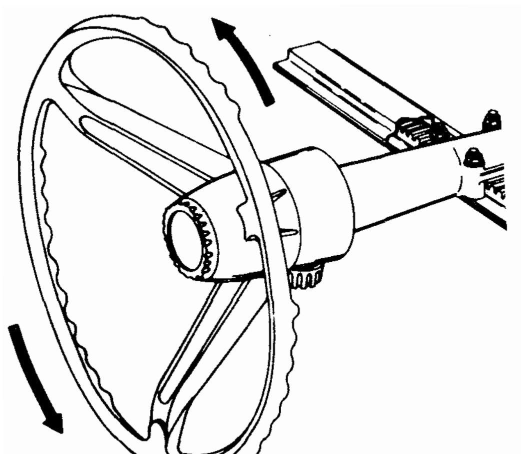
2

Place the cable and drum-and-bracket assembly in position with the hole in the drum aligned with the hole in the shaft. Slide the gear shaft through the cable drum and into the forward bushing. Install the drum-to-gear shaft retaining screw and lockwasher. Tighten the screw securely. Turn the vertical drive steering gear to center the upper gearcase with the lower gearcase. This position will be the dead-ahead position. Install the vertical drive as outlined in Chapter 10, Stern Drive.

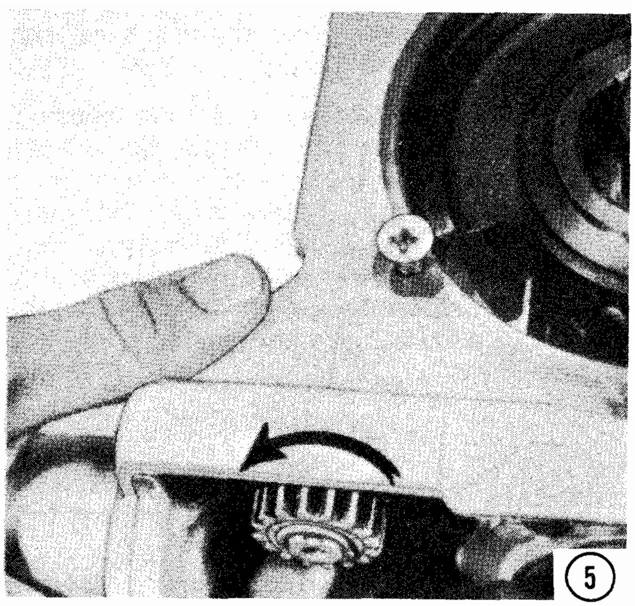


3

3- This step **MUST** be followed in the sequence given to avoid putting the cable drum-and-bracket assembly off-center in relation to the helm and thus causing the helm shaft to bind in the bushings. Position the helm steering shaft at its mid-point of full travel, hard-over to hard-over. Slide the cable drum-and-bracket assembly onto the helm with the angle-adjustment bracket located on the helm stud. Secure it with a long nut and clamp nut. Run the inner clamp nut down several threads to clear the bracket. Align the hole in the cable drum with the hole in the helm shaft nut. Insert the screw and lockkwasher, and then tighten it.

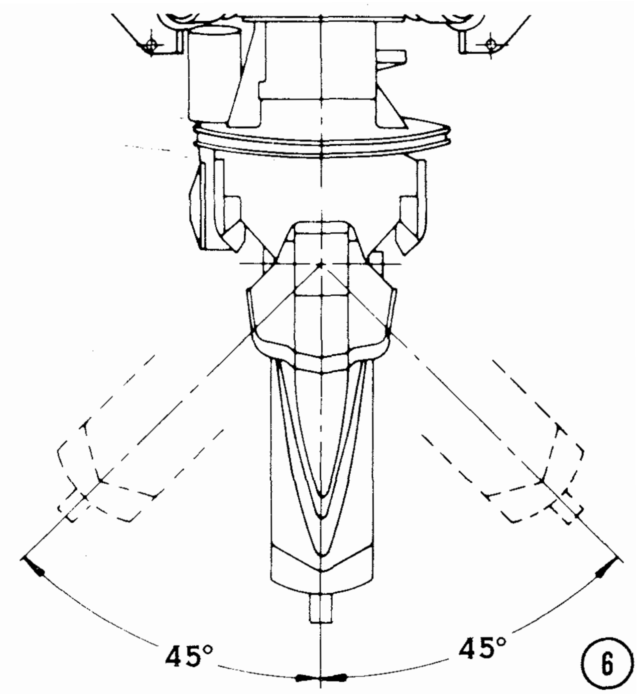

4

4- Before the stern drive is installed, turn the helm hard-over in one direction. Now, count the number of turns to hard-over in the opposite direction. Divide the total number of turns from hard-over to hard-over by two, and then turn the helm back that number of turns. The helm is now centered.


5

5- Turn the upper gearcase steering spur gear by hand until the upper gearcase inside the exhaust housing is centered. Install the stern drive, see Section 10-18.

6- After the stern drive has been installed, its turning limits **MUST BE CHECKED.** Turn the helm hard-over in both directions and note the travel of the stern drive. If the stern drive travels farther in one direction than theother, remove the stern drive and repeat steps 4 and 5, then install the stern drive and check the travel.

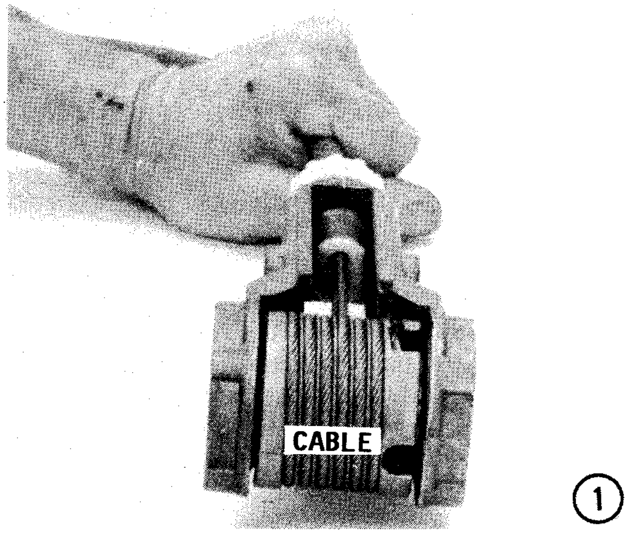


6

CABLE DRUM-AND-BRACKET DISASSEMBLY

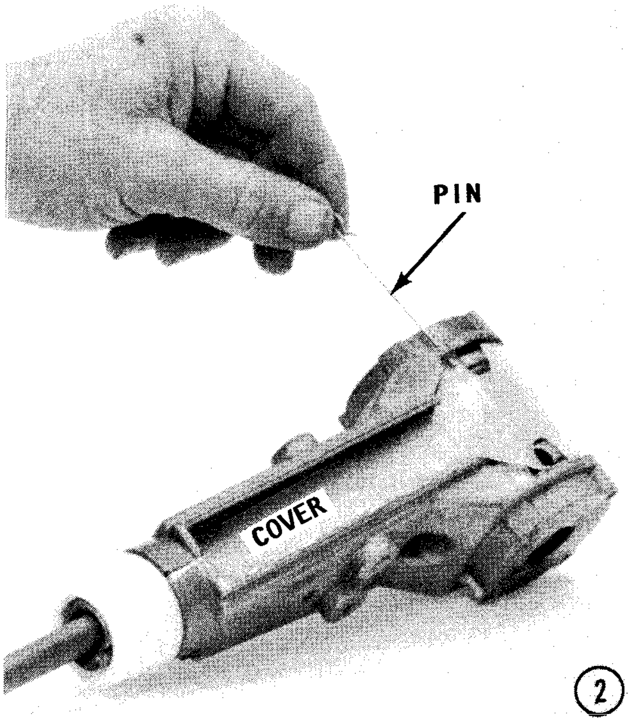
1- If the boat installation requires the cable and housing to pass through an opening too small for a cable drum-and-bracket assembly, the assembly must be disassembled and the cables unwound and dislodged from the drums. The cable can then be passed through the opening, and then the unit assembled. Begin the disassembly by sliding the pastic guard out of the bracket. Next, mark the cable (anchored to the end of the pulley) with paint at the end of the hole for the drum-to-shaft screw. This mark **MUST** be made in order to assemble the cable correctly to the pulley.

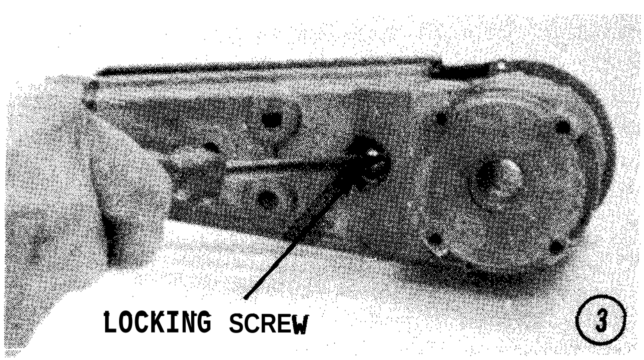
2- Remove the rollers and pins from both sides of the drum-and-bracket assembly. Unscrew the cable tension adjusting nut.

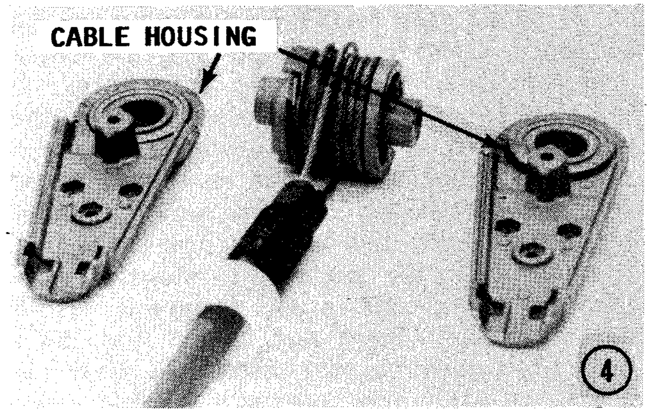


3– Remove the cable drum bracket clamp screw.

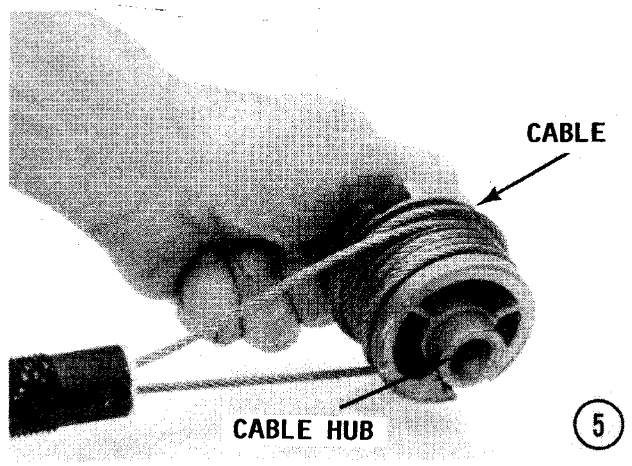
4– Pull the brackets apart. **DO NOT REMOVE** the bearings or lubricant from the bracket.







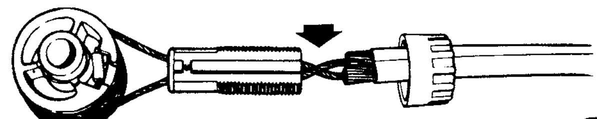
5– TAKE NOTE how the ends of the cables are trapped in the pulley and how the cables lead from the drum into the cable housing. Unwind and dislodge the cable terminals from the steering drum.



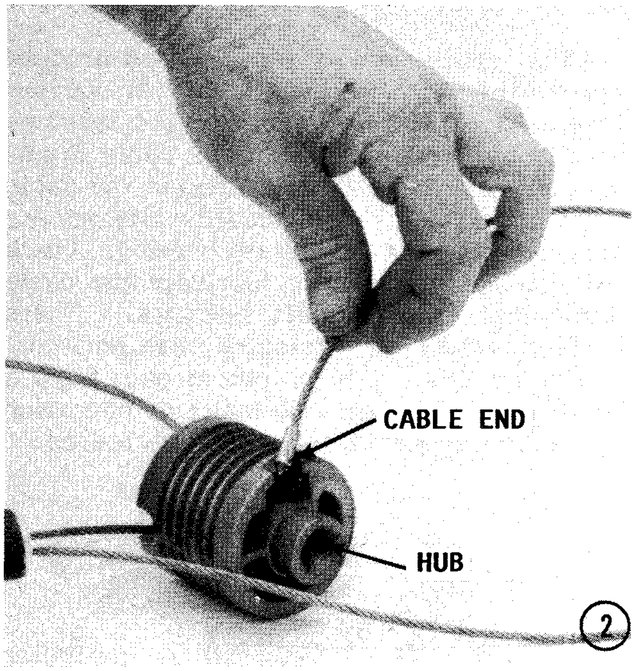
ASSEMBLING

1– Check to be sure the cable is not twisted or crossed between the tensioner and the cable housing.

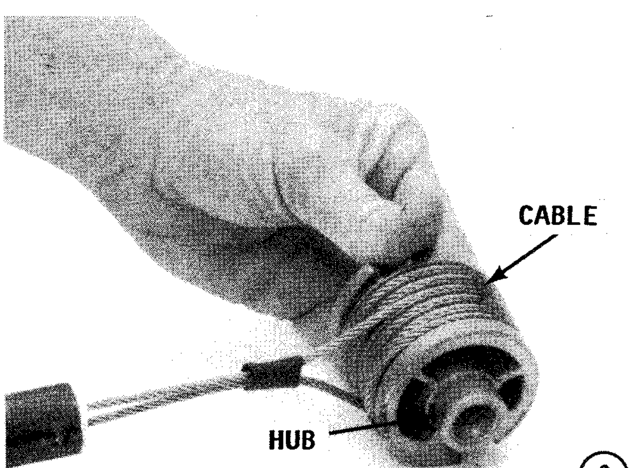
2– Hold the tensioner on the housing, and at the same time, insert the marked end of the cable into the end of the drum with the retaining screw hole. Wind the cable onto the drum and **TAKE CARE** to prevent the cable from unwinding. Now, insert the unmarked cable into the opposite end of the drum and wind it onto the spool. Hold the cable securely.

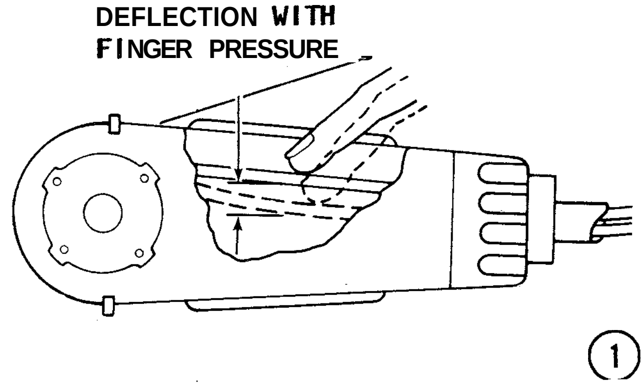


CABLES TWISTED 1



3- Wind tape around the cables to hold them in place while the bracket is being assembled to the drum. Install the brackets to the cable drum. **TAKE CARE NOT** to twist the cable 180°. Install one side of the bracket, then remove the tape before installing the other side. Secure the brackets with the screw and nut. Turn the cable adjusting nut onto the cable guide and tensioner. Insert the roller and pins onto the brackets. Check for binding. The tension nut must be loosened slightly for the following check. The cable drum should turn with light finger pressure. If any binding occurs, find the cause, and then reassemble the unit.

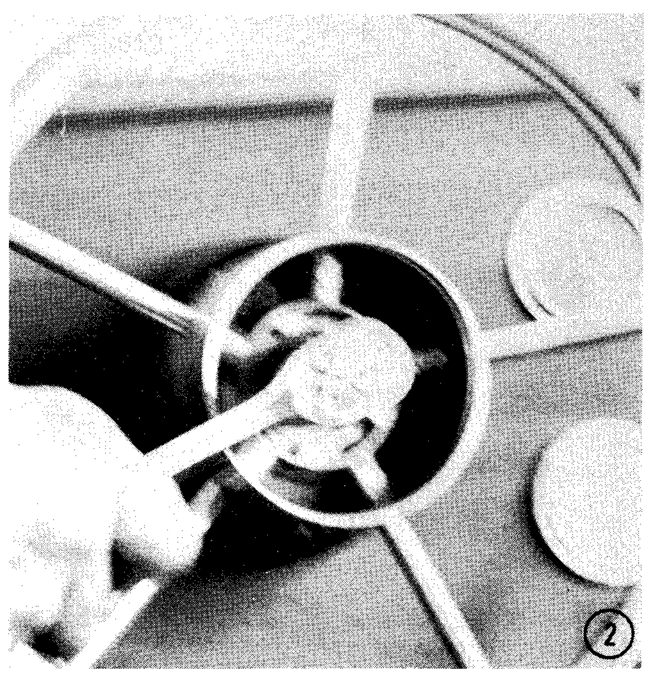


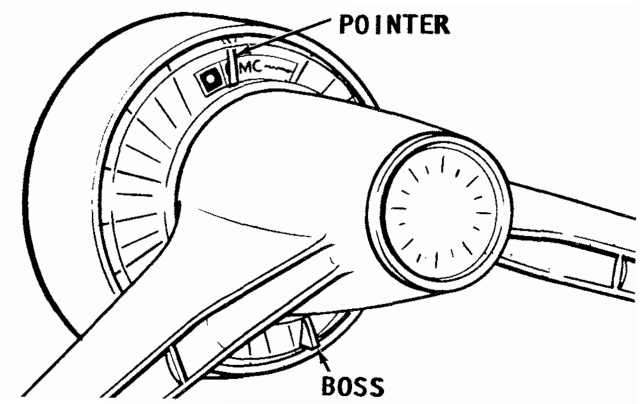


TRU-COURSE ADJUSTMENTS

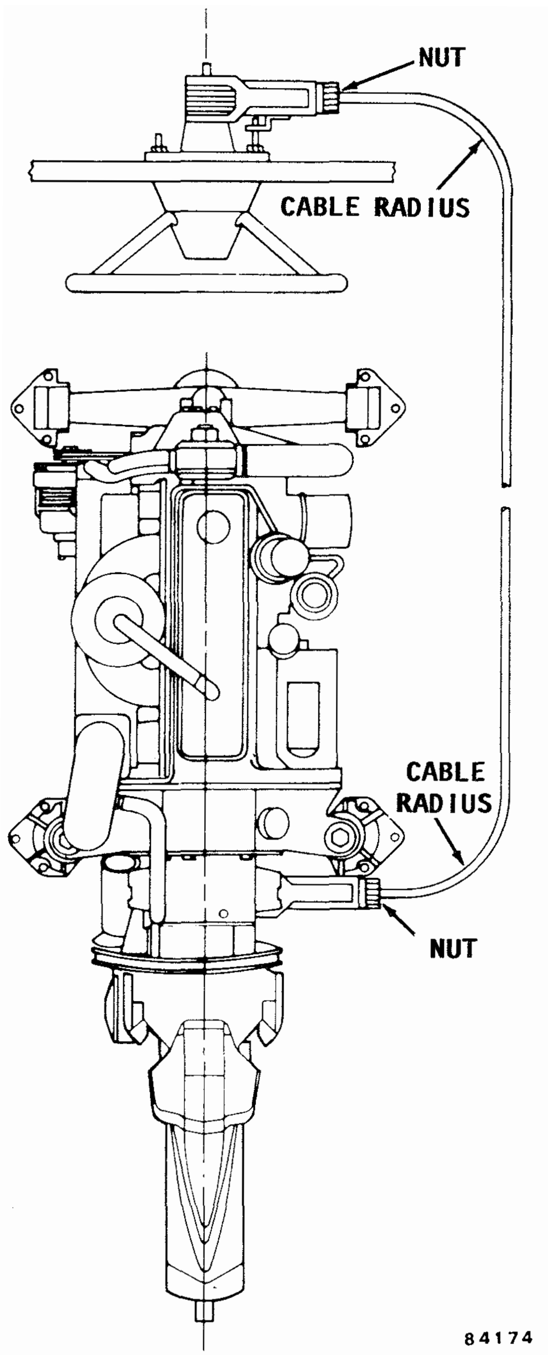
1- Remove the plastic shield from the cable drum-and-bracket assembly. Tighten the cable tension nuts on each end of the cable drum-and-bracket assemblies to allow 1/2" deflection, as shown. **TAKE CARE** not overtighten the nuts because it would cause increased steering effort. After making the adjustment, rotate the helm from hard-over to hard-over a few times. Readjust the tension, if desired. Install the plastic shields.

2- To adjust the steering wheel spokes for symmetry, snap out the medallion, and then remove the nut and Belleville washer. Pull the steering wheel free, and then install it with the spokes in the desired position. Slip the Belleville washer onto the shaft, with the high center of the washer facing the nut. Install and tighten the nut securely. Snap the medallion back into place.





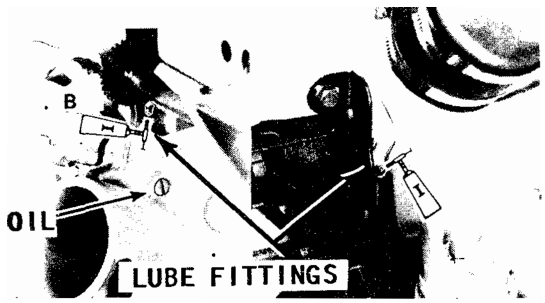
Adjusting the steering wheel rudder indicator.



Tru-Course steering installation.

TRU-COURSE MAINTENANCE

The cable and the drum-and-bracket assemblies may be purchased in various lengths from 10 to 24 feet and are serviced as a complete assembly. The cable drums turn on self-lubricating bearings in the cable drum brackets. Two lubrication fittings are provided in the intermediate housing. These two fittings are used to lubricate the cable drum shaft fore-and-aft bushings. These bushings MUST be lubricated with anti-corrosion material. One or two strokes from a hand gun about every 60 hours of operation will keep the bushings properly lubricated.



Lubrication points for the steering system.

7-13 MECHANICAL STEERING

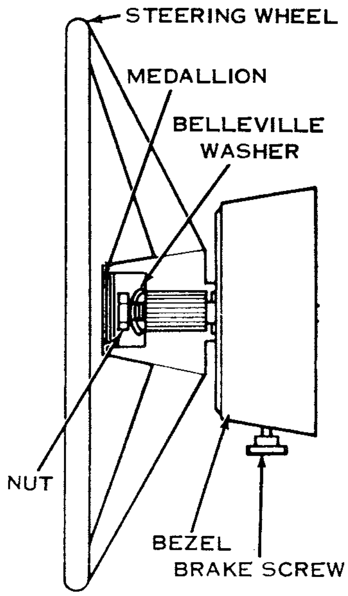
Two models of mechanical push-pull steering are available. One is sold as an assembly only, including the rack, housing, cable, and transom plate. The part number for the cable is 380514. The last two digits indicate the cable length.

The other unit is called an Over-Under Steering Helm. The cable is sold separately. The rack, housing, and transom plate are not included with the cable. The part number of this unit is 171914. As with the other unit, the last two digits indicate the cable length. In both cases, the part number is stamped on the steering cable.

These systems are designed to mount parallel to the dash. A special adagter is available to mount the wheel at a 20 angle to the dash to meet individual preference.

An adjustable brake knob on the bottom side of the shaft housing permits selection of the desired degree of "free wheel".

The cable run should be routed with a minimum number of bends for the most efficient operation. The radius of any one bend should not be less than 5".

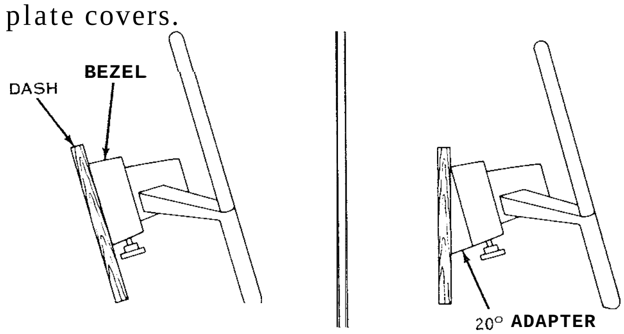


Major parts of the steering wheel and brake screw arrangement.

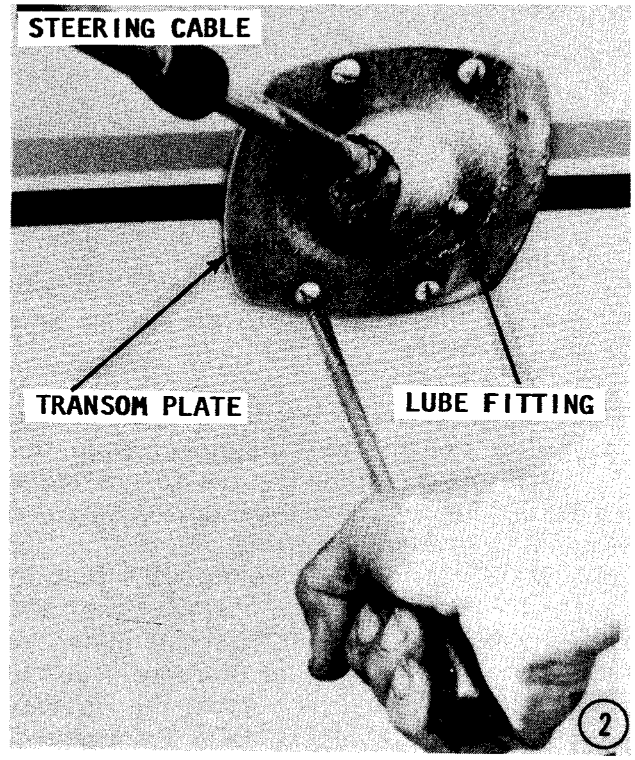
CABLE REMOVAL

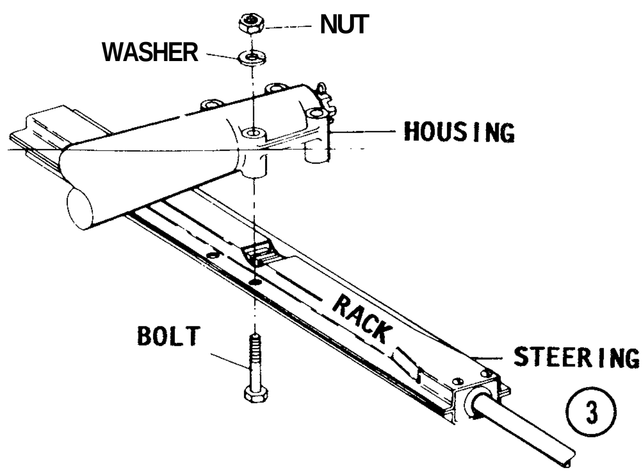
1- Remove the cable from the stern drive by removing the one bolt holding the cable to the stern drive terminal assembly.

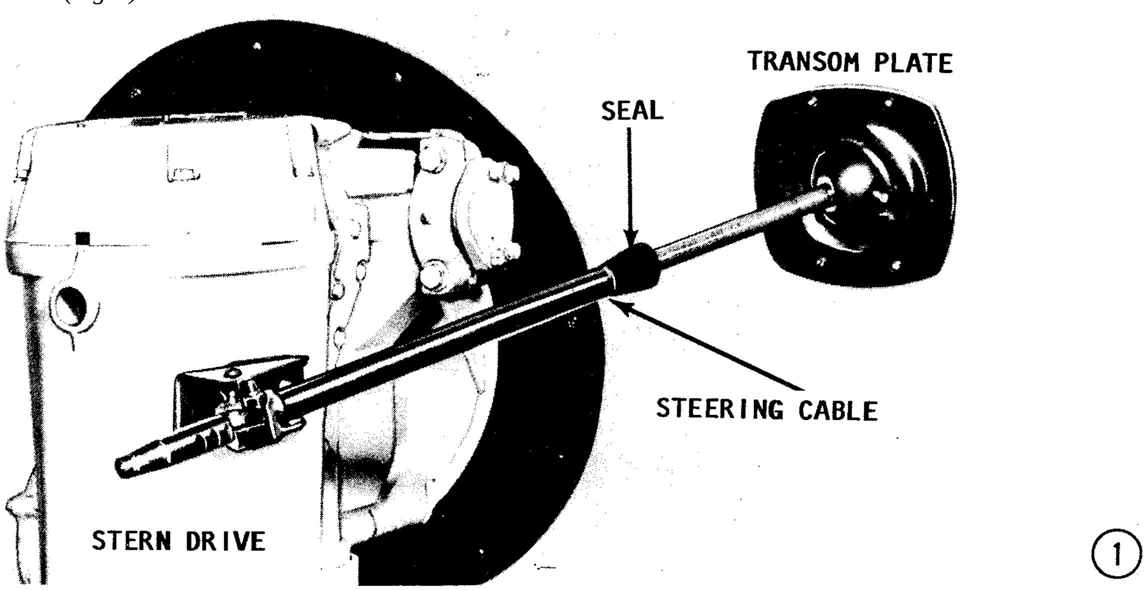
2- Remove the four bolts on the transom plate covers.

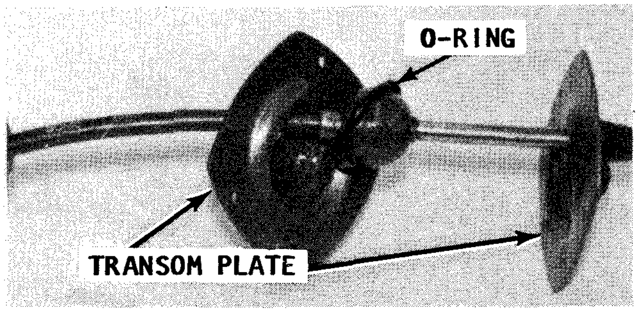


Dashboard mounted steering wheel without an adapter (left) and with one (right).



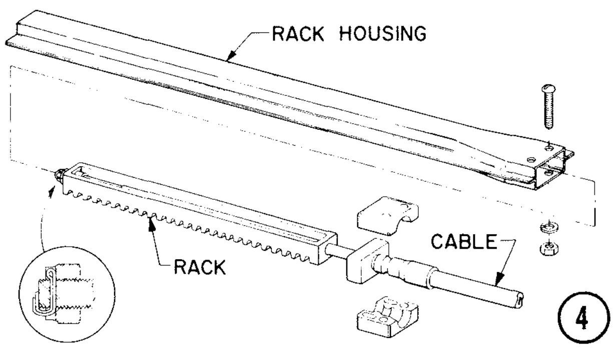






Arrangement of parts to pass the steering cable through the transom.

3- Remove the rack housing under the dash. Remove the rack assembly from the shaft housing by removing the four attaching bolts. Remove any tape or ties that are supporting the cable along its run. The cable MUST be removed through the hole in the transom. On some installations, the rack assembly must be removed to allow the cable to pass through the transom. In the No. 2 units, the rack is part of the steering helm assembly and MUST NOT be removed. Remove the cable from the rack assembly, and then pull the cable out the hole in the transom.



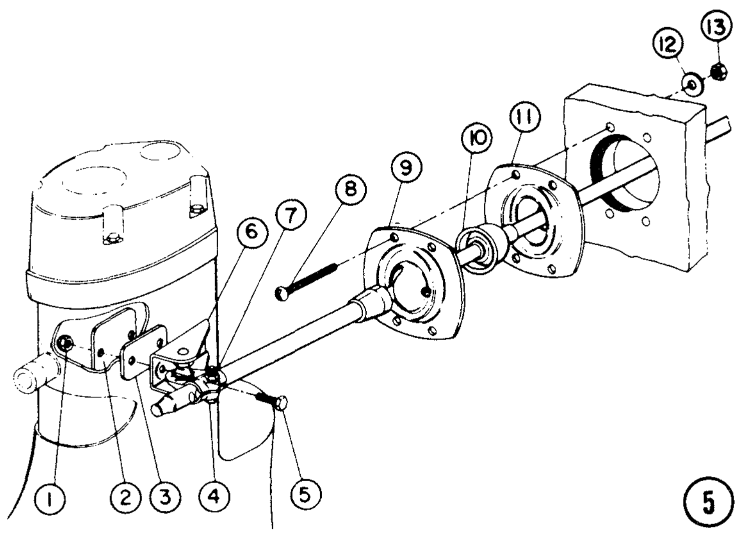
Item	DESCRIPTION	No. Req'd
1	Elastic Stopnut, Hex 5/16-24	2
2	Back plate	1
3	Front plate	1
4	Bolt, Hex Hd, 5/16-18 x 1/2 Lg.	1
5	Bolt, Hex Hd, 5/16-24 x 7/8 Lg.	2
6	Terminal assembly	1
7	Nut, Hex 5/16-18	1
8	Screw, Rd. Hd. 1/4-20 x 3" Lg.	4
9	Transom Plate, Outer	i
10	Seal	1
11	Transom Plate, Inns	1
12	Flat washer, 1/4 I.D.	4
13	Nut, Hex 1/4-20	4

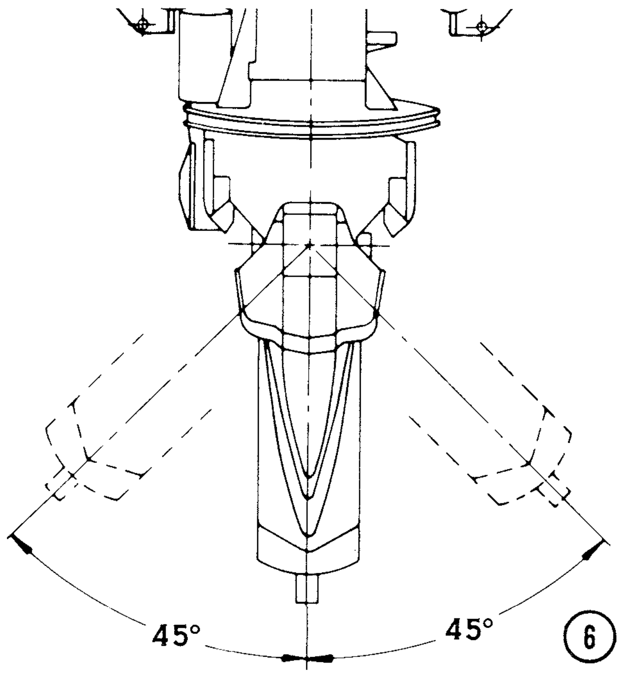
CABLE INSTALLATION

4- For some installations, the rack housing may have to be removed from the cable in order to reroute the cable. For other installations, the cable rack may have to be removed. In either case, TAKE CARE when handling the cable not to kink or bend the exposed cable end.

5- The part numbers given in this step in parentheses, refer to indexed numbers on the accompanying illustration. Insert the cable assembly through the hole in the transom and feed the cable forward to the helm. The transom plate (11) must be sealed by laying a small bead of waterproof caulking compound onto the flange where the plate contacts the transom. Position the plate (11) against the transom and secure it with bolts (8), washers (12), and nuts (13). CHECK the O-ring seal to be sure it is properly seated. Tighten the plate nuts securely. Insert the end of the cable through the stern drive terminal assembly (6). Insert the bolt through the hole using any of the slots in the cable end.

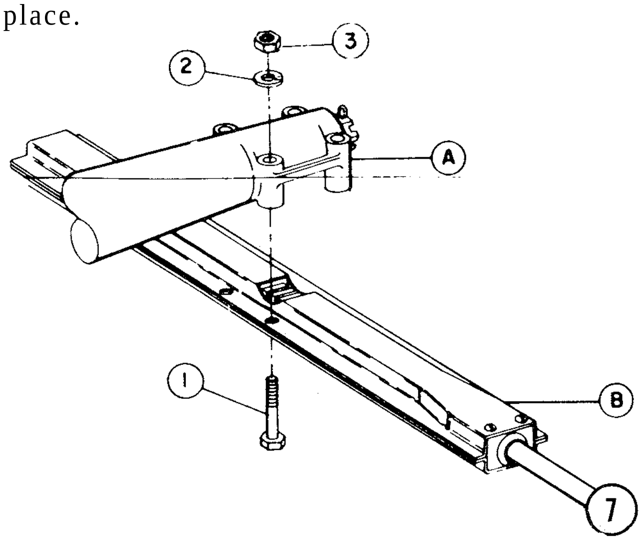
6- Turn the stern drive by hand hard-over to one side, and then hard-over to the oppostie side. If the drive will turn farther one way than the other, remove the bolt in the stern drive and relocate it in the correct slot. After the stern drive is centered, install the nut on the bolt securing the cable end. Support the cable along its run about every 6" with cable clamps, web straps, or similar devices. NEVER clamp the cable tightly at any point. DO NOT support the cable closer than 5" forward of the transom to allow free movement of the cable. The





path of cable should be kept clear of gear to allow enough clearance for cable movement when the stern drive unit is tilted up. Keep the rack clean and lubricated.

7- Position the rack against the shaft housing. CHECK TO BE SURE the teeth on the rack index with the teeth on the pinion gear before tightening the rack in place.

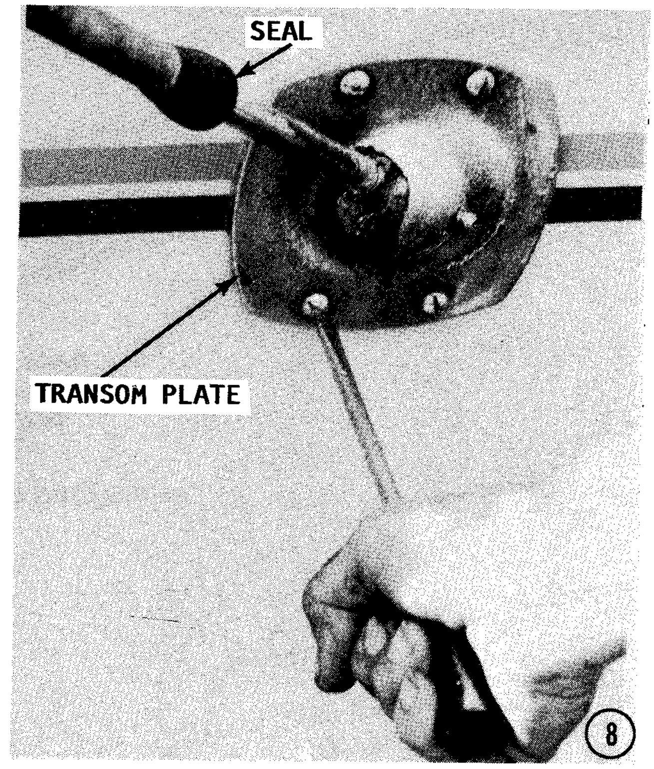


8- Install the four bolts and nuts through the assembly. BE SURE the cotter pin is in the nut on the end of the steering cable which protrudes out the end of the rack.

OVER-UNDER STEERING HELM

DESCRIPTION

The Over-Under helm provides parrallel routing of the cables along either the



starboard or port side of the boat when rounting down both sides is not possible.

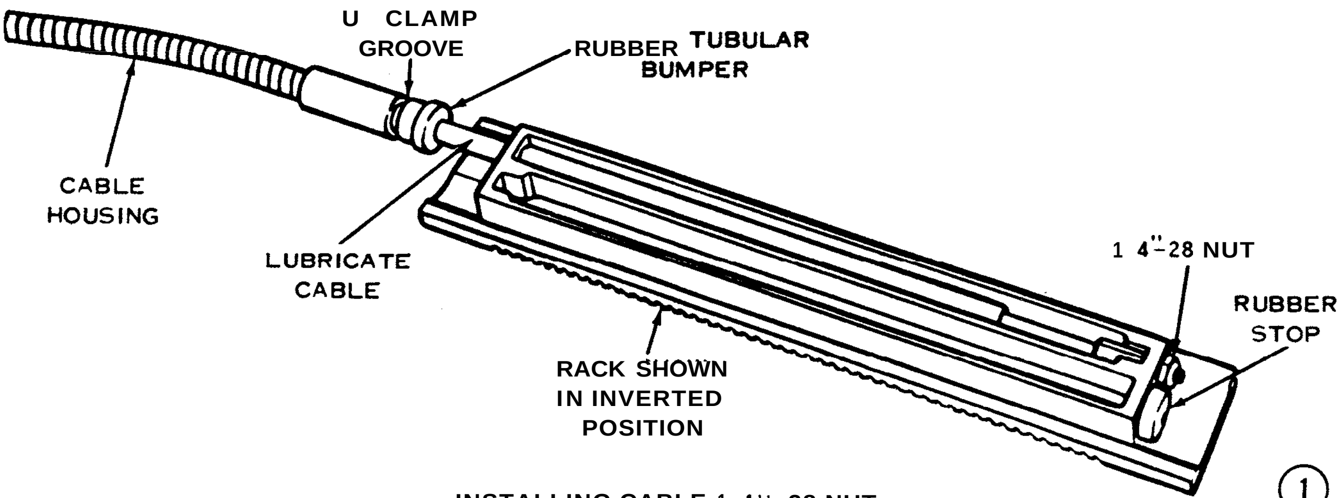
The Over-Under unit mounts at the stern drive and transom in the same manner as the assembly type unit. The difference with this unit is the hook-up at the dash.

7-14 OVER-UNDER CABLE REPLACEMENT

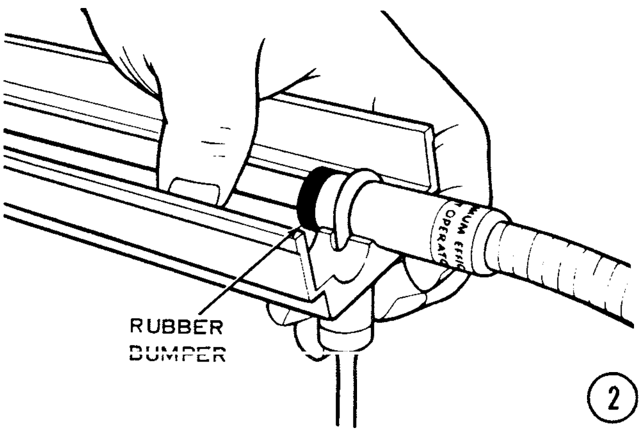
REMOVAL

1- Slide the cable through the large hole in the rack until the threaded fittings on the inner cables pass through the small hole in the end of the rack. Install the 1/4" x 28 nut. Slide the rack to the end of the channel in order to tighten the nut.

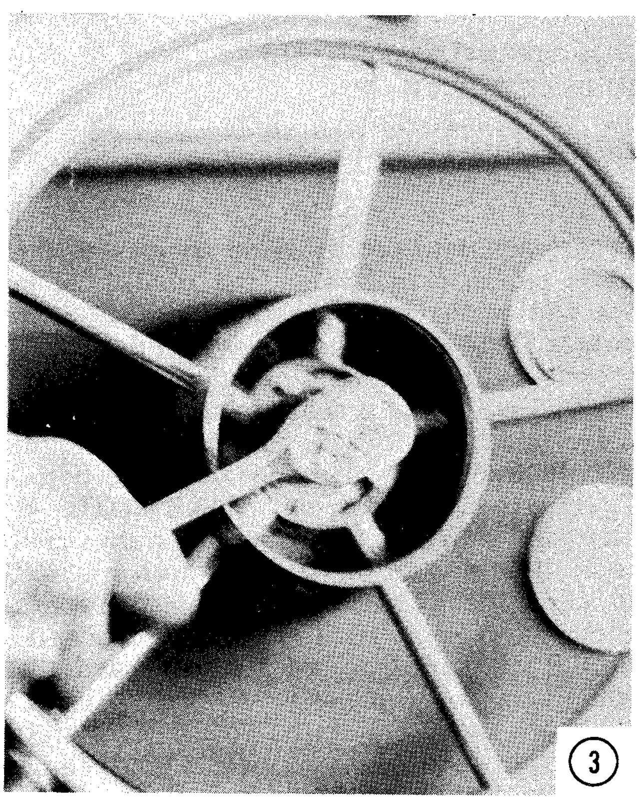
2- Center the grooves in the ends of the cable housing between the U-bolt holes in the channels, and then install the U-bolts. Tighten the nuts securely. TAKE NOTE: It may be necessary to swing the stern drive back slightly from the full port turn position to align the grooves in the cable housings with the U-bolt holes in the channels. Install the tubular rubber bumpers and the guide bars in the opposite end of the channel, using U-bolts, nuts, and washers. Install the upper rack and channel to the helm. Snap the dust covers in place.



INSTALLING CABLE 1 4''-28 NUT



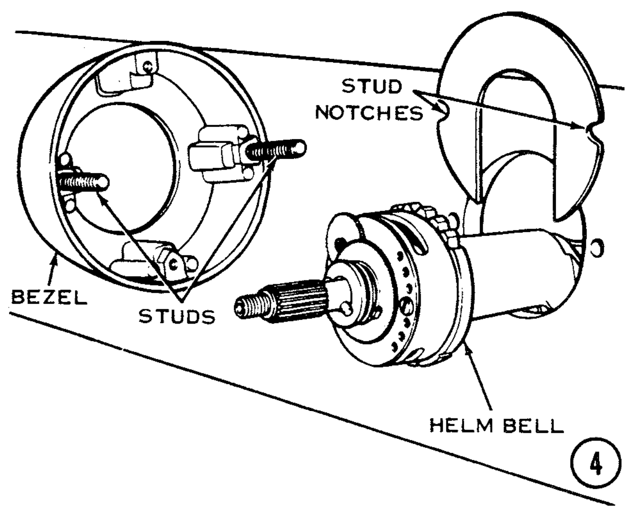
TIGHTENING CABLE HOUSING U BOLT



OVER-UNDER HELM REMOVAL

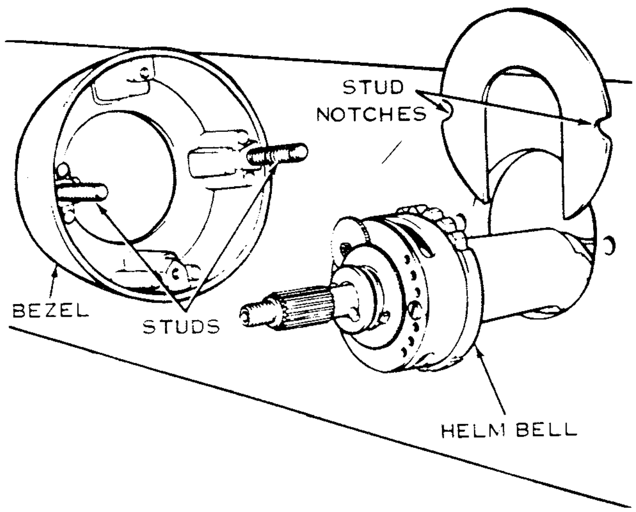
3- Remove the medallion in the center of the steering wheel. Remove the nut, washer, and steering wheel. Remove the bezel by removing the two nuts from the back side of the dash, and then pulling the bezel straight out. If necessary, use a small block of wood over the ends of the studs and tap the bezel out of the dash.

4- Remove the horseshoe plate from the helm shaft. Remove the helm assembly from the dash.



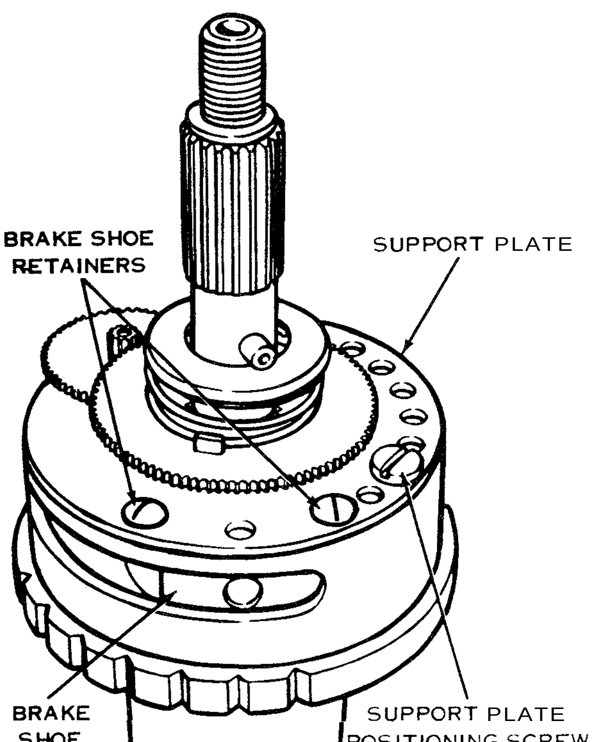
HELM INSTALLATION

5- Insert the helm through the hole in the dash. Slide the horseshoe plate into position over the neck of the helm between the bell and the dash. If a 20 degree adapter is used, slide the bezel through it and over the helm.

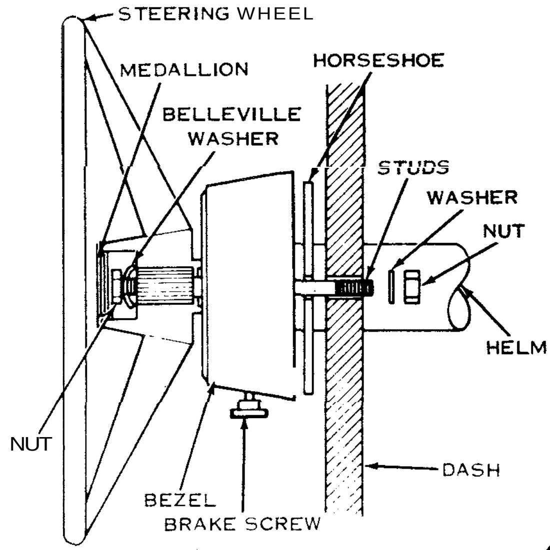


INSTALLING HELM HORSESHOE 5

6- Notches on the helm casting permit inclining the rack from a horizontal position in either direction, in increments of 15, 30, 45 degrees. The brake shoe must be repositioned the same number of degrees, but in the opposite direction to the rack, if an inclination is made. This inclination adjustment MUST be done before the bezel is installed. To reposition the brake, remove the screw attaching the support plate. The holes are spaced 15, 30, and 45 degrees from center. Rotate the plate in a direction opposite to the inclined rack, and then replace the screw. The brake is now on the



REPOSITIONING BRAKE SHOE 6



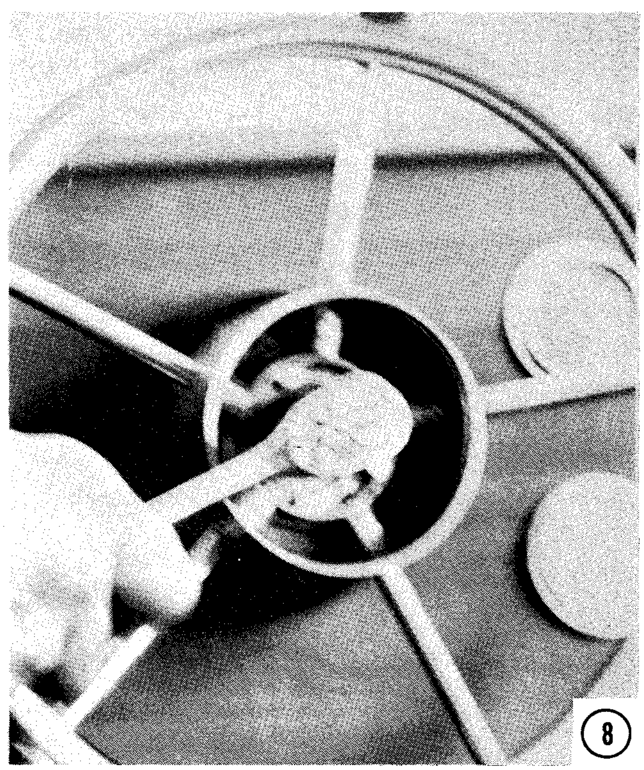
DASH INSTALLATION SECTIONAL 7

bottom in relation to the bezel. Install the bezel into the dash with the studs on the bezel passing through the cutouts in the plate and through the holes in the dash.

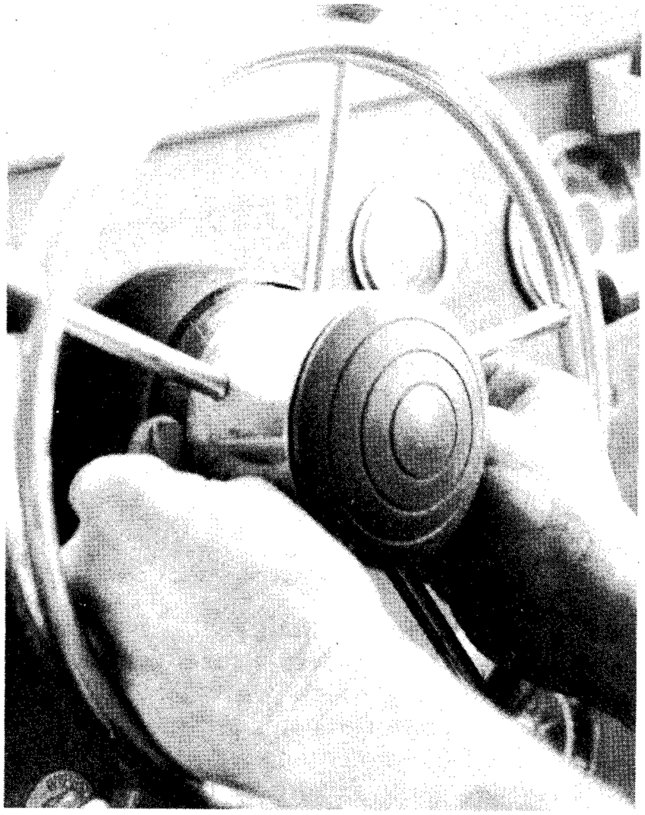
7- Secure the helm to the dash with the washers and nuts. Position the stern drive for a dead-ahead course.

8- Install the steering wheel with the high center of the belleville washer facing the nut. Tighten the nut and snap the medallion in place.

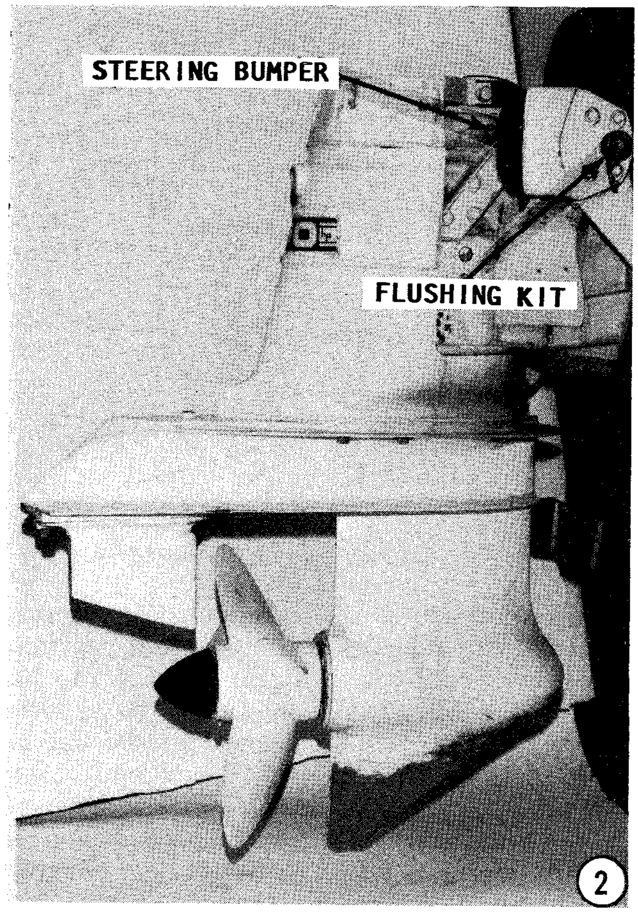
9- Position the rudder indicator for a dead-ahead course by grasping the boss on the lens and turning it as required.



8



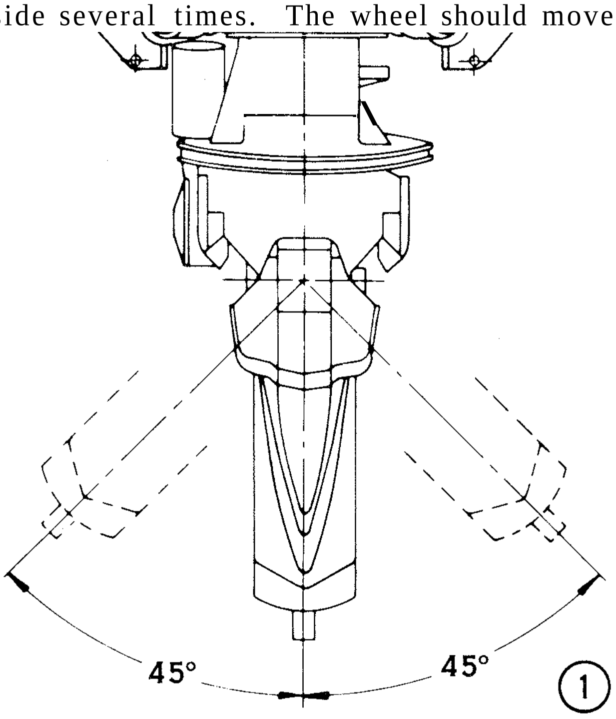
9



2

7-15 MECHANICAL STEERING FINAL CHECKS AND ADJUSTMENTS

1- Turn the helm from hard-over to hard-over and check to be sure the stern drive is turning its full radius. Loosen the brake knob and turn the wheel from side-to-side several times. The wheel should move smoothly and easily with uniform pressure throughout the turning range. If considerable pressure is required, check the cable run for bends of less than 5" radius; cable hangers or supports being too tight or distorting the cable; the stern drive tilted up; the stern drive not free to turn; or the skeg making contact with the ground.



1

2- SLOWLY raise and lower the stern drive unit and check to be sure the cable is not strained where it passes through the transom. **CHECK CLOSELY** when the stern drive is fully titled and turned hard-over in either direction.

MAINTENANCE

The cable ball **SHOULD BE** lubricated periodically with a good grade of waterproof lubricant, OMC Triple Guard, or equivalent. If the boat is used in salt water, lubrication should be done more often.

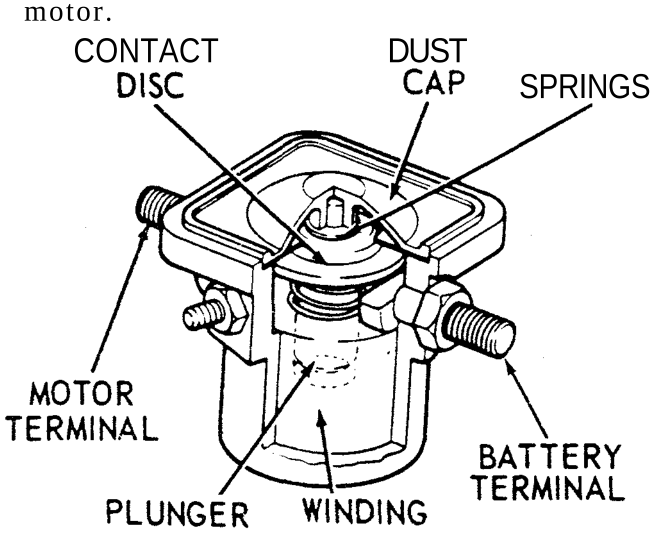
8 TILT MECHANISM

8-1 DESCRIPTION AND OPERATION

All stern drive engine installations are equipped with an electric tilt mechanism to lift and lower the stern drive. The mechanism consists of: A direct-current motor; a hammer-blow coupling; a worm shaft; a worm wheel-and-clutch assembly; two tilr solenoids; a tilt switch; battery; and the necessary wiring for activation and control of its operation. The tilt system is wired to the ignition switch "I" terminal. This wiring arrangement allows operation of the system only when the ignition switch is in the ON position.

SOLENOIDS

Two solenoids are installed side-by-side, one for the up movement and the other for the down movement. These solenoids perform mechanical jobs electro-magnetically by completing the heavy current electrical circuit between the battery and the tilt motor.



A cutaway drawing of a cranking motor solenoid with major parts identified.

The solenoids are completely sealed units consisting of: A plunger and contact disc assembly; a coil winding; a contact disc return spring; and four terminals. One of the larger terminals is for the battery lead connection; the other for the motor lead. One of the two smaller terminals is for the switch control lead connection; the other for the ground lead.

When the control switch is in the ON position and the tilt toggle switch is activated, an electric current flows through the coil winding; rhe plunger and contact disc is drawn inward; the circuit between the battery and tilt motor terminals is completed; and the battery current flows from the battery to the tilt motor.

A return spring is located just below the contact disc. When the electric circuit is completed, the spring is compressed by the magnetic pull on the plunger and contact disc. When the electric circuit is broken (the control toggle switch is released) the magnetic pull on the plunger and contact disc drops to zero; the compressed return spring pushes the contact disc away from the motor and battery studs of the solenoid; and the circuit is broken.

HAMMER-BLOW COUPLING

The hammer-blow coupling installed between the tilt motor and the tilt worm shaft performs a very important function. The coupling allows the tilt motor to rotate 90 degrees before engaging the tilt worm shaft half of the coupling. This feature allows the tilt motor to gain speed before it begins moving the heavy load of the stern drive. The possiblity of overloading the system at the beginning of tilt movement is therefore minimized.

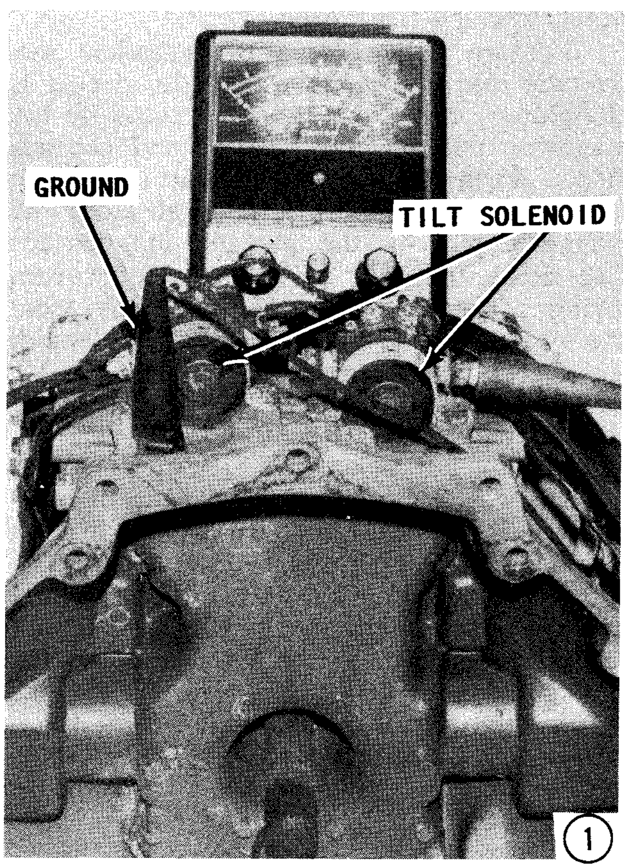
The hammer-blow coupling is designed as the weakest link in the tilt mechanism system, thereby preventing damage to the more expensive parts. The hammer-blow coupling is the first place to check if a tilt problem is encountered.

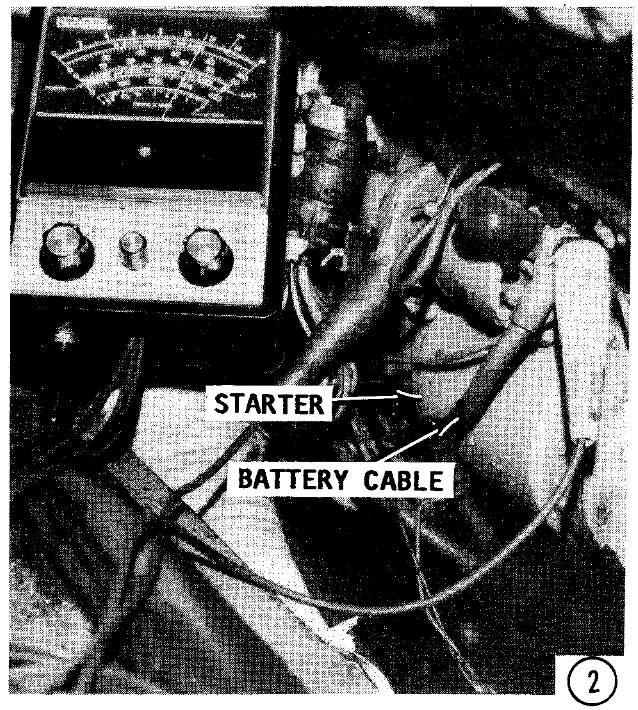
CLUTCH PACK AND WORM GEAR

The clutch pack and worm gear are part of the intermediate housing and are serviced from outside the boat. In order for the stern drive to tilt up if it should strike an object, the clutch is designed to slip at 130-160 ft-lbs. The clutch pack and worm gear also prevents the stern drive from tilting up when the drive is in reverse. A quadrant attached to the upper gear housing is used to tilt the stern drive by operating from the spur gear of the clutch pack.

8-2 TROUBLESHOOTING THE TILT MECHANISM

1- Check the condition of the boat battery and bring it up to a full charge, if necessary, before troubleshooting the tilt mechanism. Make contact with one probe of a voltmeter to the UP or **DOWN** motor





lead and to a good ground with the other probe. Activate the tilt toggle switch with the ignition switch to the **ON** position and note the voltage. If the meter indicates 12 volts and the system fails to operate, the motor is at fault.

2- If no voltage is indicated during step 1, make the following additional voltage tests: Make contact with one probe of the voltmeter to the input side of the tilt solenoid and to a good ground with the other

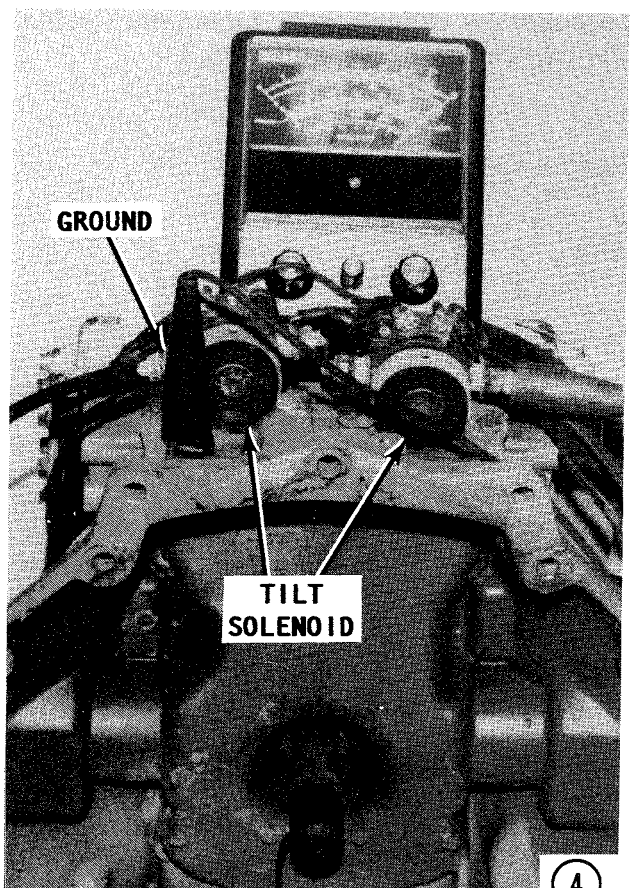
probe. Make contact with the probes between the starter solenoid input and ground. If voltage is present for these two tests, then the trouble is in the solenoids, the tilt switch, or in the tilt switch wiring.

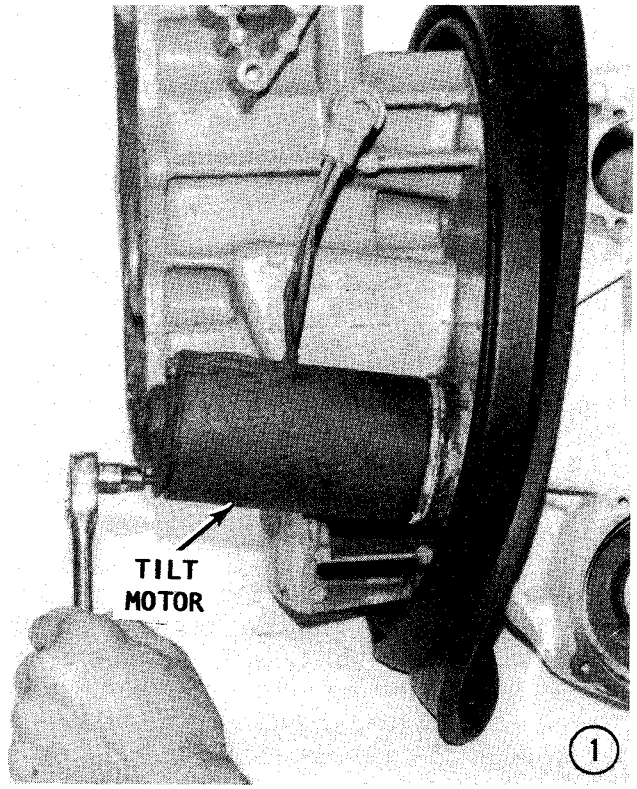
3- Check for voltage between the ignition switch and the tilt switch under the dash. Make contact with one probe of the voltmeter to the input side of the solenoid and ground, and then move the tilt switch to each position. Voltage should be present at both solenoids.

4- Check each solenoid: Connect one probe of a voltmeter to the solenoid output and the other probe to a good ground. Move the tilt switch to the position matching the solenoid being checked, either up or down. If the voltmeter fails to indicate voltage, the solenoid is defective. If the tilt motor runs, but the stern drive fails to move up, remove the tilt motor to check the hammer-blow coupling and clutch pack assembly. Check carefully around the pivot arms on the stern drive for corrosion.

8-3 TILT MOTOR SERVICE

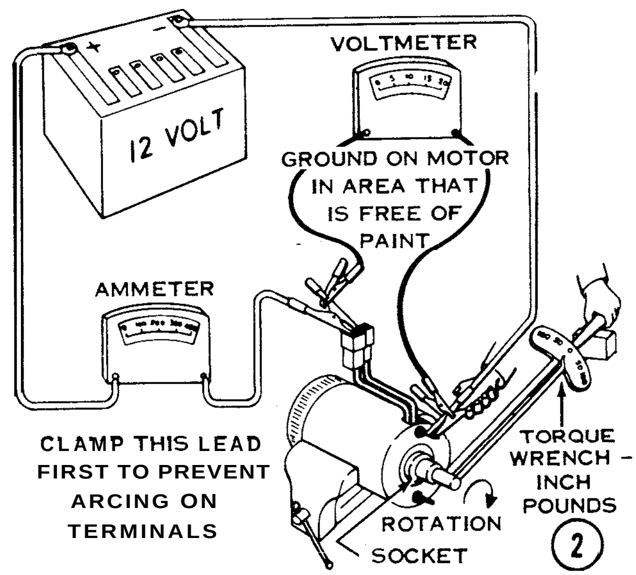
The following procedures give detailed step-by-step instructions for removal, disassembly, cleaning, and assembly of the tilt motor. The steps are keyed by number to the illustrations. The sections are coded for easy reference when performing other work.





REMOVAL

1- The tilt motor is installed on the port side of the engine under the exhaust manifold. Back out the two 3/8" thru-bolts (newer units have 1/2" bolts thru 2 caps on the motor and into the housing), until the motor will come free from the intermediate housing. Install two 1/4" x 20 nuts on the thru-bolts to hold the motor together until it is ready for testing.



TESTING

2- A no-load test of the tilt motor would not give positive results due to the motor construction. However, a stall-torque test will provide information essential when overhauling the motor. To make a stall-torque test: Clamp the motor in a vise. Connect a fully-charged 12 volt battery and an ammeter in series with the tilt motor. Connect the battery lead to the green tilt motor lead for clockwise rotation. Connect one lead of a voltmeter to the green or blue tilt motor lead and the other probe to a good ground. **TAKE NOTE:** The voltmeter must be connected to the **SAME** tilt motor lead as the battery.

Now, attach an inch-pound torque wrench to a screwdriver socket attachment and secure it to the slotted end of the armature shaft. Mometarily complete the electrical circuit and note the readings on the torque wrench, voltmeter, and the ammeter. The results should be: 11 volts; 120 amps; and not less than 27 in.-lbs. **TAKE CARE** not to operate the tilt motor any longer than necessary to observe the readings or the motor will overheat.

Allow the motor to cool, and then perform a similar test for the opposite rotation. Remove the battery lead from the blue or green tilt motor wire, and connect it to the other lead in the connector. Again, momentarily complete the electrical connection and note the three readings. The readings should be the same as for the first test.

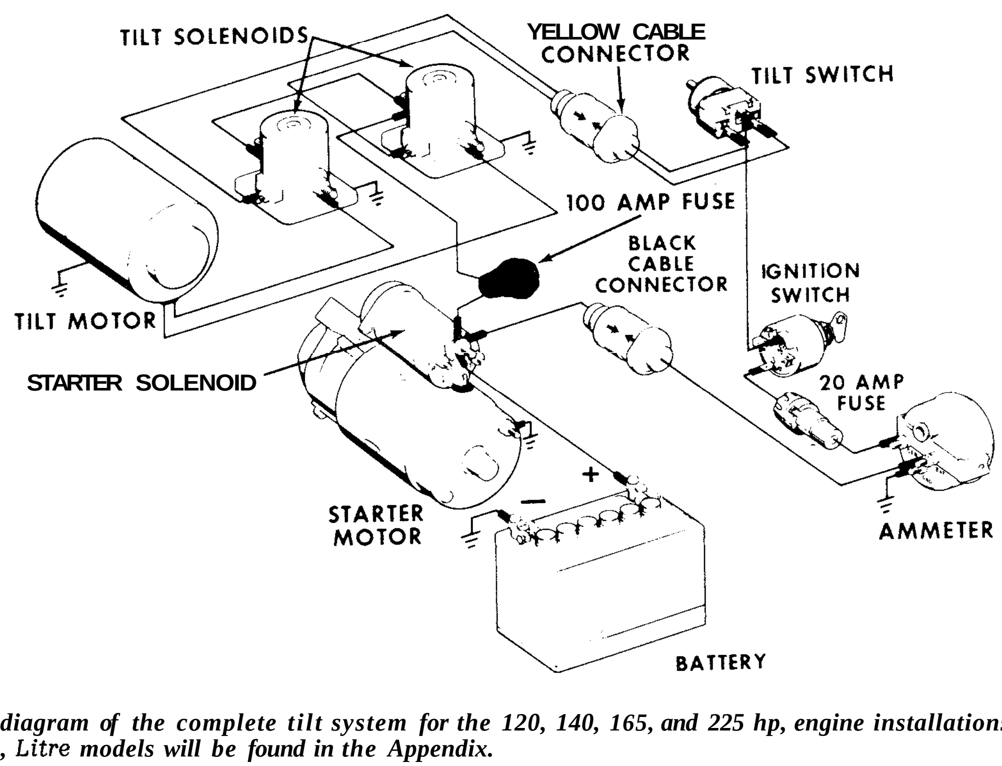
If the current reading and the torque value are both low, the indication is high resistance in the internal connections or in the brush contacts.

If the current reading is high with a low torque value, a faulty armature or field windings is the problem.

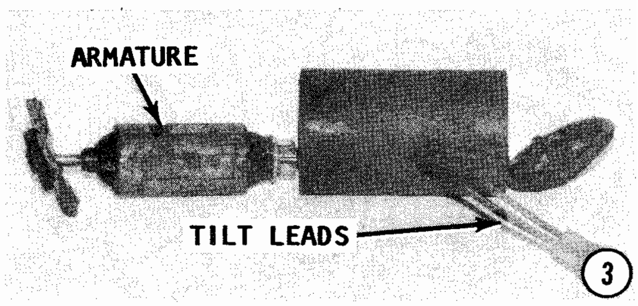
To check the armature: Complete the stall-torque test as outlined in Step 2. Now, turn the wrench in the opposite direction to the tilt motor rotation and perform the test. If there is a noticeable change in the torque value, or if dead spots with no torque value at all are -indicated, the armature requires attention.

TILT MOTOR DISASSEMBLY

3- Remove the magna shield sealing compound on the outside of the tilt motor with a wire brush. If necessary, remove stubborn material with a cloth dipped in solvent. **USE CARE** when using the solvent not to allow any to seep inside the motor because the solvent will soften the insulation on the armature and field.



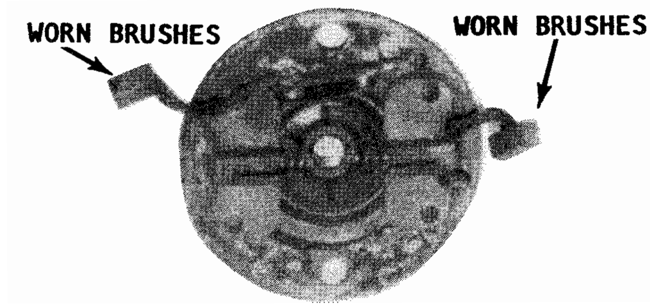
Functional diagram of the complete tilt system for the 120, 140, 165, and 225 hp, engine installations. Diagrams for the 2.5 and 3.0, Litre models will be found in the Appendix.



Remove the nuts on the through-bolts, and then take off the drive-end head assembly. **TAKE CARE** not to loose the washers on the armature shaft. Pull the armature out of the frame and field coil assembly. Remove the commutator-head assembly and **TAKE CARE** not to break the wire attached to the field coil.

CLEANING AND INSPECTING

Clean the parts with a dry cloth. **DO NOT** clean either head in solvent, because it will remove the lubricating oils in the armature shaft bushings. Naturally, lack of lubrication will cause bearing and armature shaft wear. **DO NOT** clean the armature in solvent, because the solvent will leave traces of oil residue on the commutator segments. This oil will cause arcing between the commutator and brushes.

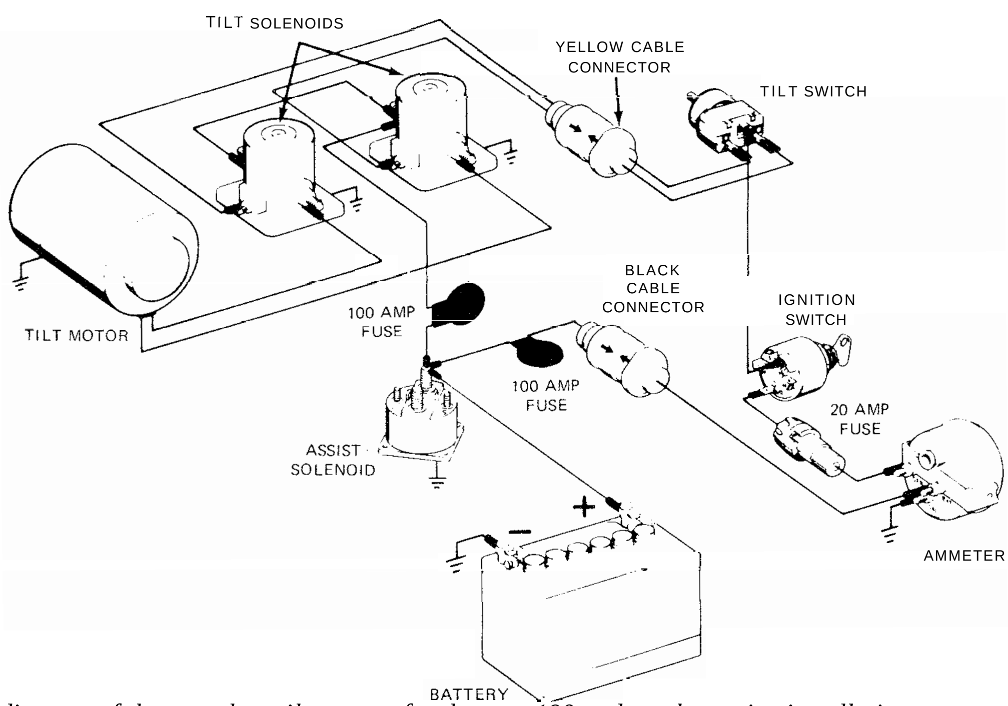


Worn brushes, as described in the text, must be replaced to ensure satisfactory service.

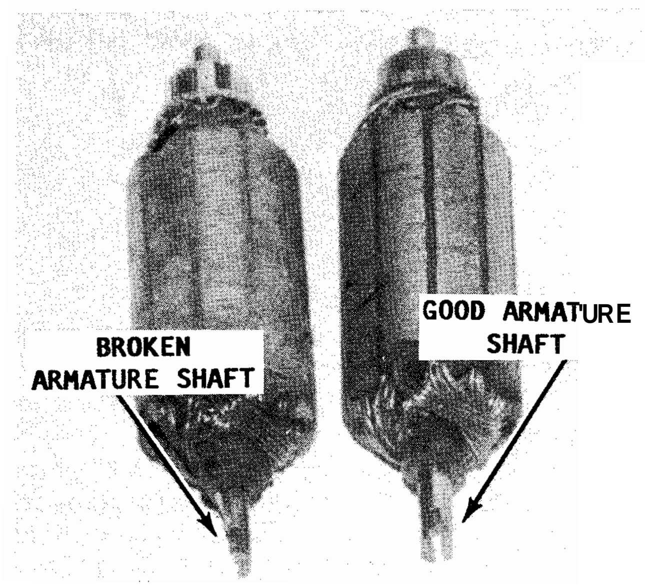
Brushes

Replace the brushes if they are worn half way or to 1/2" in length. To replace the brushes: Cut the old brushes away, but leave about 1/4" to 3/8" of the lead attached to the end head. Splice a new brush to the section of the remaining lead. Wrap the splice with several turns of fine wire to help keep the leads together during soldering. Hold the soldering iron against the splice long enough for solder to flow completely through the splice. After the solder has cooled, trim the ends of the wrapping wire.

If you do not have the time or desire to install the new brushes properly, the brush head may be purchased as a complete assembly with the brushes installed.



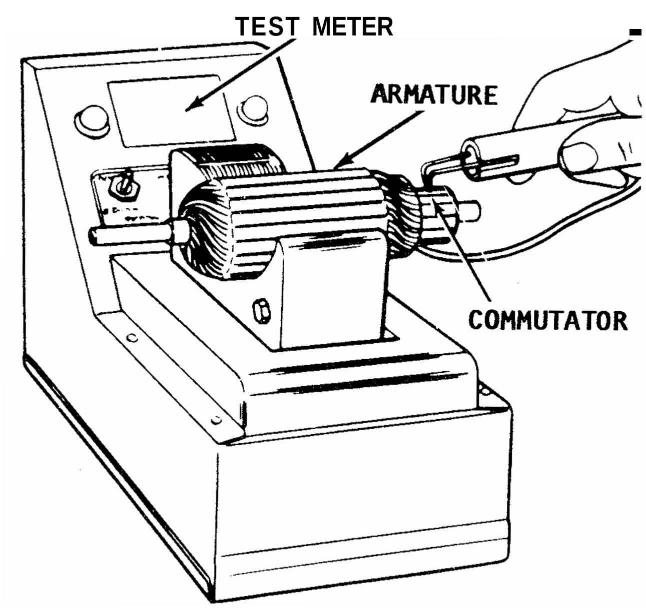
Functional diagram of the complete tilt system for the 175, 190, and 235 hp engine installations. Diagrams for the 3.8, 4.3, 5.0, and 5.7 Litre models will be found in the Appendix.



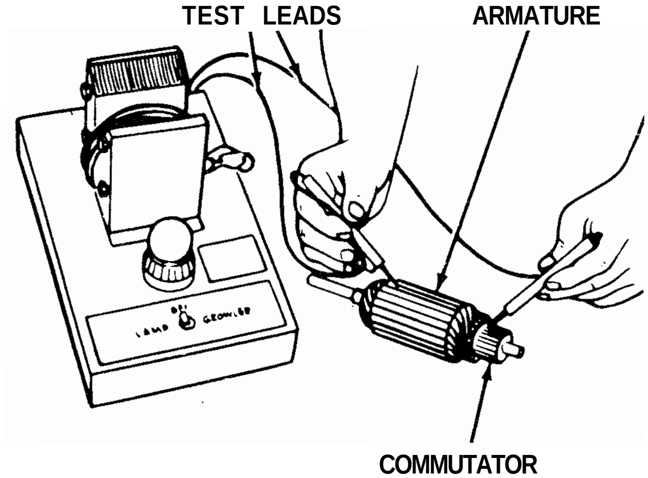
Tilt motor armatures showing damaged shaft (left).

Armature Shorted

The armature **CANNOT** be checked on a growler. Due to internal connections and low resistance of the windings, all of the coils will check out shorted. However, the armature can be tested using an AC milli-ammeter, five milliamperes with 100 scale divisions, and making tests between the commutator segments. Move from one segment to the next and watch closely for changes in the meter readings. The segments should all check out with almost the same reading. If a test between two segments indicates a significant lower reading, the winding is shorted.



Checking for no continuity between the armature segments.



Armature check for a short: one test light lead on each commutator segment, alternately, and the other lead on the armature core. No continuity.

Armature Grounded

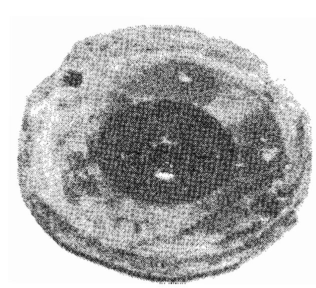
Connect one lead of a continuity tester to a good ground, and then move the other lead around the entire surface of the commutator. Any sign of continuity indicates the armature is grounded and **MUST** be replaced.

If the commutator segments are dirty or show signs of wear (roughness), clean between the bars, and then true it in a lathe. **NEVER** undercut the mica because the brushes are harder than the insulation.

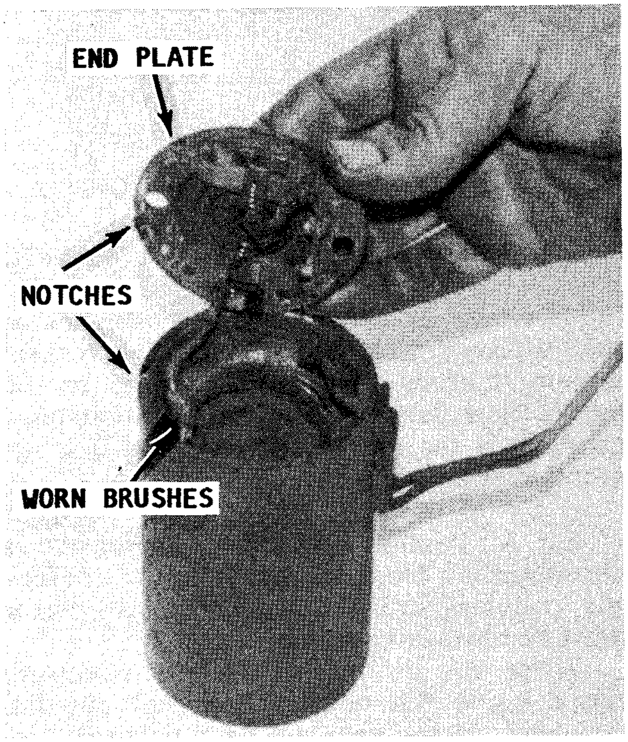
After turning the armature, the insulation between the segments **MUST** be undercut to a depth of 1/32". The undercut **MUST** be flat at the bottom and should extend the full width of each insulated groove and beyond the brush contact in both directions. This will prevent segment insulation from being smeared over the commutator as the segments wear.

After undercutting, the commutator should be sanded to remove the ridges left during the undercutting. Now, clean the commutator thoroughly to remove any metal chips or sanding grit.

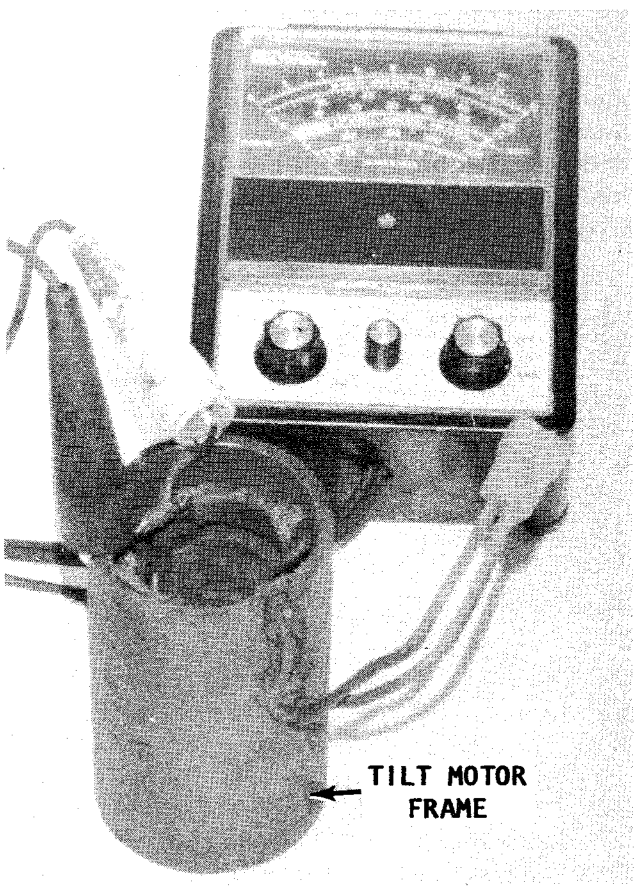
Repeat the shorting and grounding tests on the armature.



Badly corroded tilt motor end cap.



End plate brush holder partially removed to expose the brush holders, springs, and worn brushes.



Testing the field coils, as described in the text.

End Head Bushings

Side play of each end head on the armature should be checked carefully. Any side play indicates bearing wear and the end head **MUST** be replaced, because the bearings are not serviced separately. If heads with worn bearings are returned to service the armature will rub against the pole shoes, or the armature shaft may actually bind.

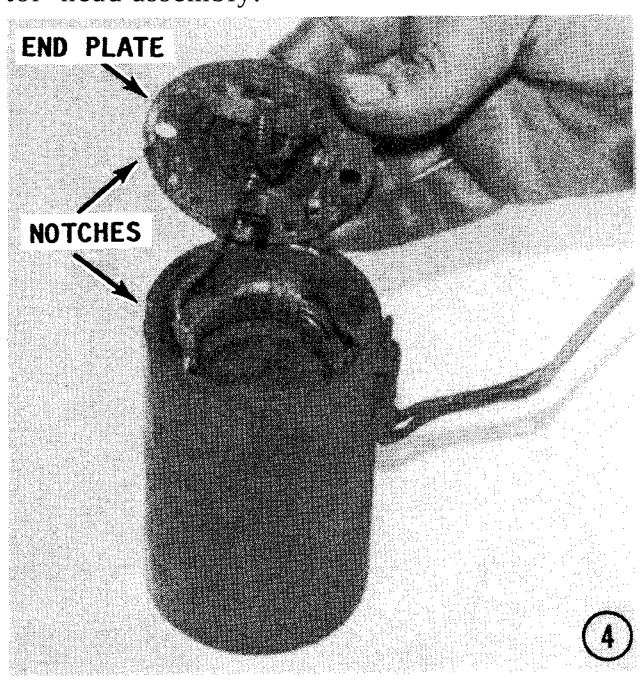
If the commutator end head is to be replaced, cut the lead connecting it to the field coil as close to the end head as possible. Solder the new end lead to the brush holder.

Field Coils

The field coils are series-wound and are not grounded to the frame. To test the field coils for a short: Make contact with one probe of a test light to the blue or green tilt motor lead and to a good ground on the frame with the other probe. If the test light comes on, the filed coil is grounded and **MUST** be replaced. The field coils are only available as a complete field coils and frame assembly.

ASSEMBLING THE TILT MOTOR

4- Apply a few drops of medium engine oil to the felt at the armature shaft drive-end head bearing. Apply a very light coating of oil to the armature shaft at the DRIVE—END **ONLY.** Install the armature into the field frame, with the commutator segments at the same end as the commutator-head assembly.



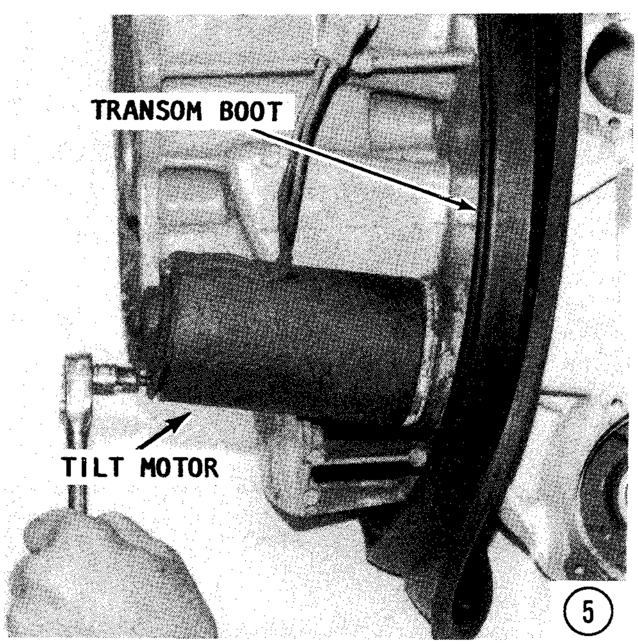
Pull the brushes back into the brush holder. With the armature extended out of the frame, slip the commutator head over the armature until the brushes are riding on the commutator segments. The commutator head and frame notches **MUST** align as the head is installed on the frame.

Install the washers on the drive-end of the armature, and then place the drive head onto the frame. The drive-end head scribe line **MUST** match the frame scribe line. Install the bolts through the drive head, into the frame, and out the commmutator head. Install 1/4" x 20 nuts to hold the tilt motor together until it is installed. **CAREFULLY** pull on the blue and green leds to remove any slack.

After assembly is complete, coat all electrical connection with Gaco N-110, or equivalent. Use a waterproof sealer, liquid latex or equivalent, to coat both end head seams, the pole shoe screws, through-bolts heads, and the area where the electrical leads come out of the motor.

INSTALLATION

5- Install the tilt motor into the intermediate housing with the keyway in the coupler aligned with the slot in the coupler armature shaft. Use a 3/8" wrench (newer units have two 1/2" bolts thru the caps and into the housing), to tighten the thru-bolts to a torque value of 5-7 ft-lbs. Connect the electrical plugs. Perform a functional check of the motor for proper operation.



TILT MOTOR SPECIFICATIONS

Rotation	Reversible
Minimum torque	27 in.-lbs
Amperes	120
Voltage, approx.	11
End play	0.0 10-0.040"

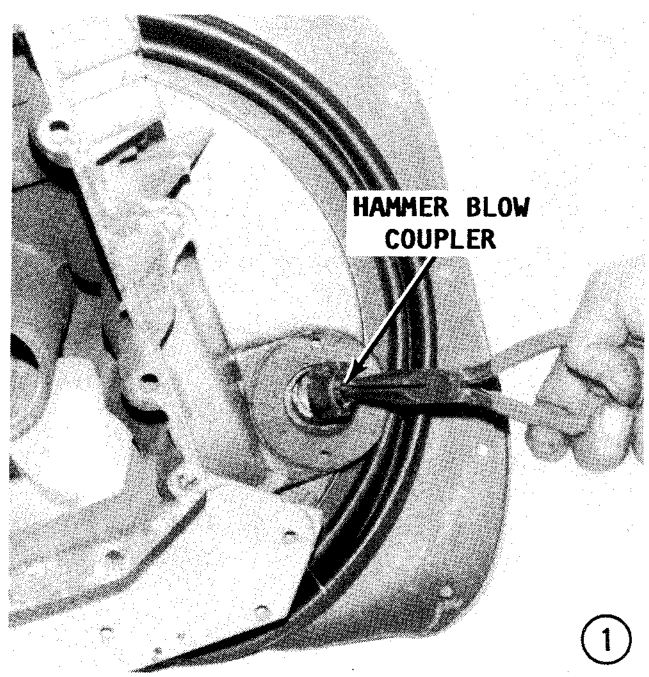
8-4 HAMMER-BLOW COUPLING SERVICE

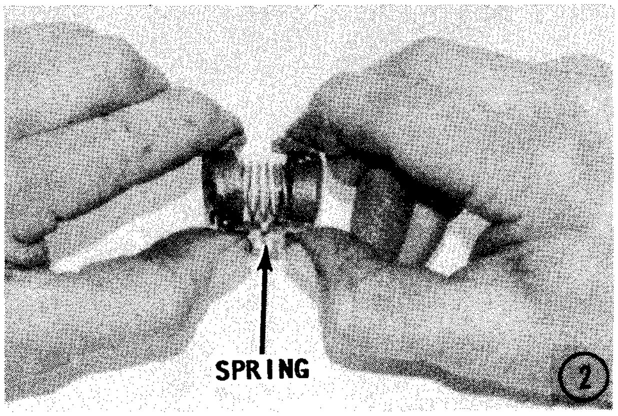
The hammer-blow coupling is designed as the weakest link in the tilt mechanism system, thereby preventing damage to the more expensive parts. The hammer-blow coupling is the first place to check if a tilt problem is encountered.

1- All hammer-blow coupling service is accomplished from inside the boat. Before the couplers are removed, the tilt motor must be removed; see Section 8-3.

After the tilt motor has been removed, reach inside the housing and pull out the couplers. If the couplers have been damaged or broken, it will probably be necessary to remove the pieces with a pair of needle-nose pliers.

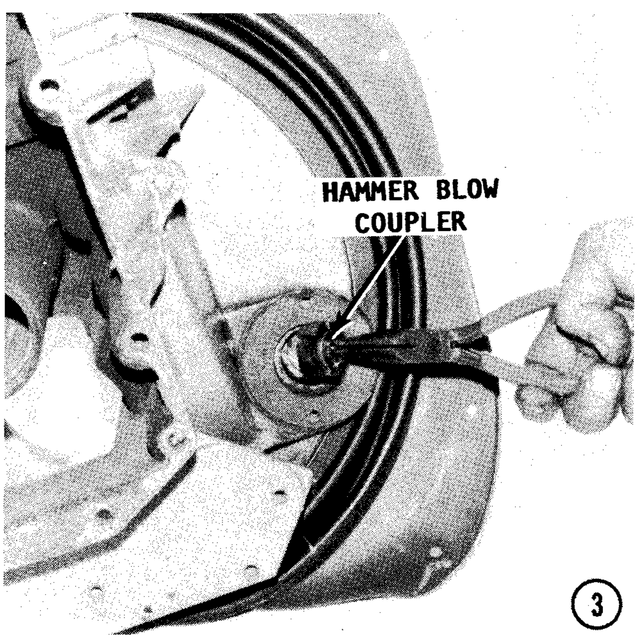
2- There are three parts to each coupler, two halves and a spring. Each halve is identical. Either side of the coupler may face the tilt motor. The spring keeps the coupler together and applies tension on the assembly. To assemble and load the coupler: Hook one end of the spring into the inside of one coupler. Slide the other half on top of the spring and hook it into the slot of the

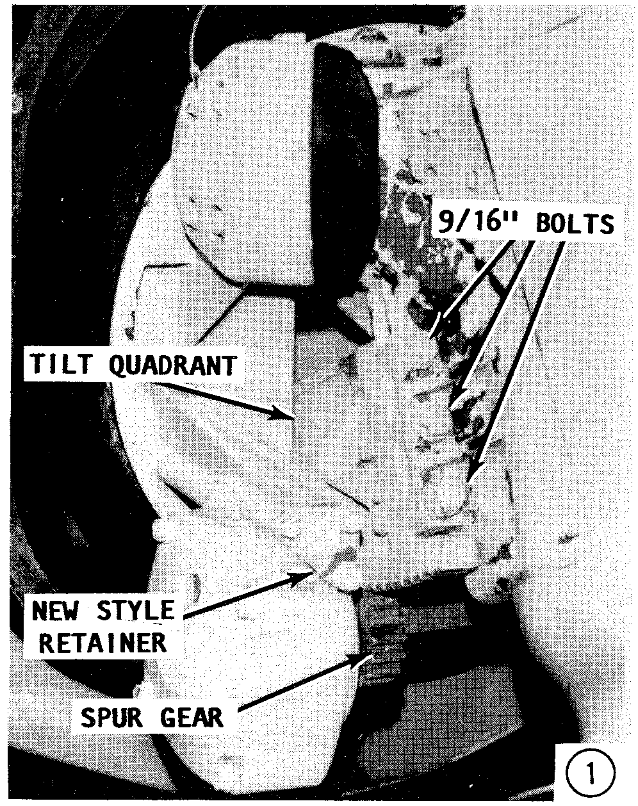




coupler. Hold both halves together and slide the coupler half past the clutch ears. The couplers have a key that fits into the shaft of the armature and the worm gear shaft inside the intermediate housing. TAKE **CARE** not to distort the armature and worm gear shaft slot. Make a pre-assembly test to be sure the keyway in the coupler fits into the slot of the worm gear. Also make another pre-assembly test by installing the coupler onto the end of the armature shaft to be sure the coupler will slide on freely without binding.

3- Slide the nylon washer over the end of the worm gear. Install the coupler assembly into the intermediate housing with the keyway in the coupler indexed into the slot of the worm gear shaft. Install the tilt motor; see Section **8-3,** Step 5, on the previous page.

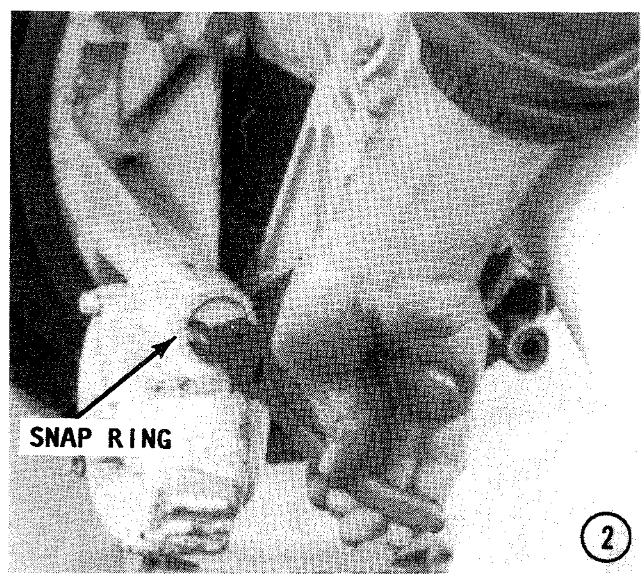


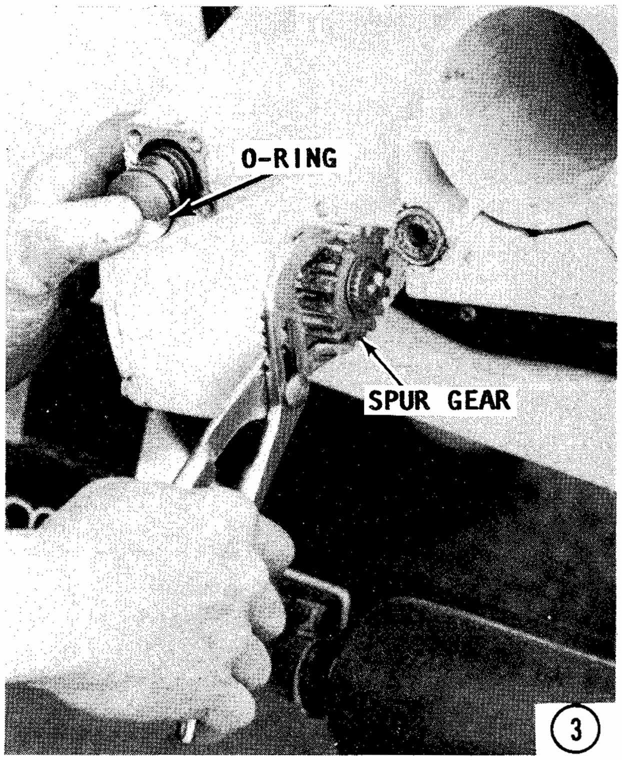


8-5 TILT CLUTCH AND WORM GEAR SERVICE

The clutch and worm gear are installed in the intermediate housing on the port side of the stern drive. The assembly is accessible from outside the boat. In order to service this unit of the tilt mechanism, the tilt quadrant must be removed, or the stern drive removed, see Chapter 10.

1- Lift the stern drive as high as possible and secure it in place as a safety pre-

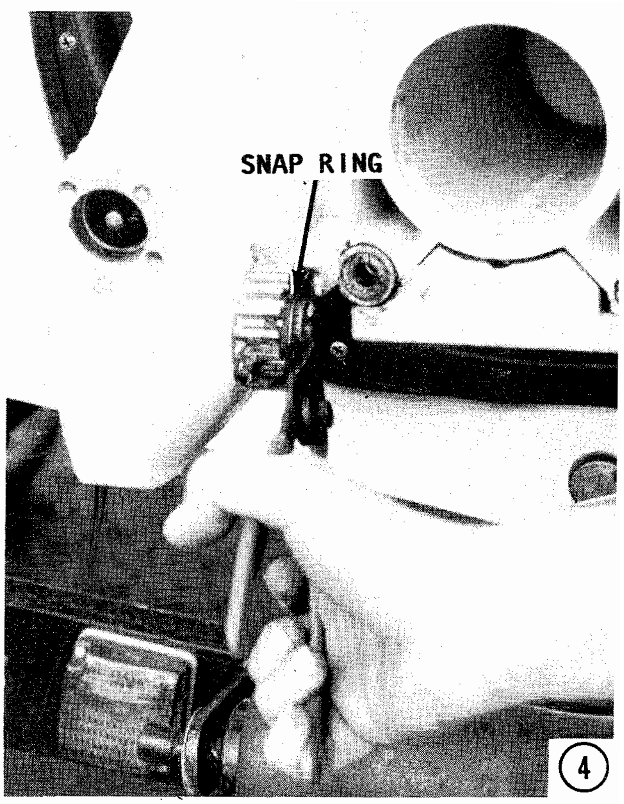


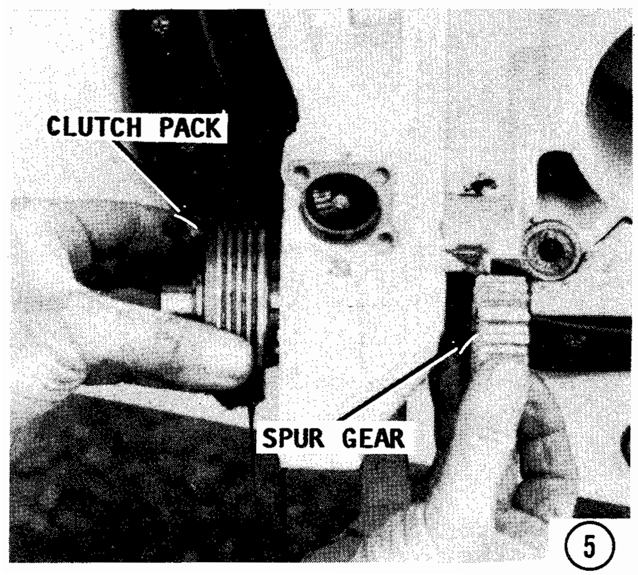


caution. Remove the three 9/16" bolts securing the quadrant to the stern drive.

2- Remove the worm gear by taking out the Truarc snap ring with a pair of Truarc pliers.

3- Turn the small spur gear and work the worm gear free.



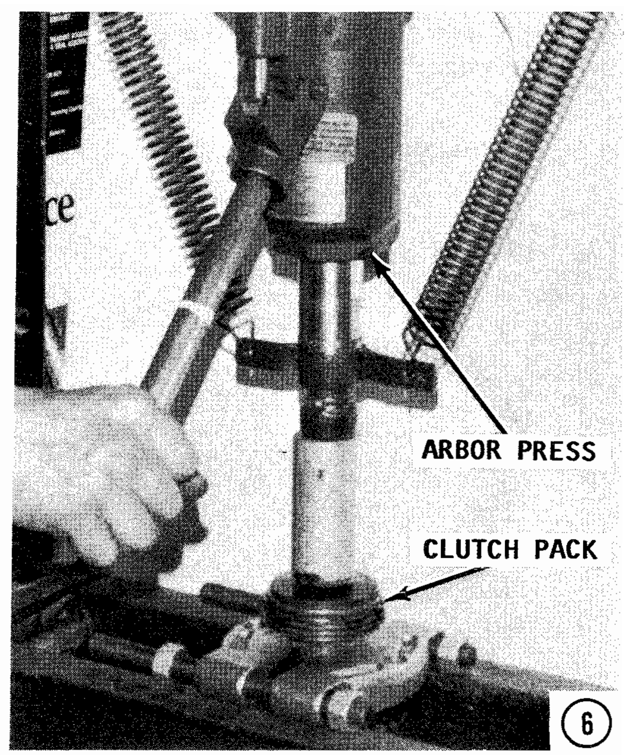


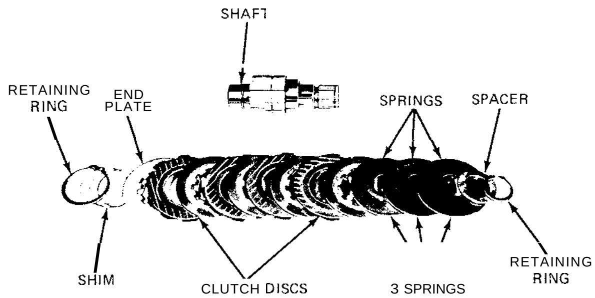
4- Remove the Truarc snap ring on the spur gear.

5- Remove the cover plate. Tap the clutch pack shaft with a mallet to jar the clutch pack loose. When the pack begins to move out, remove the spur gear from the starboard side with one hand and the clutch pack from the port side with the other hand, as shown.

DISASSEMBLY

6- Place the clutch-and-shaft assembly in an arbor press. Release the retaining ring by depressing the belleville springs. A suitable tool for depressing the clutch can be made from a piece of pipe.





Arrangement of the clutch assembly parts.

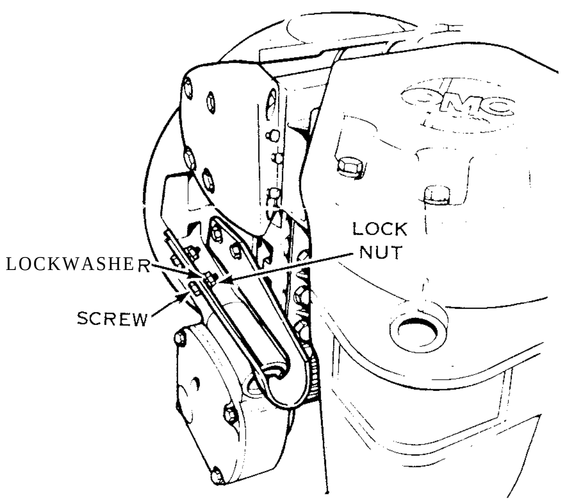
Remove the clutch discs from the shaft and inspect for excessive wear or damage. If damage or corrosion is discovered, the complete clutch pack with shim(s) should be replaced. The clutch disc assembly width (with shims) is held to very close tolerance. This width controls the torque required to "slip" the clutch. Therefore, all shims included in the service package should be used. Individual shims are available should one of the shims be damaged during the work.

CLEANING AND INSPECTING

Inspect the slot on the end of the worm gear shaft to be sure it is not distroted or bent. If the slot is damaged, the shaft **MUST** be replaced. Inspect the worm gear for wear or burrs.

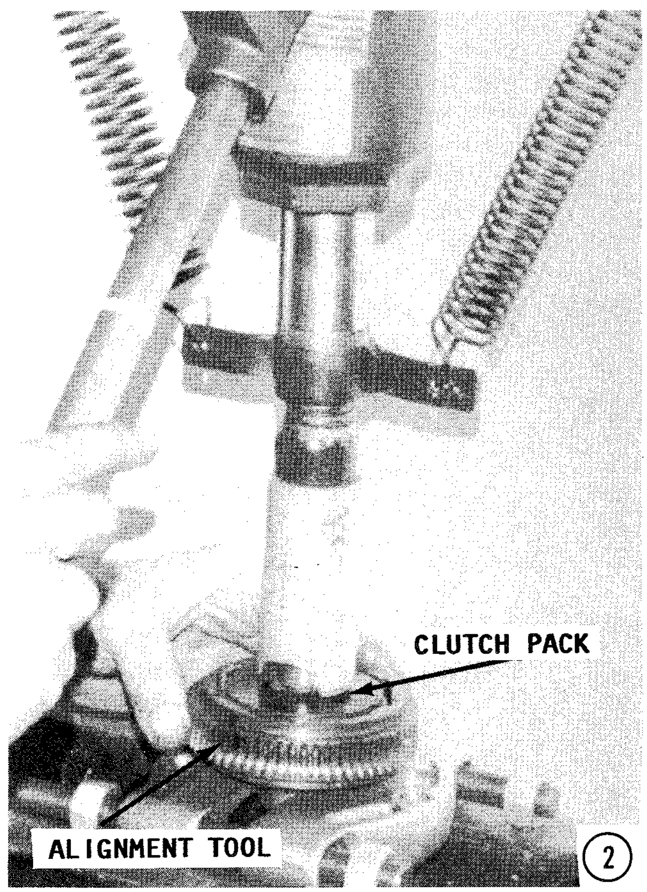
CLUTCH AND WORM GEAR ASSEMBLING AND INSTALLATION

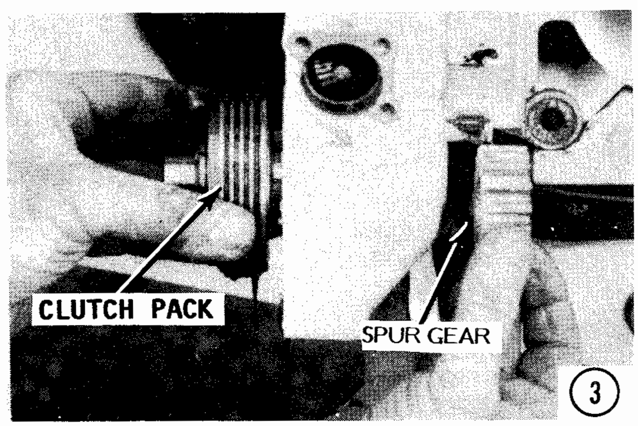
1- Install a **NEW** oil seal at the starboard side of the tilt clutch cavity, if the old one was removed. **TAKE NOTE,** the lip of the seal **MUST** face towards the housing.



Tilt worm retainer kit, Part No. 981348, available at your OMC dealer to replace the snap ring on early models.

2- Soak the clutch discs in 4-cycle oil for at least 15 minutes before they are assembled. Use the worm wheel as a guide and assemble the clutch pack inside the wheel. Press the assembly together and secure it by snapping the Truarc retaining





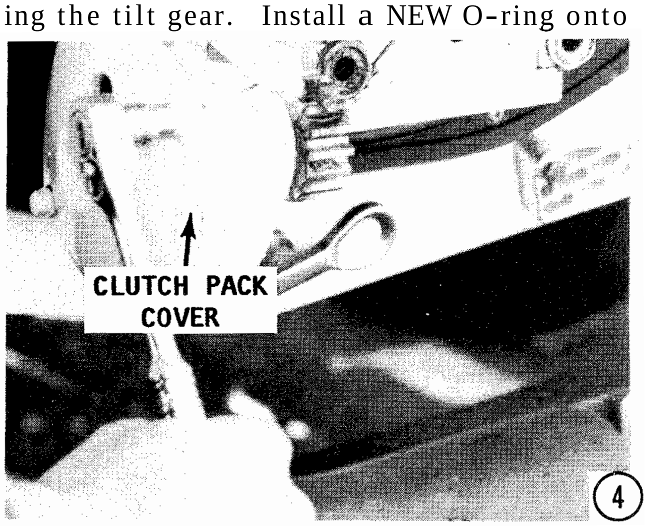
ring into place. Install the thrust washer onto the splined end of the clutch shaft with the chamfer facing the assembly. Push it on as far as it will go.

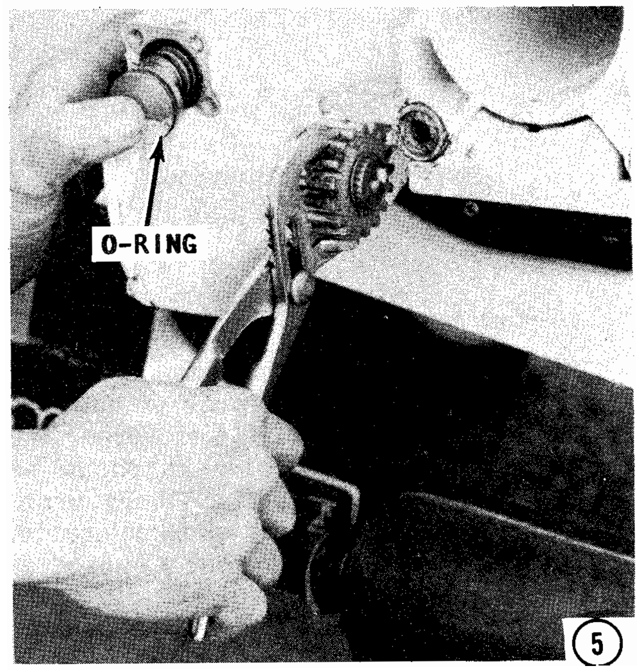
3- Hold the tilt gear in placed, and then install the clutch assembly into the clutch housing.

4- Coat the face of a **NEW** gasket with gasket sealer, and then position it on the clutch cover plate. Install the cover plate with the word UP at the top of the tilt housing. Install the four attaching bolts and tighten them to a torque value of 5-7 ft-lbs. Install the tilt gear on the spline shaft and lock it in place with a Truarc retaining ring. Fill the clutch housing with S.A.E. 30 weight oil.

5- Slide the thin nylon washer onto the slotted end of the worm gear shaft until they make contact with the worm gear drive pins. Slide the slotted end of the worm gear onto the rounded end of the worm gear shaft until it indexes with the locking pin. Insert the slotted end of the worm gear shaft into the worm gear bore and through the bronze bushing.

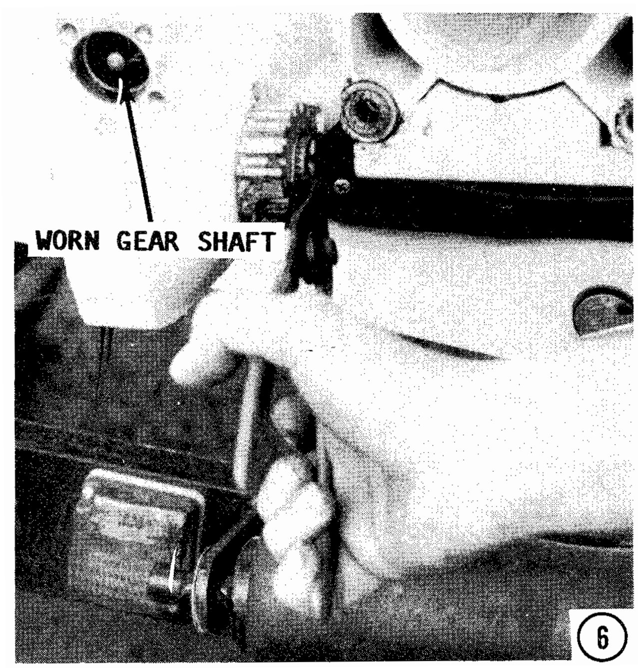
Slide the worm gear into place by turning the tilt gear. Install a NEW O-ring onto





the bearing retainer and coat it with anti-corrosion lubricant. Press the bearing retainer into the end of the worm gear bore with your thumbs. **TAKE** CARE not to damage the O-ring.

6- Use a pair of Truarc ring pliers and install the retaining ring to secure the bearing in place. If the tilt quadrant was removed, position it on the spur gear and secure it with the three 9/16" bolts. Install the stern drive, if it was removed, see Chapter 10.



9
COOLING

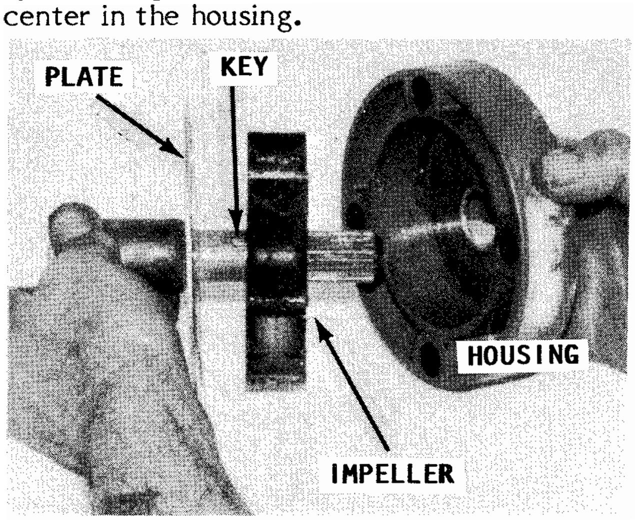
9-1 DESCRIPTION

An impeller-type pump (make-up pump) installed in the vertical drive supplies circulating coolant to the engine. In addition to this pump, a conventional centrifugal-type recirculating pump is mounted at the front of the engine cylinder block. This circulating pump is similar to the pump installed on an automobile engine.

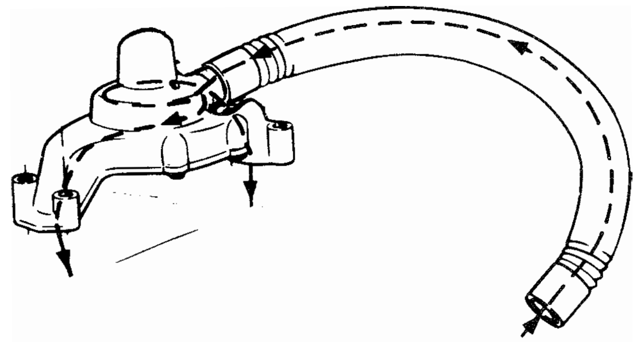
Because of the pump installed in the stern drive, the following caution **MUST ALWAYS** be observed before starting the engine for any reason, at any time:

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.

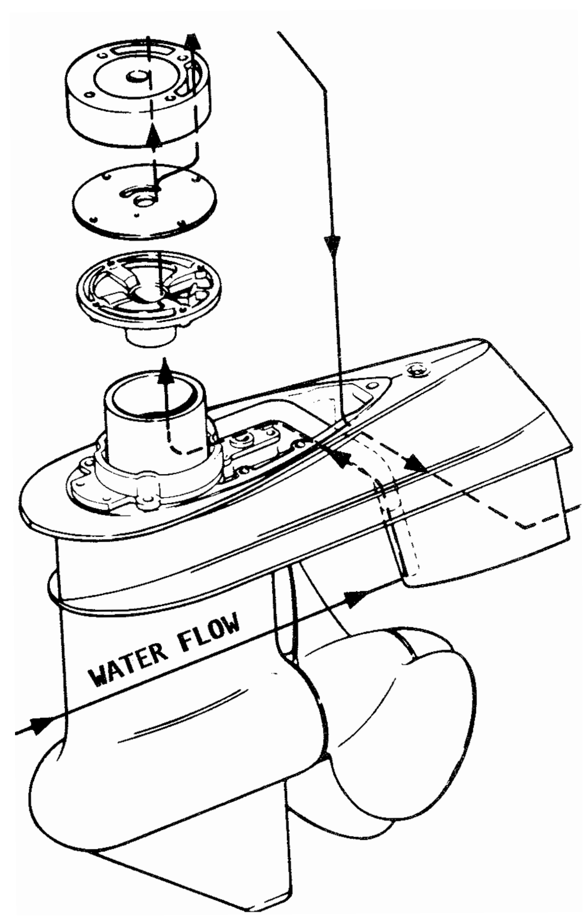
The impeller pump in the vertical drive is keyed to the vertical driveshaft and is a self-priming pump. During slow-speed operation, the impeller functions as a centrifugal pump. An eccentric action is developed by the impeller because it is offset from center in the housing.



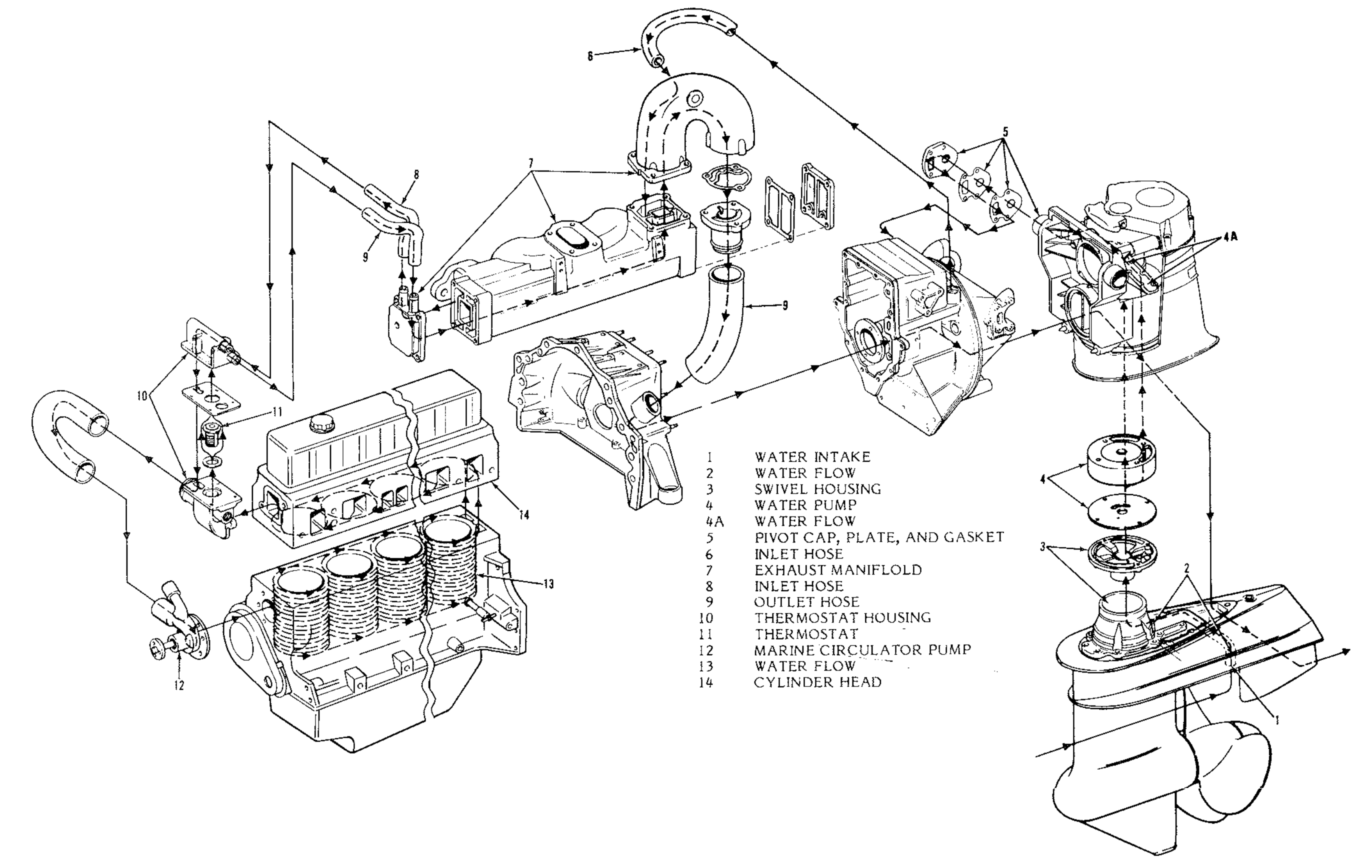
Arrangement of parts for the stern drive water pump, housing, impeller, key, and plate.



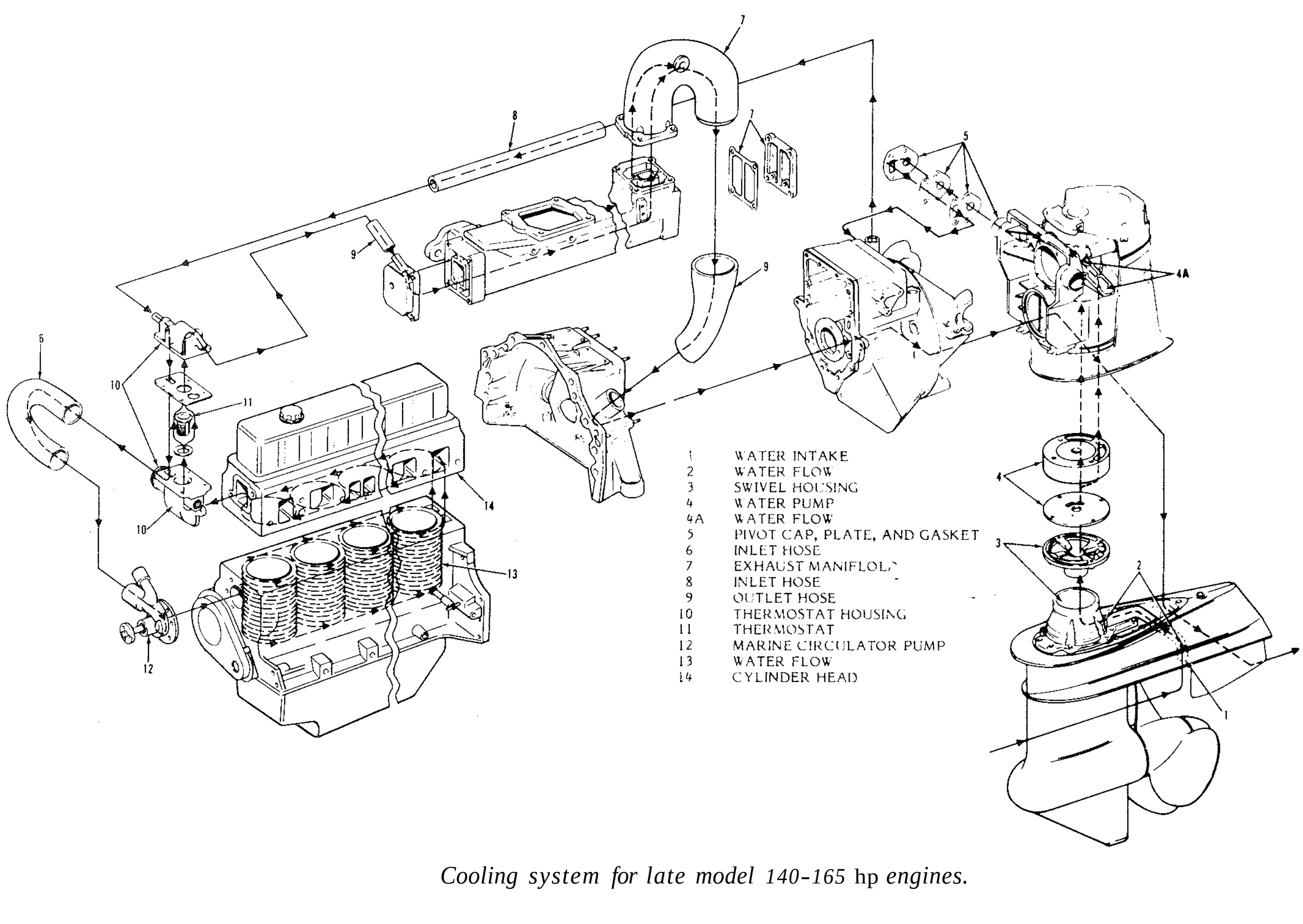
Routing schematic of coolant flow through the engine circulating pump.



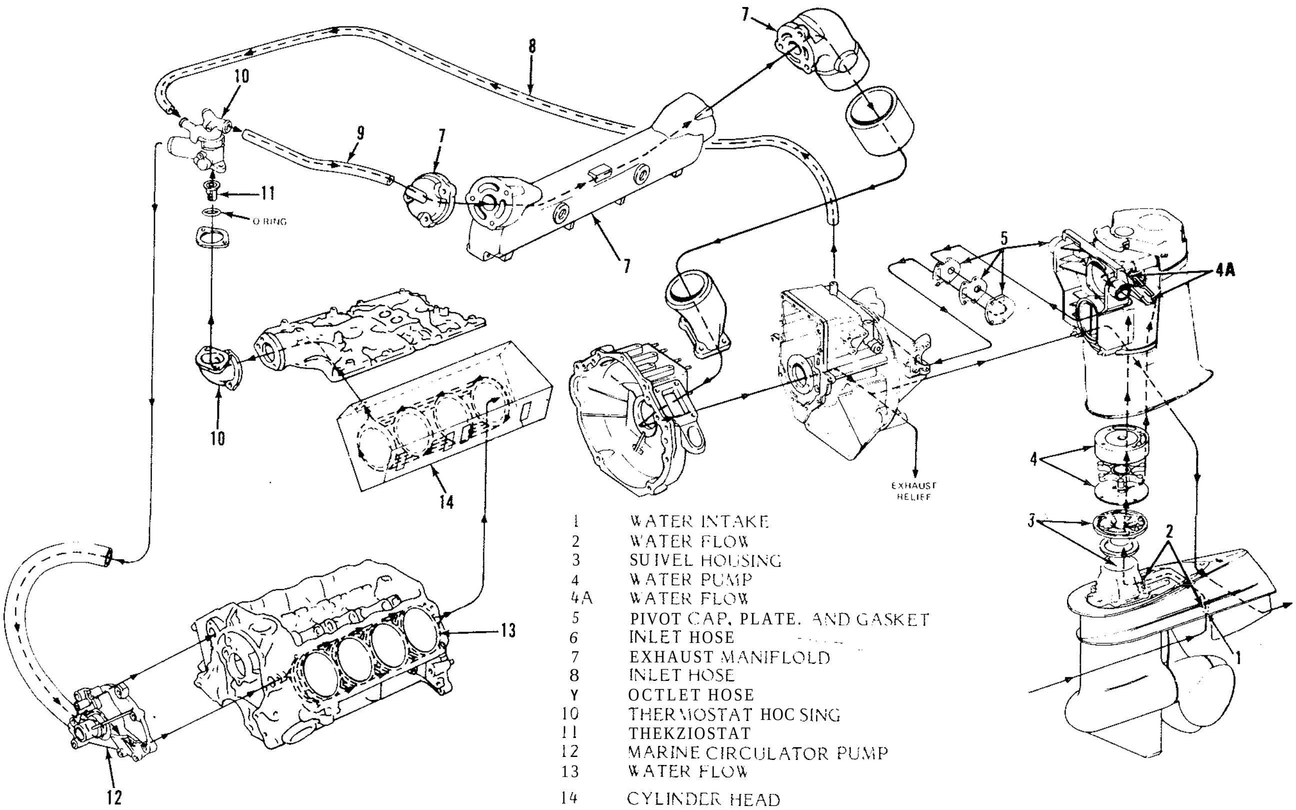
Routing schematic of coolant flow from the stern drive.



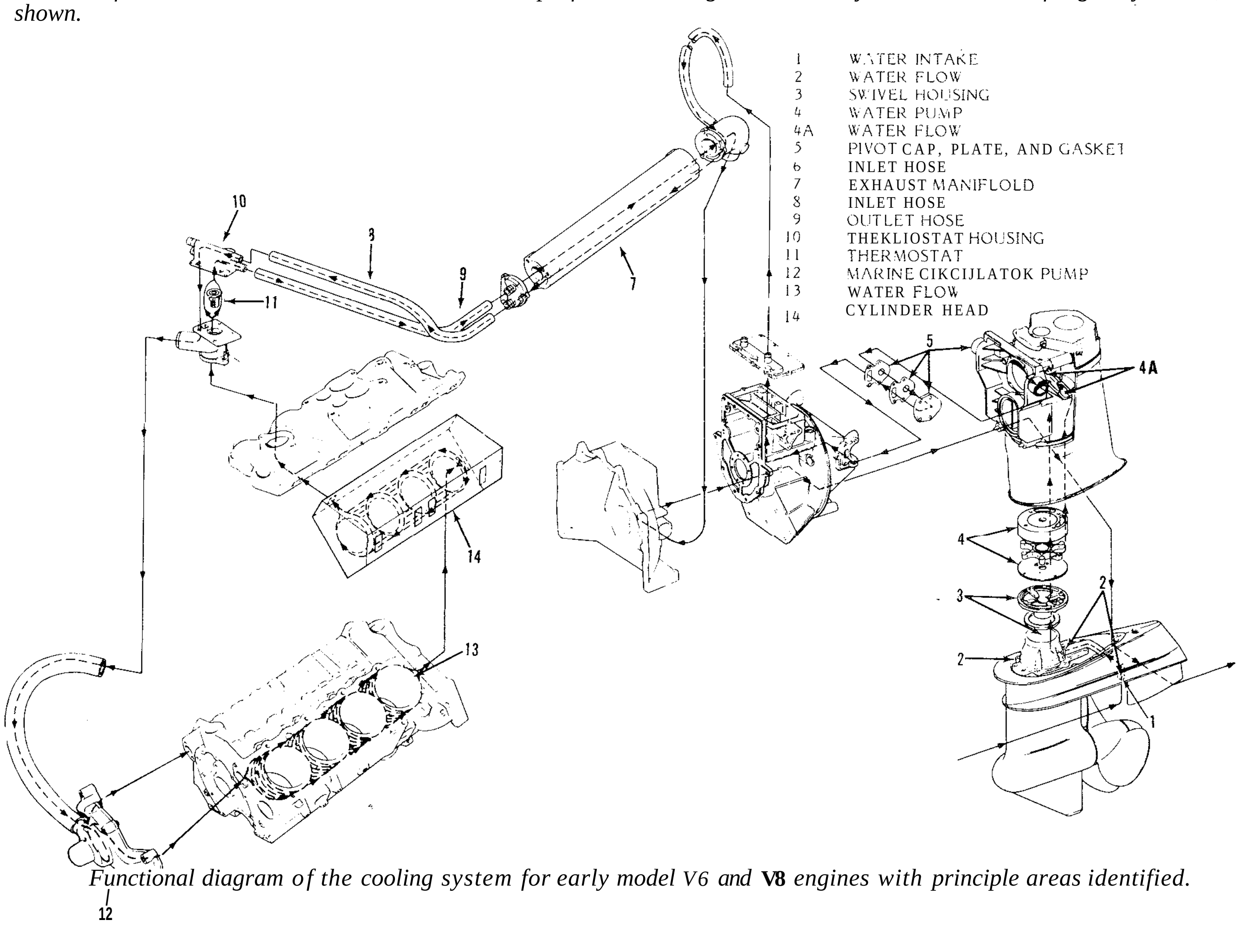
Cooling system for early 120 hp engines.



Cooling system for late model 140-165 hp engines.



*Functional diagram of the cooling system **for** late model V8 engines with principle areas identified. The water flow is identical for the **3.8** and **4.3 Litre V6** models except for circulating around six cylinders instead of eight cylinders, as shown.*



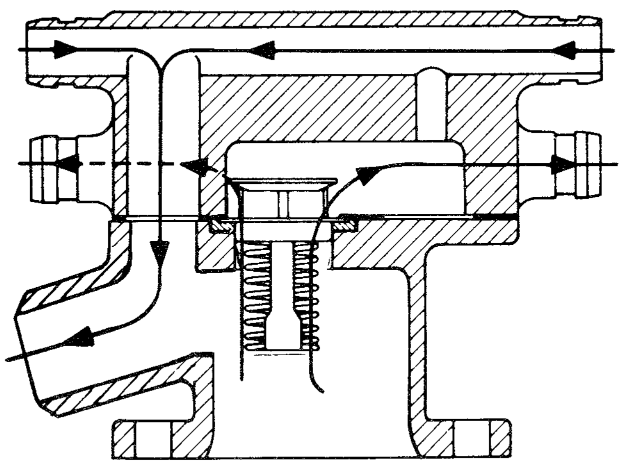
*Functional diagram of the cooling system for early model V6 and **V8** engines with principle areas identified.*

12

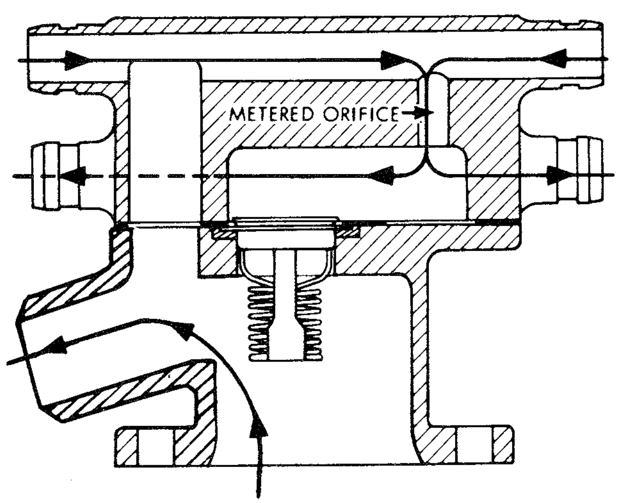
During high-speed operation, the impeller blades are prevented from making contact and following the inside perimeter of the pump housing because of the resistance of the water as it passes through the pump. The blades flex toward the center of the impeller and function as a circulator.

The centrifugal-type pump on the engine block operates in much the same manner as the pump on an automobile engine installation. The pump has a pulley attached to the pump shaft hub at its forward end, and this pulley is driven by a belt from the crankshaft pulley. The pump shaft-and-bearing assembly is pressed into the water pump cover. The bearing is permanently lubricated during manufacture and sealed to prevent loss of lubricant and entry of dirt. A non-adjustable seal pressed into the pump cover seals the pump against coolant leakage. The bearings are a special type for marine installations and use in salt water. Therefore, **NEVER REPLACE THE PUMP WITH AN AUTOMOTIVE-TYPE.**

Cooling water for the engine is drawn in through the intake in the lower unit by the make-up pump in the vertical drive. It is then carried from the impeller housing through the vertical drive and both end caps to the intermediate housing and on to the engine. There are two routes for the coolant to enter the engine:

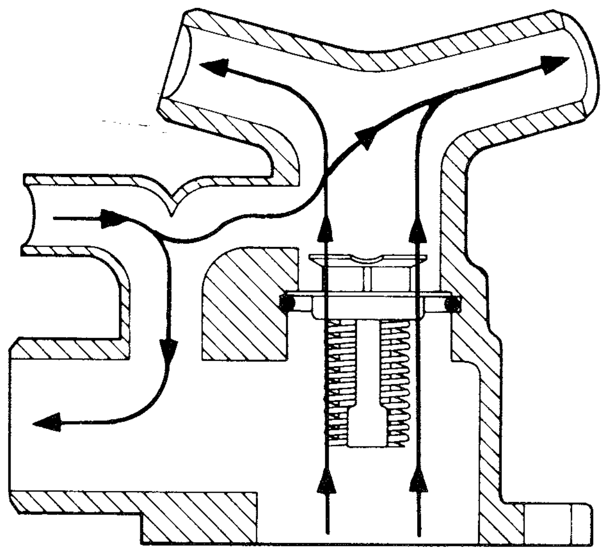


WATER FLOW WITH WARM ENGINE

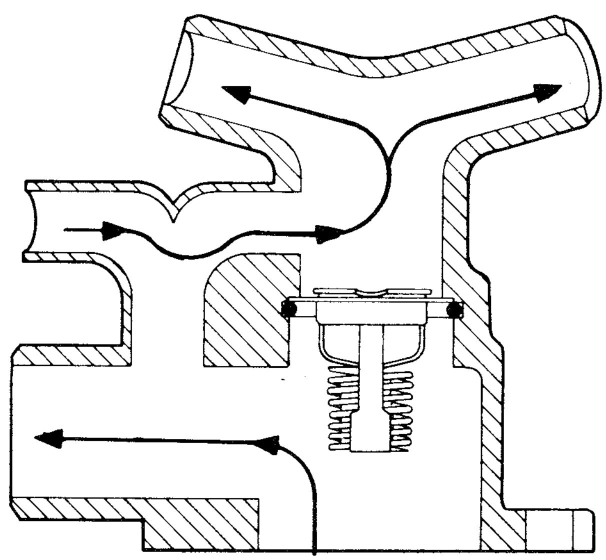


WATER FLOW WITH COLD ENGINE

Routing of coolant flow in the thermostat housing, on V6 and V8 engines.



WATER FLOW WITH WARM ENGINE



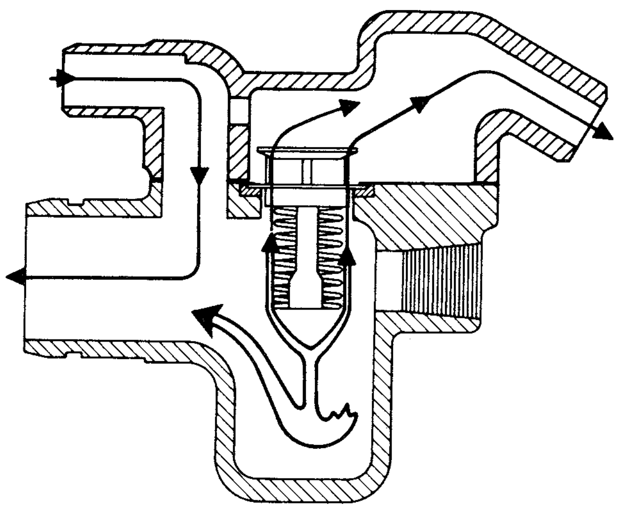
WATER FLOW WITH COLD ENGINE

Routing of coolant flow in the thermostat housing, 1974-1979 V8 engines.

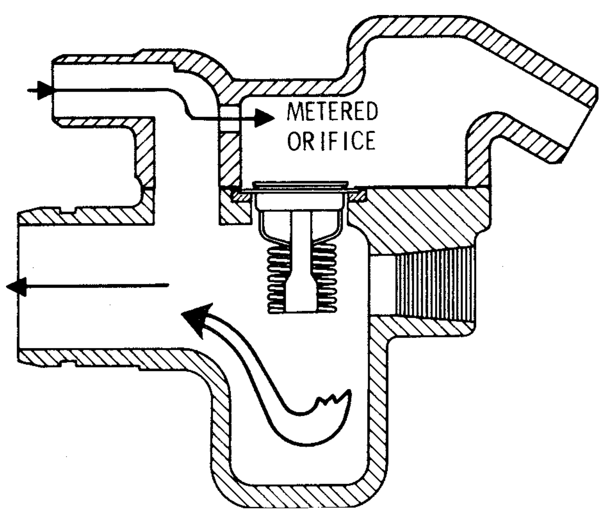
1- From the water intake, it is forced through the hose(s) running between the top of the intermediate housing and the manifold elbow(s). From this point the coolant is moved forward in the inner passage of the manifold to the end cap where it enters the hose connected between the inner nipple of the end cap and the uppermost nipple of the upper thermostat housing, then into the engine.

2- On late model engine installations, the water from the intermediate housing is moved through a single intake hose on the starboard side of the engine to the inlet nipple of the upper thermostat housing. From there, the coolant is forced downward through the lower thermostat housing where it enters a flexible hose attached to the inlet pipe of the engine circulating water pump. This inlet is a part of the pump cover and passes the coolant into a low-pressure area located at the axis of the impeller. Vanes on the rotating impeller throw the water outward and into the cylinder block.

After moving the full length of the the cylinder block, the water is forced upward through two passages and into the cylinder head where it moves forward to cool the combustion chamber areas. When it reaches the forward end of the cylinder head, the water enters the rear of the lower thermostat housing. The thermostat will be open, if the water in the block has reached operating temperature, allowing a portion of the water to be pumped upward past the thermostat to the upper thermostat housing. The remaining water is returned through the flexible hose to the water pump for recirculation through the block. The water which was pumped upward past the thermostat, enters the hose connected to the upper thermostat housing outlet and moves into

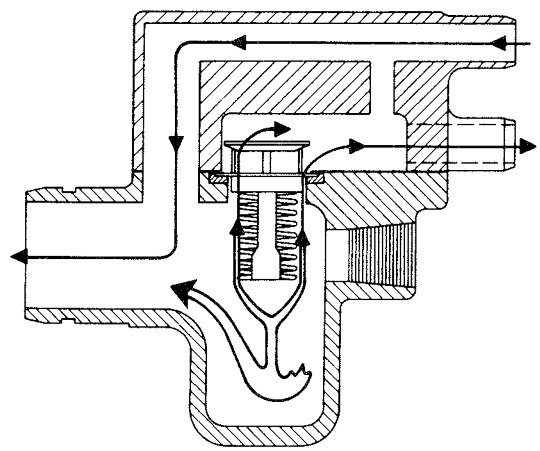


WATER FLOW WITH WARM ENGINE

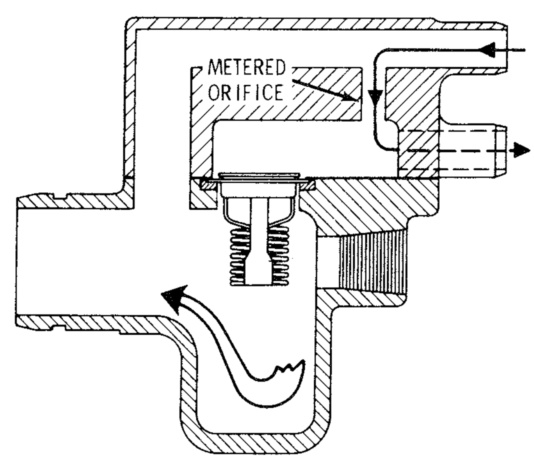


WATER FLOW WITH COLD ENGINE

Routing of the coolant flow in the thermostat housing, 140-165 hp engines.

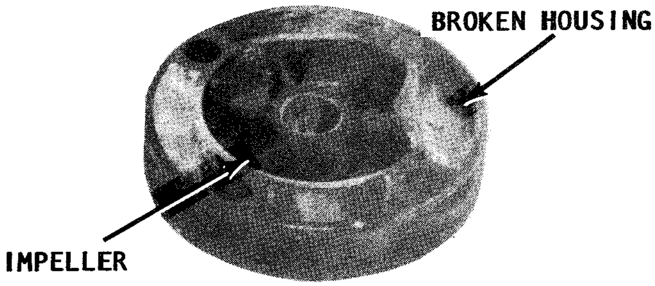


WATER FLOW WITH WARM ENGINE



WATER FLOW WITH COLD ENGINE

Routing of coolant flow in the thermostat housing, 120 hp engines.

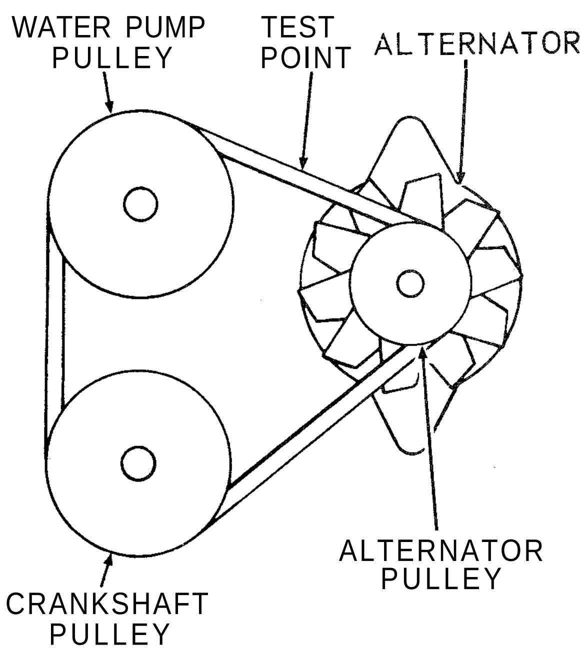


Water froze in this stern drive water pump because the boat was stored with the stern drive in the up position and the water was trapped inside the pump. ALWAYS lower the stern drive when laying up the boat for winter storage.

the manifold end cap. From the end cap the water is forced rearward through the manifold passages and into the high-rise elbow.

All water entering the high-rise elbow is mixed with the exhaust gases prior to entering the exhaust hose. This mixture of exhaust gases and water moves into the adapter in the intermediate housing and vertical drive and is discharged from the system under water.

If the engine is cold and the thermostat is operating properly, no water will pass the thermostat to be discharged overboard. Instead of passing the thermostat, the water is returned to the water circulating pump



Correct tension of the drive belt is essential to prevent rapid wear of the water pump and alternator bearings, if the belt is too tight; or excessive belt wear, offensive noise, fluctuating alternator output, or engine overheating, if the belt is too loose. If the belt is cracked, frayed, or bottoms in the pulleys, it should be replaced at the first opportunity.

through the flexible hose and recirculated through the block for a quick warm-up.

While the water inside the block is recirculating, the water pump in the stern drive is pumping water to a closed thermostat in the block. Since this water is not able to enter the block, pressure would soon build up to the point where the thermostat would be forced off its seat allowing the water to pass. This condition would result in a greatly increased warm-up period.

To prevent this increase in pressure within the system, a metered orfice is installed to relieve the pressure.

9-2 TROUBLESHOOTING

A leak or an overheating condition are the usual signs of a problem in the cooling system. The temperature gauge and the sending unit installed on the engine are two areas to check first. To test these two items, see appropriate section in Chapter 6, Electrical Service.

Two of the first tests to be performed on the engine are an air bubble test and a water flow test.

The preliminary testing section of this chapter is followed by detailed testing procedures to pinpoint any problem in the cooling system.

The final section outlines necessary steps to perform a pressure test of the combusiton chambers for a crack and also to service the exhaust manifold and thermostat.

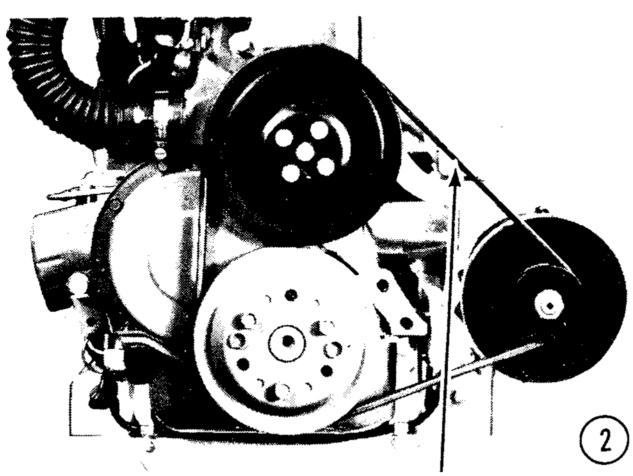
PRELIMINARY COOLING SYSTEM TESTS

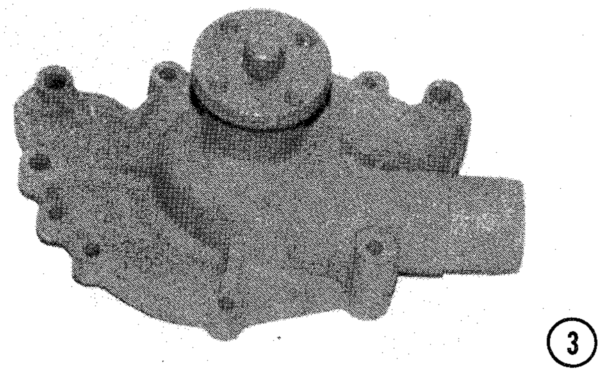
1- With the stern drive submerged in water, and the engine operating at about 600 rpm, check the flow of water at the starboard side of the pivot trunnion caps. On late model installations, the water flow will be discharged at the ball gears. If the stream is small, or is not steady, the stern drive water pump is not operating properly, or the water pickup is clogged. If there is a good, steady, flow of water, the water pump and pickup are in good condition.

2- Check the tension of the drive belt for the water pump on the engine. With the engine running, observe rotation of the water pump pulley. If the pulley is not running true, the drive belt may be be worn and need replacing, or the water pump may be

damaged. If the water pump leaks while the engine is running, the pump mounting may be loose; the seal in front of the pump may be defective; or the water pump may be worn and need to be replaced. If preliminary inspection does not reveal the problem, the water pump **MUST** be removed and checked for wear, internal corrosion, blockage, or possible damage.

3- Replace the pump if it is damaged or corroded. Water pump parts are not available to rebuild the pump. **NEVER** replace a



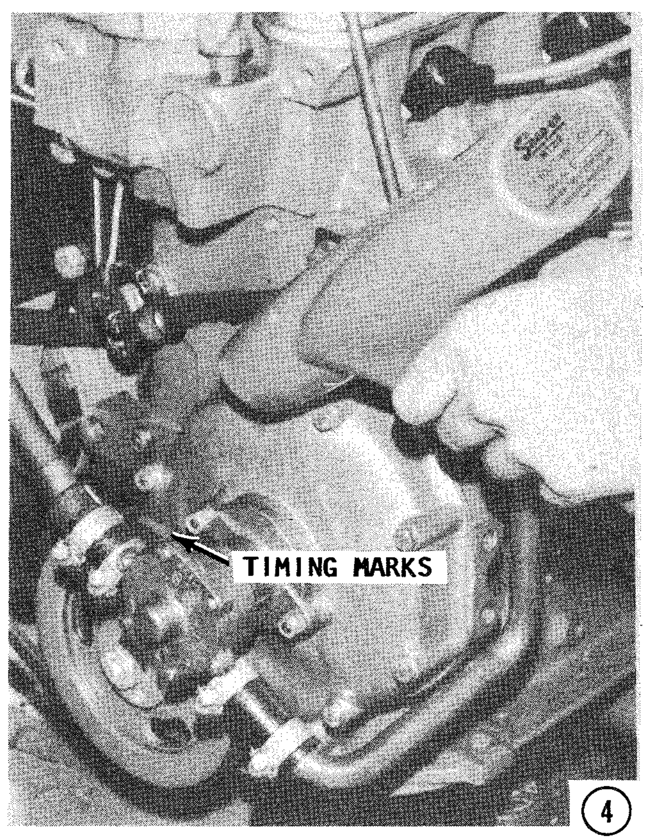


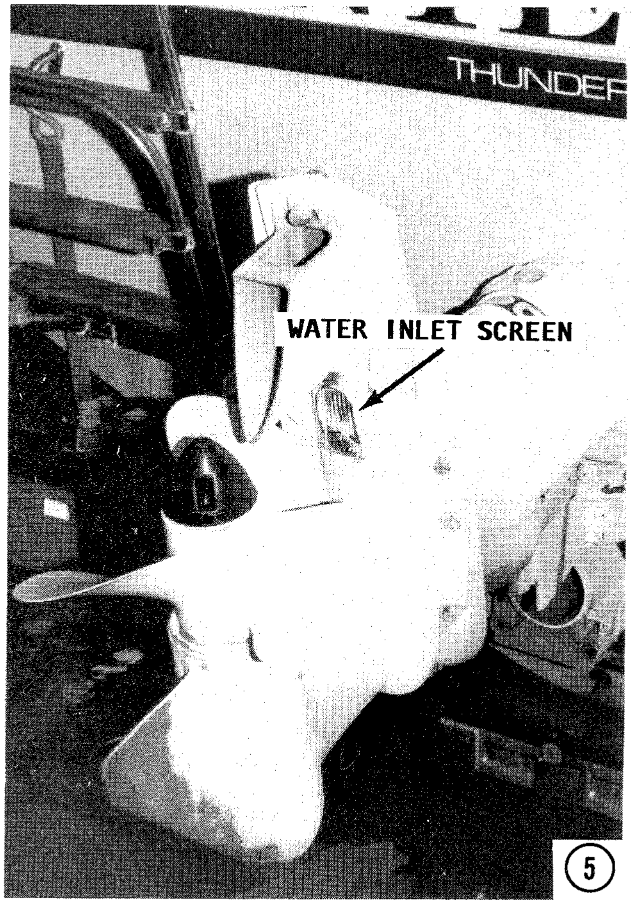
marine pump with an automotive water pump because the marine pump is designed and built to withstand marine operation, including service in salt water.

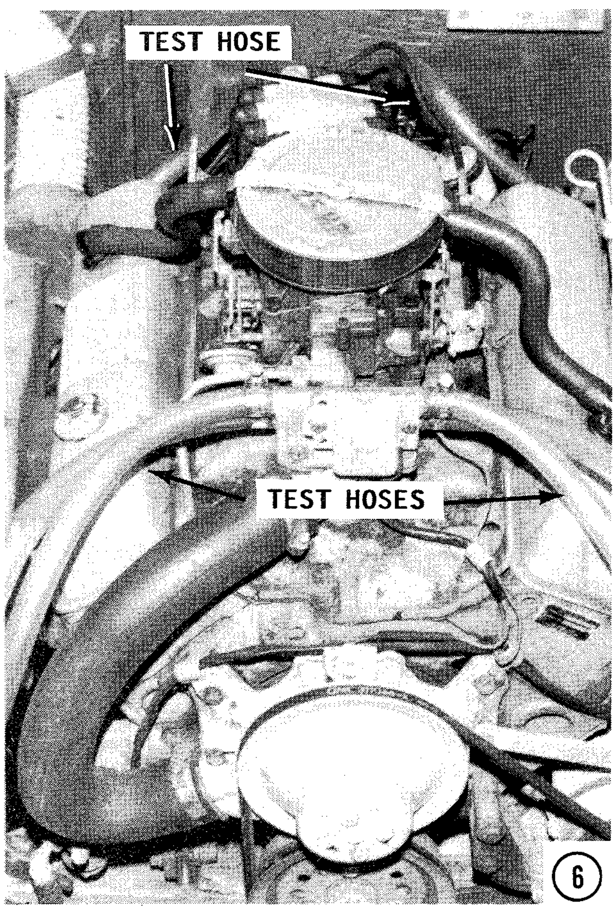
4- Engine running too hot: Problem may be caused by retarded ignition timing. See the Tuning section of Chapter 5, Ignition Service.

5- Other heating problems: May be caused by a blocked water intake screen or a loose screen in the water pickup in the stern drive lower unit.

6- Exhaust gas test: This test will determine if exhaust gases are passing through the engine. It will also prove the water flow through the block. First, replace all existing hoses with the clear plastic type. A flush kit FORCES water through



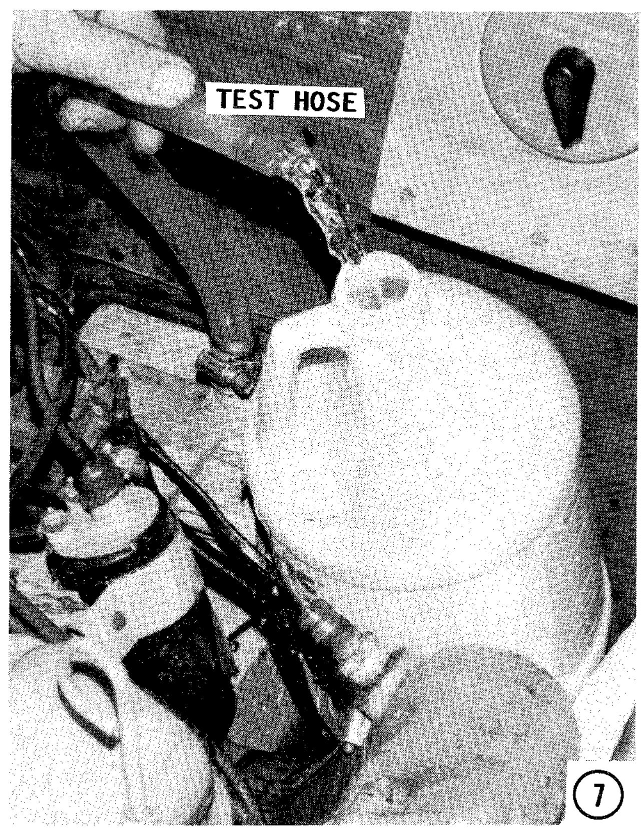




the engine. Therefore, **NEVER** use a flush kit for this test.

Submerge the stern drive in water. With the engine running at about 650 rpm, place your hand on each of the plastic hoses. Feeling light vibrations indicates gas bubbles are passing through the hose. Refer to the flow charts to pinpoint the source of the gas bubbles.

7- To check the water flow from the stern drive and thru the engine: Remove the plastic hose between the exhaust elbow and the intermediate housing at the exhaust elbow. On a V-8 engine installation, the hose may be disconnected on either side. On late model engines, this hose extends from the exhaust elbow to the thermostat housing. Hold a container over the end of the hose; run the engine at about 550 rpm; and note the time required to fill the container. Compare this time with the specification given in the accompanying chart. If the container does not fill in the required time, one or more of the following problems may be at fault: A clogged water pickup; a defective water pump; a leak in the pump seals; or an obstruction in the intermediate housing passage. As the container fills, hold the end of the hose beneath the surface of the water and check for bubbles. Bubbles indicate the water tube grommets at either



end of the stainless steel tube from the water pickup to the water pump in the lower unit, or the swivel bearing seals are permitting exhaust gas to enter the cooling system. See Chapter 10, Stern Drive for service in this area.

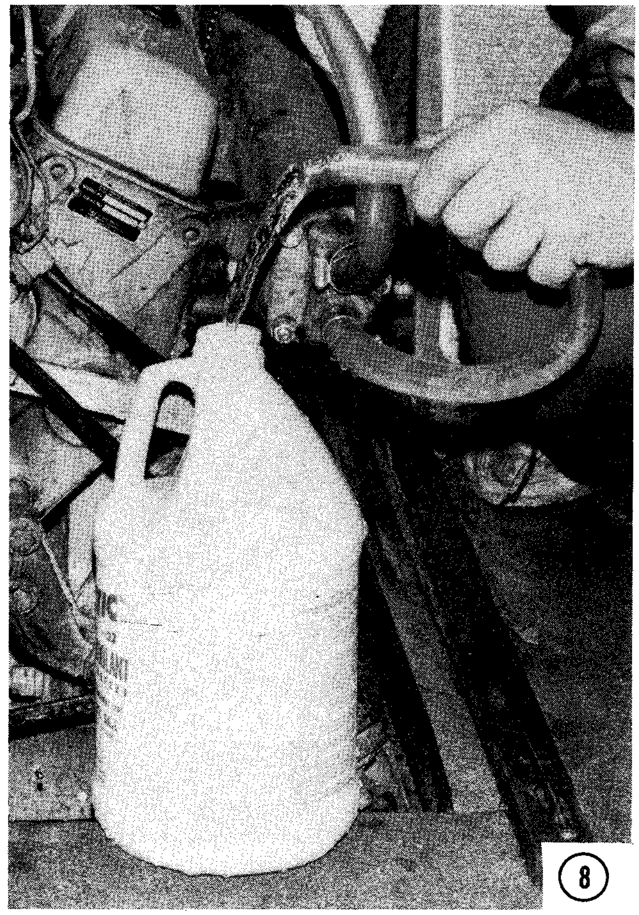
8- Replace the intermediate-to-manifold plastic test hose with the regular hose. On V-type engine installations, remove the lower exhaust manifold-to-upper thermostat housing inlet hose at the thermostat housing. On in-line engines, remove the inner (starboard) exhaust manifold-to- upper thermostat inlet hose at the thermostat. On late model engine installations, water does not enter the engine through the exhaust manifold, but is routed from the intermediate housing to the thermostat housing. Therefore, this test does not apply.

Hold a container over the end of the hose and run the engine at about 550 rpm. The container should fill in the time specified in the accompanying chart. As the container fills, hold the end of the hose under the surface of the water and check for bubbles. If the water supply is short, according to the chart, or if air bubbles are present, a porous defective elbow gasket; a clogged exhaust manifold; or a clogged exhaust elbow is to blame.

On V8 engine installations, **TAKE TIME** to make this test on both the starboard and port exhaust manifolds.

Replace the plastic test hose from the lower exhaust manifold to the upper thermostat housing with the regular hose.

9- On V-type engines: Remove the plastic test hose from the thermostat to the upper exhaust manifold, at the manifold. On in-line engines: Remove the port side (outer) plastic test hose from the thermostat to the exhaust manifold, at the manifold. Hold a container over the end of the

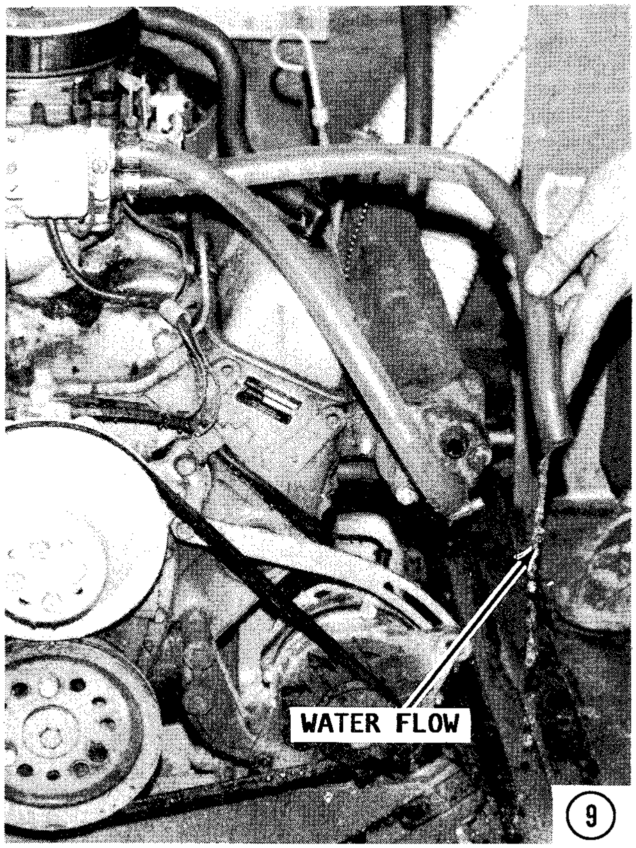


8

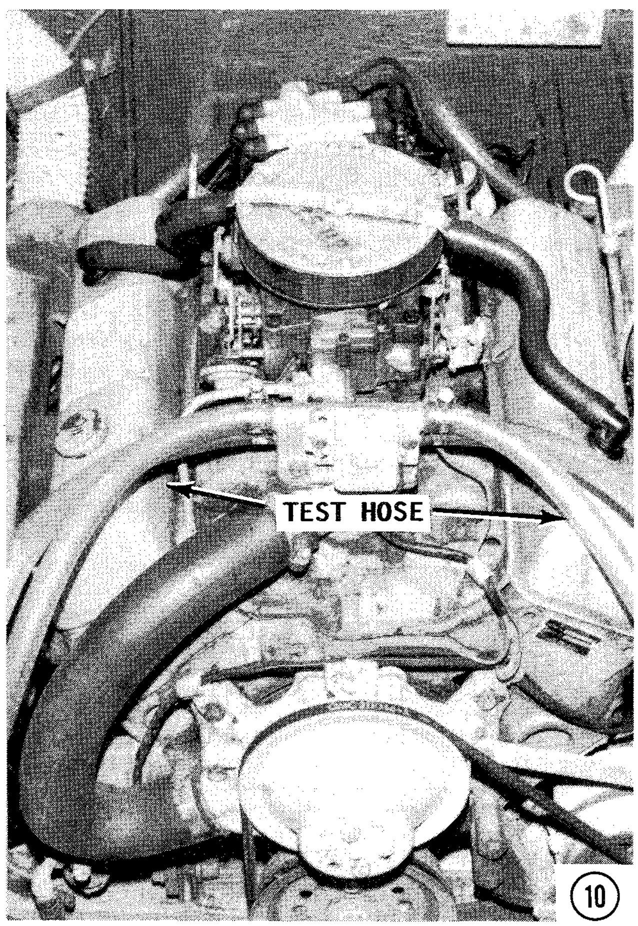
hose and run the engine at about 550 rpm and note the time required to fill the container. As the container fills, submerge the end of the hose in the water and check for bubbles. Compare the fill time with the time given in the accompanying chart. If the container fails to fill in the required time or if air bubbles are present, the problem could be: A leaking head gasket; a crack in the block; a defective engine water pump; or a defective thermostat. On V-8 engines, **TAKE TIME** to make the test on both the port and starboard manifolds.

WATER CIRCULATION SYSTEM TEST SPECIFICATIONS (ENGINE RPMS 550)

TEST NUMBER	HOSE TO REMOVE	TIME TO FILL A GALLON CONTAINER (In Seconds)		
		100,120 & 140 Hp Engines	**165** Hp Engines	**185,200,210, 225 & 245** Hp Engines
1	None	—	—	—
2	Intermediate housing-to-manifold	20-25	17-23	15-20
3	Manifold-to-thermostat housing inlet	25-30	37-42	35-40
4	Thermostat housing outlet-to-manifold	30-35	32-38	25-35



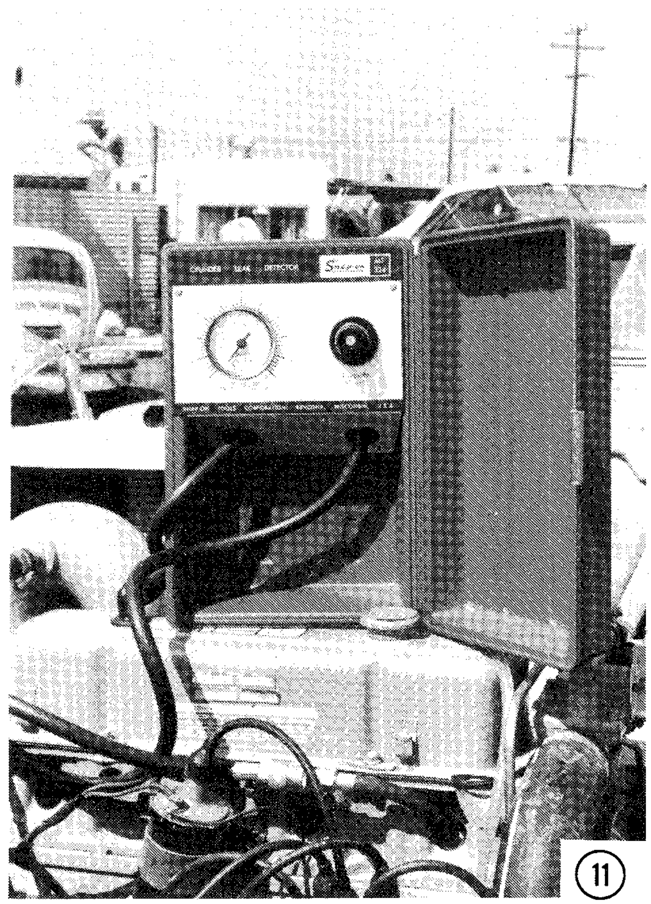
9



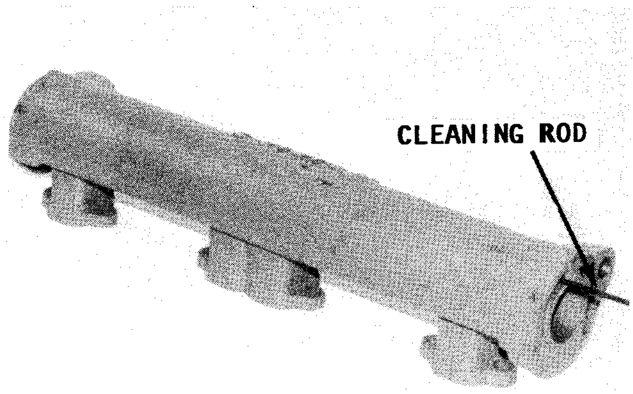
10

10- After performing the previous nine tests, almost any problem in the cooling system should have been isolated. Replace all of the plastic test hoses with the regular operating hoses. **TAKE NOTE:** The hoses between the exhaust manifold and the thermostat housing are installed from the bottom nipple on the exhaust manifold to the top nipple on the thermostat.

11- **A** crack in the engine combustion chamber can be verified by introducing compressed air into each cylinder while checking the coolant at the thermostat housing for bubbles. To perform this test: Install a cylinder air tester in the hose adapter in the No. 1 spark plug hole. Rotate the crankshaft until No. 1 cylinder is at TDC, firing position. Check the distributor points. The points should just be starting to open. Introduce full air line pressure to the the cylinder. Repeat the test for each cylinder after the cylinder has been brought to the TDC position and the breaker points have been observed as just starting to open for the cylinder being tested. Any loss of air pressure during any of these tests indicates either a blown head gasket or a crack in the block. **BAD NEWS, VERY BAD NEWS!**



11



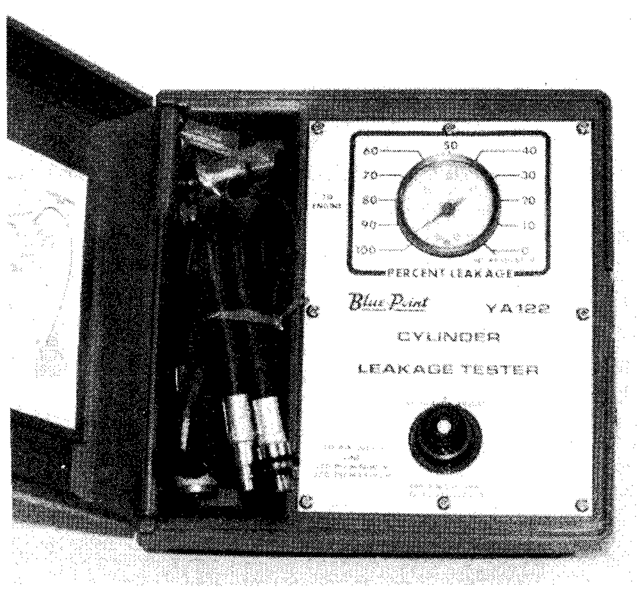
To ensure adequate water flow, the exhaust manifolds should be cleaned every 350-450 hours of engine operation.

9-3 EXHAUST MANIFOLDS

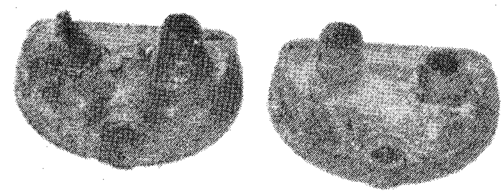
Many engine failures and heating problems can be traced to the exhaust manifold and elbow systems. However, before proceeding with the work outlined in this section, be sure you have **TAKEN TIME** to make the tests and checks suggested in the previous sections of this chapter.

REMOVAL

Remove the four water hoses between the exhaust manifold and the thermostat. On late model engines, only two hoses are installed. Remove the two water inlet hoses between the intermediate housing to the exhaust elbow. On late model installations, this hose connects the intermediate housing



A commercial cylinder leakage tester is available at modest cost, if considerable work on several engines is performed on a regular basis.



These corroded end cap nipples must be replaced with a new set.

to the thermostat housing. Remove the exhaust hoses between the elbow and the side of the intermediate housing.

Remove the nuts from the studs located along the side of the head to support the exhaust manifolds. Remove the manifolds. Remove the exhaust elbows and end caps.

CLEANING AND INSPECTING

Carefully check the engine exhaust ports for any sign of rust or indication water has entered the ports from the exhaust manifold. If there is any evidence of porosity, or that water has passed between the water passages and the exhaust chambers, the manifold being inspected **MUST** be replaced. Water leaking from the water passages into the exhaust system could cause water to pass into the engine through the exhaust valves.

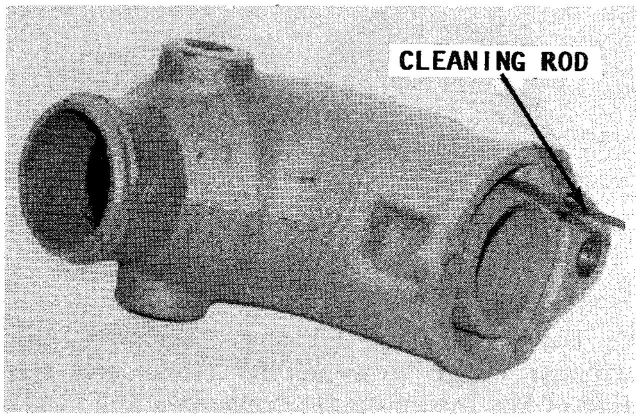
Check the exhaust elbow water passage. Blow air or force water through the passage to verify the passage is not clogged. Check the inside of the exhaust hose closely for any sign of burning. Any evidence of burning indicates a lack of water passing through the manifold or elbow.

The manifolds and elbows should be cleaned and rodded out every 300 to 400 hours of operation, or every 3-1/2 to 4 years, whichever occurs first.

Soak the manifold and elbow for about three hours in Muriatic Acid, obtainable from any swimming pool service outlet. To the author's knowledge, OMC did not manufacture an aluminum manifold. **HOWEVER,** previous engine owners may have installed an aluminum manifold. Therefore, **NEVER** use any type of acid on any aluminum part.

After they have soaked, wash them thoroughly with water and then rod out the passages with a stiff rod to break loose any debris in the passage. Wash them again with water and use the rod a second time.

Clean the mating surfaces of the exhaust manifold, elbow, and the block.



The exhaust elbow should be cleaned every 350-450 hours of engine operation to ensure adequate water circulation.

INSTALLATION

Position **NEW** gaskets on the end plates and elbows. Install the manifolds to the cylinder heads and start the nuts onto the studs. Tighten the nuts alternately. On some engines, the manufacturer does not install a gasket between the exhaust manifold and the engine block. However, if an exhaust leak between these surfaces is suspected, gaskets may be obtained from the local automotive parts dealer. A substitute for a new gasket would be to coat the surfaces of the manifolds and the matching surfaces on the black with Permatex "Form-A-Gasket" or equivalent.

Install and connect the inlet, outlet, and exhaust hoses an the manifold.

Start the engine and check for water, fuel, and exhaust leaks.

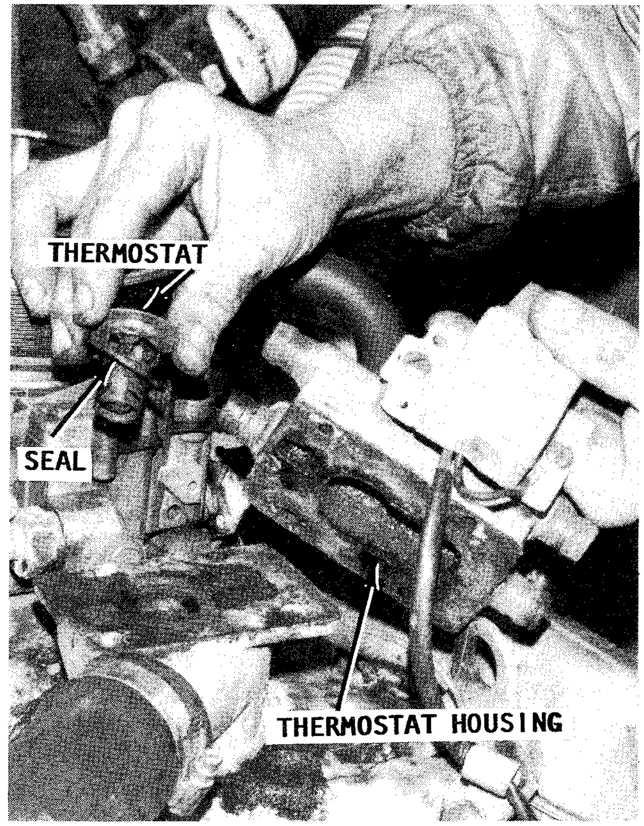
CAUTION: Water must circulate through the lower unit to the engine *my* time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.

9-4 THERMOSTAT REPLACEMENT

1- Drain the water from the block by opening the water drain valves. Remove the thermostat cover, and then lift out the thermostat.

Inspect the thermostat for leakage by holding it up to the light when the thermostat is at room temperature. A light leak around the perimeter indicates the thermostat is not closing, and **MUST** be replaced. If the thermostat is fully open, it is defective and **MUST** be replaced.

2- Apply a coating sf Perfect Seal, or equivalent, to both sides of a **NEW** gasket.



Thermostat replacement, as described in the text.

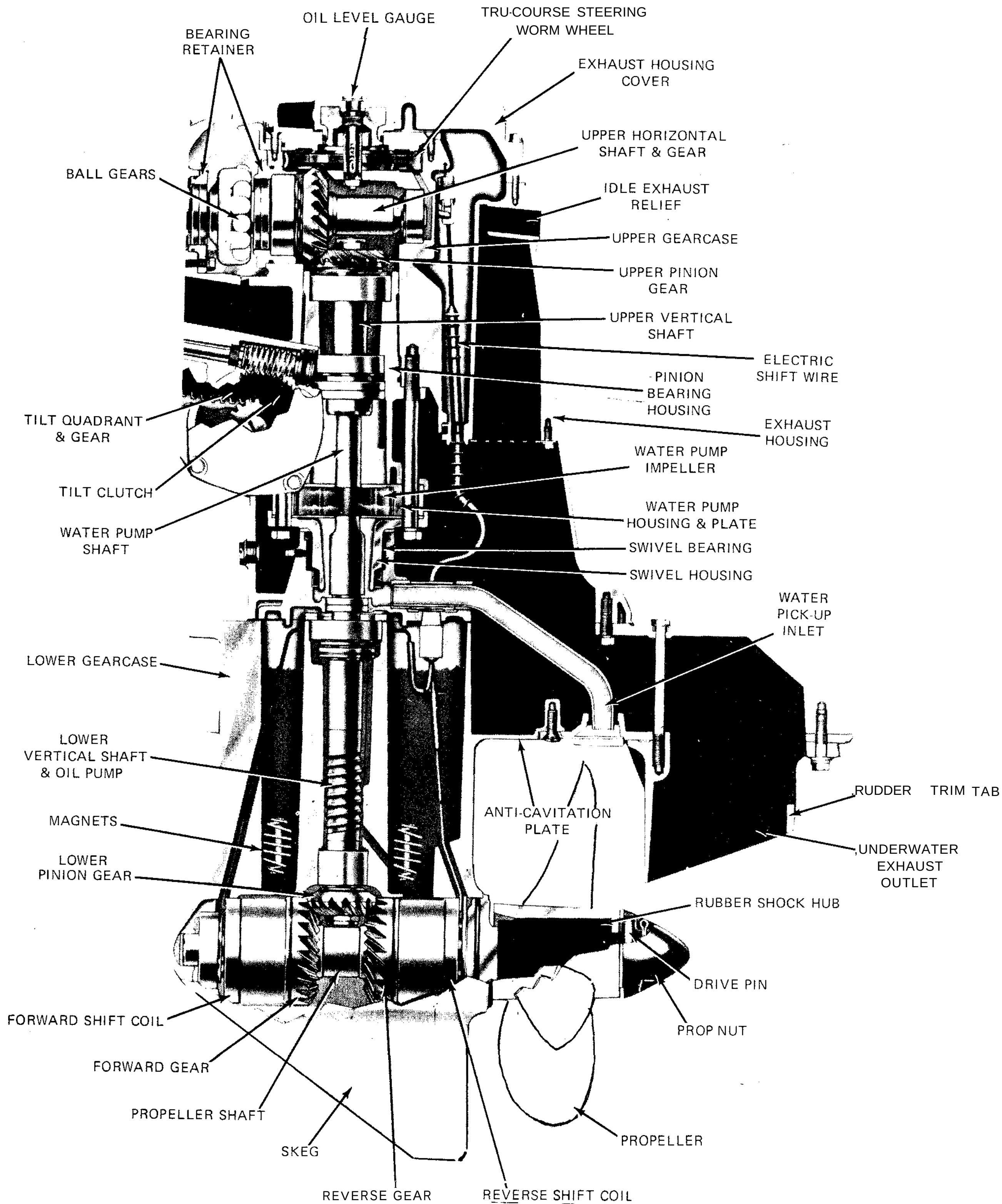
Install the gasket and thermostat as shown. Place the therrnostat cover over the housing, and install the cover bolts. On in-line engines: tighten the bolts to 30 ft-lbs. On V8 engines: tighten the bolts to 15 ft-lbs.

9-5 WATER PUMP REMOVAL

Replacement of the water pump in the stern drive involves many tasks, considerable time, and attention to detail, to ensure proper performance after the work is completed.

As an assist in understanding more about the stern drive water pump, the following paragraphs explain which units must be removed **IN SEQUENCE** in order to replace the water pump.

1- The water pump is located inside the lower section of the upper housing of the stern drive. Therefore, first the stern drive must be removed from the boat, see Stern Drive Removal, Section 10-5 or 10-27. The upper housing must then be separated from the lower housing as detailed in Upper Housing Removal, Section 10-6 or 10-27A.



Detailed sectional view of an OMC stern drive showing internal working parts. Notice the location of the water pump, swivel housing, and the water pickup tube. Proper installation and operation of these items is essential to efficient cooling of the engine and the stern drive.

1

2- Detailed illustrated instructions for removal of the water pump will be found in Water Pump Removal, Section 10-7.

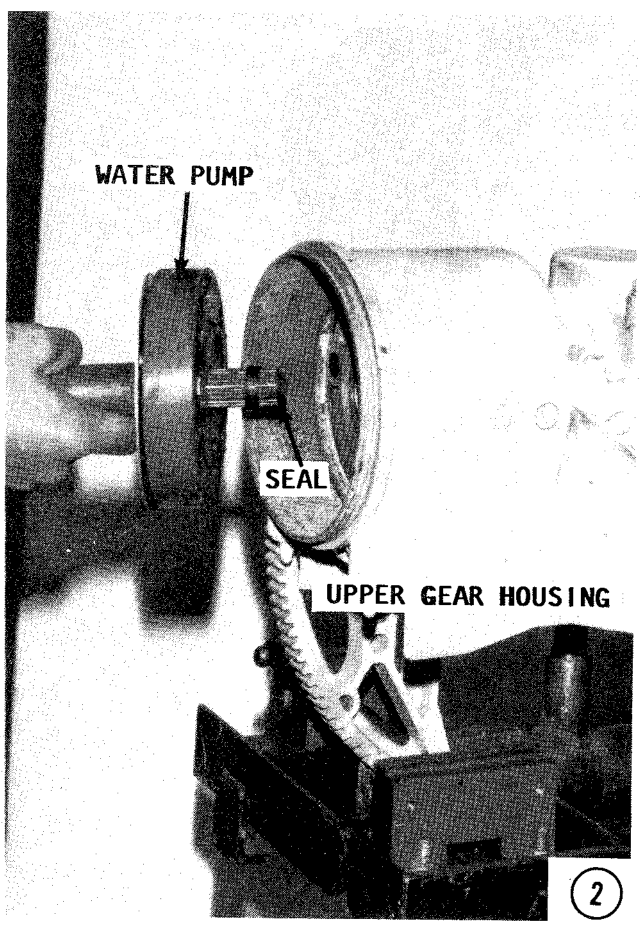
TAKE NOTE: It is possible to install the water pump without performing the work given in Step *3*. However, if they are not performed, the new pump may not move the water to the engine in the required volume and replacement of the pump will not give the desired results.

3- The exhaust housing is not considered a part of the water pump repair. However, the housing must be removed in order to remove the swivel housing.

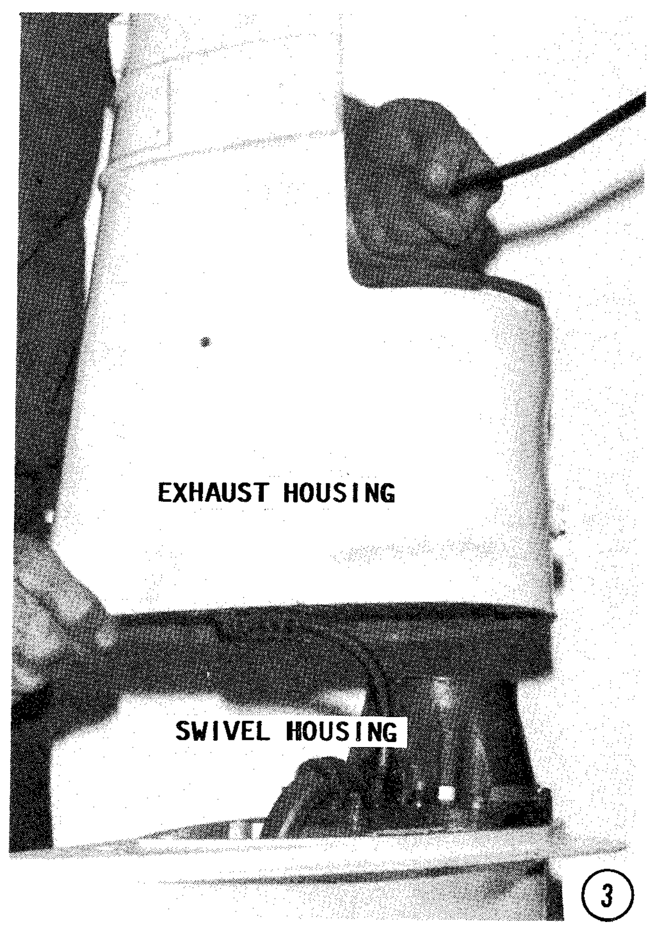
Therefore, remove the exhaust housing, see Exhaust Housing Removal, Section 10-14 or 10-35.

The swivel housing and water pickup tube play a critical role in the cooling system. Any exhaust gases or leakage at the swivel housing will cause failure of a new water pump.

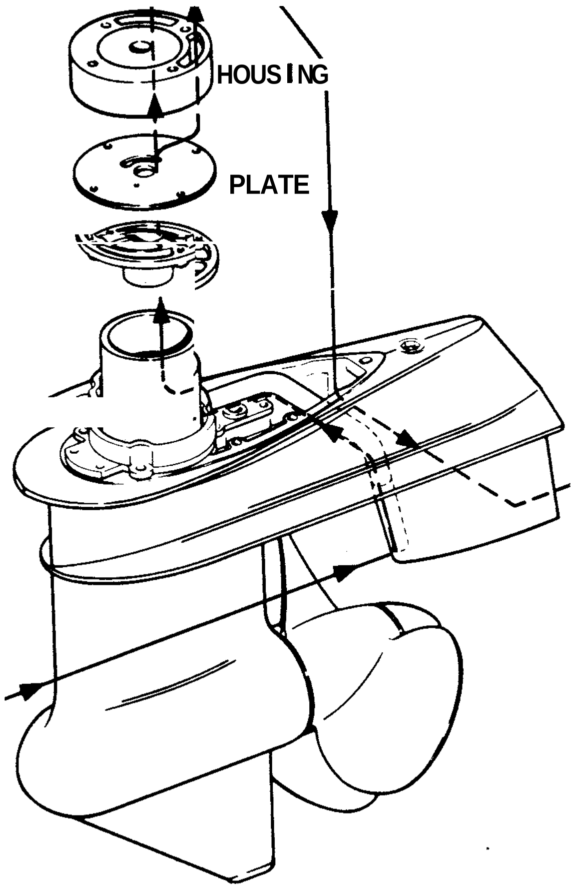
Therefore, remove and service the swivel housing, see Swivel Housing Removal, Section 10-12 or 10-36.



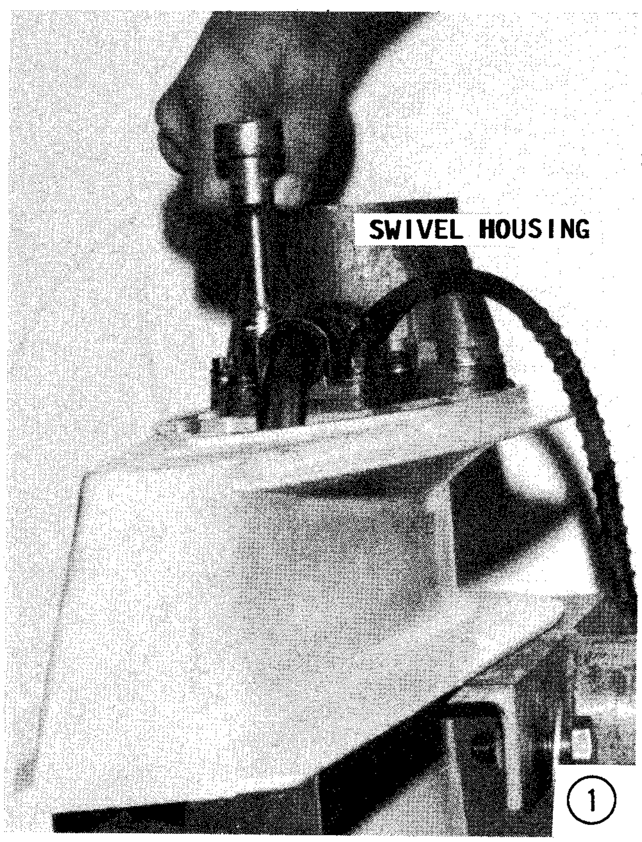
2

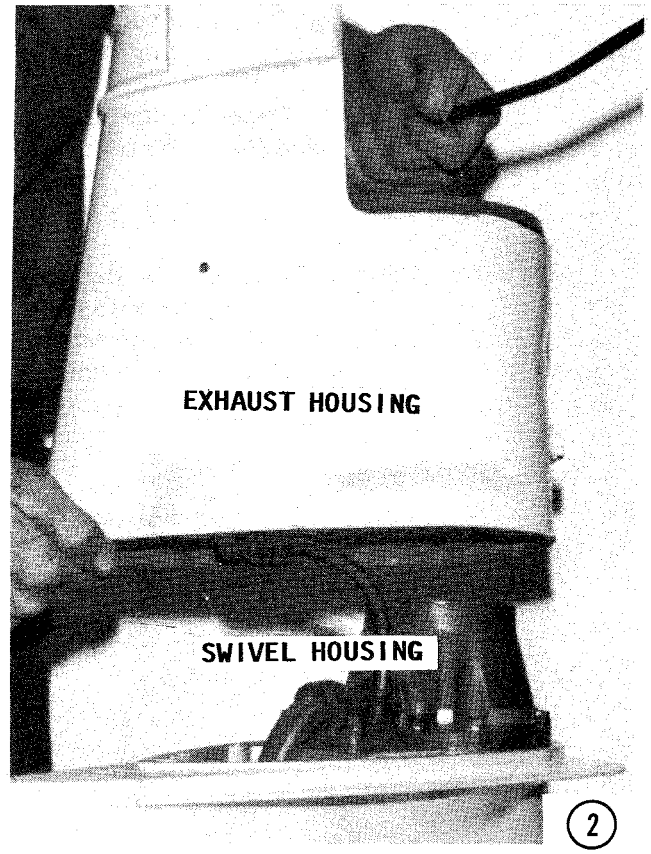


3



Water circulation through the lower unit.



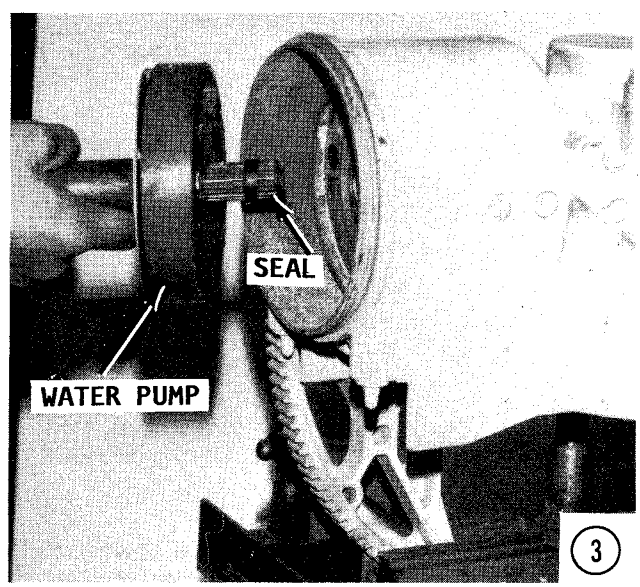


9-6 WATER PUMP ASSEMBLING

I- Assemble the swivel housing seals, gasket, and water intake tube, see Swivel Housing Assembling, Section 10-18 or 10-37.

2- Install the exhaust housing, see Exhaust Housing Installation, Section 10-19 or 10-56.

3- Install the water pump to the upper gear housing, see Water Pump Installation, Section 10-13 or 10-34.

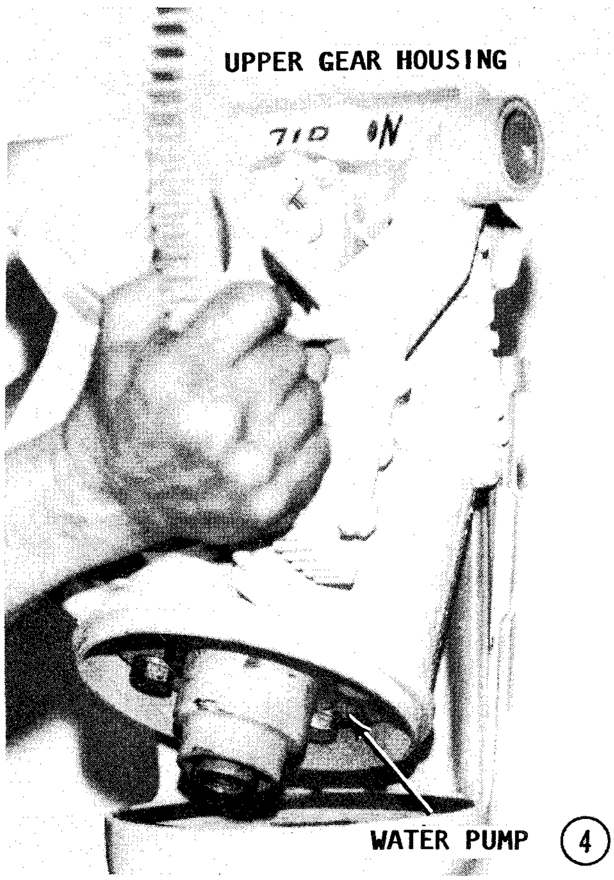


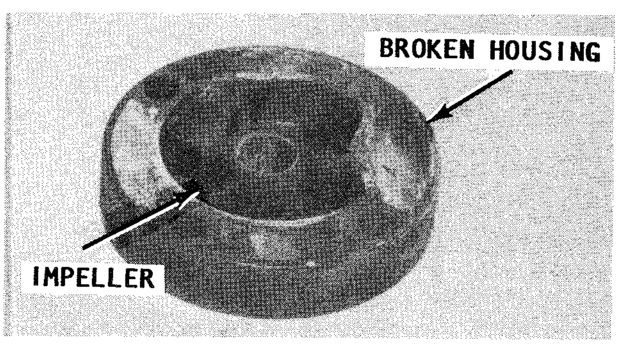
4- Install the upper housing into the exhaust housing, see Upper Housing Installation, Section 10-20 or 10-57.

5- Install the stern drive to the intermediate housing, see Stern Drive Installation, Section 10-21 or 10-58.

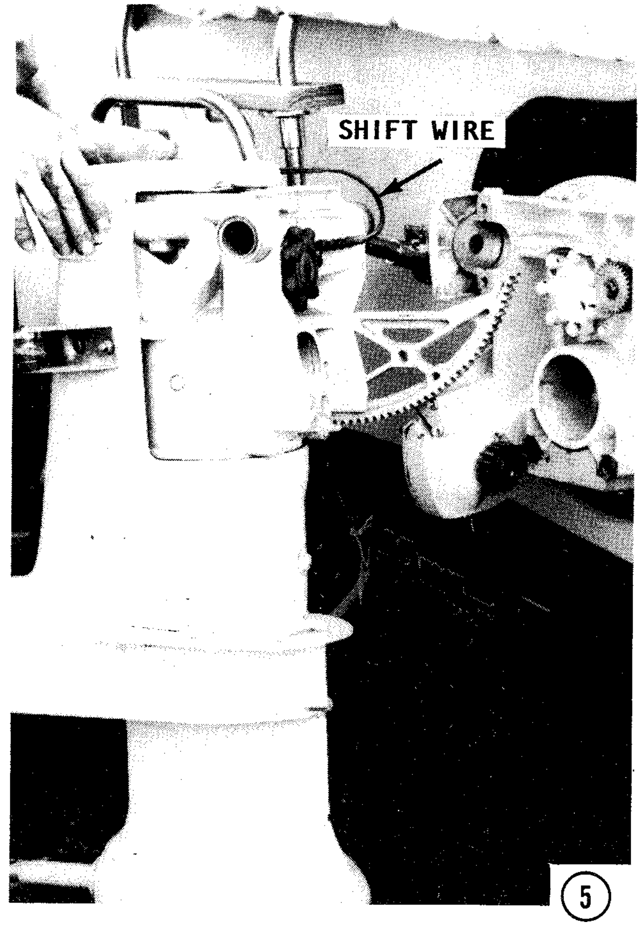
6- Start the engine and perform a functional check of the cooling system.

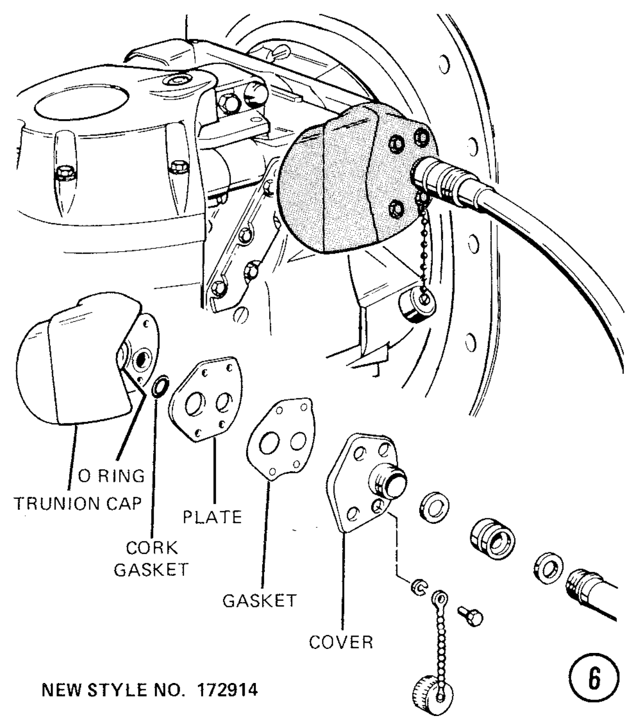
CAUTION: Water must circulate through the lower unit to the engine any time the engine is run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.





Damaged water pump resulting from leaving the stern drive in the up position during freezing weather.





Arrangement of internal parts in an OMC flushing adapter kit and the kit installed on the engine.

10
STERN DRIVE

10-1 DESCRIPTION

Electromatic gearcases were used on all OMC stern drive installations between 1964 and 1977. From 1978 through 1981, OMC used a mechanical assisted power shift unit with propeller exhaust. Since 1982, the shifting has been by mechanical linkage only. Each drive contains an upper and lower unit.

The electromatic shift stern drive is presented in the first portion of this chapter from Section 10-2 thru 10-21. The mechanical assisted power shift and the mechanical shift stern drives are combined in Sections 10-22 thru 10-60.

10-2 EARLY STERN DRIVE UNITS MODELS 1964 THRU 1977

Three different lower units were used on the early model stern drives.

Type-1 A small unit used on the 88 to 90 hp and on some 120 hp drives.

Type-2 Larger unit, without shims in the power train, installed from 1964-67.

Type-3 A large unit, with shims in the power train, installed from 1967 thru 1977.

The type 2 and Type *3* units are easily identified by the number of bolts on the exhaust housing cover: The Type 2, 1964-67 uses four bolts; and the Type-3 units, 1967-77 has five bolts. A complete Type-2 unit may be replaced with a Type 3. It is also possible to use either the upper or lower units as a replacement, but only as a complete assembly, upper or lower.

ALWAYS check to be sure the gear ratio is the same when replacing a complete unit.

When the unit is shifted to the forward position, an electric switch in the shift box closes the circuit to the forward electromagnetic coil in the gearcase. After the coil is energized, magnetism attracts and anchors the free end of the clutch spring to the flange of the clutch hub. The revolving gear causes the spring to wrap around the hub, creating a direct coupling with the propeiler shaft.

Power is transmitted through the pinion gear, forward gear, clutch, and propeller shaft to the propeller.

When the stern drive is shifted to the reverse position, the reverse coil is energized, and the same sequence of events takes place. The reverse gear assembly is **ALWAYS** the one nearest the propeller.

The boat battery provides 12-volt power for operation. When the key is in the **ON** position, power moves through the ignition switch to the switch in the shift box, and on to the lower unit of the stern drive. A cutout switch is incorporated in the shift switch. This cutout switch prevents the starter from being energized except when the shift lever is in the **NEUTRAL** position.

The necessary wiring is routed from the dash to the shift box; then to the port side of the engine; aft to a knife-disconnect fitting just above the tilt motor; then out to the stern drive. The forward shift wire is green and reverse wire is blue. An easy way to remember the color code is green for go, forward that is.

10-3 STERN DRIVE SERVICE MODELS 1964 THRU 1977

The service procedures in the following sections are divided into five major groups:

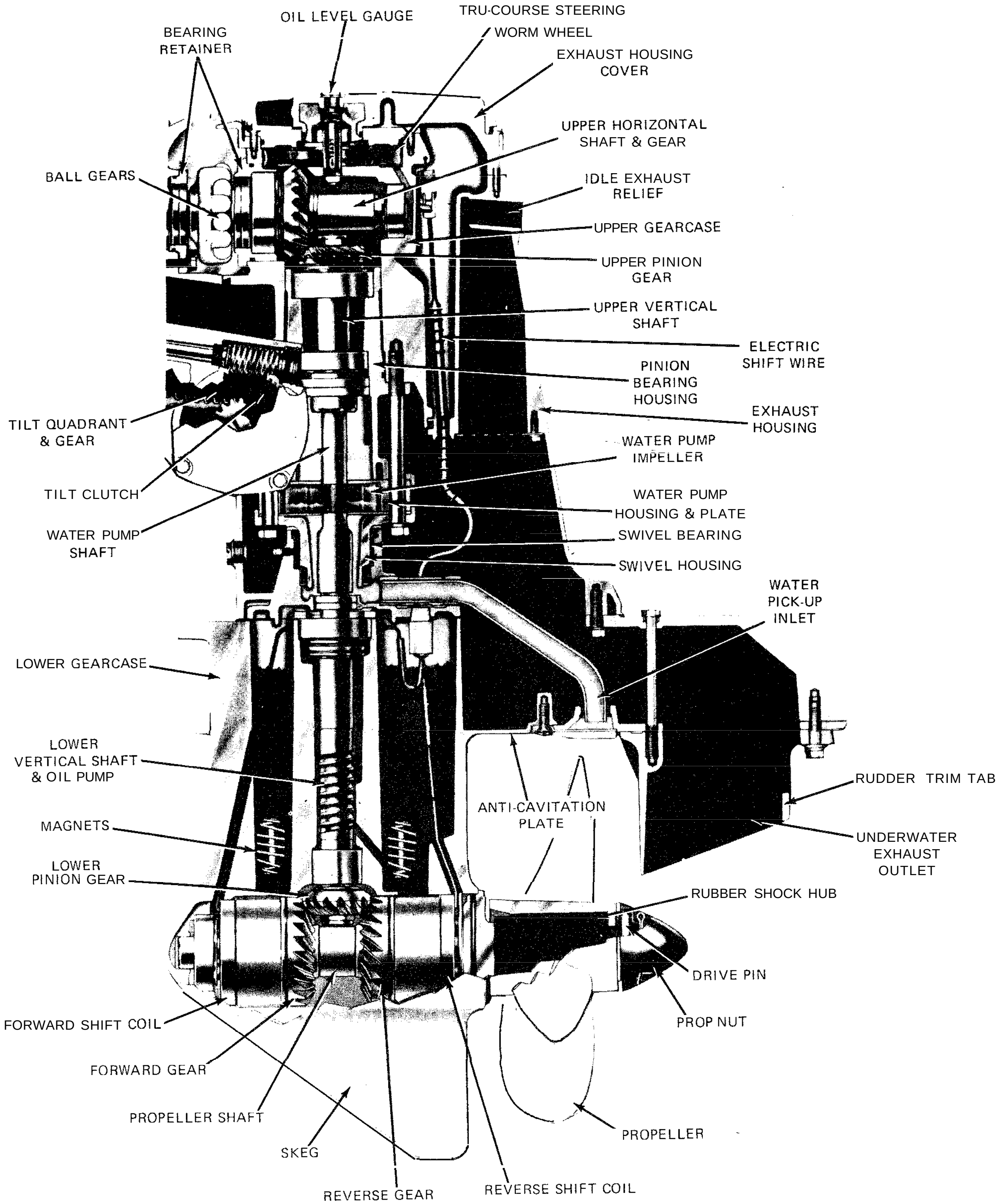
1- Troubleshooting; Section 10-4.

2- Stern drive removal from the intermediate housing; section 10-5.

3- Servicing the upper gear housing; Section 10-6.

4- Servicing the lower unit; Section 10-16.

5- Replacing the stern drive; Section 10-21.



Detailed sectional view of an OMC stern drive showing all internal working parts.

Each of the service groups are further divided into subordinate procedures for removal, disassembly, cleaning and inspecting, assembly, and installation.

10-4 TROUBLESHOOTING

In order to prevent unneccessary service work, specific troubleshooting should be performed. The following steps present a logical sequence of tests and checks to pinpoint problems in the stern drive.

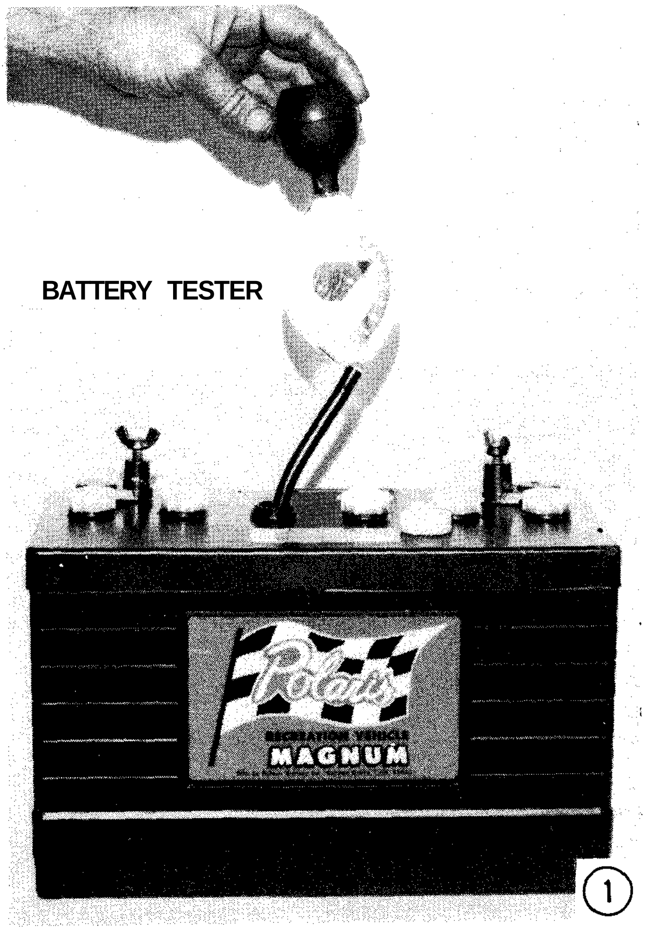
1- Battery Check: Begin with a thorough check of the battery. Measure the gravity of the electrolyte in each cell by withdrawing only enough to lift the float. Take the reading at eye level. A fully charged battery cell should read 1.280; at half-charge, 1.210; and a dead battery will read only 1.150. If the electrolyte level is low, bring it up to full level with clean clear water. **NEVER** ADD **ACID** to a battery cell. If water is added, it is not possible to take an accurate reading until the battery has been charged for a few hours.

2- Battery Voltage: Check the total battery voltage for a full 12 volts. Clean any corrosion from on or around the cables and terminals. Remove the cables, clean the posts until bright metal is visible. Scrape out the inside of the battery terminals, then connect and tighten them securely*

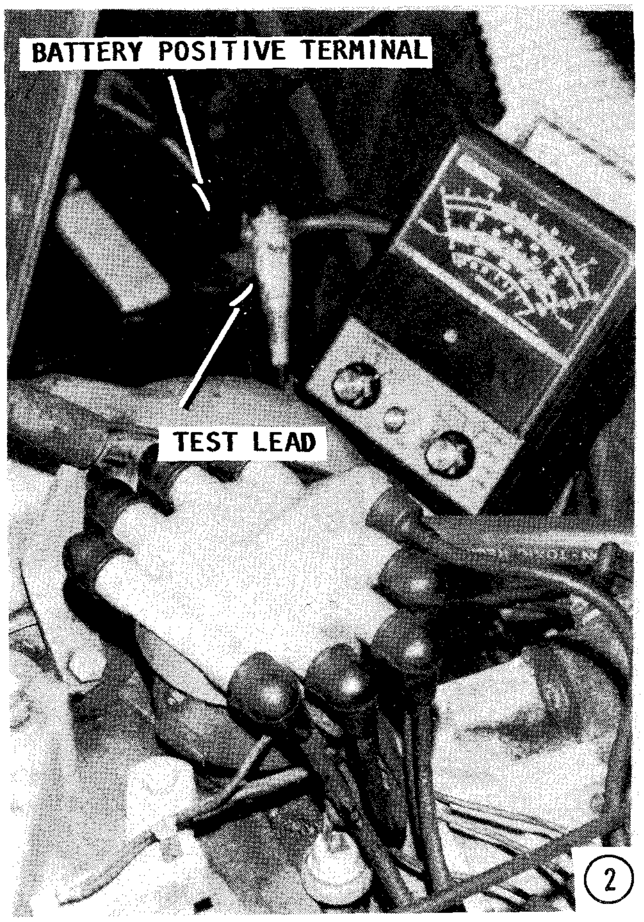
3- Amperage Draw Check: Turn the ignition switch to the ON position and observe the amperage reading on the dash ammeter. If an ammeter is not installed on the dash, one must be temporarily connected to the system for this test by first removing the wire marked **BAT** from the key switch, and then connecting the ammeter in series with this wire and the key switch terminal marked **BAT.**

Check the current draw. If the draw exceeds 2.5 amps in either gear, disconnect the shift wires at the shift wire disconnects on the port side of the engine, just below the exhaust manifold and just above the tilt motor in the intermediate housing. A higher reading than *2.5* amps indicates a short in the wiring; in the shift switch; or in the shift box.

A normal current draw indicates a shorted wire from the intermediate housing to the lower unit, or a short in one of the coils.



1



2

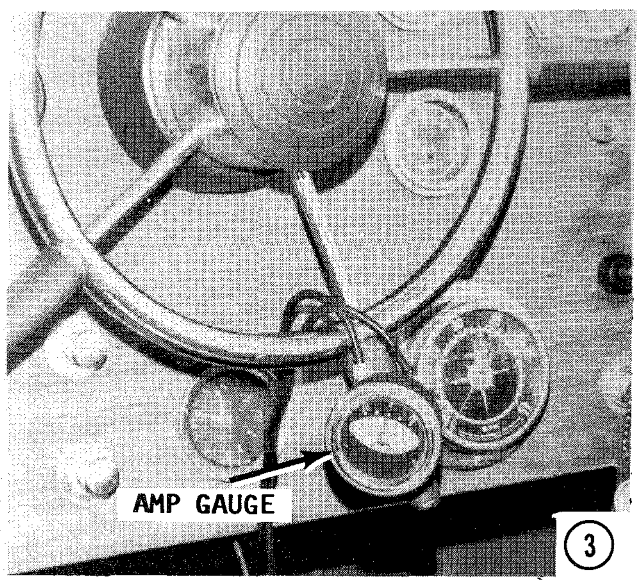
See the stern drive repair sections of this chapter.

A broken drive shaft in the intermediate housing, upper gear housing, or in the lower unit, indicates both forward and reverse gears were energized at the same time. Check the shift box, shift switch, and the wiring to the lower unit.

4- Defective Wiring Check; Leave the wire marked **BAT** disconnected from the key switch for this test. Check the wiring leading to the ignition switch and from the switch for 12 volts. If the reading is less than 12 volts, the switch is defective and should be replaced.

5- Shift Box and **Coil Tests** Connect one lead of a voltmeter to the green wire of the shift box, and the other lead to a good ground. Turn the ignition switch to ON, and move the shift lever into forward gear. The voltmeter must indicate 12 volts. Next, connect the voltmeter to the blue wire, shift into reverse gear, and the voltmeter should indicated 12 volts. If the voltmeter fails to indicate 12 volts during either one of these tests, the shift box requires service, see Chatper 7, Accessories.

Leave the shift wires disconenected; turn the ignition switch **OFF;** move the shift lever to the **NEUTRAL** position; and connect one lead of an ohmmeter to the green (forward) wire leading from the intermediate housing to the stern drive, and the other lead to a good ground. The ohmmeter should indicate from 4.5 to 6.5 ohms. Make the same test for reverse gear, the blue wire leading from the intermediate housing to the stern drive and check for the same reading. If the ohmmeter fails to indicate the required resistance, a wire is broken, or the coil in the stern drive is shorted.

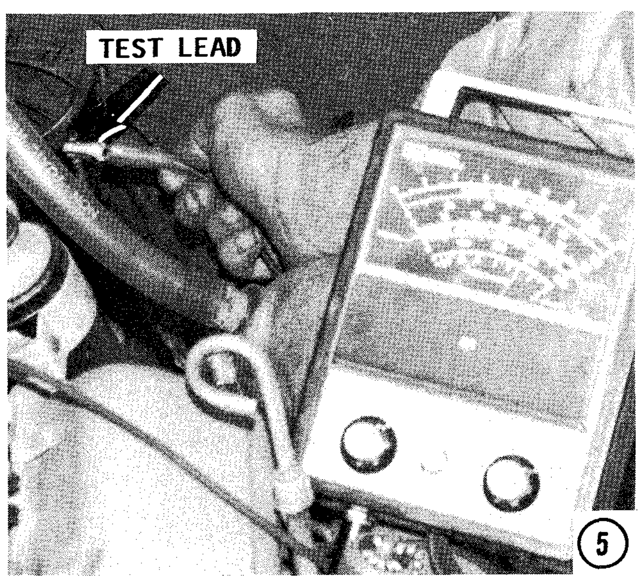


3

4

10-5 STERN DRIVE REMOVAL FROM INTERMEDIATE HOUSING MODELS 1964 TO 1977

1- Disconnect each of the shift wires by slipping back the sleeves and breaking the quick-disconnect . These connections are located above the tilt motor on the port side.



5

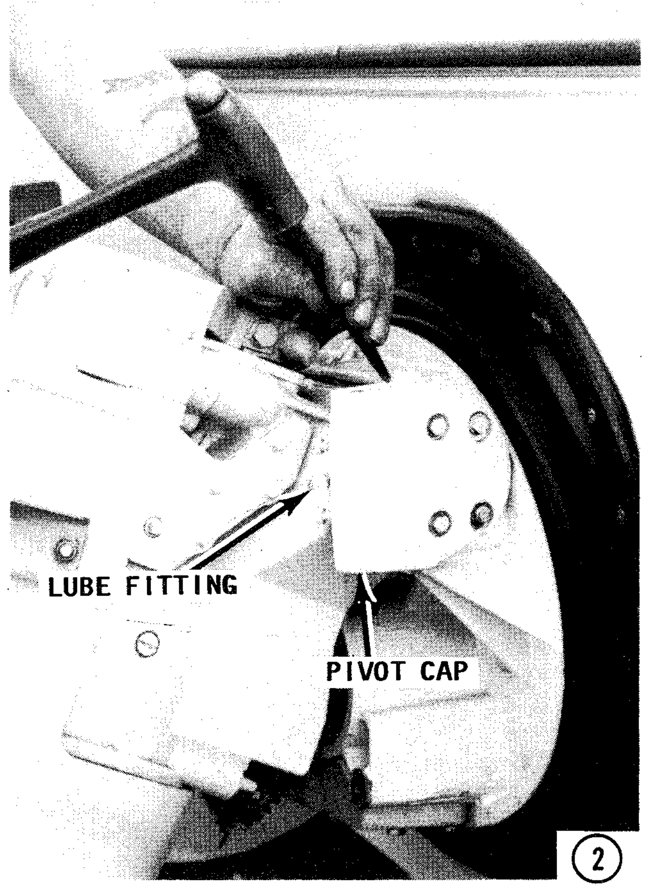
2– TAKE CARE to be sure the pivot liners remain on the pivot arms to protect the machined surfaces and that the pivot caps are kept in order to permit installation on the same side from which they are removed. Each cap on the top of the intermediate housing has a R or L mark for indentification. If you are unable to clearly determine the mark, then make your own mark with a centerpunch to ensure the caps will be installed properly. THE **CAPS MUST NEVER BE INTERCHANGED.** Tilt the stern drive upward approximately 10 to 15 degrees.

3– Remove the four cap screws securing the end cover plates to the intermediate housing. Remove the ground wire between the cap screws and the rear pivot cap screw. This wire is used to ground the lower unit and if this wire is not installed BE **SURE** to do so during assembly.

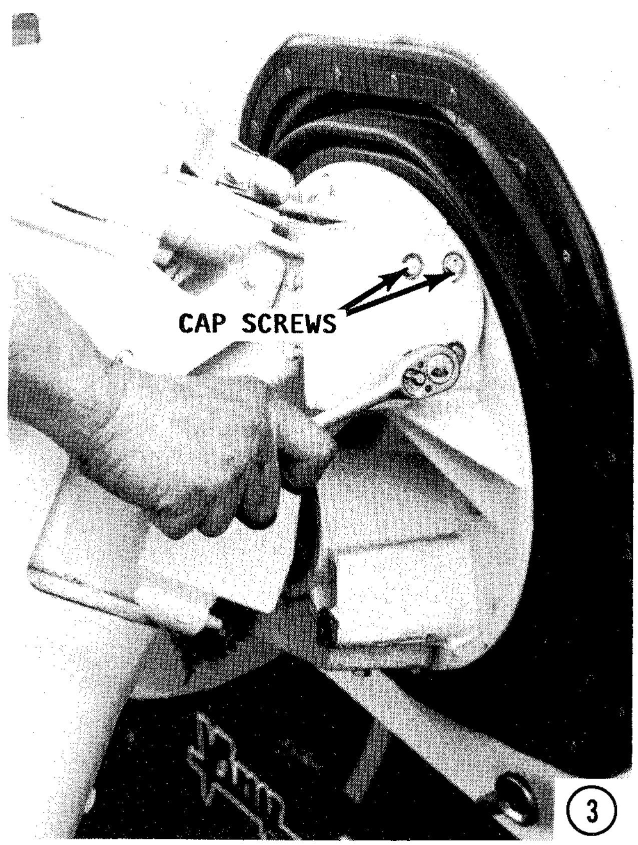
4– **SUPPORT** the unit by holding the exhaust outlet in an upward position, and remove the four pivot cap screws.

5– After the pivot caps have been removed, use the tilt quadrant as a lever and ease the unit back while carefully feeding the shift cable from the intermediate housing. The knobs on the cable stop water from entering the boat. **MARK** the ball gears to ensure proper tooth engagement during installation.

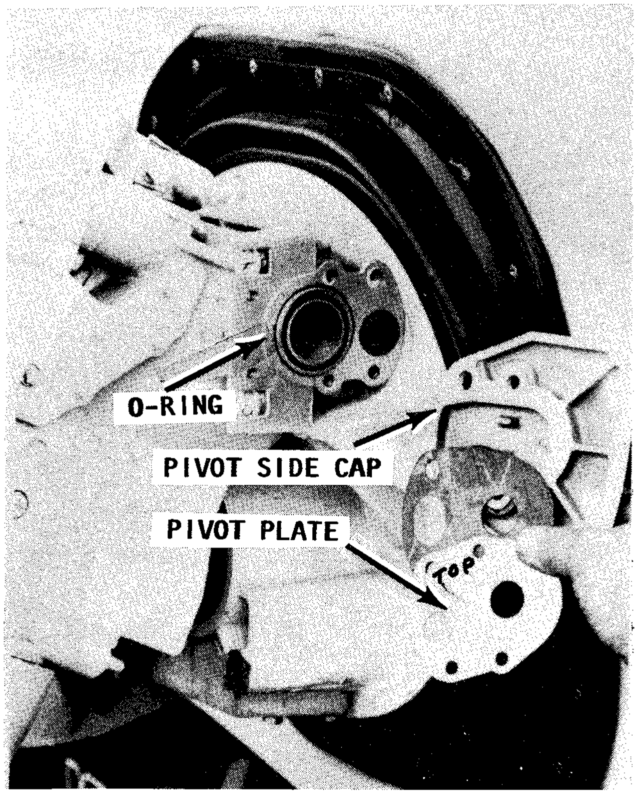
①



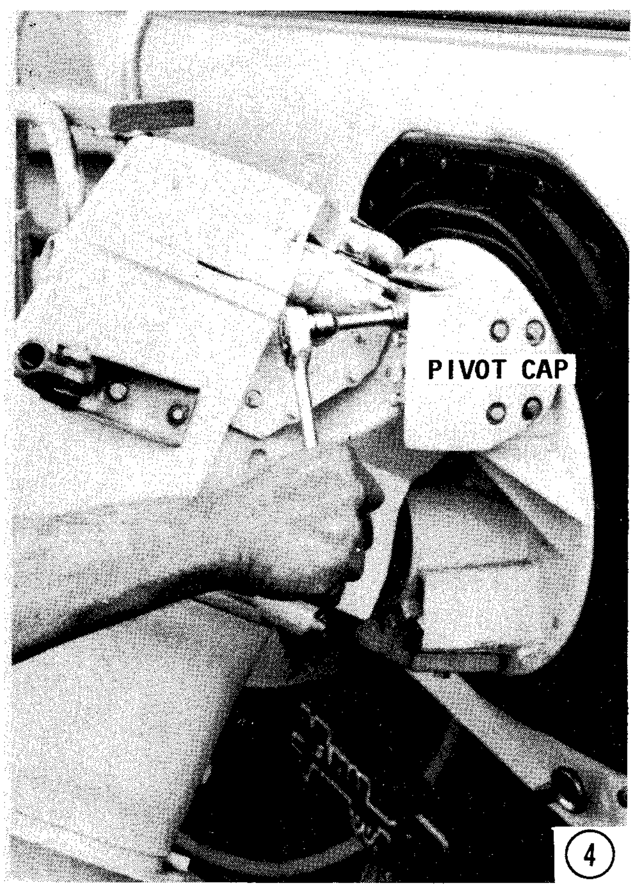
②

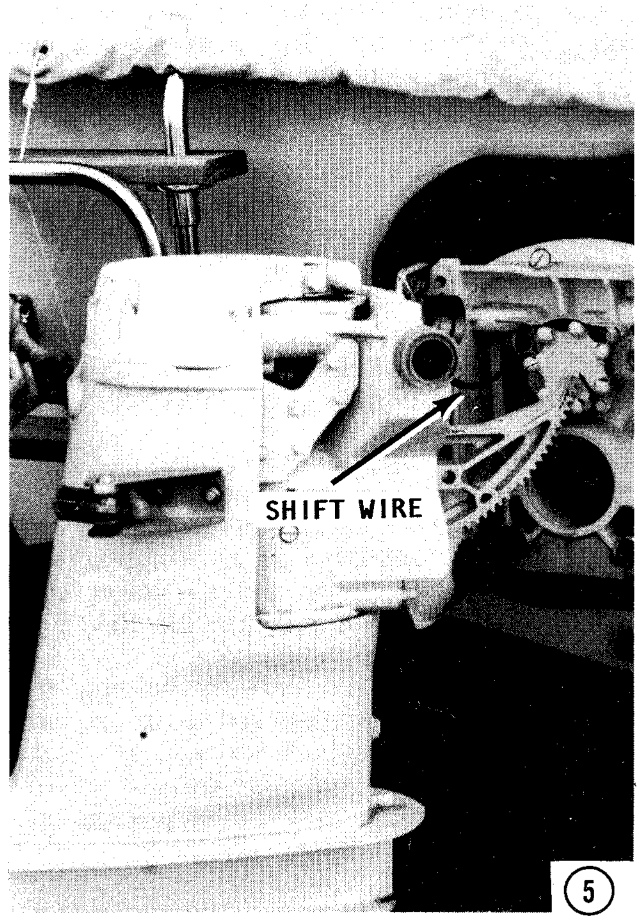


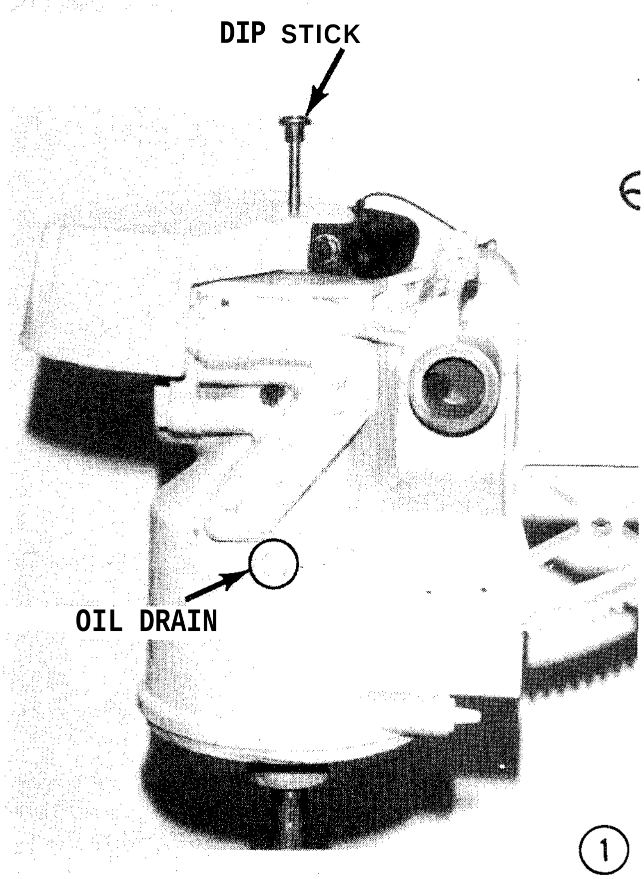
③

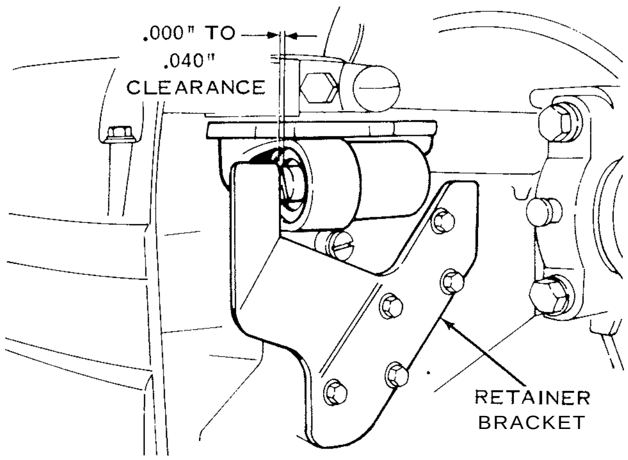


Installation of the pivot cap plate. The water intake hole in the plate MUST be aligned with the matching hole in the intermediate housing. The word TOP is stamped on the plate as an aid to proper installation.







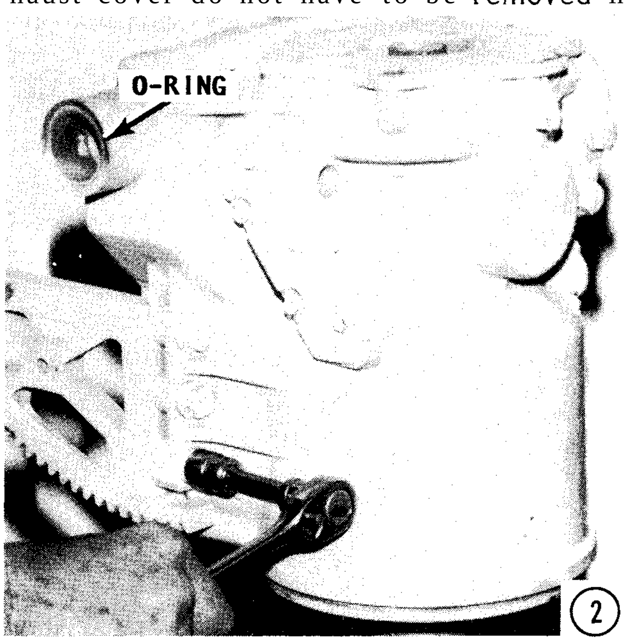


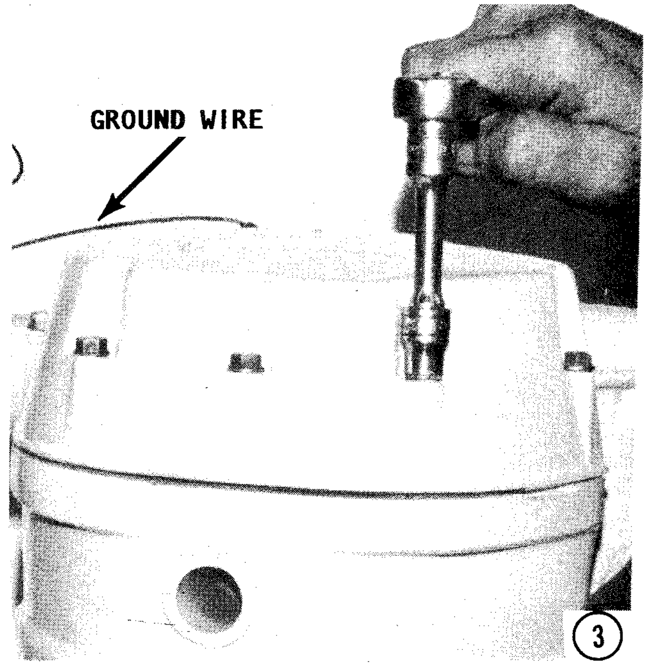
Worm gear retainer kit for installation on any early model upper gear housing to prevent the worm gear plug from working out. Loss of the plug will result in loss of steering.

10-6 UPPER GEAR HOUSING REMOVAL MODELS 1964 TO 1977

1- Support the stern drive in some type of fixture and remove the plugs identified as **OIL DRAIN** and **OIL LEVEL** or **VENT,** then drain the oil from the upper housing. On newer models, the oil level measurement is accomplished with a dip stick in the center of the exhaust housing.

2- It is not necessary to remove the tilt quadrant, unless the unit is damaged. To do so, first remove the three bolts on the port side of the unit. If working on a 1967 or newer model, the rubber bumper and the two bolts securing the bumper to the exhaust cover do not have to be removed in

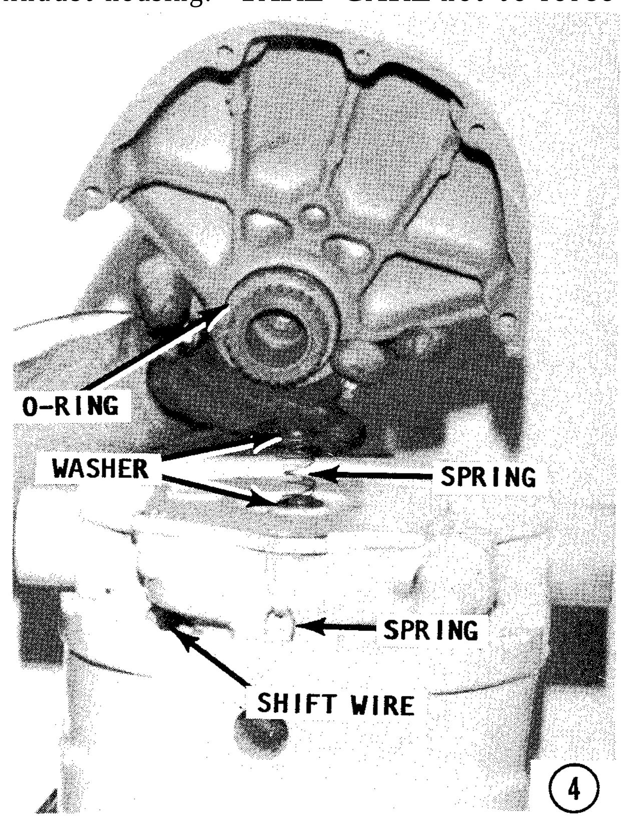




order to remove the cover. On models prior to 1967, the bolt and bumper must be removed to permit removal of the exhaust cover.

3- Remove the exhaust housing cover attaching screws. On models since 1967, five screws secure the exhaust housing cover in place; prior to 1967, only four screws were used.

4- Pry and work the cover free of the exhaust housing. **TAKE CARE** not to force



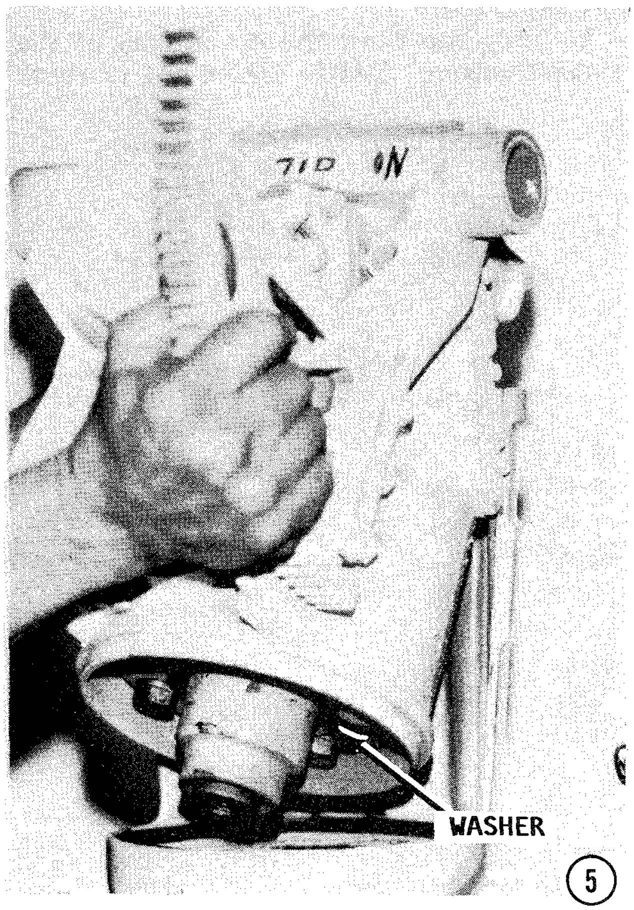
the cover. On models prior to 1967, the cover must be worked free of the worm wheel. Remove the spring and washers used to provide a good ground for the electric shift mechanism. Remove the shift cable wire clamp, and then pull the shift cable out of the upper gear housing. Remove the spring and clamp from the shift cable and move the cable to one side.

5- Lift the upper gear housing straight up; tilt it back; then move it free of the lower unit. Remove the large nylon washer from the bottom of the swivel housing. **TAKE NOTE** how one side of the washer is concave to fit against the swivel housing. If the upper gear housing does not require service, set it aside and continue with Section 10-16 for servicing the Lower unit.

10-7 WATER PUMP REMOVAL MODELS 1964 TO 1977

Replacement of the water pump in the stern drive involves many tasks, considerable time, and attention to detail, to ensure proper performance after the work is completed.

As an assist in understanding more about the stern drive water pump, the following paragraphs explain which units must be removed IN SEQUENCE in order to replace the water pump.



The water pump is located inside the stern drive. Therefore, the stern drive must be removed. See Stern Drive Removal, Section 10-5.

The water pump is located in the lower section of the upper housing. Therefore, the upper housing must be removed from the lower housing as detailed in Upper Housing Removal, Section 10-6.

Remove the water pump as detailed in the latter part of this section.

TAKE NOTE: It is possible to install the water pump without servicing the water pickup tube in the swivel housing. However, if it is not performed, the new pump may not move enough water to the engine and replacement of the pump will not give the desired results.

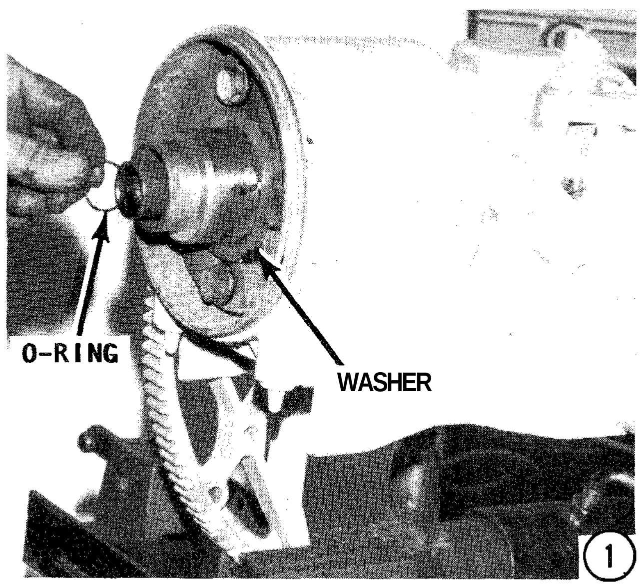
The exhaust housing is not considered a part of the water pump repair. However, the housing must be removed in order to remove the swivel housing.

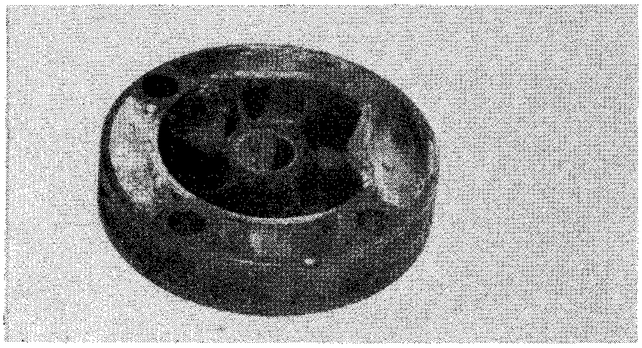
Therefore, remove the exhaust housing, see Exhaust Housing Removal, Section 10-14.

The swivel housing and water pickup tube play a critical role in the cooling system. Any exhaust gases or leakage at the swivel housing will cause failure of a new water pump.

Therefore, remove the swivel housing, see Swivel Housing Removal, Section 10-15.

TAKE MOTE- The following steps take up the work after the upper gear housing has been removed, as described in Section 10-6.





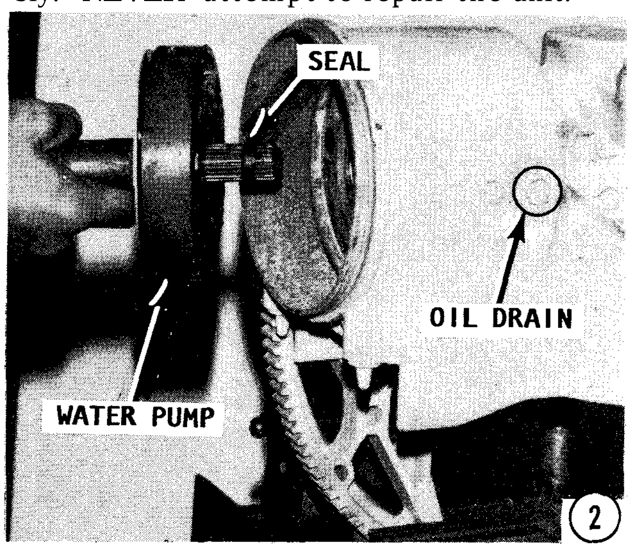
Water froze in this stern drive water pump because the boat was stored with the stern drive in the up position and the water was trapped inside the pump. ALWAYS lower the stern drive when laying up the boat for winter storage.

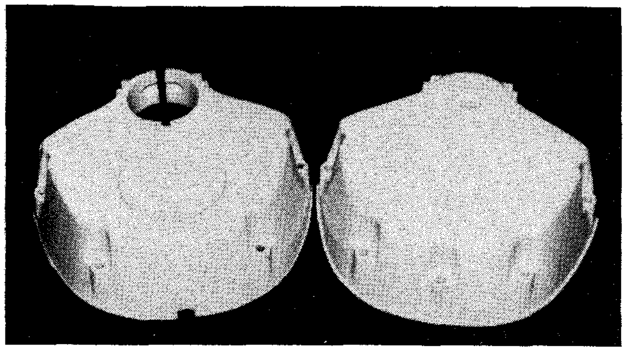
1– Remove and discard the O–ring in the goove in the lower end of the water pump shaft. **NEVER** attempt to use an old ring. **ALWAYS** use a new one during installation.

2– Remove the four bolts securing the swivel plate in the upper housing. Remove the swivel plate. If necessary, tap the swivel housing with a light mallet to break the seal on the water pump plate. kift the driveshaft, impeller plate, impeller, and impeller housing off as an assembly. It may be necessary to use a punch and tap the impeller housing out of the bearing housing. Remove and discard the spline seals from the top of the driveshaft, and then lift the impeller and impeller housing off the driveshaft. **ALWAYS** replace the housing key and plate to prevent overheating.

CLEANING AND INSPECTING

Inspect the water pump plate for wear and corrosion. If any part of the pump is defective, **REPLACE** the pump as an assembly. **NEVER** attempt to repair the unit.





Larger units are identified by the number of bolts securing the cap. Four bolts, left, were used on models from 1964–67; and five bolts, right, on units manufactured since 1967.

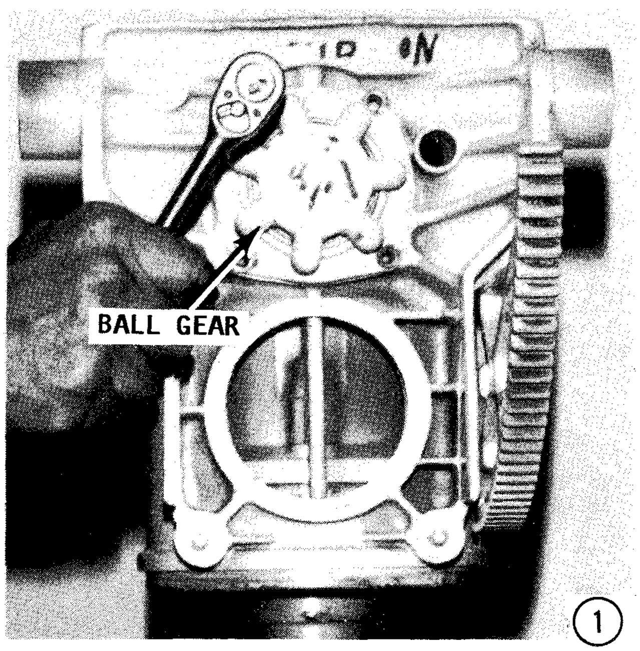
WATER PUMP ASSEMBLING

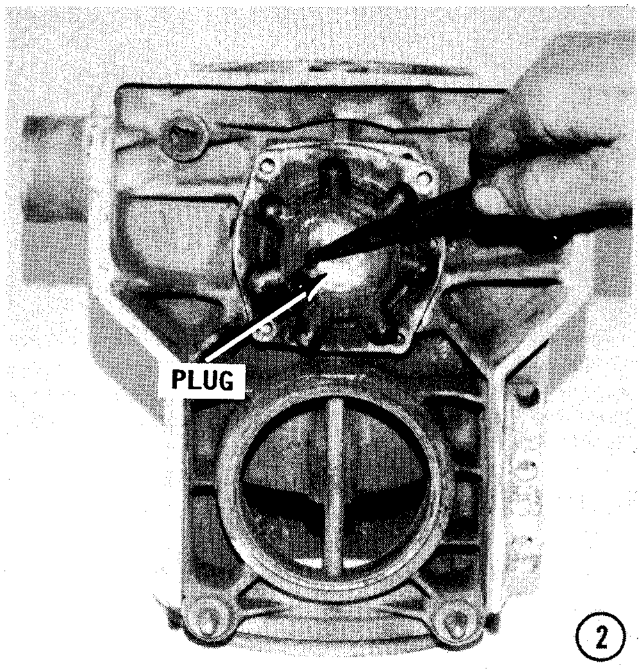
Assembly sf the water pump is covered in Section 10–13 , in sequence with other assembly arid installation work on the lower unit.

10–8 BALL GEAR DISASSEMBLING MODELS 1964 THRU 1977

1– Remove the four screws and lockwashers from the upper gear housing, and then pull out the ball gear, shaft, and bear ing assembly. Pry the assembly out of the gearcase with a large screwdriver positioned at one side of the opening in the top of the gearcase. Remove the color–coded shims from the rear of the bearing retainer. There should be no more than two shims.

2– Two seals are installed behind the ball gear. To replace these seals, the plug





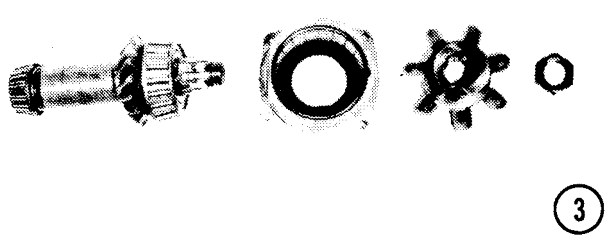
in the center of the ball gear must be removed. Remove the plug by first punching a hole in the plug and then popping it out of the ball gear.

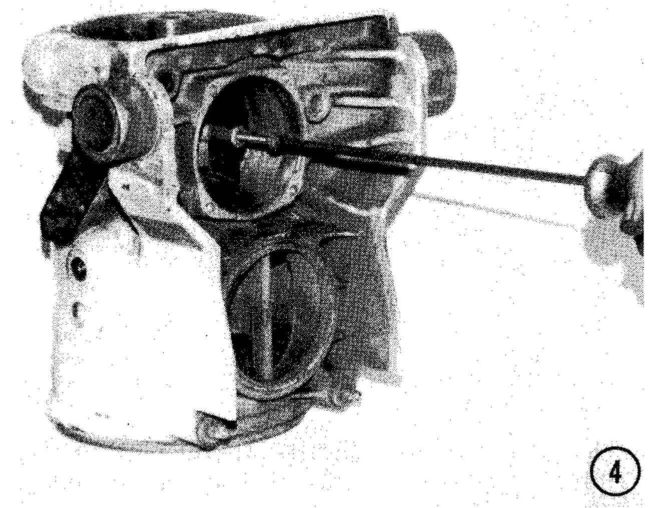
3- On some models, in addition to being pressed onto the shaft, the ball gear is further secured with a nut. If the nut is installed, remove it, and then press the ball gear from the shaft. Remove the seal cap and two seals. **TAKE NOTE** how the seals are installed **BACK-TO-BACK** with the seal lips pointing in opposite directions.

4- The ball gear assembly has a bearing cup and shims located in the rear of the upper gearcase retained with Loctite. The cup may be very difficult to remove. For this reason, puller-relief grooves are provided at the top and bottom of the gearcase to permit use of a slide hammer. Remove the cup, and then the shims.

10-9 BEARING HOUSING DISASSEMBLING MODELS 1964 THRU 1977

1- Am O-ring holds the bearing housing in the upper gearcase. To remove the bearing housing, grasp it firmly and snap it

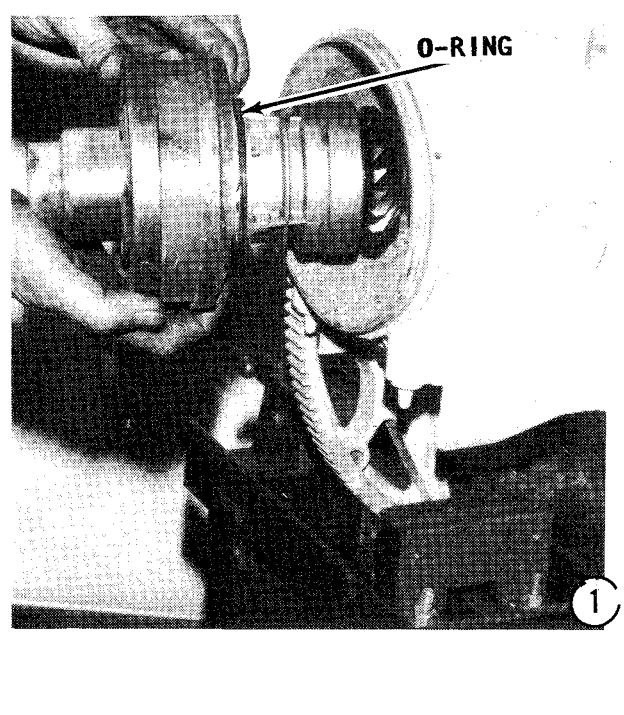


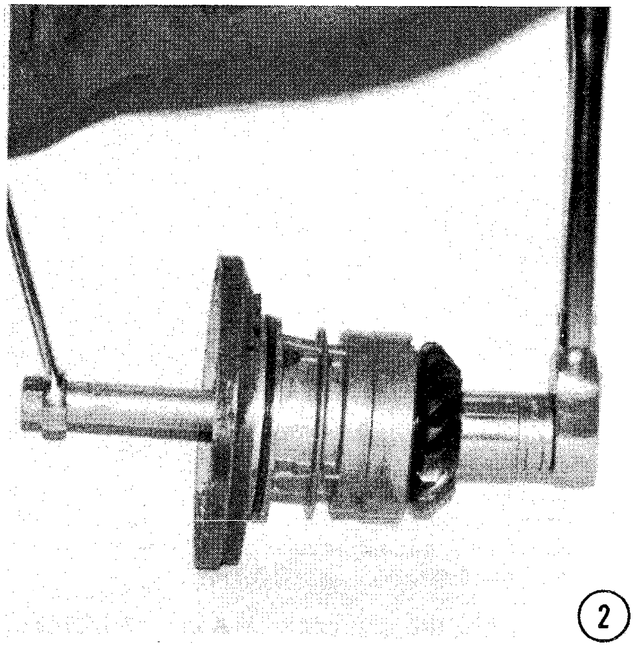


straight back and out of the gearcase. Remove and **DISCARD** the O-ring. **DISCARD** the shims installed on top of the bearing housing to establish the proper tolerances in the drive system parts. **ALWAYS** install a new O-ring and shims during installation.

2- Secure the pinion gear nut in a vise. Use special socket, No. 311875, to remove the driveshaft nut. **DISCARD** the nut because it has lost its locking ability. Remove the pinion gear and bearing assembly from the upper driveshaft. Remove and discard the O-ring seal.

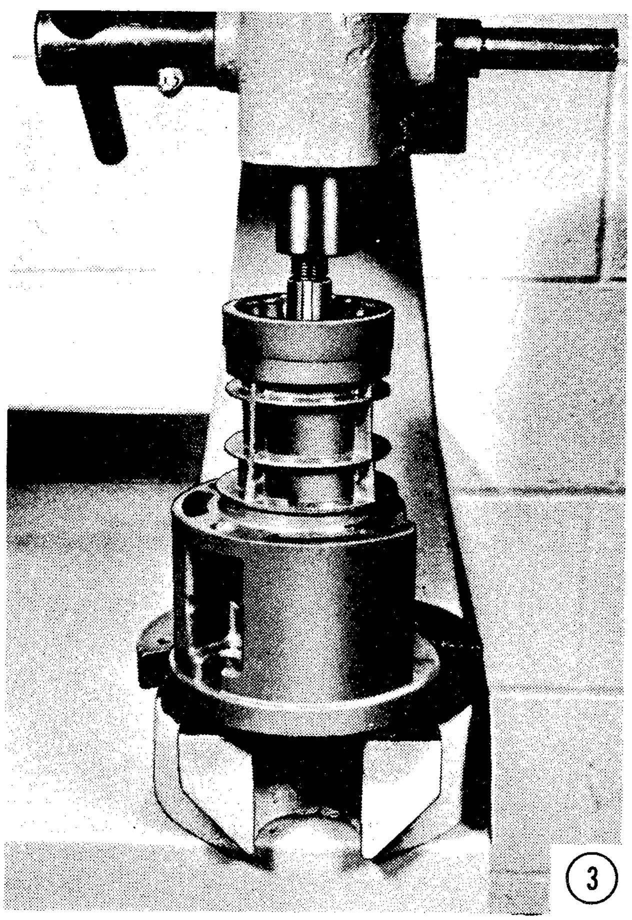
3- Two seals hold the upper driveshaft in position in the bearing housing. Place the bearing housing on a soft base in an arbor press, and then **CAREFULLY** force the driveshaft and seals from the housing. **TAKE NOTE** how the seals are installed



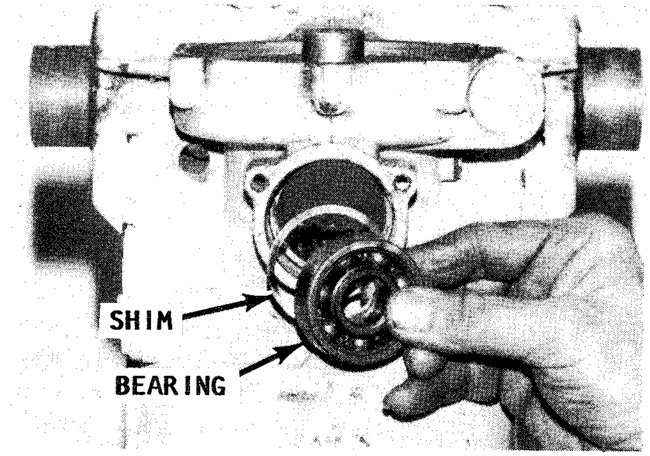


2

BACK-TO-BACK with the seal lips pointing in opposite directions. DISCARD the seals. **ALWAYS** install new seals as a prevention against leaks. The pinion gear and bearing are serviced **ONLY** as an assembly. Individual replacement parts are not available. Therefore, shimming is always required to obtain the proper running clearance.



3

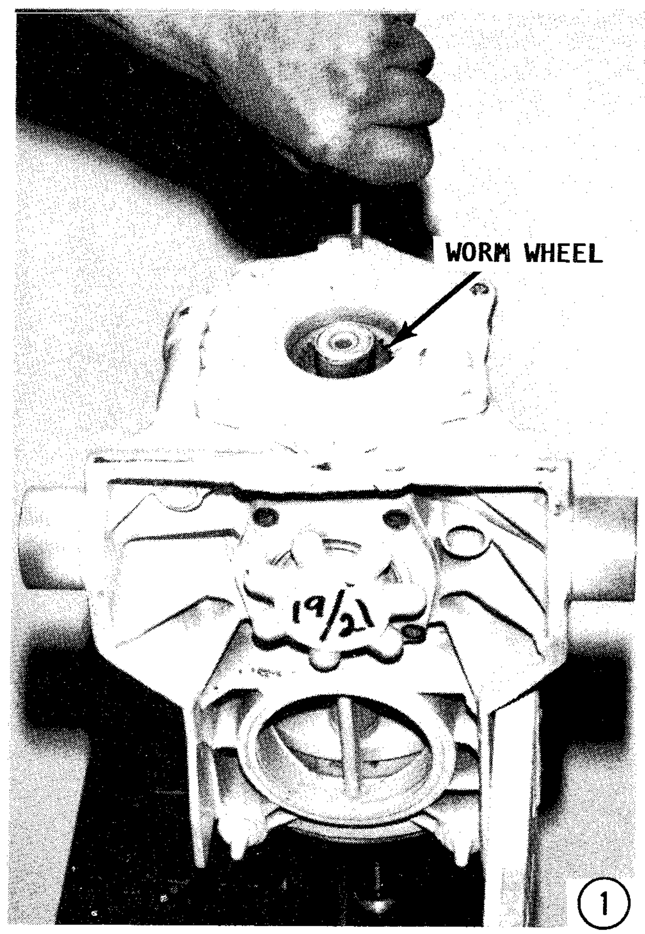


Installation of the bearing and shim into the back side of the upper gear housing on very early model units.

10-10 WORM GEAR STEERING DISASSEMBLING MODELS 1964 THRU 1977

1- Remove the upper gear housing cover plate by removing the six screws.

2- Rotate the spur gear at the front of the gearcase counterclockwise until the worm wheel is at the rear of the gearcase;



1

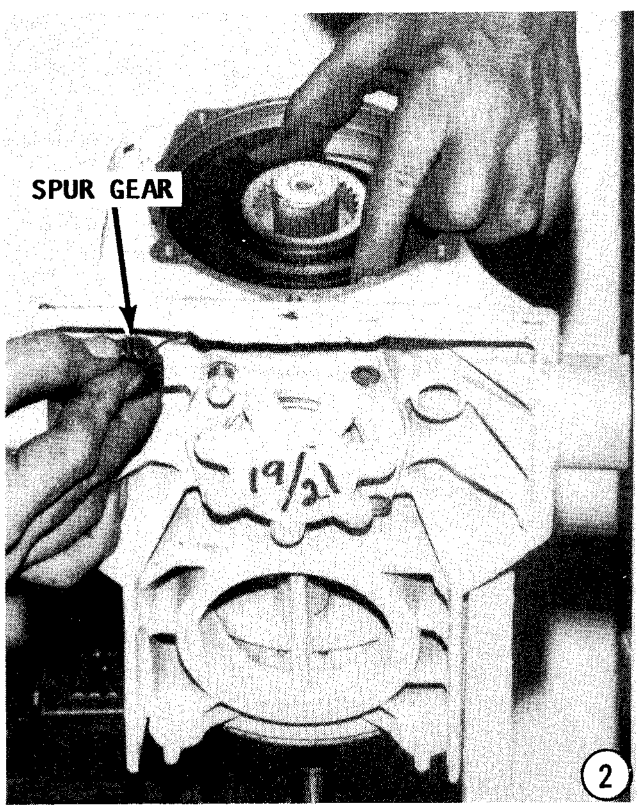
then lift the worm wheel straight up and out. Notice the number of shims on the pivot shoulder at the top of the upper gear-case. These shims restrict the up-and-down movement of the vertical drive to 0.005" to 0.015". A damaged shim **MUST** be replaced in order to obtain the proper tolerance.

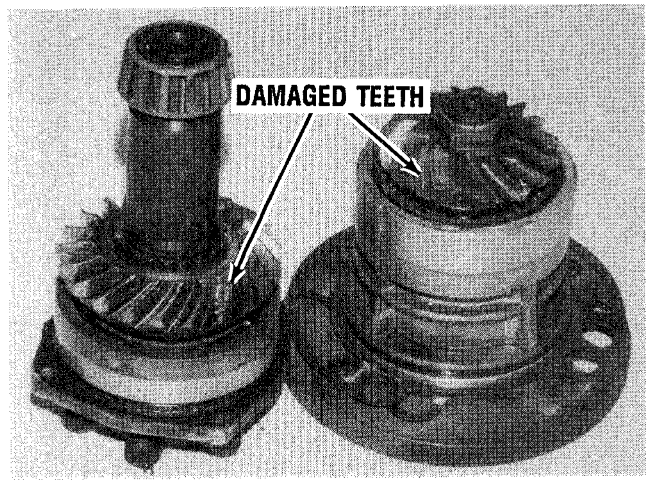
CLEANING AND INSPECTING

Wash all parts in solvent and blow them dry with compressed air. **NEVER SPIN** the ball or roller bearings with air or they will be ruined. Remove all seal and gasket material from mating surfaces. Blow all water and oil passages, and screw holes clean with air.

After the parts are clean and dry, apply a coating of light engine oil to the bearings and bright mating surfaces of the shafts and gears as a prevention against corrosion.

Check for evidence of water in the oil reservoir of the upper gearcase. If there is any sign of water, check the oil retainer seals and O-rings to be sure they are in good condition and are properly installed. Any water in the oil reservoir most likely entered the upper gearcase through the water pump bolt cavities. To prevent further water from entering, the water pump bolt threads **MUST** be coated with Permatex No. 2 during assembly.



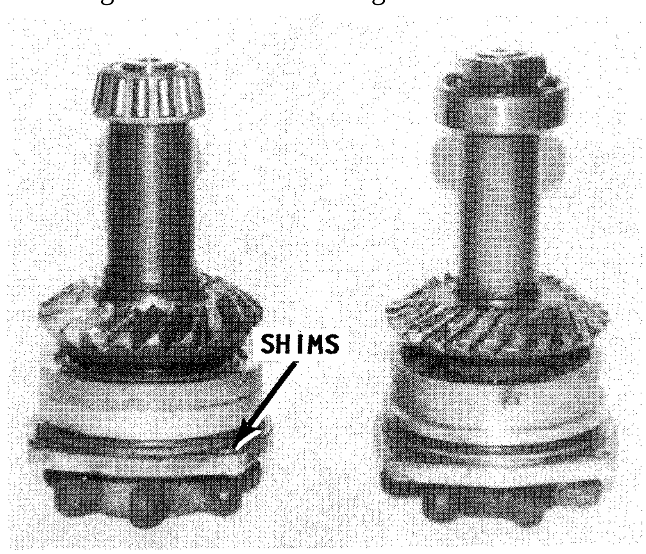


Damaged pinion gear teeth may be the result of overheating and/or lack of adequate lubrication. Improper shimming will usually cause discoloration and/or excessive gear wear.

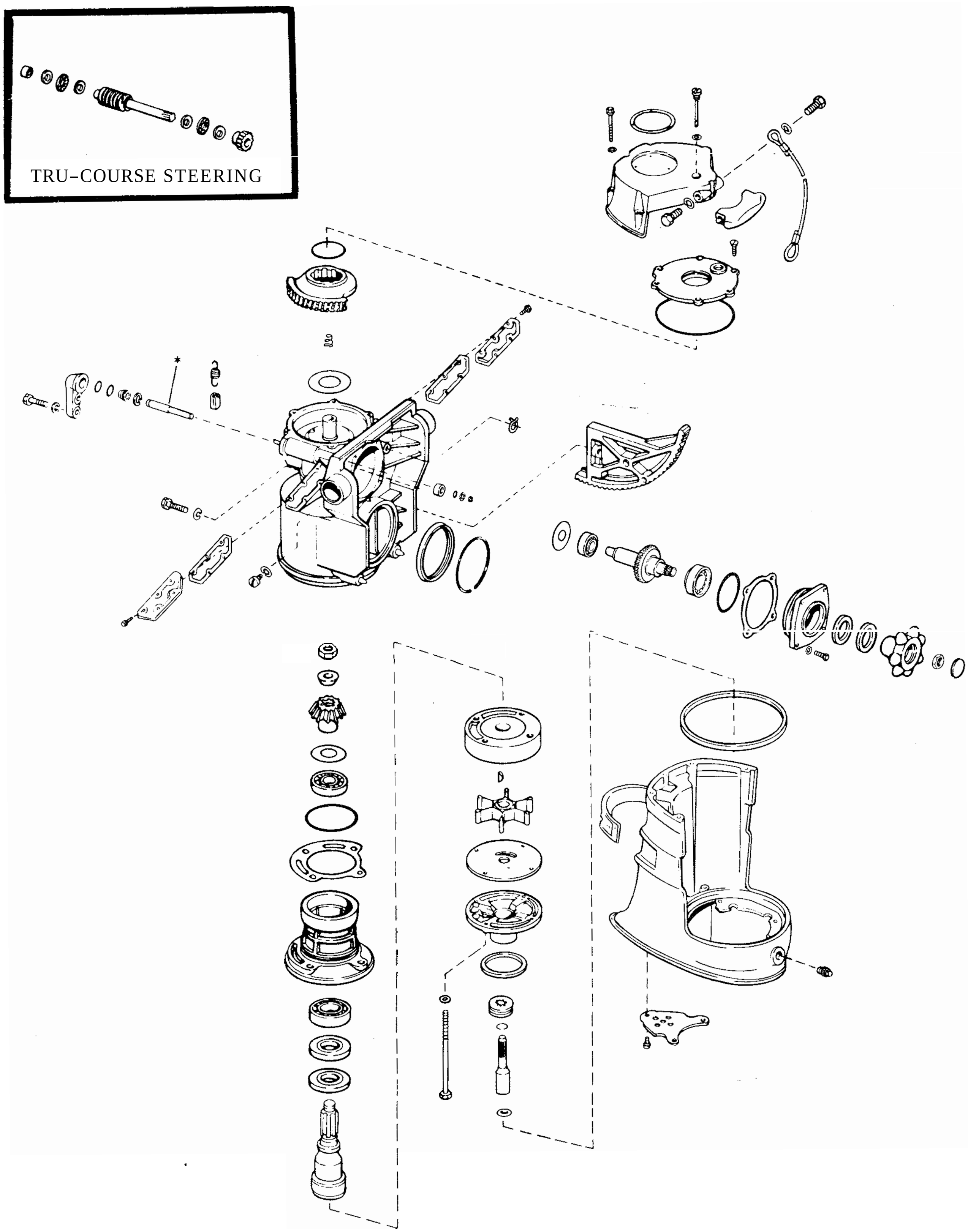
Inspect the shaft bearing surfaces, splines, and keyways for wear and burrs. Check for evidence of an inner bearing race turning on the shaft. Check for damaged threads. Roll the shaft on a flat surface and check to be sure it is not bent.

Carefully check the inside and outside surfaces of the gearcases, housing, and covers for cracks. Pay special attention to the areas around screw and shaft holes. Verify all traces of old gasket material has been removed from mating surfaces. Check O-ring grooves for sharp edges which could cut a new seal. Inspect gear teeth and shaft holes for wear and burrs.

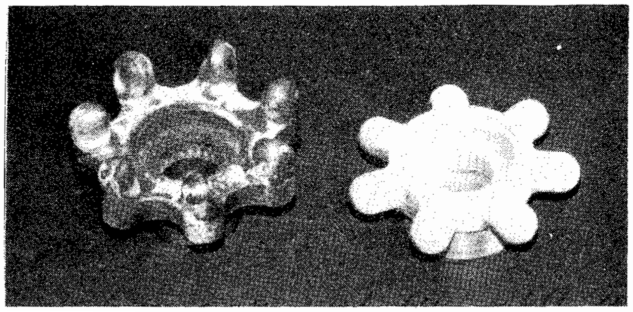
Inspect all bearings for roughness, pitting, and flat spots, by holding the center bearing race and turning the outer race.



Shims were not used on the input driveshaft in the upper gear housing from 1964-67 (right). Since 1967, shims are installed, as shown (left).



Exploded view of the OMC upper gear housing. The Tru-Course steering worm gear is an accessory to the housing.



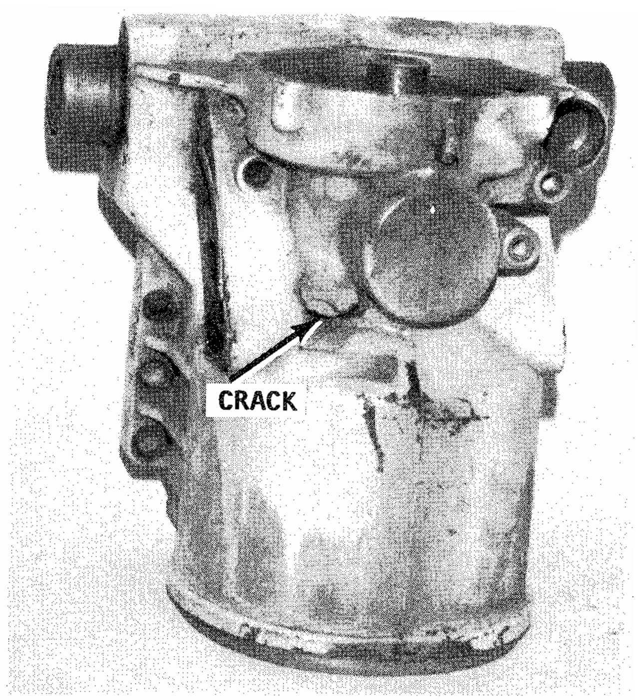
Worn ball gear, left, ***MUST*** *be replaced with a new one, right.*

Check the outside diameter of the outer races and the inside diameter of the inner races for evidence of turning in the housing or on a shaft. Any sign of discoloration or scores is an idication of overheating.

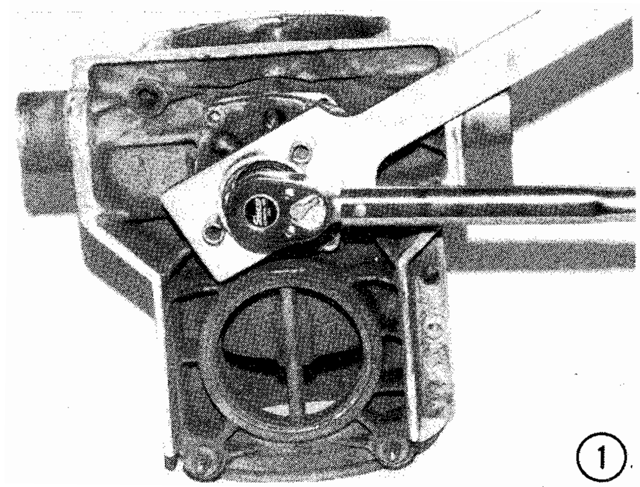
Check the thrust washers for wear and distortion. If they do not have uniform thickness and lay flat, they **MUST** be replaced.

10-11 BALL GEAR ASSEMBLING MODELS 1964 THRU 1977

1- Install the ball gear shaft into the upper housing **WITHOUT** the O-ring and shims. Install a couple bolts to hold the bearing cap. The unit will stay in place and enable you to install the ball gear onto the driveshaft. **CHECK** to be sure the splines



This upper housing failed because it was not shimmed properly. The text explains in detail how to prevent this type of expensive damage.



are clean. Install the nut, if one is used, and tighten it to a torque value of 96 ft-lbs.

2- Install the seal plug over the nut in the center of the ball gear and flatten the plug with a hammer. Now, remove the assembly in preparation to properly shimming the driveshaft.

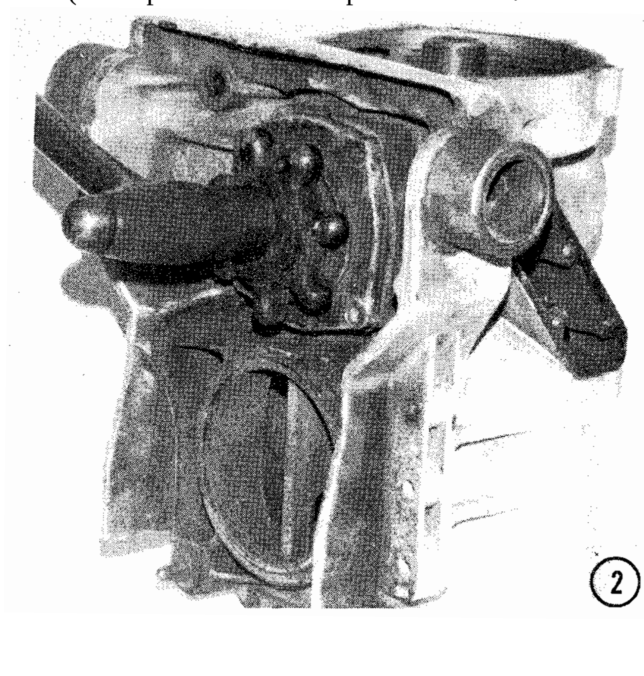
3- This step outlines the procedure for determining the amount of shimming required for the driveshaft. Obtain special shimming tool for the unit being serviced as follows:

Part No. 908572

100 hp -- 1972-73
120 thru 155 hp late 1967 to 1977
165 hp -- 1972-76
170 hp -- 1974-77
175 hp -- 1974-77
190 hp -- 1974-77
235 hp -- 1974-77

Part No. 908573

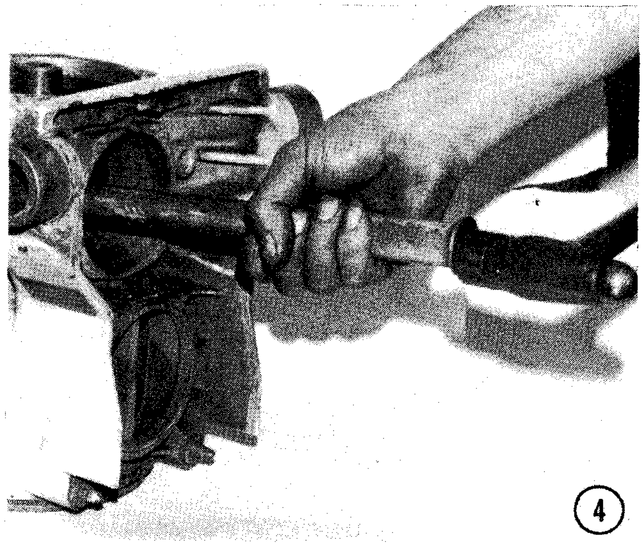
185 thru 245 hp -- late 1967-76
(Except 190 & 235 hp -- 1974-77)



First, it is necessary to determine the number of shims required to locate the bearing cup properly at the rear of the upper gearcase. The cup locates the ball gear driveshaft and gear within the gearcase. Place the bearing cup on the bearing, at the rear end of the shaft. Now, apply equal pressure around the cup while rotating the cup to break the oil film. Next, locate and position the shim gauge, as shown. Load and rotate the bearing while measuring the gap between the shim gauge and the loaded bearing cup with a feeler gauge. The measurement equals the amount of shimming required to locate the gear in the proper position. Place the upper gear housing on a suitable surface with a wooden block under the bearing cup.

4- Handle the shim **CAREFULLY.** If it is bent or becomes the least bit distorted, it **MUST** be replaced. Position the shim in the bearing cup. Use the "ball gear bearing race installer and drive handle" to **CAREFULLY** drive the cup squarely into its seat.

5- Make a trial assembly by inserting the assembly into the gearcase **WITHOUT** the bearing retainer or O-ring seal. Press down on the bearing assembly and at the same time turn the ball gear to break the oil film. Measure the gap between the gearcase and the rear of the bearing retainer with a feeler gauge. This measurement **LESS** 0.002" equals the shims required to properly **PRELOAD** the ball gear shaft bearing. **TAKE NOTE** how each shim has a tab



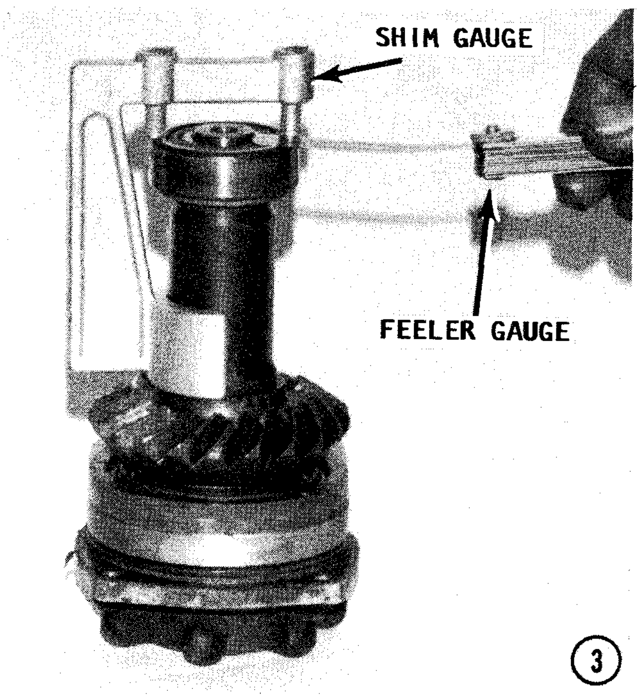
4

on its upper edge. This tab on the shim **MUST** be aligned with the tab on the retainer. Install- the O-ring seal on the retainer. Place the ball gear shaft-and-bearing assembly into the upper gearcase and secure it with the screws and lockwashers. Tighten the screws to a torque value of 5-7 ft-lbs.

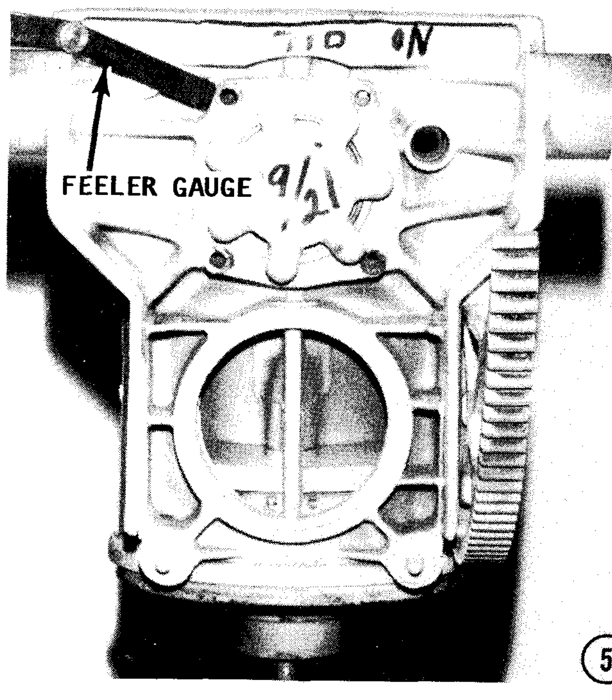
10-12 BEARING HOUSING ASSEMBLING MODELS 1964 THRU 1977

1- Press the top bearing cup into the housing using tool No. 314436. Install the cup in the bottom of the housing in the same manner using tool No. 314434.

2- TAKE NOTE: If the original pinion gear and bearings are to be installed, then the old shims may be used, provided they



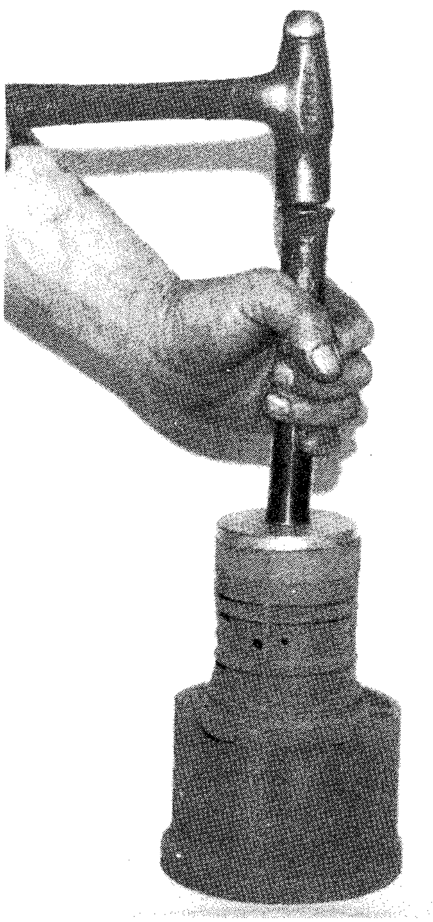
3

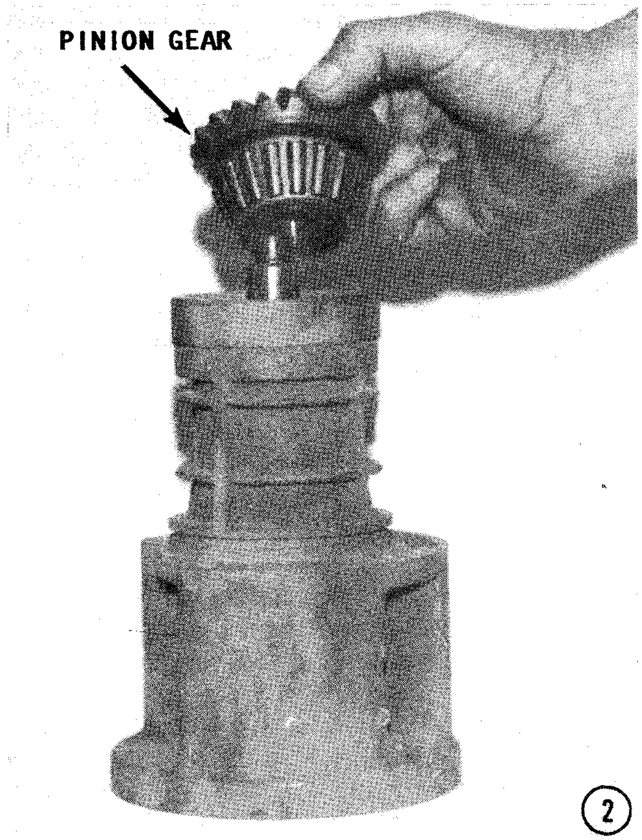


5

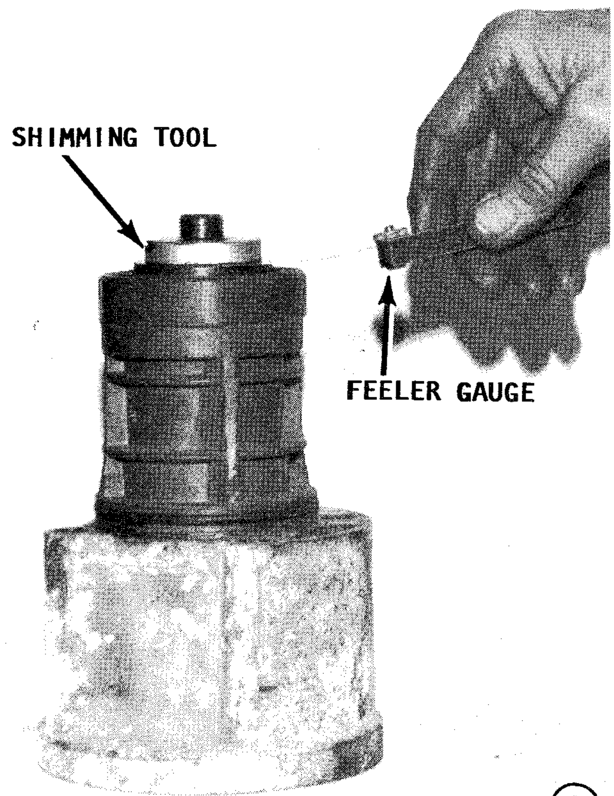
are serviceable. If a new pinion gear or bearing is to be installed, the following procedure **MUST** be followed to determine the proper shims required to properly pre-load the bearing: First, position a support for the upper driveshaft in such a manner to allow the housing freedom to rotate. Set the support beneath the shaft, and then place the housing over the shaft. Exert a firm downward pressure on the housing and rotate the housing around the shaft to laod the housing and to break the oil film. The oil film **MUST** BE **BROKEN** before accurate shim measurements can be made. An unbroken oil film can cause the measurement to be in error by several thousands of an inch. Slide the pinion bearing onto the top of the driveshaft.

3- Place shim gauge tool No. 314725 over the shaft; press down on the bearing to apply a load; and them press down on the shim gauge to prevent it from moving. Continue to exert some pressure on the shim gauge and measure the gap between the shim gauge and the inner race of the bearing. The measurement will indicate the amount of shimming required to properly preload the vertical drive bearing. A minimum of one shim and a maximum of three shims **MUST** be used. The illustration does not show preloading in order to afford a

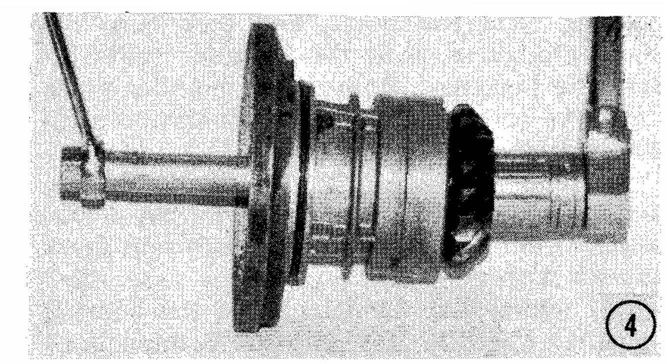

1



2



3

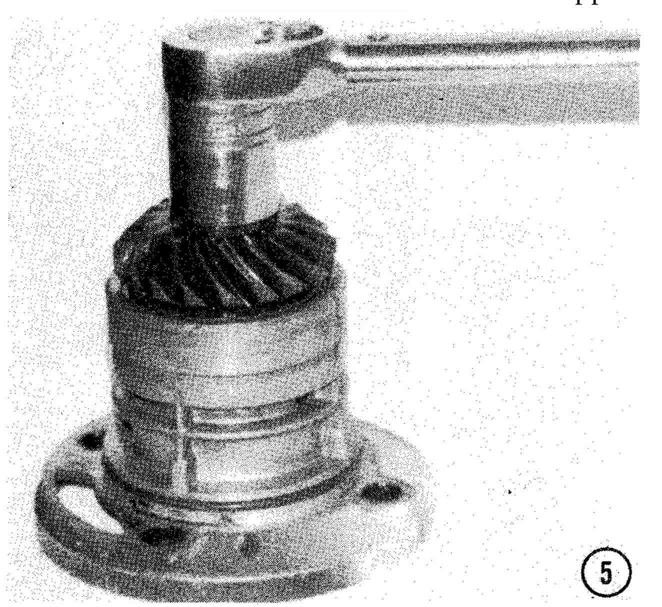


clear view of the measurements. The parts catalogue will indicate the proper part numbers of available size shims. Lubricate the gear and bearing with No. 80 gear oil. Position the correct size and number of shims on the gear. Use Tool No. 314437 to press the bearing onto the gear with an arbor press.

4- Install the pinion gear and bearing onto the upper driveshaft. **ALWAYS** use a new locknut because the locking ability of the old one is ruined when it is removed. Install the nut finger-tight. Use Tool No. 314438 and a vise on the lower end of the driveshaft. Tighten the locknut to a torque value of 70-80 ft-lbs.

5- Stand the bearing housing on end. Use a torque wrench and socket to check the rolling torque value which should not exceed 28 in.-lbs. If the torque value is more, perform step 3, in order to determine the proper size and number of shims.

6- Apply a light coating of Anti-corrosion Lubricant onto the two bearing housing bottom seals. Position them **BACK-TO-BACK** with the lips facing in opposite directions over the bottom of the upper driveshaft. Place Tool No. 314694, behind the seals. Use an arbor press to seat the seals.



7- Shims must be used to position the bearing housing inside the upper gearcase. Obtain special shimming tool for the unit being serviced as follows:

Part No. 314723
120 hp -- Late 1967-71
155 hp -- Late 1967-73

PART No. 907971
100 & 120 hp -- 1972 with "S" suffix
165 hp -- 1972-76
140 hp -- 1973-77
170 hp -- 1974-77
175 hp -- 1974-77
190 hp -- 1974-77

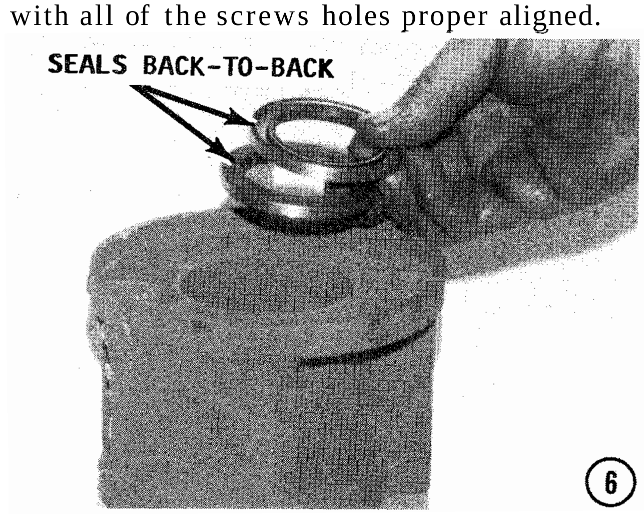
Part No. 908285
100 & 120 hp -- 1972 with "C" suffix
100 & 120 hp -- 1973-77

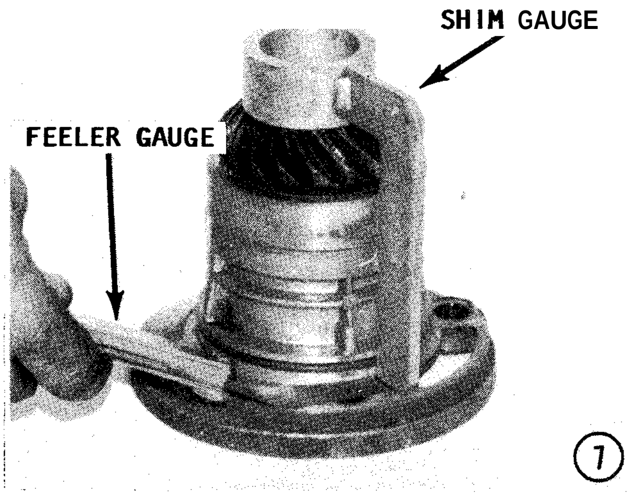
Part No. 314726
185 thru 245 hp -- Late 1967-76
(Except 235 hp low profile)

Part No. 909078
235 hp -- 1975-77

Load the pinion bearing and gear and at the same time, measure the clearance to determine the number and size shim/s necessary. During the 1973 model year, the ball gear seal retainer was stamped with a **No. 5** and requires the use of Tool ,908285 for an accurate measurement.

8- Position a **NEW** O-ring into the groove of the bearing housing. Install the bearing housing into the upper gear housing with all of the screws holes proper aligned.





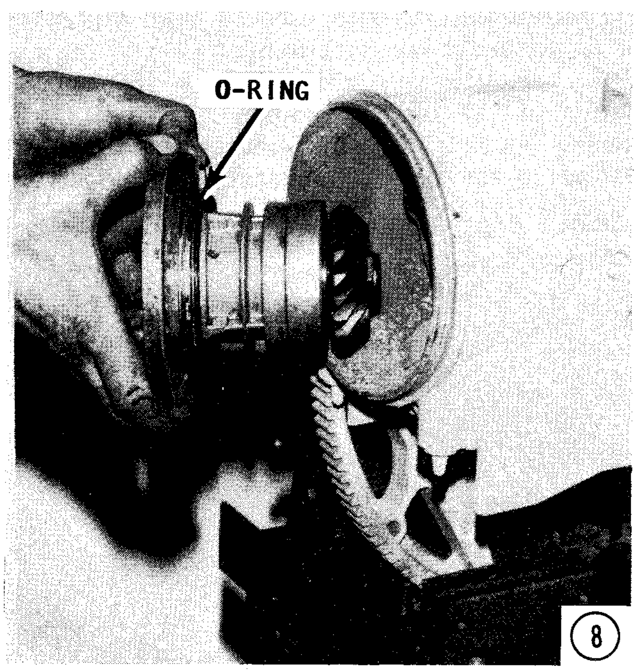
10-13 WATER PUMP ASSEMBLING MODELS 1964 THRU 1977

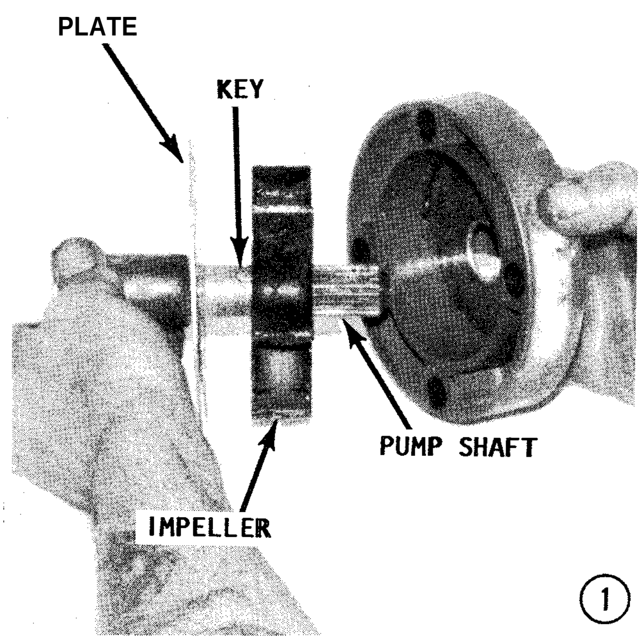
1- Slide the impeller plate onto the water pump shaft with the side stamped **PUMP SIDE** and **T** facing the impeller. Check to be sure the impeller wear surface is facing the externally splined end of the shaft. Install a **NEW** impeller key in the water pump driveshaft, and then a NEW impeller over the key. Apply a coating of Permatex No. 2 to the outer 1/4" of the upper and lower edges of the impeller plate to seal the impeller plate to the impeller and to the swivel housing. If Permatex is not used, the pump may pull exhaust gases into the pump cavity. Slide the impeller housing onto the shaft, and then turn the shaft clockwise until the impeller seats inside the housing. Rotate the impeller plate until the screw holes align with the holes in the impeller housing.

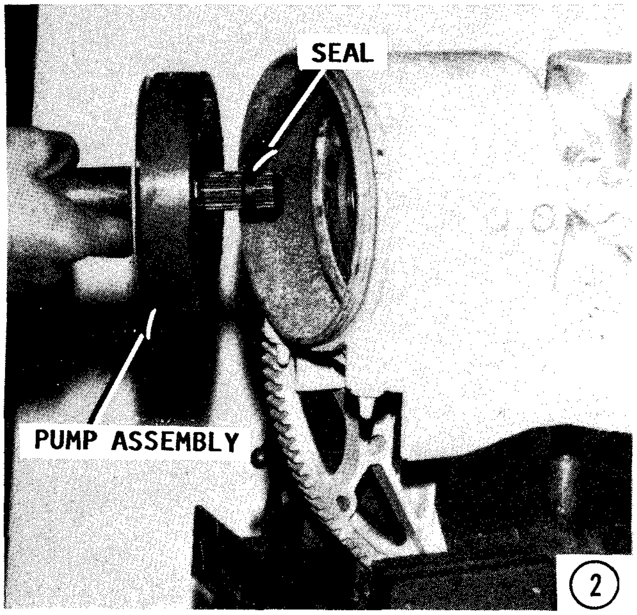
2- Use 3M Sealer EC1300 as an adhesive and install a new split seal onto the driveshaft. Lubricate the seal and external shaft splines with gear oil. Install the assembled water pump into the bottom of the bearing housing. **CHECK TO BE SURE** the splines of the two shafts are properly engaged and the mounting holes of the bearing housing and water pump are aligned with those in the upper gearcase.

3- Install the swivel housing onto the water pump. Coat the threads of the attaching screws with Permatex No. 2, and then secure the bearing housing, water pump, and-swivel housing with the screws and lockwashers. Tighten the screws **ALTERNATELY AND JUST A LITTLE AT A TIME** to avoid damaging the shims in the bearing housing. Tighten the screws to a torque value of 30-36 ft-lbs. Install a **NEW** O-ring seal into the groove inside the lower end of the water pump shaft. Apply a coating of OMC Sea Lube Multi-Purpose Grease to the splines inside the lower end of the water pump shaft.

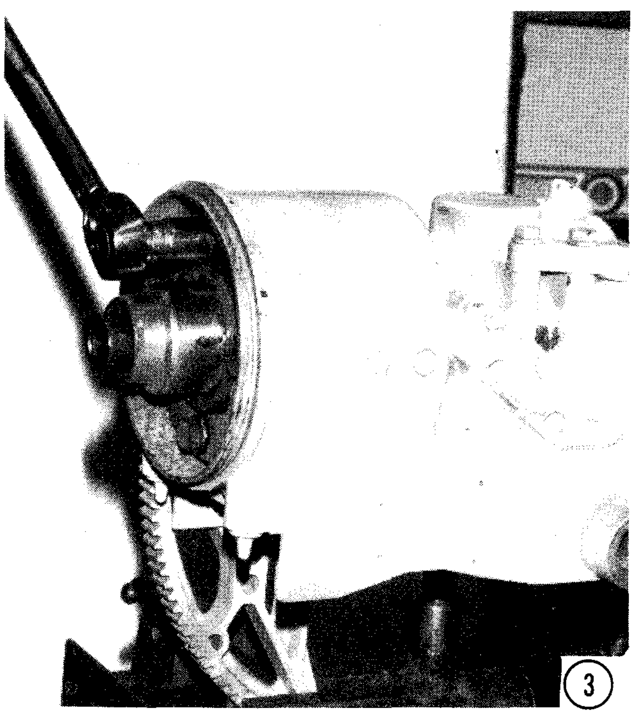
If this is the only work to be done, see Section 10-20 to install the upper gear housing into the lower unit and Section 10-21 to install the stern drive to the intermediate housing. If the lower unit is to be serviced, set the upper gear housing assemb-







ly to one side until the lower unit work has been completed. The swivel housing is an important part of the water pump installation. In order to perform a complete water pump repair, it is necessary to continue with removal of the exhaust housing and the swivel housing to replace the swivel housing seals.



10-14 EXHAUST HOUSING REMOVAL MODELS 1964 THRU 1977

The stern drive must be removed, see Section 10-5; and the upper gear housing removed, see Section 10-6 before the exhaust housing can be removed. The following procedures pickup the work after the upper gear housing has been removed.

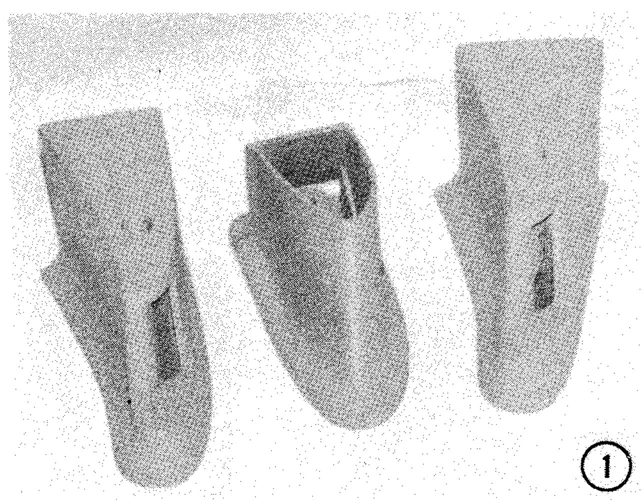
1- Remove the 9/16" bolt at the rear of the rudder and on top of the gearcase, then remove the rudder. Three types of rudders are used in the 1964-75 lower units as shown in the accompanying illustration. Kits are available to allow a change-over from one type of rudder and plate to another.

2- Remove the rudder plate by removing the screw -on the bottom side of the lower unit just above the propeller shaft, as shown.

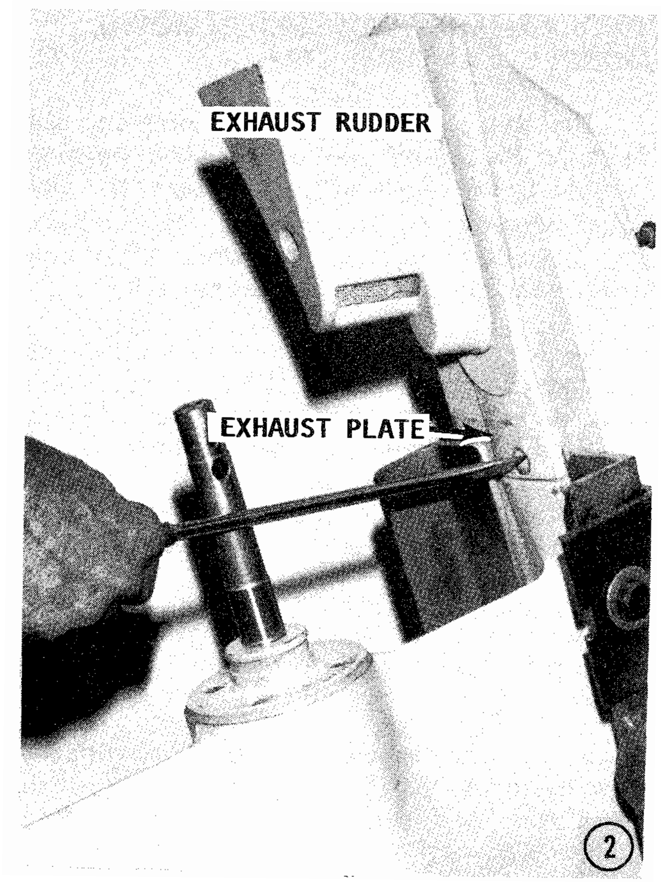
3- Seven screws secure the exhaust housing in place. Support the housing with one hand, and remove the screw located inside the cavity at the bottom of the cavitation plate.

4- Remove the remaining six exhaust housing attaching screws and lockwashers.

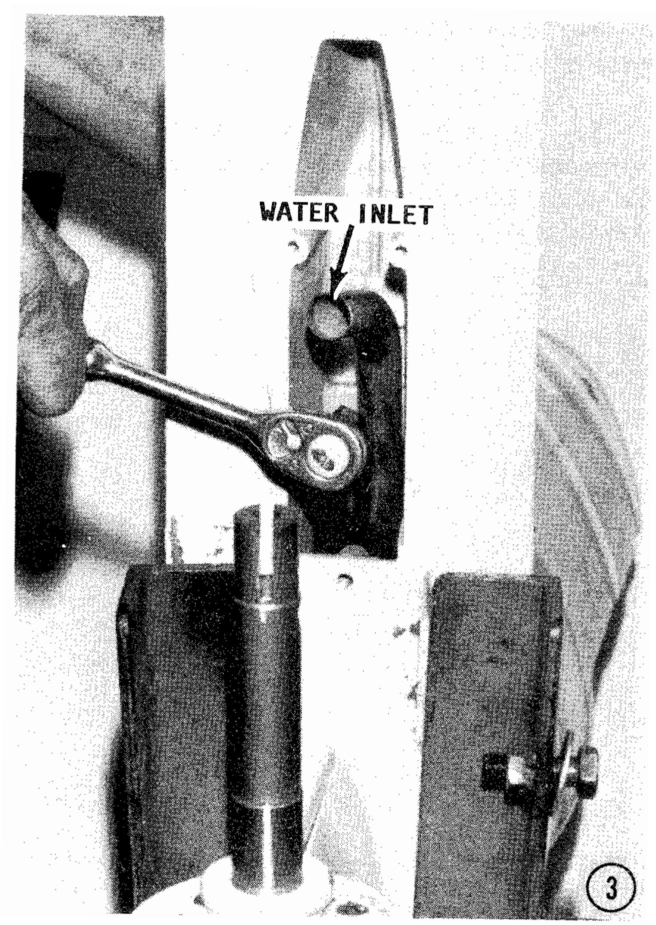
5- Apply a liberal amount of lubricant onto the shift wire, and then remove the exhaust housing and at the same time pull the shift wire out of the housing.



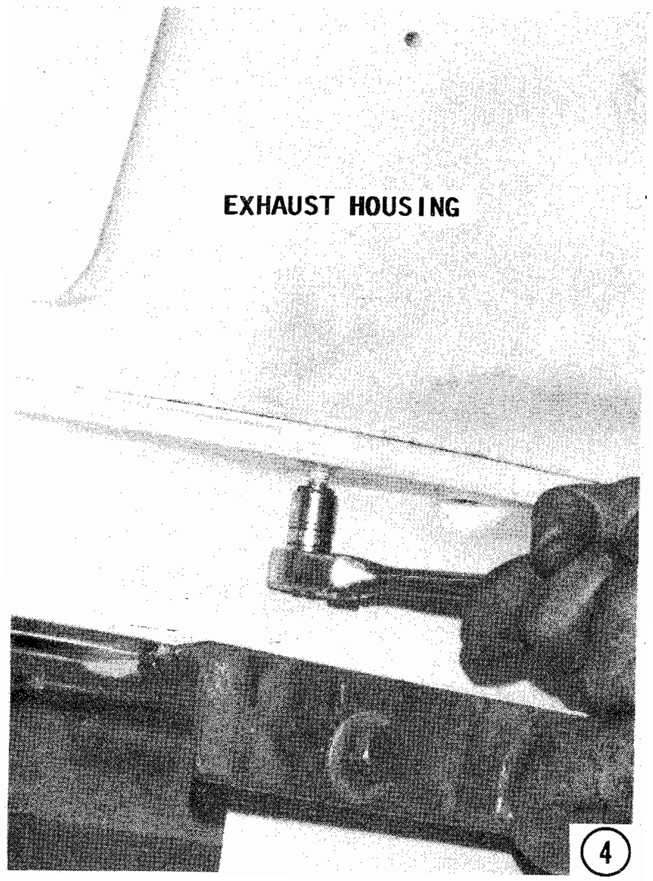
Exhaust rudders used on the lower unit: rudders 1964-66 (left), 1966-72 (right), and 1972-79 (center). Rudder plates are NOT interchangeable.


EXHAUST RUDDER
EXHAUST PLATE

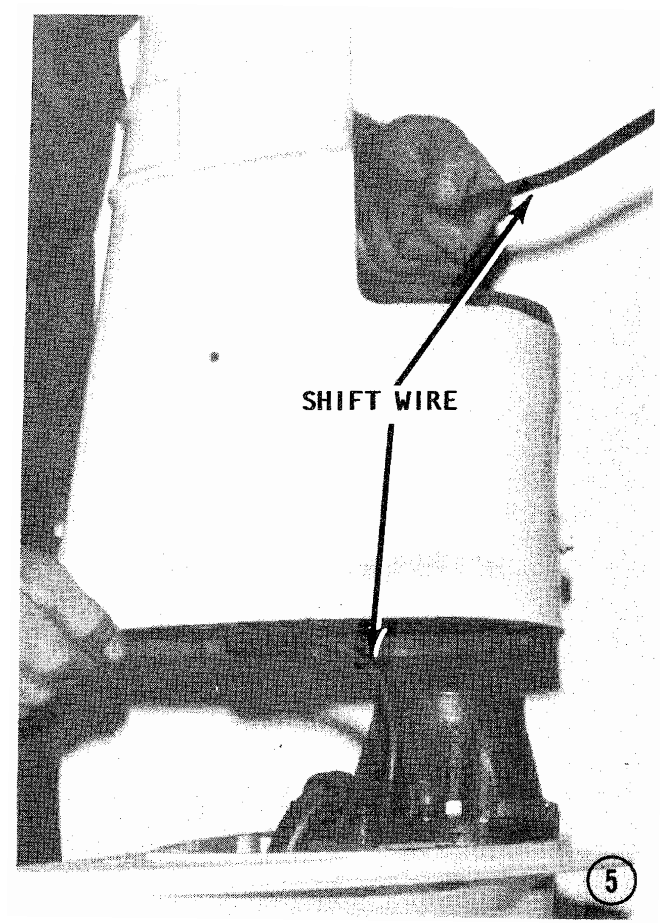
2


WATER INLET

3


EXHAUST HOUSING

4


SHIFT WIRE

5

10-15 SWIVEL HOUSING REMOVAL MODELS 1964 THRU 1977

Before the swivel housing can be removed, the following work must be performed.

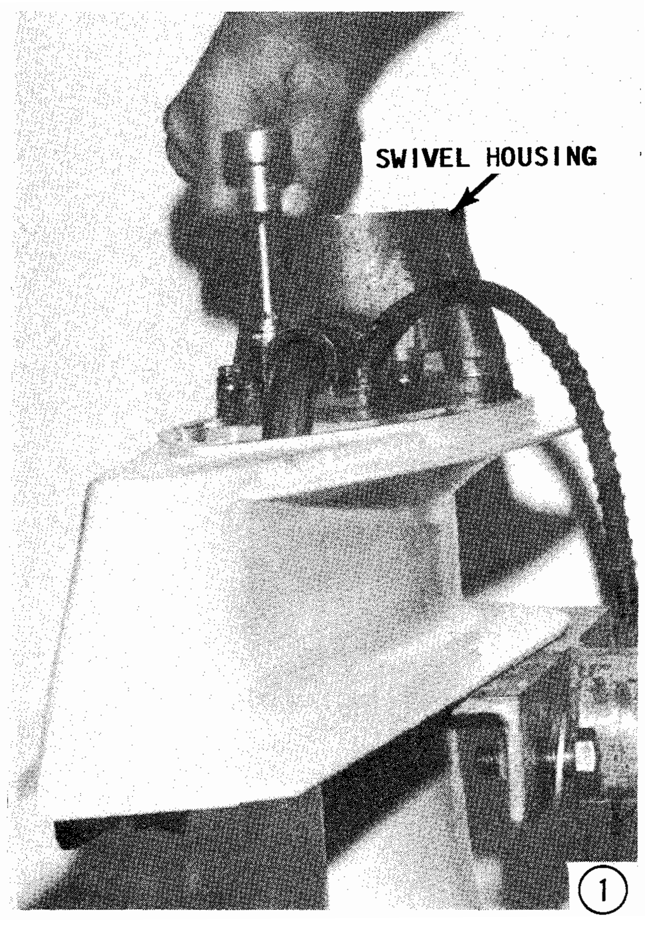
Remove the stern drive: Section 10-5

Remove the upper gear housing; section 10-6.

Remove the exhaust housing; section 10-14.

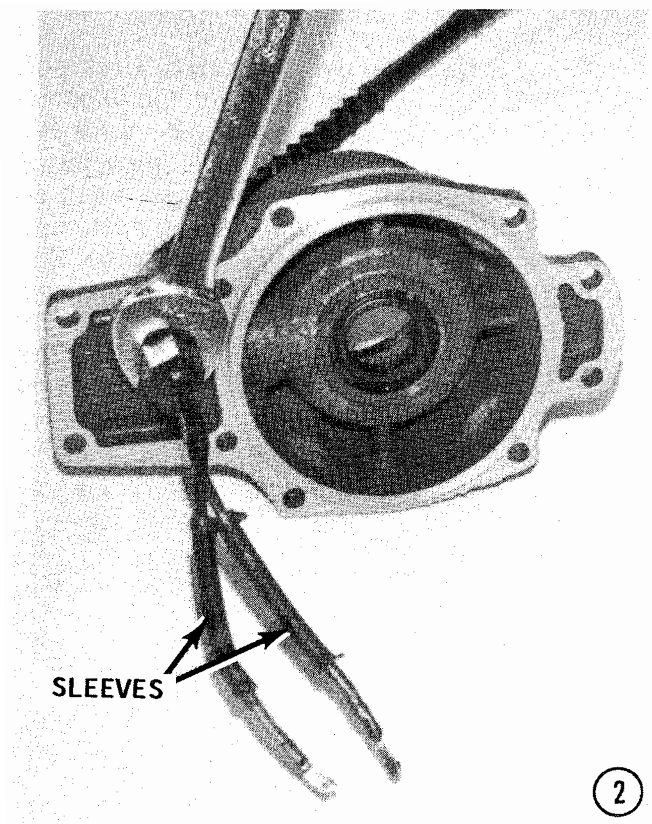
The following procedures pickup the work after the upper gear housing has been removed. **A GOOD WORD BEFORE STARTING:** Replacement of the swivel housing seals is not the easiest of tasks, expecially if the proper tools are not available. However, a complete new swivel housing can be purchased with new seals installed at moderate cost from your local OMC dealer. You may want to consider this route before disassembling the swivel housing.

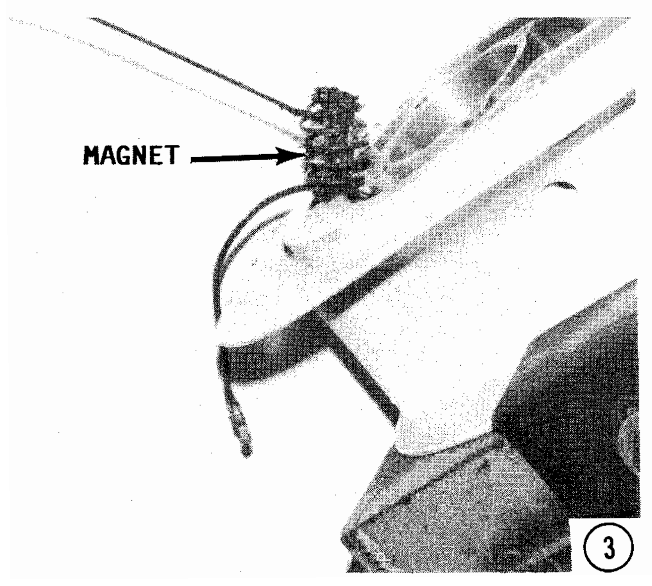
1- Remove the eight screws, ten screws on some models, securing the swivel bearing assembly to the lower unit. **SLOWLY** lift the assembly off the gearcase and **TAKE CARE** not to damage the shift cables. Slide the insulating tubings off the shift cable connectors and separate them. Remove and **DISCARD** the gasket.



2- It is not necessary to remove the cable tube or shift cable unless the cable is burned or shorted. Use an 11/16" wrench to remove the tube through which the cable passes. Check the seals in the swivel and replace them if they are damaged.

3- Metal particles are trapped from the oil in the lower gearcase by two magnet-and-spring assemblies. These assemblies can be removed with a piece of wire if one end is bent to form a hook.



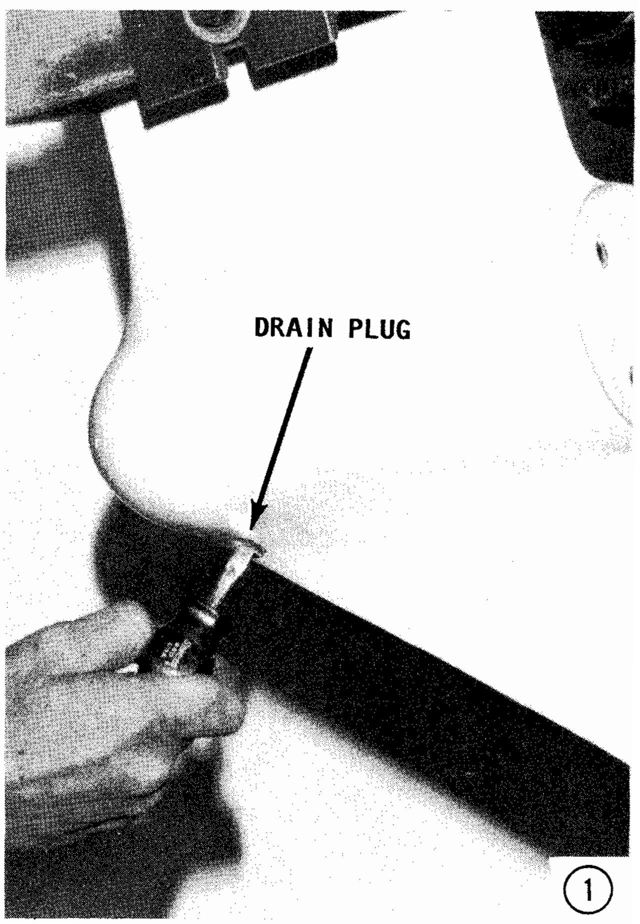


10-16 LOWER UNIT REMOVAL MODELS 1964 THRU 1977

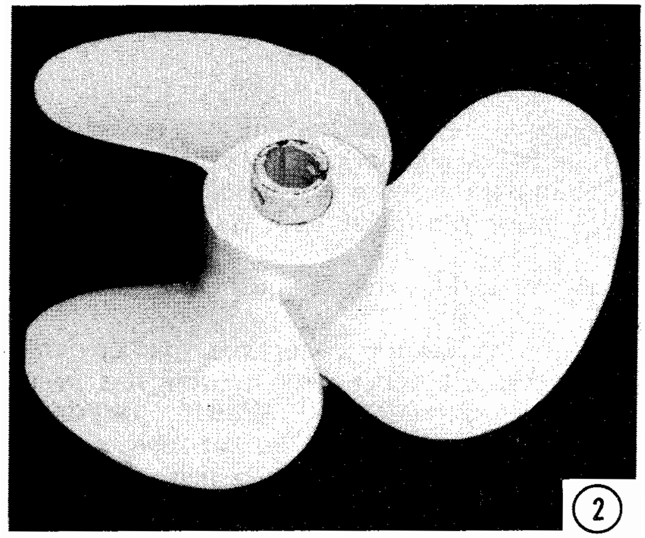
The stern drive must be removed, see Section 10-5; the upper gear housing removed, see Section 10-6; the exhaust housing removed, see Section 10-14; and the swivel housing removed, see Section 10-15, before the lower unit can be serviced. The following procedures pick up the work after the swivel housing has been removed.

1- Remove the plugs marked **OIL DRAIN** and **OIL LEVEL** or **VENT;** tilt the unit slightly and allow the oil in the lower unit to drain completely.

2- To remove the propeller, first pull the cotter key, and then remove the propeller nut, drive pin, and washer. Because the drive pin is not a tight fit, the propeller is able to move on the pin and cause burrs on the hole. These burrs may make removing the propeller difficult. To overcome this problem, the propeller hub has two grooves running the full length of the hub. Hold the shaft' from turning, and then rotate the propeller 1/4 turn to position the grooves over the drive pin holes and the propeller can then be pulled straight off the shaft.



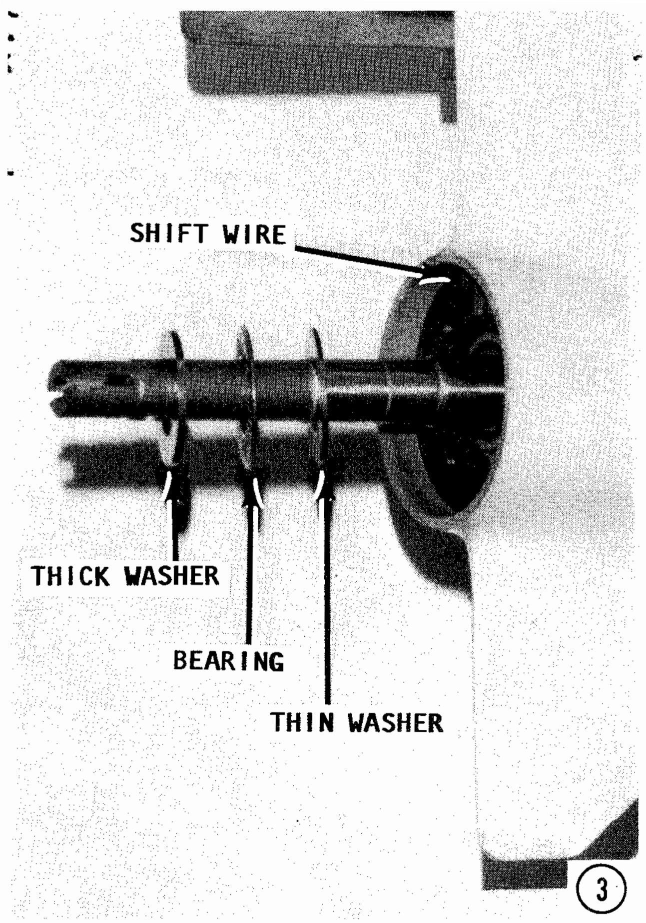
1



2

After the propeller has been removed, file the drive pin holes on both sides of the shaft to remove the burrs.

3- Remove the four screws securing the gearcase head to the lower unit, and then slide the gearcase head off the propeller shaft. Observe the reverse coil wire at the top of the coil. **DO NOT** remove the coil at this time. On early models, remove the two thrusts washers and the thrust bearing from the shaft. On later models, remove the



3

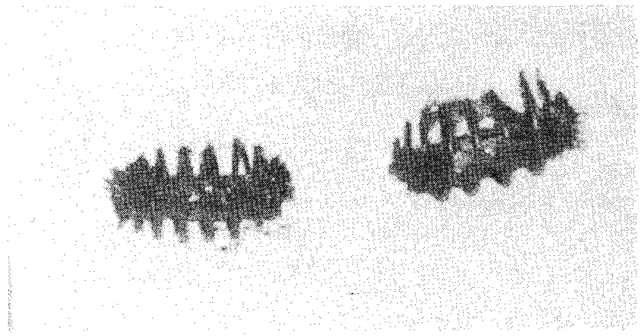
shims. **BEAR** IN **MIND** the order of the shims, washers, and the bearing as an aid to installation. Notice the difference in the washer thickness. The thinner washer must be installed first against the reverse coil.

4- Remove the Truarc ring securing the reverse coil in place. **CAREFULLY** pull the reverse coil lead down and out the hole prior to removing the reverse coil in the next step.

5- Grasp the propeller shaft firmly, and then jerk hard to pull the propeller shaft, reverse coil, and reverse drive gear out as an assembly. **ONE WORD:** On early model lower units, the shaft has a cam. In order to remove the shaft, the high side of the cam must be **DOWNWARD** to prevent damaging the oil pump in the bottom of the lower unit when the shaft is removed.

6- A pinion gear and locknut hold the driveshaft in the gearcase. Hold the nut with a 1-1/16" wrench and at the same time, use a torque bar and special tool No. 311875 to turn the driveshaft. **DISCARD** the locknut after it is free because its locking ability is ruined once the nut has been removed. Remove the pinion gear.

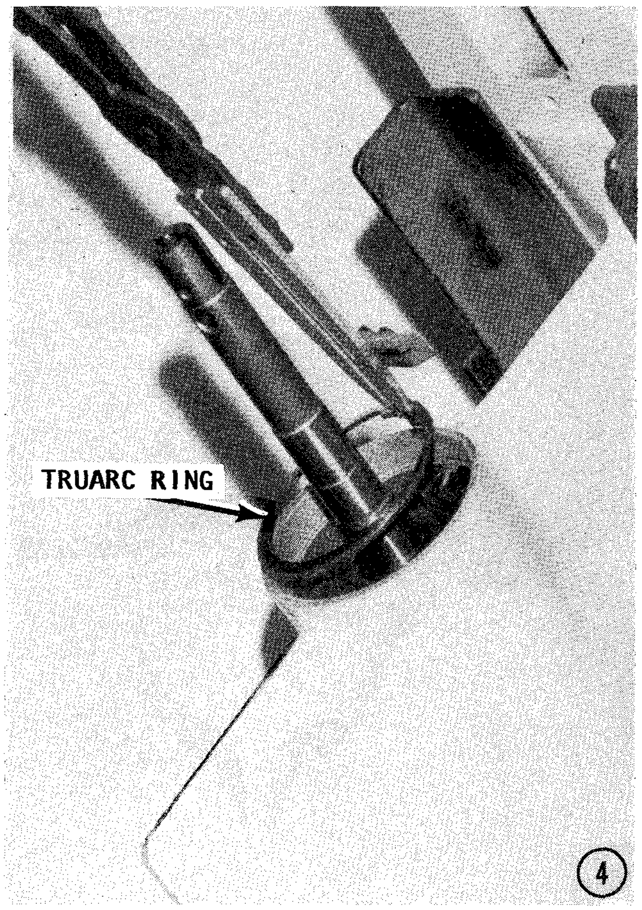
7- Remove the four bearing plate attaching screws, and then lift the plate from the top of the lower gearcase.

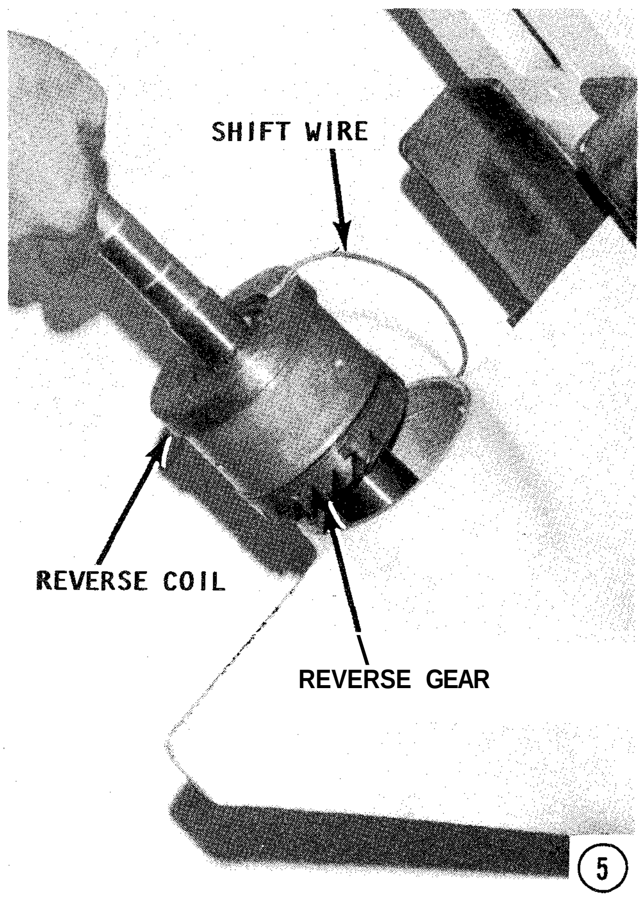


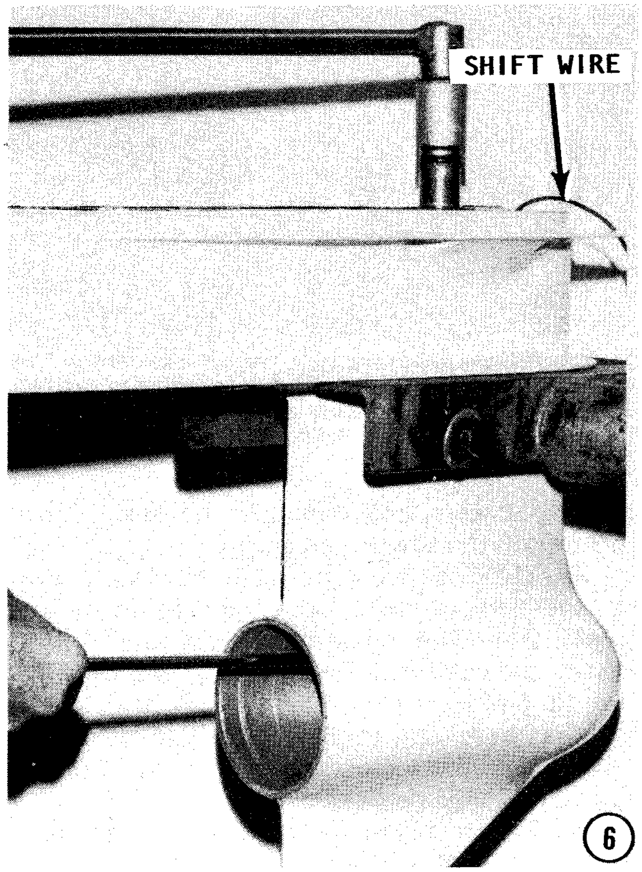
Iron fillings attracted to a magnet installed in the lower unit to prevent them from circulating in the oil. The amount of fillings shown is excessive and may have been caused by improper shimming or by lack of adequate lubrication.

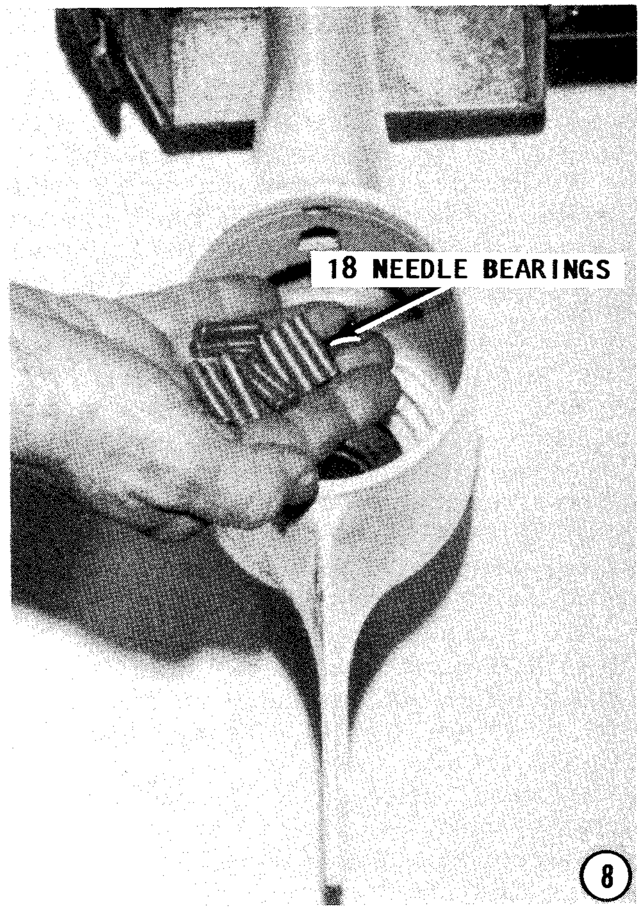
8- CAREFULLY lift the driveshaft out of the lower unit, and then remove the shims from- the bottom side of the driveshaft. Reach inside the housing and remove the 18 pinion roller bearings. If the lower unit has been operated when the level of the gear oil is low, the upper bearing on the driveshaft will be destroyed.

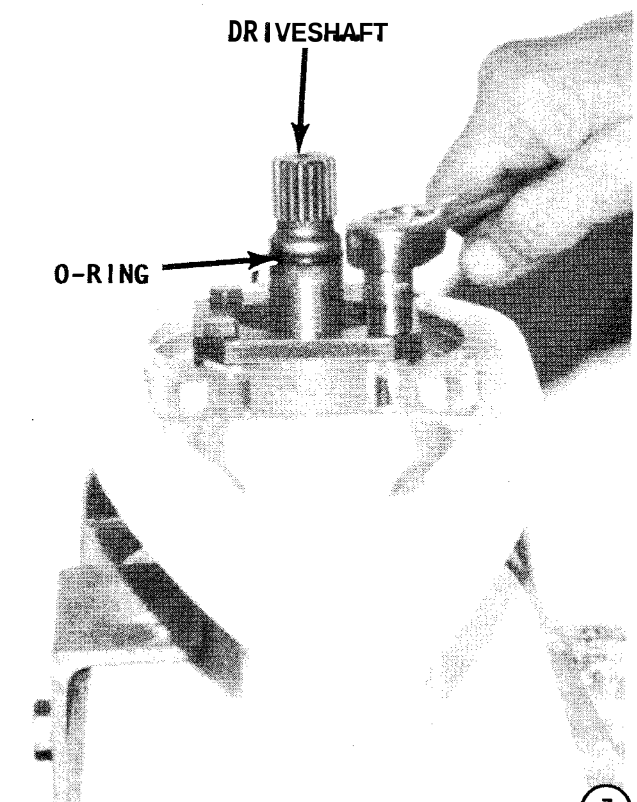
9- Reach inside the housing; insert two fingers into the center of the forward gear assembly; and then withdraw the assembly.

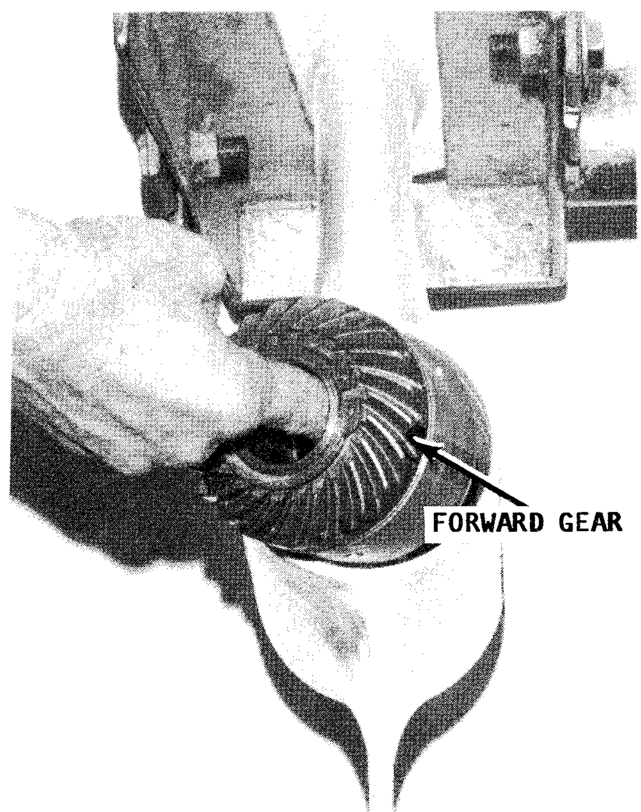





SHIFT WIRE
6


18 NEEDLE BEARINGS
8


DRIVESHAFT
O-RING
7


FORWARD GEAR
9

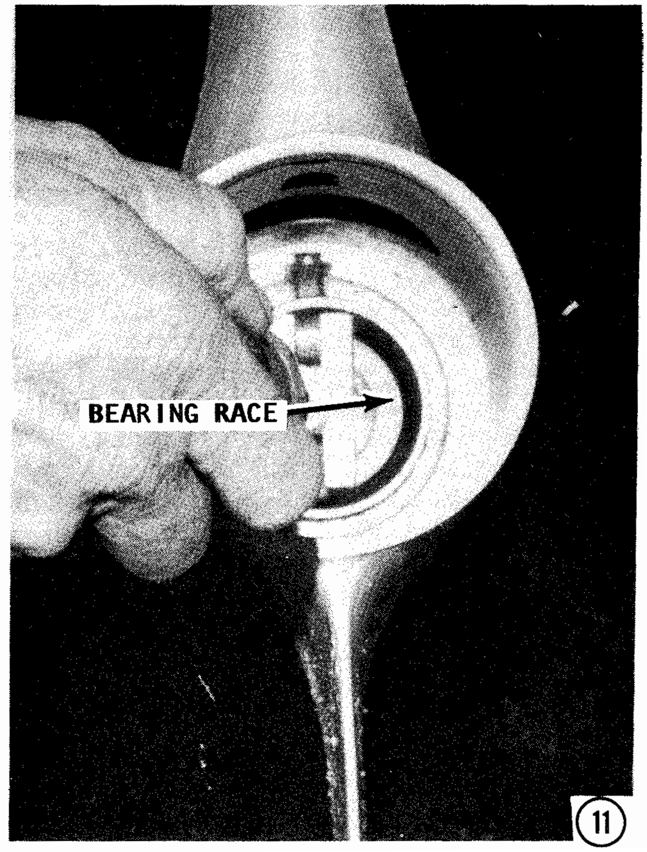
10- Remove the forward shift wire clamp on top of the housing. Use Slide Hammer No. *380658* to remove the forward coil and wire lead. **TAKE CARE** to pull the coil out evenly to prevent it from binding in the housing.

11- Use special tool No. *380657* and a slide hammer to remove the forward bearing cup from the lower gearcase. Shims are installed at the front of the gearcase to position the forward gear assembly properly. If the shims appear damaged, they **MUST** be replaced. If they are not damaged, keep them with the forward bearing cup.

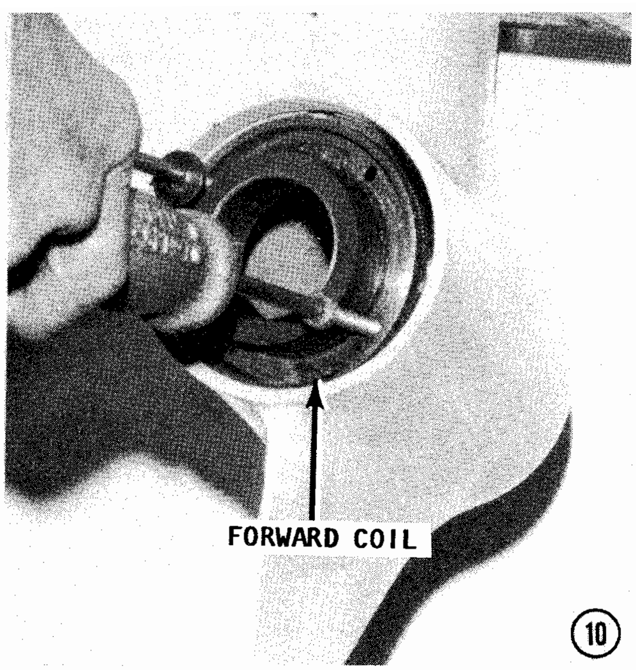
12- Remove the forward gear using a pair sf Truarc retaining ring pliers to remove the ring securing the gear to the hub.

1 3 Lift the hub from the drive gear-and-spring assembly. Slide the sleeve from the clutch spring.

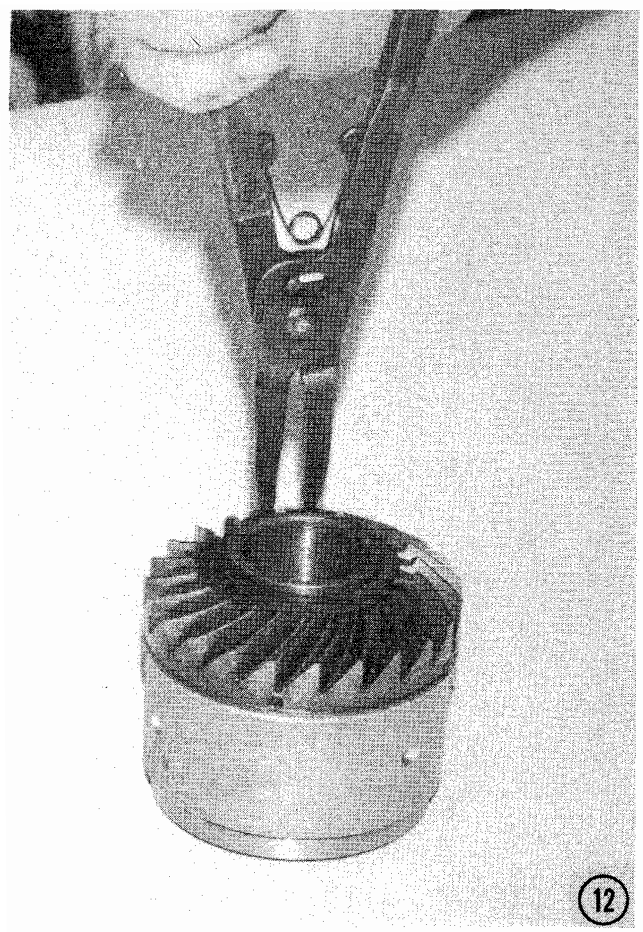
14- Remove and **DISCARD** the three Allen setsrews securing the clutch spring to the forward drive gear. Remove the spring from the gear. Remove the nylon spacer installed to keep the spring straight. If either the gear or the bushing is damaged, they must both be replaced as a set, **NEVER** just one item. To remove the reverse drive gear asembly, follow the same procedure as was used for the forward hub assembly. Forty (40) needle bearings are used on the reverse clutch hub. The forward hub has a bronze bearing. **NEVER** interchange these bearings.



11



10



12

CLEANING AND INSPECTING

Clean the parts with solvent and blow them dry with compressed air. Remove all seal and gasket material from mating surfaces. Blow all water and oil passages, and screw holes clean with air.

After the parts are clean and dry, apply a coating of light engine oil to the bearings and bright mating surfaces of the shafts and gears as a prevention against corrosion.

Inspect the shaft bearing surfaces, splines, and keyways for wear and burrs. Check for evidence of an inner bearing race turning on the shaft. Check for damaged threads. Measure the runout on all shafts to reveal any bent condition. If necessary, turn the shaft in a lathe as a check for out-of-round.

Carefully check the inside and outside surfaces of the gearcases, housing, and covers for cracks. Pay special attention to the areas around screw and shaft holes. Verify all traces of old gasket material has been removed from mating surfaces. Check O-ring grooves for sharp edges which could cut a new seal. Inspect gear teeth and shaft holes for wear and burrs. Hold the center race of each bearing and turn the outer race to be sure it turns freely without any evidence of rough spots or binding. Inspect the rollers and balls for any sign of pits or flat spots.

Inspect the outside diameter of the outer races and the inside diameter of the inner races for evidence of turning in the housing or on the shaft. Any sign of discoloration or scores is evidence of overheating.

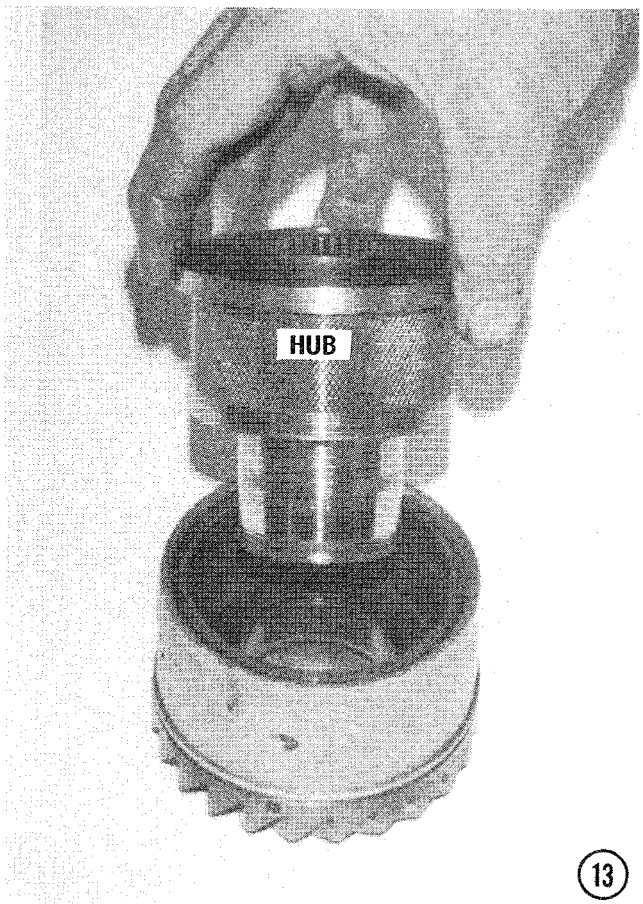
Check the thrust washers for wear and distortion. If they do not have uniform thickness and lay flat, they **MUST** be replaced.

Thoroughly clean the magnets of any metallic particles or chips.

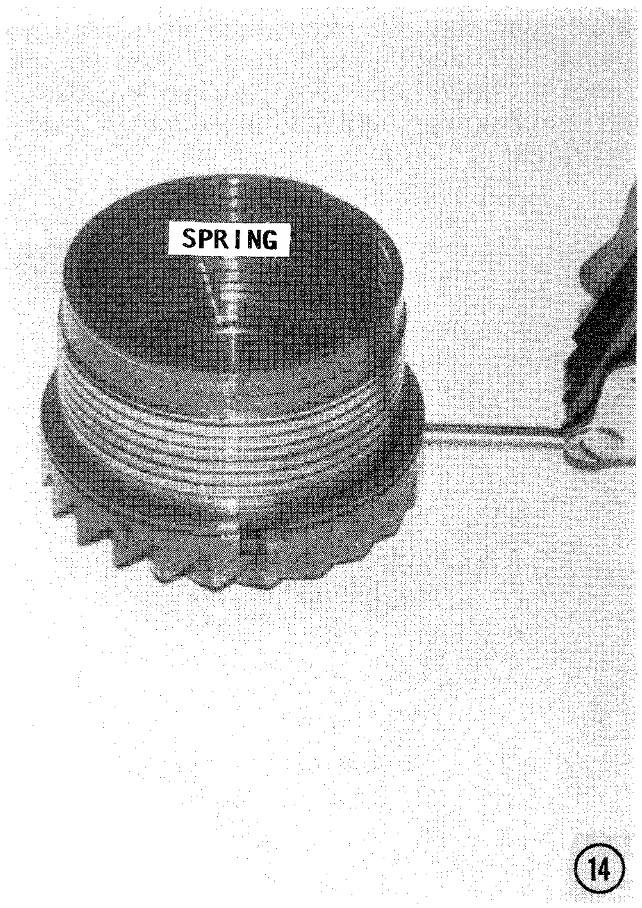
Inspect all of the springs for tension, distortion, corrosion or discoloration.

Inspect the shift cables for broken leads or damaged insulation. Use an ohmmeter and test for continuity. Use the ohmmeter to test the coil resistance which should indicate 4.5 to 6.5 ohms. Check the coil leads for breaks and damaged insulation.

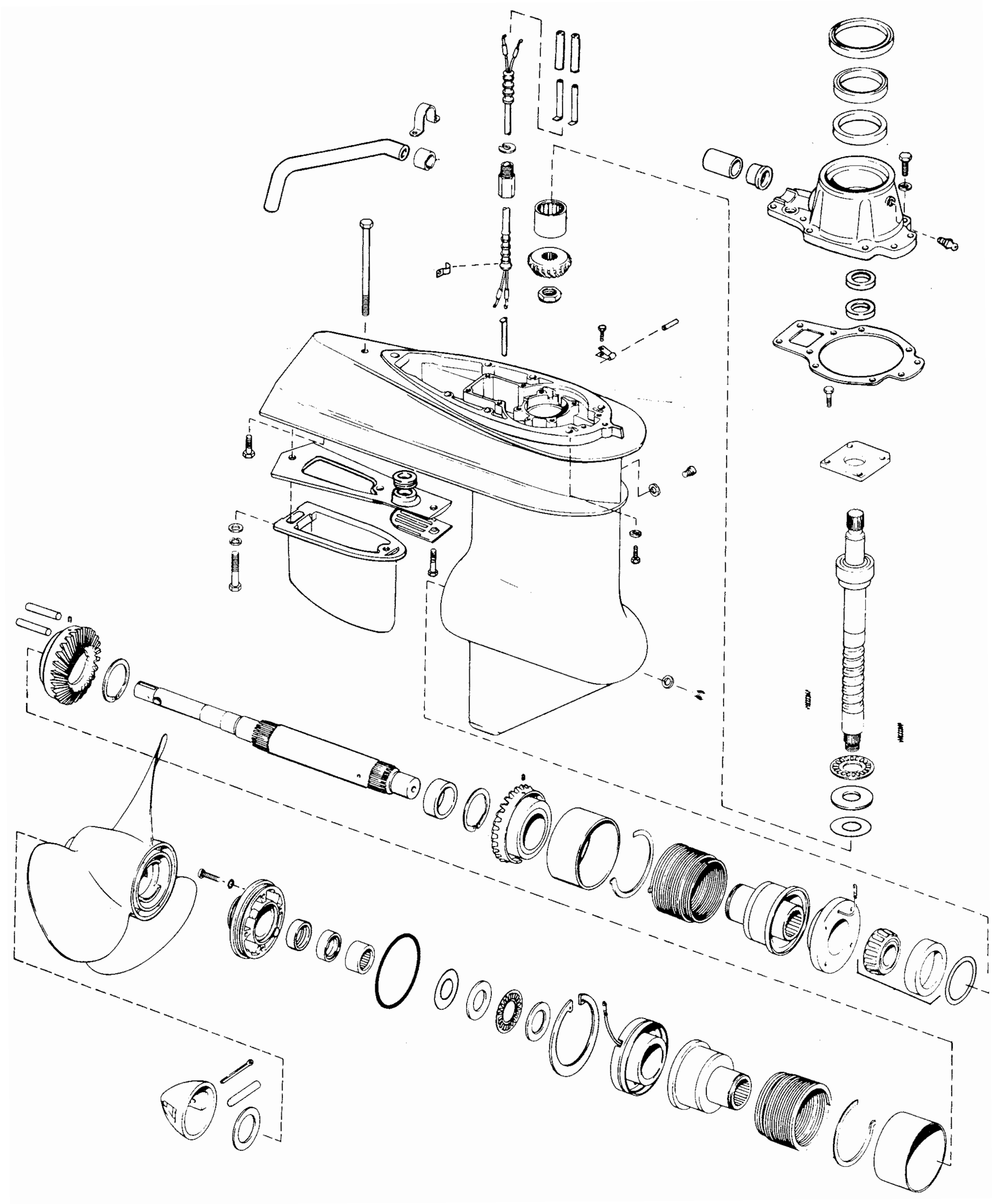
Clean and check the rudder and water intake screens. Check the water screen holes for evidence the screen is loose and has caused wear on the bottom.



13



14



Exploded view of the OMC 1967–77 stern drive.

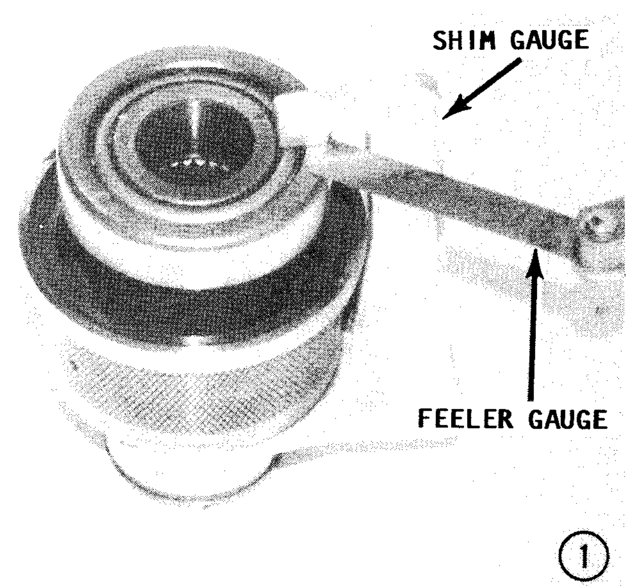
Inspect the propeller for cracks, gouged, bent, or broken blades. Replace all bent, worn, corroded, or damaged parts. Burrs can be removed with a file.

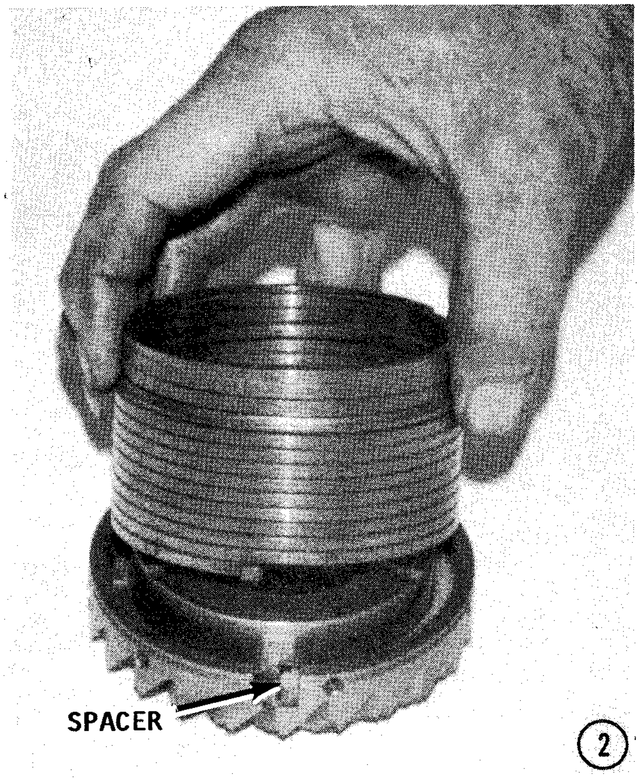
ALWAYS install **NEW** O-rings, gaskets, and seals during assembling and installation to prevent leaks.

10-17 LOWER UNIT ASSEMBLING MODELS 1964 THRU 1977

1- BEFORE the forward bearing cup can be installed, the required number of shims must be determined to locate the gear assembly properly. To make this measurement, first place the bearing and cup on the forward drive hub. The following shim determination measurement can only be taken when the clutch assembly is disassembled. The only part of the clutch assembly that is actually used when making the measurement, is the hub. Next, apply a rotating pressure to break the oil film. Now, use Gauge No. 314718 and a feeler gauge and measure the gap between the bearing cup and the shim gauge, as shown. The amount of measured gap equals the necessary shims required. **ONE WORD:** A minimum of one shim **MUST** be used, but no more than **TWO.**

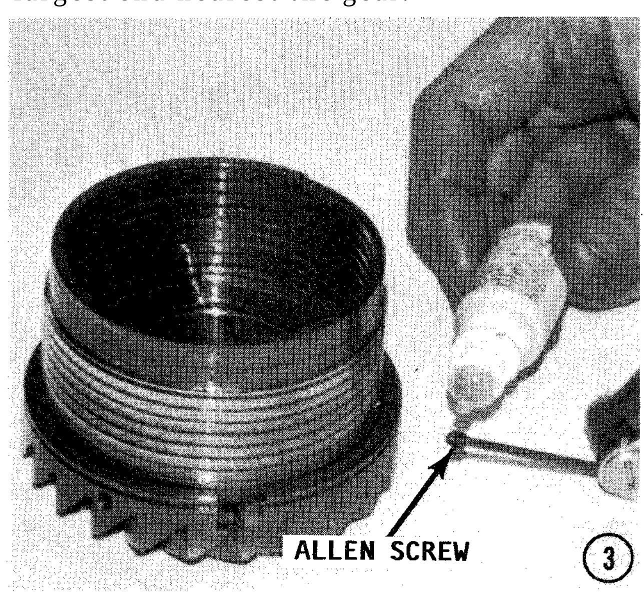
2- Insert the spacer, with its key, into the slot in the cupped end of the forward gear in such a way that it encircles the gear in the opposite direction to the normal winding of the spring coils. Place the spring in the gear with the spring key beside the spacer key. Now, shift both keys to the side of the slot against which they will pull.





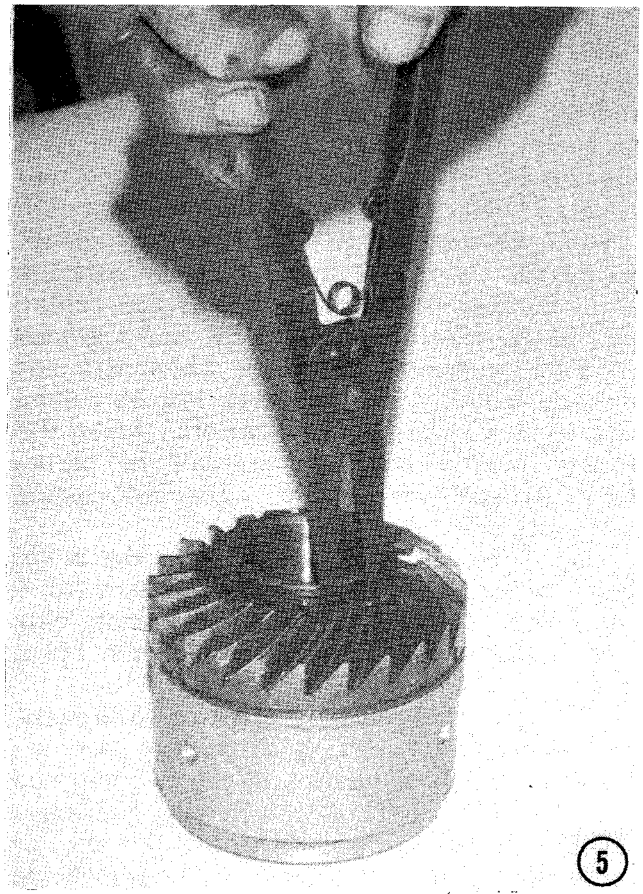
3- Coat three **NEW** setscrews with Loctite TL-242, and install them in the forward gear. Tighten the setscrews in rotation, to a torque value of 30-35 in-lbs., beginning with the one nearest the spring. Bake the assembly in a 300^{o} oven for 1/2 hour. If an oven is not available, apply Locquic Primer "T" to the screws before tightening them, and then allow them to cure for 4 hours.

4- NOTICE that one end of the sleeve has a larger opening than the other. Position the sleeve over the spring with the largest end nearest the gear.



5- The tolerance between the clutch hub and the bushing is very close. **CAREFULLY** slide the gear-and-spring assembly onto the hub. Install the Truarc snap ring with the chamfered (beveled) side of the retaining ring facing toward the gear. This arrangement places the square side of the Truarc ring in the groove of the hub.

6- Assemble the reverse gear by first installing the spacer into the cupped end of the reverse bevel gear, with its key in the slot of the bevel gear. The spacer **MUST** be positioned to encircle the cupped area in the opposite direction to the normal winding of the spring coil. Install the spring with the key indexed in the slot beside the spacer key. Slide both keys against the side of the slot they will pull against when reverse gear is selected. Coat three Allen-head cup-point setscrews with Loctite, and then install them to secure the spring to the bevel gear. Tighten the setscrews in rotation,to a torque value of 30-35 in-lbs., beginning with the one nearest the spring. Bake the assembly in a 300° oven for 1/2 hour. If an oven is not available, apply Locquic Primer "T" to the screws before tightening them, and then allow them to cure for 4 hours.



5

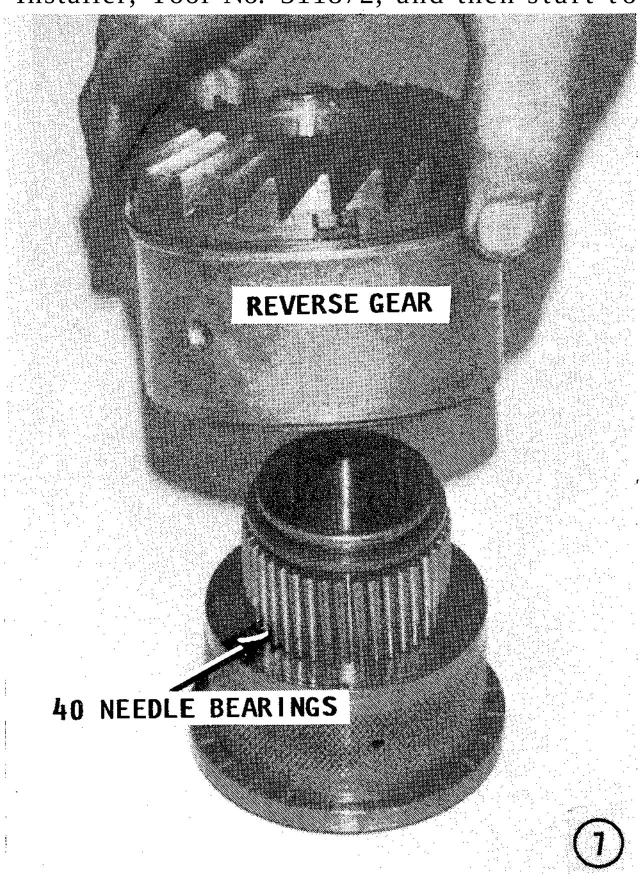
4

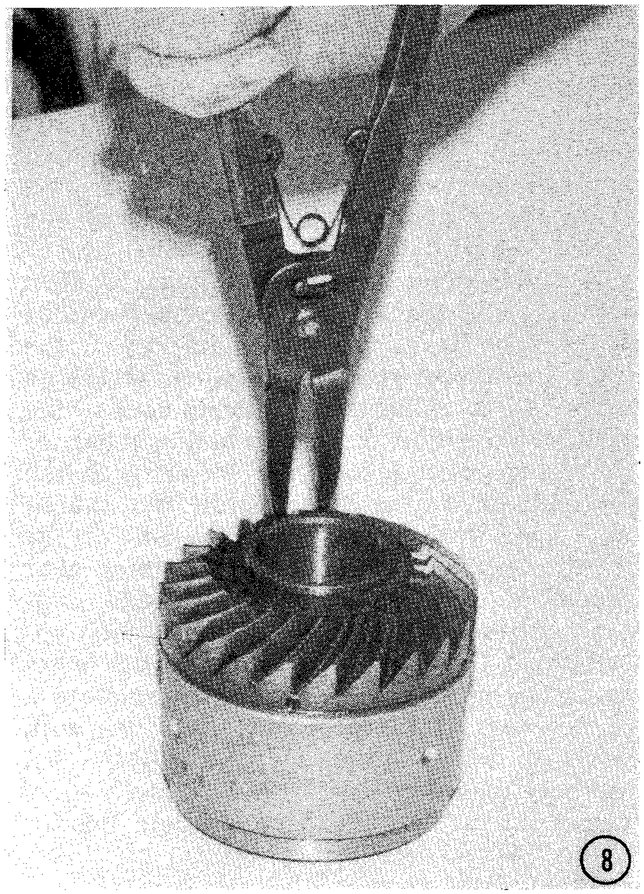
6

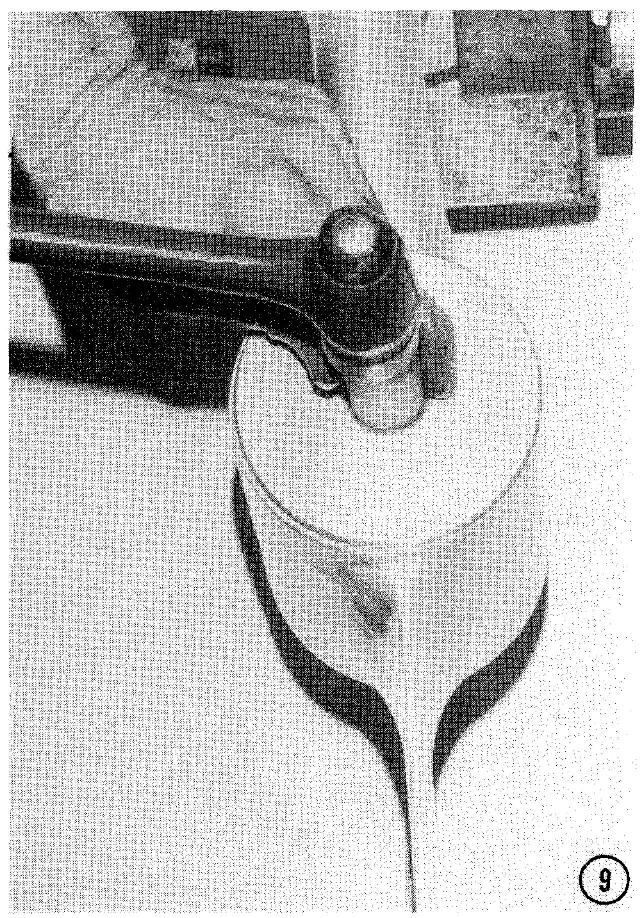
7- Slide the sleeve over the spring with the flanged end pointing away from the bevel gear. **TAKE NOTE** of the ring at the top of the reverse hub used to retain the forty needle bearings. This ring is the only visible difference between the forward and reverse hubs. Coat the needle bearings with grease or vaseline to hold them in place. **ALWAYS** count and take care to be sure the total number of needle bearings are replaced during installation. **NEVER** use a grease to hold the needles in place which will not dissolve quickly, or the parts will be ruined due to lack of initial lubrication. After the fourty needle bearings are all in place, **CAREFULLY** slide the gear-and-spring assembly down over the hub.

8- A Truarc snap ring secures the bevel gear to the hub. Use a pair of Truarc No. 6 snap-ring pliers to install this snap ring with the chamfered edge against the bevel gear.

9- Tilt the gearcase slightly to prevent the shims from shifting after they are installed. Place the shims in the bearing cup seat at the front of the lower gearcase. **CHECK** to be sure the shims are not bent or have shifted out of position. Attach Drive Handle, Tool No. 311880 to Bearing Cup Installer, Tool No. 311872, and then start to

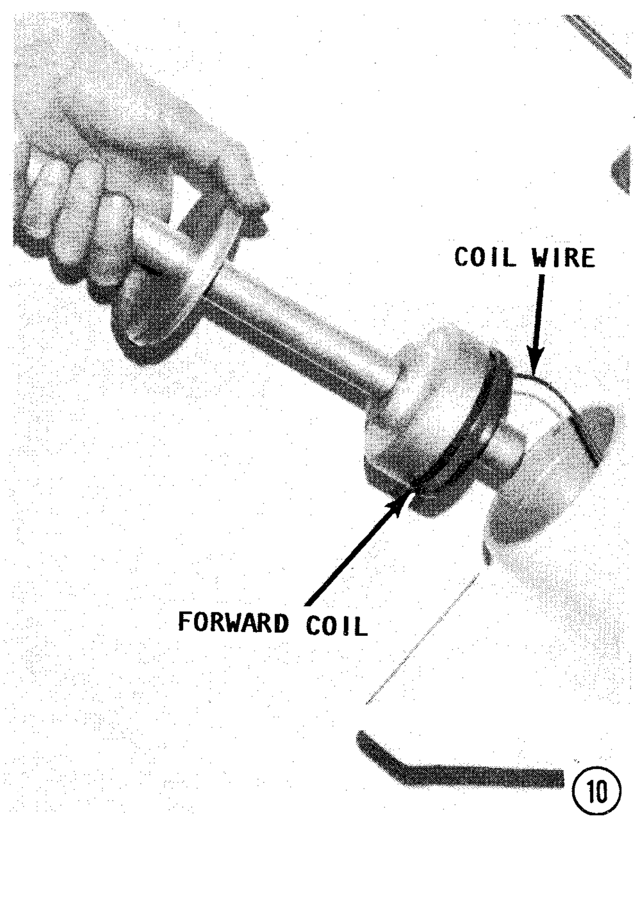


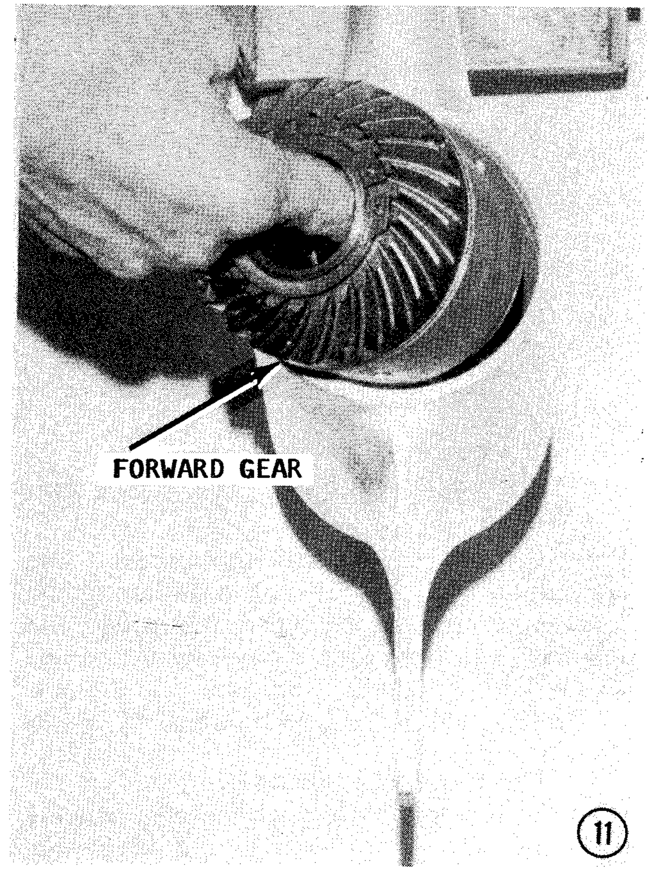




seat the cup at the front of the gearcase. Use **EXTRA CARE** not to move the bearing cup. After the cup is properly seated, install the forward bearing into the bearing cup.

10– **BEFORE COIL INSTALLATION:** Mark the front of the coil opposite the wire **ONLY WITH A LEAD PENCIL** to enable you to see the mark as the coil is installed into the rear of the housing. Mark a line to indicate the hole location in the gear housing. When the coil is properly installed, these marks **MUST** be aligned. Now, install the forward coil into the housing and at the same time feed the shift wire through the hole in the rear of the housing. As you push the coil inward, pull on the wire from inside the top of the lower unit. Next, align the mark you made on the coil with the mark on the housing. Insert the coil installer tool into the lower housing and into the coil. Press the forward coil inward and at the same time pull on the shift wire until the coil is fully seated in the housing. Remove the installer tool. After the coil is installed, use an ohmmeter to check to be sure the wire behind the coil is not shorted. The coil resistance should be 4.5 - 6.5 ohms. An infinite reading indicates an open circuit, such as a broken wire. A reading of less than 4.5 ohms indicates a short circuit,



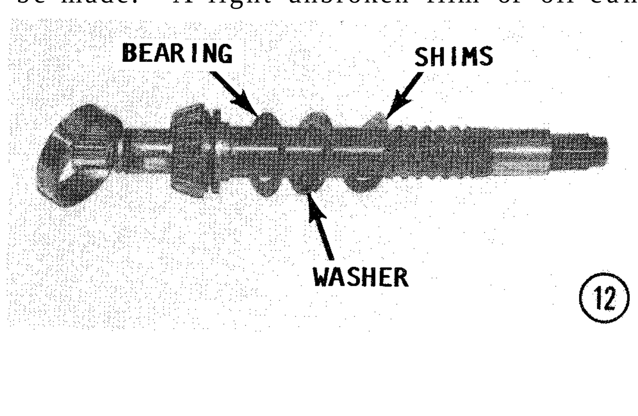


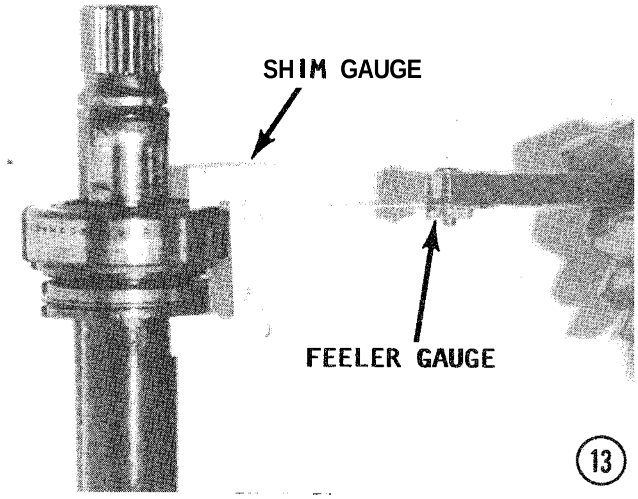
such as a bare wire making contact with the case. Replace the coil if the resistance is too high because the clutch will slip.

11– Place the forward gear assembly in the gearcase, as far forward as possible and with the gear towards the propeller.

12– Install the bearing, and cup onto the driveshaft. Support the side of the cup on two blocks of wood to allow the shaft to extend below the cup. Slide the thrust bearing and thrust washer over the driveshaft until they rest securely against the bottom of the thrust plate.

13– Position the shaft in the vertical position. Load the bearing and break the oil film by pushing down on the bearing and rotating it. The oil film **MUST** be broken before an accurate shim measurement can be made. A light unbroken film of oil can



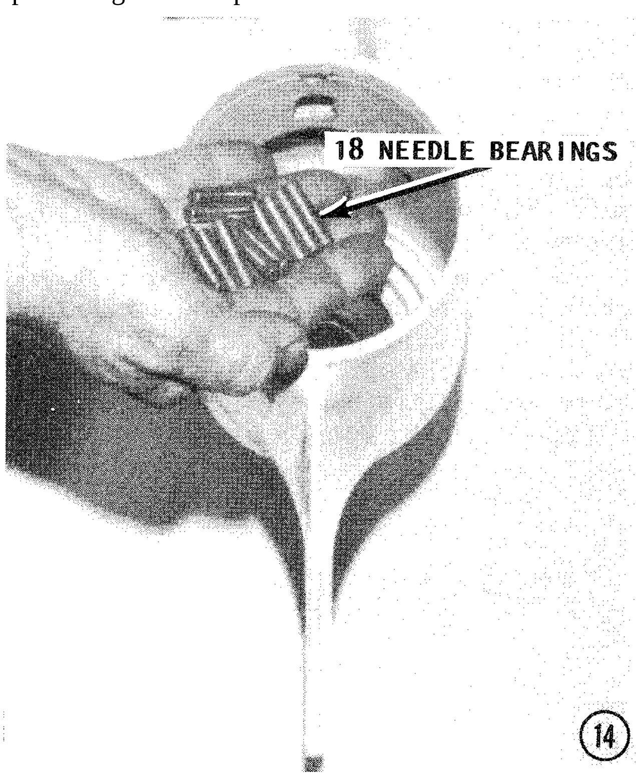


13

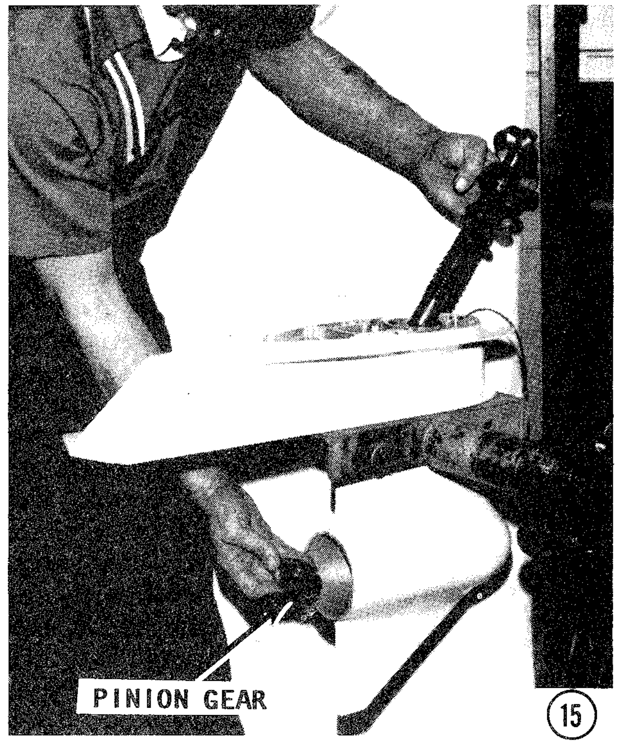
cause a error of several thousands. Use Shim Gauge No. 314720 and a feeler gauge to measure the gap between the gauge and the thrust washer. This measurement equals the amount of shims required. The Parts Catalogue lists the various sizes of shims availabe.

14– Coat the race at the bottom of the pinion driveshaft bore with needle bearing grease No. 378642. Install the 18 needle bearings and the grease will hold them in place.

15– Position the required number of shims, as determined from the measurement in step 12, onto the driveshaft. Hold the pinion gear in place inside the lower unit

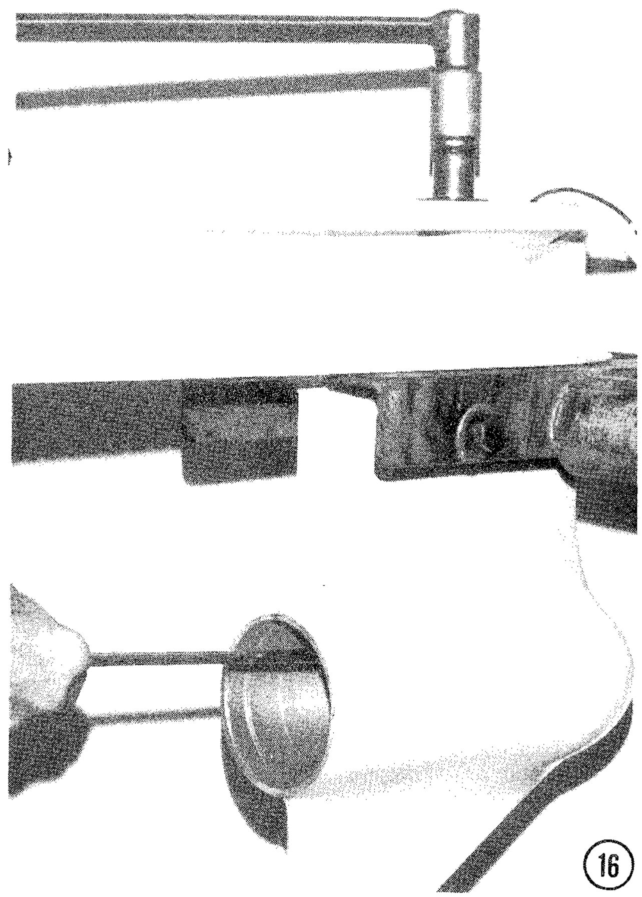


14



15

with one hand and with the other, install the driveshaft. TAKE CARE not to damage the shims as the drive shaft is lowered and engaged with the pinion gear.


16

16- Install a **NEW** locknut onto the end of the driveshaft finger-tight. **NEVER** use an old locknut because its locking ability is lost once it is removed. Tighten the locknut to a torque value of 70-80 ft-lbs using Driveshaft Holding Socket Tool No. 311875 and a 1-1/16" open-end wrench, as shown.

17- Slide the cup onto the driveshaft and over the the top of the lower gearcase bearing. Position the bearing plate over the driveshaft bearing cup. **A FEW WORDS:** Oil is pumped through the bearing directly beneath the plate and returned to the bottom of the lower gearcase. The channel cut into the bottom of the top bearing retaining plate MUST therefore be positioned on the port side of the gearcase to allow this oil to properly circulate. The four bearing plate retaining screws have lockwashers with external teeth. Now, check to be sure the retaining plate is properly positioned, and then use a 7/16" socket to tighten the screws to a torque value of 5-7 ft-lbs. Rotate the driveshaft and check the end play for 0.003". If there is not enough end play, check the shimming procedure outlined in Step 13.

18- Slide the propeller shaft gear assembly spacer onto the shaft until it is just past the two oil holes in the side of the shaft. Insert the shaft through the forward gear and coil into the bearing, with the propeller shaft spline engaged in the spline of the forward clutch hub. On early model units, check to be sure the cam is positioned over the oil pump.

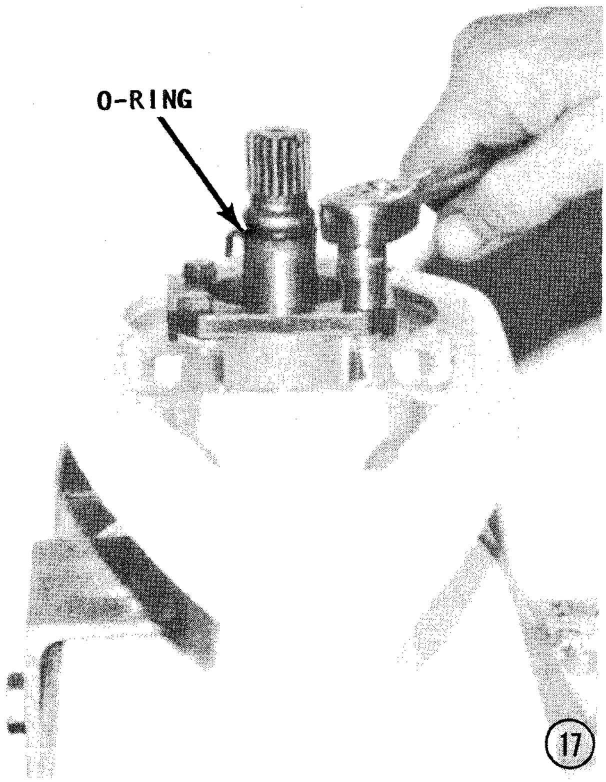
19- Place the reverse gear assembly over the propeller shaft with the gear teeth engaged with the teeth of the pinion gear.

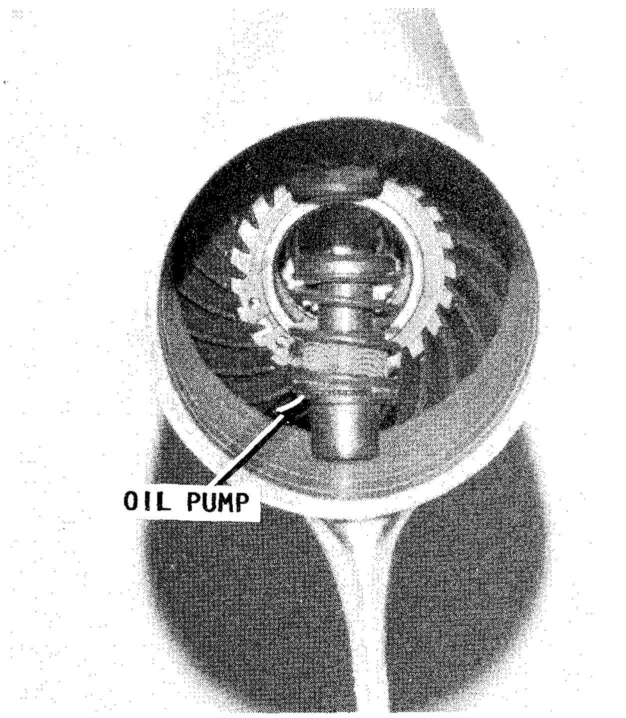
20- CAREFULLY slide the reverse coil over the propeller shaft and into the gearcase past the ring groove with the lead at the top. This lead MUST NOT be twisted or kinked as it leaves the coil.

21- Feed the lead through the hole, then reach into the cavity at the top rear of the gearcase, and pull the lead through.

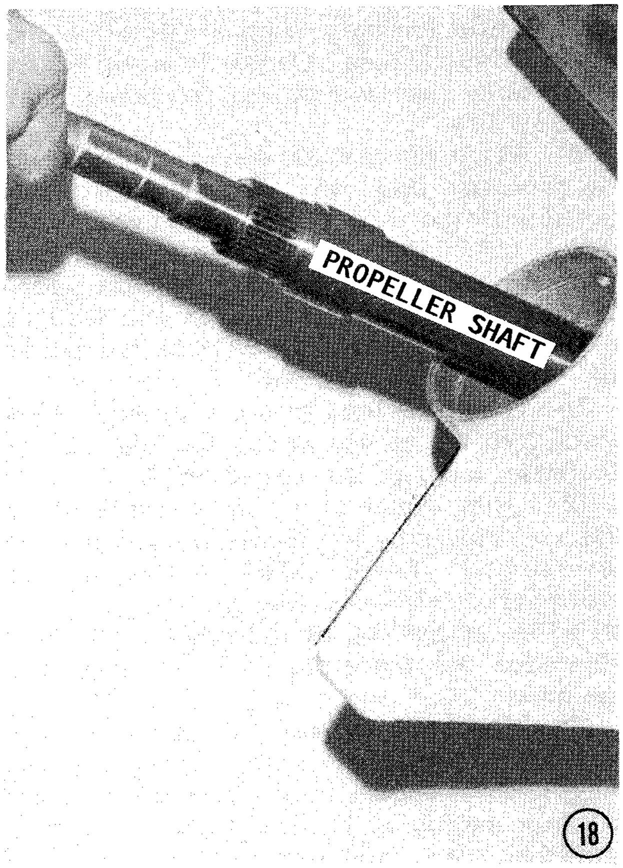
22- Using a pair of Truarc pliers, replace the snap ring into the recess and against the reverse coil. **TAKE CARE** not to damage the reverse coil wire. The snap ring opening **MUST** be at the top of the housing to allow clearnace for the shift wire to route into the hole.

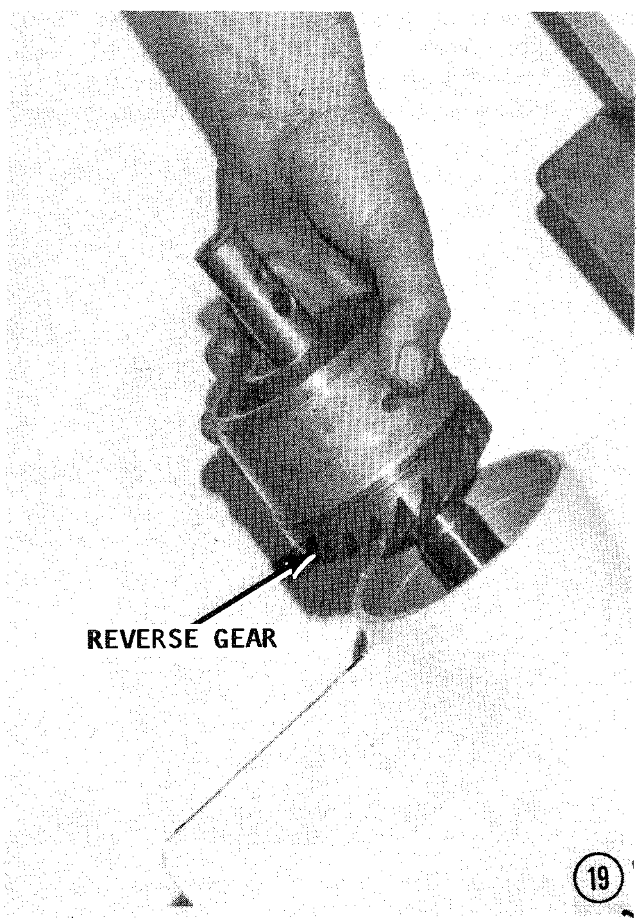
23- Check to be sure the coil and leads were not damaged during installation by making a resistance test. Set the ohmmeter selector switch to the LO OHMS position, and then zero the meter. Make contact with the black meter lead to a clean metal surface of the gearcase and with the red ohmmeter lead to the connector of the green forward coil lead. The meter reading must indicate 4.5-6.5 ohms. Conduct the

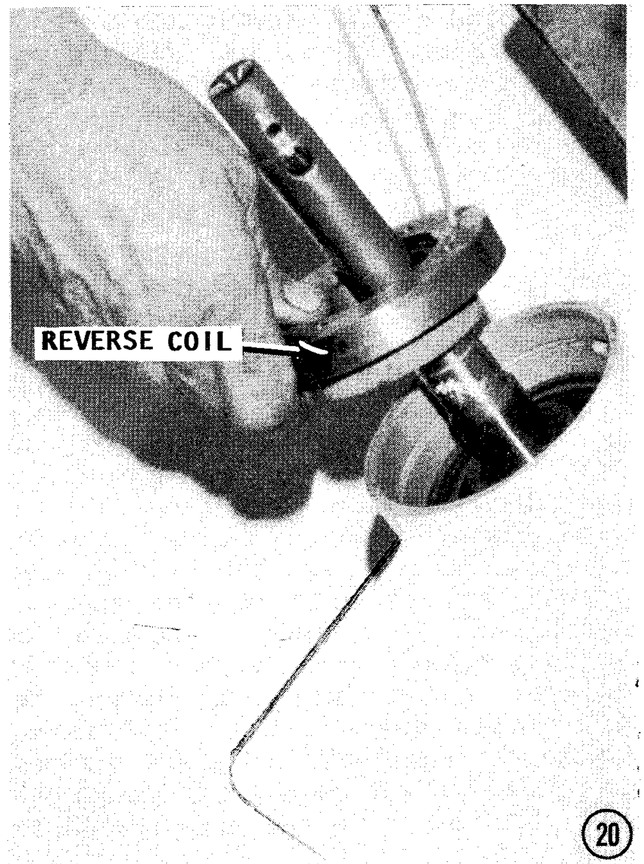




Oil pump installed in early model lower units to circulate oil to lubricate the upper driveshaft bearing.


PROPELLER SHAFT
18


REVERSE GEAR
19


REVERSE COIL
20

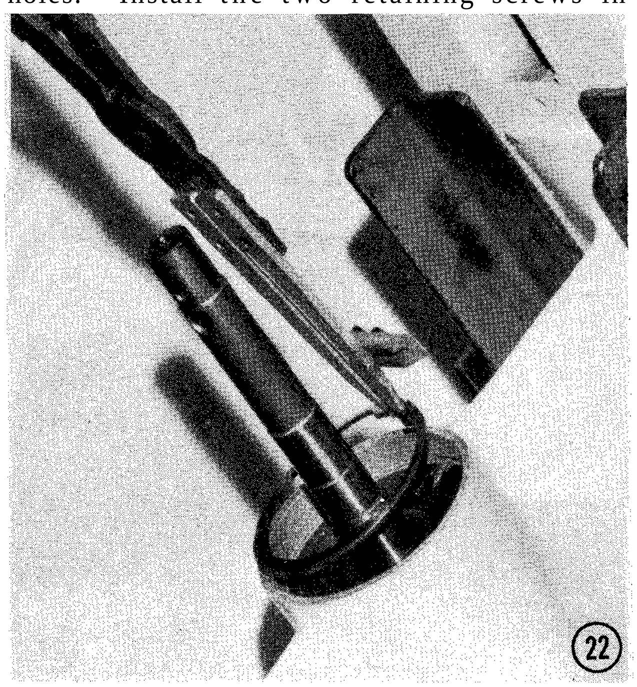

REVERSE COIL WIRE
21

same test on the reverse coil. If either coil is damaged, the unit must be repaired or replaced. Install the snap ring with the chamfered side facing in and the open part of the ring to the top to allow the reverse coil wire room to pass into the upper hole.

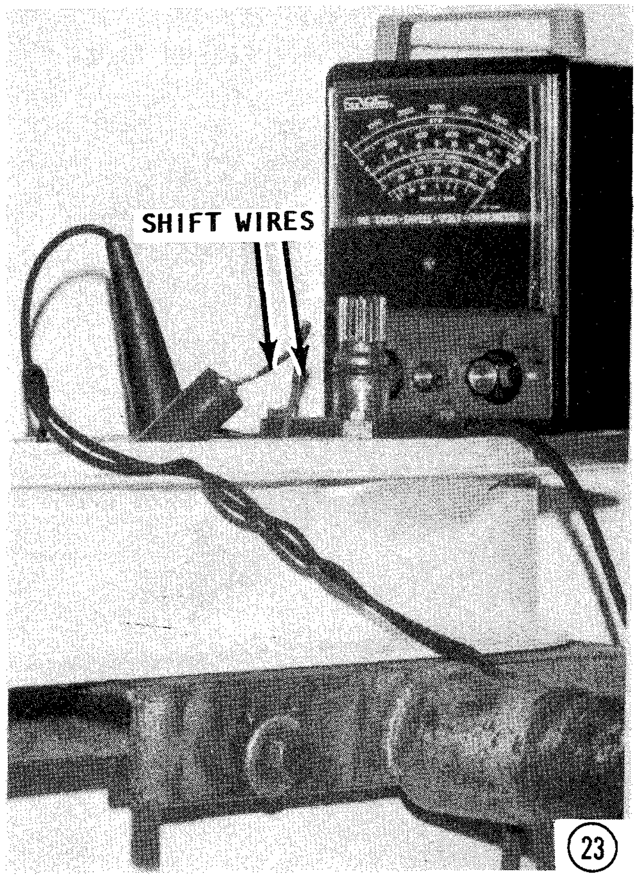
24– Install the thinner thrust washer over the propeller shaft, and then the thrust bearing, and the remaining thrust washer. This arrangement is necessary to position the reverse gear properly and to control propeller shaft end play.

25– Position Shim Gauge No. 415719 with the two arms resting on the gearcase and the body of the gauge against the stop on the propeller shaft, as shown. Press down on the washers and bearings, and at the same time measure the gap between the shim gauge and the rear thrust washer with a feeler gauge. This measurement equals the amount of shimming required for proper propeller shaft end play. Shims are available 0.002–0.010". Coat the shims with a small amount of grease, and then install them into the gearcase head. The grease will hold them in place.

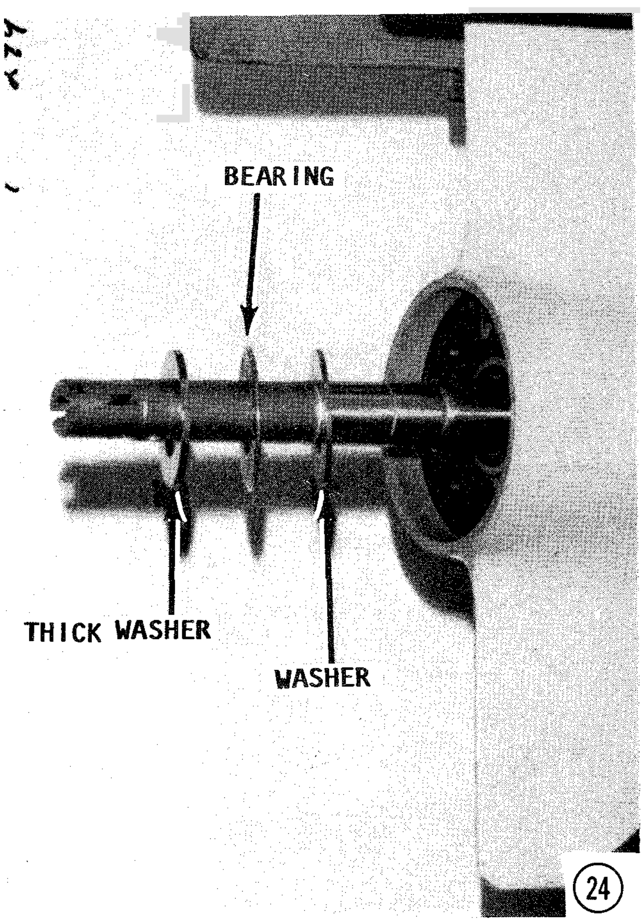
26- Alignment of the holes in the gear head with the holes in the coil is very lifficult b onc tl he is in la the ing ents the head from turning. Therefore, r allir g th gearcase l l, insert a guide pin i t opposite corner holes of the coil. Now, install the gearcase head with the holes in the head sliding over the pins in the reverse coil holes. Install the two retaining screws in



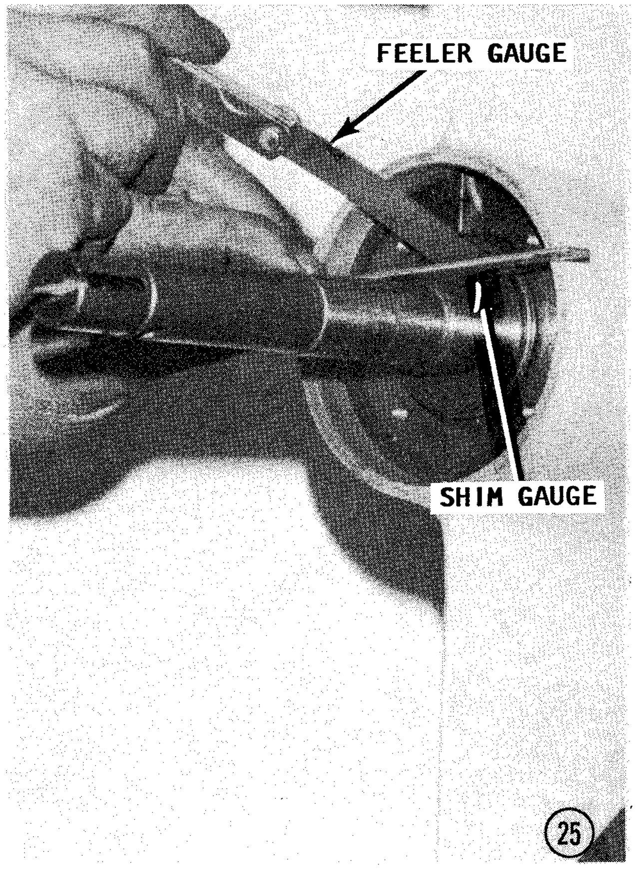
22

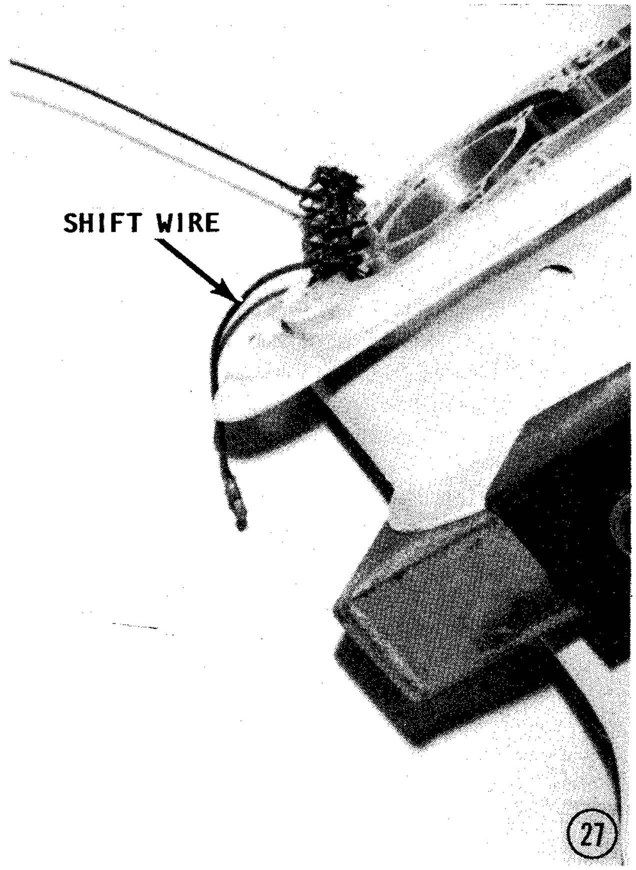


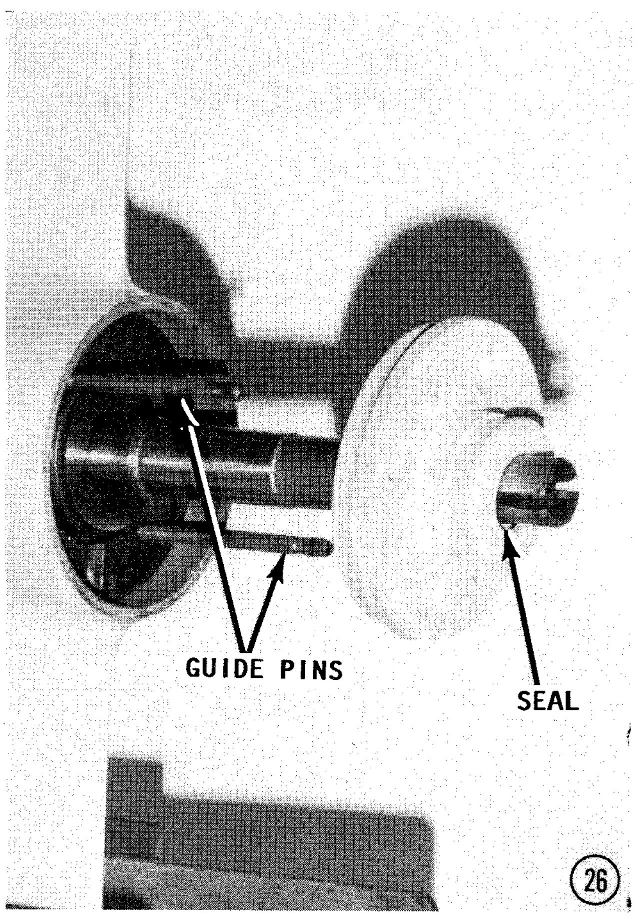
23

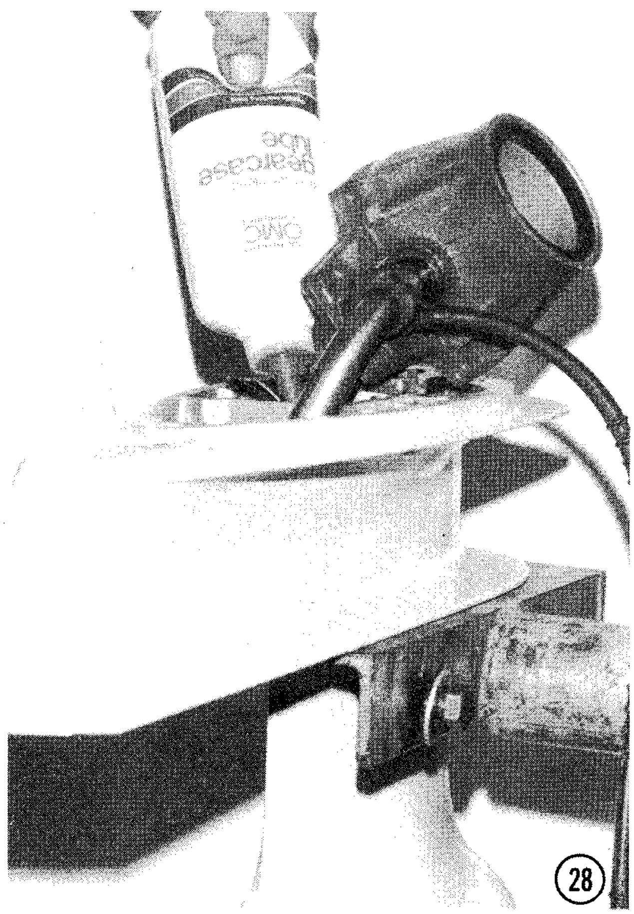


24


FEELER GAUGE
SHIM GAUGE
25


SHIFT WIRE
27


GUIDE PINS
SEAL
26


28

the holes without the pins; remove the pins; install the other two screws; and then tighten the four retaining screws to a torque value of 5-7 ft-lbs. Rotate the propeller shaft and check to be sure there is no evidence of drag.

27- Restrain the forward coil wire with the clamp and screw at the top of the gearcase. Install and push the two spring-and-magnet assemblies into the cavities at the top of the lower gearcase until they are firmly seated.

28- Install the lower unit drain plug, and then fill the unit with OMC Premium Lube (formerly Sea-Lube) oil until the oil comes out the upper level plug opening. Install the upper oil level plug.

10-18 SWIVEL HOUSING ASSEMBLING MODELS 1964 THRU 1977

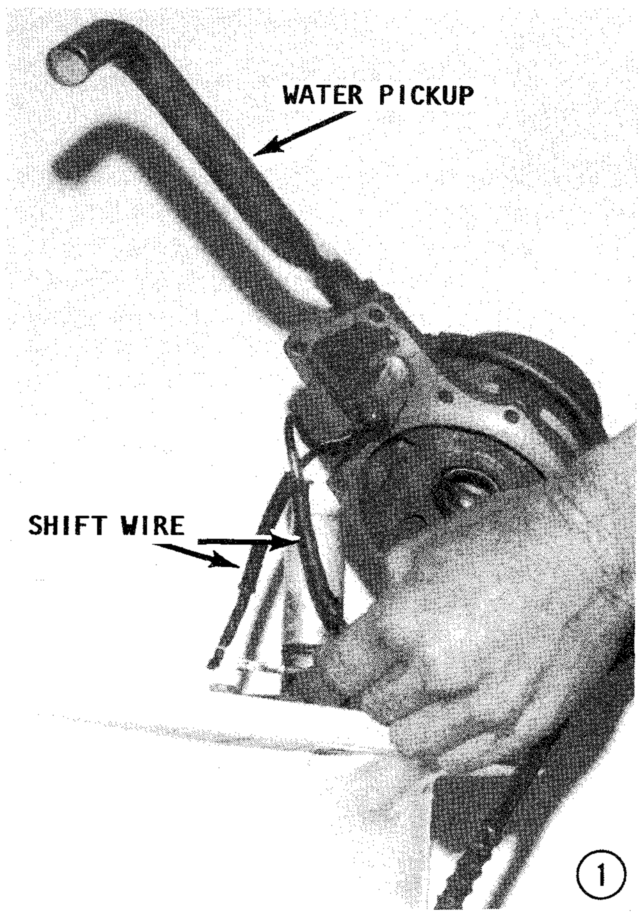
A few good words before assembling:

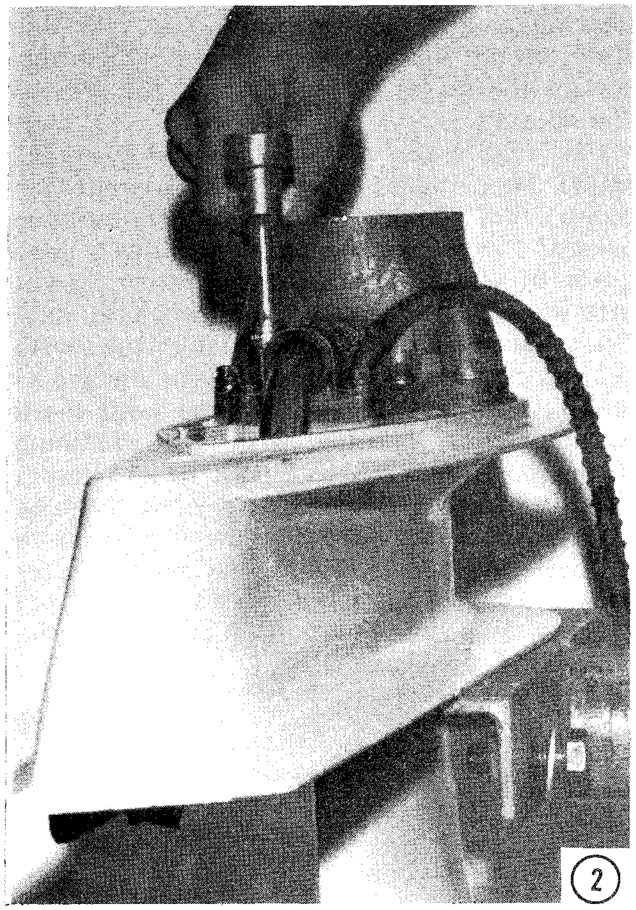
The swivel housing is an important part of the water pump installation. Take time to check all seals and replace any questionable ones or install a new swivel housing. The two bottom seals are installed back-to-back with the hard side of the seals facing each other and the sealing surfaces facing opposite directions to seal the water passageway to the water pump. The two center seals are also installed back-to-back and the top seal is installed with the hard side facing down.

The swivel housing is an important part of the water pump installation. Replacement of the swivel housing seals is not the easiest of tasks, especially if the proper tools are not available. However, a complete new swivel housing can be purchased with new seals installed at moderate cost from your local OMC dealer.

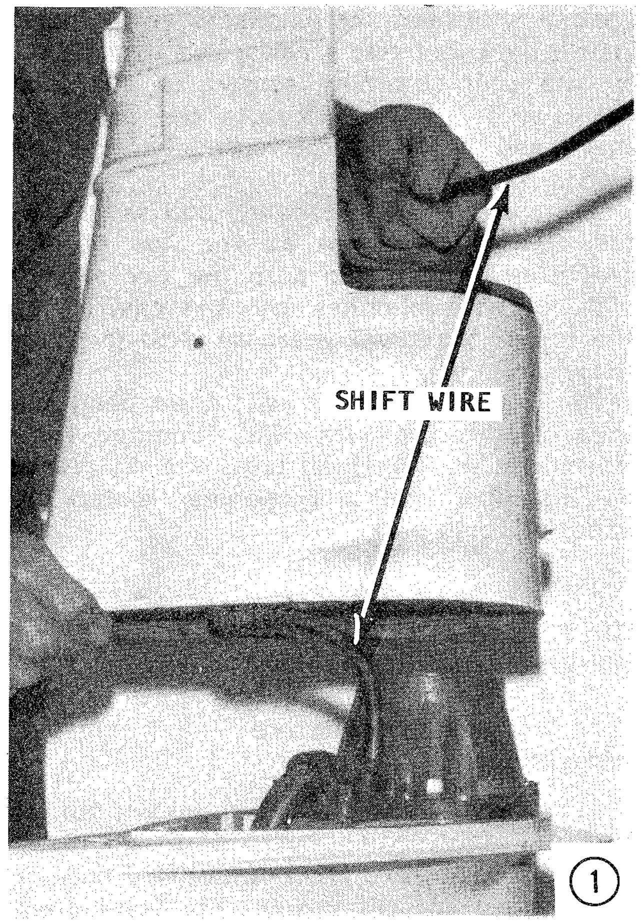
1- If the shift cable tube was removed from the swivel housing, coat the threads with a sealing compound. Secure the tube to the swivel housing with an 11/16" wrench. Position a **NEW** gasket onto the lower gearcase. Connect like colored shift wires from the swivel housing to the wires to the lower unit: Blue to blue for reverse and green to green for forward. Slide a seal protector over the driveshaft. Now, place the swivel housing over the drive shaft onto the lower unit. Install the bolts to secure the swivel bearing housing to the lower unit. At this time, do not install the two bolts which also secure the water pickup tube at the rear of the housing.

2- The water pickup tube and grommet **MUST** be installed properly to prevent the pump from sucking air. Coat the outside area of the water tube grommet with a good grade of sealing compound, and then push it into the rear of the swivel bearing assembly. Coat the end of the water pickup tube with sealing compound and push it into the grommet just far enough to align the wear mark of the nylon bushing with the retaining clamp position. TAKE CARE not to insert the tube further than necessary or the tube will be too short to roach the rudder plate at the other end. Place the nylon water tribe bushing in the mount at the rear of the housing and secure it in place with the clamp and screws.





2



1

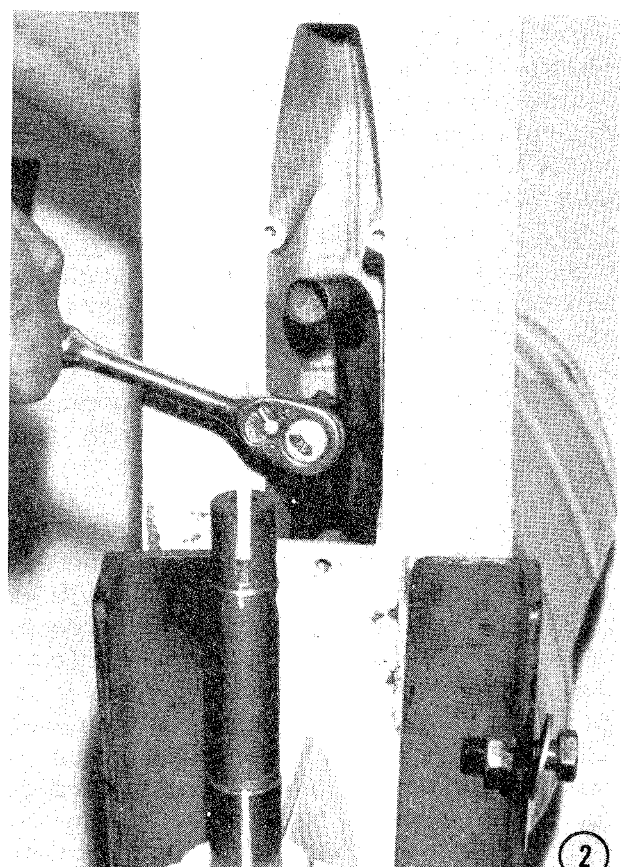
10-19 EXHAUST MOUSING ASSEMBLING MODELS 1966 THRU 1977

1- Oil the shift cable, then move the exhaust housing into place while pulling the cable through the hole in the housing.

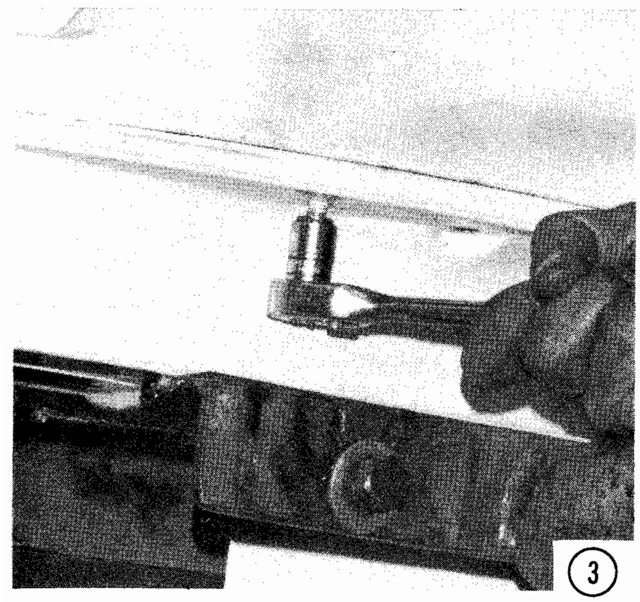
2- The exhaust housing is secured with six bolts with 1/2" heads and one bolt with a 9/16" head. Start the 9/16" bolt from the bottom into the rear of the exhaust housing first, and work it in until about 1/2" of thread has gripped. Do not tighten it at this time.

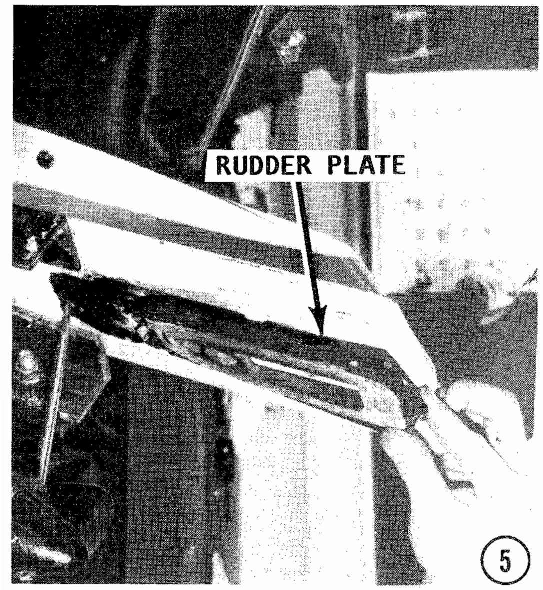
3- Install the other six bolts, and then tighten them all alternately, including the 9/16" head bolt.

4- SOME GOOD WORDS: On 1964 thru 1972 models, the water tube passes through the rudder plate and then the tube is inserted into the rubber bushing in the rudder. Since 1972, the water bushing and screen is inserted onto the water tube, and then the rudder plate and rudder is installed. Early models may be updated by installing a kit available from the local marine dealer. This kit includes a new water tube, bushing,



2



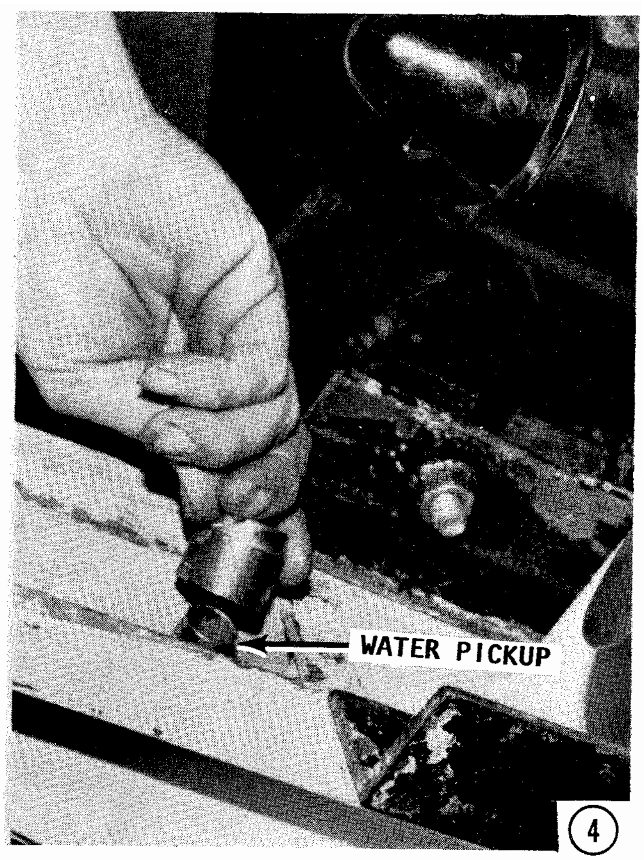


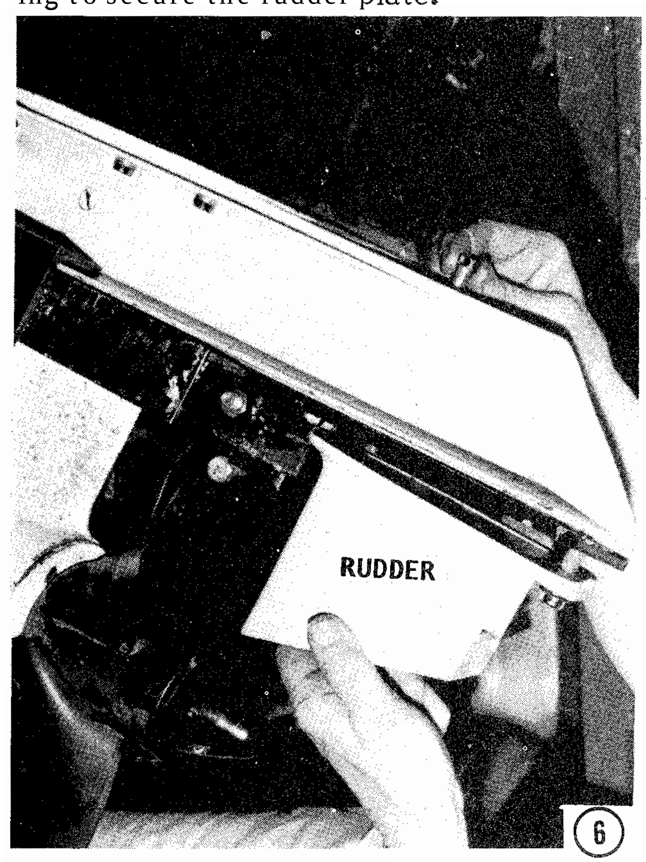
screen, rudder plate, and rudder. The new arrangement will provide a much more efficient water pickup. Now, back to the installation: Insert the water intake screen into the bushing. Coat the inside and outside surfaces of the grommet with Sealert 1000, or equivalent. Insert the grommet into the bushing with the lip at the bottom. Slide the assembly onto the lower end of the water tube.

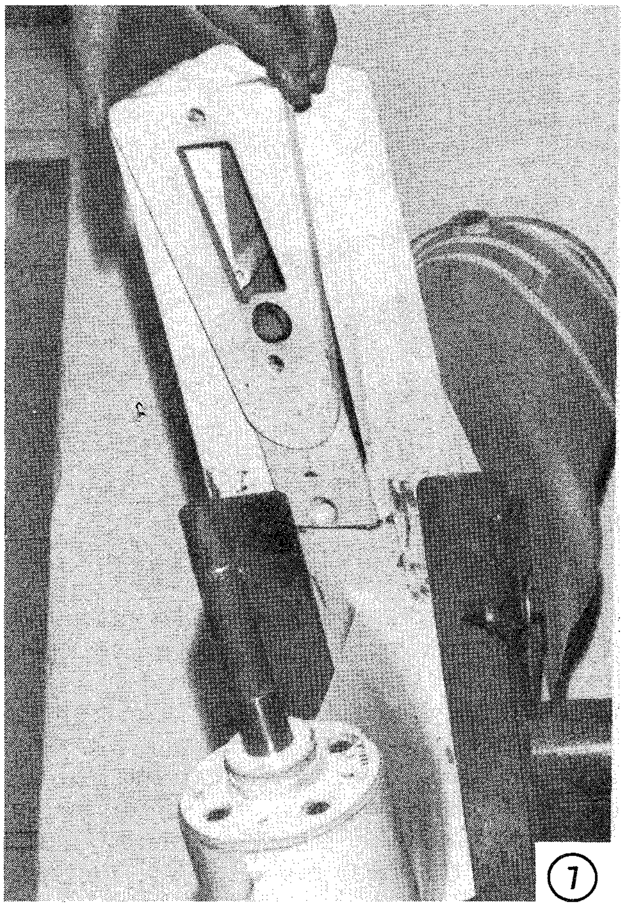
5- Slide the gearcase rudder plate over the end of the water tube sleeve. Secure it in place with the retaining screw.

6- Hold the rudder under the trim tab plate, and thread the trim tab pivot screw into the hole directly behind the exhaust housing. NEVER force the screw through the gearcase into the trim tab plate.

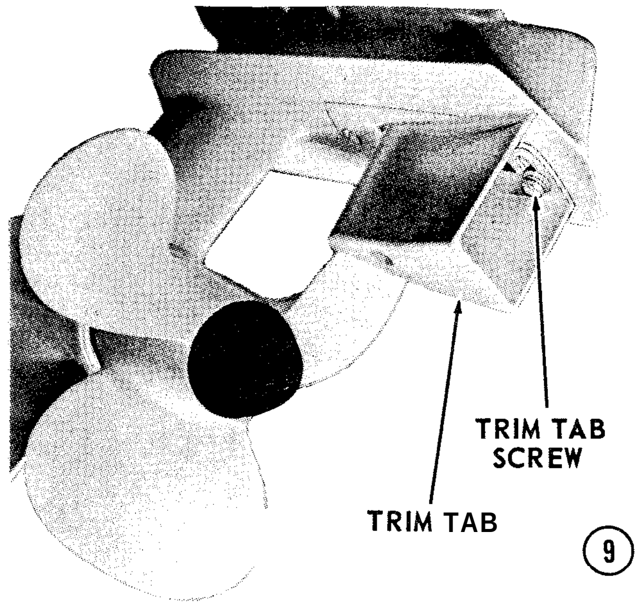
7- On the early models, place the gearcase rudder plate onto the housing, and then install the front bevel screw into the housing to secure the rudder plate.







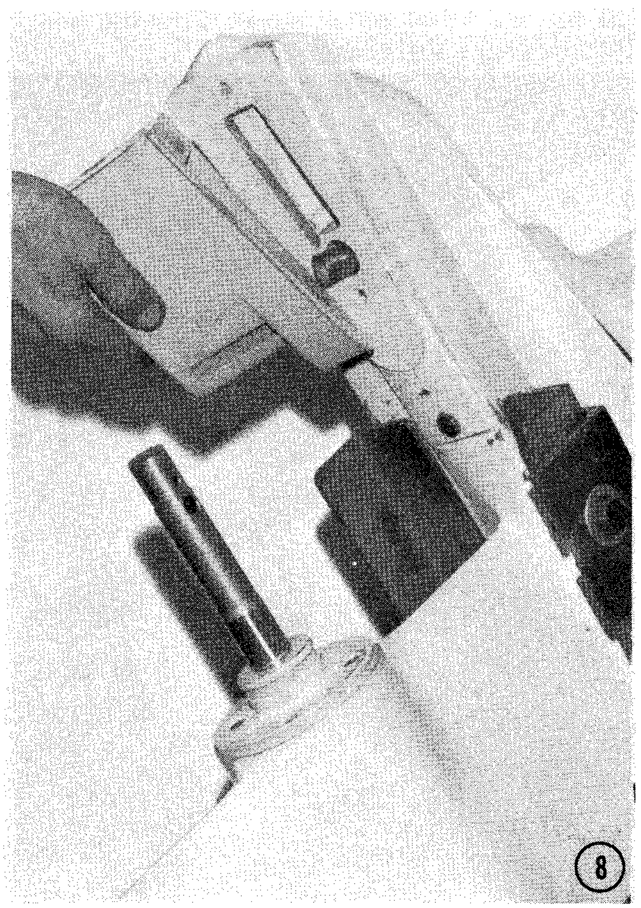
7



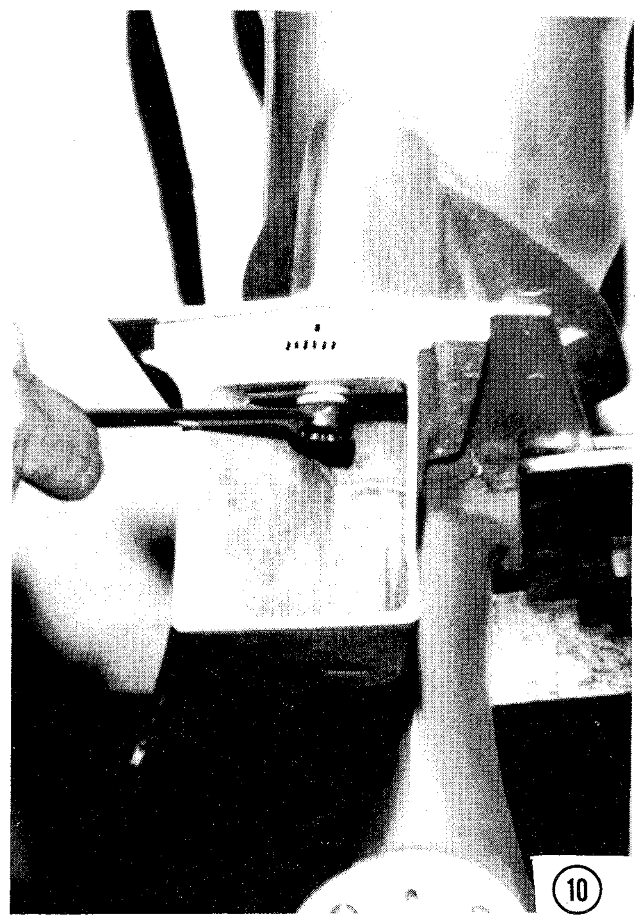
9

8- The older type exhaust rudder is under the exhaust outlet and it is also used as a water pickup. Install this type of rudder with the water tube inserted into the front part of the rudder.

9- Install the trim tab and use a 9/16" socket to tighten the pivot screw until it is just snug. Start the trim tab adjustment screw and washer.



8



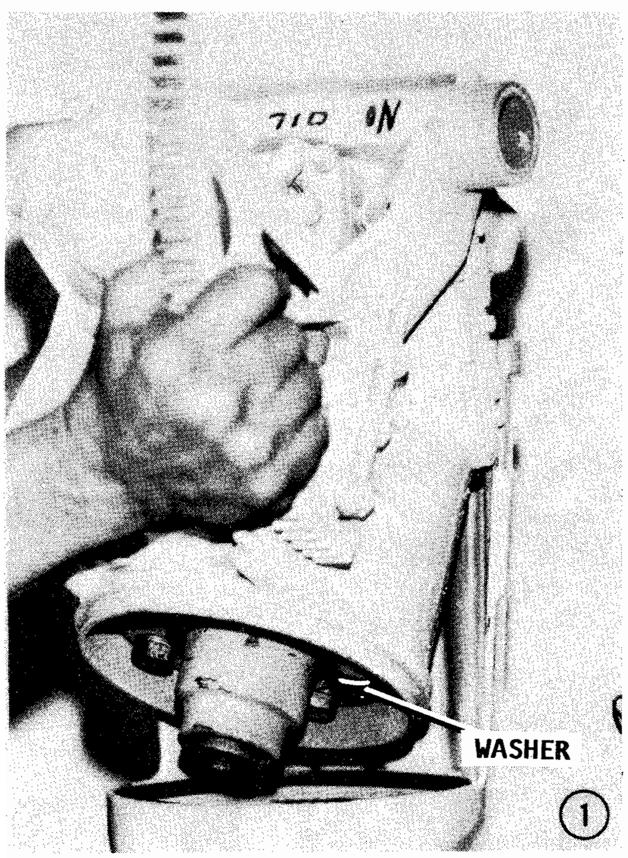
10

10- Adjust the trim tab by positioning it with the marks made during disassembly aligned. Now, tighten the adjustment screw. Tighten the pivot screw to a torque value of 18-20 ft-lbs.

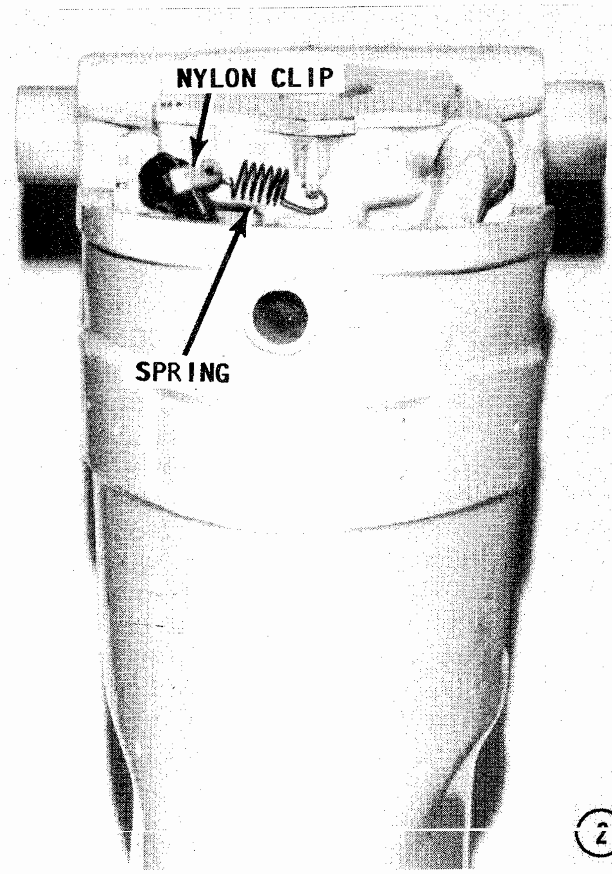
10-20 UPPER GEAR HOUSING INSTALLATION MODELS 1964 THRU 1977

1- Coat the nylon swivel housing washer with grease to hold it in place, and then install it on the upper gear housing with the concave side towards the water pump housing. Lower the upper housing slowly into the lower unit and rotate it slightly to index the splines of the lower unit drivehaft with the splines of the upper housing shaft. Feed the shift wire through the hole in the upper gear housing and secure it in place with the clip over the cable in the last groove. The cable will now be prevented from being pulled too far when it is installed into the intermediate housing.

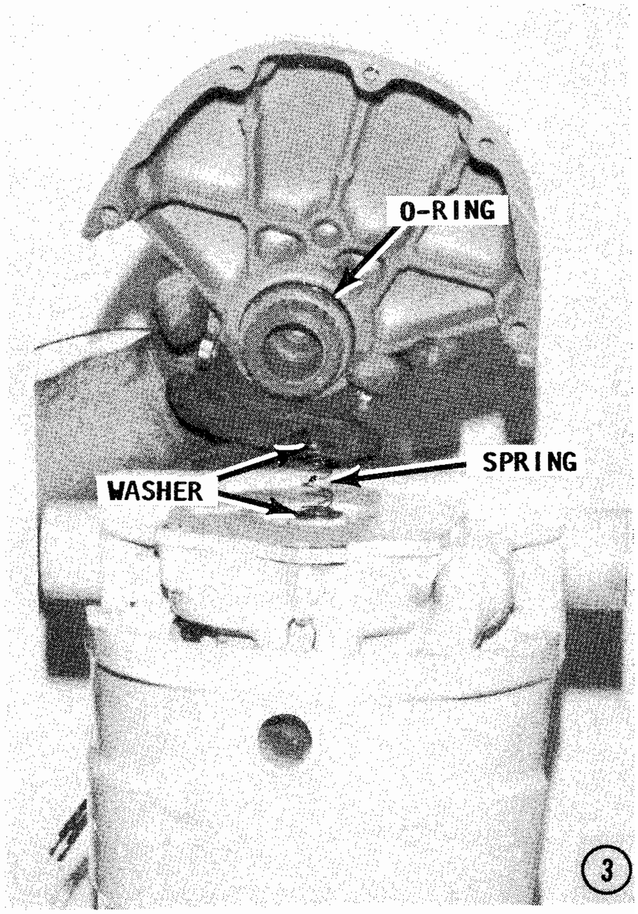
2- Install the nylon clip and spring on the shift cable on the rear of the upper gearcase. This clip and spring arrangement holds the cable clear and prevents it from becoming caught and damaged when the unit swivels.



1



2



3

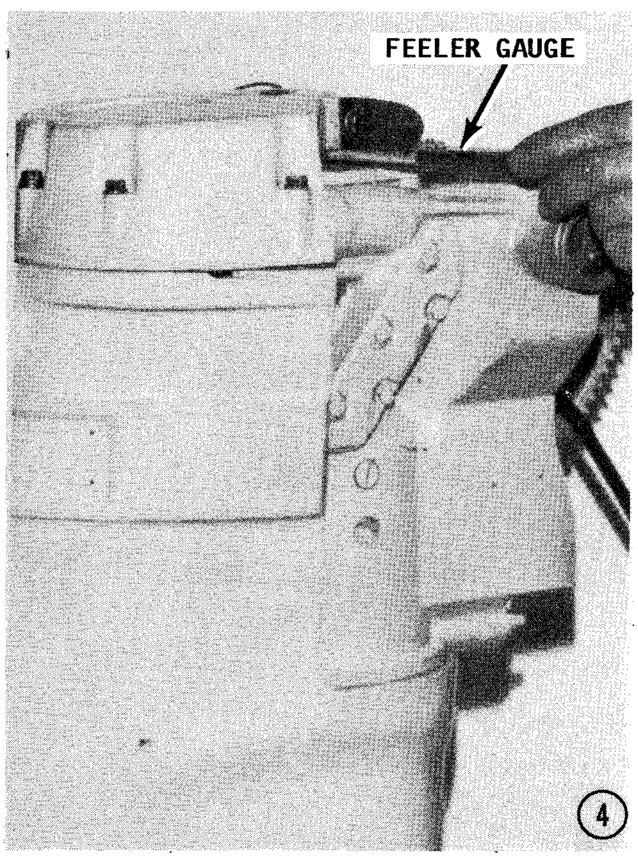
3- Install the grounding spring and washers on top of the boss of the worm gear shaft.

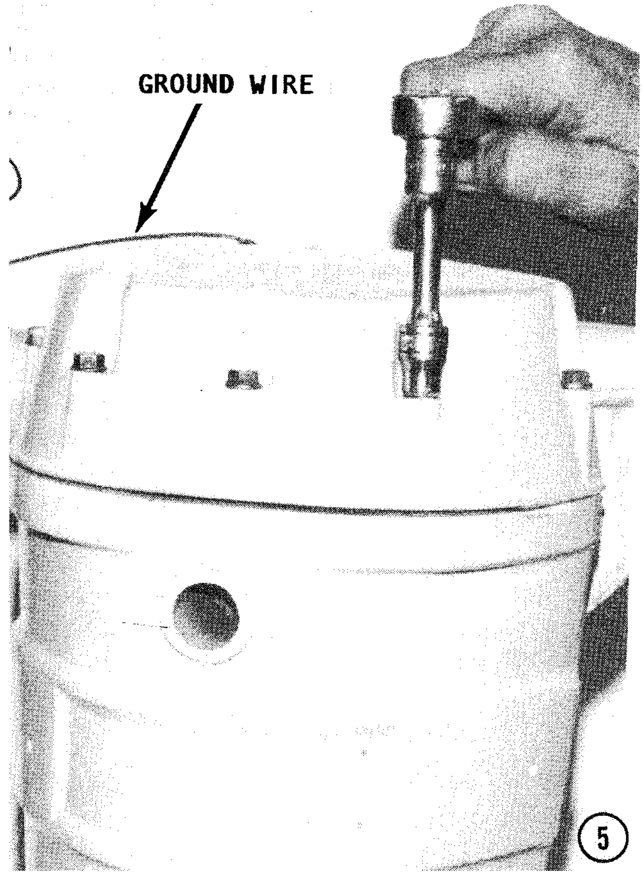
4- With the upper gearcase fully seated in position in the lower gearcase, measure the gap between the exhaust housing cover and the gear housing cover with a feeler gauge. Now, raise the upper gearcase as much as possible and again measure the gap. The difference between the two measurements **MUST NOT** exceed 0.005-0.015". Select the number of shims required to meet this requirement, and then install them over the boss in the center of the upper gearcase.

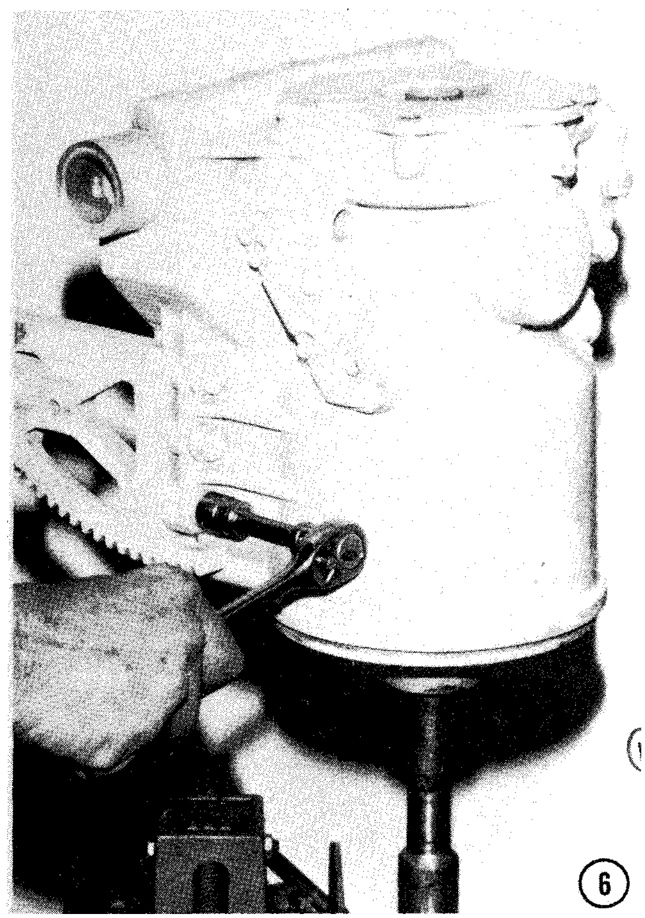
5- Install and secure the exhaust cap with the retaining screws. Secure the bumper assembly in place at the front of the exhaust housing cover with the two attaching screws. Tighten the screws to a torque value of 5-7 ft-lbs.

6- Secure the tilt quadrant to the upper gear housing with the three 9/16" bolts.

7- Remove the fill plug in the top of the exhaust cover plate, just behind the rubber bumper and fill the upper gear housing with OMC Premium Lube (formerly Sea-Lube) oil. **TAKE MOTE** there are two plugs on the starboard side of the stern drive. The bottom plug is installed to drain the unit and the upper one is the oil-level plug. To fill

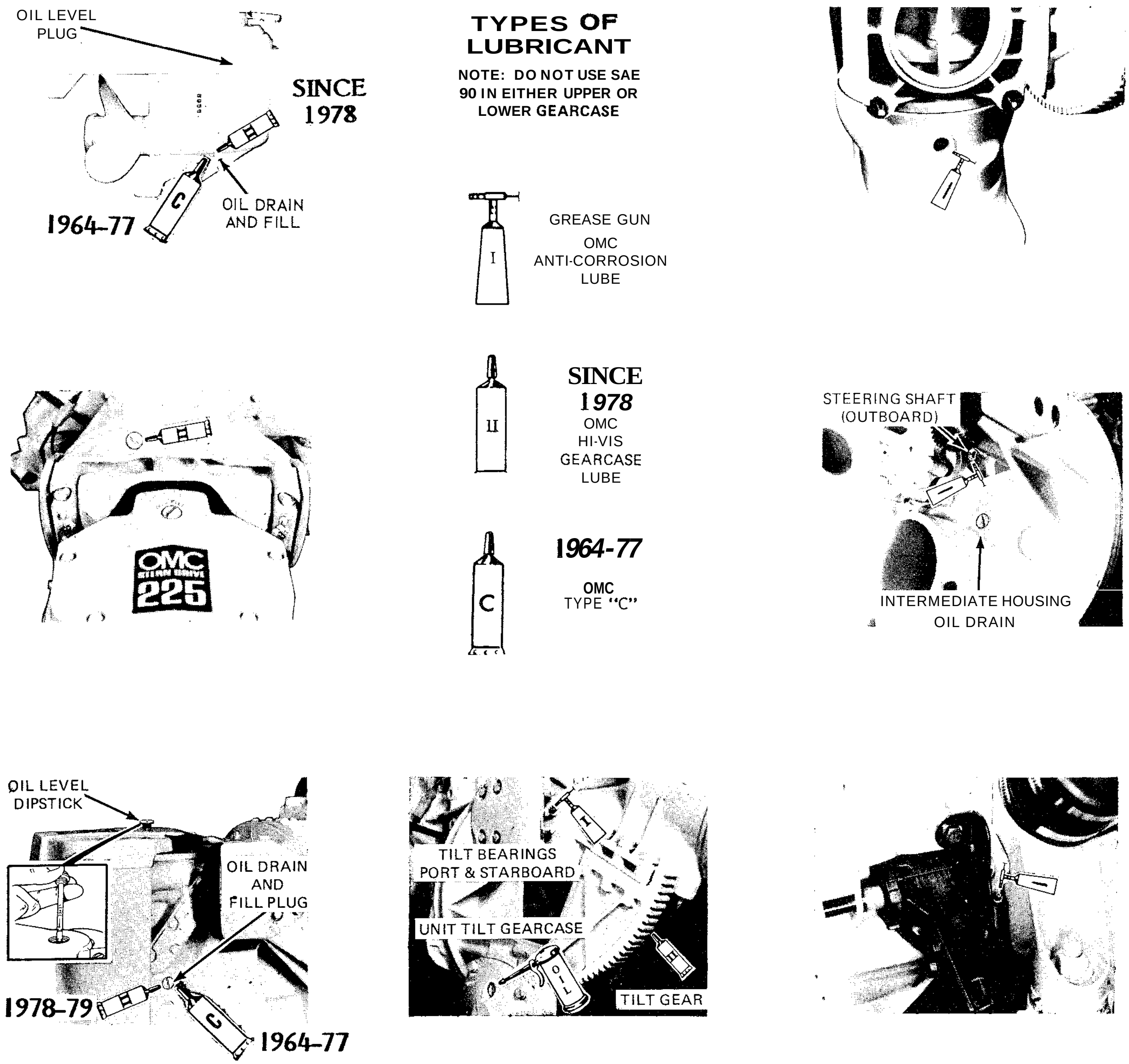






the upper housing, pour the oil in at the top until it appears at the oil-level port, then install and tighten both plugs. On some late model units prior to 1978, one plug is located on top with a dip stick for checking oil level and a lower drain plug in the same location on the starbaord side as on the earlier models.

If the lower unit was not filled with oil prior to installing the swivel housing, do so at this time. Remove the oil plug on the starboard side at the bottom of the lower unit, just under the cavitation plate. Force OMC Premium Lube oil into this opening until it appears at the level port. Install and tighten the oil-level plug and the fill plug.



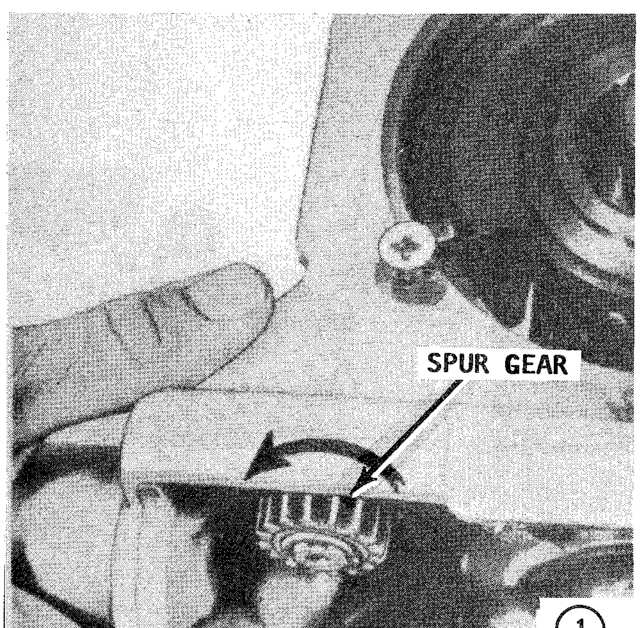
Points of lubrication and the type of lubricant to be used.

10-21 STERN DRIVE INSTALLATION MODELS 1964 THRU 1977

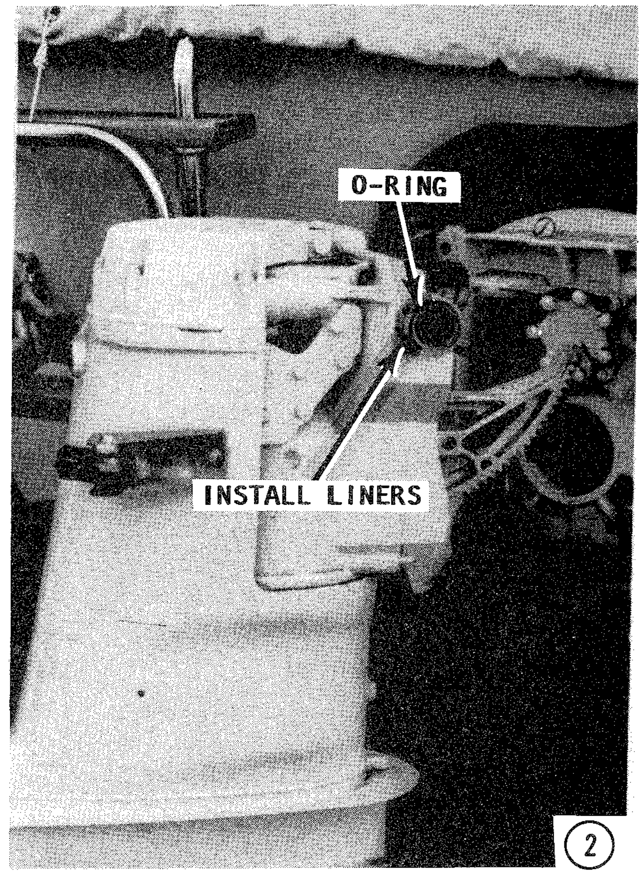
1- Rotate the boat steering wheel to the center position. Turn the small gear on the front side of the upper housing until the upper housing is centered with the lower housing. Move the stern drive into position behind the intermediate housing and rest the tilt quadrant on the tilt gear.

2- Coat **NEW** O-ring seals with grease, and then insert them into the groove of the pivot arms on both sides. Slide the liners onto both pivot arms with the split in the liner facing forward towards the boat. This position will be opposite (180°) from the pivot cap grease fitting. Feed the shift cable into the intermediate housing as far as possible. The cable will be pulled in more later on in the work. Align the marks on the ball gears made during removal; use the tilt quadrant as a lever; tilt the stern drive upward; then install the pivot caps. **REMEMBER,** the pivot caps were identified for right and left during disassembly. The caps should **NEVER** be interchanged from one side to the other.

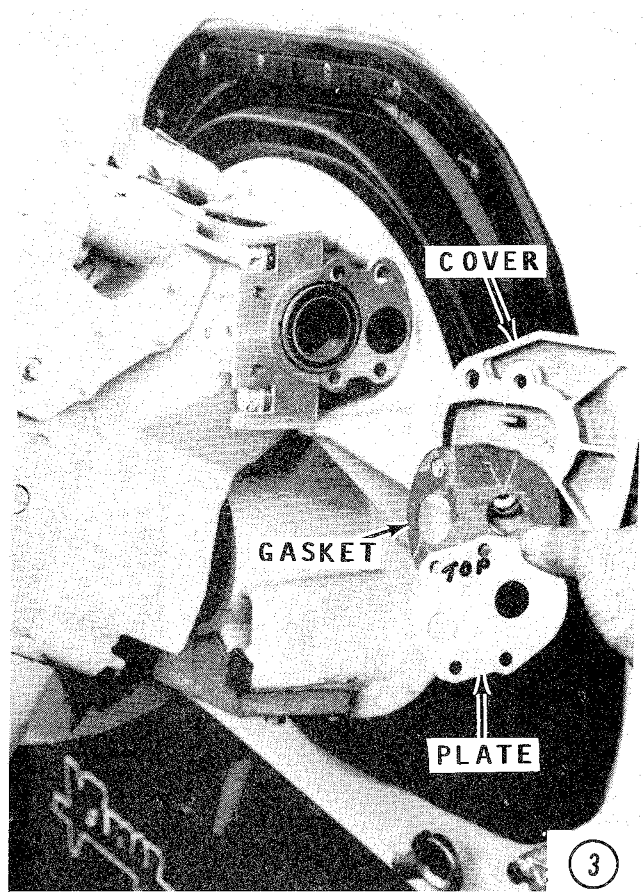
3- Before replacing the pivot side caps, **A GOOD WORD:** The word **TOP** is stamped on the side plate gasket and also on the side plate. Install the plate, gasket, and cap, in that order, with the holes in the plate and gasket aligned with the holes in the intermediate housing.



1



2

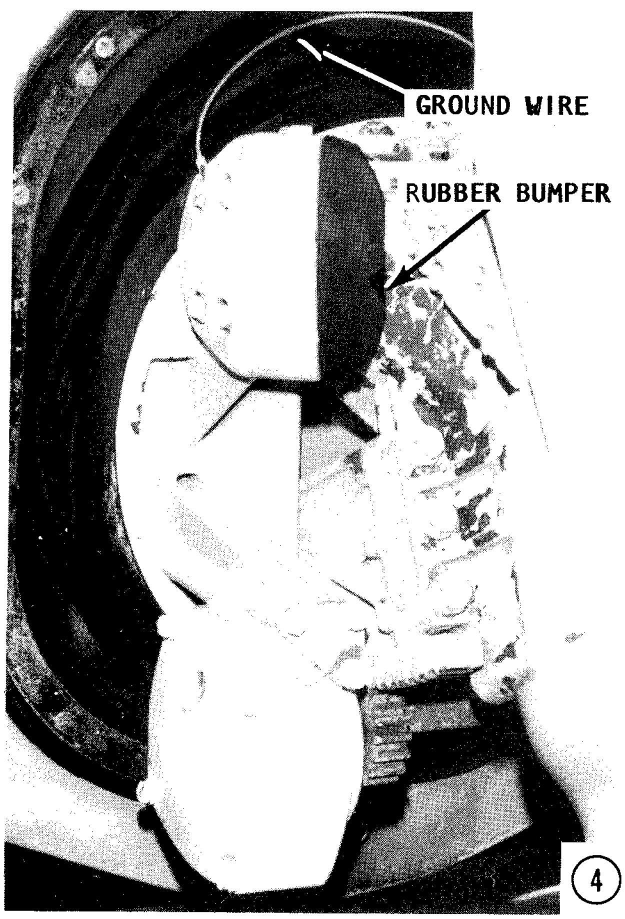


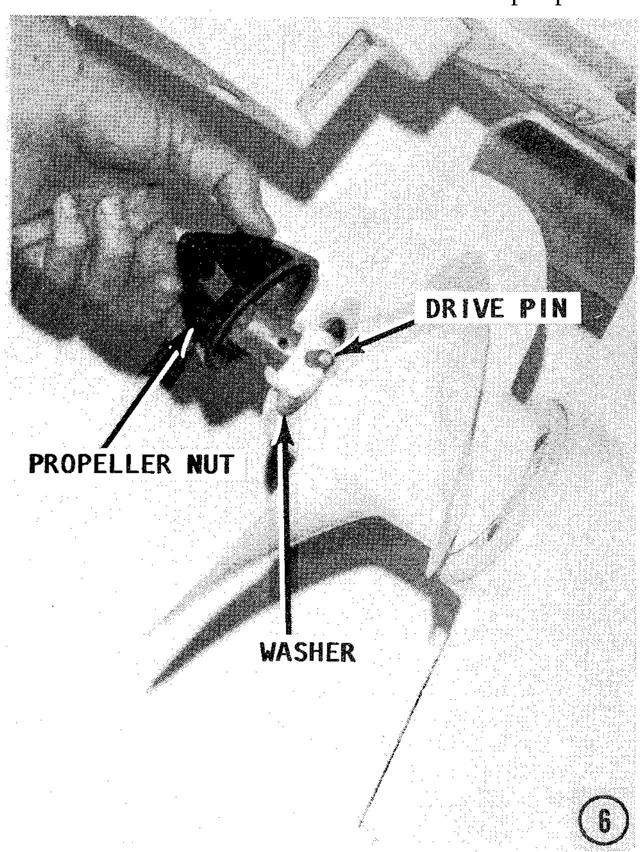
3

4– Check to be sure the ground wire on the upper gearcase housing to the upper cap assembly is properly installed. Install the four bolts to the housing. Reach up under the stern drive and apply a small amount of grease to the shift cable as an aid to pulling the wire into place.

5– From a position inside the boat and just above the tilt motor, pull the wires in until the knobs are fully seated in the holes of the intermediate housing. Connect the shift cables: Blue to blue for reverse and green to green for forward. Check movement of the stern drive by operating the tilt switch. The unit should move with ease without any evidence of binding.

6– A FEW GOOD WORDS: The propeller washer and drive pin play an extremely important role. When shifting gears during normal operation, or if the propeller should hit an underwater obstacle, the propeller is subjected to considerable shock. A washer is installed between the propeller and drive pin. This washer MUST always be in place for proper operation. If the hub should slip, the propeller will move back towards the propeller nut and lock against the drive pin. The washer is designed to stop propeller movement so the drive pin can be easily removed for service. Now, on with the installation: Coat the propeller

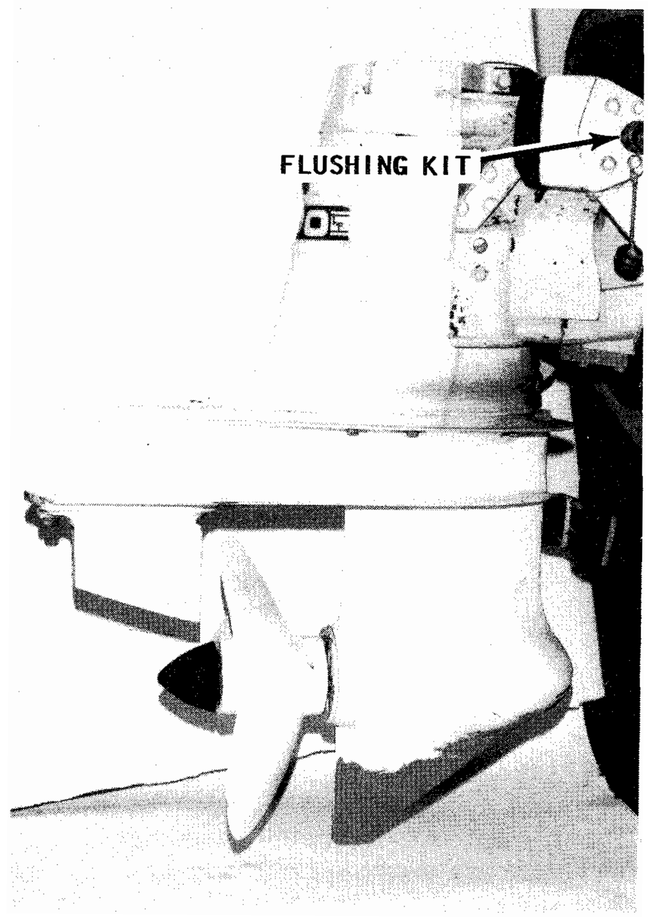




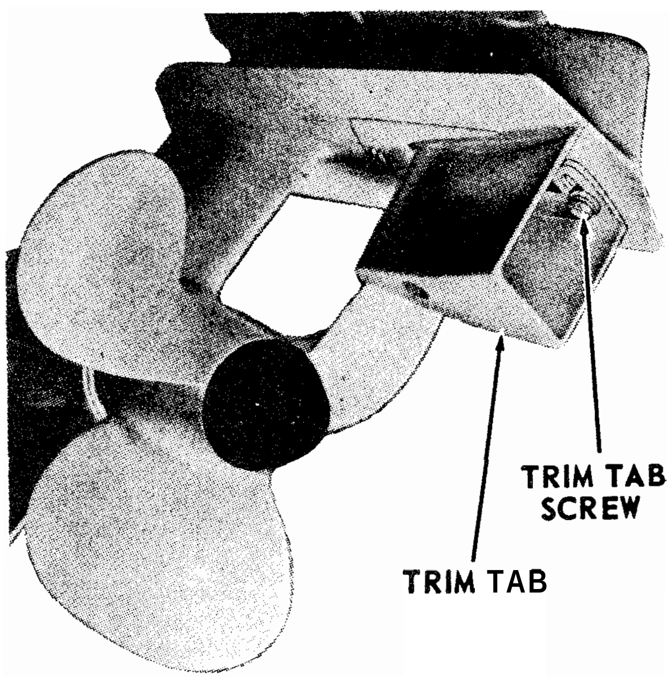
shaft with an anti-corrosion grease. Install the propeller with the drive pin holes aligned. Install the washer and drive pin. Slide the propeller cap into place and secure it with the cotter key.

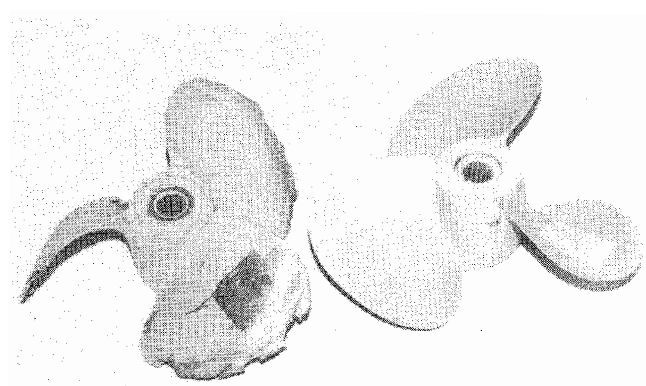
7- Make a functional test of the steering system for proper operation. When the steering system is correctly balanced for high-speed operation, the steering effort will normally be slightly higher at a little less than planning speed or when coming back on course from a port turn. If this condition is objectionalble, loosen the rudder adjustment screw and move the rudder just a bit to port. If the steering is pulling to one side or the other, adjust the rudder to the same side to which the boat is pulling.

CAUTION: Water must circulate through the lower unit to the engine any time the engine & run to prevent damage to the water pump in the lower unit. Just five seconds without water will damage the water pump.



OMC flushing attachment kit installed to ensure adequate water circulation through the stern drive and engine during engine run-up while the boat is out of the water.





Satisfactory boat performance is not possible if a damaged propeller (left) is installed following service work on the engine, stern drive, or other systems.

10-22 STERN DRIVE UNITS MODELS SINCE 1978

Stern drive units since 1978 utilize a mechanical power assisted shift mechanism. Engine exhaust is funnelled out through the propeller. This arrangement is popularly referred to as a "prop exhaust" system. As with other types of shift mechanisms, the sequence begins at the shift box. As the shift control lever is moved to the desired position, **FORWARD, NEUTRAL,** or **REVERSE,** movement is tramsmitted through a cable to a shift converter mounted on the rear of the engine. The converter transmits the movement, through a mechanical arm to a second cable combination to a power assisted shift mechanism in the lower unit,

The power shift assist contains a servo-cylinder valve which is controlled from the remote control gear box thru the converter and cables, just described. A hydraulic pump installed in the lower unit circulates oil through the lower unit and supplies oil under pressure to the servo valve. This pump is mounted in the forward end of the gearcase and is driven by the forward gear. In the shifting sequence, the shift control cable controls the servo cylinder valve. The valve directs the hydraulic force to assist placing a clutch dog in the desired position.

Unlike the electric shift of units prior to 1978, this shift arrangement is difficult to operate without the engine running because the hydraulic pump in the lower unit does not operate to supply pressurized oil to the servo valve for the power assist operation.

The prop exhuast system results in a much more quiet unit because the exhaust gases are discharged underwater through the propeller. This arrangement is much more efficient due to the exhaust gases filling the low pressure area directly behind the propeller. This low pressure area is caused by the spinning movement of water coming off the propeller. In addition to these two inprovements, tests have proven the new thru hub exhaust reduces drag to a significant degree.

10-23 STERN DRIVE SERVICE MODELS SINCE 1978

The stern drive installed on boats with 120 hp and 140 hp engines is identified as a **400** stern drive. **A** heavier unit is used with the larger hp engines and is classed as a **800** stern drive. The instructions in the following sections cover both series of stern drives but are basically for the **800** stern drive units. Differences for the **400** stern drive will be clearly indicated.

The service procedures are divided into five **MAJOR** groups:

1- Troubleshooting; Section 10-24.

2- Stern drive removal from the intermediate housing; Section 10-26.

3- Servicing the upper gear housing; Sectian 10-27.

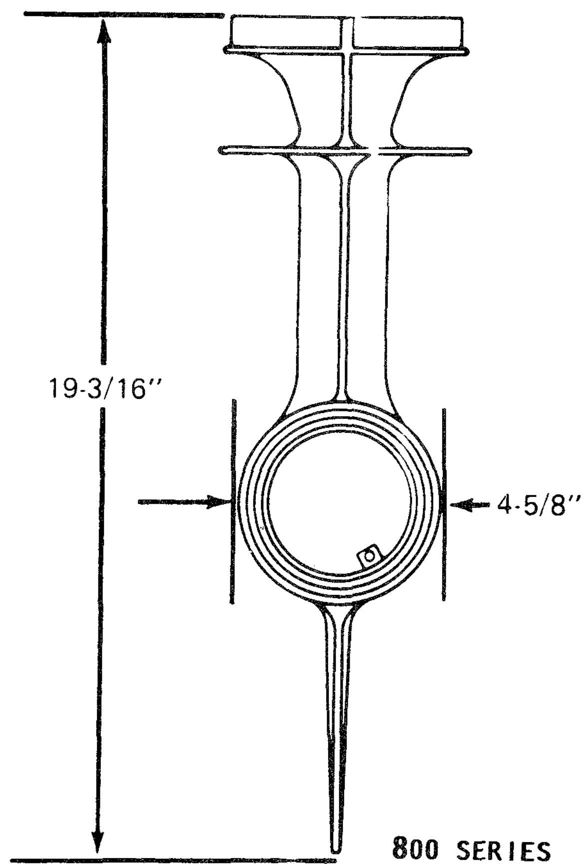
4- Servicing the lower unit; Section 10-38.

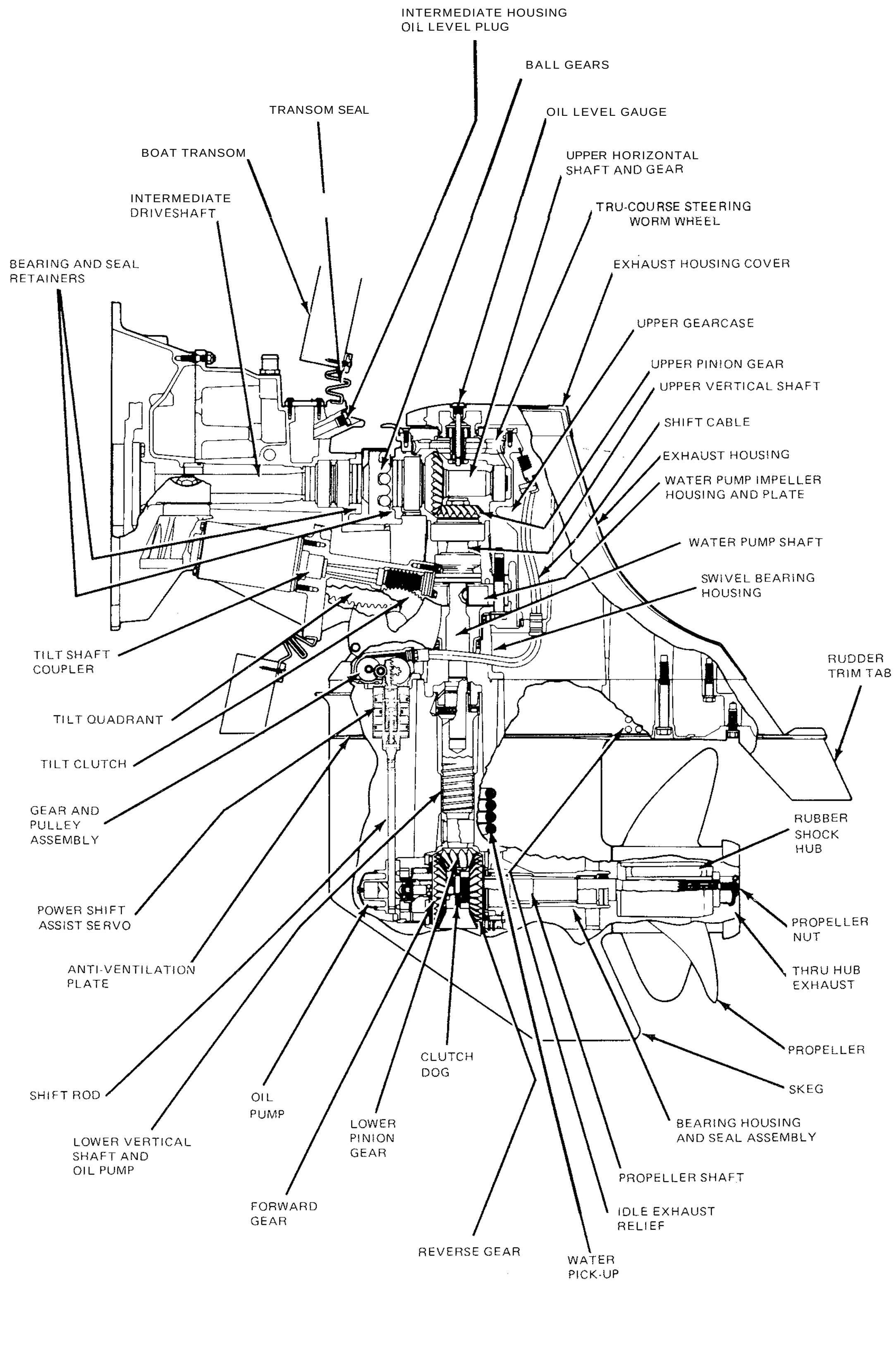
5- Replacing the stern drive; Section 10-58.

Each of the service groups are further divided into subordinate procedures for removal, disassembling, cleaning and inspecting, assembling, and installation.

10-24 TROUBLESHOOTING

In order to prevent unneccessary service work, specific troubleshooting should be performed. The following steps present a logical sequenmce of tests and checks to pinpoint problems in the stern drive.



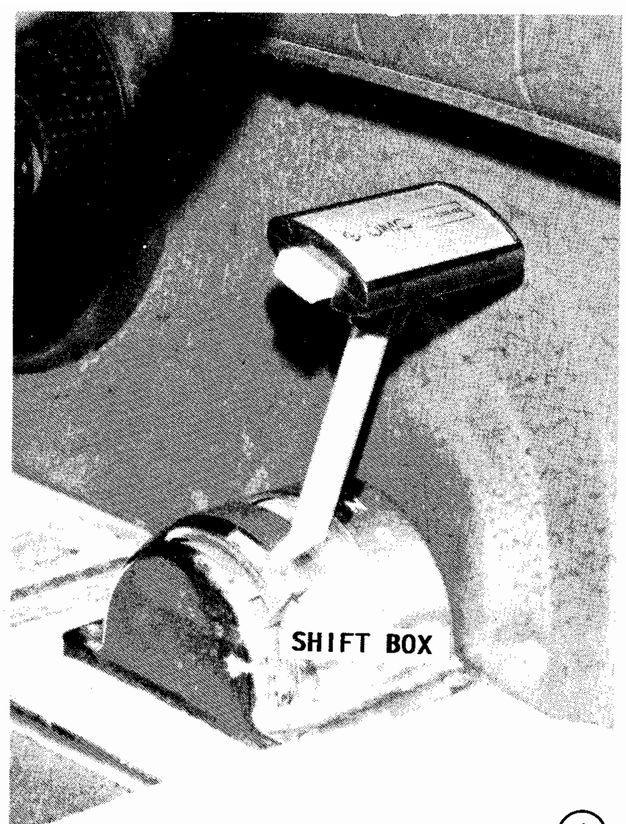


Sectional view of the 400/800 Series stern drive.

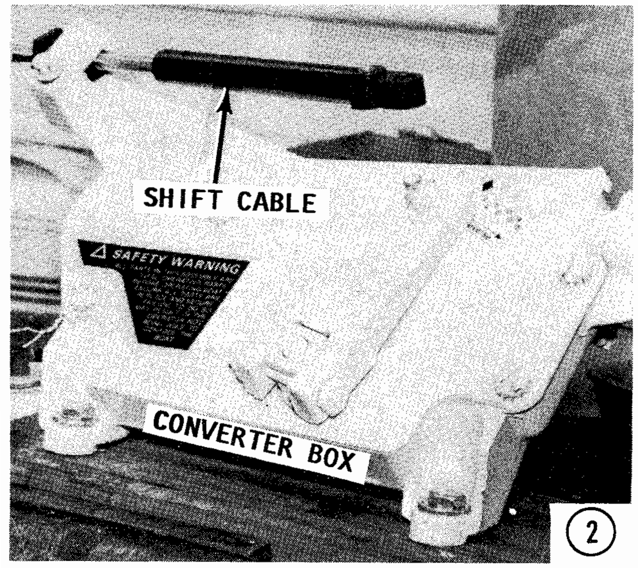
1- Hard Shifting: Disconnect the shift cable at the converter mounted at the rear of the engine. Move the shift lever at the shift control box from one position to another. With the cable disconnected at the converter, the shift lever should move freely. If movement of the shift lever continues to be stiff, the problem may be in the shift box or the cable between the control box and the converter needs to be replaced.

If movement of the shift lever is free with the cable disconnected at the converter, the problem is either in the converter or in the lower unit. Move the shift lever at the converter from forward to reverse and at the same time have a helper rotate the propeller. If the shifting is stiff while the helper is turning the propeller, the trouble is in the shift cable between the converter and the power assist servo valve in the lower unit. Repair to this portion of the shift mechanism requires removal of the stern drive.

2- **Lower Unit Fails To Engage Fully:** If the lower unit fails to fully engage in forward or reverse, or if the unit fails to hold in gear, the converter most likely requires adjustment. For proper adjustment of the converter, see Section 10-60.

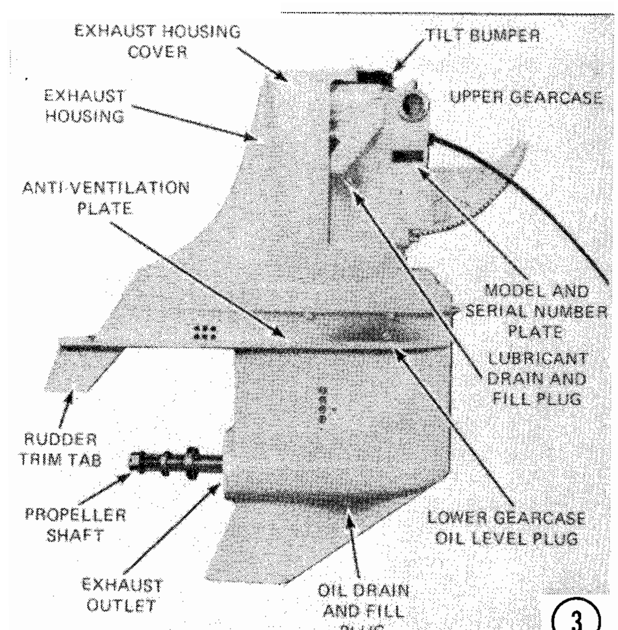


1

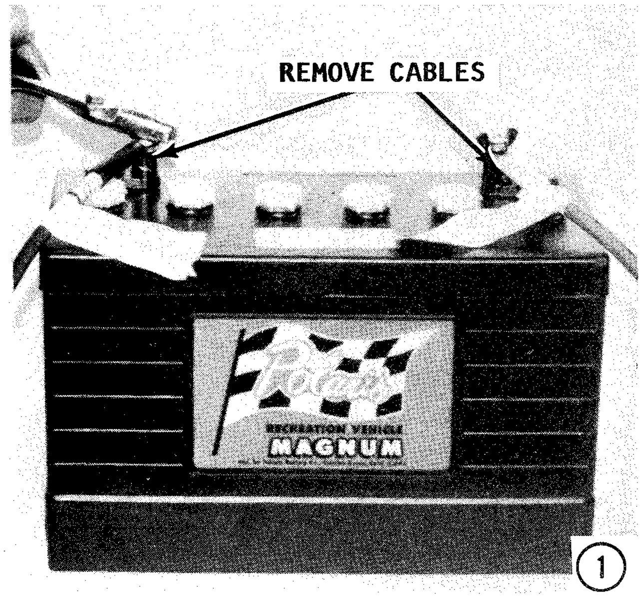


2

3- **Water In The Upper or Lower Unit:** In most areas, a double seal arrangement is used to retain the oil in the unit and to prevent water from entering. Therefore, if water has entered the unit, the most logical action is to assume one or more of the seals has failed. To test the seals, first the unit must be removed and the oil and water drained. Next, introduce compressed air into the drain plug oil. **NEVER** exceed 15 psi of air or serviceable seals will be blown. With the unit pressurized, submerge it in water and observe for air bubbles. When the leaking area is discovered, refer to the proper section for repair procedures.



3



1

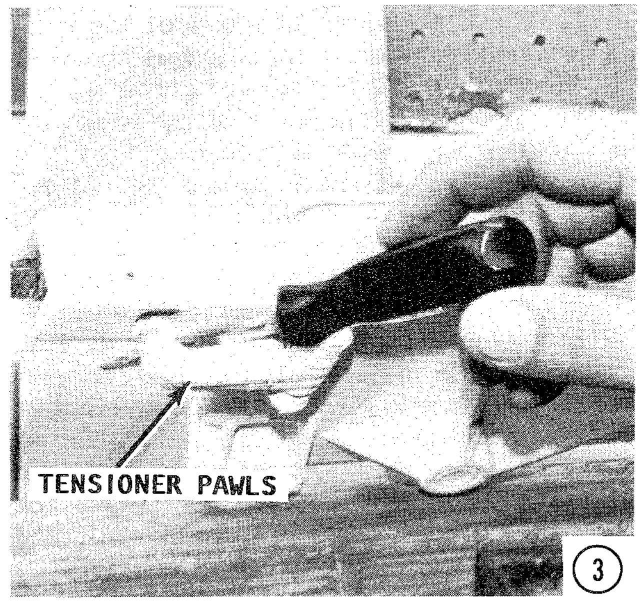
10-25 SHIFT CONVERTER SERVICE

CABLE REMOVAL

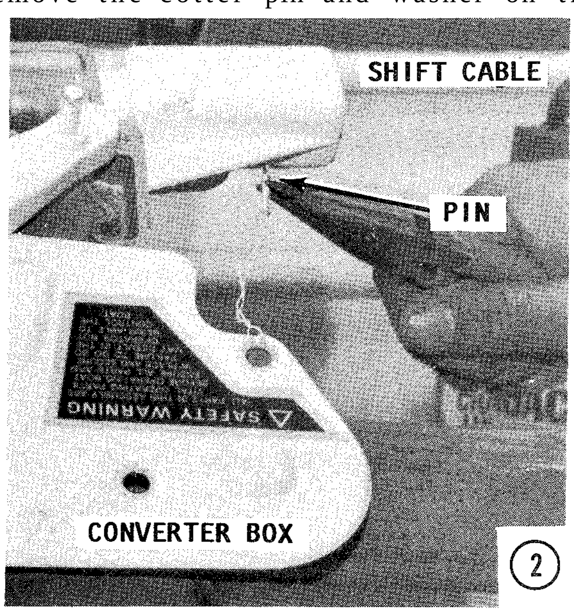
1- Disconnect the cables from the battery posts as a precaution against shorting the shift core wires on electrical parts while disassembling the cable. If the core wires should be shorted, they would be damaged to the point of requiring replacement. Continued use of a shift cable with damaged core wires may result in breakage of the wire. If the core wire should break, the operator would lose control of the boat.

2- To disconnect the shift cable from the converter box, mounted on the rear of the engine, first loosen the anchor bolt and remove the cotter pin and washer on the shift arm. Next, remove the shift arm, and then remove the four cover screws, Remove the cover, and reach inside the control box and remove the plastic cable guide. Now, turn the two hitch pins upward and pull them out of their retaining holes.
Lift the two cables out of their retaining holes in the converter housing.

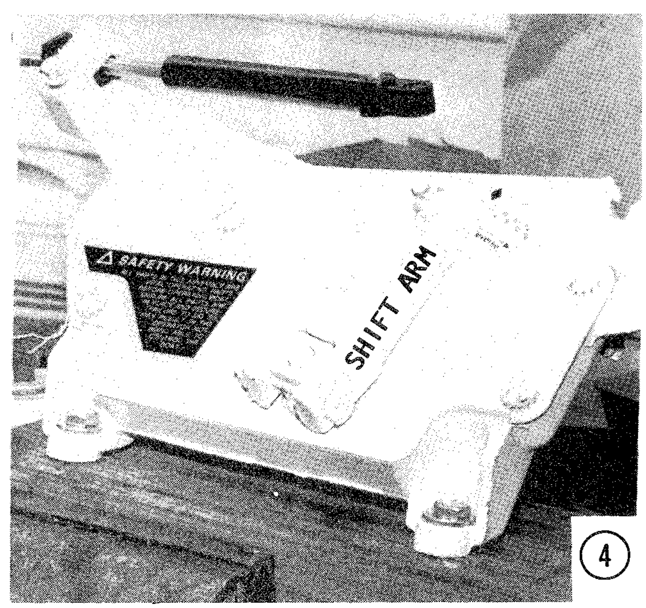
3- The shift cable from the lower unit enters the converter box through a square opening on the port side. Two tensioner pawls are located on the bottom side of the square tubing. Release the tension on the cable by inserting a screwdriver between the housing and the pawls. Insert the screwdriver only far enough to disengage the tensioner. If the screwdriver is inserted



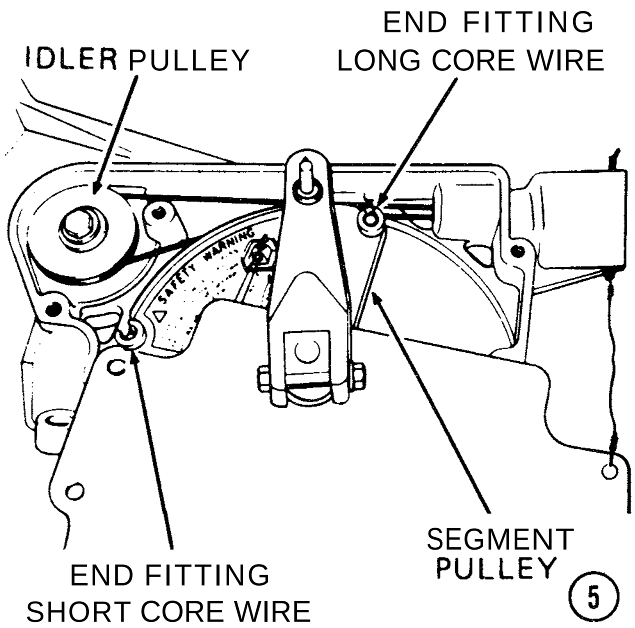
3



2



4

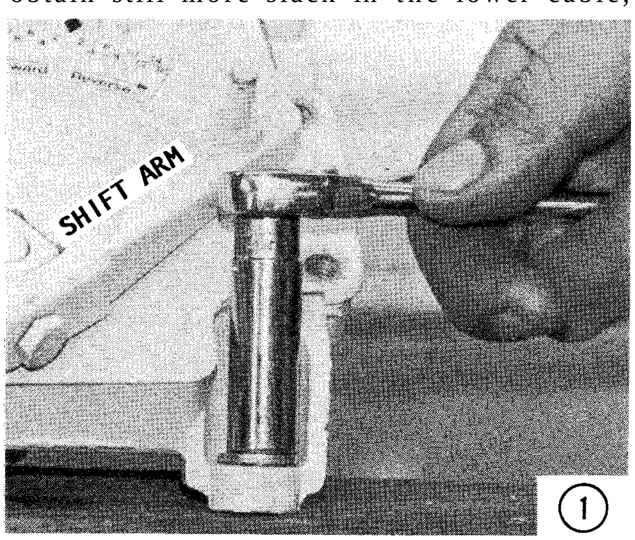


further than necessary, the pawls may deform or dislocate the torsion spring. If the spring should become deformed or dislocated, the shift mechanism would not operate properly.

4- Push the shift cable towards the starboard side of the converter box and at the same time, insert a cotter pin in the hole in the square tubing, as shown. After the pin is inserted, the tension on the cables in the converter box will be completely relieved.

5- Additional slack may be gained by rotating the segment pulley to the left. Remove the upper shift core wire from the idler pulley and the outer groove of the segment pulley. Remove the wire end fitting from the segment pulley pocket. Now, rotate the segment pulley to the right to obtain still more slack in the lower cable, and then remove the lower wire from the segment pulley and the end fitting from the pocket. **CAREFULLY** pull the shift cable harness out of the converter housing.

STOP: If the cable was removed from the converter box in order to remove the stern drive, further diassembly is **NOT** required. However, if the cable was removed in preparation for additional work on the converter box, then proceed with the next section.

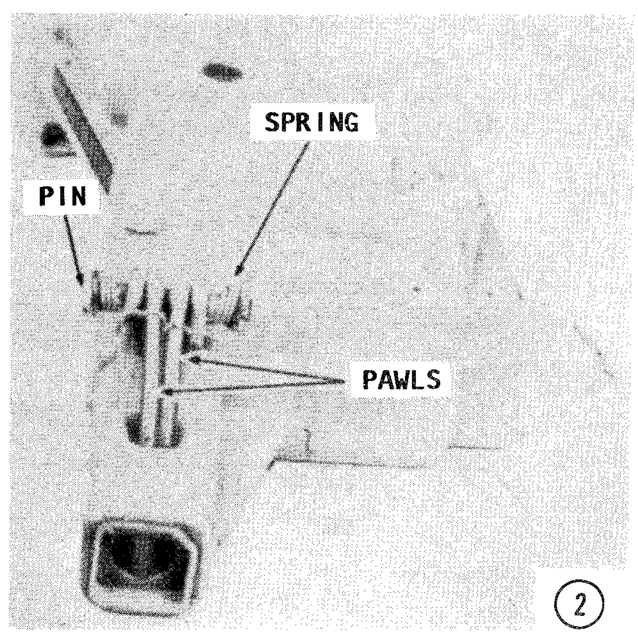


SHIFT CONVERTER DISASSEMBLING

These procedures pickup the work after the shift cable has been removed from the converter box as outlined in the previous section.

1- Remove the shift converter box from the mounting brackets. Remove the 7/16" nut securing the idler pulley in place, and then remove the idler pulley. **TAKE CARE** not to lose the nylon spacers installed on each side of the pulley. Turn the converter box over and remove the cotter pin, washers, pin, spring, and pawls.

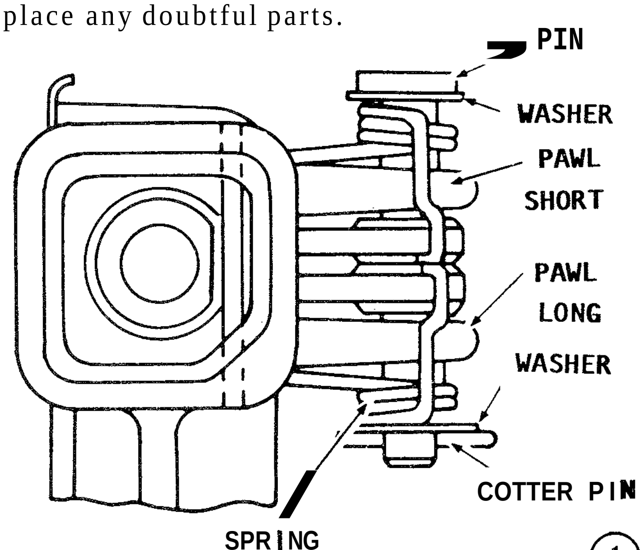
2- Push in on the cable tensioner rack with a screwdriver and at the same time, insert a nail or cotter pin in the rectangular tubing to hold the rack in place. Drive out the roll pin with a punch. **TAKE NOTE:** The cable tensioner rack is spring-loaded. Therefore, use caution when removing the nail or cotter pin inserted earlier in this step. Before removing the pin, **ALWAYS** aim the open end of the tensioner rack away from your body or another person. Push in



on the cable tensioner rack again with a screwdriver and at the same time remove the nail or cotter pin. **SLOWLY** release the pressure on the screwdriver until the spring is completely extended. Remove the cable tensioner rack, liner, and spring.

CLEANING AND INSPECTING

Inspect all of the converter box parts for excessive wear, burrs, nicks, or cracks. Replace any doubtful parts.

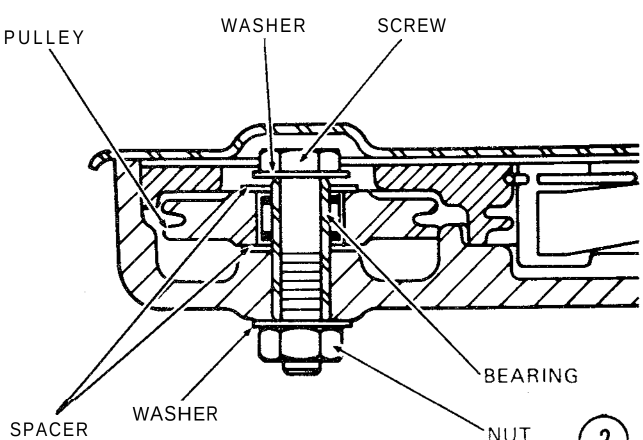


1

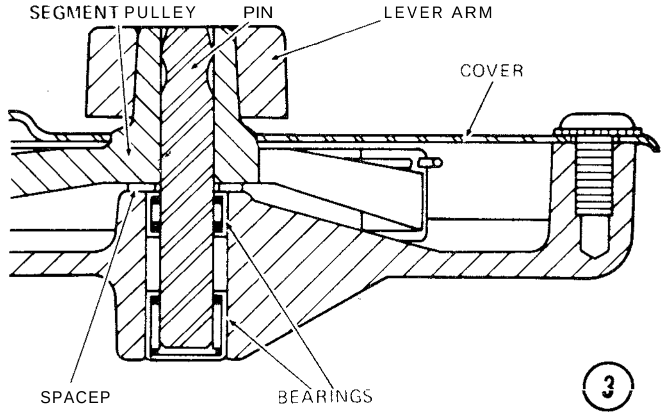
SHIFT CONVERTER ASSEMBLING

In order for the shift mechanism to function efficiently, careful attention **MUST** be taken to ensure each part is installed properly and in sequence.

1– Install the rack, spring, and liner. Drive the roll pin into place with a punch and hammer. Install the pin, washer, spring, short pawl, long pawl, washer, and the cotter pin. The short pawl **MUST** be installed nearest the pin head.



2



3

2- Lubricate the idler pulley bearing with OMC Multi–Purpose, or equivalent, grease. Install the mounting screw, two washers, two spacers, and the nut. Tighten the nut to a torque value of 5–7 ft-lbs.

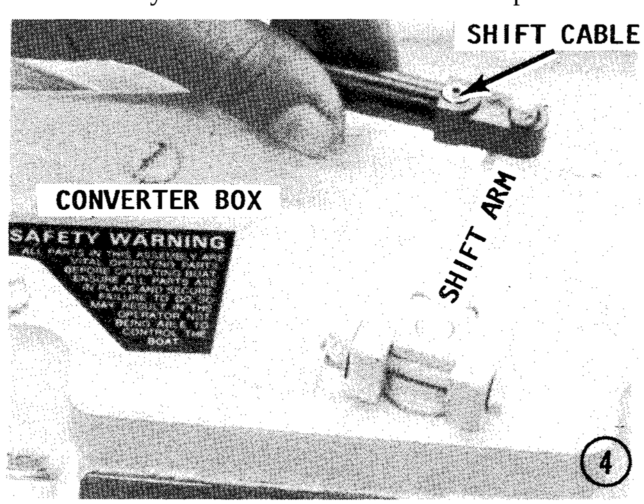
3- Install the shift housing cable guide. Lubricate the lever arm and the two pin asembly bearings with OMC Multi–Purpose, or equivalent, grease. Install the cover, segment pulley, and spacer.

4- Install the shift converter assembly onto the mounting brackets at the rear of the engine. To replace and adjust the shift cables, see Section 10–60.

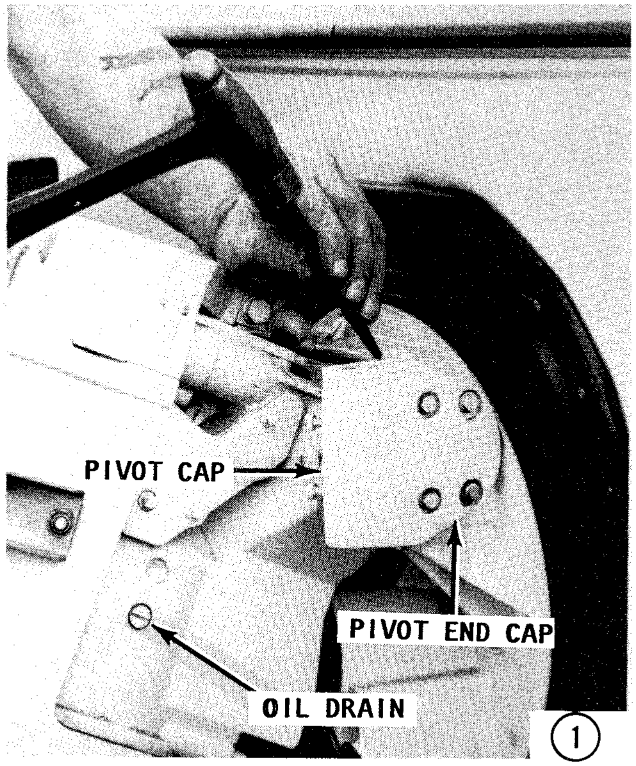
10–26 STERN DRIVE REMOVAL MODELS SINCE 1978

Before the stern drive can be removed, the shift cables must be removed; see Section 10–25.

1– Tilt the stern drive upward approximately 10 to 15 degrees. **TAKE CARE** to be sure the pivot liners remain on the pivot arms to protect the machined surfaces and that the pivot caps are kept in order to permit installation on the same side from which they are removed. Each cap on the



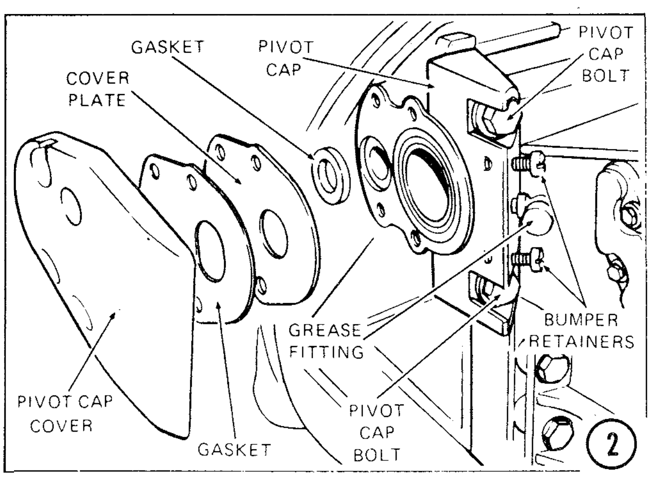
4

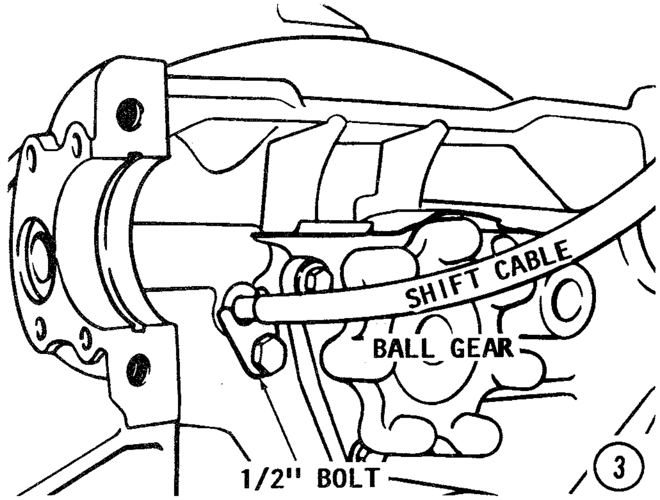


top of the intermediate housing has a **R** or L mark for indentification. If you are unable to clearly determine the mark, then make your own mark with a centerpunch to ensure the caps will be installed properly. **THE CAPS MUST NEVER BE INTERCHANGED.**

2– Remove the four cap screws securing the end cover plates to the intermediate housing. Remove the ground wire between the cap screws and the rear pivot cap screw. This wire is used to ground the lower unit and if this wire is not installed **BE SURE** to do so during assembly.

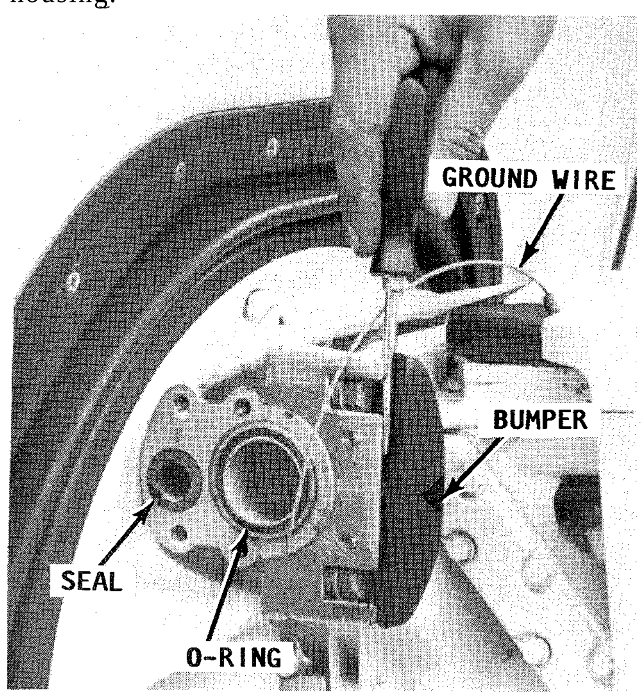
3– Remove the rubber pads covering each of the pivot caps. Raise the stern drive up to the full tilt position, and then remove the 1/2" bolt and keeper securing the shift cable to the intermediate housing.



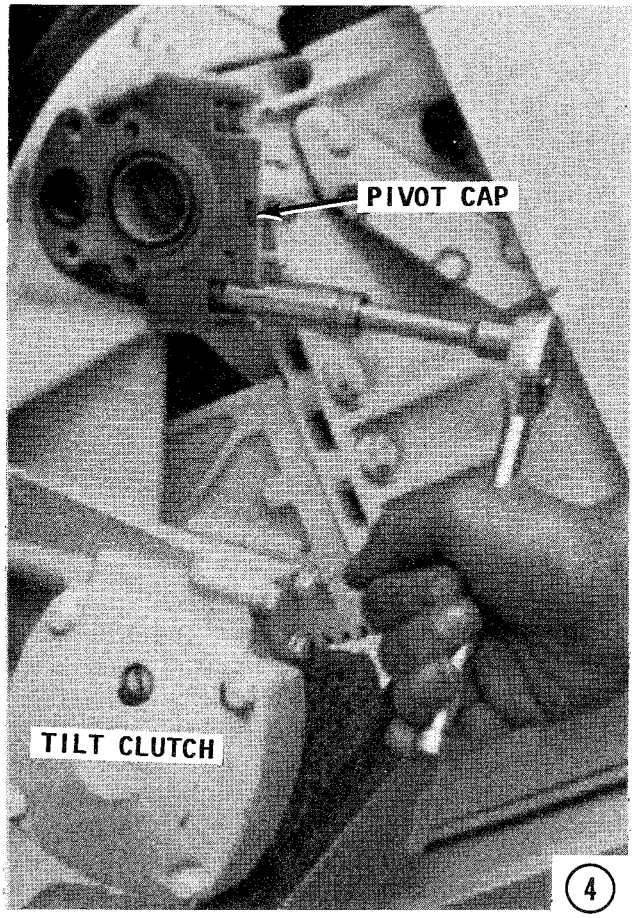


4– SUPPORT the unit by holding the exhaust outlet in an upward position, and remove the four pivot cap screws.

5– After the pivot caps have been removed, use the tilt quadrant as a lever and ease the unit back while carefully feeding the shift cable from the intermediate housing. The knobs on the cable stop water from entering the boat. **MARK** the ball gears to ensure proper tooth engagement during installation. Support the stern drive in some type of fixture and remove the plugs identified as **OIL DRAIN** and **OIL LEVEL** or **VENT,** then drain the oil from the upper housing. The oil level measurement is accomplished with a dip stick in the center of the exhaust housing.



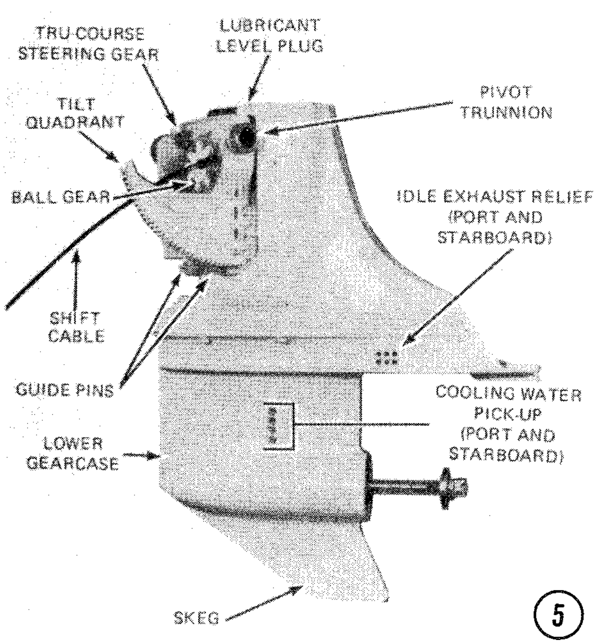
The stern drive MUST be in the full down position before the rubber bumper can be removed.



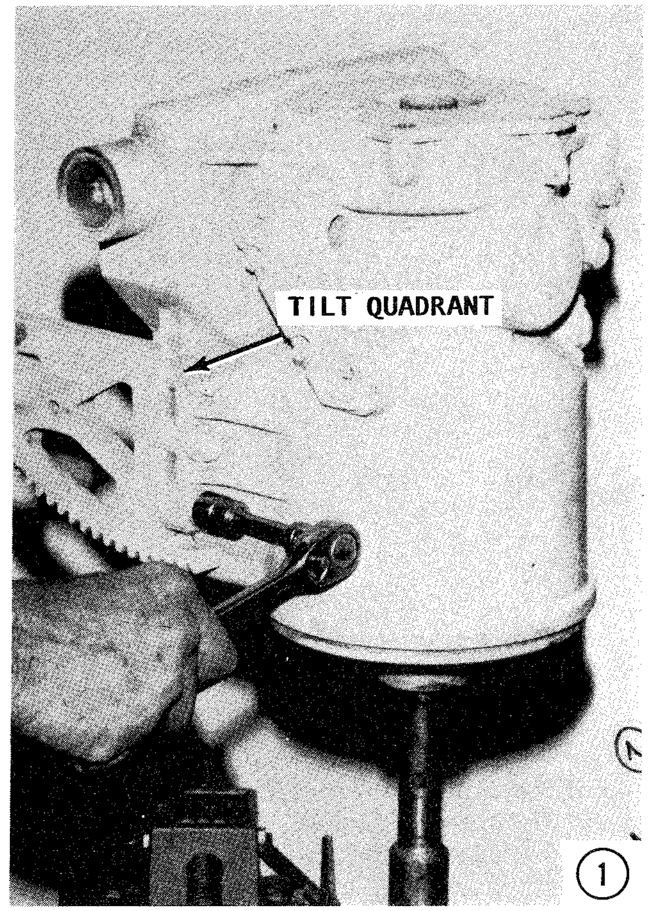
4

10-27 UPPER GEAR HOUSING REMOVAL MODELS SINCE 1978

1- It is not necessary to remove the tilt quadrant, unless the unit is damaged. To do so, first remove the three bolts on the port side of the unit.



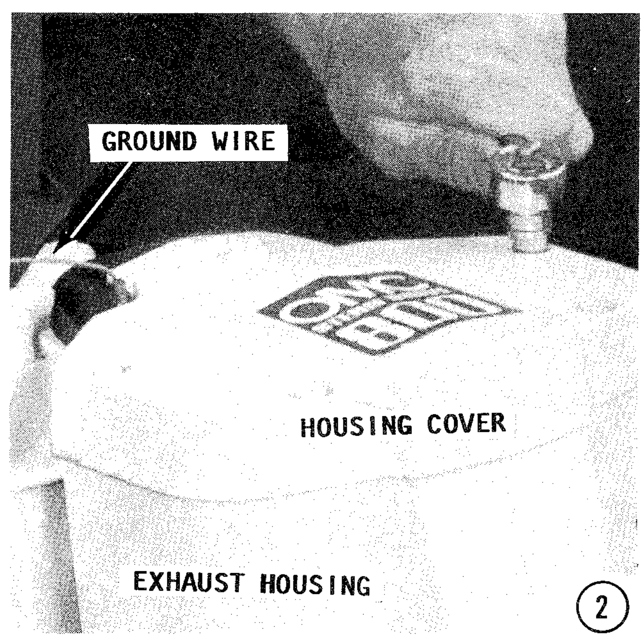
5



1

2- Remove the exhaust housing cover attaching screws.

3- Pry and work the cover free of the exhaust housing. TAKE CARE not to force the cover. Remove the spring used to provide a good ground. Remove the spring and clamp from the shift cable and move the cable to one side.



2

4- Lift the upper gear housing straight up; tilt it back; feed the shift cable out of the upper gear housing as the housing is moved free of the lower unit. Remove the large nylon washer from the bottom of the swivel housing. **TAKE NOTE** how one side of the washer is concave to fit against the swivel housing. If the upper gear housing does not require service, set it aside and continue with Section 10-39 for servicing the lower unit.

10-28 WATER PUMP REMOVAL MODELS SINCE 1978

Replacement of the water pump in the stern drive involves many tasks, considerable time, and attention to detail, to ensure proper performance after the work is completed.

As an assist in understanding more about the stern drive water pump, the following paragraphs explain which units must be removed IN **SEQUENCE** in order to replace the water pump.

The water pump is located inside the stern drive. Therefore, the stern drive must be removed. See Stern Drive Removal, Section 10-26.

The water pump is located in the lower section of the upper housing. Therefore, the upper housing must be removed from the lower housing as detailed in Upper Housing Removal, Section 10-27.

Remove the water pump as detailed in the latter part of this section.

TAKE NOTE It is possible to install the water pump without servicing the swivel housing. However, if it is not performed, the new pump may not move enough water to the engine and replacement of the pump will not give the desired results.

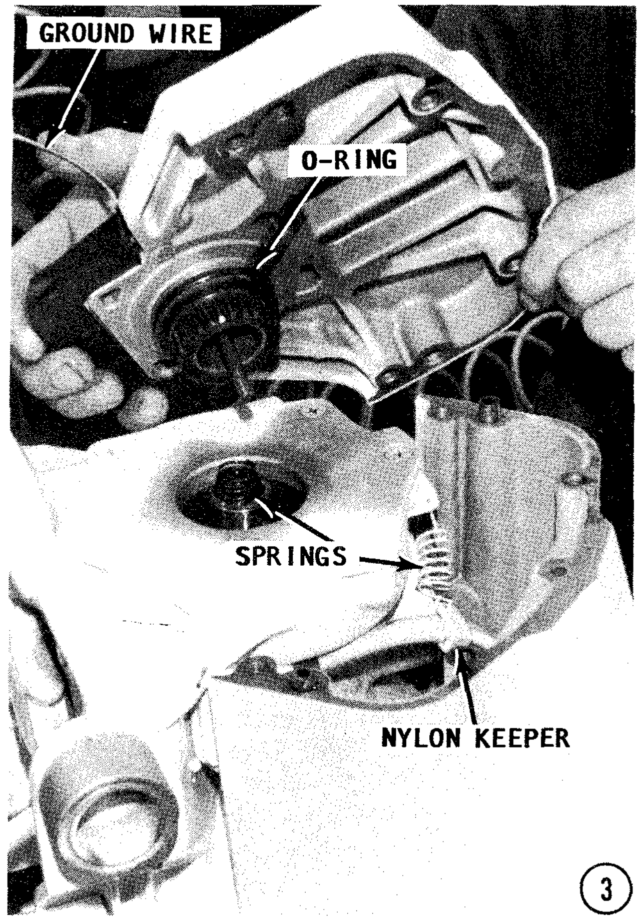
The exhaust housing is not considered a part of the water pump repair. However, the housing must be removed in order to remove the swivel housing.

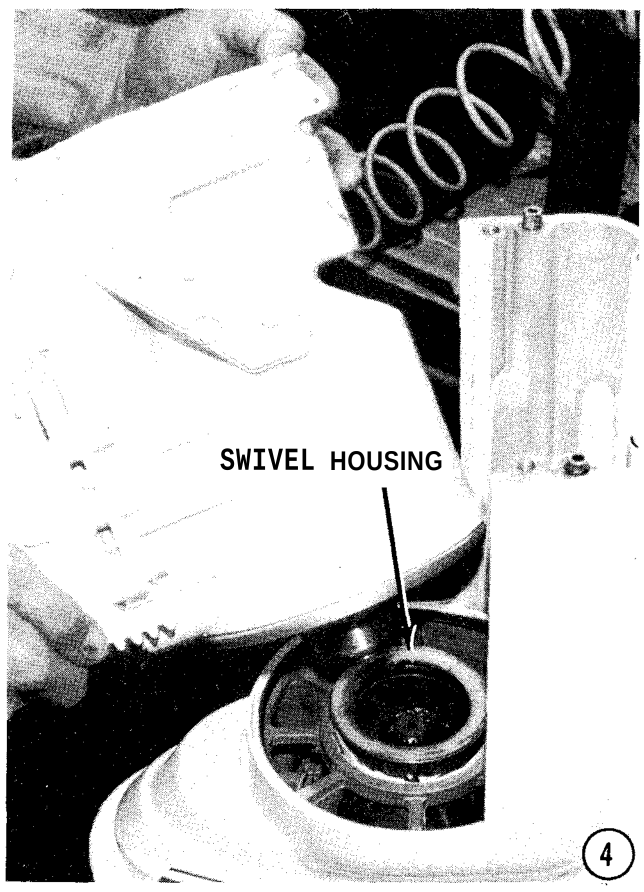
Therefore, remove the exhaust housing, see Exhaust Housing Removal, Section 10-35.

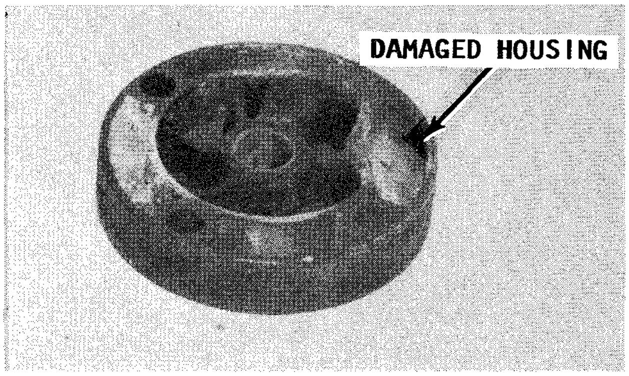
The swivel housing plays a critical role in the cooling system. Any exhaust gases or leakage at the swivel housing will cause failure of a new water pump.

Therefore, remove the swivel housing; see Section 10-36.

TAKE NOTE: The following steps take up the work after the upper gear





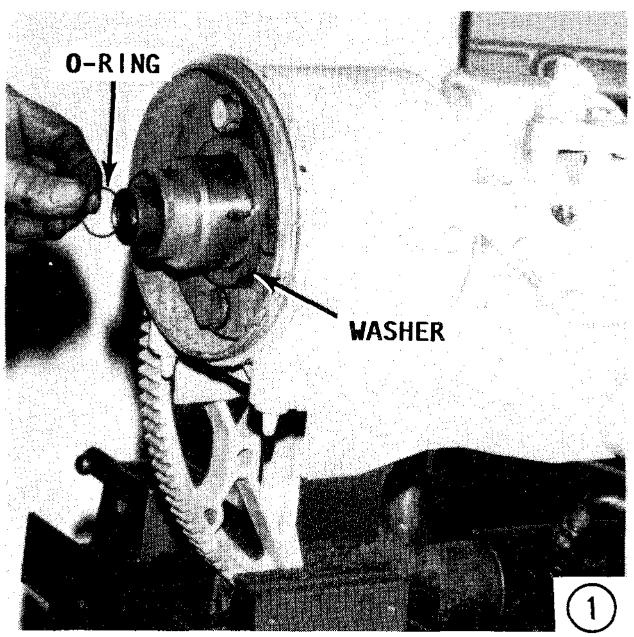


Water froze in this stern drive water pump because the boat was stored with the stern drive in the up position and water was trapped inside the pump. ALWAYS lower the stern drive when laying-up the boat for winter storage.

housing has been removed, as described in Section 10-27.

1- Remove and discard the O-ring in the groove in the lower end of the water pump shaft. **NEVER** attempt to use an old ring. **ALWAYS** use a new one during installation.

2- Remove the four bolts securing the swivel housing in the upper housing. Remove the swivel housing. If necessary, tap the swivel housing with a light mallet to break the seal on the water pump plate. Lift the driveshaft, impeller plate, impeller, and impeller housing off 2s an assembly. It may be necessary to use a punch and tap the impeller housing out of the bearing housing. Remove and discard the spline seals from the top of the driveshaft, and then lift the impeller and impeller housing off the driveshaft. **ALWAYS** replace the housing key and plate to prevent overheating.



CLEANING AND INSPECTING

Inspect the water pump plate for wear and corrosion. If any part of the pump is defective, **REPLACE** the pump as an assembly. **NEVER** attempt to repair the unit.

WATER PUMP ASSEMBLING

Assembly of the water pump is covered in Section 10-34, in sequence with other assembly and installation work on the upper unit.

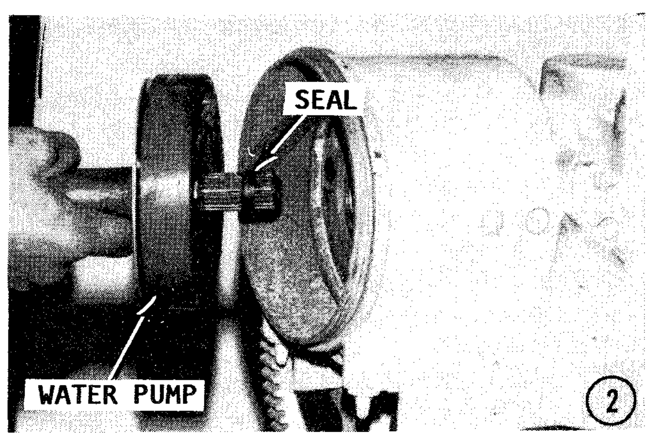
10-29 BALL GEAR DISASSEMBLING MODELS SINCE 1978

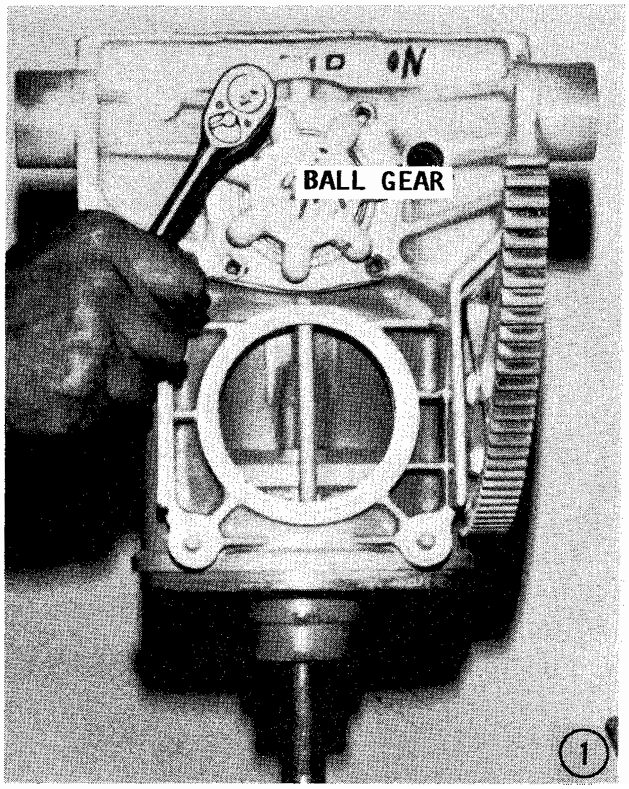
1- Remove the four screws and lockwashers from the input ball gear in the upper gear-housing. Pry the assembly out of the gearcase with a large screwdriver positioned at one side of the opening in the top of the gearcase. Remove the color-coded shims from the rear of the bearing retainer. There should be no more than two shims.

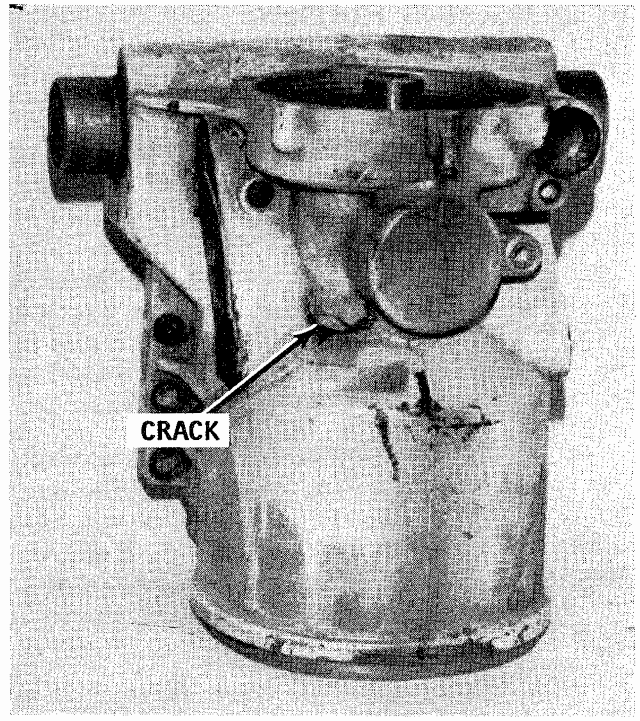
2- Two seals are installed behind the ball gear. To replace these seals, the plug in the center of the ball gear must be removed. Remove the plug by first punching a hole in the plug and then popping it out of the ball gear.

3- On all models, in addition to being pressed onto the shaft, the ball gear is further secured with a nut. Remove the nut securing the ball gear to the shaft, and then press the ball gear from the shaft. Remove the seal cap and two seals. **TAKE NOTE** how the seals are installed **BACK-TO-BACK** with the seal lips pointing in opposite directions.

4- The ball gear assembly has a bearing cup and shims located in the rear of the

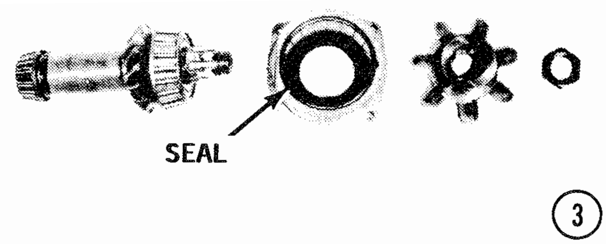


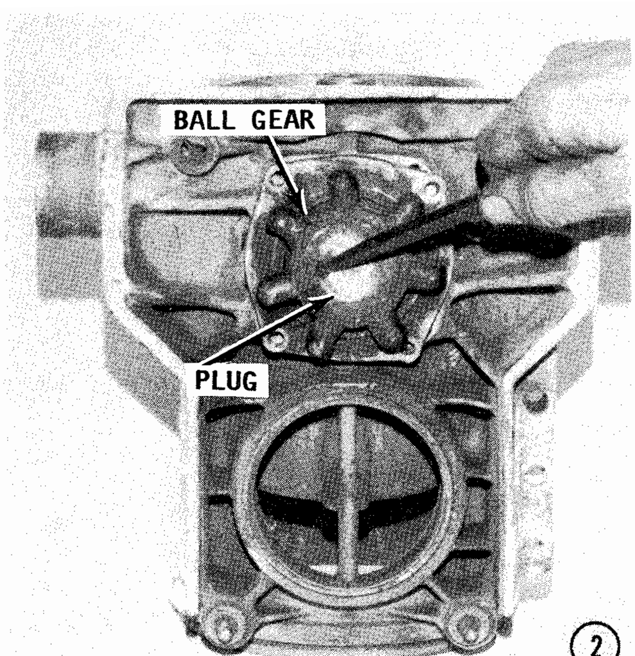


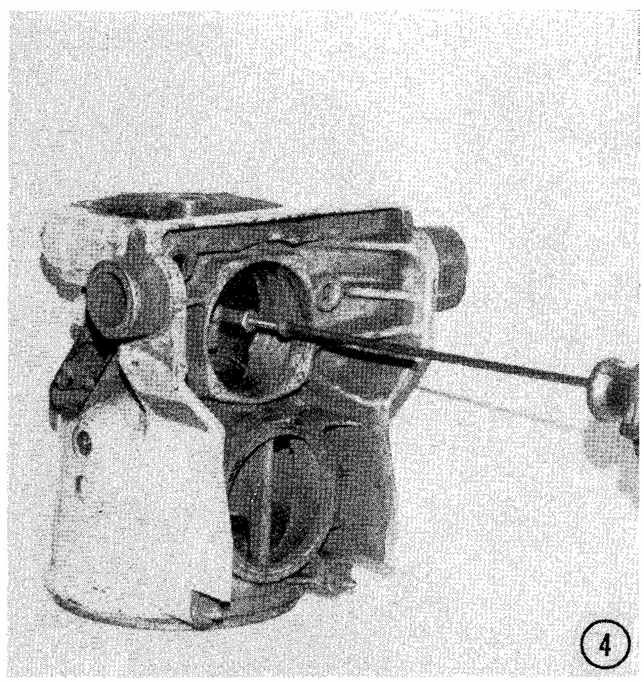


This upper housing failed because it was not shimmed properly. The text explains in detail how to prevent this type of expensive damage.

upper gearcase retained with Loctite. The cup may be very difficult to remove. For this reason, puller-relief grooves are provided at the top and bottom of the gearcase to permit use of a slide hammer. Remove the cup, and then the shims.





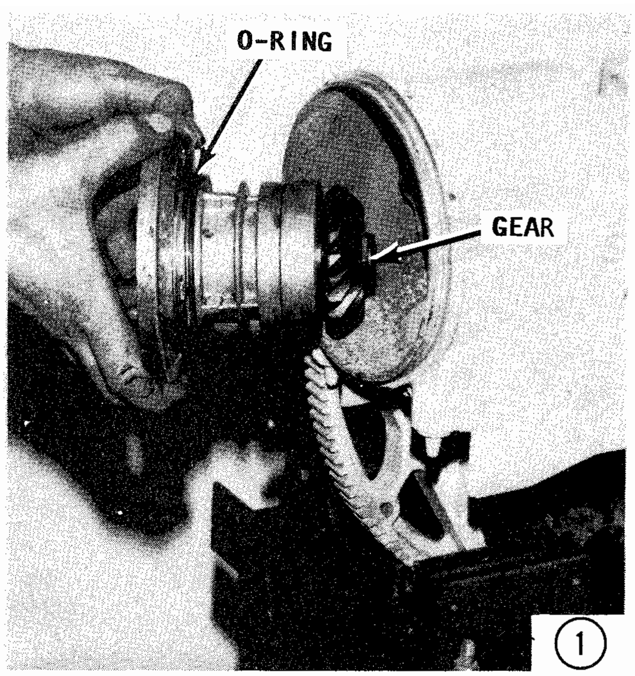


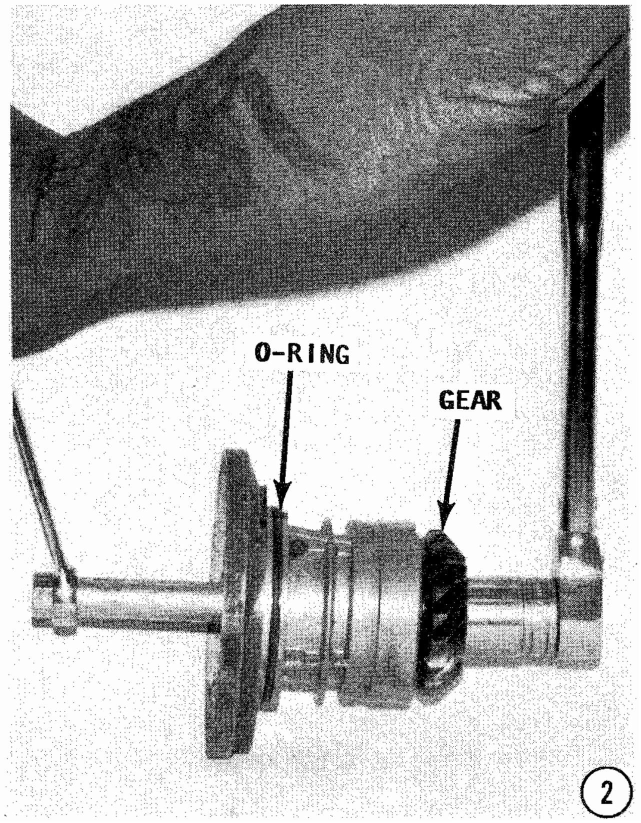
10-30 BEARING HOUSING DISASSEMBLING MODELS SINCE 1978

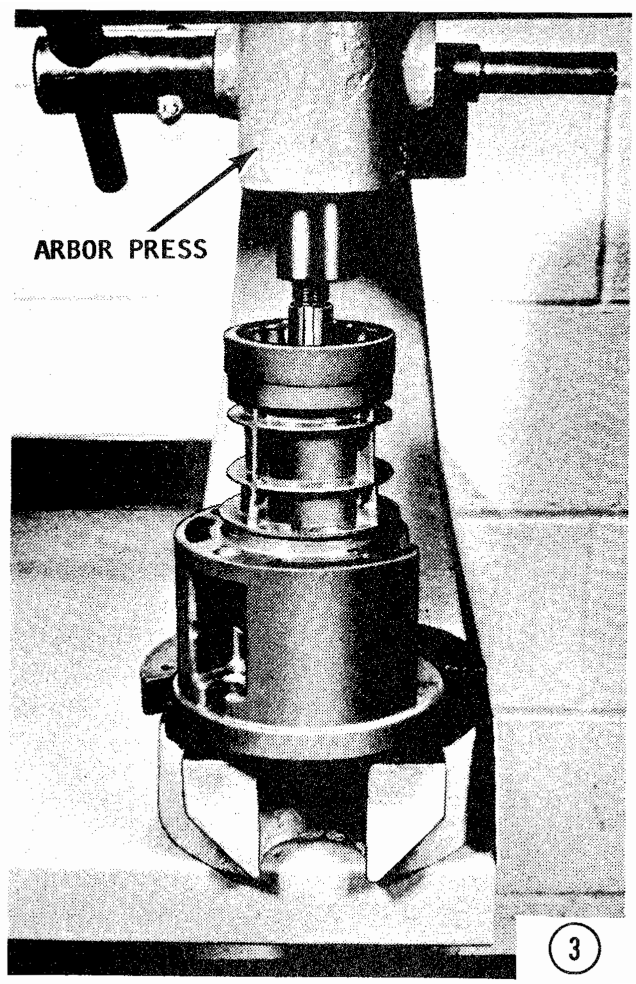
1– An O–ring holds the bearing housing in the upper gearcase. To remove the bearing housing, grasp it firmly and snap it straight back and out of the gearcase. Remove and DISCARD the O–ring. DISCARD the shims installed on top of the bearing housing to establish the proper tolerances in the drive system parts. ALWAYS install a new O–ring and shims during installation.

2– Secure the pinion gear nut in a vise. Use special socket, No. 311875, to remove the driveshaft nut. DISCARD the nut because it has lost its locking ability. Remove the pinion gear and bearing assembly from the upper driveshaft. Remove and discard the O–ring seal.

3– Two seals hold the upper driveshaft in position in the bearing housing. Place the bearing housing on a soft base in an arbor press, and then CAREFULLY force the driveshaft and seals from the housing. **TAKE NOTE** how the seals are installed **BACK-TO-BACK** with the seal lips pointing in opposite directions. DISCARD the seals. **ALWAYS** install new seals as a prevention against leaks. The pinion gear and bearing are serviced **ONLY** as an assembly. Individual replacement parts are not available. Therefore, shimming is always required to obtain the proper running clearance.







10-31 WORM GEAR STEERING DISASSEMBLING MODELS SINCE 1978

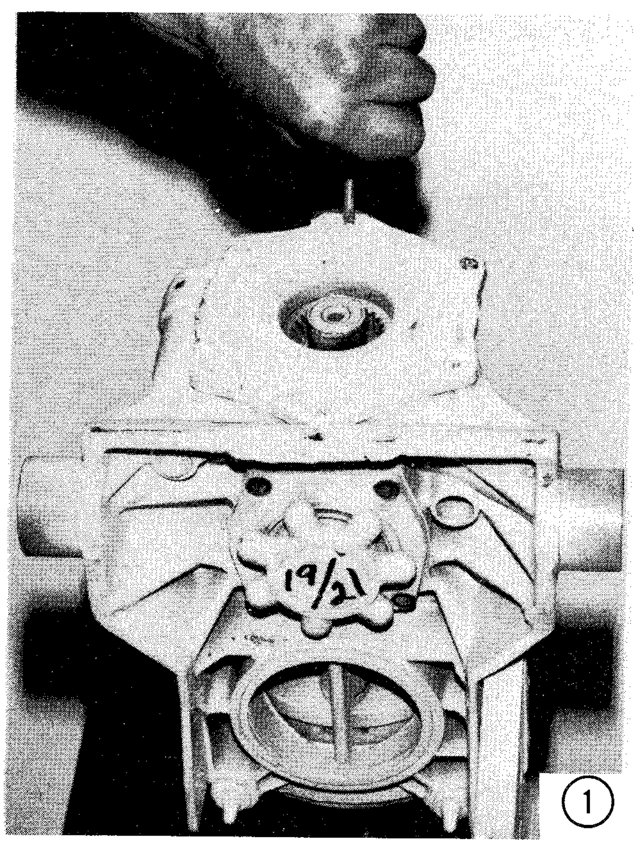
1- Remove the upper gear housing cover plate by removing the six screws.

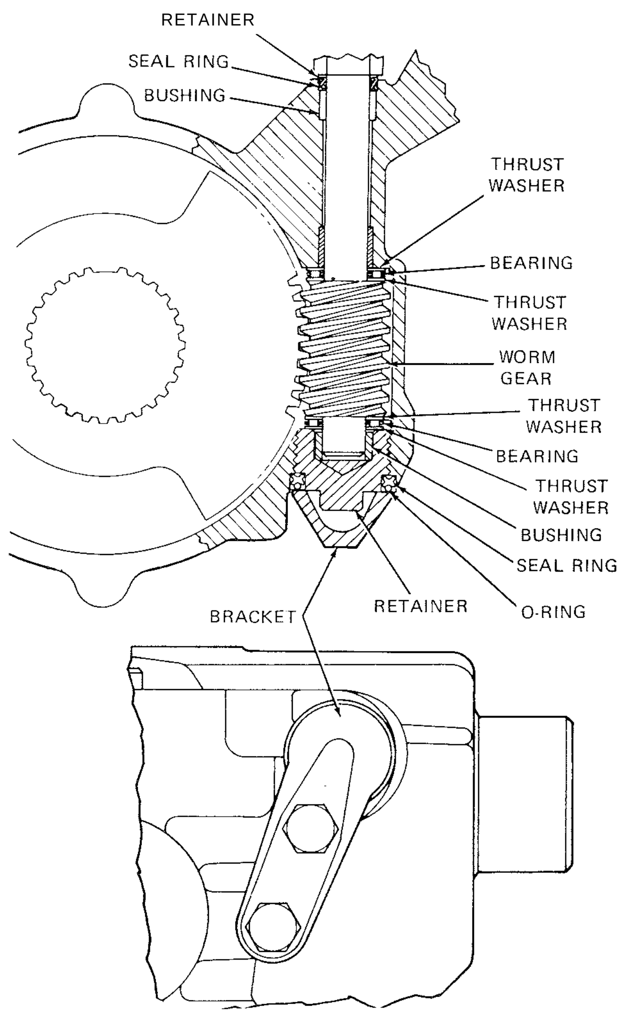
2- Rotate the spur gear at the front of the gearcase counterclockwise until the worm wheel is at the rear of the gearcase; then lift the worm wheel straight up and out. Notice the number of shims on the pivot shoulder at the top of the upper gear-case. These shims restrict the up-and-down movement of the vertical drive to 0.005" to 0.015". A damaged shim **MUST** be replaced in order to obtain the proper tolerance.

CLEANING AND INSPECTING

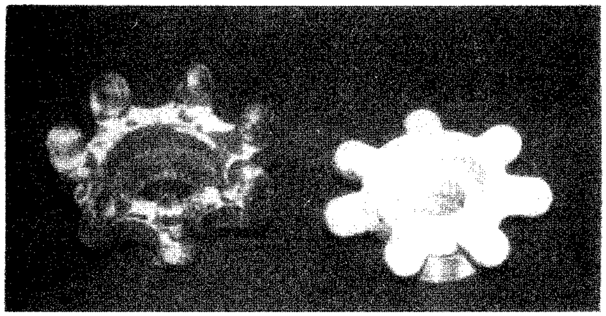
Wash all parts in solvent and blow them dry with compressed air. **NEVER SPIN** the ball or roller bearings with air or they will be ruined. Remove all seal and gasket material from mating surfaces. Blow all water and oil passages, and screw holes clean with air.

After the parts are clean and dry, apply a coating of light engine oil to the bearings and bright mating surfaces of the shafts and gears as a prevention against corrosion.





The retaining bracket installed on late model stern drive units to prevent the worm gear from working out of the upper gear housing.



*Worn ball gear (left) MUST be replaced with a new **one** (right).*

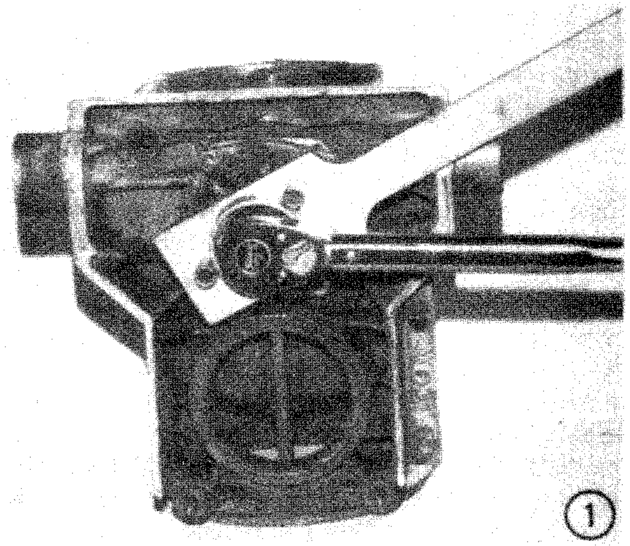
Check for evidence of water in the oil reservoir of the upper gearcase. If there is any sign of water, check the oil retainer seals and O-rings to be sure they are in good condition and are properly installed. Any water in the oil reservoir most likely entered the upper gearcase through the water pump bolt cavities. To prevent further water from entering, the water pump bolt threads MUST be coated with Permatex No. 2 during assembly.

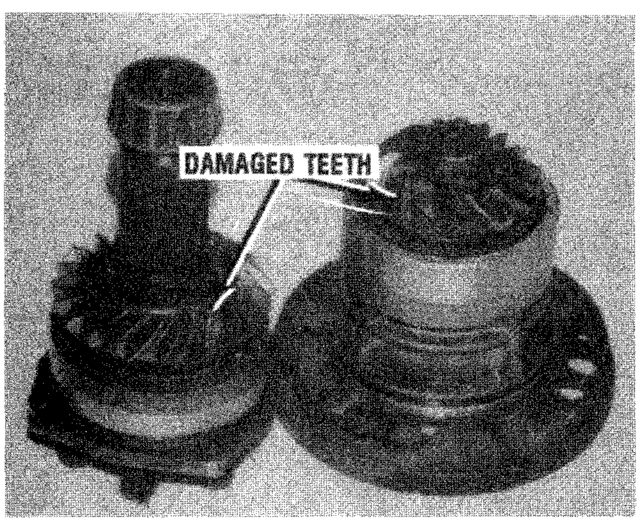
Inspect the shaft bearing surfaces, splines, and keyways for wear and burrs. Check for evidence of an inner bearing race turning on the shaft. Check for damaged threads. Roll the shaft on a flat surface and check to be sure it is not bent.

Carefully check the inside and outside surfaces of the gearcases, housing, and covers for cracks. Pay special attention to the areas around screw and shaft holes. Verify all traces of old gasket material have been removed from mating surfaces. Check O-ring grooves for sharp edges which could cut a new seal. Inspect gear teeth and shaft holes for wear and burrs.

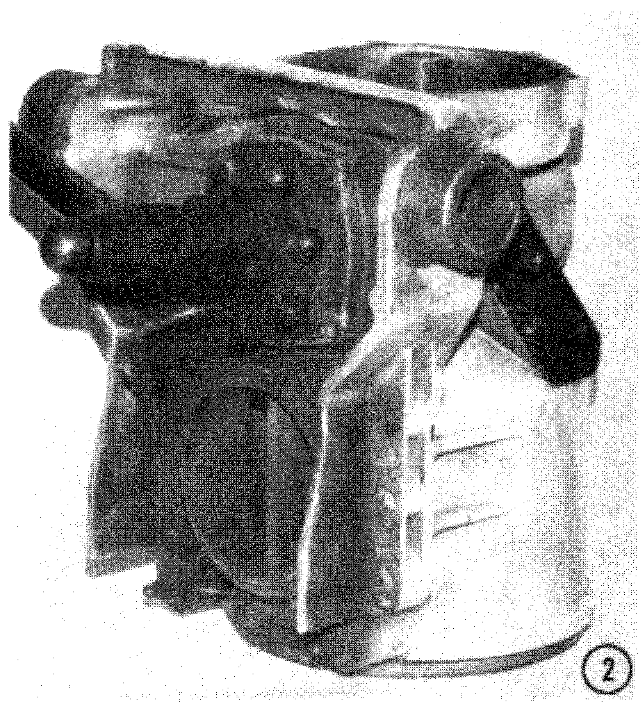
Inspect all bearings for roughness, pitting, and flat spots, by holding the center bearing race and turning the outer race. Check the outside diameter of the outer races and the inside diameter of the inner races for evidence of turning in the housing or on a shaft. Any sign of discoloration or scores is an indication of overheating.

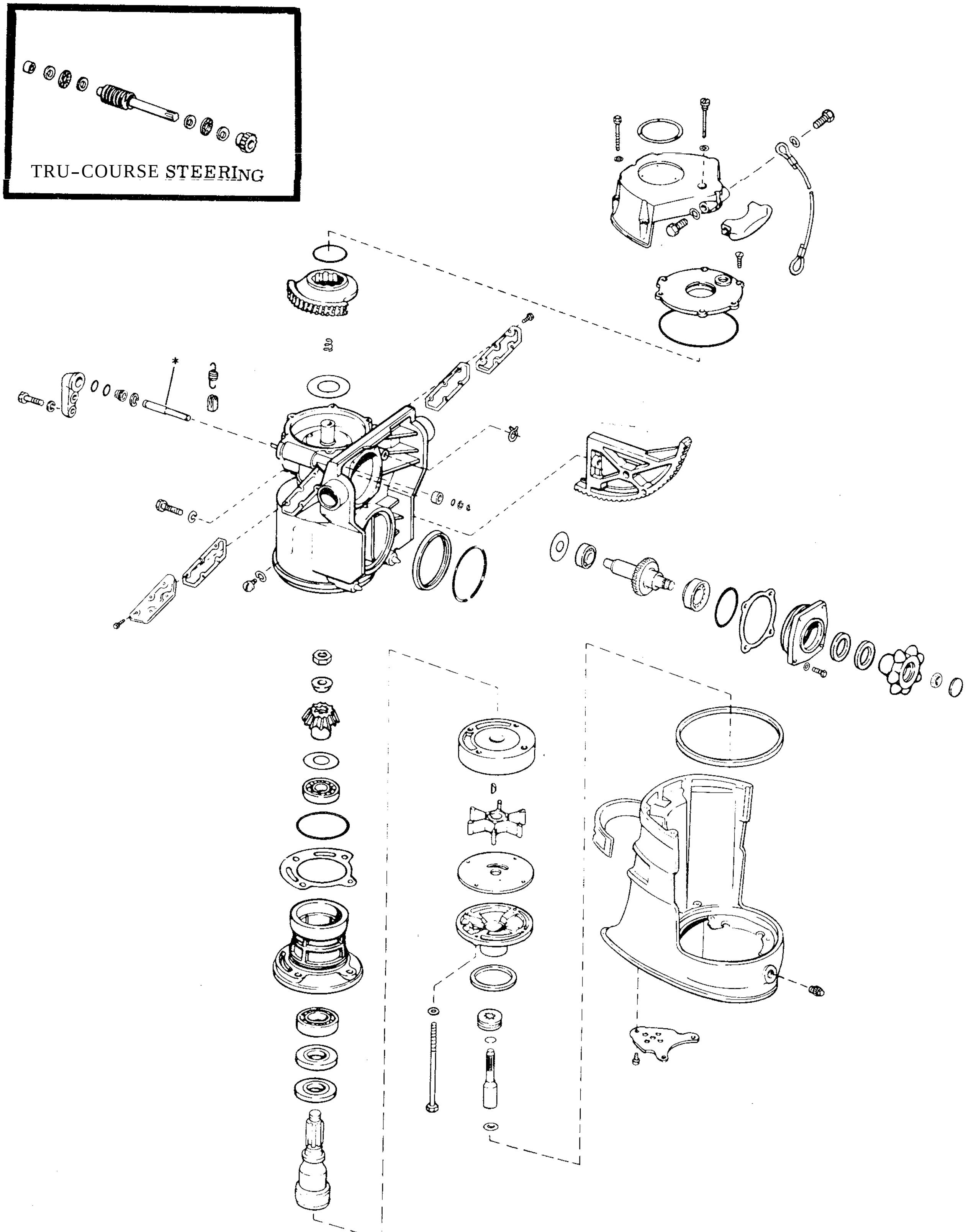
Check the thrust washers for wear and distortion. If they do not have uniform thickness and lay flat, they MUST be replaced.





Damaged pinion gear teeth may be the result of overheating and/or lack of adequate lubrication. Improper shimming will usually cause discoloration and/or excessive gear wear.





Exploded view *of the upper gear housing.*

10-32 BALL GEAR ASSEMBLING MODELS SINCE 1978

1- Install the ball gear shaft into the upper housing **WITHOUT** the O-ring and shims. Install a couple bolts to hold the bearing cap. The unit will stay in place and enable you to install the ball gear onto the driveshaft. **CHECK** to be sure the splines are clean. Install the nut, if one is used, and tighten it to a torque value of 96 ft-lbs.

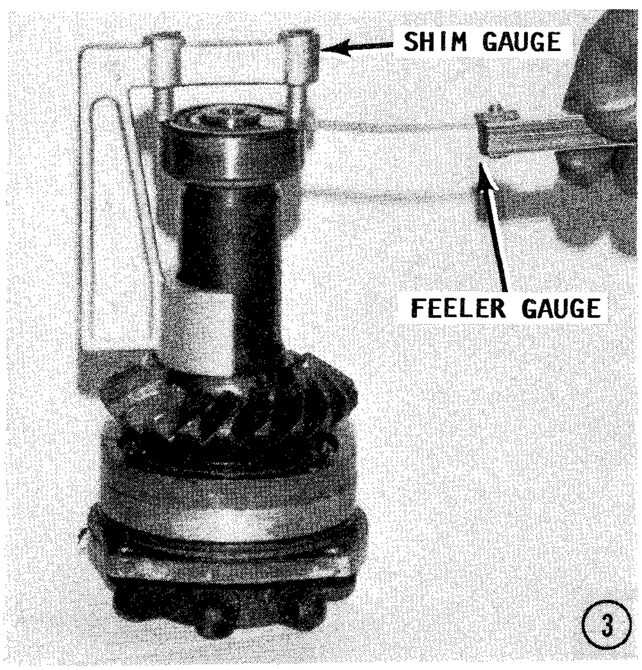
2- Install the seal plug over the nut in the center of the ball gear and flatten the plug with a hammer. Now, remove the assembly in preparation for proper shimming of the driveshaft.

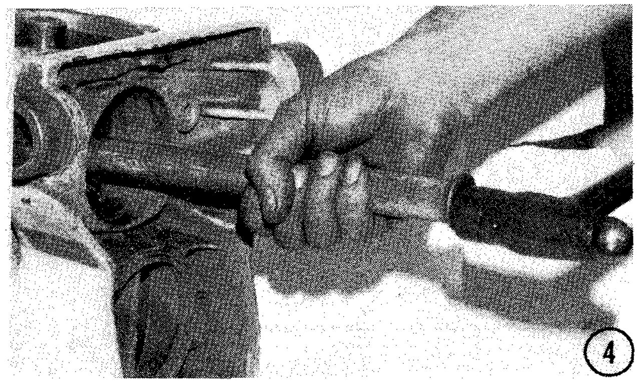
3- This step outlines the procedure for determining the amount of shimming required for the driveshaft. Obtain special shimming tool for the unit being serviced as follows:

Part No. 908573
400 and 800 Stern Drives -- Since 1978

Part No. 908572
3.8 Litre -- Since 1981

First, it is necessary to determine the number of shims required to locate the bearing cup properly at the rear of the upper gearcase. The cup locates the ball gear driveshaft and gear within the gearcase. Place the bearing cup on the bearing, at the rear end of the shaft. Now, apply equal pressure around the cup while rotating

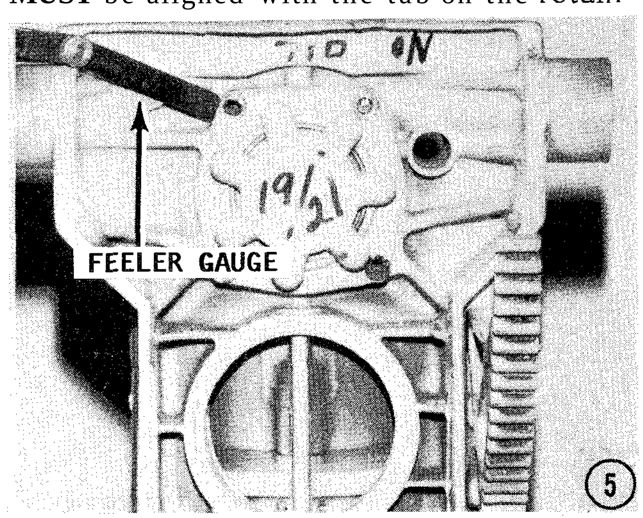




the cup to break the oil film. Next, locate and position the shim gauge, as shown. Load and rotate the bearing while measuring the gap between the shim gauge and the loaded bearing cup with a feeler gauge. The measurement equals the amount of shimming required to locate the gear in the proper position. Place the upper gear housing on a suitable surface with a wooden block under the bearing cup.

4- Handle the shim **CAREFULLY.** If it is bent or becomes the least bit distorted, it **MUST** be replaced. Position the shim in the bearing cup. Use the "ball gear bearing race installer and drive handle" to **CAREFULLY** drive the cup squarely into its seat.

5- Make a trial assembly by inserting the assembly into the gearcase **WITHOUT** the bearing retainer or O-ring seal. Press down on the bearing assembly and at the same time turn the ball gear to break the oil film. Measure the gap between the gearcase and the rear of the bearing retainer with a feeler gauge. This measurement **LESS** 0.002" equals the shims required to properly **PRELOAD** the ball gear shaft bearing. **TAKE NOTE** how each shim has a tab on its upper edge. This tab on the shim **MUST** be aligned with the tab on the retain-

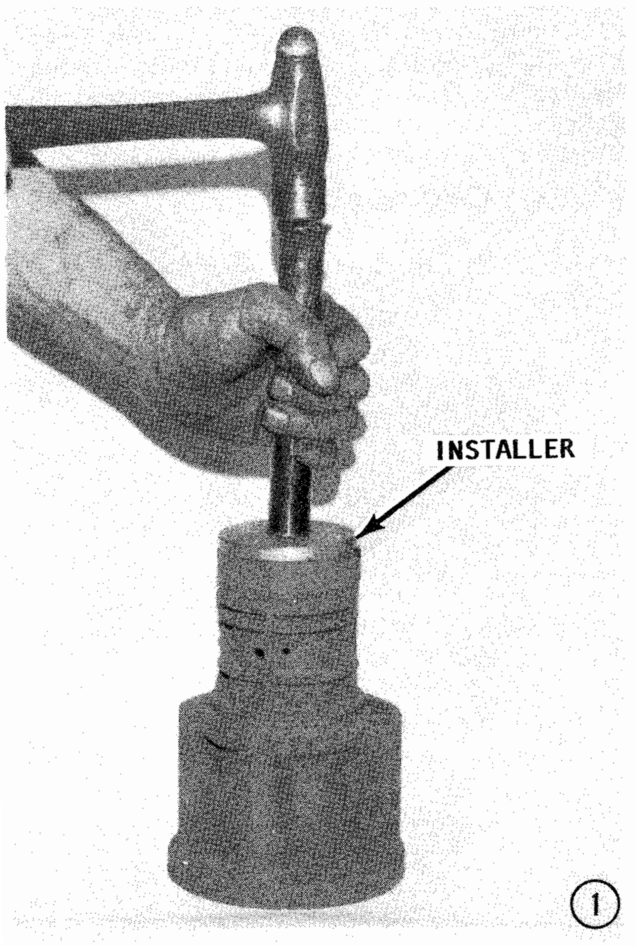


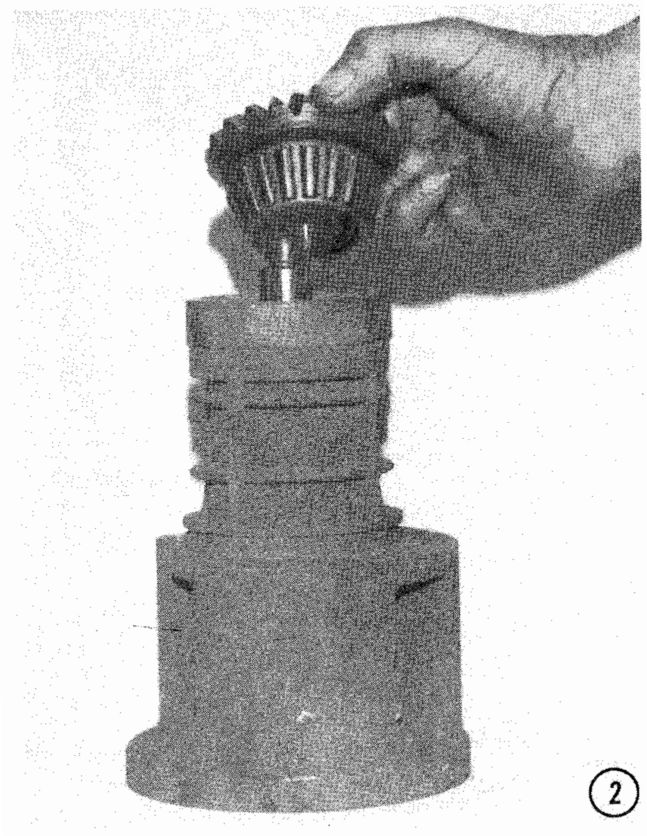
er. Install the O-ring seal on the retainer. Place the ball gear shaft-and-bearing assembly into the upper gearcase and secure it with the screws and lockwashers. Tighten the screws to a torque value of 5-7 ft-lbs.

10-33 BEARING HOUSING ASSEMBLING MODELS SINCE 1978

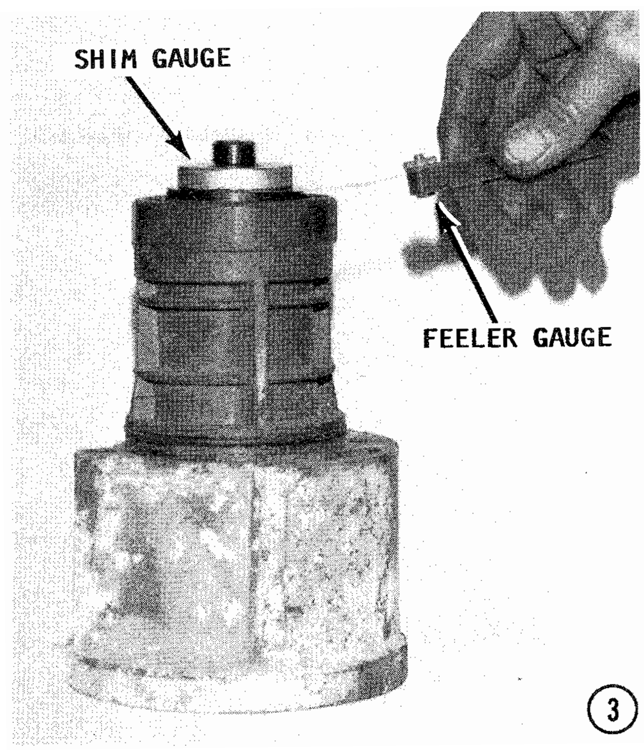
1- Press the top bearing cup into the housing using tool No. 314436. Install the cup in the bottom of the housing in the same manner using tool No. 314434.

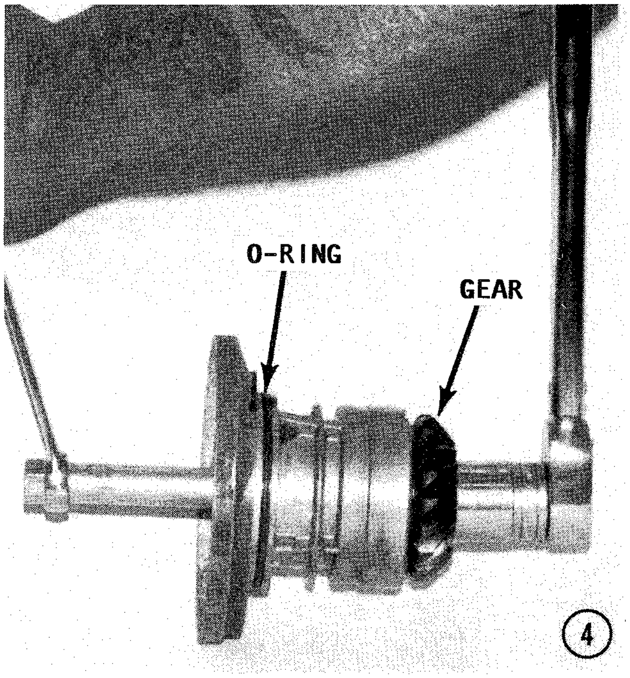
2- **TAKE** NOTE: If the original pinion gear and bearings are to be installed, then the old shims may be used, provided they are serviceable. If a new pinion gear or bearing is to be installed, the following procedure **MUST** be followed to determine the proper shims required to properly preload the bearing: First, position a support for the upper driveshaft in such a manner to allow the housing freedom to rotate. Set the support beneath the shaft, and then place the housing over the shaft. Exert a firm downward pressure on the housing and rotate the housing around the shaft to load





the housing and to break the oil film. The oil film **MUST BE BROKEN** before accurate shim measurements can be made. An unbroken oil film can cause the measurement to be in error by several thousands of an inch. Slide the pinion bearing onto the top of the driveshaft.



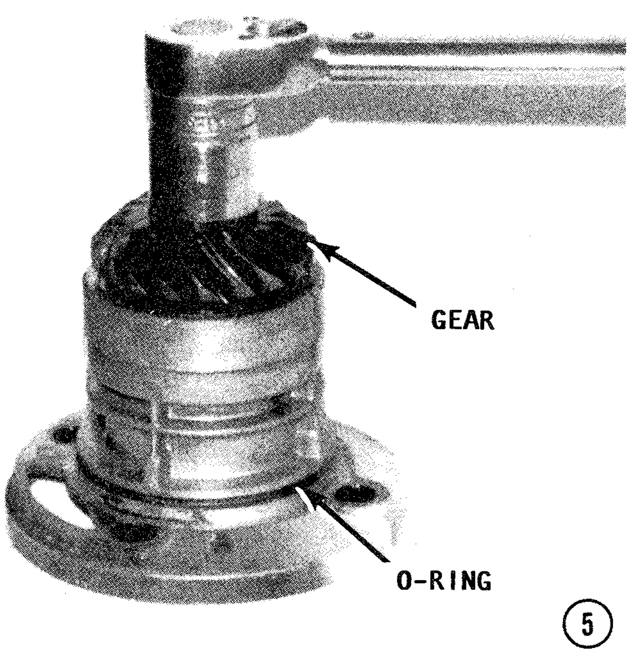


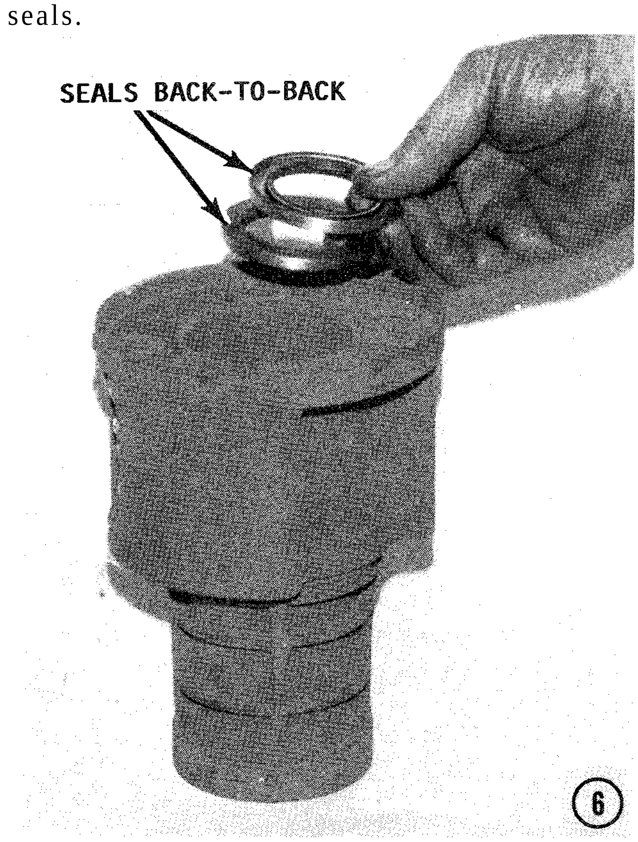
3- Place shim gauge tool No. 314725 over the shaft; press down on the bearing to apply a load; and then press down on the shim gauge to prevent it from moving. Continue to exert some pressure on the shim gauge and measure the gap between the shim gauge and the inner race of the bearing. The measurement will indicate the amount of shimming required to properly preload the vertical-drive-bearing. A minimum of one shim and a maximum of three shims **MUST** be used. The illustration does not show preloading in order to afford a clear view of the measurements. The parts catalogue will indicate the proper part numbers of available size shims. Lubricate the gear and bearing with No. 80 gear oil. Position the correct size and number of shims on the gear. Use Tool No. 314437 to press the bearing onto the gear with an arbor press.

4- Install the pinion gear and bearing onto the upper driveshaft. **ALWAYS** use a new locknut because the locking ability of the old one is ruined when it is removed. Install the nut finger-tight. Use Tool No. 314438 and a vise on the lower end of the driveshaft. Tighten the locknut to a torque value of 70-80 ft-lbs.

5- Stand the bearing housing on end. Use a torque wrench and socket to check the rolling torque value which should not exceed 28 in.-lbs. If the torque value is more, perform step 3, in order to determine the proper size and number of shims.

6- Apply a light coating of Anti-corrosion Lubricant onto the two bearing housing bottom seals. Position them **BACK-TO-BACK** with the lips facing in opposite directions over the bottom of the upper driveshaft. Place Tool No. 314694, behind the seals. Use an arbor press to seat the seals.





7– Shims must be used to position the bearing housing inside the upper gearcase. Obtain special shimming tool for the unit being serviced as follows:

Part No. *909078*
400 and 800 Stern Drives -- Since 1978

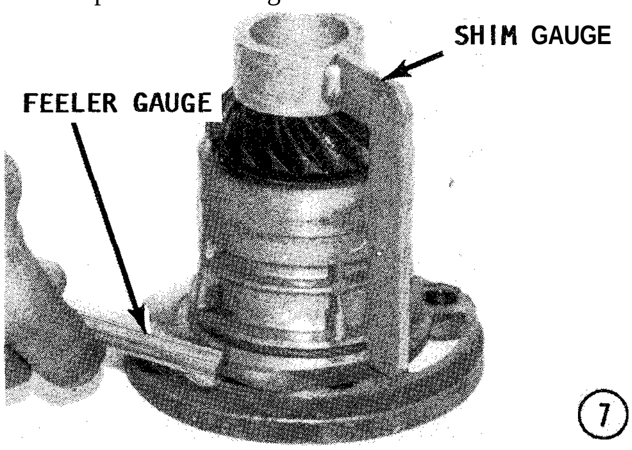
Part No. *907971*
3.8 Litre -- 1981–85
4.3 Litre -- 1986 and on

Load the pinion bearing and gear and at the same time, measure the clearance to determine the number and size shim/s necessary. Use Tool No. 909078 and measure the clearance between the tool and the housing, as shown.

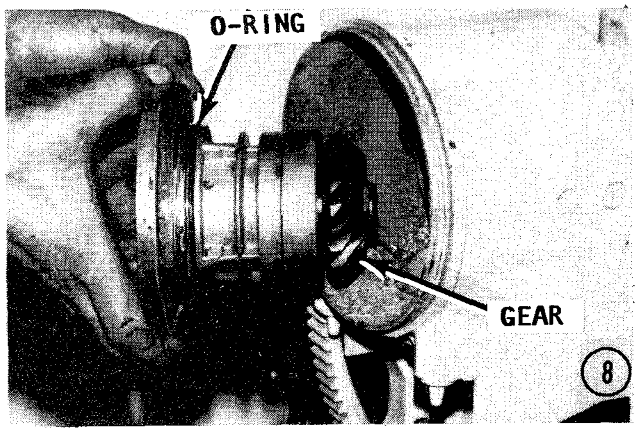
8– Position a **NEW** O-ring into the groove of the bearing housing. Install the bearing housing into the upper gear housing with all of the screws holes properly aligned.

10-34 WATER ***PUMP*** ASSEMBLING MODELS SINCE 1978

1– Slide the impeller plate onto the water pump shaft with the side stamped PUMP SIDE and T facing the impeller. Check to be sure the impeller wear surface is facing the externally splined end of the shaft. Install a NEW impeller key in the water pump driveshaft, and then a **NEW** impeller over the key. Apply a coating of Permatex No. 2 to the outer 1/4" of the upper and lower edges of the impeller plate to seal the impeller plate to the impeller and to the swivel housing. If Permatex is not used, the pump may pull exhaust gases into the pump cavity. Slide the impeller housing onto the shaft, and then turn the shaft clockwise until the impeller seats inside the housing. Rotate the impeller plate until the screw holes align with the holes in the impeller housing.



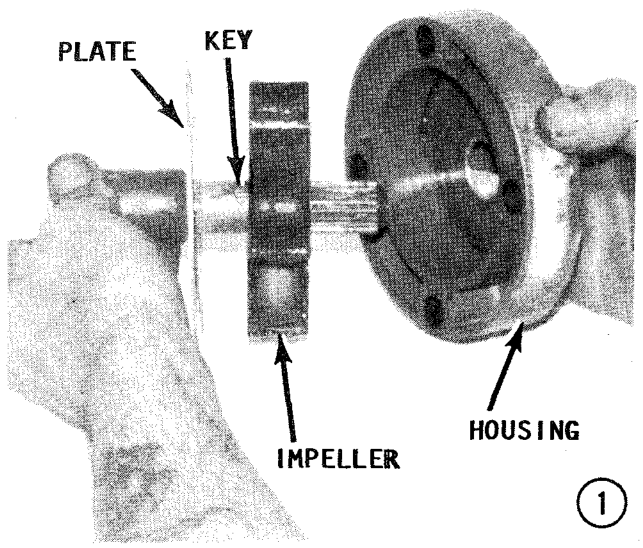
7



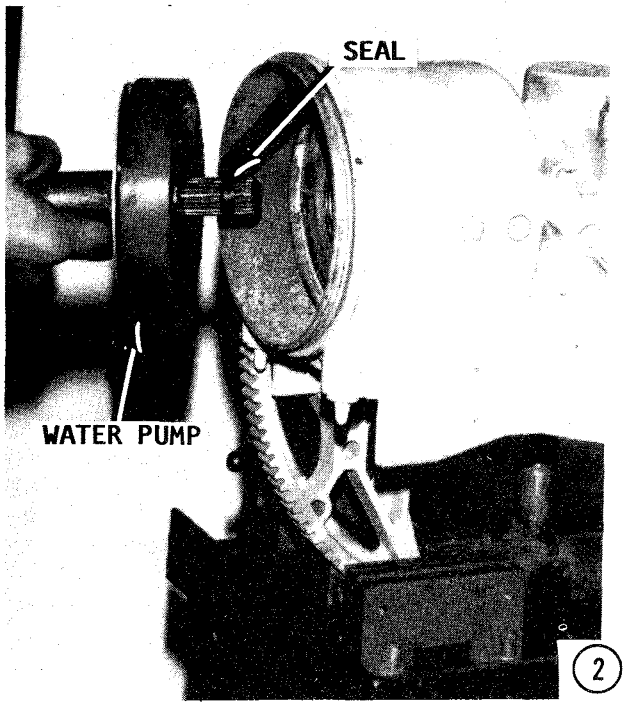
8

2– Use 3M Sealer EC1300 as an adhesive and install a new split seal onto the drive-shaft. Lubricate the seal and external shaft splines with gear oil. Install the assembled water pump into the bottom of the bearing housing. CHECK TO BE SURE the splines of the two shafts are properly engaged and the mounting holes of the bearing housing and water pump are aligned with those in the upper gearcase.

3– Install the swivel housing onto the water pump. Coat the threads of the attaching screws with Permatex No. 2, and then secure the bearing housing, water pump, and swivel housing with the screws and lockwashers. Tighten the screws **ALTERNATELY AND** JUST A LITTLE AT **A TIME** to avoid damaging the shims in the bearing housing. Tighten the screws to a torque value of 30–36 ft-lbs. Install a **NEW** O-ring seal into the groove inside the lower end of the water pump shaft. Apply a coating of OMC Sea Lube Multi-Purpose Grease to the splines inside the lower end of the water pump shaft.

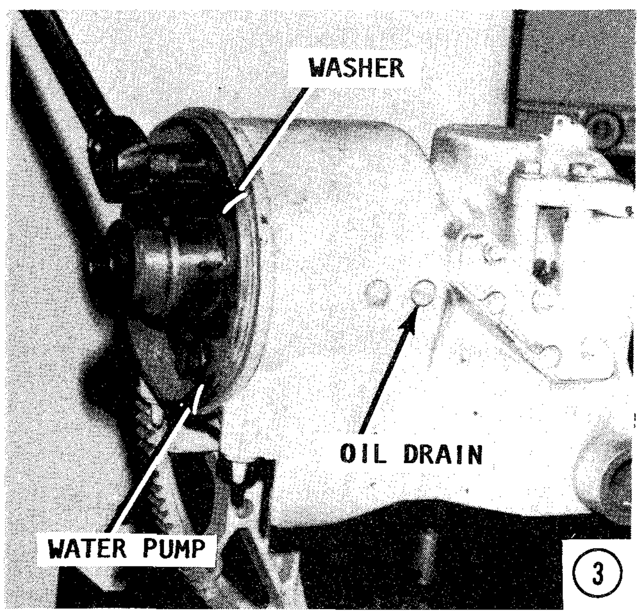


1



2

If this is the only work to be done, see Section 10-58 to install the upper gear housing into the lower unit and Section 10-59 to install the stern drive to the intermediate housing. If the lower unit is to be serviced, set the upper gear housing assembly to one side until the lower unit work has been completed. The swivel housing is an important part of the water pump installation. In order to perform a complete water pump repair, it is necessary to continue with removal of the exhaust housing and the swivel housing to replace the swivel housing seals.



3

10-35 EXHAUST HOUSING REMOVAL MODELS SINCE 1978

The stern drive must be removed (see Section 10-26), and the upper gear housing removed (see Section 10-27), before the exhaust housing can be removed. The following procedures pickup the work after the upper gear housing has been removed.

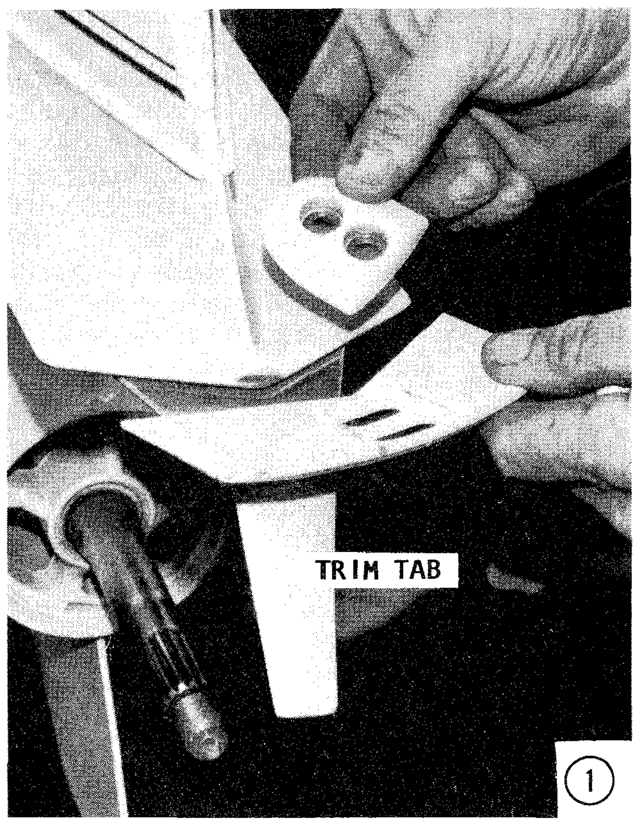
1- Support the stern drive in some type of fixture. Scribe a mark on the trim tab and a matching mark on the lower unit housing to ensure installation of the trim tab in the same position from which it is removed. Loosen the two 3/8" screws on top of the trim tab, and remove the 7/16" screw from the bottom. Remove the trim tab.

2- Remove the four screws attaching the exhaust housing to the lower unit.

3- Remove the screw from the underside of the anti-cavitation plate. Remove the screw from inside the trim tab recess.

4- Clean the excess silicone sealer from the swivel bearing housing. Work the exhaust housing off the swivel housing and at the same time feed the shift cable out of the exhaust housing.

To replace the exhaust housing, if no further work is required, see Section 10-56.



1

10-36 SWIVEL HOUSING REMOVAL MODELS SINCE 1978

Before the swivel housing can be removed, the following work must be performed.

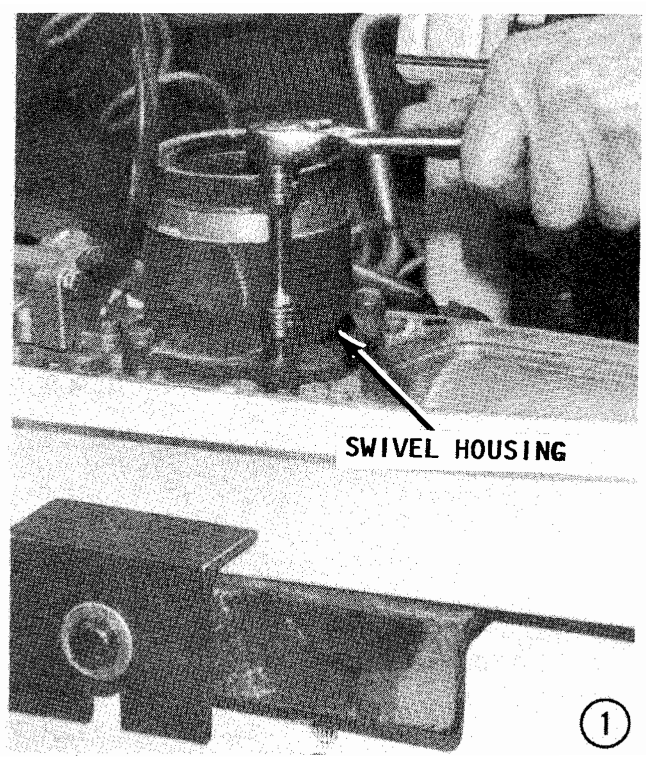
Remove the stern drive: Section 10-26

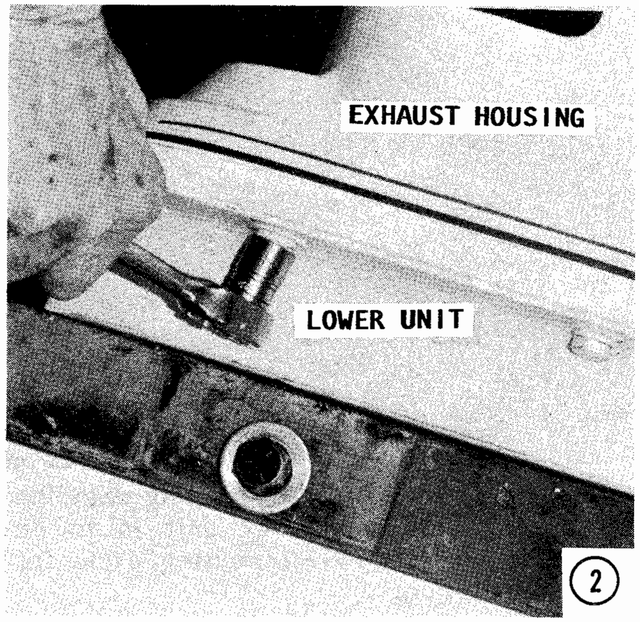
Remove the upper gear housing; section 10-27.

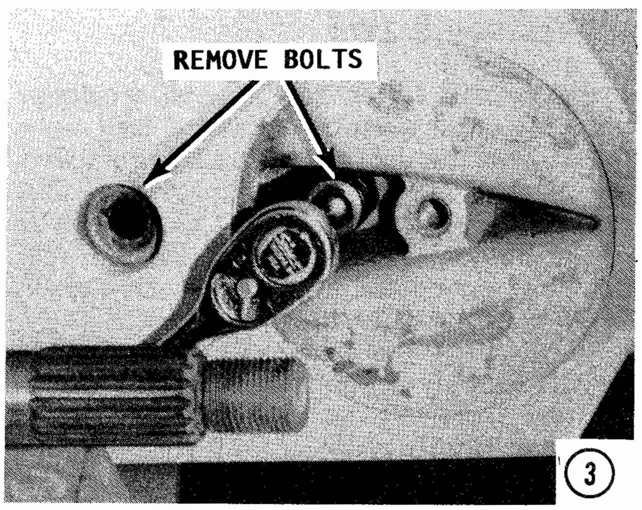
Remove the exhaust housing; section 10-35.

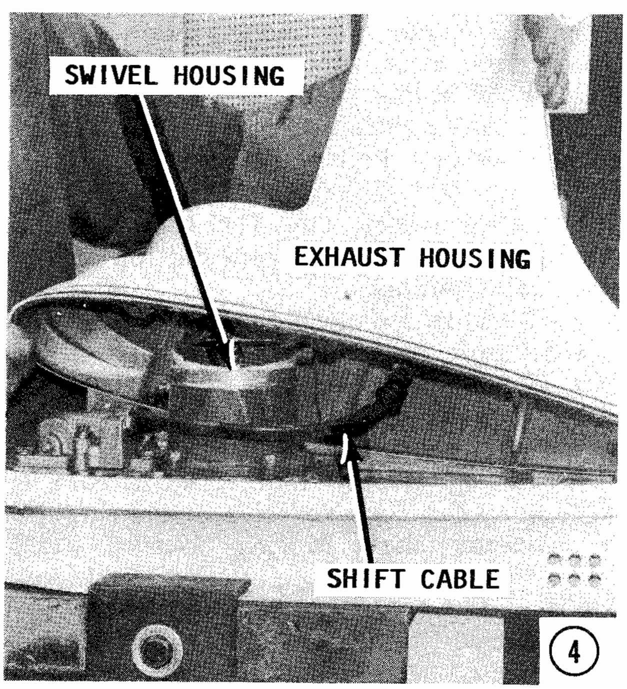
The following procedures pickup the work after the upper gear housing has been removed. **A GOOD WORD BEFORE STARTING:** Replacement of the swivel housing seals is not the easiest of tasks, expecially if the proper tools are not available. However, a complete new swivel housing can be purchased with new seals installed at moderate cost from your local OMC dealer. You may want to consider this route before disassembling the swivel housing.

1- Remove the four screws securing the swivel bearing housing. Use a plastic-faced hammer or rubber mallet and tap sideways and upwards on the bearing housing to break the seal, and then remove the housing from the lower unit.









CLEANING AND INSPECTING

Remove and DISCARD the seals from the housing. Use a drift pin and rubber mallet to drive the seals free. Clean all of the silicone sealer from the outside diameter of the swivel housing. Inspect the housing for cracks, nicks, or burrs.

The steel backed Teflon bearing, near the top of the swivel bearing assembly, is pressed into place and **CANNOT** be serviced independently.

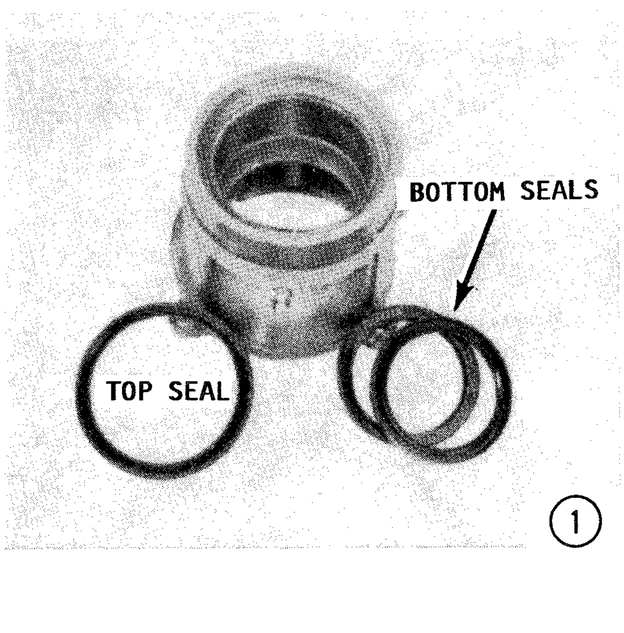
If the bearing is scored, or heavily worn (is out-of-round by more than 0.005") the swivel housing **MUST** be replaced. The bearing serves as the lower steering pivot and assists in maintaining proper alignment between the upper and lower units.

10-37 SWIVEL HOUSING ASSEMBLING MODELS SINCE 1978

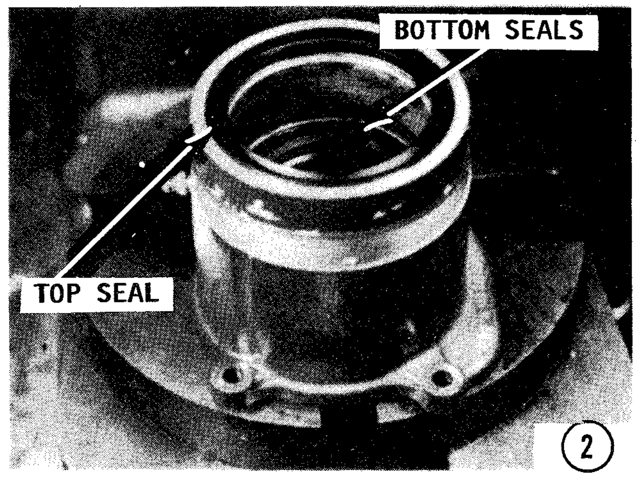
1- Coat the outside diameter of the seals with OMC Gasket Sealing Compound, or equivalent. Use seal installer Tool No. 314432 and install the seals **BACK-TO-BACK** (hard surfaces against each other). Coat the outside diameter of the top seal with OMC Gasket Sealing Compound, or equivalent. Press the seal into place using installer Tool No. 314431 and with the seal lip facing the tool. **TAKE CARE** to install the seal squarely into position.

2- Clean any excess sealer from the seals, and then coat the seal lips with OMC HI-VIS Gearcase Lube, or equivalent.

ONE MORE WORD: If rebuilding the swivel housing does not include replacing the water pump, then place a **NEW** gasket on the housing and install the housing onto the lower unit. If the lower unit is to be serviced, set the swivel housing aside for later installation.



1



2

10-38 LOWER UNIT REMOVAL MODELS SINCE 1978

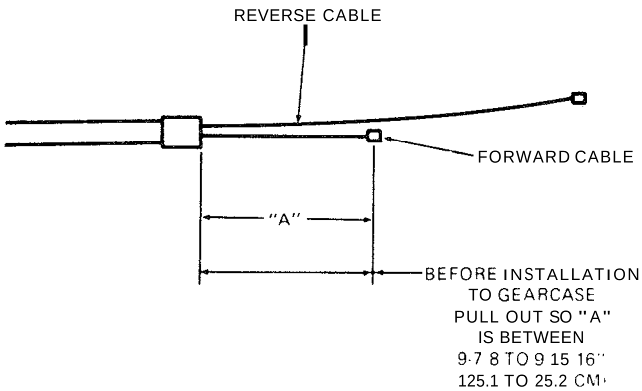
Before the lower unit can be serviced, the stern drive must be removed (see Section 10-26), the upper gear housing removed (see Section 10-27), the exhaust housing removed (see Section 10-35), and the swivel housing removed (see Section 10-36). The following procedures pick up the work after the swivel housing has been removed.

1- Remove the plugs marked **OIL DRAIN** and **OIL LEVEL** or **VENT;** tilt the unit slightly and allow the oil in the lower unit to drain completely.

2- Remove the shift cable housing by first removing the six screws using a 7/16" wrench. Next, tap the housing sideways and upward with a rubber mallet to break the seal. **NOTICE** the two cables inside of the the shift cable. Also note that one is longer than the other. Pull on the shorter of the two and the shift housing will lift off of the rack and lower unit. **ON THE 400 SERIES,** remove the adapter ring from the top of the shift assist cylinder.

3- Remove the propeller cotter pin and propeller nut. Slide the propeller off of the shaft. Remove the shaft bearing housing by removing the four 7/16" bolts from inside the bearing housing.

4- Use Universal Puller Tool No. 307636 and Puller Legs Tool No. 321631 and remove the propeller shaft bearing housing. **ON THE 400 SERIES,** use Puller Tool No. 307636 and two 5/16" x 8" rods with washers. Remove the housing and **DISCARD** the O-ring.

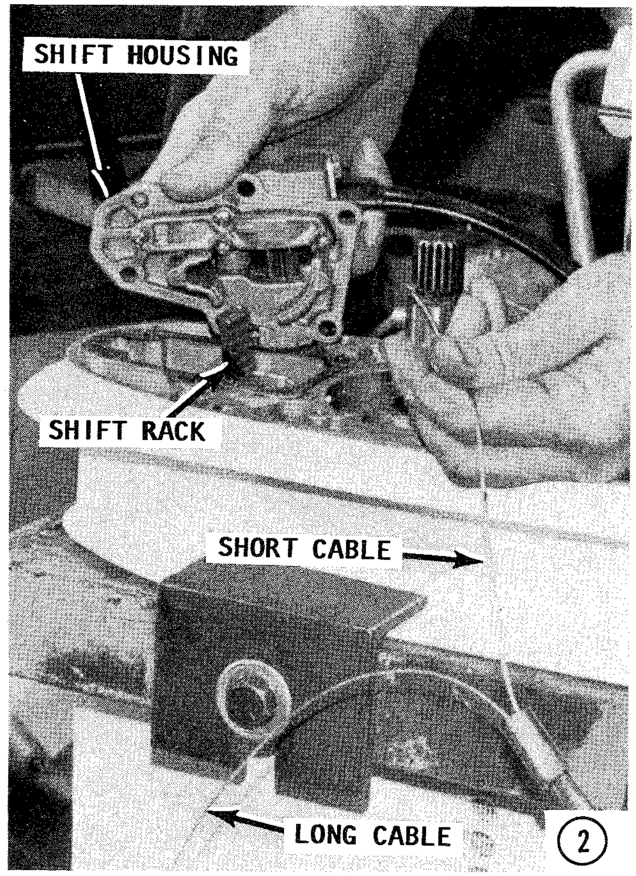


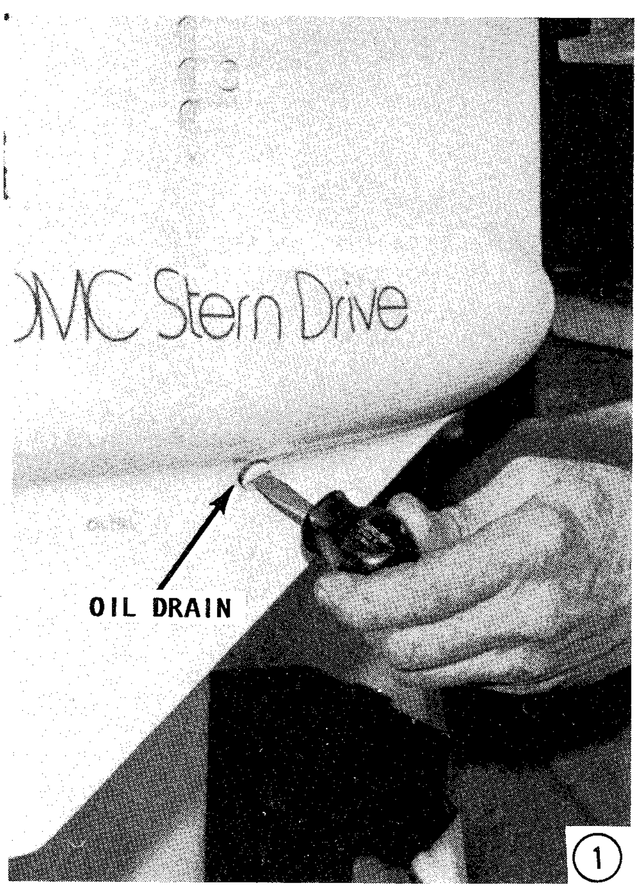
Correct measurement for the shift wires protruding out of the shift gear cable housing.

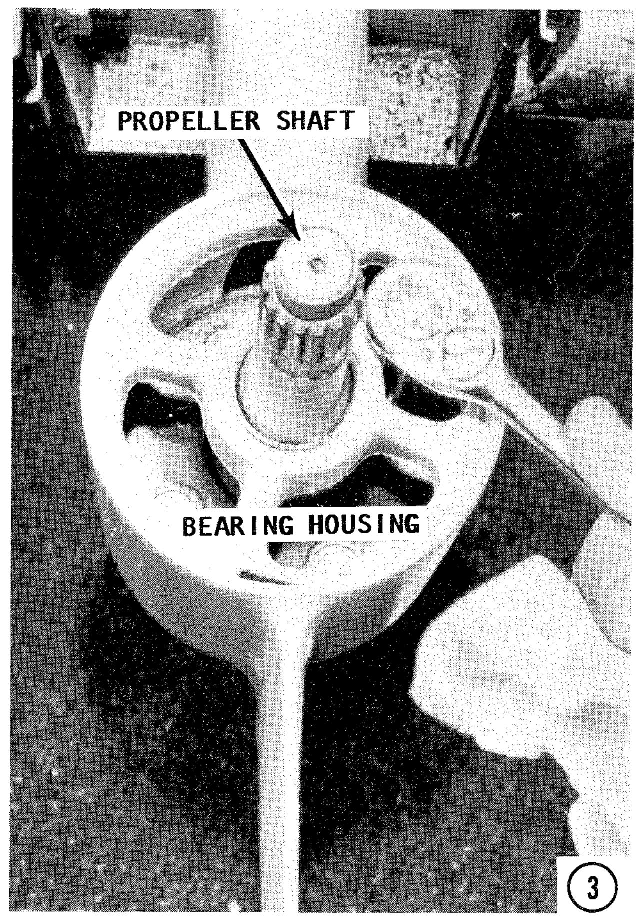
5- Remove the two truarc snap rings from inside the lower housing with a pair of No. 7 Truarc pliers.

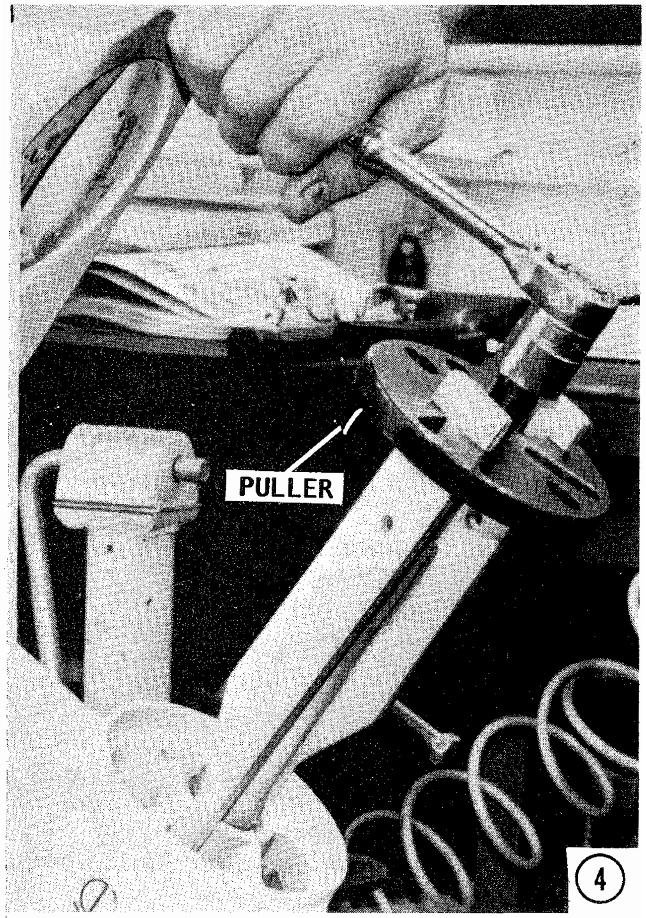
6- Reach into the lower unit and pull the reverse gear up off of the propeller shaft. As the reverse gear is removed, the retaining ring, fiat washer, and flat bearing will all come with the gear as an assembly.

7- Hold onto the gear shaft of the power assist cylinder on top of the lower unit with one hand and with the other hand grasp the propeller shaft.

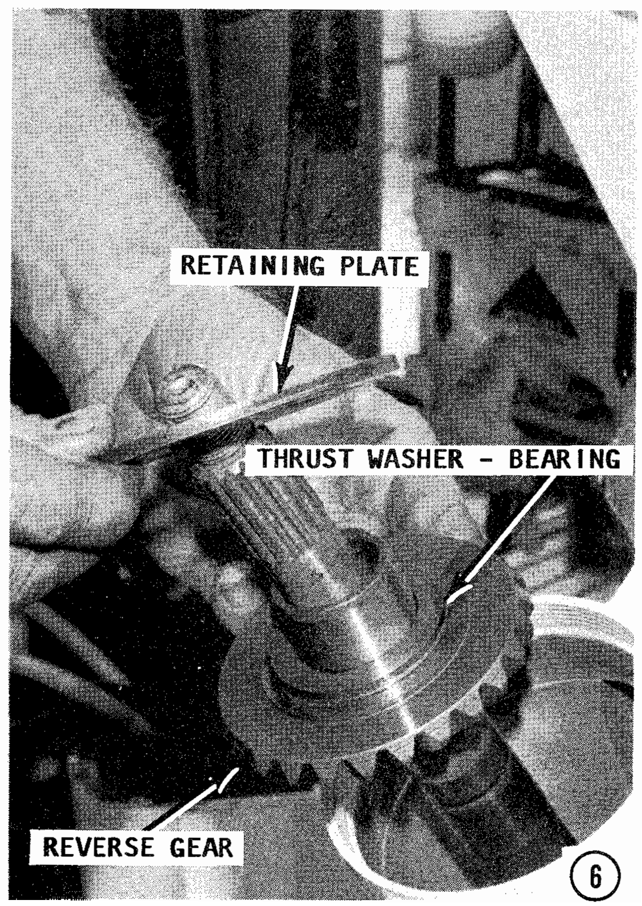


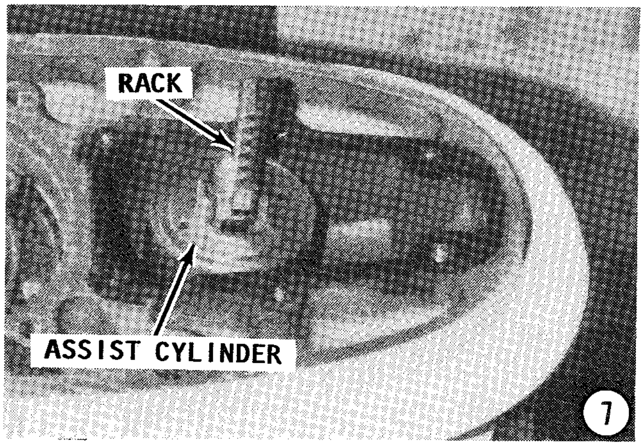






Truarc snap rings properly installed in the lower unit housing.

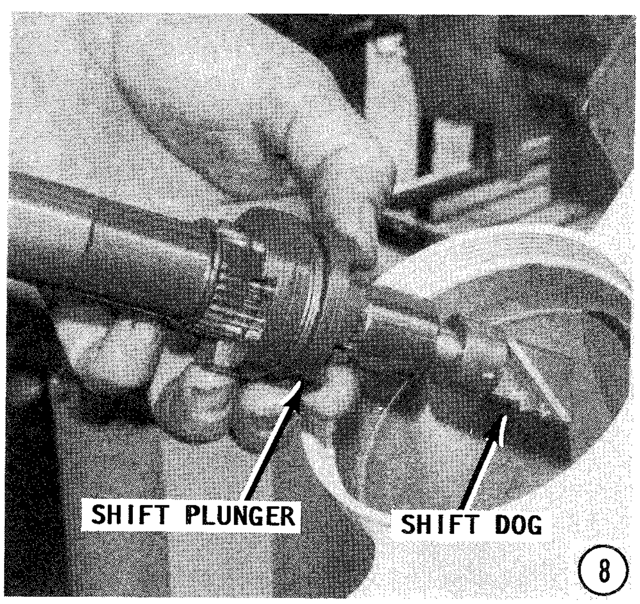


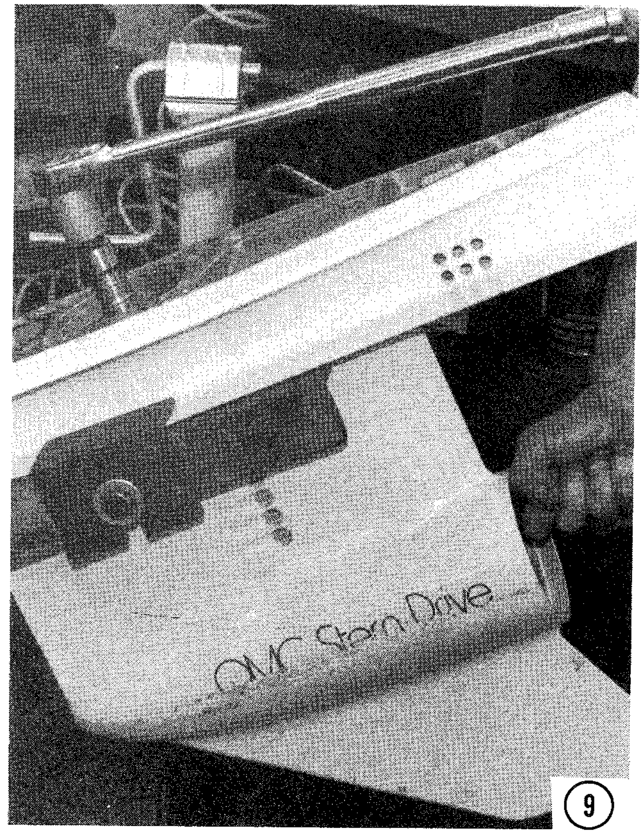


8- Pull outward on the propeller shaft and at the same time pull upward on the assist cylinder. Remove both units from the lower unit. The reverse gear, thrust bearing, washer, and retainer plate will all come out together with the propeller shaft.

A GOOD WORD AND A BAD WORD: If trouble is encountered in removing the propeller shaft, it may be necessary to use a slide hammer installed on the end of the shaft. However, and here is the bad news, the use of the slide hammer will destroy the assist cylinder shift rod and the shift plunger. If the slide hammer is required to remove the propeller shaft, the lower unit has serious problems and any damage caused to the assist cylinder shift rod and shift plunger is of minor importance compared to the major problem in the lower unit.

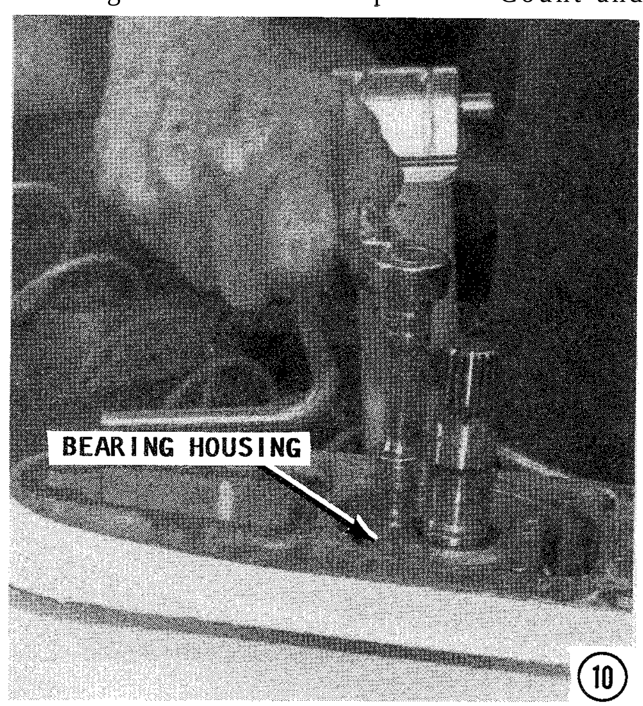
9- A pinion gear and locknut hold the driveshaft in the gearcase. Hold the nut with a 7/8" wrench and at the same time, use a torque bar and special tool No. 311875 to turn the driveshaft. **DISCARD** the locknut after it is free because its locking ability is ruined once the nut has been removed. Remove the pinion gear.

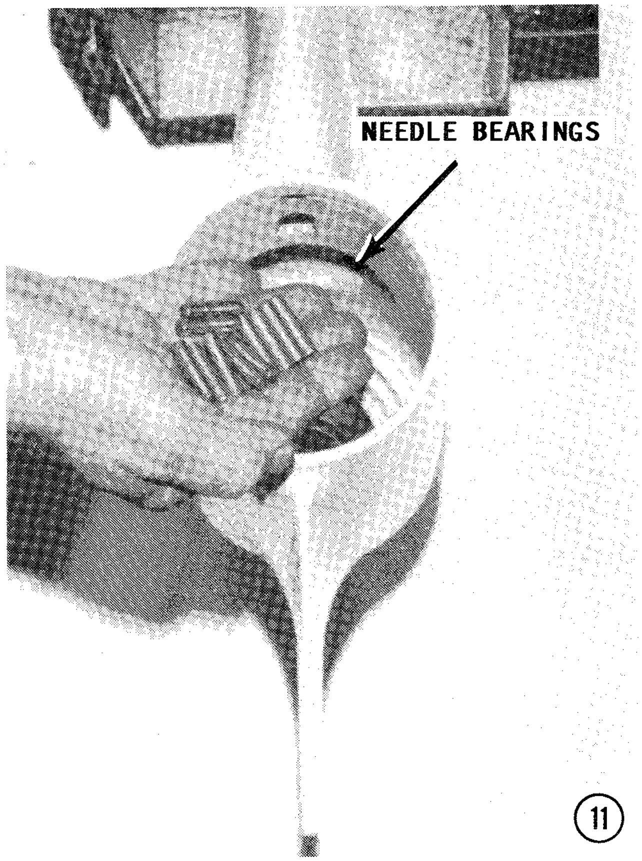




10- Remove the four screws and washers securing the driveshaft bearing housing. **BE PREPARED** to catch the pinion needle bearings as the vertical driveshaft is removed.

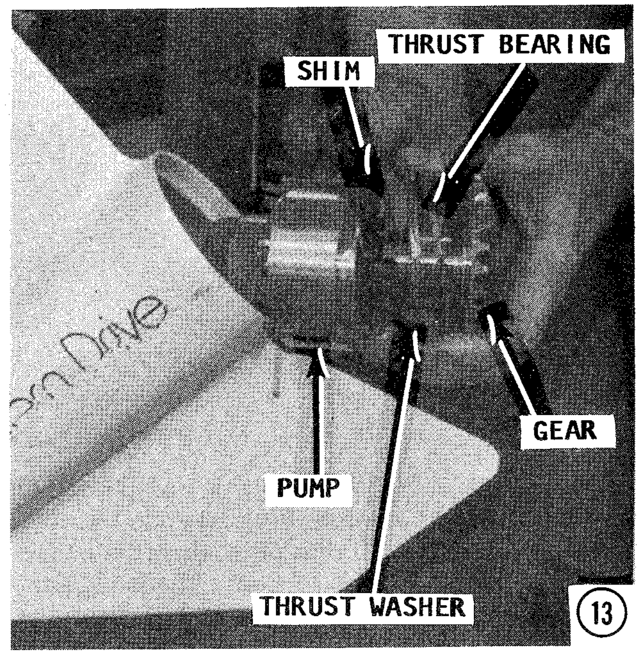
11- On the **400 SERIES** units, the needle bearings will remain in place. Count and





record the number of needle bearings to ensure the correct number is used during installation.

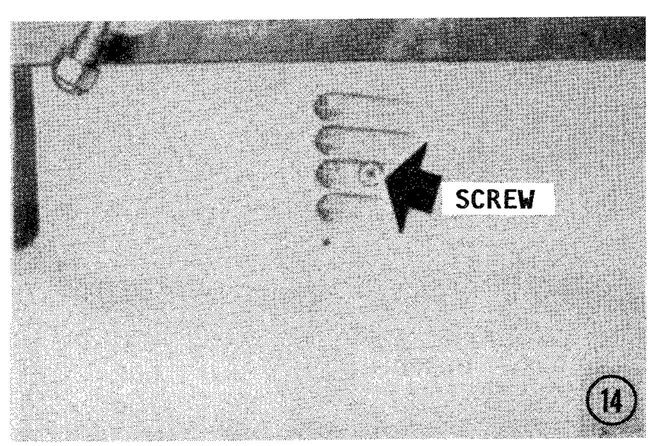
12– Remove the vertical driveshaft, bearing housing, shims, thrust washer, and thrust bearing from the housing.

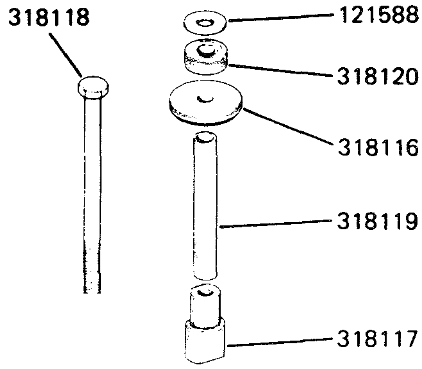


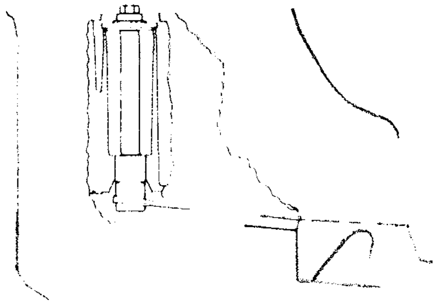
13– Reach inside the lower unit and remove the forward gear and the oil pump. **TAKE** CARE not to damage or lose any of the needle bearings in the oil pump assembly. Count and record the number of needle bearings as an aid to installation.

14– Remove the set screw securing the water intake screen and pinion bearing race in place from the starboard side of the lower unit. Remove the intake screen.

15– Remove the pinion bearing race using Tool No. 321521 and the parts of Tool No. 385546. The needle bearings MUST be in place to remove the race. The bearings house the puller and hold it in place. Pull the race from the top of the lower unit. On the 400 SERIES, the bearing assembly is pushed downward and out with Tool No. 318117 or Tool No. 311880.

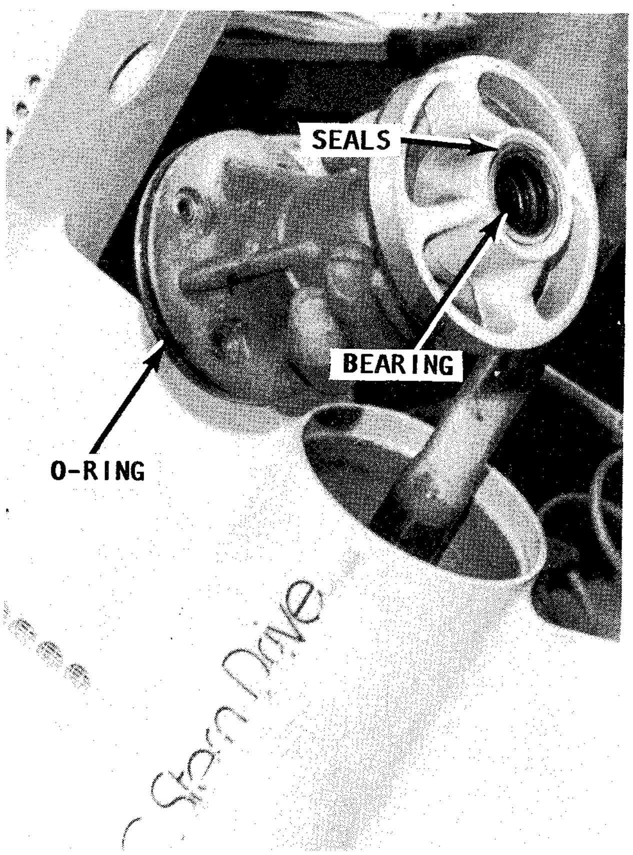




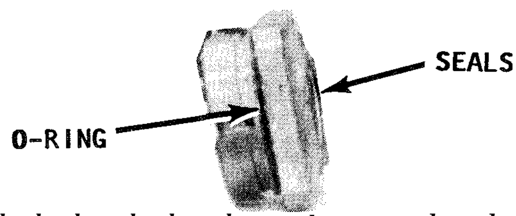


400 SERIES

15



The seals and bearing may be removed with a punch and mallet, if necessary.



The back-to-back seals may be removed, as described in the text.

10-39 PROPELLER SHAFT BEARING HOUSING DISASSEMBLING MODELS SINCE 1978

Drive the oil seals out with a punch and mallet. The bearing may be removed in the same manner. if necessarv.

10-40 DRIVESHAFT BEARING HOUSING DISASSEMBLING MODELS SINCE 1978

1- Remove the two back-to-back seals with special Tool No. 31886 and an old water pump shaft from a high profile upper gear housing. The bearing **CANNOT** be replaced if it is damaged. The bearing and housing **MUST** be replaced as an assembly.

GLEANING AND INSPECTING

Clean the parts with solvent and blow them dry with compressed air. Remove all seal and gasket material from mating surfaces. Blow all water and oil passages, and screw holes clean with air.

After the parts are clean and dry, apply a coating of light engine oil to the bearings and bright mating surfaces of the shafts and gears as a prevention against corrosion.

Inspect the shaft bearing surfaces, splines, and keyways for wear and burrs. Check for evidence of an inner bearing race turning on the shaft. Check for damaged threads.

Carefully check the inside and outside surfaces of the gearcases, housing, and covers for cracks. Pay special attention to the areas around screw and shaft holes. Verify all traces of old gasket material has been removed from mating surfaces. Check O-ring grooves for sharp edges which could cut a new seal.

Inspect the outside diameter of the outer races and the inside diameter of the inner races for evidence of turning in the housing or on the shaft. Any sign of discoloration or scores is evidence of overheating.

Check the thrust washers for wear and distortion. If they do not have uniform thickness and lay flat, they **MUST** be replaced.

Clean and check the rudder and water intake screens. Check the water screen holes for evidence the screen is loose and has caused wear on the bottom.

Inspect the propeller for cracks or gouged, bent, or broken blades. Replace all bent, worn, corroded, or damaged parts. Burrs can be removed with a Pile.

ALWAYS install **NEW** O-rings, gaskets, and seals during assembling and installation to prevent leaks.

10-41 PROPELLER SHAFT BEARING ASSEMBLING MODELS SINCE 1978

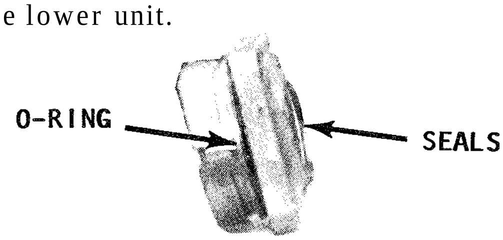
1- Install **NEW** bearings in the propeller shaft bearing housing, if they were removed. Use Tool No. 314641 to install the large forward end bearing.

2- Use Tool No. 321517 to install the small rear end bearing. On **400 Series** models, use Tool No. 317061 to install the small rear end bearing. Coat the seal cases with OMC Gasket Sealing Compound, or equivalent.

3- Install the **NEW** seals back-to-back with the hard surfaces against each other, using Tool No. 321562. This position will place one seal lip facing out and the other seal lip facing in. On **400 Series** models, use Tool No. 311869 to install the seals. Clean any excess sealing compound from the seals. Coat the seal lips with HI-VIS or anti-corrosion lube after the seals are installed. Set the completed assembly to one side until ready for installation into the lower unit.

10-42 DRIVESHAFT BEARING HOUSING ASSEMBLING MODELS SINCE 1978

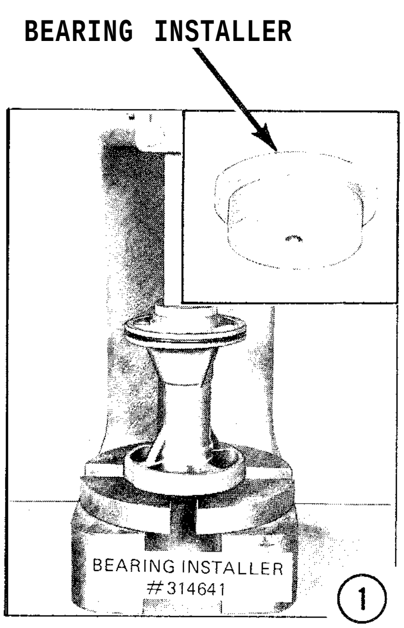
Coat the outside diameter of the seals with OMC Gasket Sealing Compound, or equivalent. Install the seals back-to-back with the hard surfaces against each other using Tool No. 314433. After the seals are installed, clean any excess sealing compound from the seals, and then coat the bearing and seal lips with OMC HI-VIS Gearcase Lube. Set the completed housing assembly to one side until ready for installation into the lower unit.

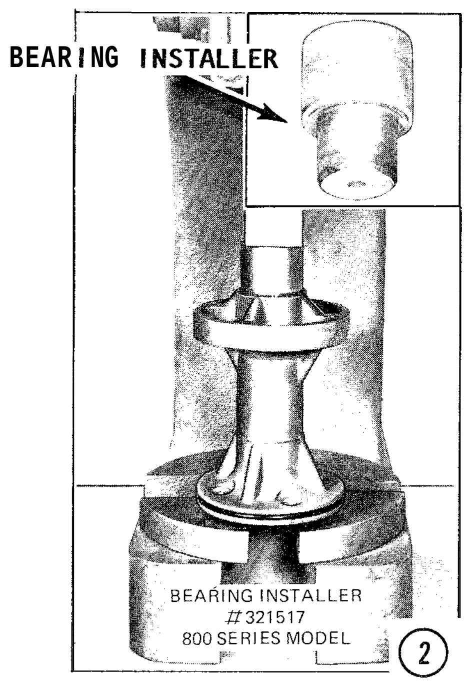


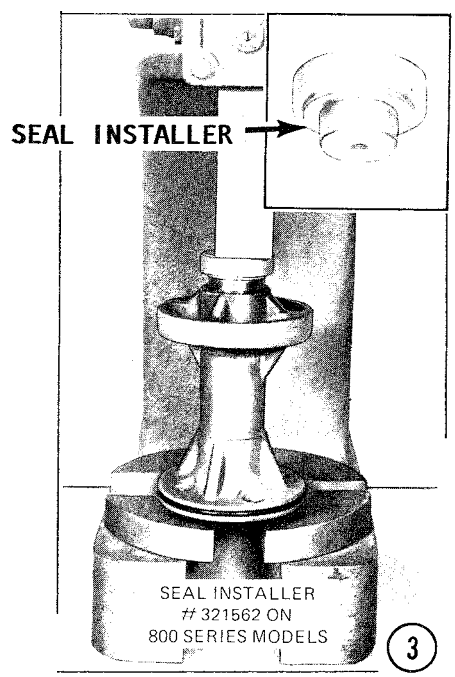
*Install the back-to-back seals using Tool **No.** 314433.*

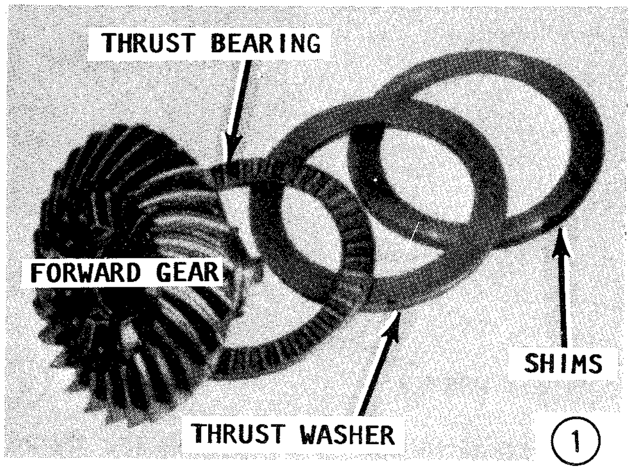
10-43 OIL PUMP AND FORWARD GEAR DISASSEMBLING MODELS 1978—81

1- Remove The forward gear thrust bearing, washer, and shims from the oil pump. **TAKE CARE** not to damage or lose





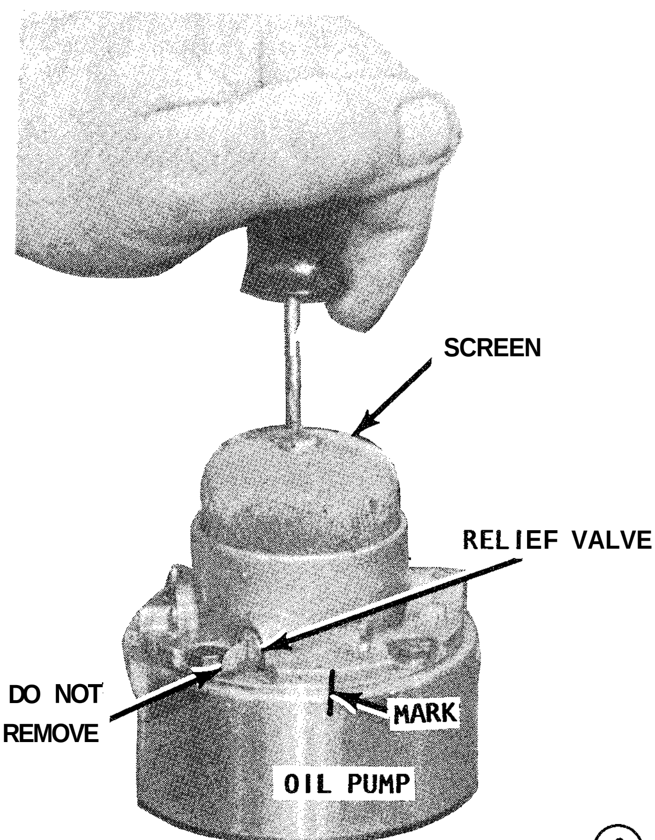




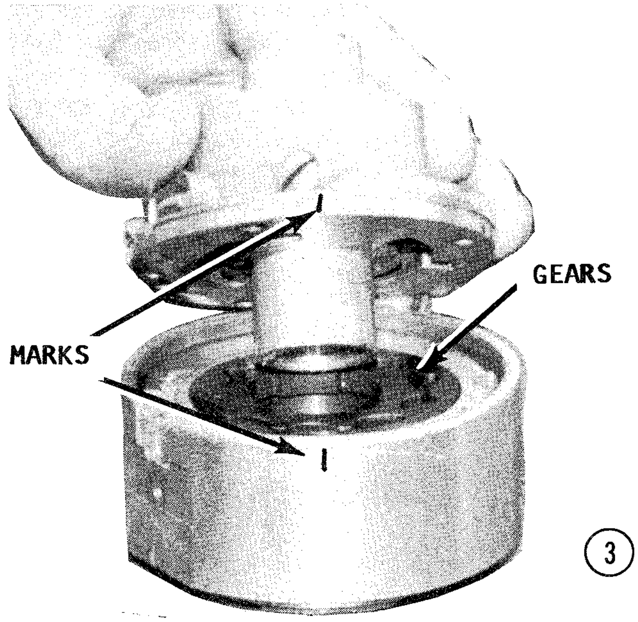
1

any of the needle bearings inside the oil pump. If the pump bearing is not serviceable, the pump and bearing **MUST** be replaced as an assembly.

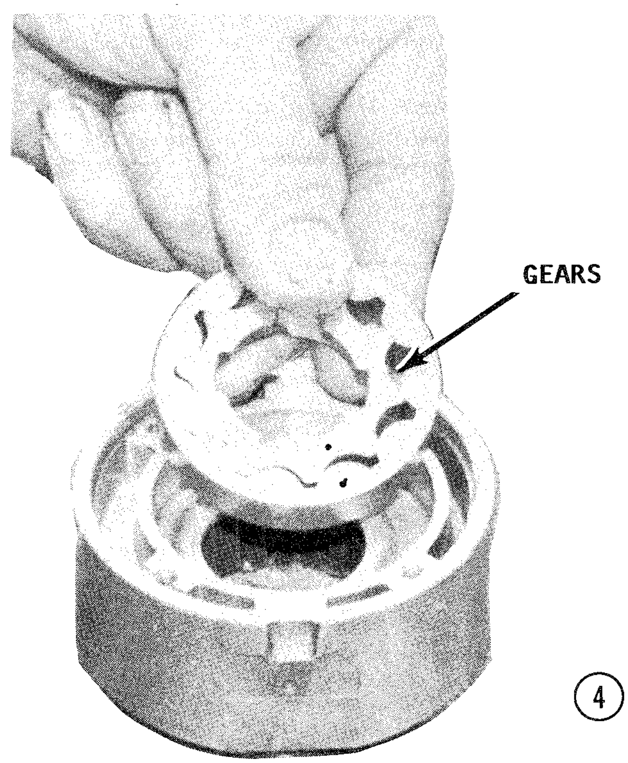
2– It is seldom necessary to remove the bearing case from the pump housing. However, to remove the bearing case, use Tool No. 380657. Remove the screw on the oil pump securing the filter screen in place. Scribe a mark on the oil pump cover and a matching mark on the pump as an aid to aligning the cover onto the pump during assembling.



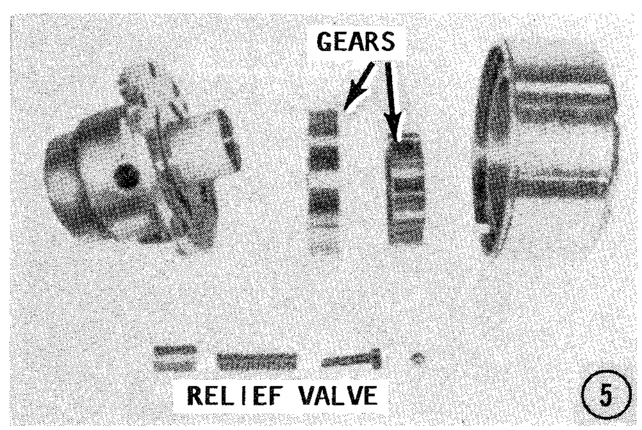
2



3



4



5

3- Remove the oil pump cover plate by removing the four attaching screws. Lift the cover off the pump.

4- Remove the two oil pump gears. NOTICE the dot on each gear. Both of these dots will face upward during assembling. If the gears do not have the dots showing, take time to make an identifying mark with a lead pencil on each gear, as an aid to assembling the gears properly.

5- A screw on the side of the oil pump secures the pressure relief valve. If this valve is removed and installed at a different setting, the change in pressure may cause hard shifting.

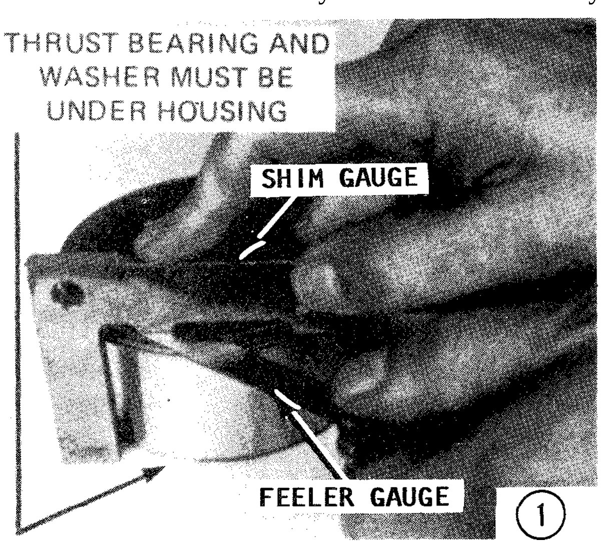
CLEANING AND INPSECTING

Clean the parts with solvent and blow them dry with compressed air. After the parts are clean and dry, apply a coating of light oil to the bearing and bright mating surfaces.

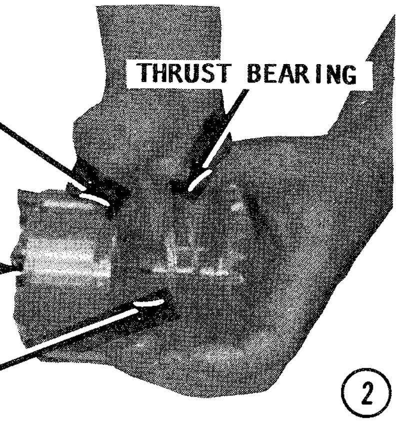
Inspect the bearing surfaces, oil pump gears, and forward gear for wear and burrs. Carefully check the inside of the oil pump for wear or burrs. Pay special attention to the areas around the screw and shaft holes. Inspect the thrust washer and bearing. Lay the bearing on the washer, apply hand pressure and turn the bearing. The bearing should turn freely under the hand pressure.

10-44 OIL PUMP AND FORWARD GEAR ASSEMBLING MODELS 1978—81

1- Before the oil pump and forward gear can be assembled, the clearance needed between the pump housing and the forward gear must be accurately determined. Lay



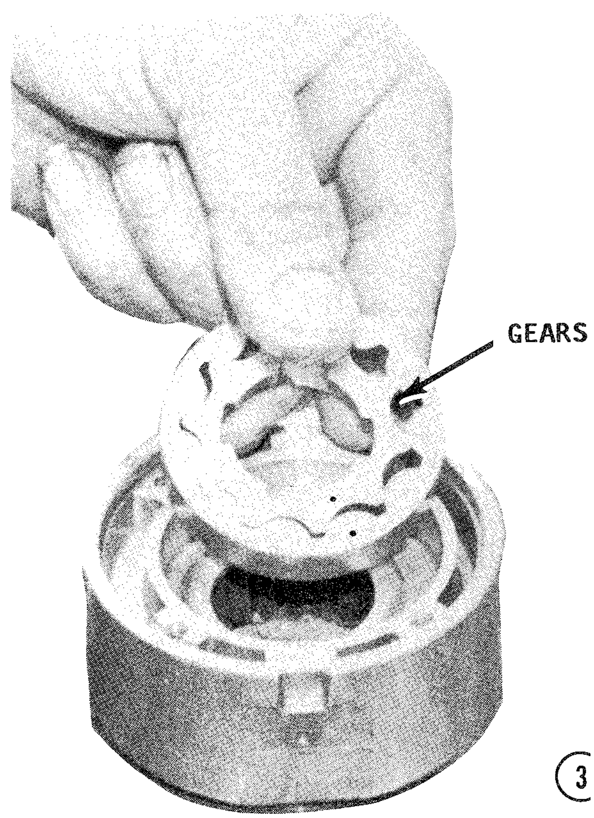
1



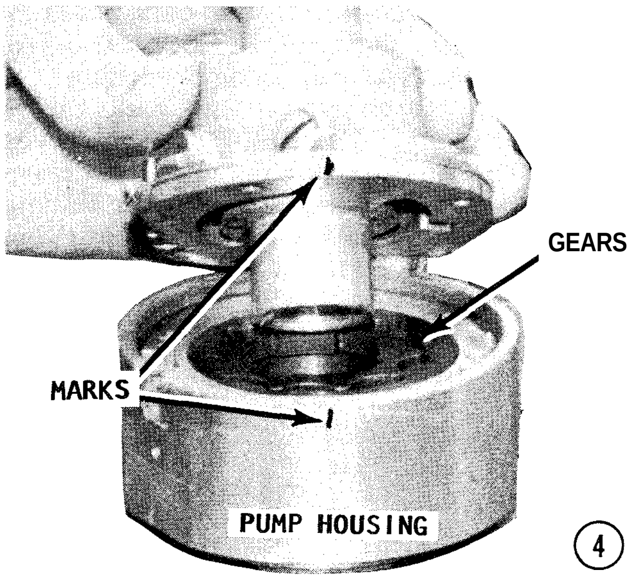
2

the pump on a flat surface with the thrust bearing and the thrust washer installed. Use Tool No. 324797 and a feeler gauge to measure the distance between the tool and the housing. This measurement is the amount of shimming required. Install the bearing race, if it was removed from the oil pump by first supporting the pump housing from inside the oil pump gear recess. Supporting the housing in this manner will prevent any distortion. Now, press the forward gear bearing race into place until it is flush with the housing. On the 400 Series, this bearing is not removeable.

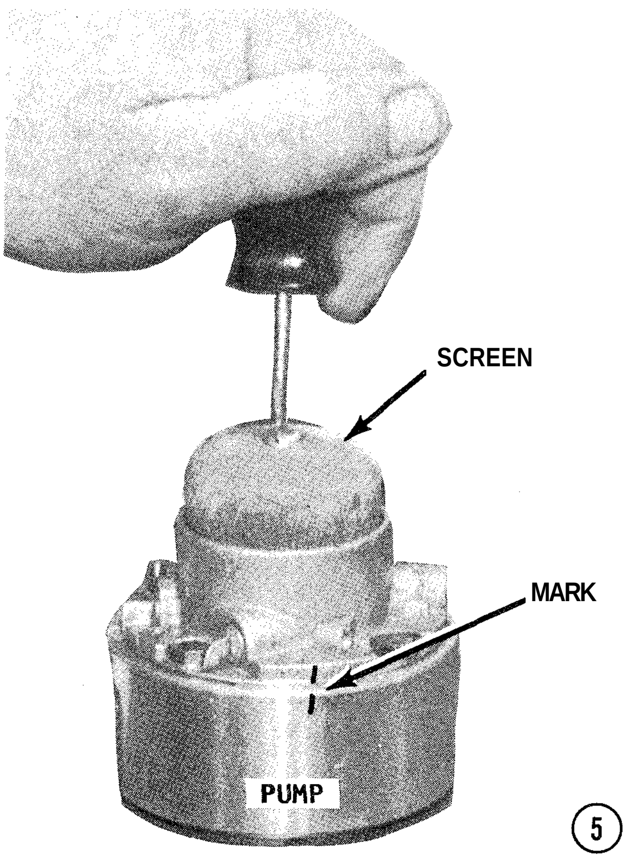
2- Count the number of forward gear needle bearings and compare the figure with the recorded number removed during disassembly. Coat the needle bearings with OMC



3



Needle Bearing Grease, or equivalent. Carefully install the needle bearings in position in the bearing housing. The grease will hold them in place. Coat the thrust bearing with OMC HI-VIS Lube, or equivalent. Place the thrust bearing, thrust washer, and the number of shims determined in Step I, onto the forward gear. Slide the assembled gear into the oil pump.



3- Position the oil pump gears in the pump housing, and then rotate the gears by turning the forward gear. If the gears do not turn smoothly, remove the outer oil pump gear, turn it over, and install it again. Repeat the test.

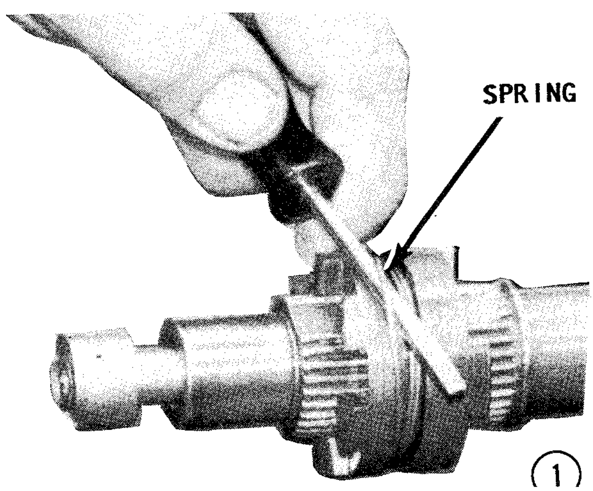
4- Align the marks on the oil pump cover and the housing made during disassembly, and then secure the cover in place with the attaching screws. Tighten the screws to a torque value of 3-4 ft-lbs. **TAKE CARE** to tighten the screws to the proper torque value. If they become loose, the hydraulic pressure will fall or the shift system to become jammed.

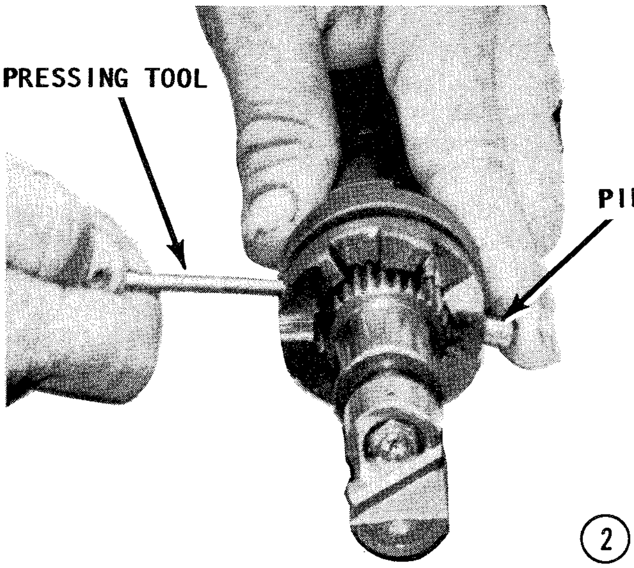
5- Install the filter screen and secure it in place with the attaching screws. Set the completed assembly aside until ready for installation into the lower unit.

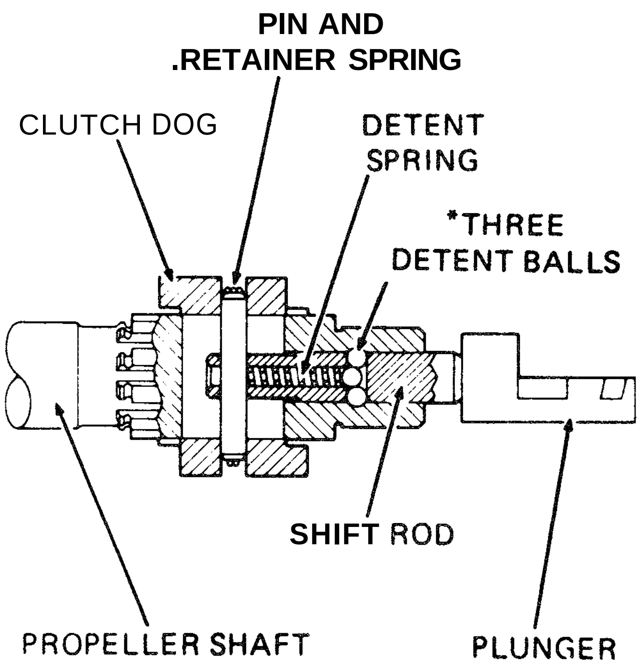
10-45 PROPELLER SHAFT AND SHIFTER DISASSEMBLING

1- Remove the coil spring from the groove in the shift clutch dog.

2- Stand the propeller shaft upright with the plunger down. USE **CARE** when removing the clutch dog retaining pin because the plunger is spring loaded. A good idea is to have the pin pointing toward a wall or the side of a box to prevent the balls and spring from travelling too far and being lost. Hold the shaft and **CAREFULLY** remove the clutch dog retaining pin. **BE PREPARED** to watch for the three detent balls and the spring inside the propeller shaft. Hold the shaft firmly, remove the retaining pin, and then slowly lift up on the shaft. **ALWAYS DISCARD** the retaining spring and install a new one during assembling.







Sectional drawing showing the clutch dog and related parts properly installed onto the propeller shaft.

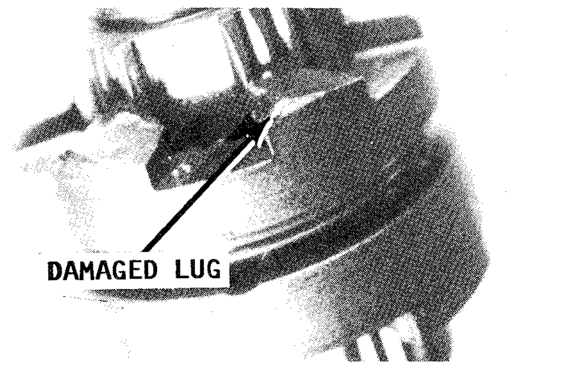
CLEANING AND INSPECTING

Inspect the plunger closely checking to be sure the groove on the end of the plunger is not bent and does not have any burrs. Any wear in this area will reuslt in hard shifting. Inspect the three balls for roundness and for flat spots.

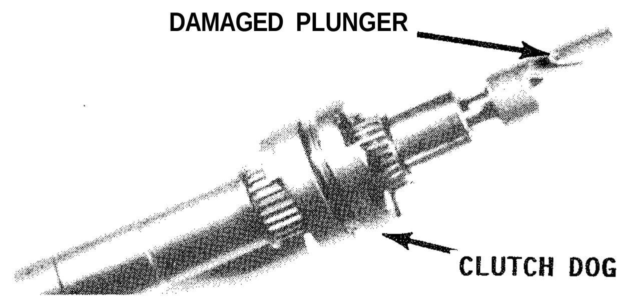
Check the spring to be sure it has flat ends and is not distorted in any way. Check the lugs on the clutch dog to be sure they are square and the edges are not rounded. If the lug edges are rounded, the clutch dog **MUST** be replaced.

Check movement of the clutch dog on the propeller shaft to be sure it moves freely without any indication of binding.

Inspect the splines on the end of the propeller shaft. Clean the spline grooves. Slide the propeller onto the shaft and check to be sure it moves freely without binding. If it does not move freely, spend more time cleaning the splines on the shaft and the grooves inside the propeller.



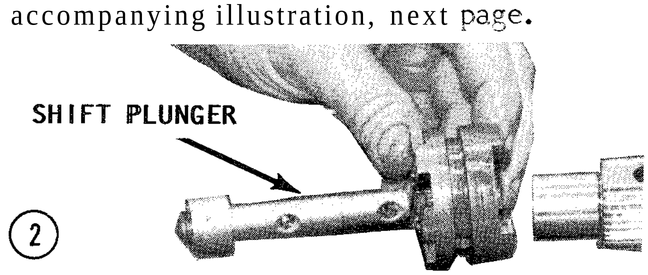
Damaged clutch dog caused from improper shifting habits.

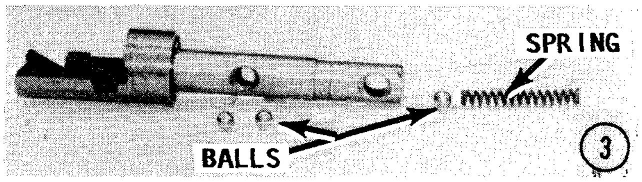


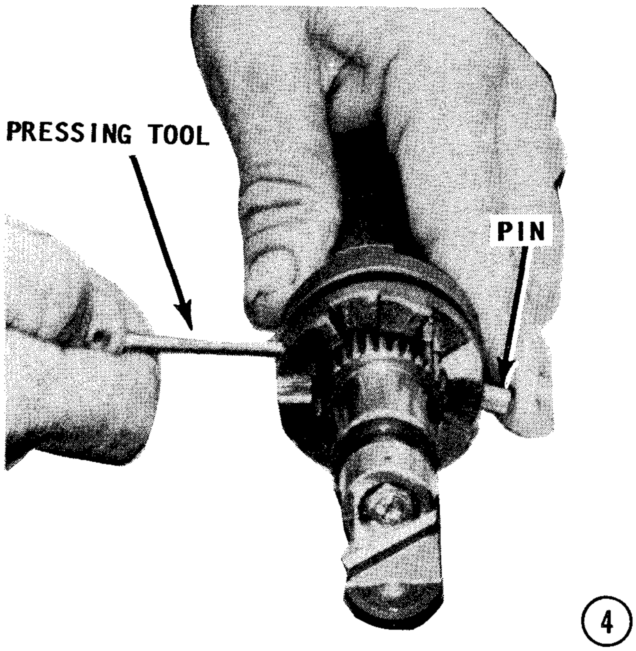
Damaged shift plunger caused by the operator shifting with the engine running at a high rpm.

10-46 PROPELLER SHAFT AND SHIFTER ASSEMBLING MODELS SINCE 1978

1- MAKING A TOOL: In order to assemble the shift rod and clutch dog onto the propeller shaft, it will be necessary to make a simple detent spring depressing tool. This can be accomplished by cutting off a piece of 9/32" diameter round bar stock approximately 6-inches long. Flatten one end of the bar stock, as shown in the accompanying illustration, next page.





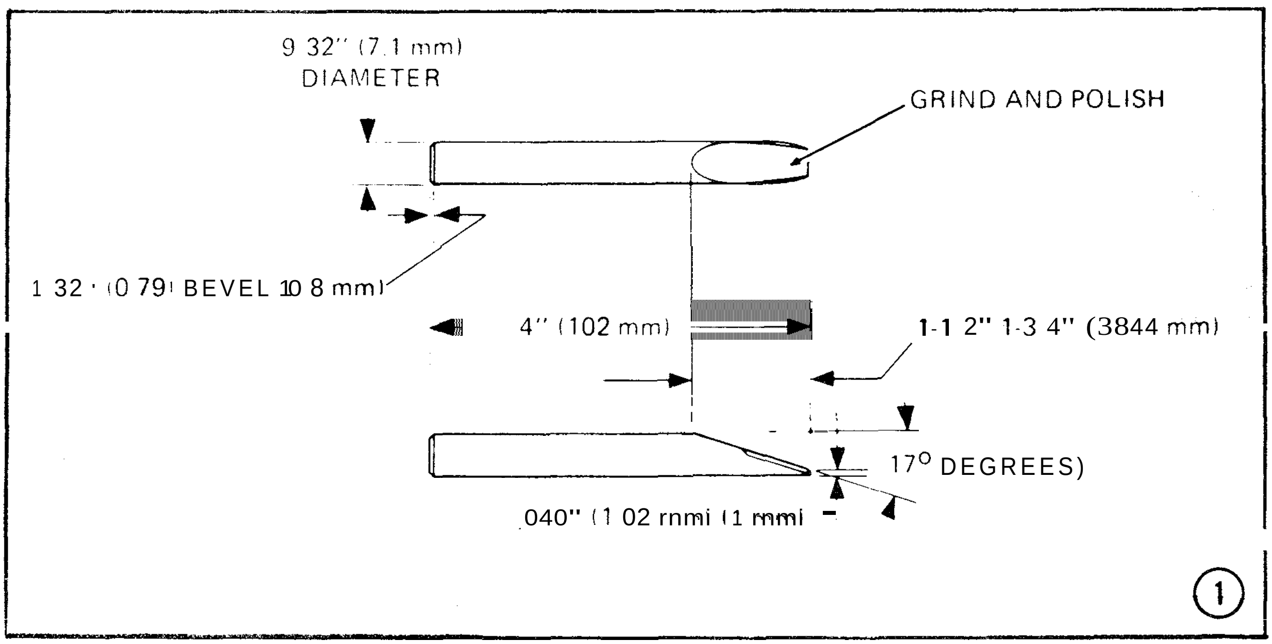


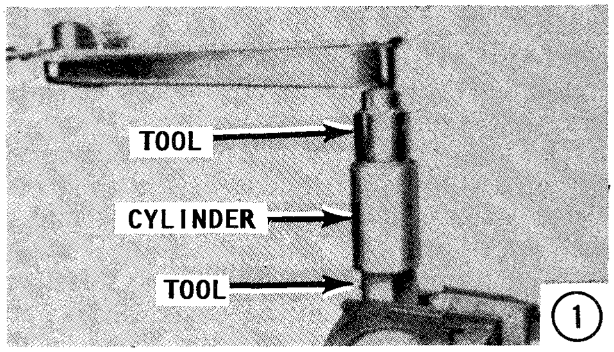
2– Cover the propeller shaft with a light coating of oil. Slide the clutch dog onto the shaft with the three-lug end facing the propeller end of the shaft. Align the holes in the clutch dog with the slot in the propeller shaft. **TAKE MOTE:** The 400 **Series** clutch dog has three lugs on both ends. The words **PROP** END are stamped on the side intended to face the propeller.

3– Insert two of the detent balls into the detent ball hole in the side of the shift rod. Insert the third detent ball into the end of the shfit rod, and then place the spring through the hole in the end of the shift rod. Now, hold the balls in the shaft, and at the same time carefully align the holes in the shift rod and the clutch dog with the slot in the propeller shaft. Next, insert the shift rod into the propeller shaft until the detent balls slip into the grooves in the propeller shaft.

4– With the holes in the clutch dog still aligned with the holes in the shift rod, start the wedge end of the special tool made before Step 1, into the hole with the flat side facing the end of the detent spring.

Continue pushing the tool into the hole until the end of the tool barely comes out the opposite side. Now, press the clutch dog retaining pin in through the clutch dog. As the retaining pin is inserted, the tool will be forced out. Secure the pin in place with the retaining spring. **TAKE** CARE to be sure none of the spring coils overlap or the spring is not distorted in any way. Only through careful attention to installation of the retaining pin and spring can proper operation of the shift mechanism be expected. Set the completed assembly to one side until ready for installation into the lower unit.





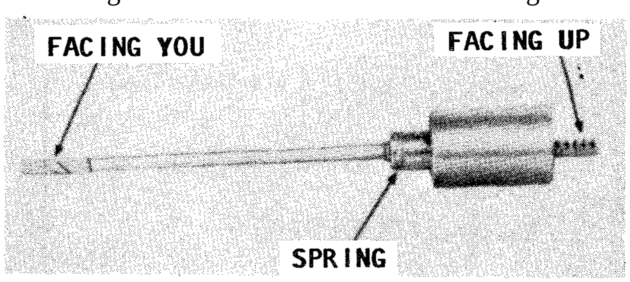
10-47 POWER ASSIST SERVO DISASSEMBLING MODELS 1978--81

1- Clamp Tool No. 386112 in a vise with soft-jaws. Position the hydraulic assist cylinder on the tool. Push the rod down, and then engage the pins of the tool in the holes provided in the bottom of the piston. **TAKE EXTRA CARE** to prevent bending the push rod. Place the spanner wrench on top of the cylinder with the pins engaged in the holes in the piston cap. Hold the spanner wrench with one hand and with the other hand, use a socket wrench to turn the cap counterclockwise. Continue rotating the cap until it is free. Center the pin thru the piston, valve and push rod to enable the piston to clear the bore. Lift off the cylinder. If necessary, remove the pin to disassemble the push rod, piston, and valve.

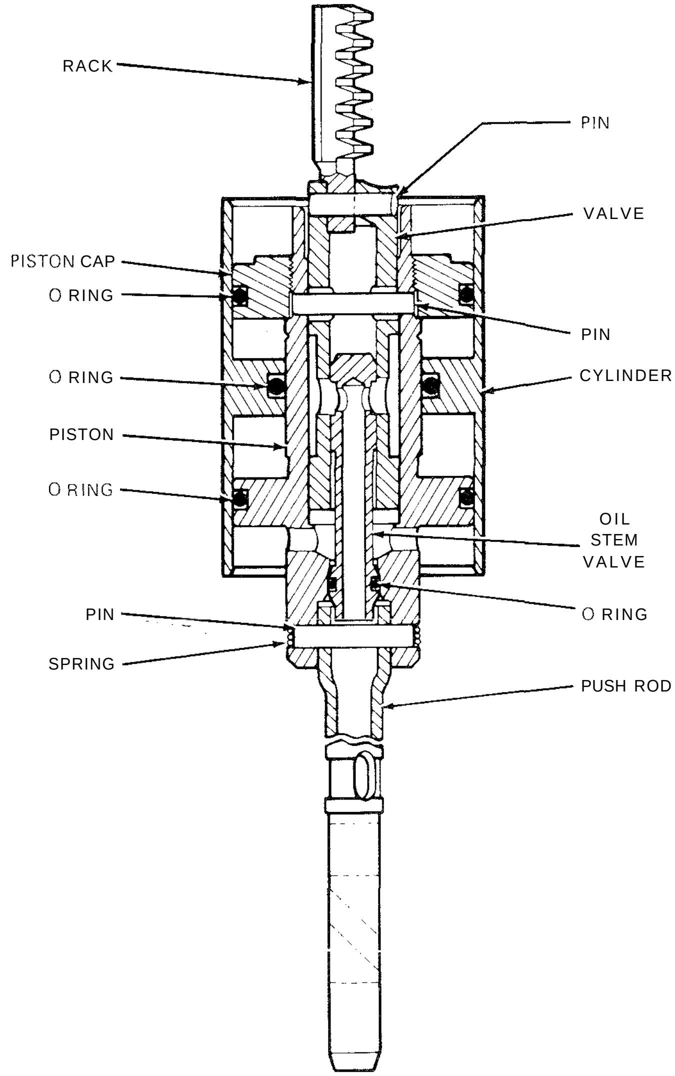
CLEANING AND INSPECTING

Check the slider on the end of the shift shaft to be sure it is not bent and is free of burrs. A small amount of misalignment in the shaft will result in hard shifting.

Inspect the teeth on the rack to be sure they are free of burrs. Remove and **DISCARD** the O-ring on the piston and the one in the cylinder. Carefully inspect the assist cylinder and replace the complete assembly if the cylinder is scored or shows other signs of excessive wear or damage.



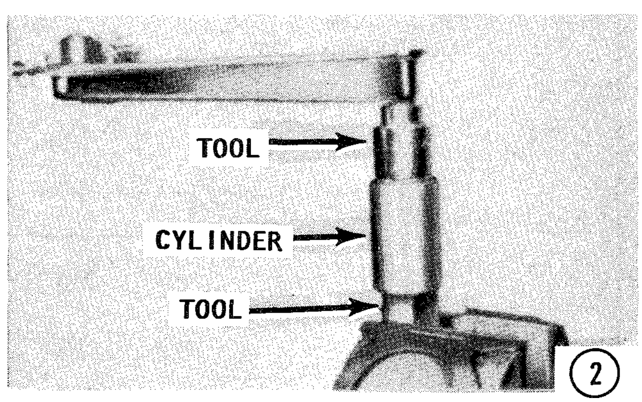
*Sectional view of the power assist servo valve assembly, showing internal working parts. The valve **MUST** move freely within the piston. Total travel of the valve is 0.050".*



Cross-section of the hydraulic assist cylinder.

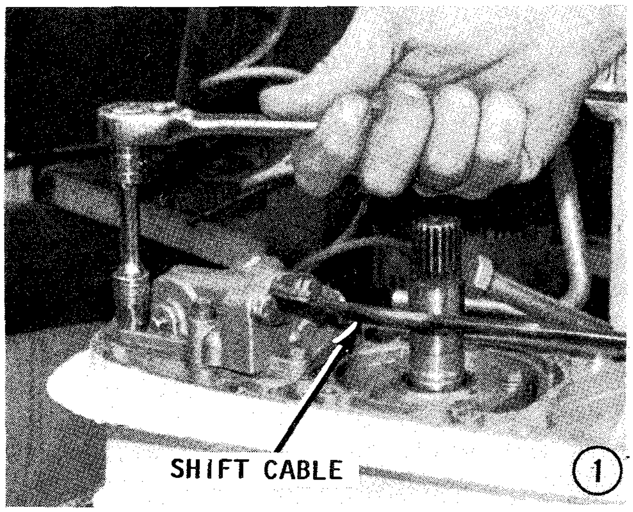
10-48 POWER ASSIST SERVO ASSEMBLING MODELS 1978--81

1- Lubricate the parts of the power assist servo assembly with OMC HI-VIS Gearcase Lube, or equivalent. Install a **NEW** O-ring onto the piston, into the cylinder, and on the piston cap. Assemble the



rack to the valve with the teeth of the rack facing the concave surface of the valve. Secure the rack in place with a short pin. PAY ATTENTION to use the proper length pin in the proper place. Use of the wrong pin will cause the shift mechanism to bind. Slide the valve into the piston and align the retaining pin holes. Hold the piston and valve assembly with one hand with the rack teeth facing upward. With the other hand, insert the push rod with the keyway facing toward you. Secure the push rod in place with the long retaining pin. Now, slide the piston and the valve and rod assembly inside the cylinder sleeve.

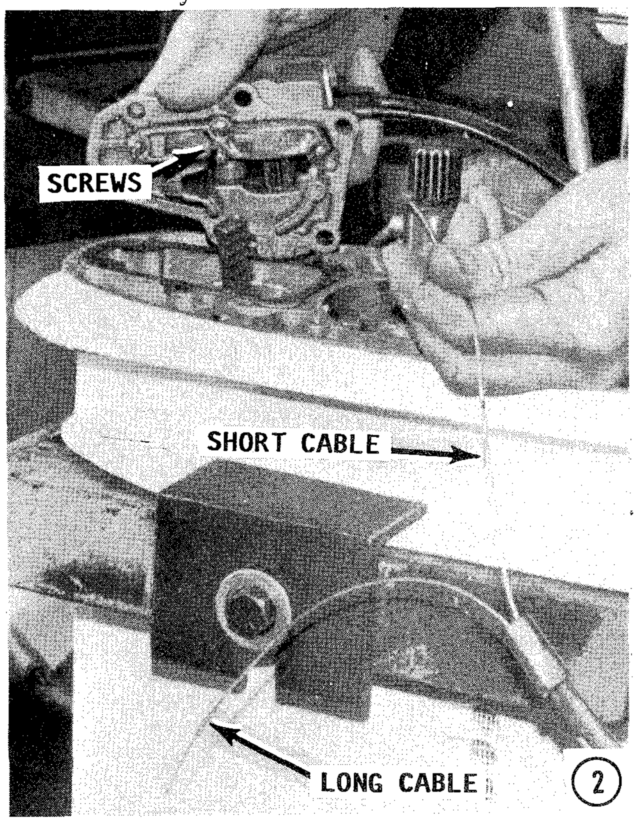
2– Install the piston cap onto the cylinder using Tool No. 386112. Tighten the cap to a torque value of 8–10 ft–lbs. Check the operation of the assembly to be sure the piston moves freely in the cylinder and the valve moves freely in the piston. Set the completed assembly aside for later installation in the gearcase.



10-49 SHIFT CABLE REMOVAL OR REPLACEMENT MODELS SINCE 1978

Other work must be performed before the shift cable in the lower housing can be replaced. The stern drive must be removed, see Section 19-26, the upper gear housing removed, see Section 10-27, and the exhaust housing removed, see Section 10-35. The following procedures pickup the work after the exhaust housing has been removed.

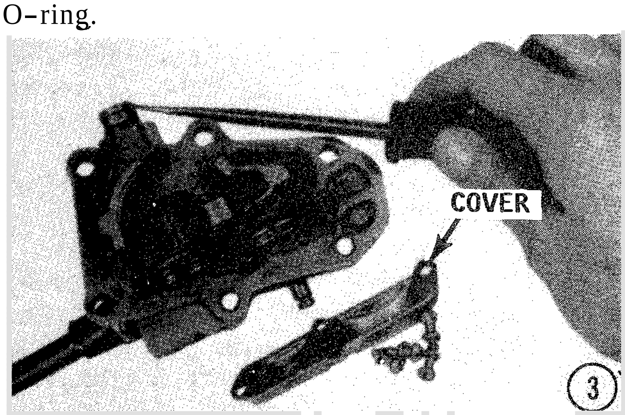
1- Remove the shift cable housing by first removing the six screws using a 7/16" wrench. Next, tap the housing sideways and upward with a rubber mallet to break the seal. NOTICE the two cables inside the shift cable. Also note that one is longer than the other. Pull on the shorter of the two, and the shift housing will lift off of the rack and lower unit. **ON THE 400 SERIES,** remove the adapter ring from the top of the shift assist cylinder.

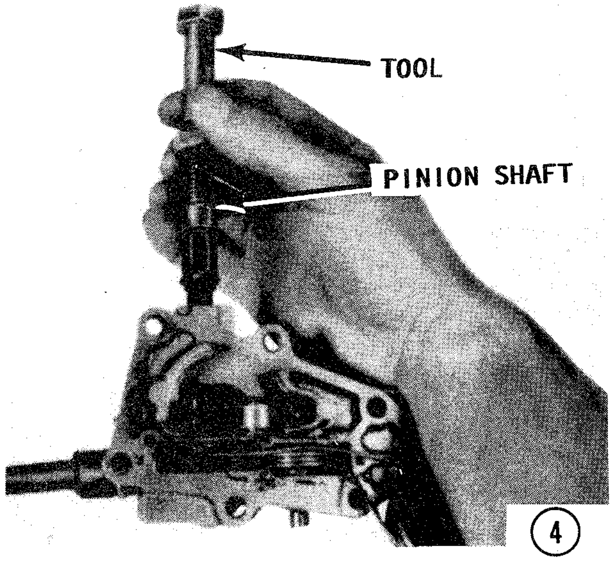


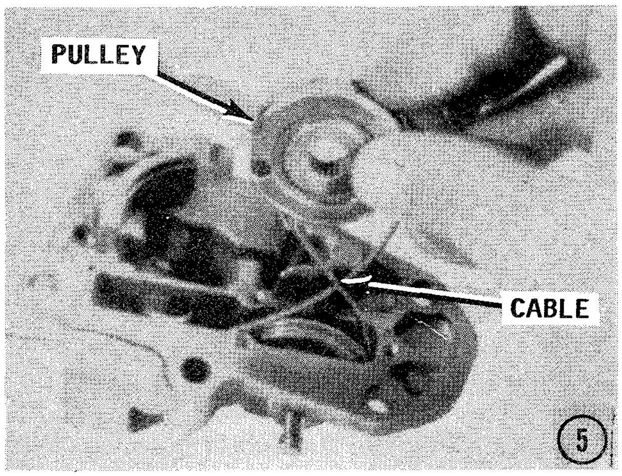
2– Remove the four shift housing cover screws and lockwashers. Lift off the cover and DISCARD the gasket.

STOP: If the shift cable housing was removed only in preparation for further work on the lower unit, additional disassembly of the shift mechanism is NOT required. However, if the shift mechanism is to be serviced, continued with the procedures in this section.

3- Pry out the pinion shaft O-ring and retainer with a screwdriver. DISCARD the O-ring.





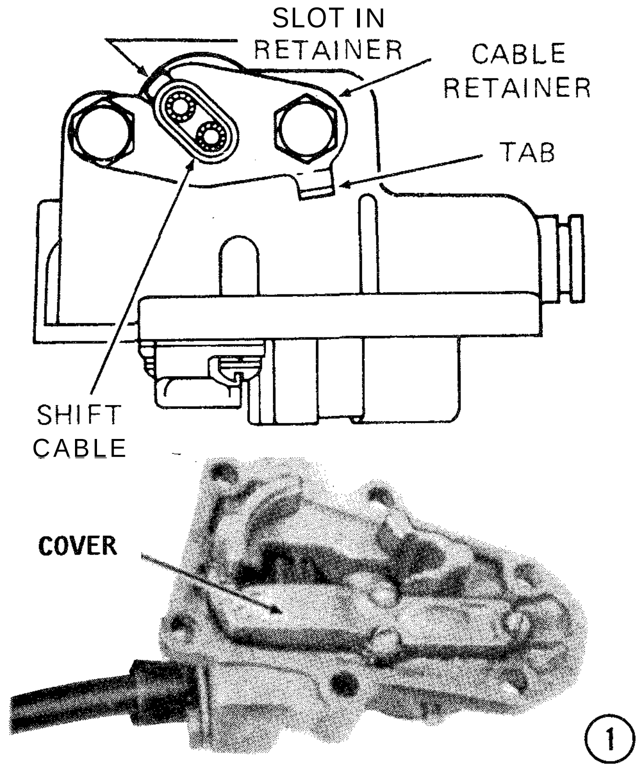


4- Thread Special Tool No. 909881 onto the end of the pinion shaft and remove the pinion shaft, bearing, and seals. DISCARD the seals.

5- Lift out the drive pulley and remove the shift cable pucks from the slots. OBSERVE the size difference of the pucks and note their slot location as an aid to installation. Pry the idler pulley shaft and O-ring from the shift housing body with a screwdirver. DISCARD the O-ring. Lift out the pulley and the two washers. Remove and DISCARD the two cable retainer serews. Pull the shift cable free of the shift housing body.

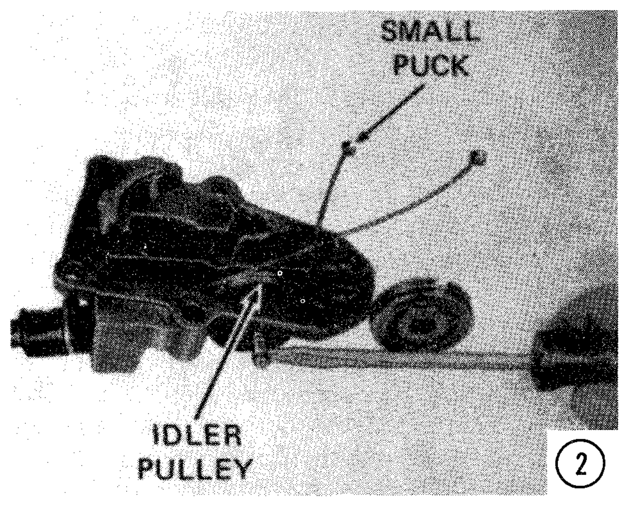
CLEANHNG AND INSPECTING

Glean all sealer from the shift housing body with solvent. Inspect the shift housing for cracks, nicks, or burrs. Inspect the seals, and bearings for wear, cracks,. and nicks. DISCARD all O-rings. Inspect the shift cable for cracks. Check the core wires to be sure they are not frayed or kinked. Replace the core wires if they are defective in any way to ensure satisfactory and long term operation.



10–50 SHIFT CABLE ASSEMBLING MODELS SINCE 1978

ONE WORD: If the only work performed involved removal and installation of the lower unit, then proceed DIRECTLY to Step 6 of this procedure. However, if the work included servicing the shift mechanism, then begin with the next paragraph to assemble the shift mechanism.

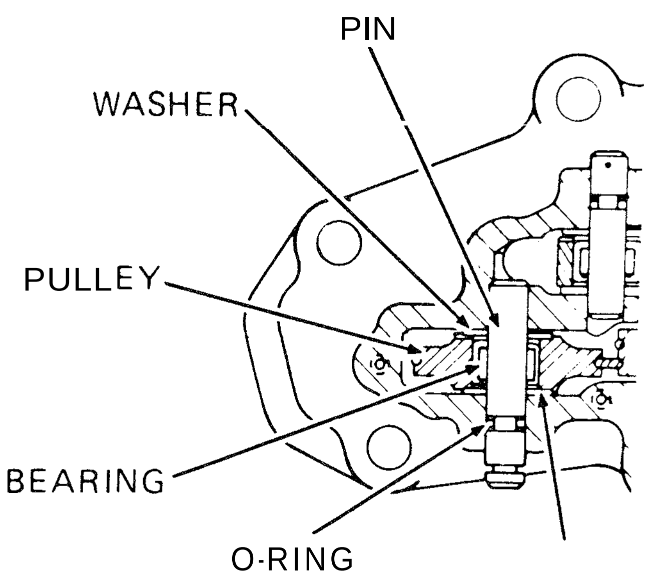


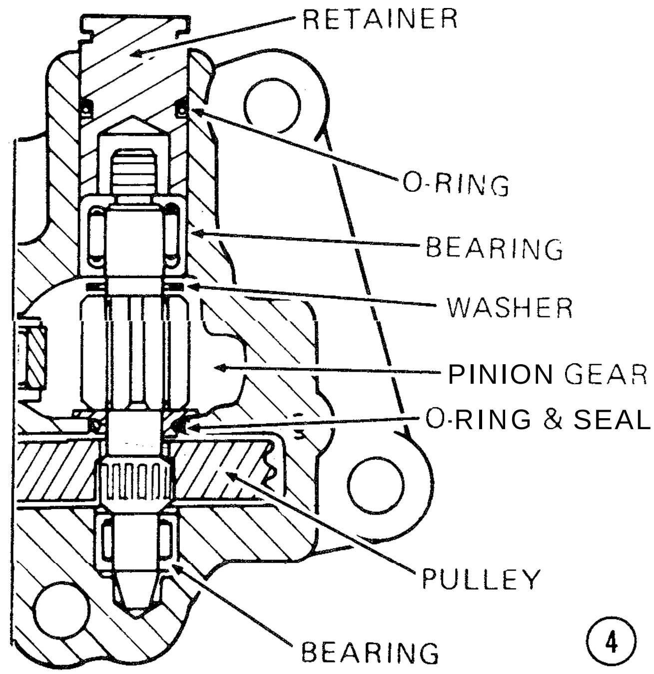
The shift mechanism is a precise mechanism and must be assembled with care and attention to detail. Check a second time to be sure all parts are in satisfactory condition. Read through the following procedure **BEFORE** starting the assembling work, and then pay attention to the sequence of installation and **TAKE CARE** that each part is properly assembled.

1– Place the retainer on the shift cable with the pre–formed bent tab facing **AWAY** and **DOWNWARD** from the shift housing body. Check to be sure the cables are parallel and feeding properly onto the pulleys. Insert the pulleys into the housing and secure them in place with **NEW** screws. Tighten the screws to a torque value of 5–7 ft-lbs.

2– Lubricate the idler pulley bearing with OMC Multi–Purpose grease, or equivalent. Slide a **NEW** O–ring onto the idler pulley shaft. In the following order, install the pin, washer, pulley, and second washer, as shown in the accompanying illustration. Push the shaft thru the pulley into the housing. Check to be sure the shift cable wire with the **SMALL** puck end runs **UNDER** the idler pulley. Now, spin the pulley and check to be sure it turns freely without binding. Seat the shaft in place with a hammer.

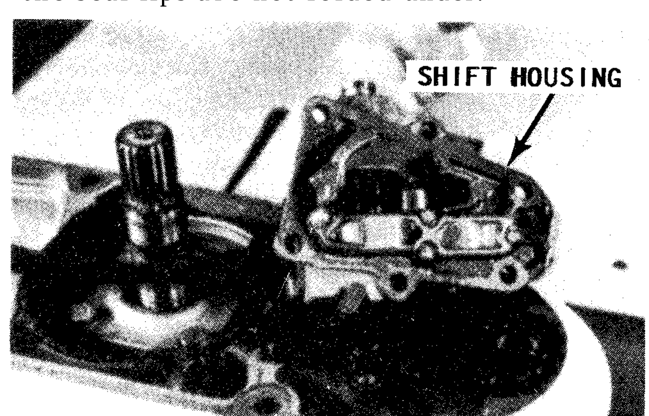
3– Lubricate the pinion shaft bearing on the shaft and the pinion bearing in the shift housing with OMC Multi–Purpose Grease, or equivalent. Check to be sure the drive pulley gooved surface faces the rack support, and then insert the cable pucks into the pulley. After the cable pucks are in place, twist the pulley 180° **CLOCKWISE.** Pull on the long cable end and bring the pulley down into the housing.





4

4– Using Special Tool No. 909967, install the O-ring and seal onto the pinion shaft with the O-ring facing **AWAY** from the pinion gear. **STUDY** the arrangement of parts in the accompanying illustration. Insert the shaft, O-ring and seal, and the washer into the housing. Now, rotate the pinion gear until the splines engage the drive pulley. Press in on the shaft until the nose slides through the pulley and into the bearing. Install the bearing using Special Tool No. 909882. This tool will set the bearing to the correct depth. Install the retainer and the O-ring. Check to be sure the seal lips are not folded under.

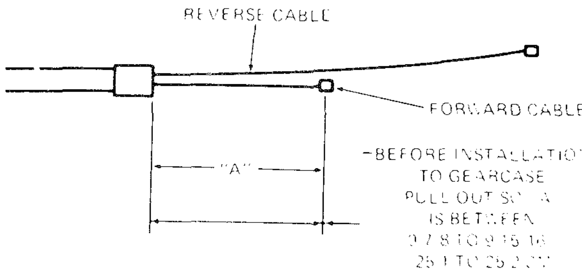


5

5- TAKE TIME to observe the routing of the shift wires to be sure they run parallel under the pulleys and DO NOT cross. Apply a coating of OMC Gasket Sealing Compound, or equivalent, to both sides of the cover gasket, and then place it in position on the housing. Install the cover and secure it with the four screws and washers. Tighten the screws to a torque value of 7-10 ft-lbs.

BEGIN with this step if the shift mechanism was disconnected only to service the lower unit.

6- Pull the short cable out of the housing until the **"A"** dimension in the accompanying illustration measures: models 1978-81, 9-7/8" to 9-15/16"; models since 1982, 4-7/8". This dimension controlls the pinion tooth position. On the **400 Series,** check to be sure the shift assist cylinder adapter is in place. **A** little needle bearing grease will hold the adapter to the housing while the housing is installed.



6

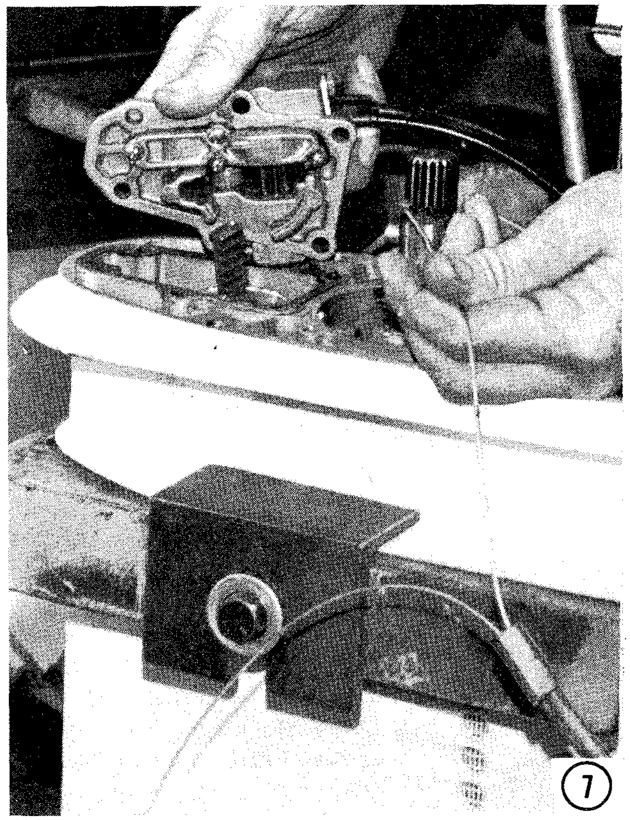
7- To install the shift housing: First, position the housing over the shift assist cylinder and engage the rack with the pinion in the shift housing. This can be accomplished by pulling on the long cable while maintaining tension on the short cable. During this operation, the forward cable will shorten, and the reverse cable will lengthen. Hold the flange of the shift housing parallel to the gearcase mounting flange to enable the pinion tooth to properly engage. As mentioned, the pinion tooth position is controlled by the dimension **"A"** given in Step 6.

8- Coat the six shift cable housing screws with OMC Gasket Sealing Compound, or equivalent. Install and tighten the screws to a torque value of 7-9 ft-lbs.

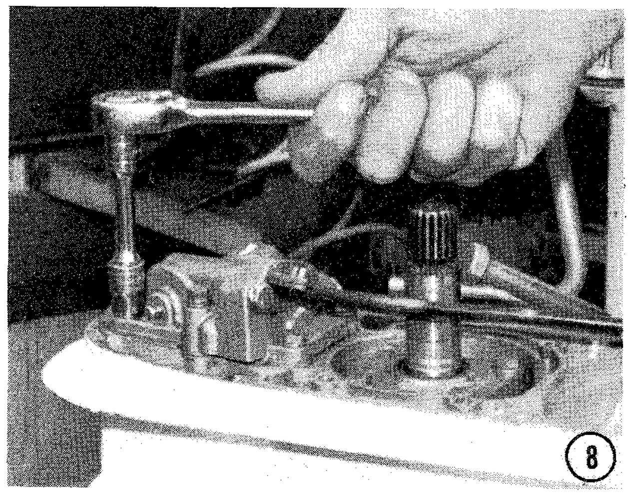
If this work was to replace the shift cable, install the exhaust housing; see Section 10-57.

Install the upper gear housing; see Section 10-58.

Install the stern drive; see Section 10-59.



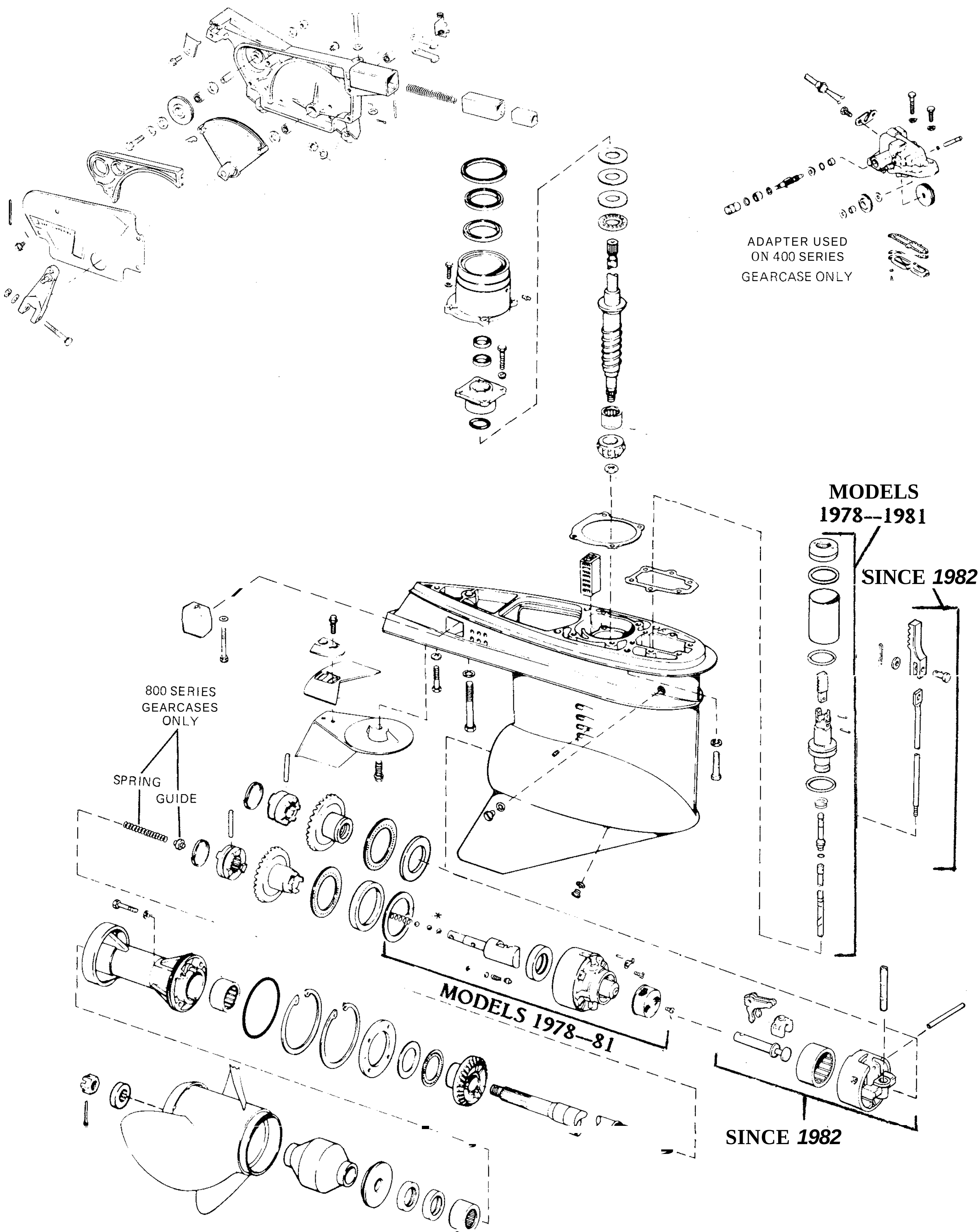
7



8

10-51 PINION BEARING SHIMMING MODELS SINCE 1978

Shims are installed between the driveshaft, thrust washer, and driveshaft bearing housing to allow the driveshaft pinion gear to mesh precisely with the forward and reverse gears. The number and thickness of the shims required **MUST** be accurately determined to ensure satisfactory service under all conditions during forward and reverse operaton. Special attention to detail and care in following the sequence of steps outlined in the next two paragraphs will ensure the correct measurement is made.



*Detent balls not used on some 800 series gearcases.

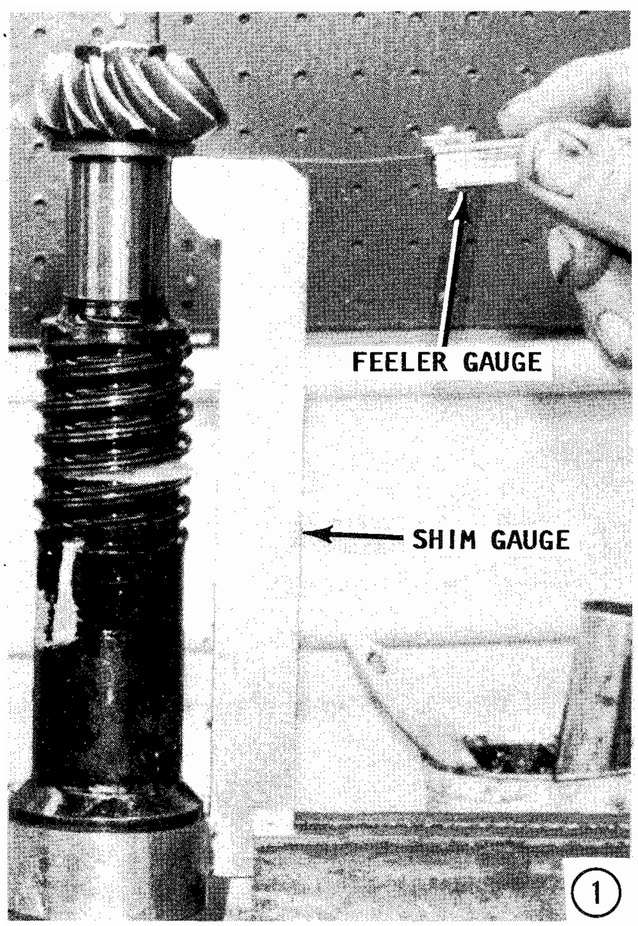
*Exploded drawing of the 400/800 Series lower unit. Since 1981, OMC has not used the series designation, **but** rather the Litre capacity of the power plant to identify the lower unit.*

1- Assemble the pinion gear to the driveshaft, and then place it in a vise. Tighten the nut to a torque value of 60-65 ft-lbs. Remove the thrust washer and bearing. Place the shims removed during disassembly onto the driveshaft shoulder. Obtain special shimming tool for the unit being serviced as follows:

Part No. 315767
400 Series Stern Drives

Part No. 321520
800 Series Stern Drives

Now, use the special shim gauge and a feeler gauge to measure the clearance between the top of the gauge and the pinion gear, as shown. If the shimming is correct, the top end of the gauge should just touch the bottom of the pinion gear with a **ZERO** clearance. Add or remove shims as required to obtain the **ZERO** clearance. Remove the nut and the pinion gear. Set the assembly and the correct number of shims aside until ready for installation.

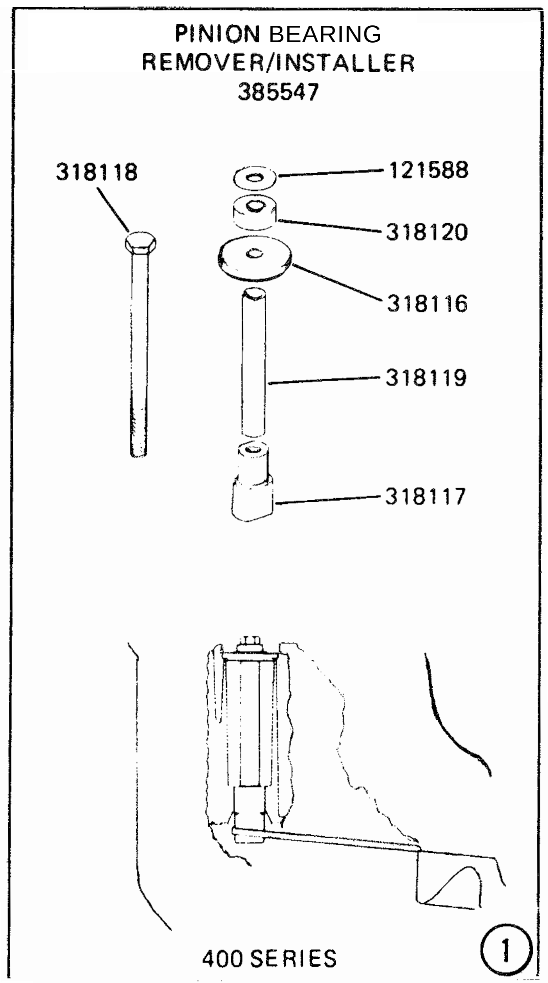


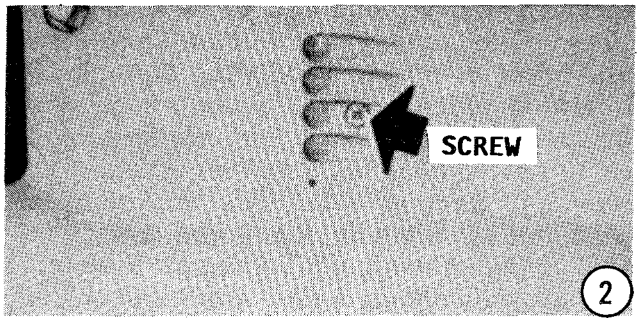
10-52 LOWER UNIT PINION BEARING RACE INSTALLATION MODELS SINCE 1978

On the **800 Series** lower unit, the pinion bearing race is installed from the top of the unit. On the **400 Series** units, the race is installed from the bottom.

1- Coat the roller with OMC Needle Bearing Grease, or equivalent, and then insert it into the bearing case. Use OMC Special Tool No. 385546 and Installer No. 321518 to install the bearing case into the **800 Series** lower units. Use Remover/ Installer Tool No. 385547 to install the bearing case in the **400 Series** units. Assemble the parts of Tool No. 385547 as shown in the accompanying illustration. On the **800 Series,** place the bearing on the installer tool with the bearing number facing the tool.

On the **400** Series, place the bearing on the installer tool with the bearing number facind **DOWN.** A little needle bearing grease will hold the bearing on the tool. On





the 800 Series, insert the tool and bearing into the gearcase, and then drive the bearing into place until the tool is seated on the face of the gearcase. Remove the tool from the gearcase.

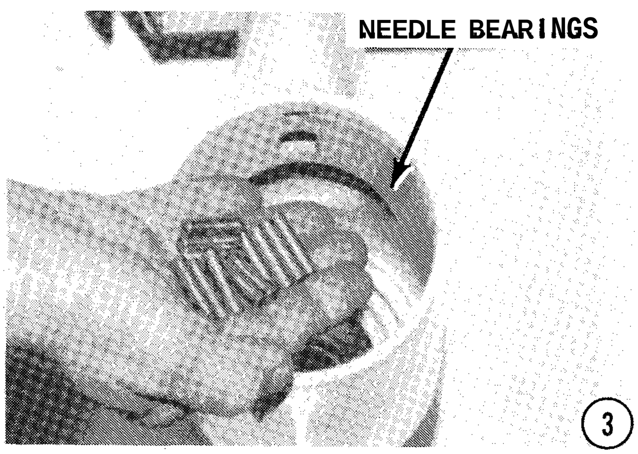
On the 400 Series, insert the tool through the driveshaft bore, and then place the bearing and remover/installer through the propeller shaft bore and screw it onto the tool. Hold the remover/installer with an open-end wrench and at the same time turn the top screw on the tool until the bearing is seated. Remove the tool and the Remover/ Installer from the gearcase.

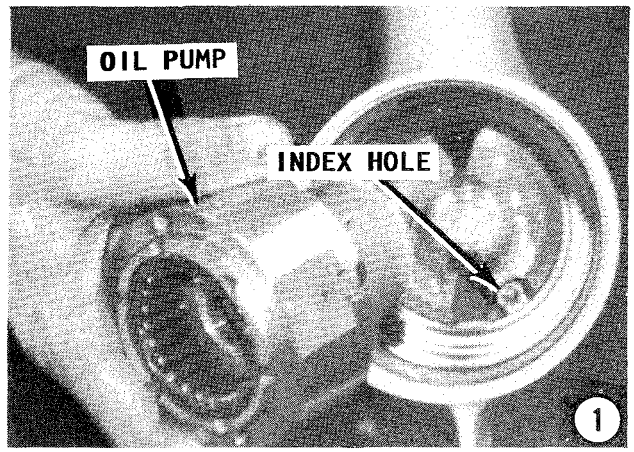
2- Snap the water pickup screen in place in the lower unit. Install the set screw into the starboard side of the lower unit to secure the pinion race and pickup screen in place.

3- Coat the pinion bearing race at the bottom of the pinion driveshaft bore with OMC Needle Bearing Grease, or equivalent. Install the same number of needle bearings by count as noted during disassembly, into the race. The grease will hold them in place.

10-53 OIL PUMP AND FORWARD GEAR INSTALLATION MODELS SINCE 1978

1- Observe the pin on the back side of the oil pump. This pin **MUST** index into the hole in the lower unit. Before installing the

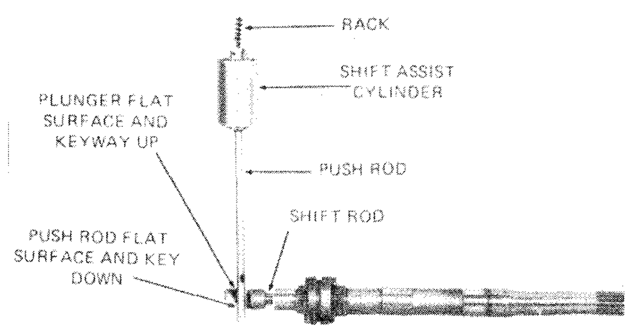




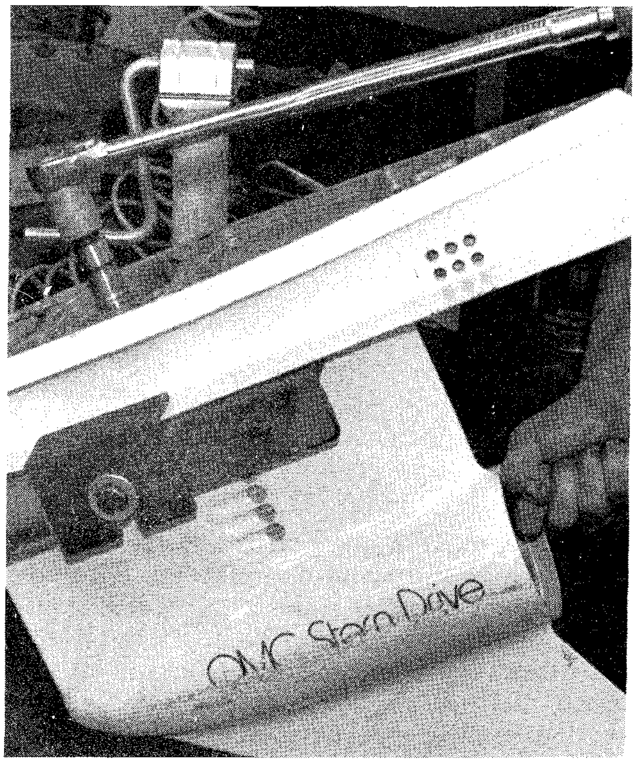
assembly, make a mark with a lead pencil on the front of the pump opposite the pin. Use a straight edge and make a mark inside the lower unit opposite the hole. Extend this mark outward about 5". Now, install the oil pump and the forward gear assembly into the lower unit with the marks on the housing aligned with the mark on the pump. Push or tap **LIGHTLY** with a rubber mallet until the assembly is fully seated in the lower unit.

10-54 DRIVESHAFT AND PINION GEAR INSTALLATION MODELS SINCE 1978

Place the pinion gear under the pinion bearing. **CAREFULLY** lower the driveshaft into the lower unit without losing any of the pinion needle bearings. Coet the driveshaft with oil, and then insert the driveshaft into the pinion gear. Secure the pinion gear to the driveshaft with the pinion nut, using Tool No. 361875 and a torque wrench. Tighten the nut to a torque value sf 60-65 ft-lbs, illustration, next page.



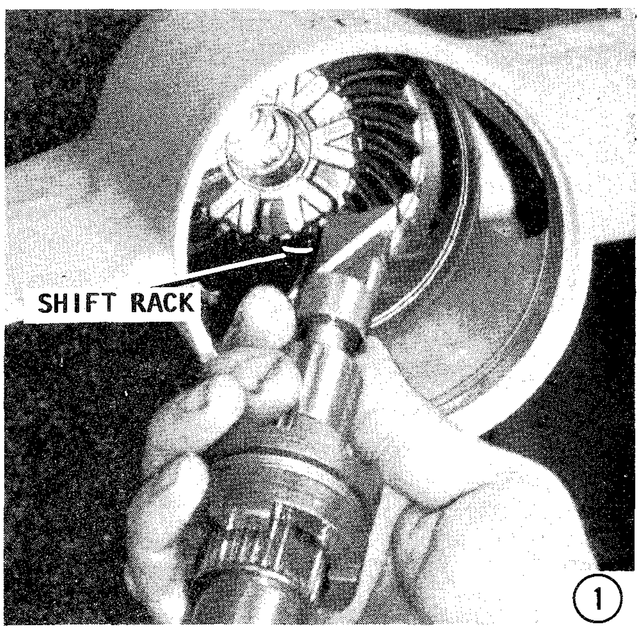
*Layout showing proper arrangement of the shift assist cylinder, push rod, and the propeller shaft as they **MUST** be installed in the lower unit.*



Tightening the pinion nut using a torque wrench, as described in the text.

10-55 PROPELLER SHAFT, ASSIST VALVE, AND PLUNGER INSTALLATION MODELS 1978--81

Installation of the propeller shaft, assist valve, and plunger is not a simple task. However, with patience, attention to detail, and an understanding of the installation sequence, the work can proceed smoothly without serious problems or the need to disassemble and repeat certain steps. The best word of advice is to read through the following procedure at least twice, or until the various parts and their relationship to each other including the installation sequence is thoroughly familar. Before these units are installed in the lower unit, some assembling on the bench can be performed.

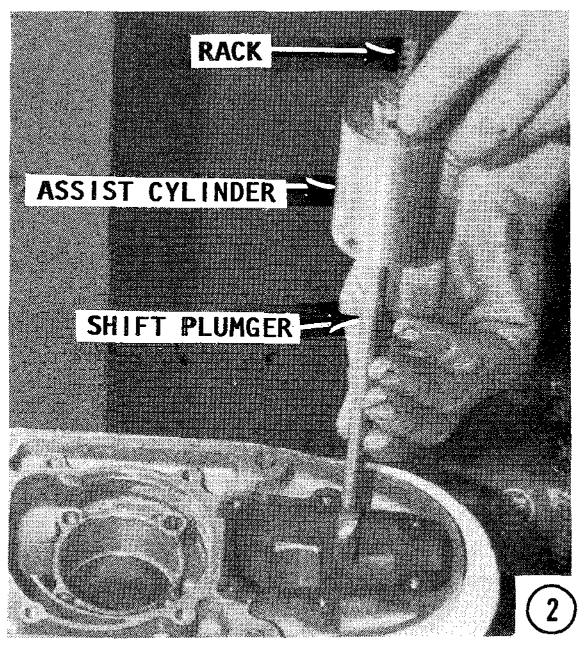


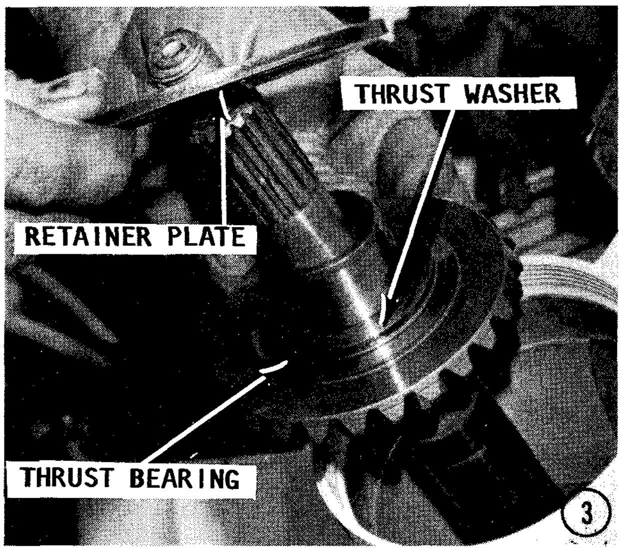
For photographic clarity, picture was taken without the pinion gear.

Assemble the propeller shaft and shifter as outlined in Section 10-46. Observe how the boss on the plunger slides into the cutaway in the shift rod. This arrangement **MUST** be accomplished when these units are installed in the lower unit. Also observe that the shift rod on the end of the propeller shaft is heavy on the back side causing the rod to rotate. Therefore, when the propeller shaft is held horizontal, the heavy side will turn the shift rod downward.

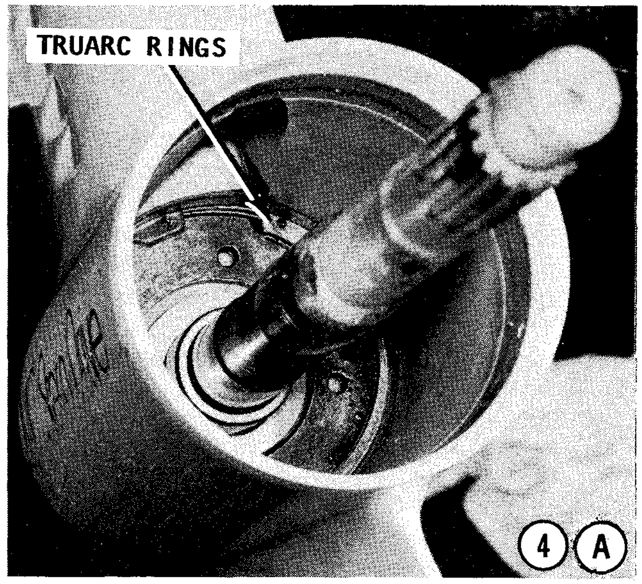
1- Lay the lower unit on a flat surface with the port side facing up. Adjust the unit on the bench to offer a clear view into the assist cylinder bore and also into the propeller shaft opening. Now, hold the propeller shaft with the heavy side of the shift rod down and insert it through the oil pump and forward gear assembly. Push the shaft in as far as possible. Use a flashlight to illuminate the interior of the shift assist cylinder bore. Observe the cutaway in the shifter rod. If you cannot see the cutaway, move the propeller shaft inward or outward until it is visible.

2- With the propeller shaft in this position, CAREFULLY insert the push rod





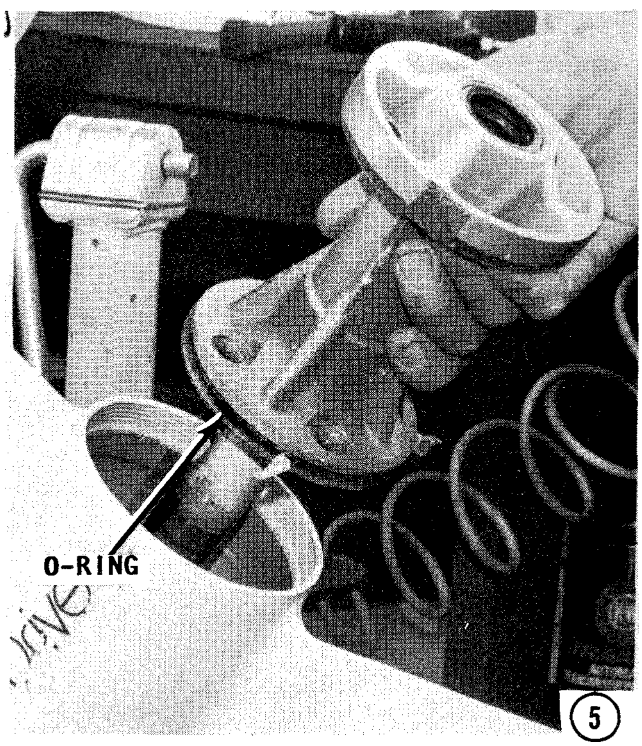
assist cylinder assembly into the gearcase with the boss on the cylinder facing down and the teeth of the shift rack facing toward the propeller. Continue to slowly move the assembly into the gearcase until it makes contact with the plunger. When the valve and plunger are properly engaged, flat-to-flat, the valve and plunger cannot be rotated. Exert a **GENTLE** downward pressure on the assist cylinder and valve assembly and at the same time, slowly **EASE** the propeller shaft backward to engage the plunger keyway with the push rod key. The gentle downward pressure on the shift assist assembly will help the push rod key to slip into the plunger keyway. After the proper alignment has been made, as just described, push the propeller shaft and shift assist



assembly inward until full engagement is reached. When the propeller shaft and the shift assist assembly are properly engaged, the assist valve and push rod **CANNOT** be rotated.

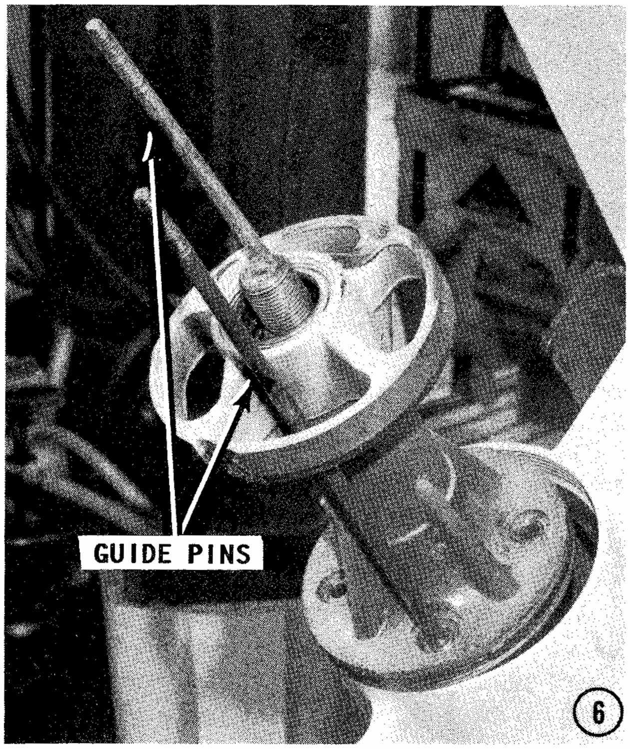
3- In the following order, install the thrust washer, thrust bearing, and the retainer plate onto the reverse gear. Install the assembled reverse gear into the lower unit.

4- WEAR SAFETY GLASSES and install the two Truarc rings using a pair of No. 7 Truarc pliers, as shown in the accompnaying illustrations 4 & 4A. These rings are under



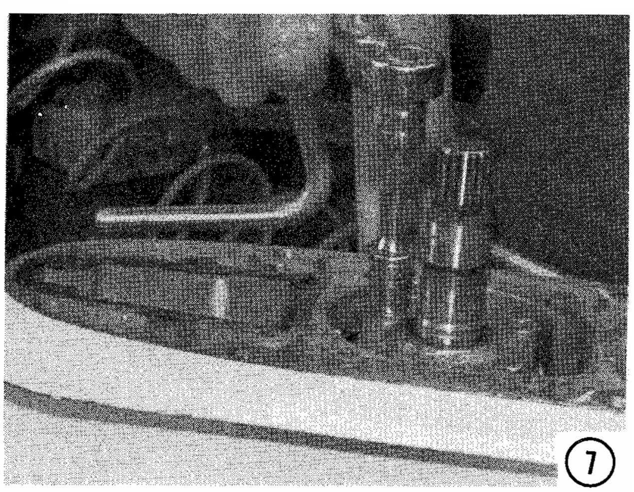
extreme pressures during removal and installation and may snap out of the pliers with tremendous force. Therefore, the need for the safety glasses.

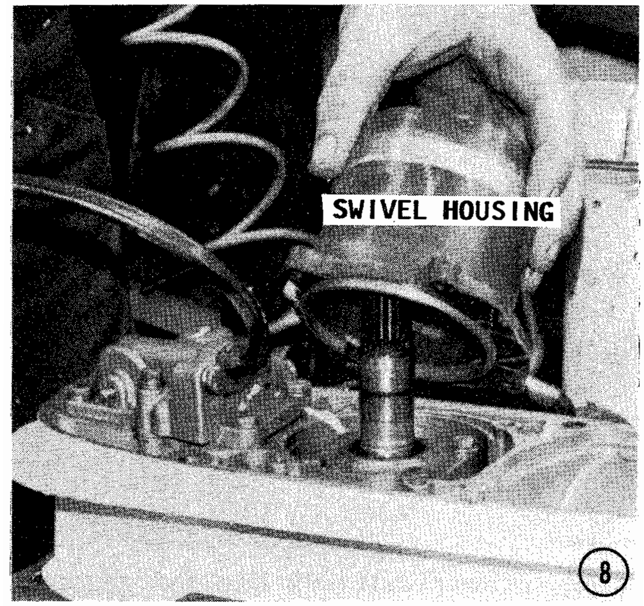
5- Install a NEW O-ring onto the propeller shaft bearing housing. Coat the O-ring and the interference ring with OMC Gasket Sealing Compound, or equivalent. Observe the cut-a-way in the propeller shaft housing. This cut-a-way allows water to drain from the housing.



6- Install the two guide pins into the retainer plate, but DO NOT thread them in more than TWO FULL TURNS.

Now, with the cut-a-way at the bottom, install the shaft housing over the guide pins and into position on the lower unit. **LIGHTLY** tap the housing into place with a





rubber mallet. Coat two NEW O-rings and the housing attaching screws with OMC Gasket Sealing Compound, or equivalent. Install two of the screws, and then remove the guide pins and install the other two screws. Tighten the screws to a torque value of 10-12 ft-lbs.

7- Install the driveshaft thrust bearing and thrust washer over the driveshaft. Install the shims on top of the thrust washer. Install the driveshaft housing using driveshaft seal protector Tool No. 318674. Coat a NEW O-ring and the four housing attaching screws with OMC Gasket Sealing Com-

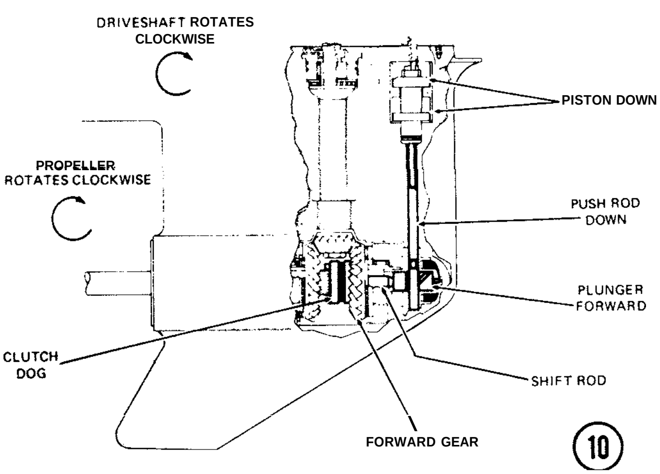
pound, or equivalent. Install the O-ring. Install the attaching screws and tighten them to a torque value of 14-16 ft-lbs.

8- Coat both sides of a **NEW** swivel bearing retainer gasket with OMC Gasket Sealing compound, or equivalent and place it in position on the lower unit. **CAREFULLY** lower the swivel bearing assembly over the driveshaft and into place. Secure the assembly with the four screws and lock-washers. Tighten the screws to a torque value of 7-9 ft-lbs. Install the shift housing and cable; see Section 10-59.

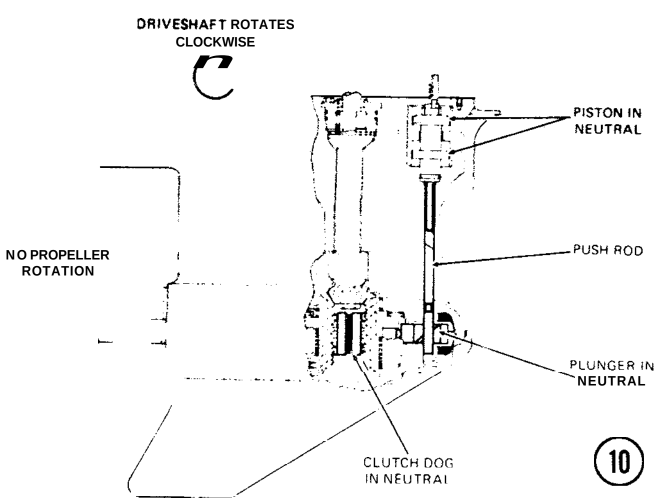
9- Perform a functional check of the shift system as follows: First, position the lower unit upright and fill it properly with OMC HI-VIS lube. The lubricant is necessary to make the the hydraulic shift assist system operational.

10- Next, insert a section of an old water pump shaft into an electric drill. The shaft may have to be worked down to fit the drill chuck. Now, slide the water pump

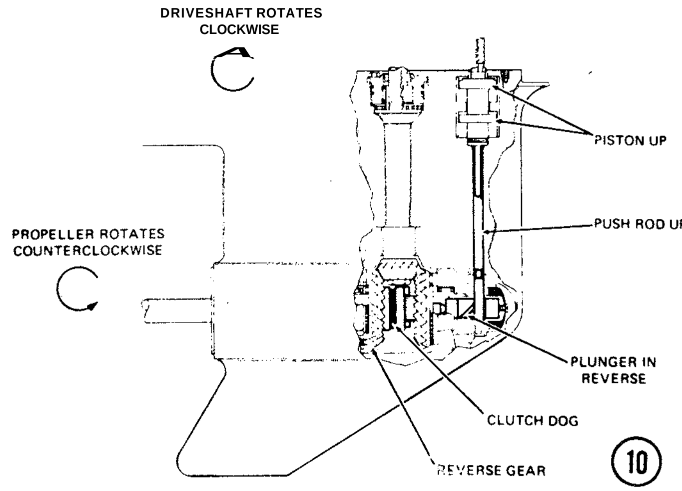
FORWARD GEAR



NEUTRAL



REVERSE GEAR

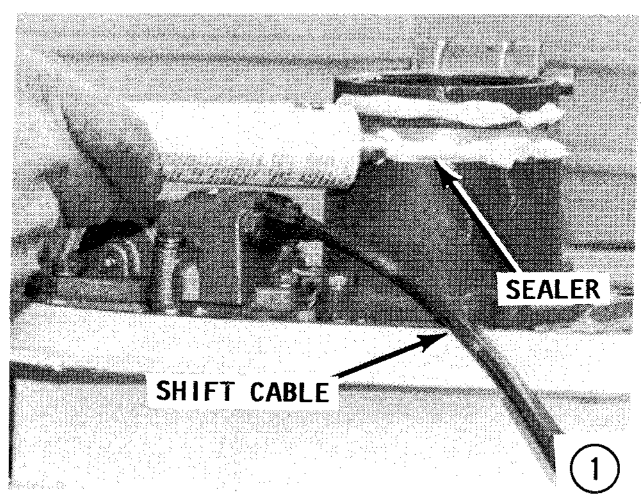


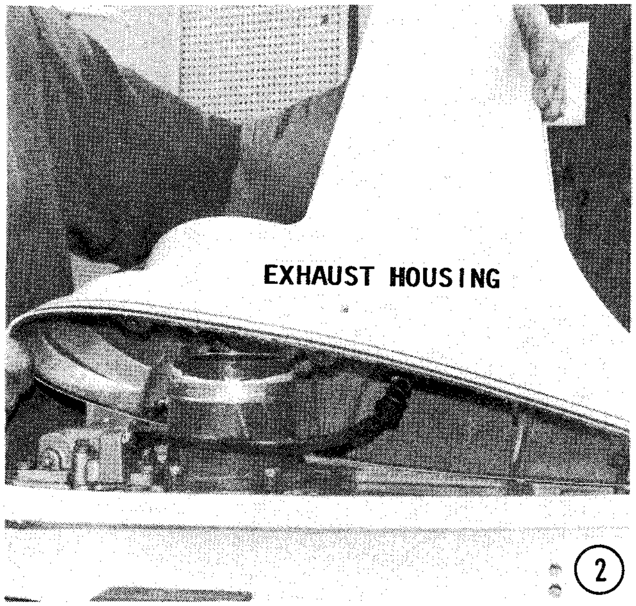
shaft piece onto the driveshaft with the grooves in the water pump shaft indexed with the driveshaft splines. Now, start the electric drill and shift the unit a number of times through all three positions, **FORWARD, NEUTRAL,** and **REVERSE** by pulling on the short cable for the forward position, and on the long cable for reverse. If there is any evidence of binding, the lower unit **MUST** be disassembled to determine the cause.

10-56 EXHAUST HOUSING INSTALLATION MODELS SINCE 1978

1- Apply a bead of Form-A-Gasket material to the mating surface of the exhaust housing and swivel housing.

2- Feed the shift cable through the hole in the exhaust housing and at the same time lower the housing into place on the lower unit.



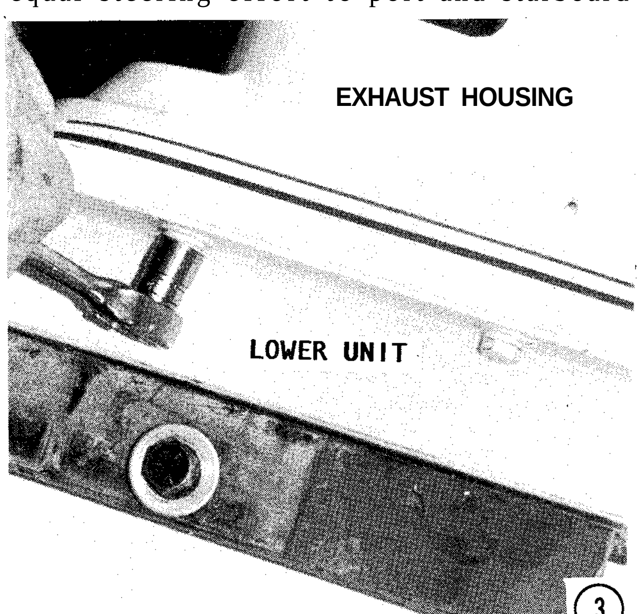


3- Dip the six attaching screws in Permatex No. 2, or equivalent. Start the four attaching screws in the side of the housing.

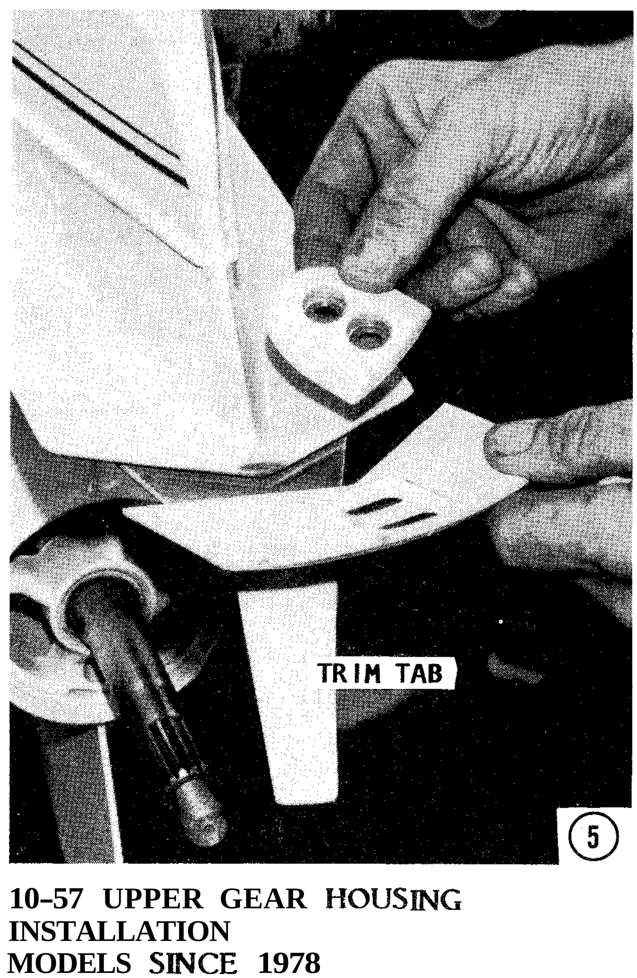
4— Start the one screw inside the trim tab cavity. Tighten all five screws started thus far, to a torque value of 18-20 ft-lbs. Now, install the anti-cavitation plate screw and tighten it to a torque value of 22-24 ft-lbs.

5- Coat the trim tab mounting screw-bottom, extension, clamp plate, and clamp screws with OMC Gasket Sealing Compound, or equivalent, and then install them to the lower unit. Tighten the clamp screws to a torque value of 8-10 ft-lbs. and the trim tab mounting screw to 28-32 ft-lbs.

The trim tab may be adjusted to obtain equal steering effort to port and starboard

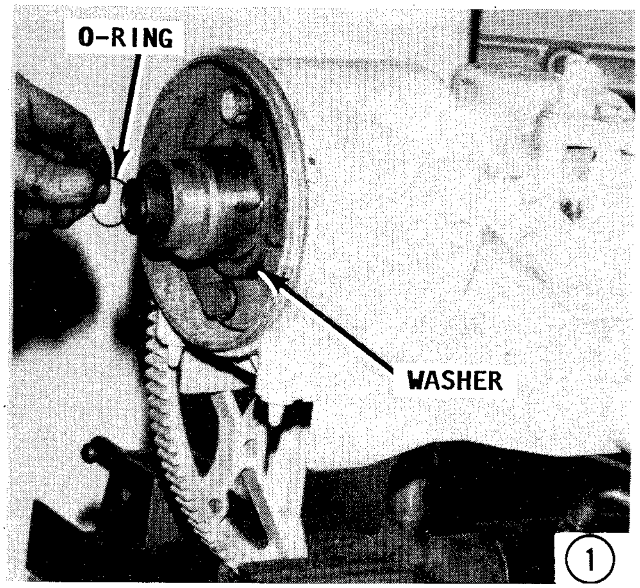


under the most frequently used engine speed and load conditions.



10-57 UPPER GEAR HOUSING INSTALLATION MODELS SINCE 1978

1- Coat the nylon swivel housing washer with a liberal amount of OMC Anti-Corrosion Lube, or equivalent. Place the washer on the bottom of the swivel housing with the

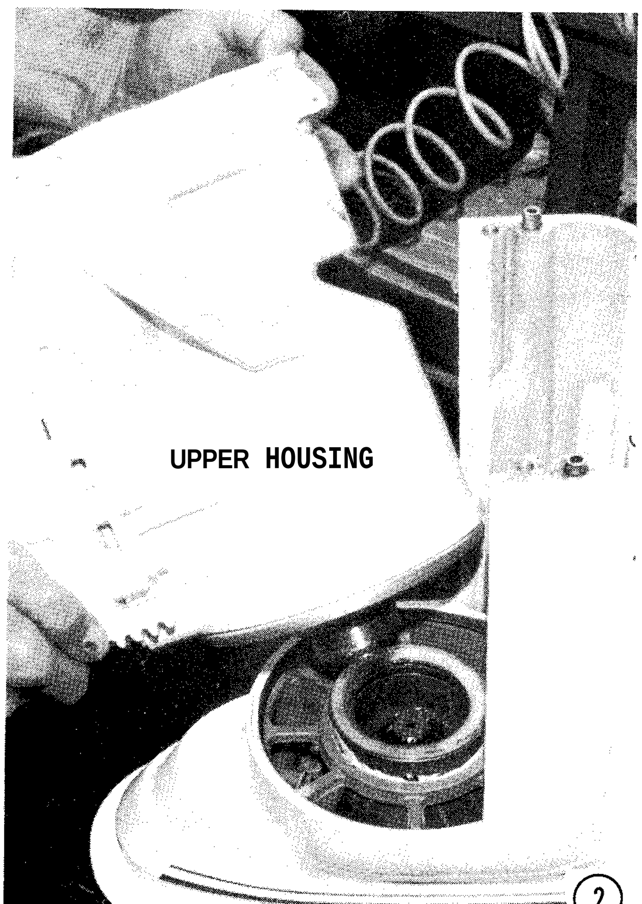


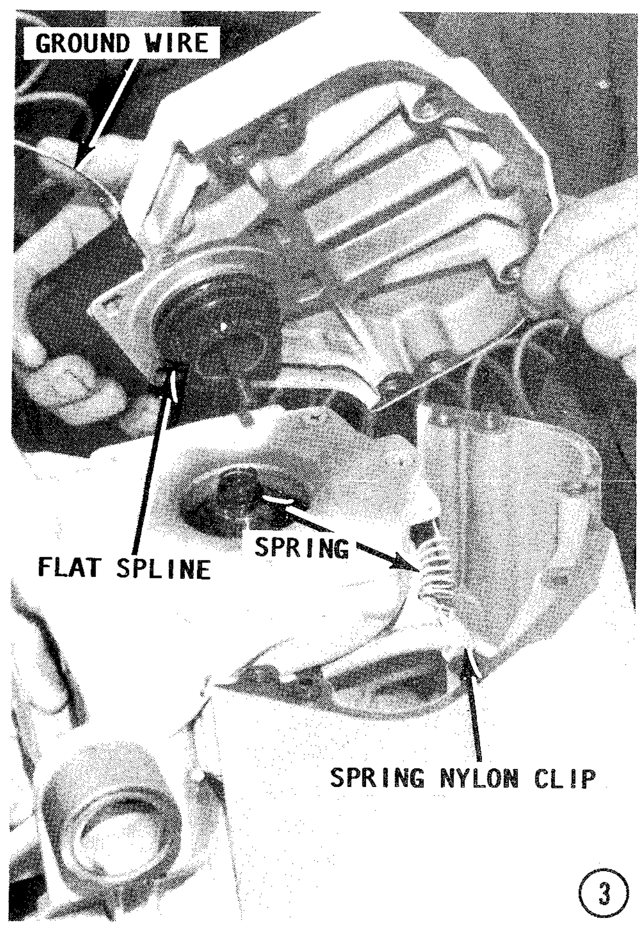
concave side towards the housing. CHECK to be sure the O-ring is installed inside the water pump shaft. (The illustration shows the ring going into place, however it should have been installed when the water pump was being assembled.)

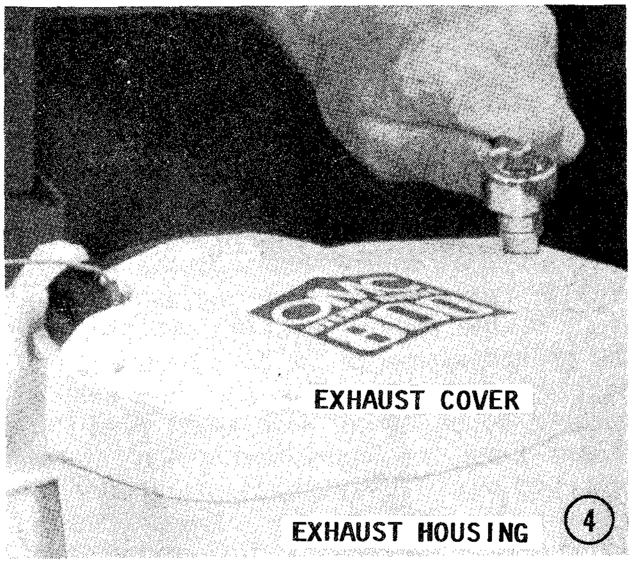
2- Feed the shift cable through the hole in the upper gear housing and at the same time lower the housing into place on the lower unit. Turn the spline back-and-forth to be sure it is properly seated.

3- Install the nylon keeper over the shift cable, and then feed one end of the spring through the holes in the keeper. Attach the other end of the spring to the boss on the aft part of the upper gear housing. On models equippped with Tru-Course Steering, align the flat on the front of the exhaust housing cover spline with the flat at the front of the worm wheel spline. Position the ground spring on the boss at the top of the upper gear housing. Coat the exhaust housing cover O-ring with OMC Anti-Corrosion Lube, or equivalent. On models equipped with Tru-Course Steering, check to be sure the flat on the exhaust housing cover spline matches the flat on the worm wheel spline, and then press the cover into positon.

4- Install the four attaching screws to secure the exhaust housing cover and tighten them to a torque value of 13-15 ft-lbs. Again, check the clearance between the exhaust housing cover and the upper gear housing. Install the bumper assembly and the ground wire assembly onto the front of the exhaust housing cover. Secure them in



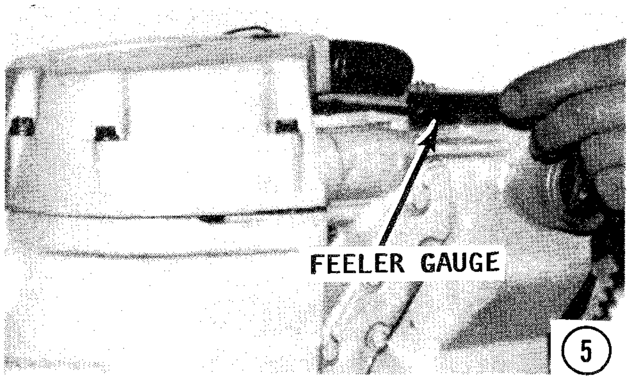


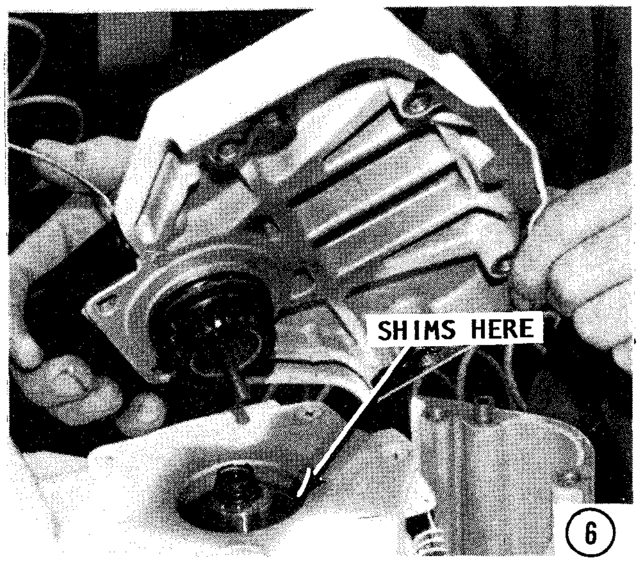


place with the two mounting screws and lockwashers. Tighten the screws to a torque value of 5-7 ft-lbs.

5- With the upper gear housing at its bottom-most position, resting naturally in the lower unit, use a feeler gauge and measure the gap between the exhaust housing cover and the upper gear housing. Now, lift the upper gear housing up as far as it will go and again measure the gap with the feeler gauge. The difference between the two measurements should not exceed 0.005" to 0.015". If the clearance is greater than 0.015" the extra play may be brought within tolerance by shimming.

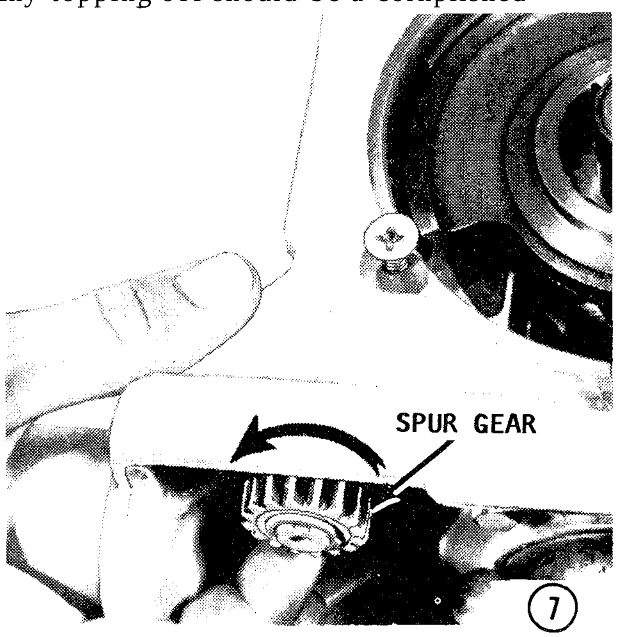
6- If shimming is required, remove the four screws securing the exhaust housing cover, and then remove the cover. Shims used to limit the upper gear housing movement are available in increments of ten-thousands inch thickness. Select the number of shims required to restrict the upper gear housing movement and install them over the steering post in the top center of the upper gear housing. Coat a NEW O-ring with OMC Anti-Corrosion Lube, or equivalent, and then install it in the exhaust housing cover.





7- Perform a steering gear rolling torque test on units equipped with Tru-Course Steering as follows: First determine if the vertical drive steering system has been properly assembled by using an inch-pound torque wrench and a 1-1/16" 12-point socket on the spur gear. Turn the gear clockwise as far as possible, and then counterclockwise simulating hard-over to hard-over. The torque reading should not exceed 10 in.-lbs.

8- Fill the upper gear housing SLOWLY with OMC HI-VIS Gearcase Lube. The oil level in the upper gear housing is measured with the oil level gauge plug just resting on the first thread of the hole in the housing. NEVER screw the gauge plug into the housing to measure the oil level. Check the oil level a second time after about 20-minutes. Any topping off should be a cornplished



through the gearcase topmost fill and oil level gauge plug. ALWAYS use a new fill plug washer. Check the oil level a third time before tightening the plug to a torque value of 10-12 ft-lbs.

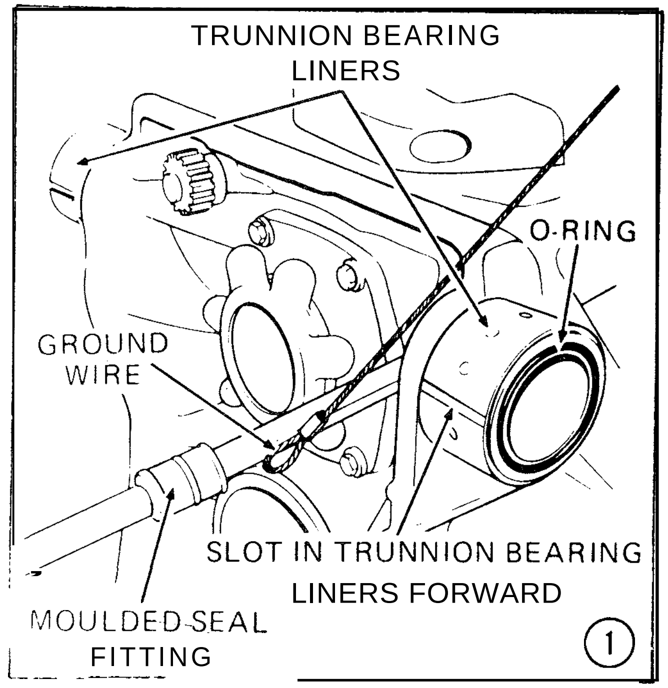
10-58 STERN DRIVE INSTALLATION MODELS SINCE 1978

BEFORE the stern drive is installed, check to be sure the battery cables at the battery have been DISCONNECTED to prevent accidental shorting of the shift core wires on electrical parts during installation of the stern drive. If the shift core wires are damaged, the entire shift cable asembly would have to be replaced.

On boats equipped with Tru-Course Steering, the steering cable MUST be installed in the boat and the helm and drum in the intermediate housing MUST be centered before the stern drive is installed.

FOLLOW the installation instructions closely to ensure the stern drive is installed in the straight-ahead position to provide equal steering to port and starboard. For detailed instructions regarding installation and adjustment of the steering system, see Chapter 7.

8

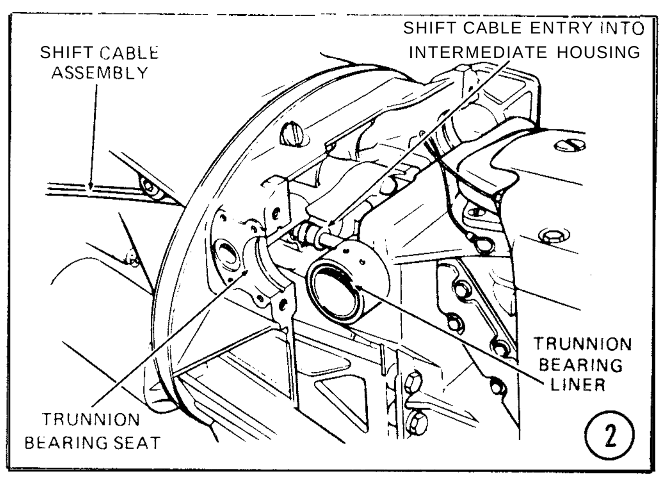


1

1- Coat NEW O-rings and trunnion bearing liners with OMC Anti-Corrosion Lube. Install the O-rings into the trunions and the liners with the slot in the liner facing FORWARD.

2- Start the core end fittings, the wires, and the shift cable into the hole through the intermediate housing. Move the stern drive into position until the trunion bearings are against the bearing seats and at the same time guide the shift cable through the intermediate housing until the molded rubber seal fitting is almost entering the intermediate housing passage. Check to be sure the turnnion bearing liners are in the proper position with the slot still facing forward.

3- The pivot caps are are identified with a R and L for right and left side installation and are NOT interchangeable. Install the



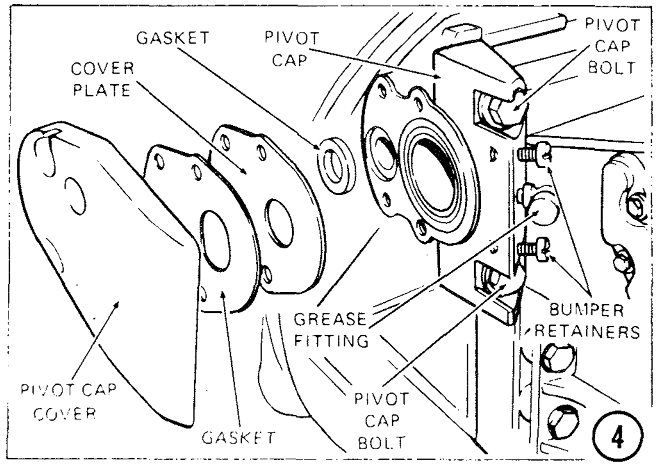
2

proper pivot cap on each side and start the attaching bolts. Bring the bolts up just snug but DO **NOT** tighten them at this time.

4- Install the gasket, cover plate, and pivot cap cover to the intermediate housing on each side. Align the holes through the plate, gasket and cover with the holes in the housing. The word **TOP** is stamped on the plate as an aid to installation. Install the attaching screws with the ground wire under the upper forward screw on the left (port) side cover. Tighten the cover screws to a torque value of 5-7 ft-lbs.

5- Tighten the pivot cap bolts on each side to a torque value of 18-20 ft-lbs. Lubricate each trunnion with OMC Anti-corrosion Lube, or equivalent, through the fitting on each cap. On units equipped with Tru-Course steering, coat the outer steering shaft fitting under the steering gear and the fitting on the side of the intermediate housing with OMC Anti-Corrosion lubricant, or equivalent.

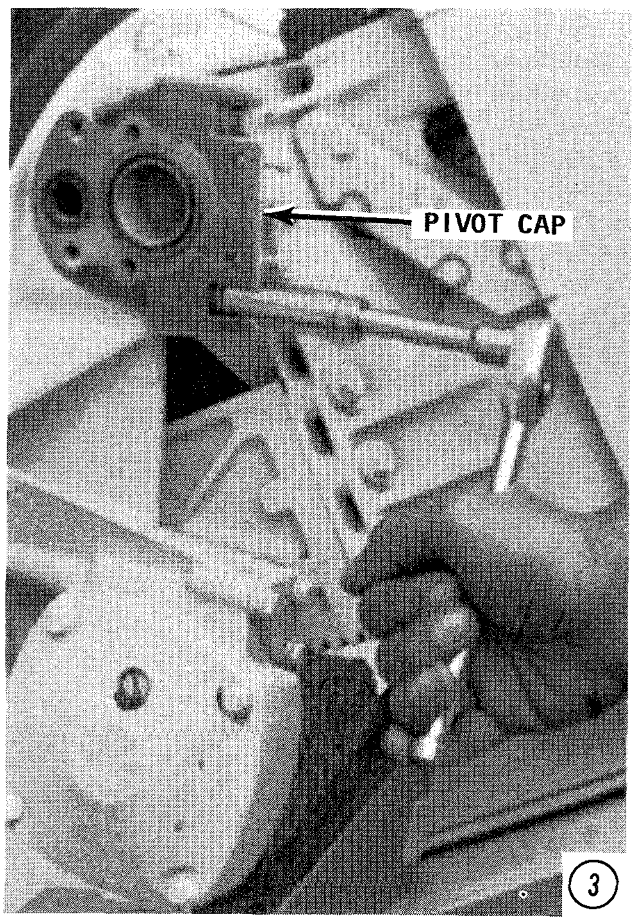
6- CAREFULLY pull the cable through the intermediate housing until the rubber bushing on the cable enters the hole. Pull the fitting into the hole until it is flush with the housing surface. **TAKE CARE NOT** to



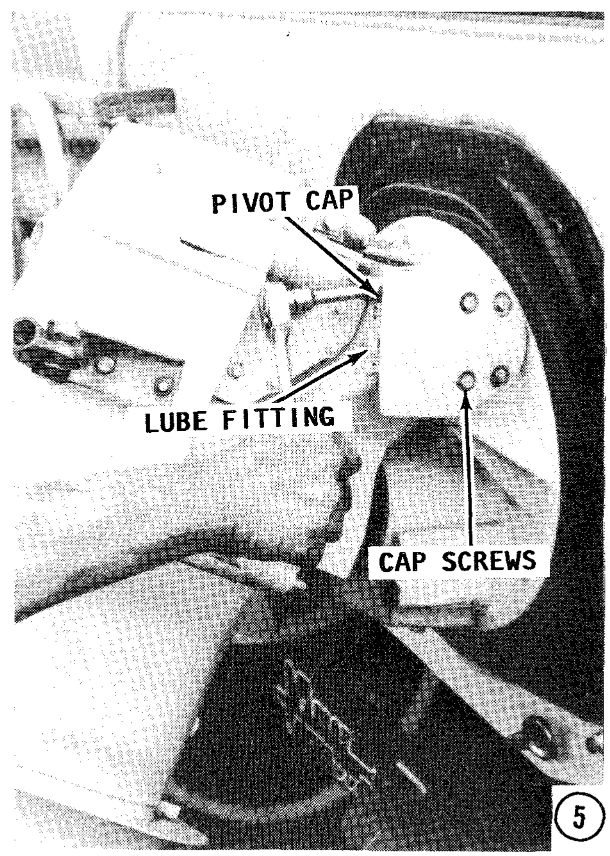
4

pull the bushing through the hole because it is tapered and once through the hole cannot be pulled back into position without serious damage to the cable. Lay the shift cables inside the boat on the deck on the port side and be sure they do not come in contact with any electrical part.

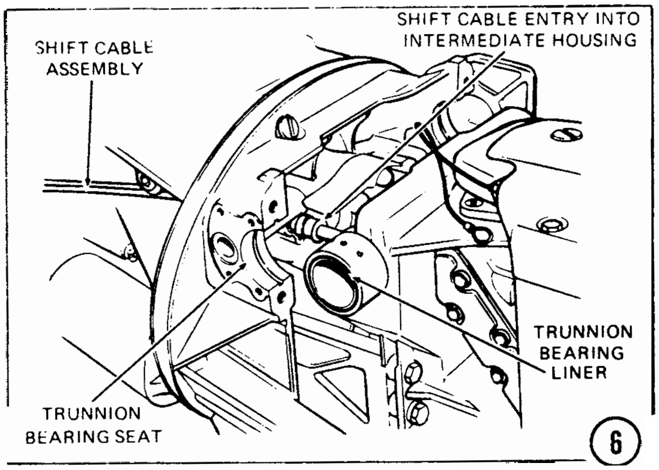
7- Temporarily connect the cables to the battery and raise the stern drive to the full up position. From outside the boat, install the cable retainer screw, lockwasher, cable retainer, and external lockwasher, into the intermediate housing, as shown. **NOTICE** the position of the external lock-washer. These parts must be installed, as



3

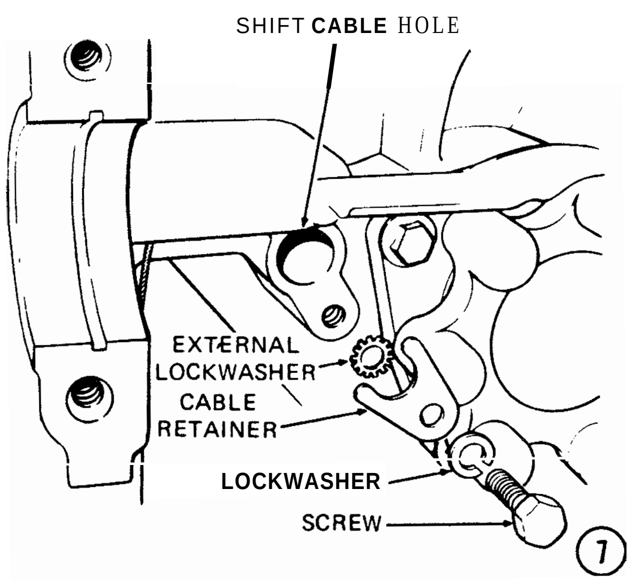


5



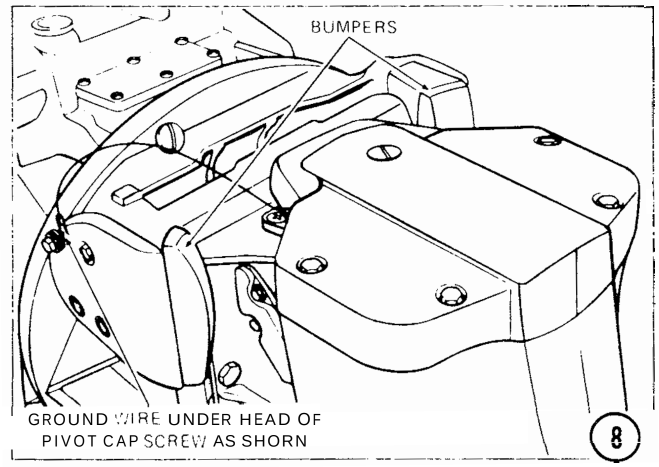
shown, to prevent the rubber bushing on the cable from slipping out and water entering the boat. Tighten the cable retainer screw to a torque value of 5-7 ft-lbs.

8- Lower the stern drive to the full down position. The stern drive **MUST** be in the full down position in order to install the bumpers. Disconnect the battery cables at the battery. Insert a drop or two of oil into each bumper hole, and then push them onto the pivot caps.



10-59 SHIFT CONVERTER CABLE INSTALLATION MODELS SINCE 1978

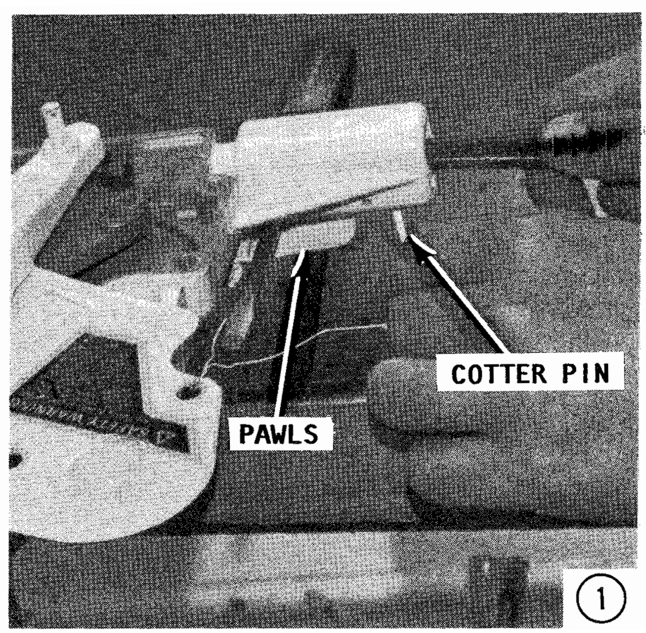
The following procedures pickup the work after the shift converter has been installed according to the instructions outlined in Section 10-25.

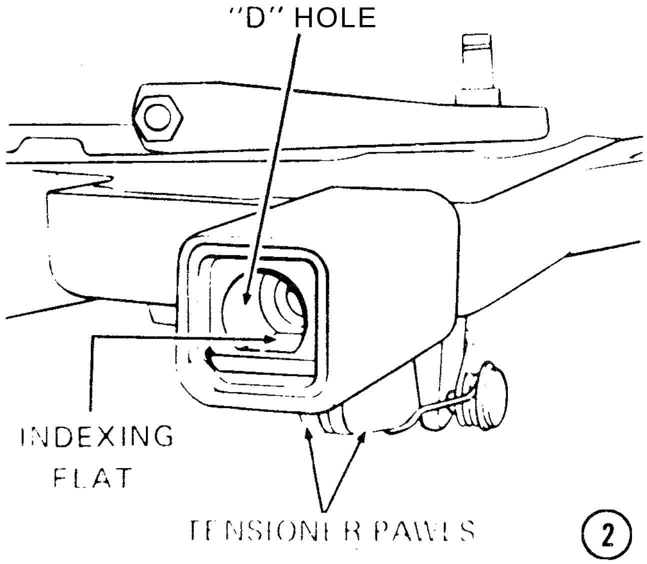


1- Check to be sure the cotter pin is in position in the hole in the square tubing of the converter box, and the screwdriver is still in place between the converter box and the pawls.

2- **CAREFULLY** feed the cable cores one-at-a-time through the **"D"** hole into the shift converter housing. Align the flat on the cable with the flat in the housing, and then push the cable into place.

3- Lay the short cable core into the lower groove of the segment pulley, and then insert the plug of the end fitting into its recess with the cable passing through the slot. Lay the long cable core wire over the top of the idler pulley, then around the pulley and along the upper groove of the segment pulley. Insert the end fitting into its recess with the cable core passing through the slot.
Check to be sure the cable cores are **NOT CROSSED.** Crossed cables would result in

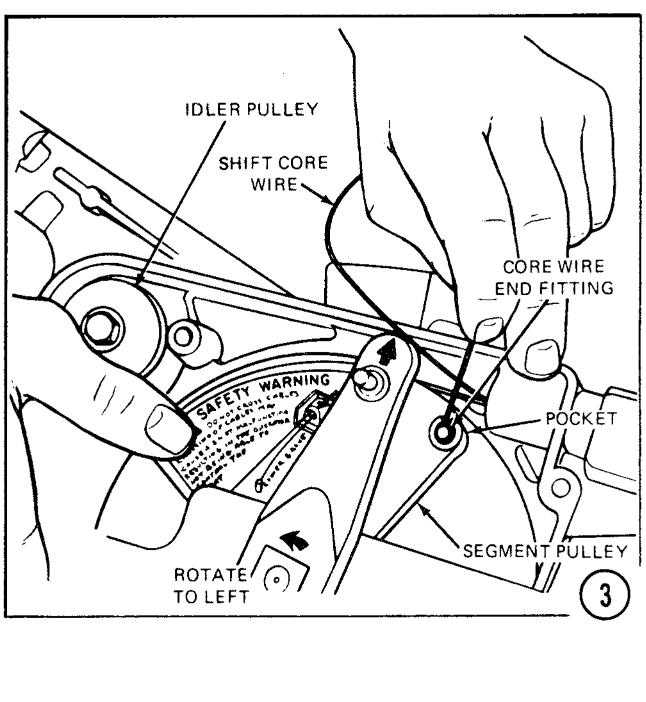


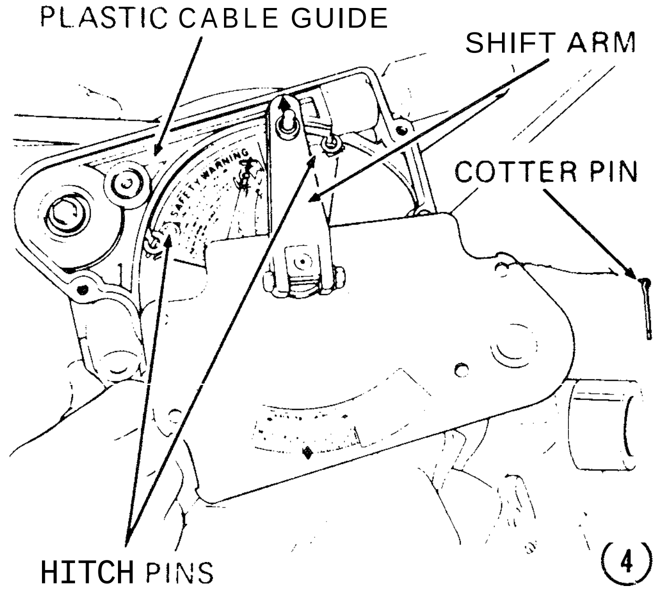


very hard shifting. Check to be sure each end fitting is fully seated in its recess and the core wires pass through the slots properly*

4- Install a hitch pin through the boss of each end fitting recess with the round ends facing inward, and then turn them downward to lock the end fittings in place.

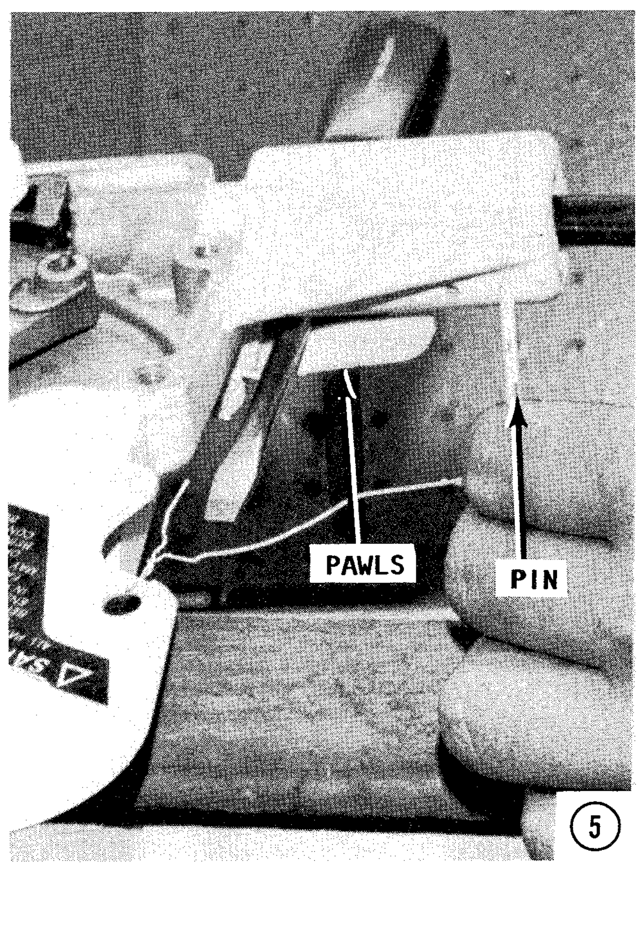
5- Remove the cotter pin and screwdriver from the square tubing of the shift coverter, placing spring tension on the cable cores. Now, carefully check the installation work thus far. The cables should be properly seated in their grooves in the segment pulley and around the idler pulley. The cables should not be crossed, and the end fittings should be fully seated in their recesses and secured in place with the hitch pins.

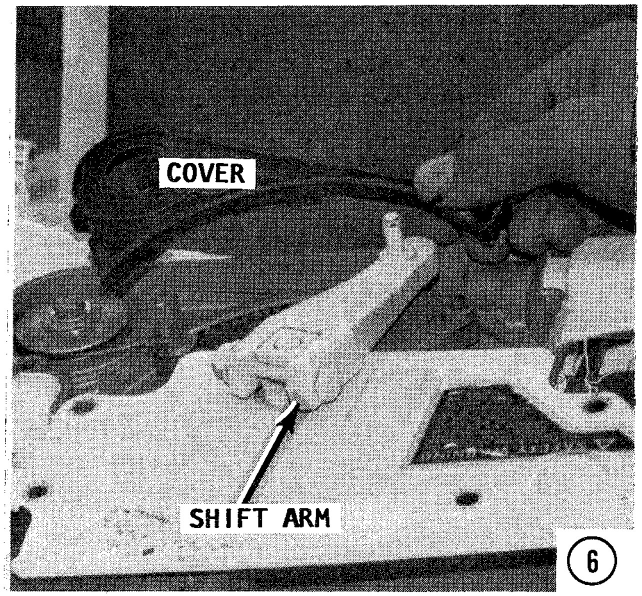




6- Install the black plastic cable cover over the shift cable cores. Install the cover plate and secure it in place with the four attaching screws. Install the shift arm.

ONE MORE WORD: Any time the stern drive is removed from the boat, or any parts of the shift system have been replaced, the shift mechanism MUST be properly adjusted according to the procedures outlined in the next section.





6

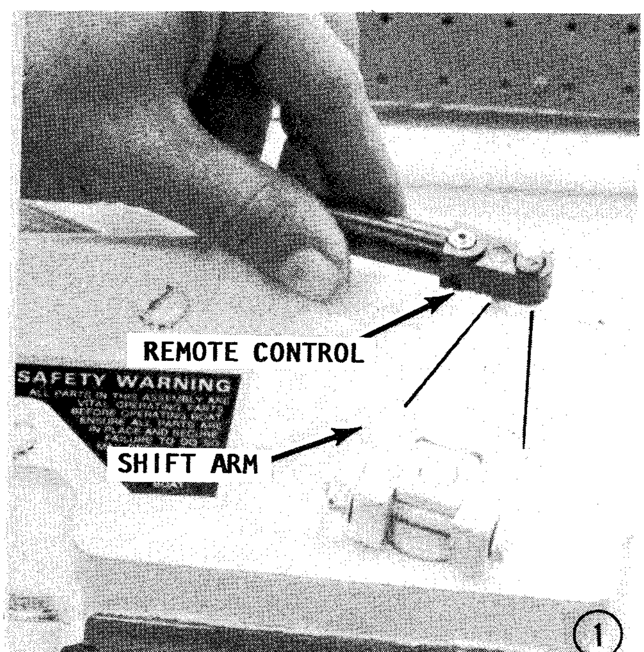
10-60 SHIFT MECHANISM ADJUSTMENT MODELS SINCE 1978

1- Disconnect the remote control shift cable, if it is attached. Remove the plastic alignment fixture, if it is installed.

2- Remove the propeller before starting the engine to prevent possible serious injury from someone coming in contact with it while the engine is operating and the stern drive is in gear.

3- Start 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.

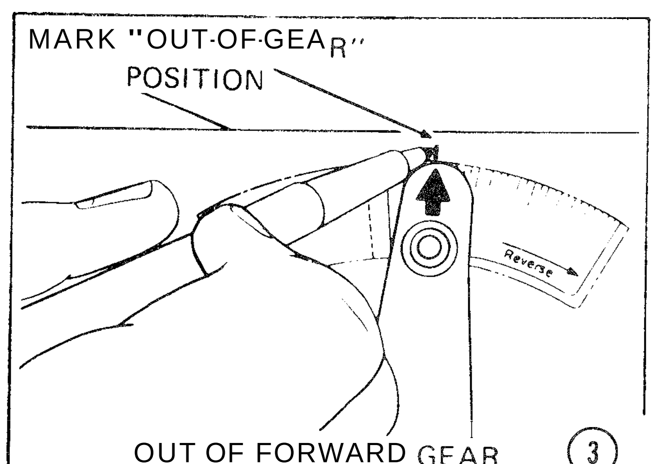


1

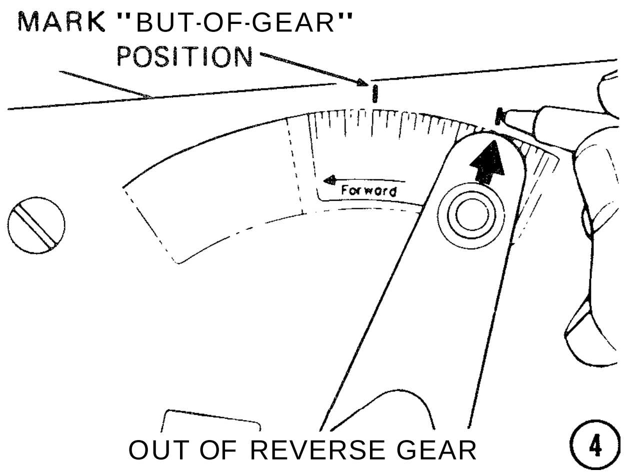

2

With the engine running, move the shift arm on the shift converter housing to the full forward position. Now, slowly move the arm in the opposite direction until the unit moves out of FORWARD gear, Mark this position on the decal in line with the arrow on the shift arm.

4- Move the shift arm to the full rearward positon. Slowly move the arm in the opposite direction until the unit moves out of **REVERSE** gear. Again, make a mark on the decal in line with the arrow on the shift arm.



3



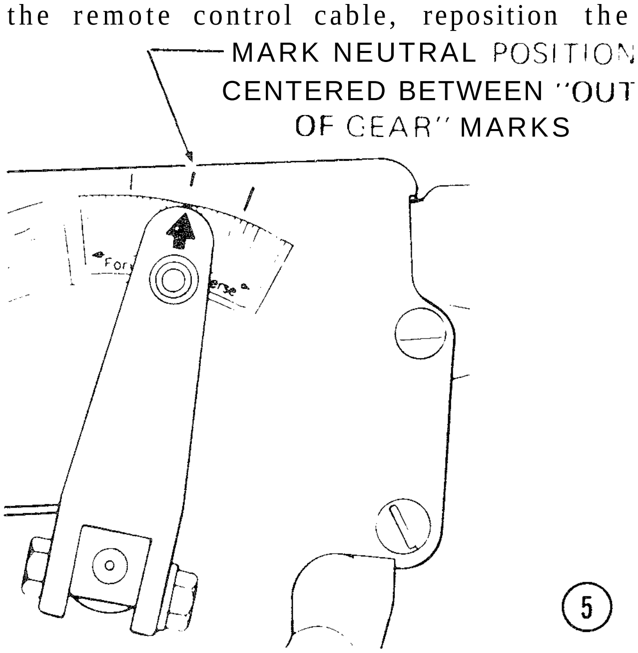
4

5- Make a third mark on the decal at the mid-point between the first two marks. This mark will indicate the correct nominal **NEUTRAL** position.

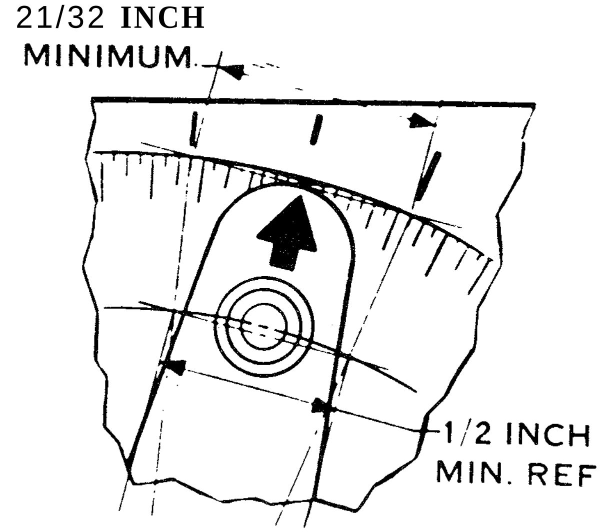
6- The distance between the first and second marks **MUST** be at least 21/32", as shown in the accompanying illustration. Repeat the procedure to verify the accuracy of the marks. If the distance between the first and second mark is less than the required minimum, the engine may start while in gear creating a very hazardous condition. Therefore, the shift system **MUST** be carefully checked to determine why the neutral range is less than the minimum required for safe operation. Stop the engine.

7- To install the remote control cable, first loosen the retainer screw, and pivot retainer to clear the anchor pocket. Insert the remote control cable, reposition the retainer, and then tighten the screw **FINGERTIGHT.**

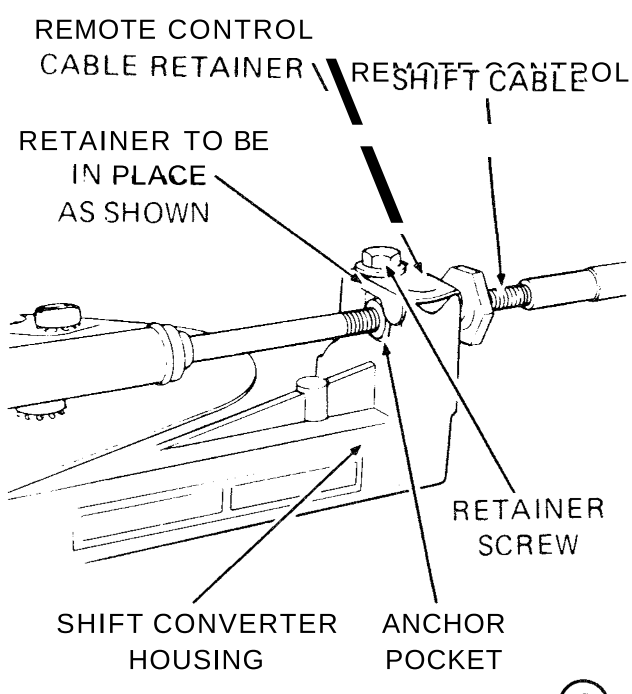
8- Position the shift arm at the **NEUTRAL** mark. Slip the shift cable end over the pin on the shift arm. If it is necessary to move the shift arm off the mark, adjust the black knob in the anchor pocket until the shift cable end can be slipped over the pin with the shift arm on the **NEUTRAL** mark. After adjustment has been made, tighten the retainer screw to a torque value of 5-7 ft-lbs. Install the washer and cotter pin on the shift arm.



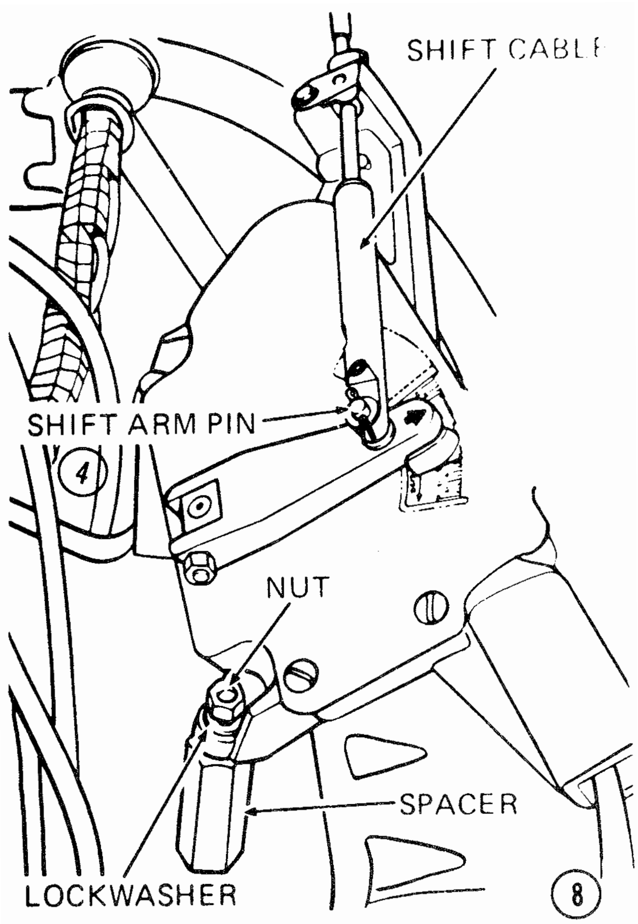
5

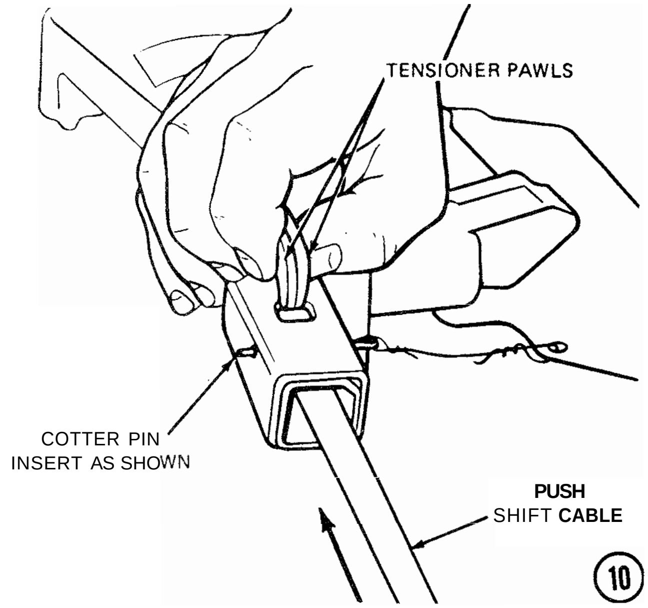


6



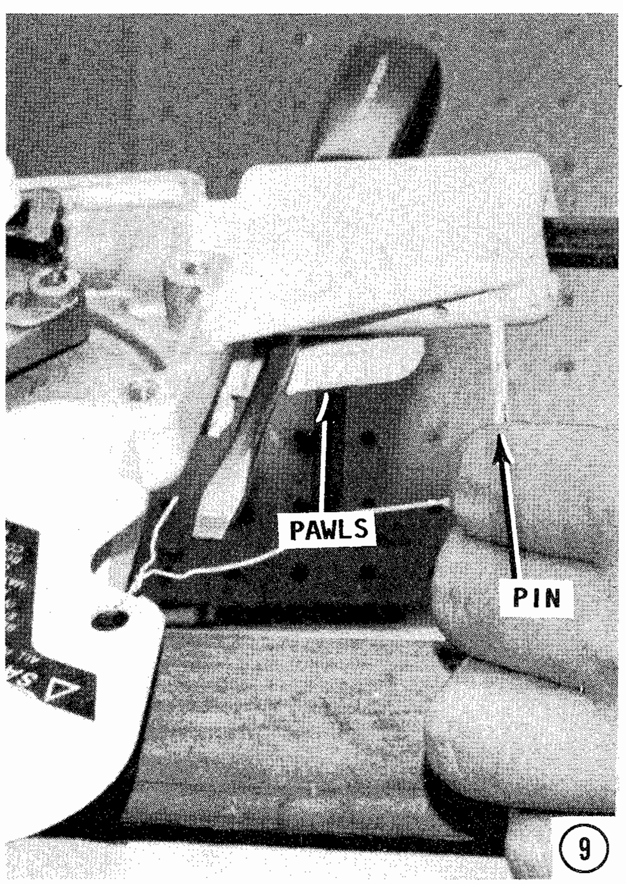
7

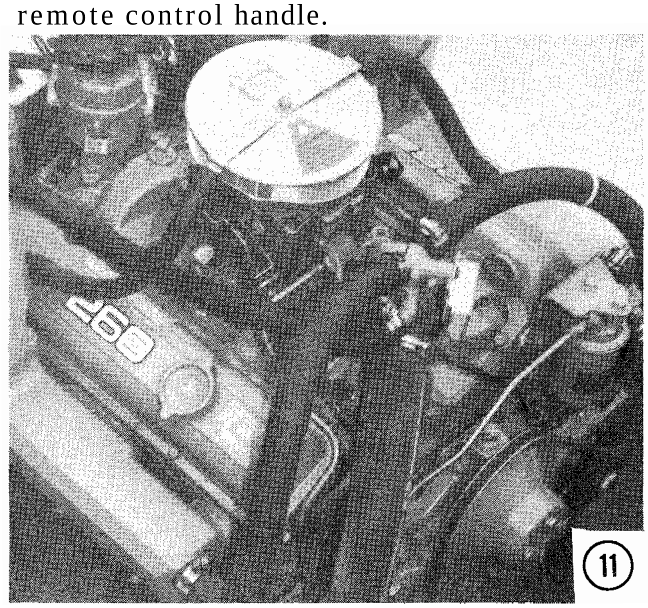




9- Check to be sure the cotter pin which is attached by a wire to the shift converter housing, is removed. If the shift system is operated with this pin in place, the system would lose the start in gear protection or fail to function properly.

10- Check the tensioner by raising the pawls and pushing in on the shift cable assembly. DO NOT raise the pawls any further than necessary to disengage the tensioner. The additional displacement of the pawls may cause distortion to the torsion spring or dislocate the spring. Engage the pawls again and allow the spring to automatically place tension on the cable DO NOT pull on the cable to obtain additional tension because the increased tension would increase the force required to shift at the remote control handle.





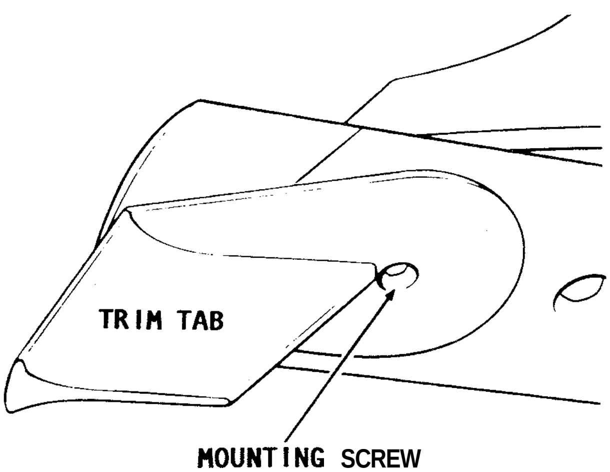
11- This step may be performed while the boat is in the water or out of the water. If the adjustment is made while the boat is out of the water an OMC Flushing Adaptor Kit should be installed to supply adequate cooling water through the stern drive and the engine.

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.**

Cycle the remote control through the three gear positions several times. Shut the engine down and attempt to start it in FORWARD. The engine should not start. Attempt to start the engine in REVERSE. The engine should not start. If the engine does start in either forward or reverse gear, readjust the remote control. If the engine still continues to start when the shift control unit is in forward or reverse positions, the NEUTRAL position MUST be adjusted as outlined in the next step.

Disconnect the remote control cable from the shift arm pin at the shift converter. Set the engine to operate at **800** rpm while the unit is in gear. Cycle the shift mechanism three or four times through the complete shift range, NEUTRAL, FORWARD, NEUTRAL, REVERSE, and NEUTRAL, to represent one cyle. The unit should shift smoothly with no delay. If the unit shifts hard, or other problems are encountered, the shift mechanism must be disassembled and inspected.



***Screw** which must be loosened to make a trim tab adjustment.*

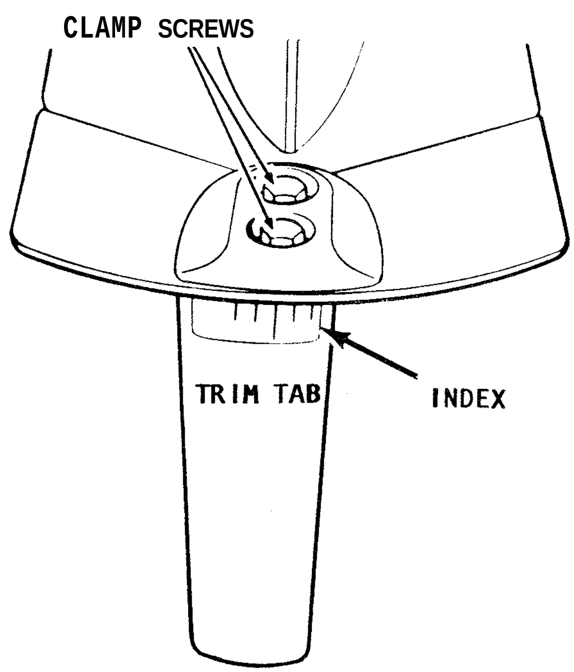
10-61 TRIM TAB ADJUSTMENT MODELS SINCE 1978

The trim tab may be adjusted to obtain equal steering effort to port and starboard under the most frequently used engine speed and load conditions.

Operate the boat at the engine speed and trim setting most frequently used. Turn the helm from hard-over in one direction to hard-over in the opposite direction. Make an evaluation to determine in which direction the least amount of effort is required.

Move the trim tab slightly to the side which seems to require the least effort, port or starboard. Tighten the trim tab clamp and mounting screws, and then recheck the adjustment. Repeat the procedure, moving the trim tab very slightly until the steering effort appears to be equal in both directions.

After a satisfactory adjustment has been made, tighten the trim tab clamp screws to a torque value of 10-12 ft-lbs. and the trim tab mounting screw to 28-32 ft-lbs.



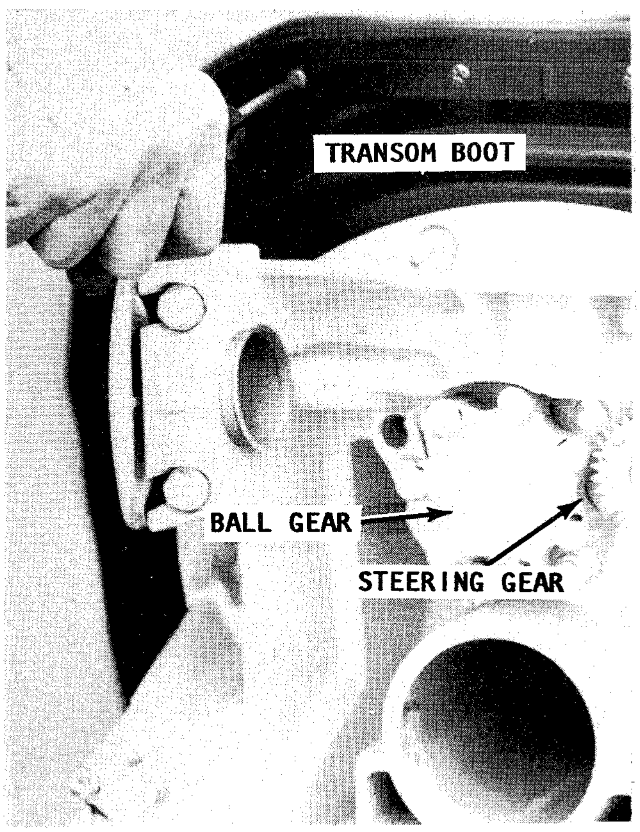
Indicator reference marks used when making the trim tab adjustment.

11 INTERMEDIATE HOUSING

11-1 INTRODUCTION

The intermediate housing is the assembly connecting the engine inside the boat to the stern drive on the outside. The forward end of the intermediate housing is attached to the engine through a bell housing adaptor. The housing then extends through the boat's transom where the stern drive is connected to the aft end.

A rubber boot surrounds the housing and is secured to the boat with sealer and screws.



The intermediate housing is the connecting link between the engine and the stern drive.

The intermediate housing contains the power-flow link between the engine and the stern drive. This is accomplished through the use of a splined shaft and coupler at the engine flywheel. At the stern drive end, the power is transmitted through a set of ball gears. The ball gear driveshaft and bearings pass through the center of the intermediate housing.

As the name implies, a tilt motor and tilt mechanism is used to raise and lower the stern drive.

The tilt motor is mounted on the port side of the intermediate housing inside the boat. Power from the tilt motor is transmitted through a clutch-and-worm gear arrangement to the tilt mechanism on the port side outside the boat.

Water for engine cooling from the lower unit passes through the sides of the intermediate housing to water outlets inside the boat.

11-2 TROUBLESHOOTING

If evidence of water leaking into the boat is noticed, the cause may be a defective rubber boot seal. Check the transom screws to be sure they are secure. Inspect the boot for holes or signs of leaking around the clamp. Replace the baot if it has lost its flexibility. If excessive driveshaft noises are heard, the cause may be defective bearings, a bad ball gear, or worn splines in the intermediate drive assembly.

A leaking boot can be replaced after removing the stern drive; see Chapter 10. Removal of the intermediate housing may be accomplished after the following work has been performed in the sequence given.

1- If the engine must be removed, see Chapter 3.

2- Disconnect the steering linkage; see Chapter 7.

3- Remove the stern drive; see Chapter 10.

4- Remove the tilt mechanism; see Chapter 8.

5- Remove the transom boot and ball gear driveshaft assembly; see Sections in this Chapter.

11-3 SERVICING THE BOOT

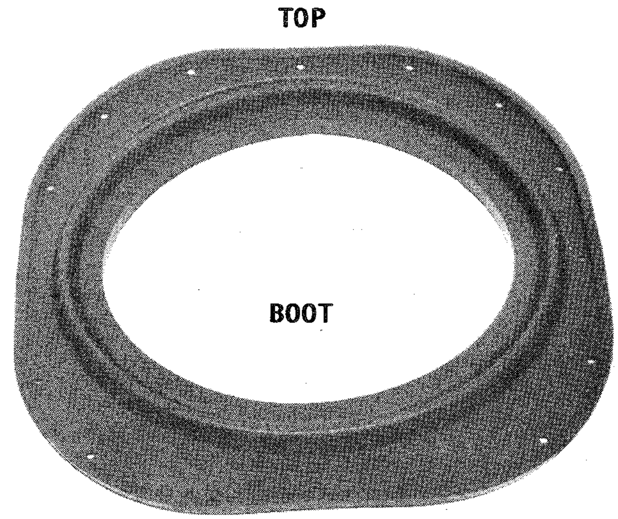
REMOVAL

1- Remove the stern drive; see Chapter 10. From outside the boat, remove all screws attaching the boot to the transom.

2- Pull the boot away from the transom far enough to permit removal of the large clamp holding the boot to the housing, and then remove the clamp. TAKE CARE not to damage the boot as it is slipped over the pivot caps and the tilt clutch housing.

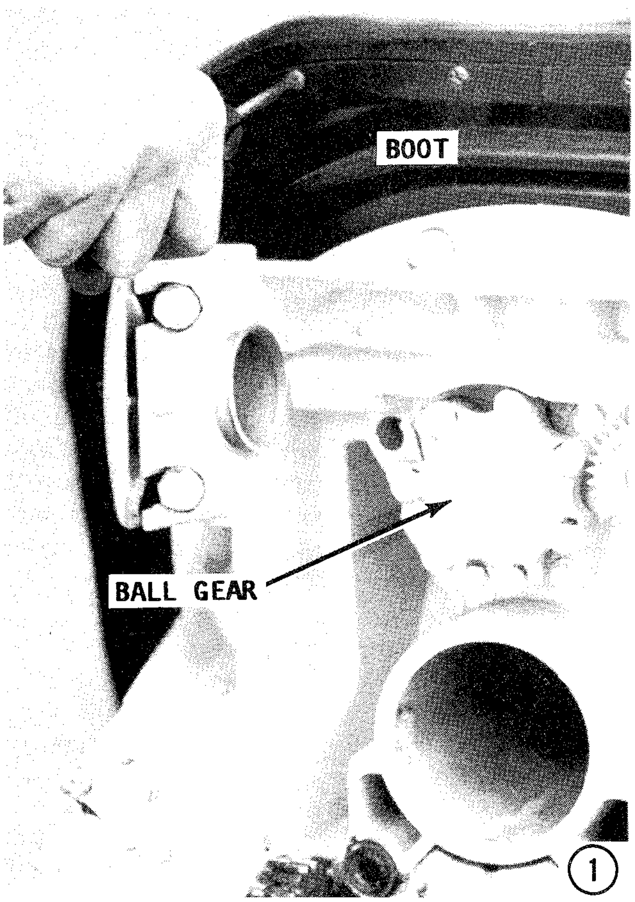
INSTALLATION

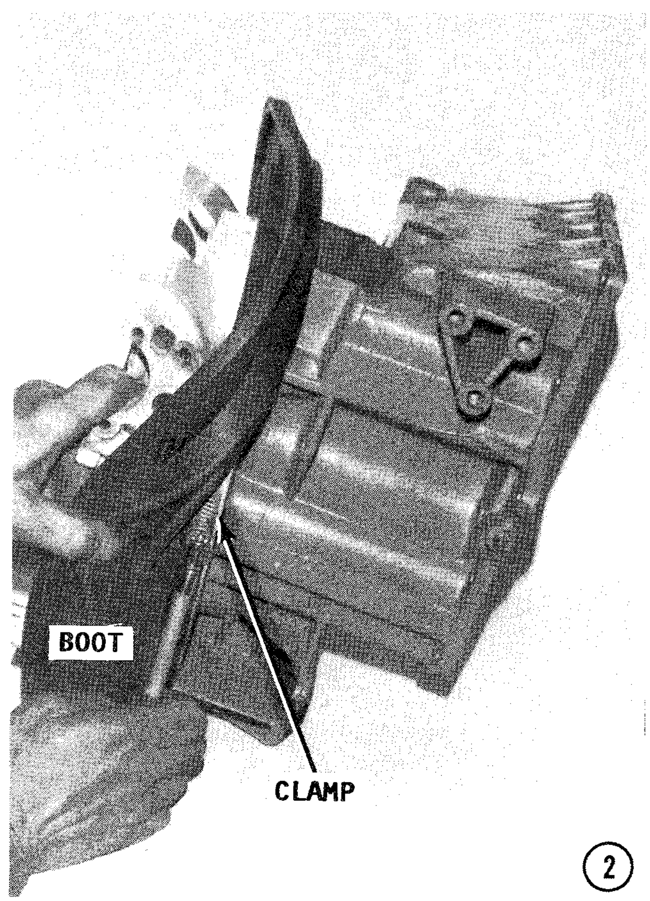
3- Clean the old sealer from the transom. Use a scraper to remove the bulky material and then wipe the surface thoroughly with acetone or other suitable cleaner. Position the clamp over the hous-



The word TOP is impregnated in the rubber to identify proper positioning of the boot during installation.

ing. Work the boot over the tilt clutch and pivot arms, and then place it in position with the impregnated word TOP upright. Fit the boot around the housing, and then tight-





en the clamp. Lay down a bead of good sealer on the transom in the approximate location for the edge of the boot.

4- Install the attaching screws through the boot into the transom with UTMOST **CARE.** ONE **SLIP** with the screwdriver might punch a hole in the boot seal. After all the screws are securely in place, install the stern drive; see Chapter 10.

11-4 BALL GEAR DRIVESHAFT

Two different driveshaft assemblies have been used over the years in the intermediate housing.

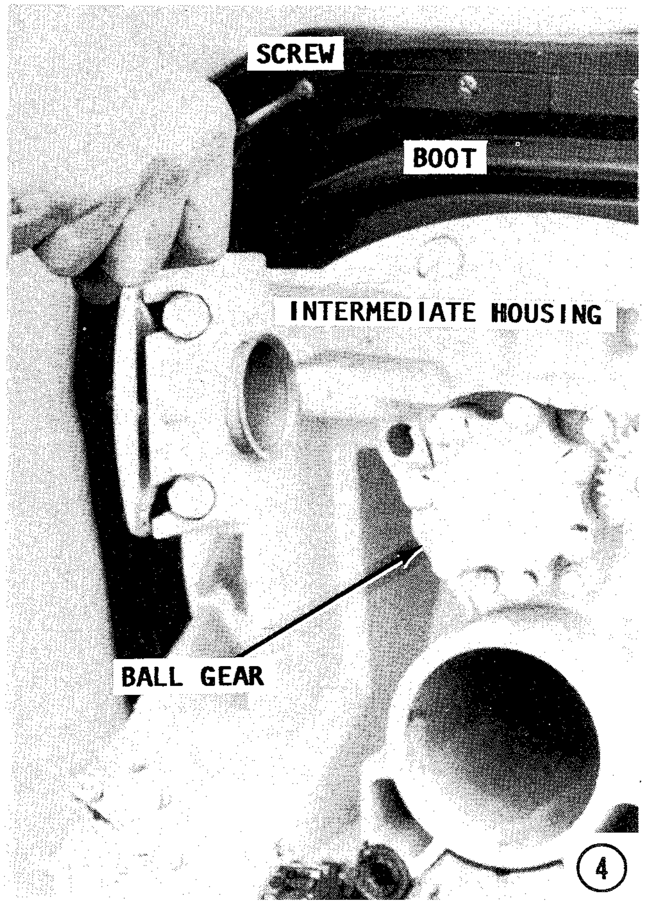
A lubrication fitting and plug was installed on early model housings. The plug on the side of the fitting **MUST** be removed any time this unit is lubricated to allow air to escape as the lubrication fills the cavity. If the plug is not removed, the driveshaft seals will be DAMAGED.

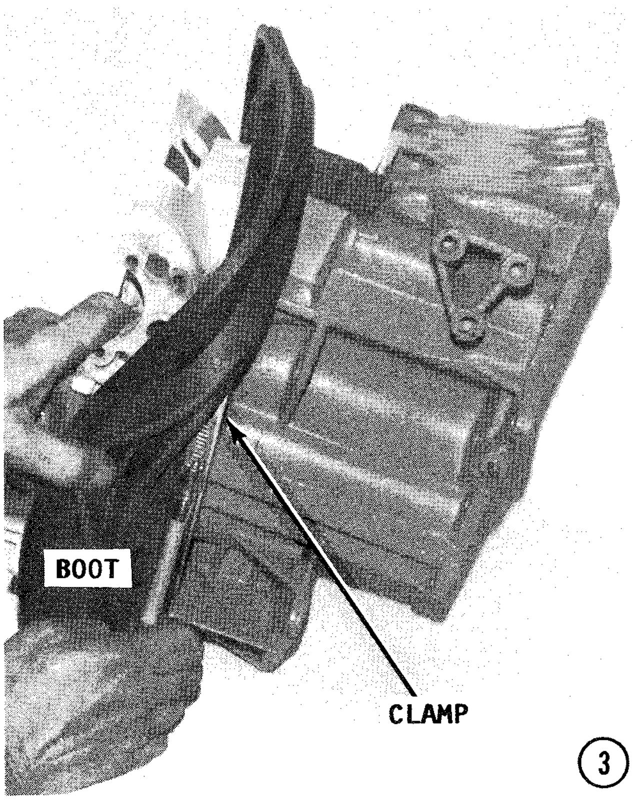
Late model housings have an oil reservoir to lubricate the driveshaft. The oil-fill plug is located on top of the housing, just aft of the transom boot.

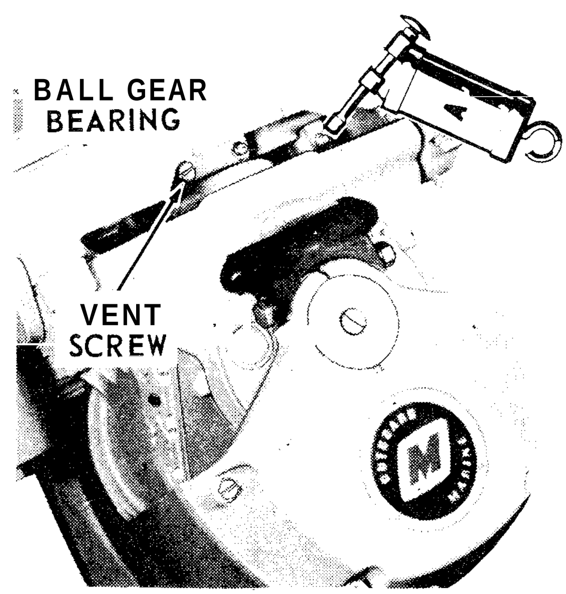
DISASSEMBLING

1- Remove the stern drive; see Chapter 10. Remove the capscrews securing the driveshaft retainer plate-and-seal assembly to the intermediate housing.

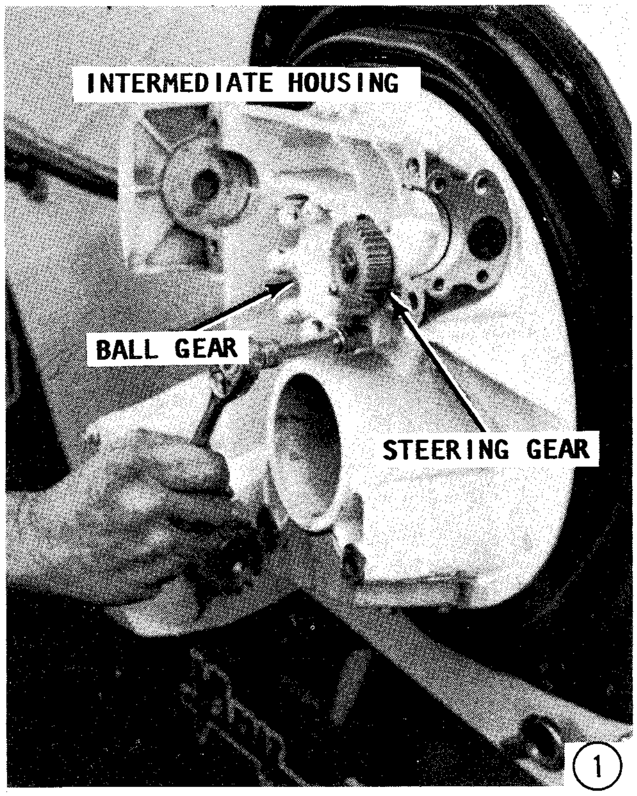
2- Pull the driveshaft-and-ball gear assembly, together with the retainer plate-and-seal assembly straight out of the housing. These two assemblies are removed in the same manner from both early and late

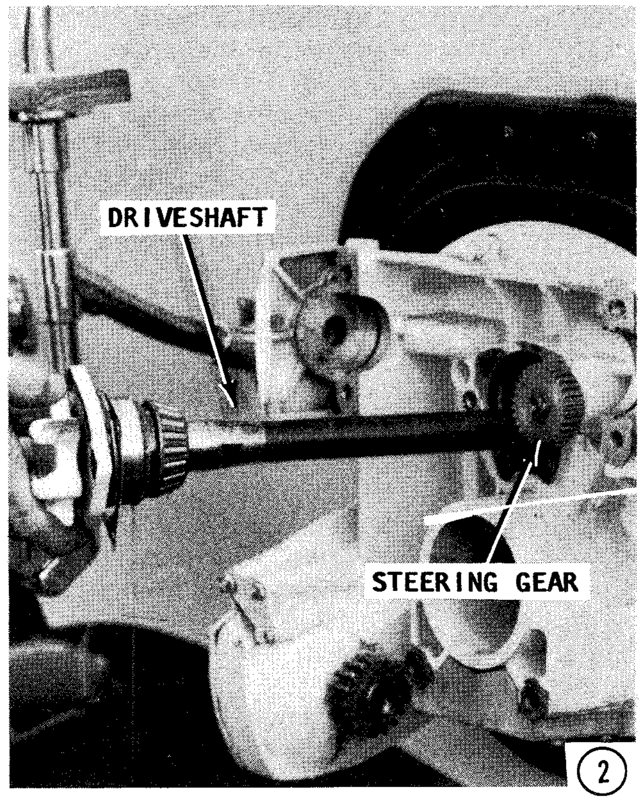






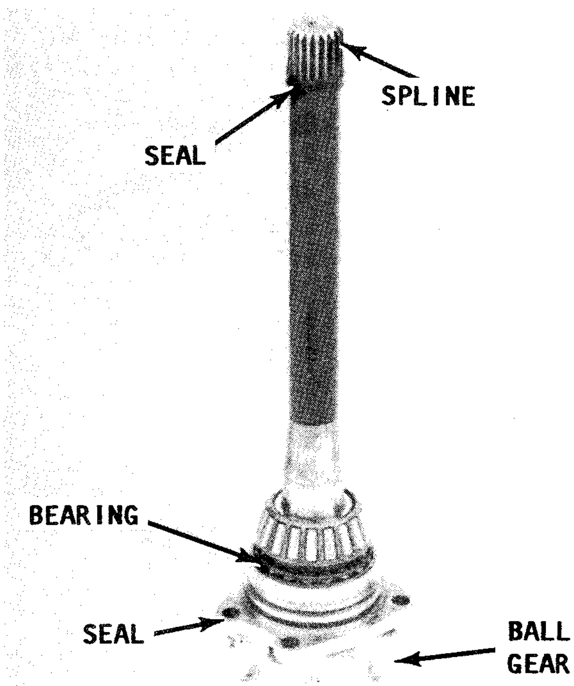
Early model intermediate housings use grease as a lubricant for the inner bearing. During replenishment of the lubricant, the vent screw must be removed to release pressure build up.



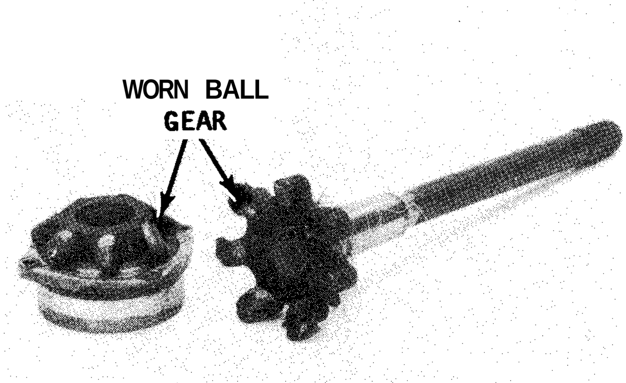


model intermediate housings. **A FEW** GOOD WORDS: If water has reached the inside of the housing, it may be necessary to use a puller or slide hammer to remove the shaft. If the driveshaft is rusted in place, the engine may have to be removed in order to drive the shaft out from inside the boat. On late model housings, the ball gear must be removed to accomplish a seal replacement. On early models, the bearings must be removed in order to replace the seal.

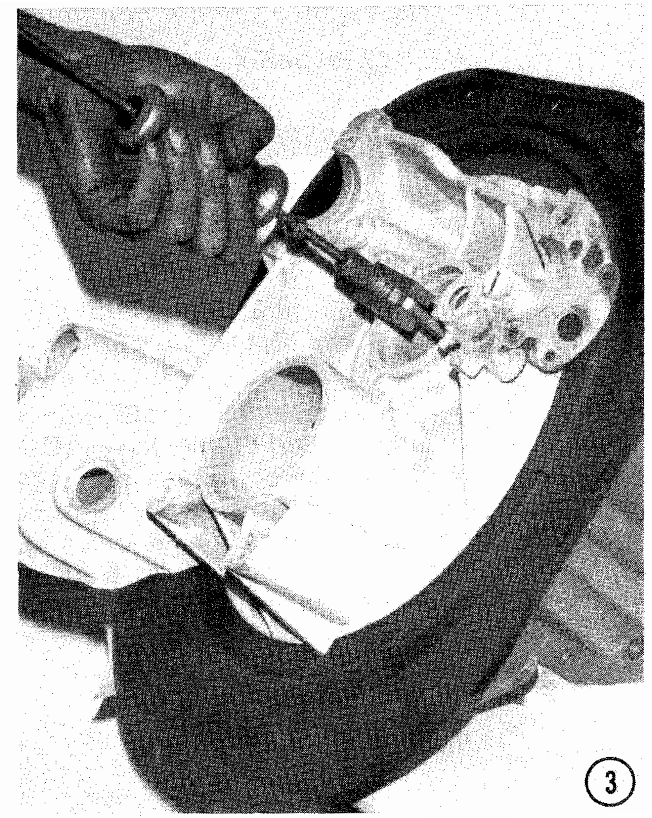
3- Use a slide hammer, and remove the inner bearing race and seal.

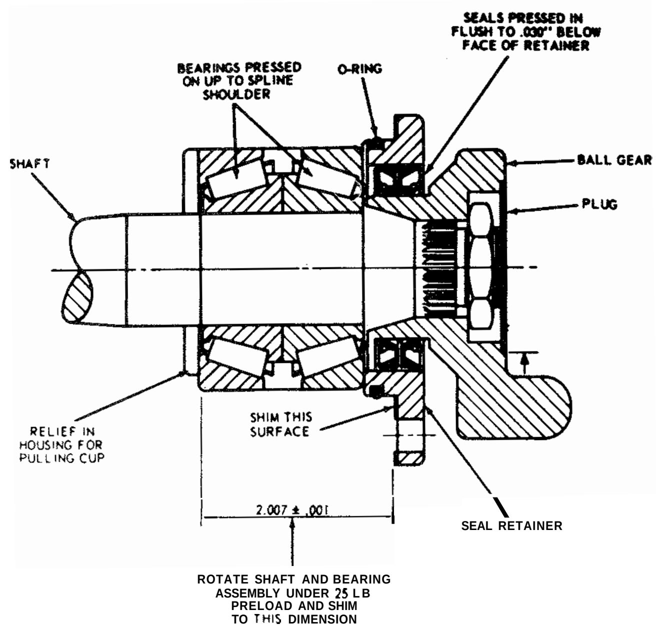


Intermediate driveshaft showing major parts mentioned in the text.



Damage to this ball gear was caused by operating the engine with the stern drive in the up position.

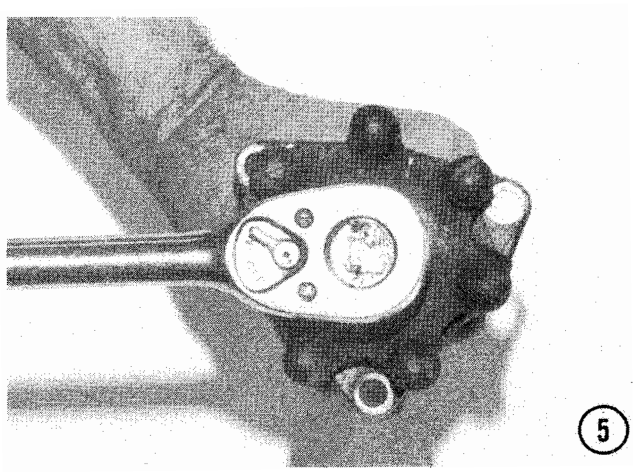


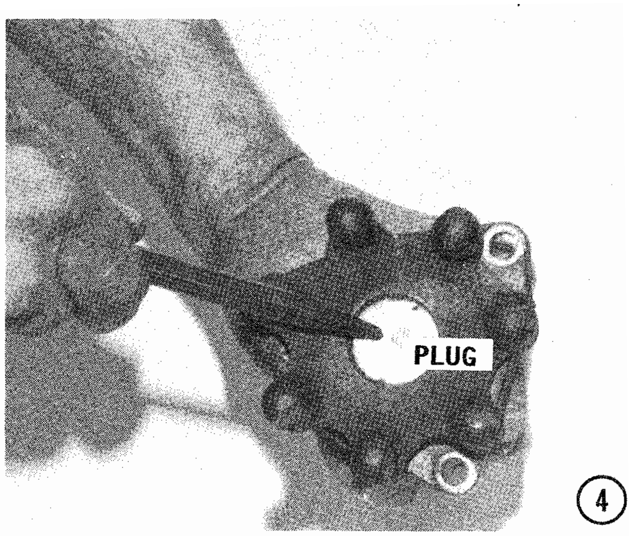


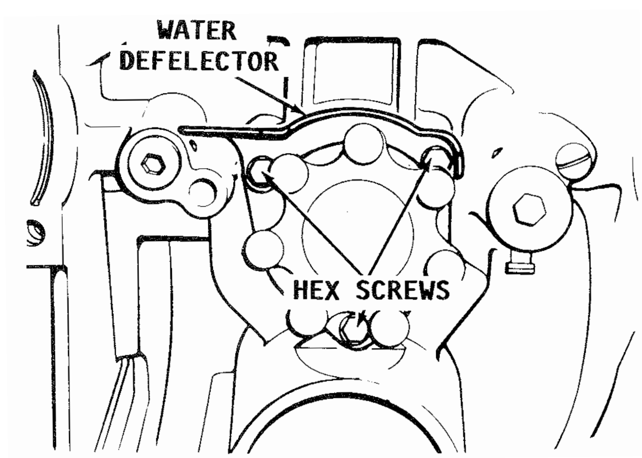
Arrangement of the driveshaft, seals, ball gears, and bearings.

4- After the driveshaft has been removed on late model housings, remove the core plug from the center of the ball gear. This can be accomplished by punching the plug about 1/4" from the edge with a prick punch, and then prying the plug out.

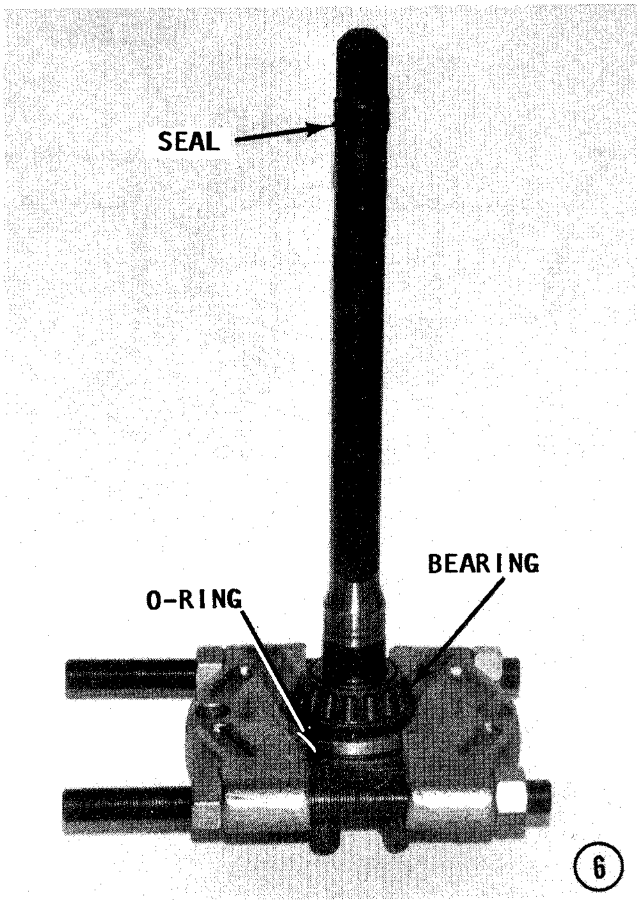
5- Loosen the retaining nut. On some models, the shaft is a press fit without a nut. Hold the nut with a 1-1/8" socket wrench, and the ball gear with tool No. 980336. Now, hold the ball gear and turn the nut free of the shaft. Press the shaft out of the ball gear.

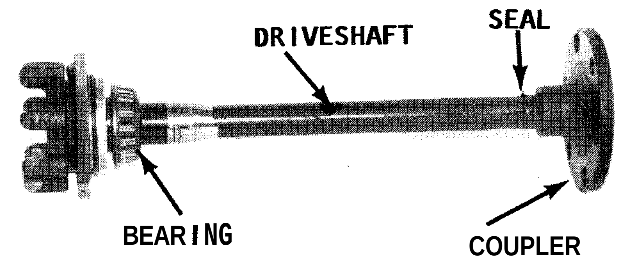






This water deflector should be installed on all 1973-76 model units for proper cooling of the ball gears.



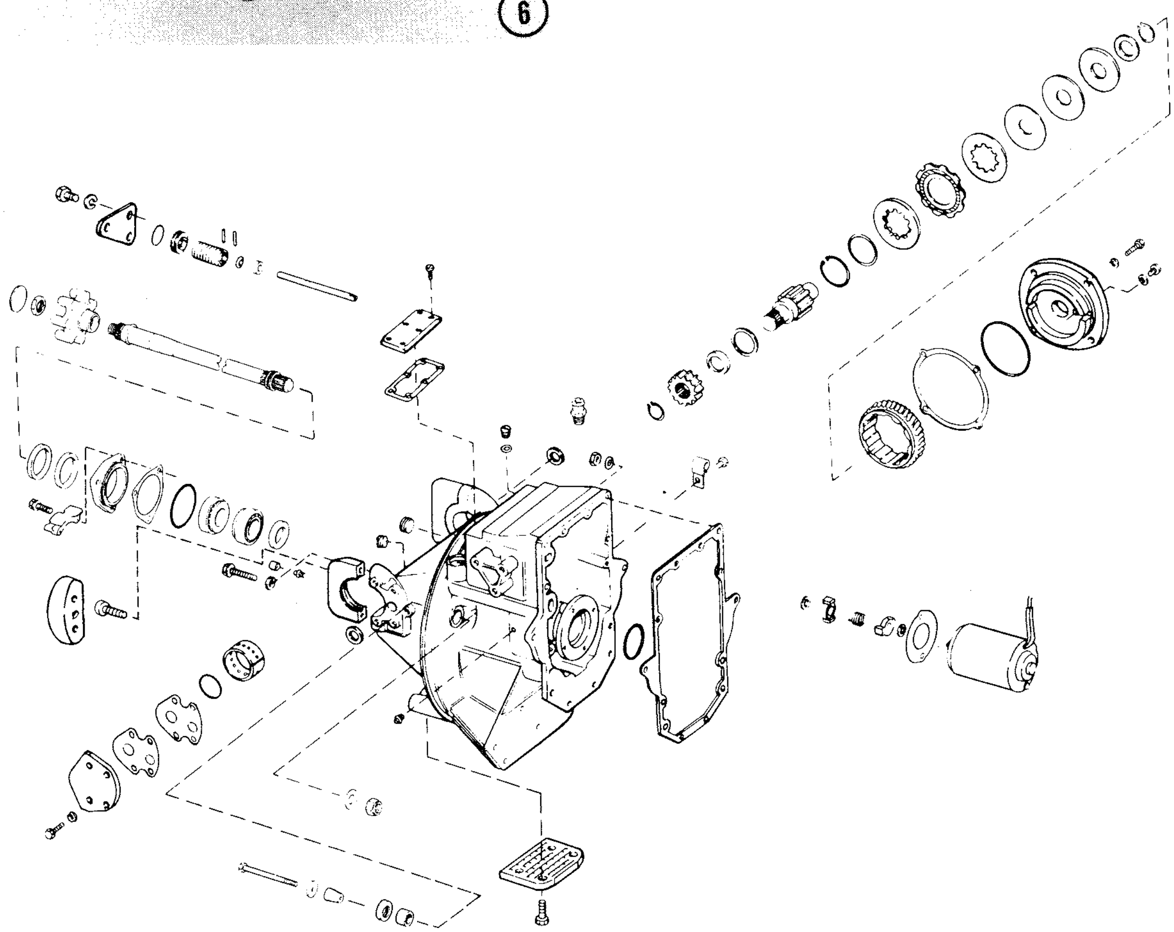


*The driveshaft **MUST** be a tight fit into the flywheel coupler.*

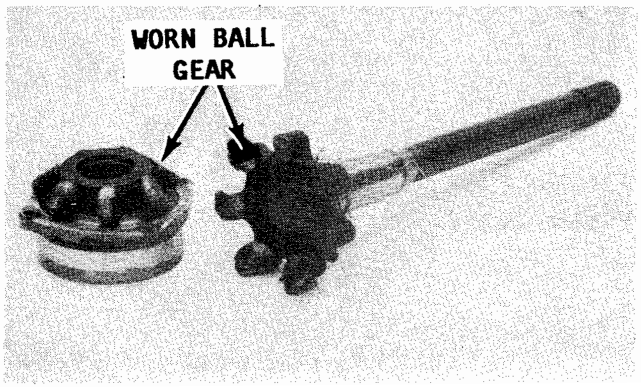
6– Press the bearings as an assembly from the engine spline end of the driveshaft. Use Mac Tool No. BS-2 behind the bearings to separate them. The inner cup is pressed into the intermediate housing and must be removed with a puller. The housing bearing race has a larger diameter than the driveshaft race; Therefore, **NEVER** interchange these races.

CLEANING AND INSPECTING

After the bearings have been removed from the shaft, slide the driveshaft into the



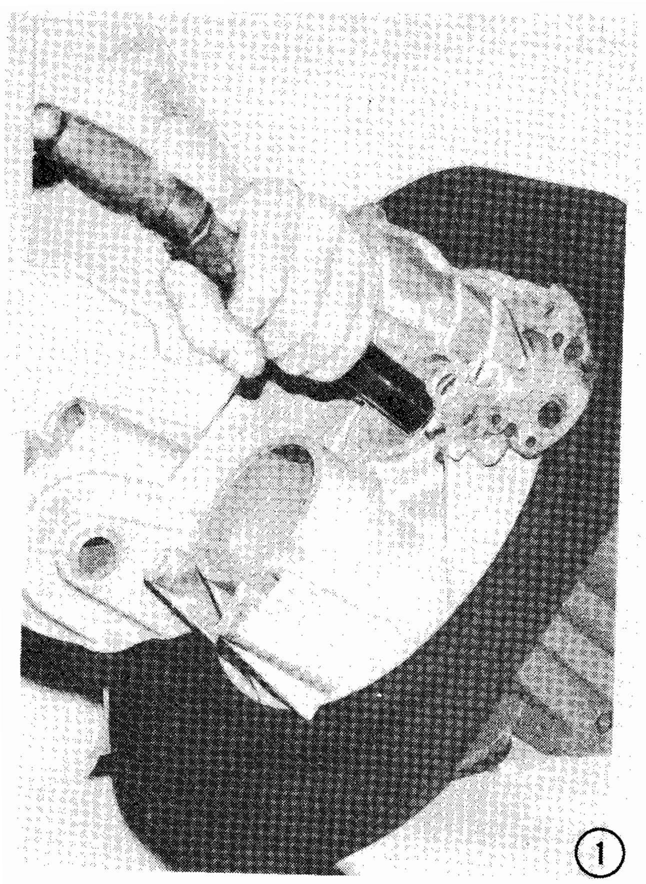
Exploded drawing of the intermediate housing. Minor design changes have been made through the years, altering the shape of some parts, but basically, the functional operation and service of the unit has remained almost constant.

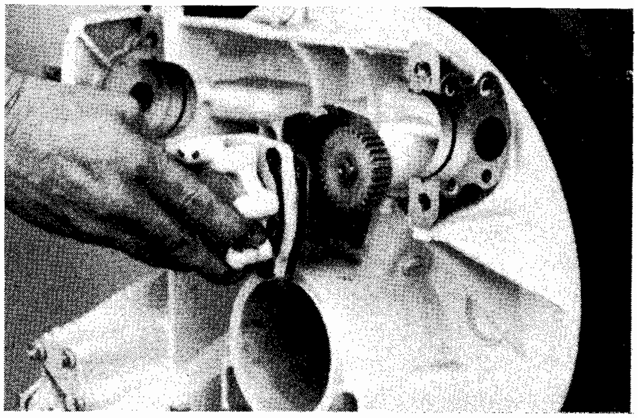


If the ball gears are worn more than 1/3 their original size, both gears ***MUST*** *be replaced.*

intermediate housing and check the play on the male and female splines. The driveshaft should be a slide fit with almost no play.

Inspect the splines on the end of the driveshaft. Replace the driveshaft if there is evidence of rotating play, wear, or if the splines have sharp edges. If the driveshaft is replaced, **ALWAYS** replace the coupler on the engine flywheel because the splines on the coupler will also be worn or damaged. To replace the flywheel coupler; see the appropriate section for your particular power plant in Chapter **3.**

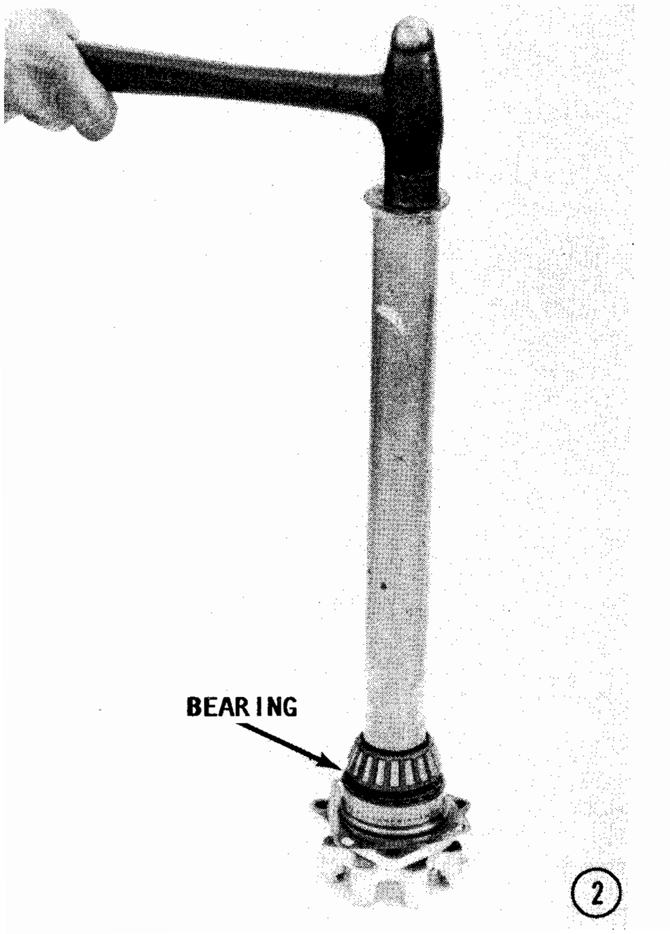




Testing for side play on the splines of the driveshaft and coupler.

ASSEMBLING THE BALL GEAR DRIVESHAFT

1– Use oil retainer installer Tool No. 308100 and an arbor press and install NEW seals in the driveshaft oil retainer. Install the seals **BACK-TO-BACK** with the lip of the inner seal facing into the intermediate housing. This arrangement will place the hard side of the seals against each other. Early model housings use only one seal.

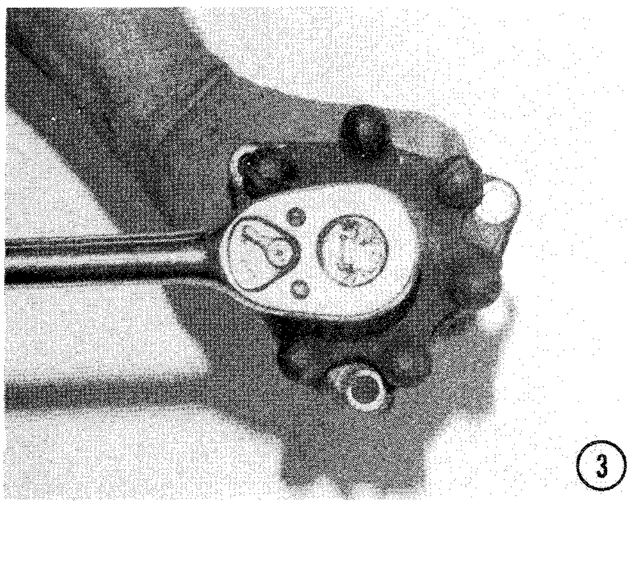


2- Use Tool No. 311873 and press both bearings onto the driveshaft until the outer bearing butts against the shoulder of the spline. Coat the splines of the driveshaft with 3M Sealer 1300, or equivalent, and then slide a **NEW** spline seal onto the driveshaft. Position the seal retainer over the ball gear end of the shaft, with the inner surface against the outer bearings. Now, stand the shaft and retainer upright on a flat surface with the ball gear end of the shaft in a hole so the shaft is supported by the retainer.

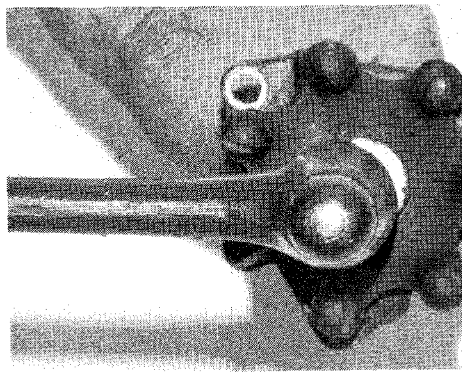
3- Check to be sure the ball gear end of the shaft and the internal diameter of the ball gear are clean and free of oil. Coat the shaft end and internal diameter of the ball gear with OMC Locquic Primer "T" and allow it to dry for at least ten minutes. Apply Loctite Keyfit to the ball gear end of the shaft, and then install the seal retainer and ball gear onto the shaft. Hold the ball gear with Tool No. 980336 and tighten the shaft nut with a 1-1/8" socket wrench to a torque value of 95-100 ft-lbs. Remove any excess Loctite. On models without the shaft nut, press the ball gear onto the shaft.

4- Apply Silastic 732 RTV Sealant to the core plug seat in the ball gear. Insert the plug in its seat, and then expand the plug by tapping it in the center with a hammer.

5- Place the outer race of the intermediate housing bearing onto the inner bearing. Hold OMC Tool No. 908286 shim gauge squarely on top of the intermediate housing. Now, measure the clearance between the end of the gauge and the flat surface of the seal retainer with a feeler gauge. Apply about a 25 pound load by pressing down on the outer bearing and at the same time measure the clearance again. The difference between the first and second



3



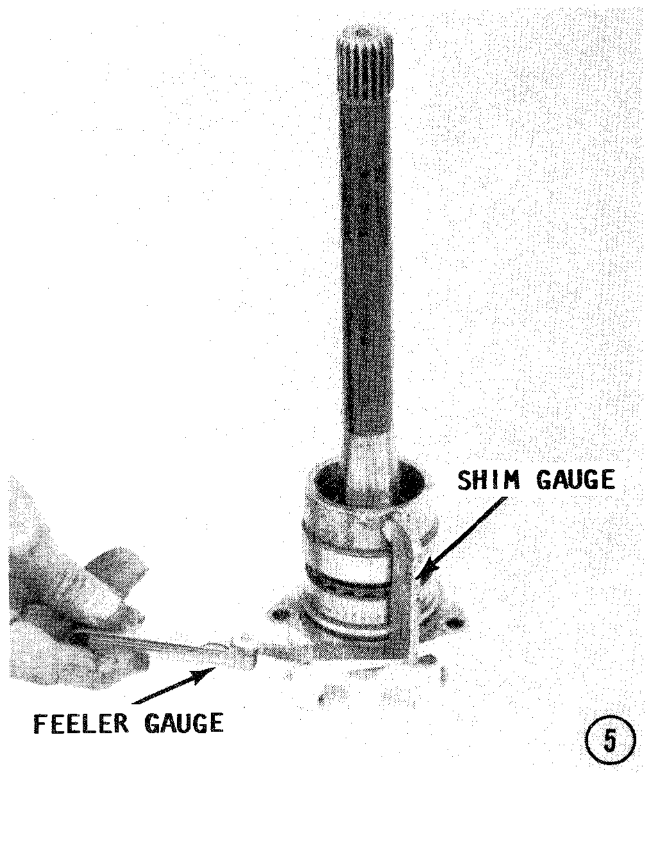
4

measurement should be 0.007 +0.001" for proper end play. Shims in varying dimensions from 0.002" to 0.010" are available to take up excessive end play. At least **ONE** shim should always be used. On early models, **NO SHIMS** are used, therefore these shafts will have some end play.

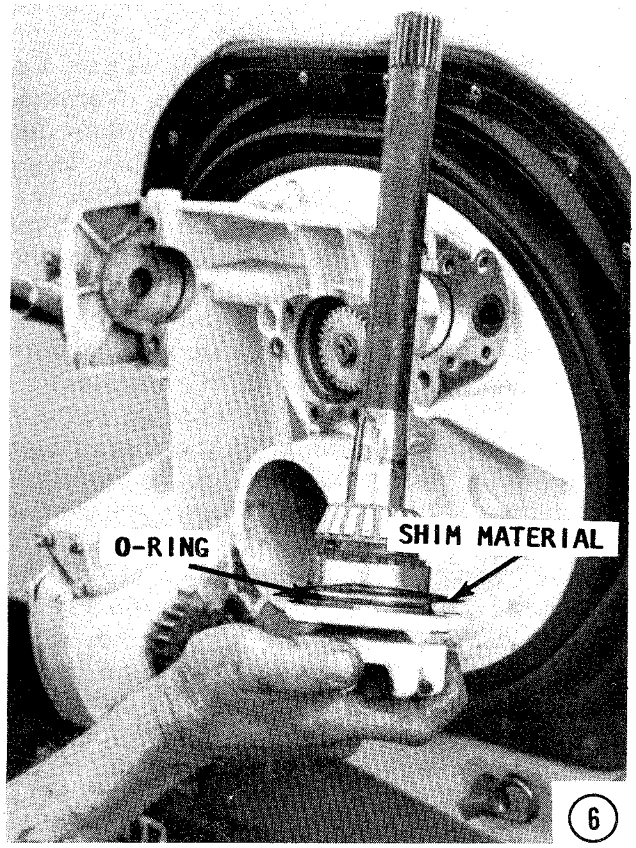
6- Slide the selected shims from the previous step over the driveshaft and down to the retainer. TAKE **NOTE:** The shims will only go onto the shaft one way. **NEVER** attempt to force them on the oppposite way.

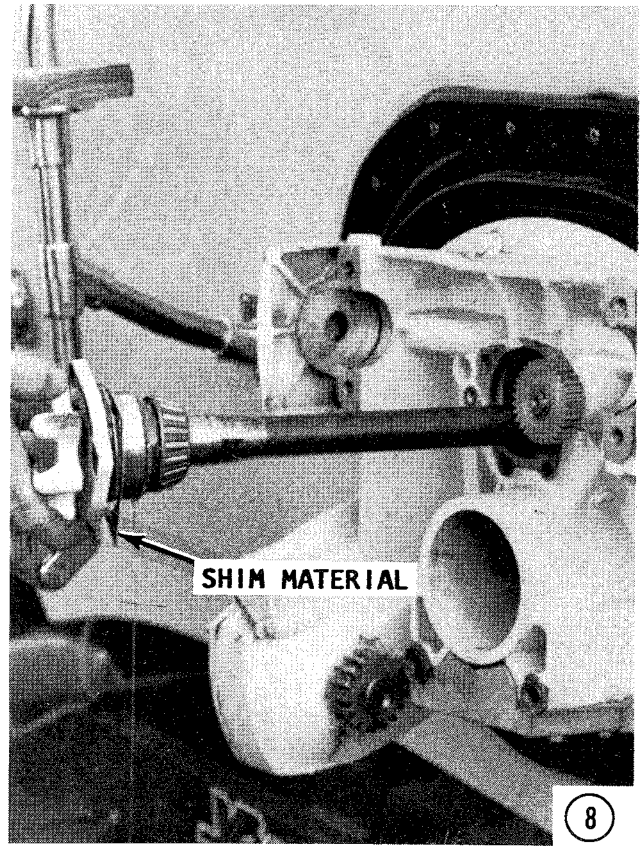
7- Install the seal onto the driveshaft, and then move it back exactly 1-3/16" from the shaft end, as shown.

8- Coat the splines of the driveshaft with multi-purpose grease. CAREFULLY



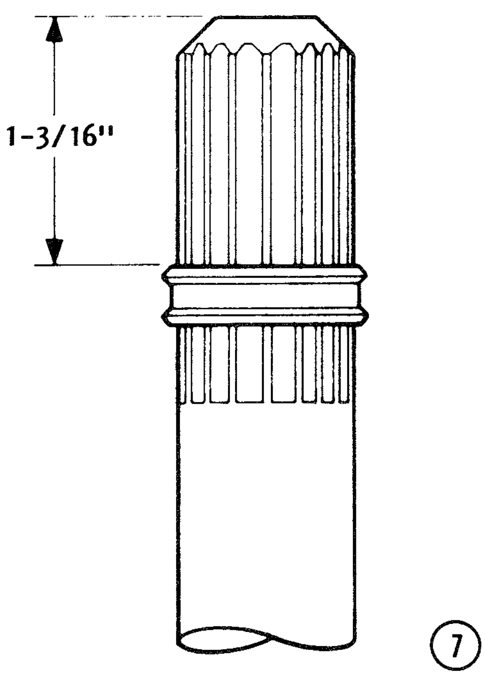
5



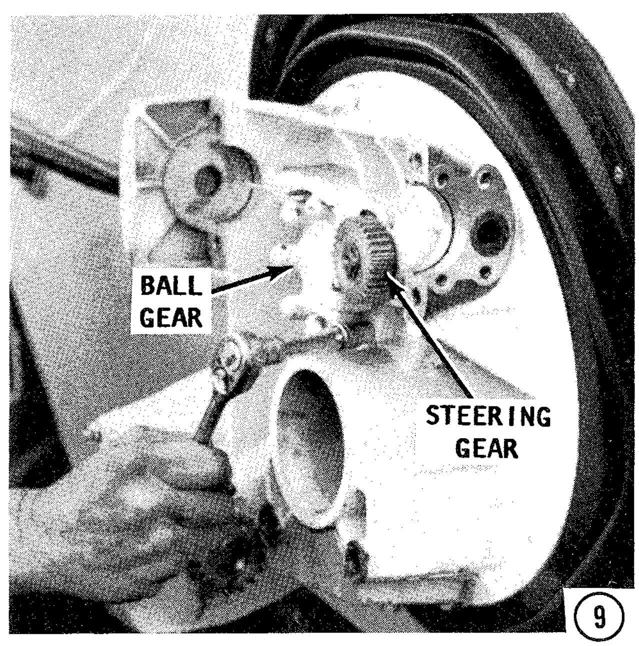


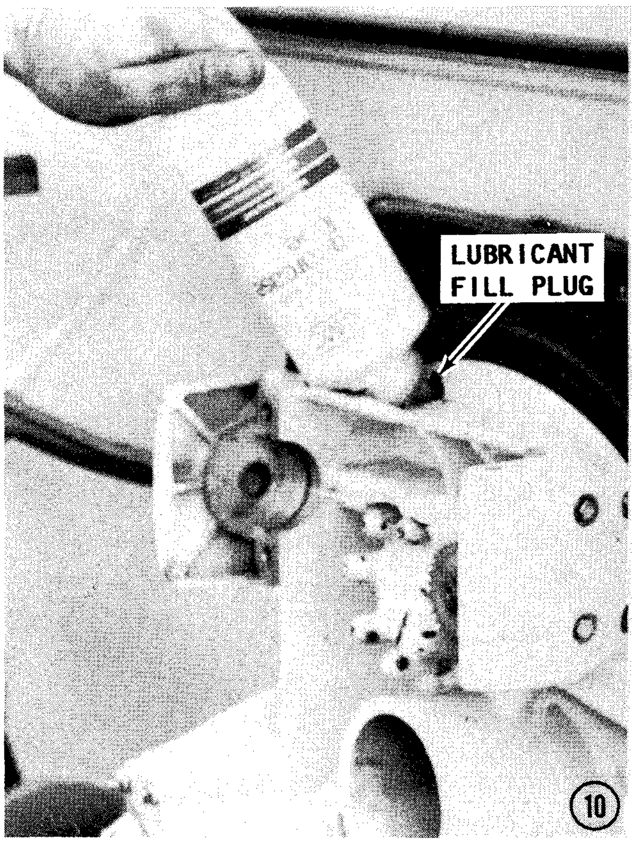
insert the splined end into the bore of the intermediate housing without tilting the bearing. Seat the driveshaft in position.

9- Install the attaching screws and washers, then tighten them to a torque value of 10-12 ft-lbs.



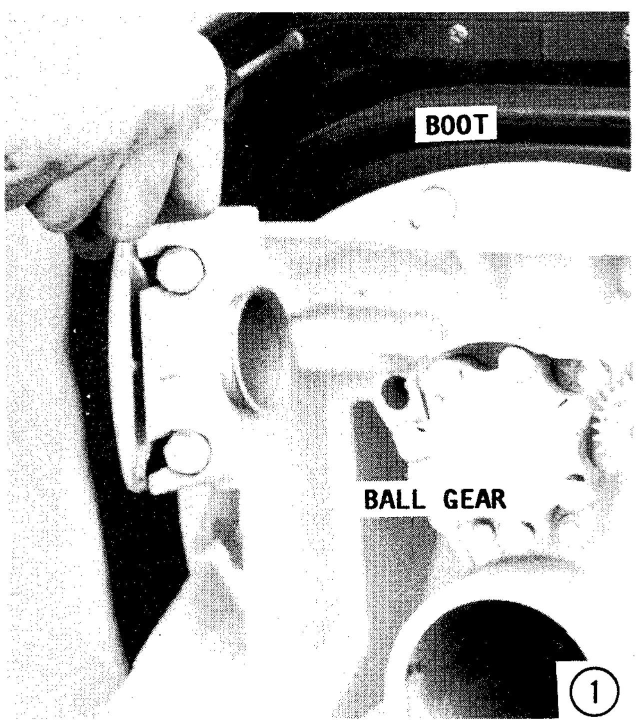
10- Remove the plug just to the port side of the driveshaft, and fill the unit with OMC Premium Lube, or lubricate the grease fitting installed on older models. **ALWAYS** remove the vent plug from the fitting to allow air to escape and prevent damage to the driveshaft seals. Install the stern drive; see Chapter 10.





11-5 INTERMEDIATE HOUSING SERVICE

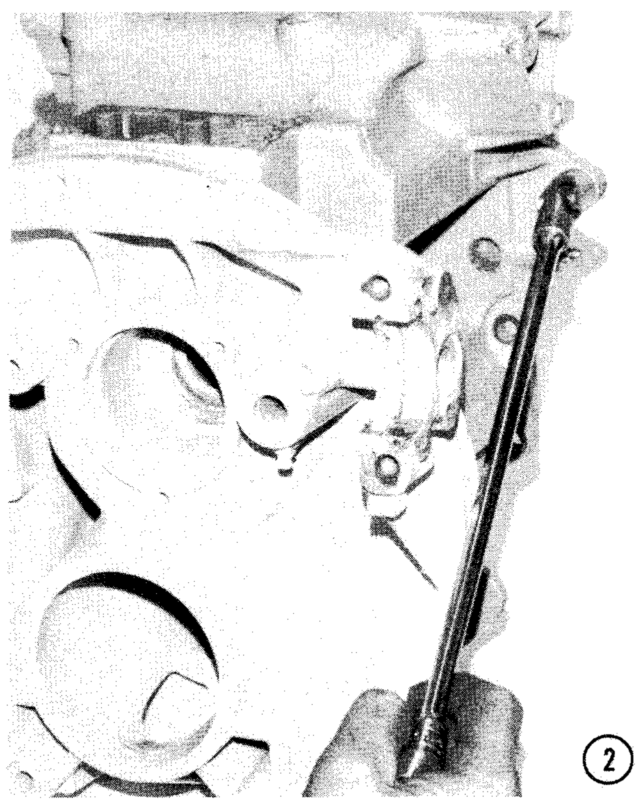
The following procedures continue the work after the stern drive has been removed; see Chapter 10, the Tru Course steering removed; see Chapter 7, and the tilt mechanism removed (if the intermediate housing is being replaced), see Chapter 8.



REMOVAL

1– From outside the boat, remove all the screws attaching the boot to the transom. Pull the boot away from the transom far enough to permit removal of the large clamp holding the boot to the housing, and then remove the clamp. **TAKE CARE** not to damage the boot as it is slipped over the pivot caps and the tilt clutch housing.

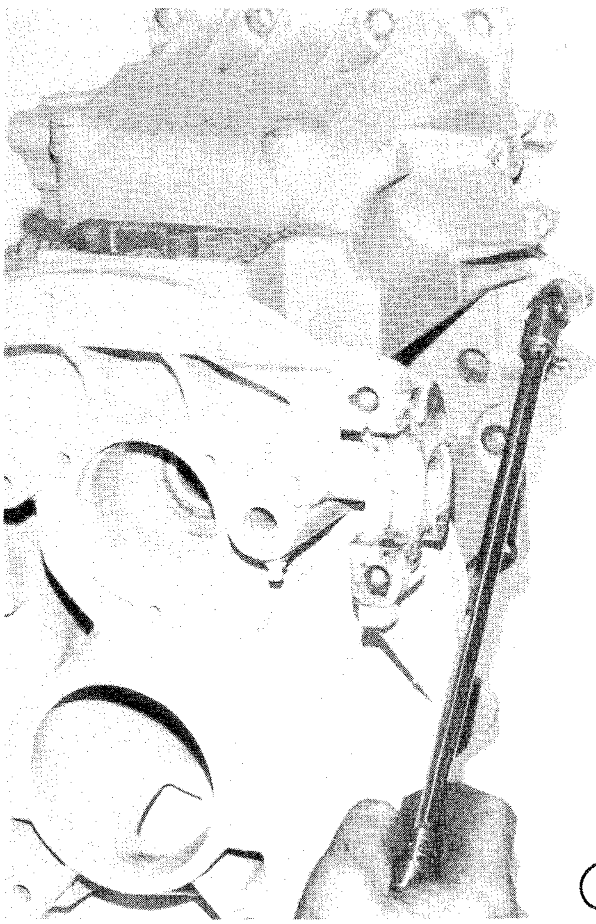
2– Under normal conditions, and with the proper tools, including a socket set with extentions and swivel joints, the engine does not have to be removed in order to remove the intermediate housing. If the engine does have to be removed, see the appropriate section in Chapter 3 for your particular power plant. Remove the tilt solenoids and wiring. Identify each wire as an aid during installation and hookup. To remove the housing without removing the engine, work through the transom or possibly from inside the boat with a socket wrench and extension with swivel joint and remove the fourteen (14) nuts and lockwashers securing the intermediate housing to the bell housing. The complete housing is now ready to be removed from the boat through the transom hole. If the tilt motor or the worm gear and clutch assembly need to be removed from the intermediate housing, see the appropriate section in Chapter 8.



CLEANING AND INSPECTING

A severe blow to the vertical drive unit could result in misalignment of the pivot cap faces causing rapid wear to the ball gears, shafts, and bearings. Therefore, the pivot cap faces must be checked for proper alignment. Use an alignment tool such as a Quadriel, as shown. The cap faces **MUST** be parallel with each other within 1/16". The upper housing pivots should also be checked in the same manner.

Inspect the seal inside the intermediate housing bearing cavity. If there is any evidence of grease or oil leaking, the bearing **MUST** be replaced. Oil or grease in the boat's bilge would also be an indication this seal was leaking. Before the seal is removed, **TAKE NOTE** of the direction of the seal lip as an aid to installing the new one properly. To install the new seal, use seal installer Tool No. 908598, attached to drive handle Tool No. 311880. Drive the seal into place with the beveled edge going into the bore first. As the seal is driven into place, **ROTATE** the drive handle to prevent damaging the seal.



1

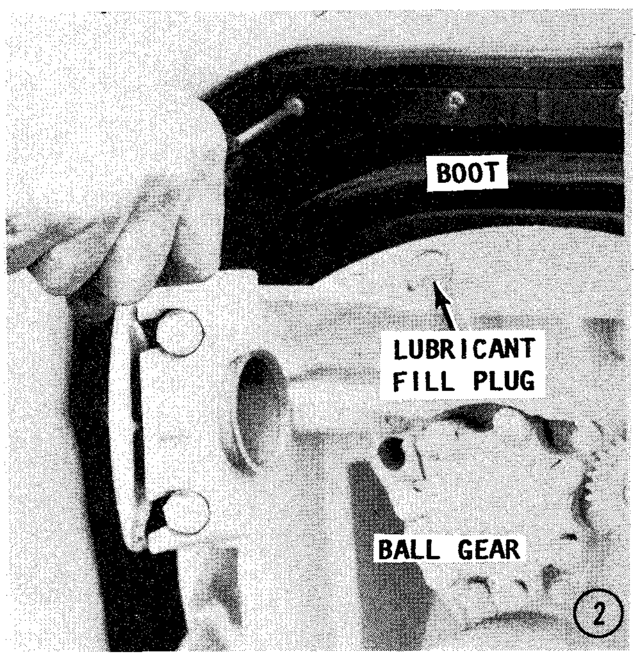
Clean the old sealer from the transom. Use a scraper to remove the bulky material and then wipe the surface thoroughly with acetone or other suitable cleaner.

INTERMEDIATE HOUSING INSTALLATION

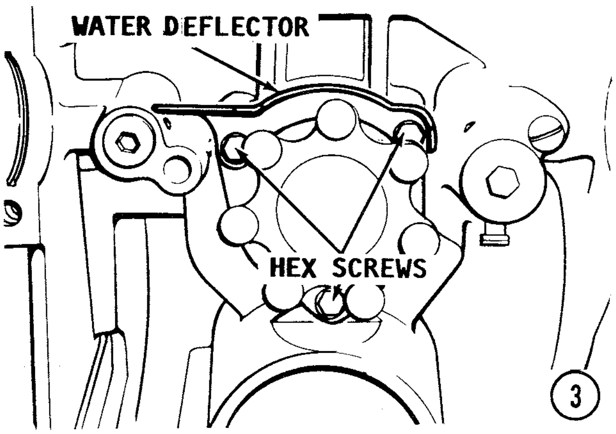
If the worm gear and clutch assembly were removed, install them to the intermediate housing; see Chapter 8. If the couplers and tilt motor were removed, install them to the intermediate housing, see Chapter 8. The following step takes up the work after these assemblies have been properly installed.

1- Install a **NEW** gasket to the bell housing. Lift the intermediate housing through the hole in the transom and attach it to the bell housing with the fourteen nuts and lockwashers. Tighten the nuts to the torque value given in the Specifications in the Appendix.

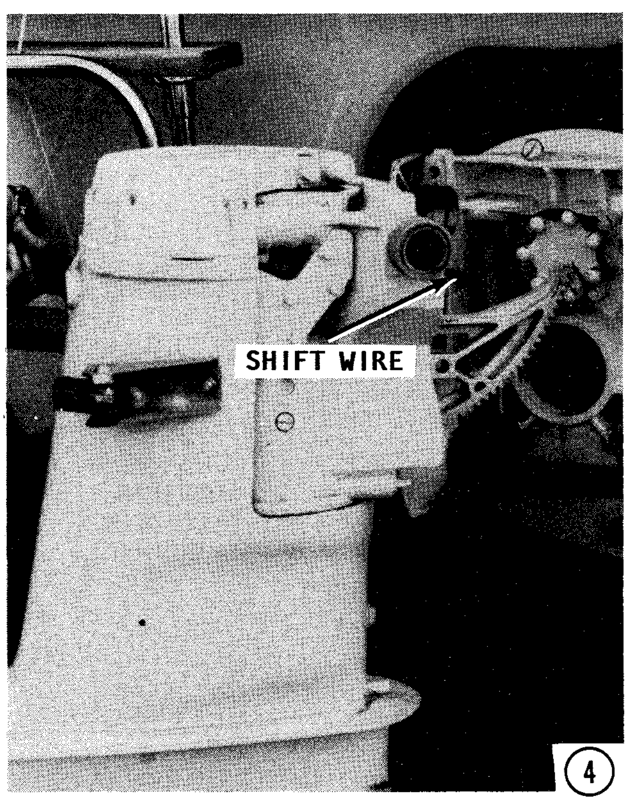
2- Position the boot clamp over the housing. Work the boot over the tilt clutch and pivot arms, and then place it in position with the impregnated word **TOP** upright. Fit the boot around the housing, and then tighten the clamp. Lay down a bead of good sealer on the transom in the approximate location for the edge of the boot. Install the attaching screws through the boot into the transom with **UTMOST CARE. ONE SLIP** with the screwdriver might punch a hole in the boot seal.



2



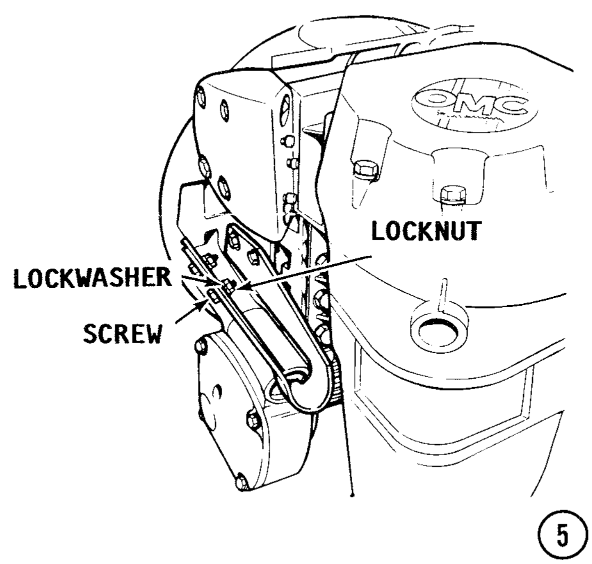
3- BEFORE INSTALLING THE STERN DRIVE, it might be well to consider installing a ball gear water defelector kit. This kit has become standard equipment on all models since 1977. By directing the tattle-tale water stream from the stern drive water pump in a different direction, the water stream is able to perform three more very important functions in addition to indicating the water pump is operating. First, it cools and protects the ball gears from overheating and wearing out, or failing due to metal fatigue. Secondly, the stream cools and protects the driveshaft seal in the intermediate housing. And the third function the stream performs is to cool and protect the seal on the ball shaft in the upper gear housing. This kit, identified as Ball Gear Water Deflector Kit No. 981576, may be purchased from your local OMC dealer at very modest cost. It may be installed in a short time with little trouble before the stern drive is installed. All necessary parts including detailed instructions and illustrations are included in the kit package.



4- After all the screws are securely in place, install the stern drive; see Chapter 10. Install the tilt solenoids and connect the wiring according to the identification made on each wire during disassembly. Start the engine and check for leaks.

CAUTION: **Water must circulate through the outdrive to the engine any time the engine is run to prevent damage to the water pump in the outdrive.**

5- ONE MORE **WORD:** If the tilt worm gear retaining ring groove has become corroded or a portion of the ring seat has been damaged, a kit may be purchased from your OMC dealer to not only correct the problem, but to prevent it from happening a second time. This kit is a more economical remedy than replacing the entire intermediate housing. Installation of the kit parts will hold the worm gear plug in the intermediate housing without the use of a snap ring. The kit is identified as Tilt Bracket Kit No. 981348 and may be installed in a very short time and without special tools or skills. Detailed instructions and illustrations are included with the parts in the kit package.



12 MAINTENANCE

12-1 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 contruction 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 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.

12-2 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.

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.

12-3 OFF-SEASON STORAGE

1- Start the engine and allow it to warm to normal 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.

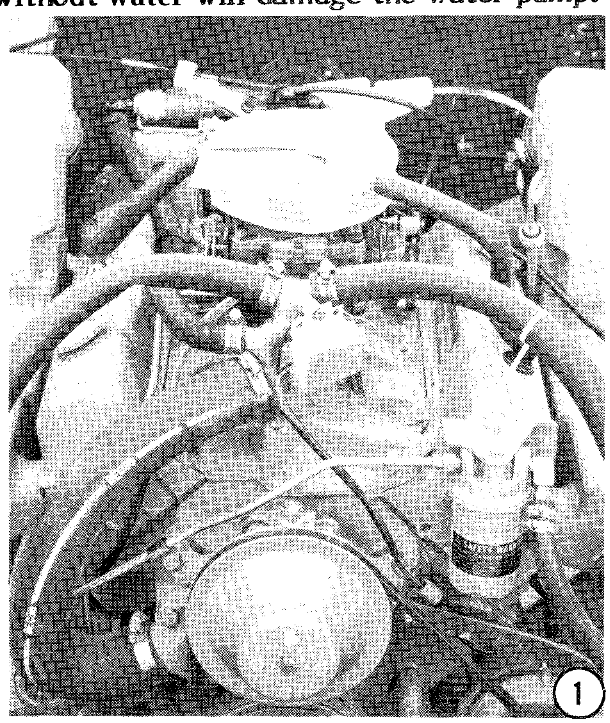
If the engine is equipped with a closed-circuit cooling system, check the anti-freeze. Add rust inhibitor if the anti-freeze has been used for more than one season. If the solution is contaminated, flush and replace with a new mixture of 50/50 ethylene glycol and water. Stop the engine, drain the oil in the crankcase, and remove the oil filter. Install a NEW filter element, and then fill the crankcase with the prescribed weight and amount of oil. Start the engine and allow it to run at a high idle for a few minutes.

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.

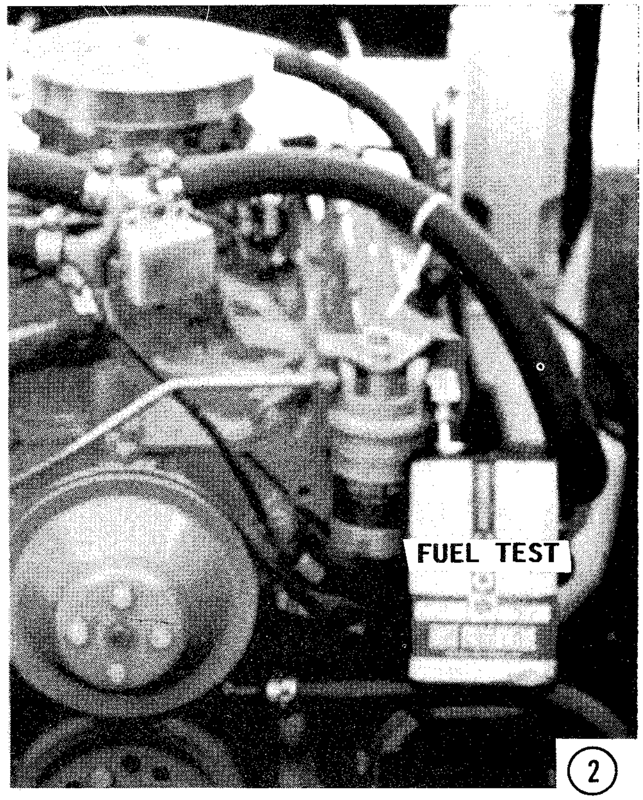
Check the oil level as indicated on the dip stick. Some amount of oil may remain in the engine without draining down into the crankcase. A slightly lower reading may, therefore, be indicated on the dip stick. Add only enough oil to bring the reading into the safe running range above the ADD mark to allow for the amount of oil held in various areas sf the engine.

2- Shut off the gasoline supply at the fuel tank. Piscnnnect the fuel line between the valve and the fuel pump. Drain the fuel from the line. Insert the end of the line disconnected from the fuel pump into a can containing several ounces of fuel mixed with a rust inhibitor. Start the engine and run it at a fast idle until it stalls from lack of fuel.

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.

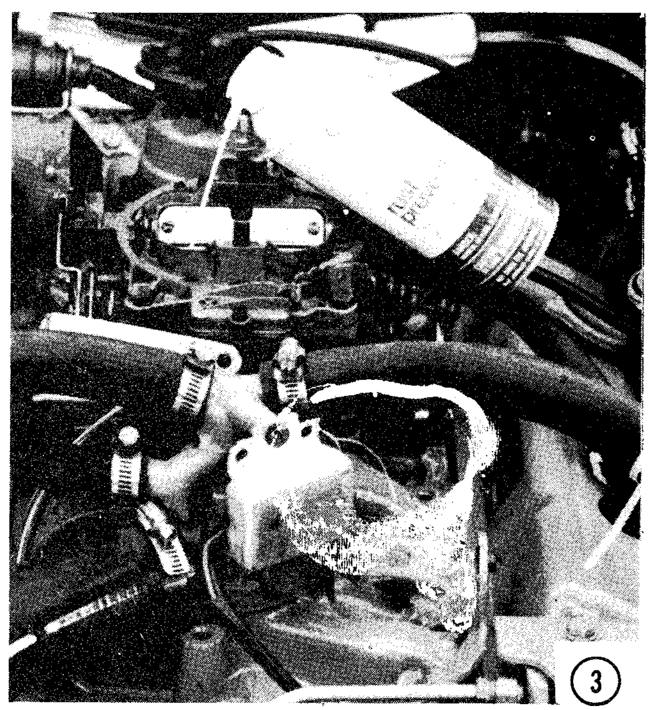


1



2

3- Remove the flame arrestor and **SLOWLY** pour about a pint of rust-preventive oil into the carburetor air intakes while running the engine at a fast idle. This can be done at the same time as Step 2, while using up the fuel in the fuel lines, fuel pump, and in the carburetor. Clean the fuel filter and sediment bowl. Install the bowl



3

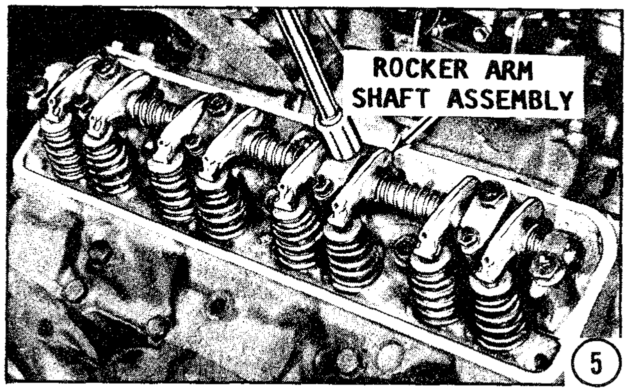
with a **NEW** gasket and reconnect the fuel line. Clean the flame arrestor in solvent, and then blow it dry with compressed air. Lubricate the alternator, starter, distributor, and control linkage.

4- Remove all of the spark plugs and squirt about a teaspoonful of rust-preventative oil into each cylinder. Crank the engine over several times to allow the oil to coat the cylinder walls. Remove any excess oil from around the spark plug holes, and then install the spark plugs.

Overhead Valve Engines

5- Remove the rocker arm covers and inspect the valve train mechanism for worn or damaged parts. Clean the inside of the covers. Apply a liberal coating of crankcase oil to the valve mechanism and onto the inside of the covers. Install the covers with **NEW** gaskets. Using new gaskets will ensure a good seal with the valve covers. Clean the outside of the engine, and then wipe it down with an oily rag. Cover the engine with a protective cover, but **ALLOW** for air circulation.

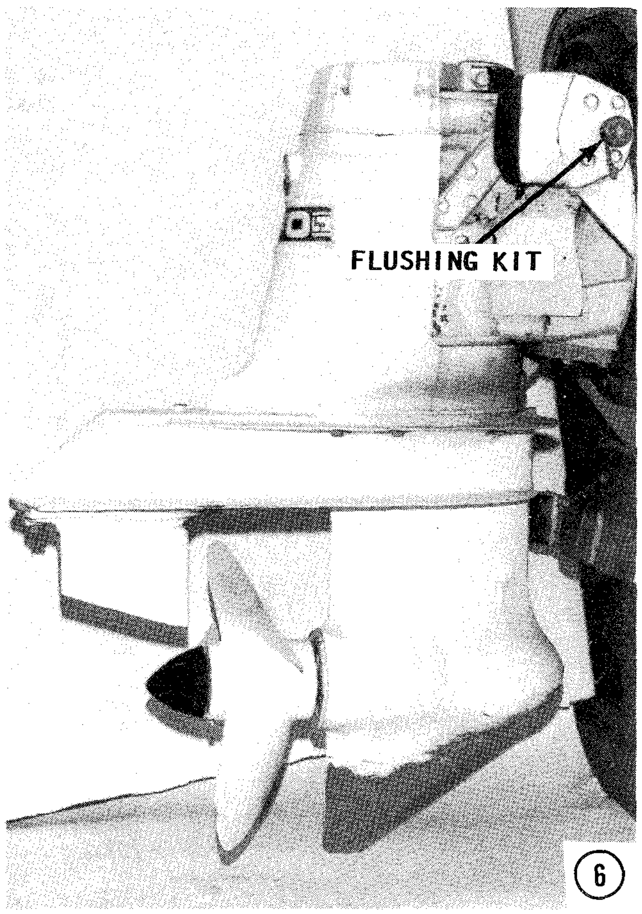
6- Flush the cooling system with fresh water. Allow the water to circulate for at



least 5 minutes. If the engine is equipped with a raw-water cooling system, open all of the engine and manifold water jacket drains. Allow the water to drain completely. **ALWAYS** have the stern drive in a horizontal position when draining the system to ensure all of the water is able to leave the system. If the stern drive is not horizontal, water will be trapped inside. If this water should freeze, the water pump will be ruined.

Leave all of the drains open. Disconnect the water hoses at the low end and allow them to drain. Remove the drain plugs from the water pumps and allow them to drain.

Remove the propeller. Clean and lubri-



cate the propeller shaft. Install the propeller. Install a NEW drive pin. Replace the cotter pin or the tab lockwasher.

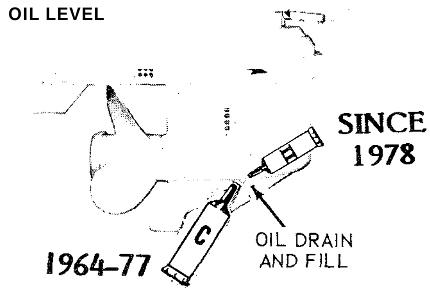
Wipe the outside of the drive unit and the gear case with an oily rag. Check all of the steering connections. Lubricate all joints and pulleys.

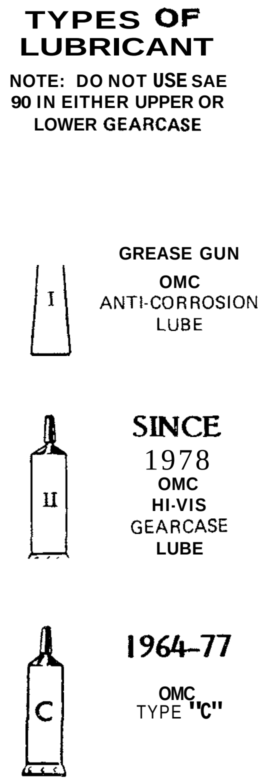
7– Check the oil level in the stern drive upper housing, the lower unit, the intermediate housing, and the tilt clutch assembly. Add lubricant, as required. Lubricate all of the fittings on the steering and stern drive.

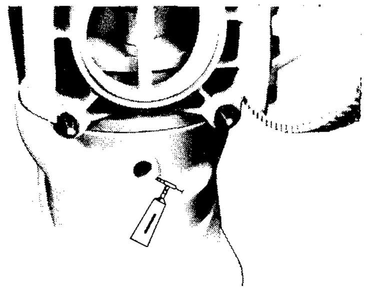
8– Seal off all openings to the carburetor and exhaust system to prevent dust, water, and insects from entering the engine.

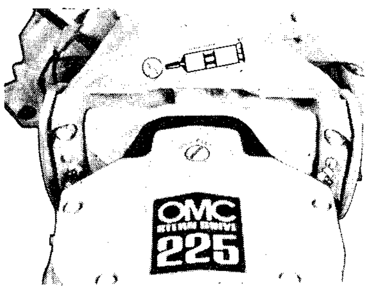
9– Remove the batteries from the boat and keep them charged during the storage period. Clean the batteries thoroughly of any dirt or corrosion, and then charge them to full specific gravity reading. After they are fully charged, store them in a clean cool dry place where they will not be damaged or knocked over.

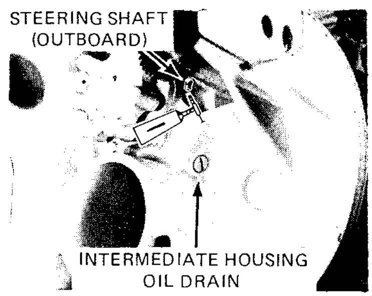
NEVER store the battery with anything on top of it or cover the battery in such a manner as to prevent air from circulating around the fillercaps. All batteries, both new and old, will discharge during periods of storage, more so if they are hot than if they remain cool. Therefore, the electrolyte level and the specific gravity should be checked at regular intervals. A drop in the

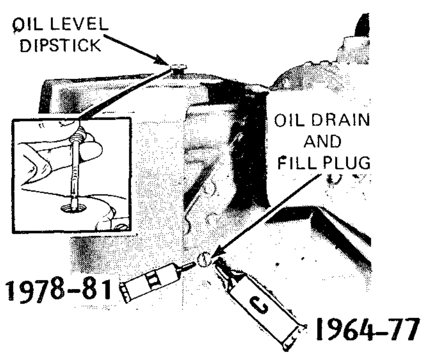


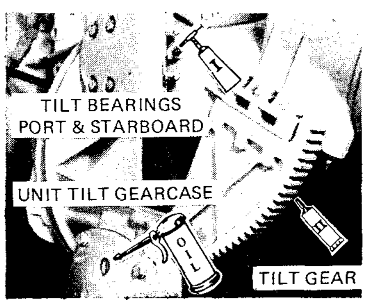


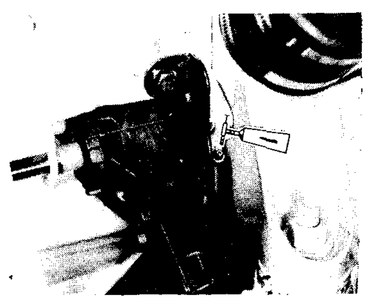




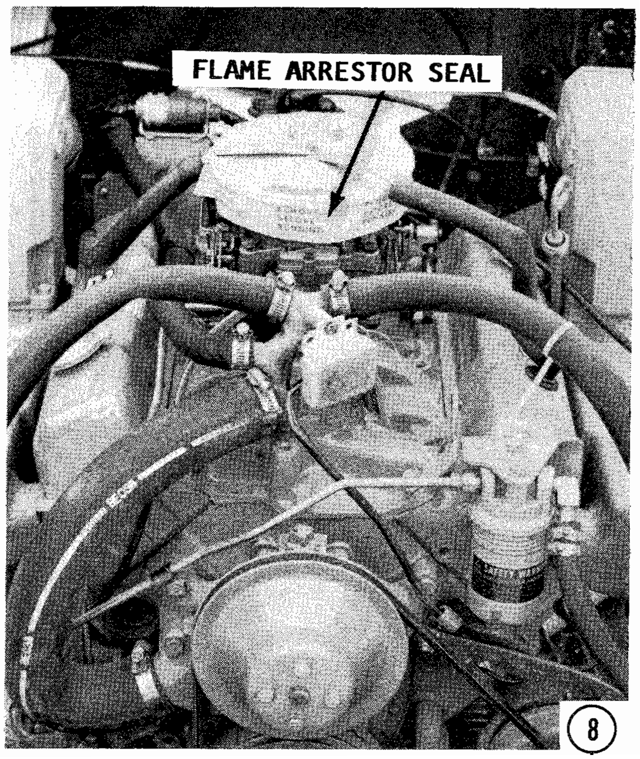








Points of lubrication and the type of Lubricant to be used. 7



8

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. 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.

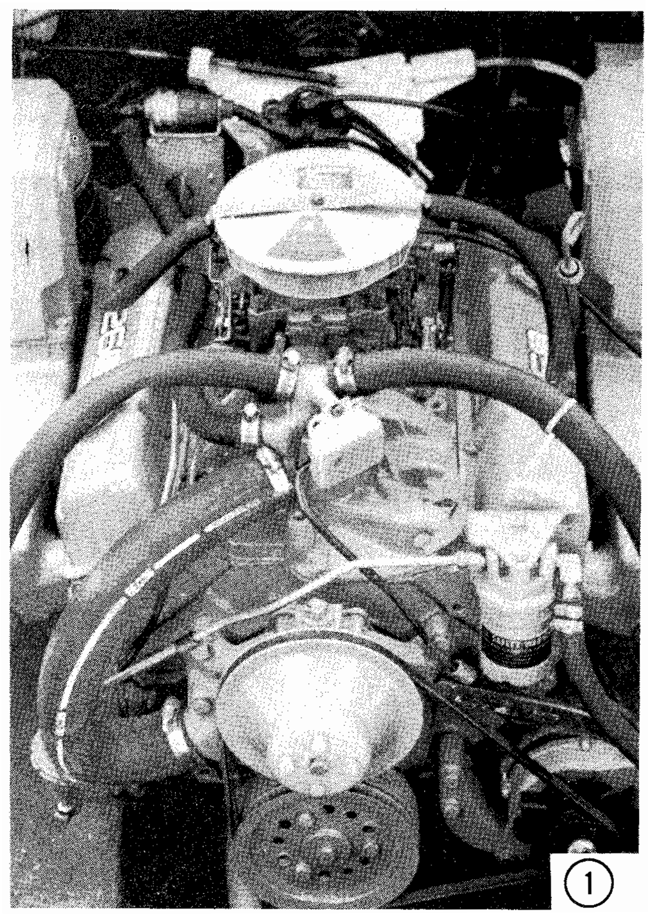
ALWAYS remove the drain plug and position the boat with the bow higher than the stern. This will allow any rain water and melted snow to drain from the boat and prevent "trailer sinking". This term is used to describe a boat that has filled with rain water and ruined the interior including the engine because the plug was not removed or the bow was not high enough to allow the water to drain properly.

9

PRE-SEASON PREPARATION

1- Lubricate the engine according to the manufacturer's recommendations. Remove, clean, inspect, adjust, and install the spark plugs with new gaskets if they require gaskets. Make a thorough check of the ignition system. This check should include: the points, coil, condenser, condition of the wiring, and the battery electrolyte level and charge.

2- Take time to check the gasoline tank and all of the fuel lines, fittings, couplings, valves, flexible tank fill, vent, and fuel



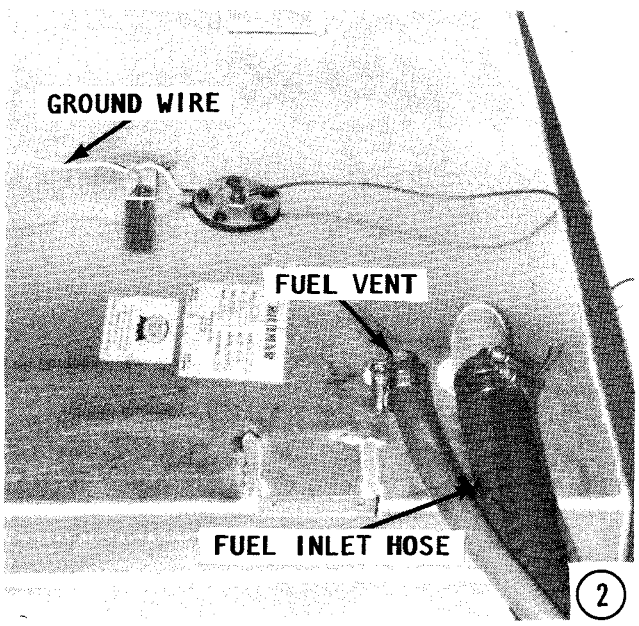
1

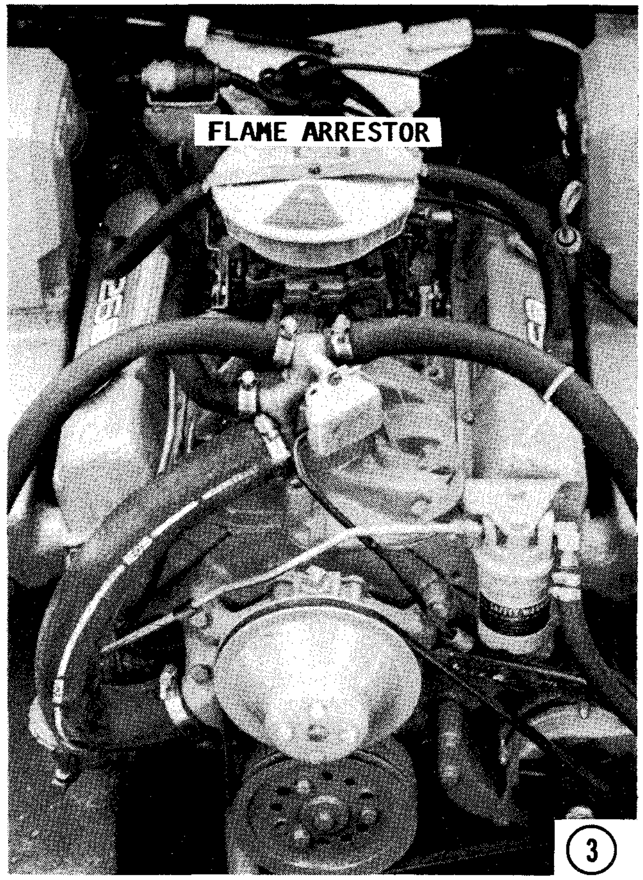
lines. Turn on the gasoline supply valve at the tank. If the gas was not drained at the end of the previous season, make a careful inspection for gum formation. When gasoline is allowed to stand for long periods of time, particularly in the presence of copper, gummy deposits form. This gum can clog the filters, lines, and passageways in the carburetor. See Chapter 4, Fuel System Service.

3- All marine engines MUST be equipped with an effective means, of backfire flame control. This can be accomplished by one of two methods. The first and most popular is through installation of a Coast Guard approved flame arrestor on the carburetor. The second method is by ducting the air intakes outside the engine compartment to the atmosphere.

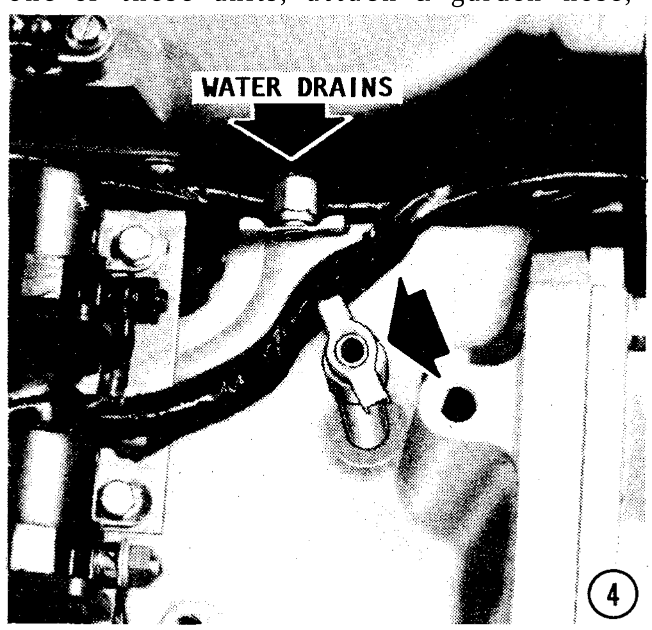
Clean and inspect the flame arrestors. Check and adjust the alternator belt tension, and replace them if they are worn or frayed. Check the oil level in the crankcase. The oil should have been changed prior to storage after the previous season. If the oil was not changed, do so and install a **NEW** oil filter.

4- Close all of the water drains. Check and replace any defective water hoses. Connect and check that the connections do not leak. Replace any spring-type hose clamps with band-type clamps, if they have lost their tension or if they have distorted the water hose. Check the sea cocks of the cooling system. Check to be sure the through-hull fittings are in good condition. If the engine is equipped with a closed-circuit cooling system, check the level of water. See Chapter 9, Cooling System.



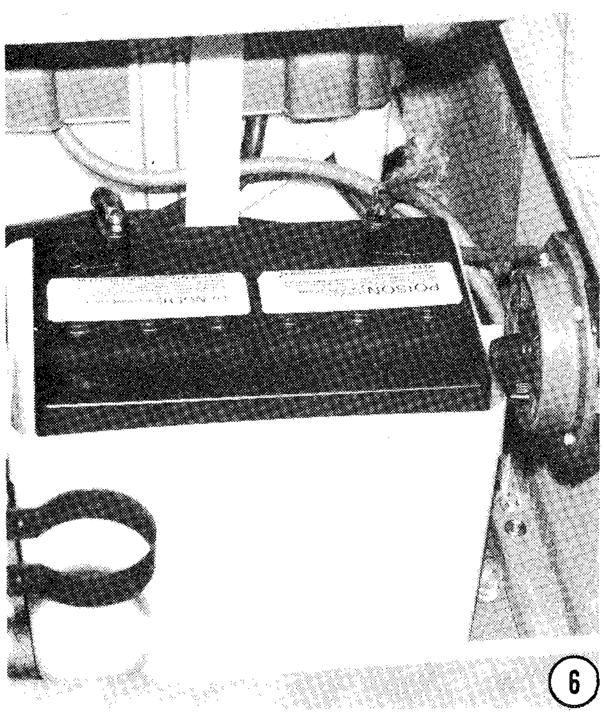


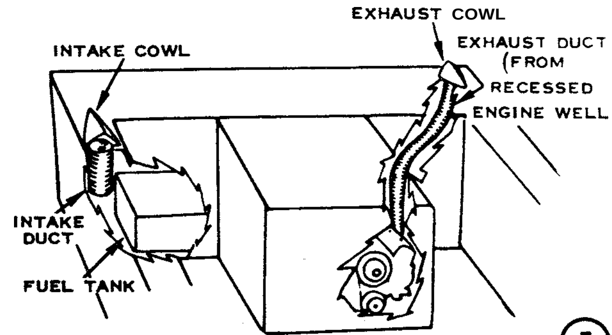
5- The engine can be run with the lower unit of the stern drive submerged in water to flush it. If this is not practical, a Flush-it attachment may be used. Two types are available. One is attached to the water pickup of the lower unit. The other, made by OMC, replaces the pivot end cap. With one of these units, attach a garden hose,



5

turn on the water, allow the water to flow into the engine for awhile, and then run the engine.


6



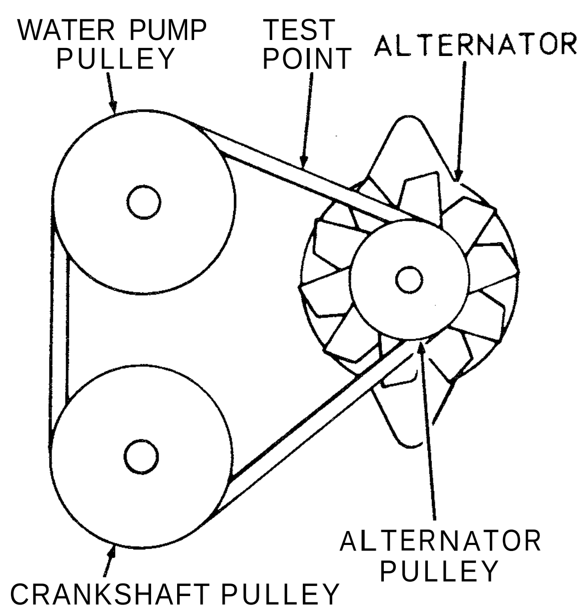
7

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.

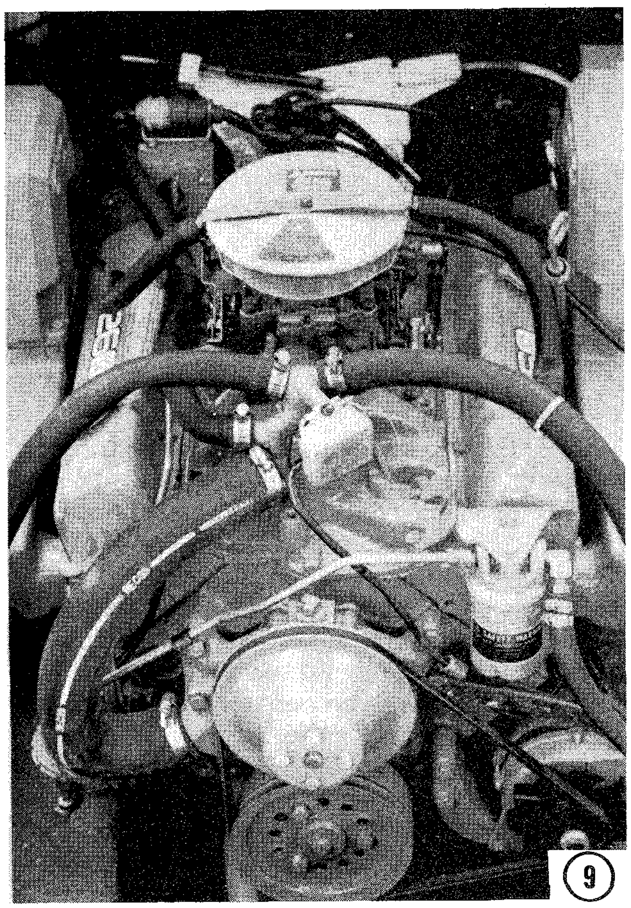
Check the exhaust outlet for water discharge. Check for leaks. Check operation of the thermostat. After the engine has reached operating temperature, tighten the cylinder head bolts to the torque value given in the Specifications in the Appendix.

6- Check the electrolyte level in the batteries 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.

7- Check the engine compartment for proper ventilation. **THERE MUST** be adequate means for removing combustible vapors from the boat. Coast Guard standards



8



include specially designed hardware to do the best job of preventing any vapors from accumulating in the engine compartment or in the bilge.

8- Check the tension of the engine drive belt to ensure proper operation of the engine water pump and alternator. If the belt can be depressed more than 1/4" midway between the water pump and alternator, loosen the alternator and make the proper adjustment to the belt.

9- Check all electrical parts in the engine compartment 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 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 check to be sure 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 water begin filling the inside.

Keep your gas tank full, the fuel pump pumping, the spark plugs sparking, the lifters lifting, and the pistons, well -- keep them working too.

Joan and Clarence

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)
feet2	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)
inches3	X 16.387	= centimetres^3 (cm^3)
inches3	X 0.01639	= litres (l)
quarts	X 0.94635	= litres (1)
gallons	X 3.7854	= litres (l)
feet^3	X 28.317	= litres (l)
feet^3	X 0.02832	= metres3 (m^3)
fluid oz	X 29.60	= millilitres (ml)
yards^3	X 0.7646	= metres3 (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)

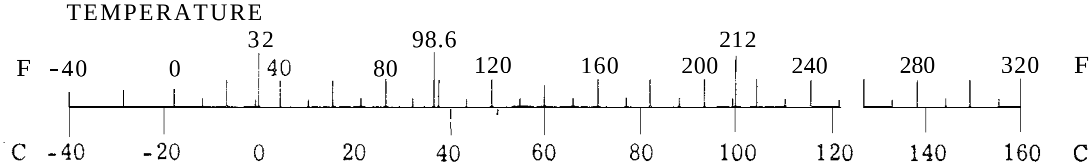
TORQUE

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

DRILL SIZE CONVERSION CHART

SHOWING MILLIMETER SIZES, FRACTIONAL AND DECIMAL INCH SIZES AND NUMBER DRILL SIZES

Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equtv.	Frac-tional	Num-ber	Milli-Meter	Dec. Equiv.	Frac-tional	Num-ber	Milli Meter	Dec Equiv	Frac-tional	Num ber	Milli-Meter	Dec. Equiv.	Frac-tional
.1	.0039			1.75	.0689			....	.1570		22	6.8	.2677			10.72	.4219	27/64
.15	.0059			....	.0700		50	4.0	.1575			6.9	.2716			11.0	.4330	
.2	.0079			1.8	.0709			....	.1590		21	....	.2720		I	11.11	.4375	7/16
.25	.0098			1.85	.0728			....	.1610		20	7.0	.2756			11.5	.4528	
.3	.0118			....	.0730		49	4.1	.1614			....	.2770		J	11.51	.4531	29/64
....	.0135		80	1.9	.0748			4.2	.1654			7.1	.2795			11.91	.4687	15/32
.35	.0138			....	.0760		48	....	.1660		19	....	.2811		K	12.0	.4724	
....	.0415		79	1.95	.0767			4.25	.1673			7.14	.2812	9/32	....	12.30	.4843	31/64
.39	.0156	1/64	....	1.98	.0781	5/64	....	4.3	.1693			7.2	.2835			12.5	.4921	
.4	.0157			....	.0785		47	....	.1695		18	7.25	.2854			12.7	.5000	1/2
....	.0160		78	2.0	.0787			4.37	.1719	11/64	....	7.3	.2874			13.0	.5118	
.45	.0177			2.05	.0807			....	.1730		17	....	.2900		L	13.10	.5156	33/64
....	.0180		77	....	.0810		46	4.4	.1732			7.4	.2913			13.49	.5312	17/32
.5	.0197			....	.0820		45	....	.1770		16	....	.2950		M	13.5	.5315	
....	.0200		76	2.1	.0827			4.5	.1771			7.5	.2953			13.89	.5469	35/64
....	.0210		75	2.15	.0846			....	.1800		15	7.54	.2968	19/64	....	14.0	.5512	
.55	.0217			....	.0860		44	4.6	.1811			7.6	.2992			14.29	.5624	9/16
....	.0225		74	2.2	.0866			....	.1820		14	....	.3020		N	14.5	.5709	
.6	.0236			2.25	.0855			4.7	.1850		13	7.7	.3031			14.68	.5781	37/64
....	.0240		73	....	.0890		43	4.75	.1870			7.75	.3051			15.0	.5906	
....	.0250		72	2.3	.0905			4.76	.1875	3/16	....	7.8	.3071			15.08	.5937	19/32
.65	.0256			2.35	.0925			4.8	.1890		12	7.9	.3110			15.48	.6094	39/64
....	.0260		71	....	.0935		42	....	.1910		11	7.94	.3125	5/16	....	15.5	.6102	
....	.0280		70	2.38	.0937	3/32	....	4.9	.1929			8.0	.3150			15.88	.6250	5/8
.7	.0276			2.4	.0945			....	.1935		10	....	.3160		O	16.0	.6299	
....	.0292		69	....	.0960		41	....	.1960		9	8.1	.3189			16.27	.6406	41/64
.75	.0295			2.45	.0964			5.0	.1968			8.2	.3228			16.5	.6496	
....	.0310		68	....	.0980		40	....	.1990		8	....	.3230		P	16.67	.6562	21/32
.79	.0312	1/32	...	2.5	.0984			5.1	.2008			8.25	.3248			17.0	.6693	
.8	.0315			....	.0995		39	....	.2010		7	8.3	.3268			17.06	.6719	43/64
....	.0320		67	....	.1015		38	5.16	.2031	13/64	....	8.33	.3281	21/64	....	17.46	.6875	11/16
....	.0330		66	2.6	.1024			....	.2040		6	8.4	.3307			17.5	.6890	
.85	.0335			....	.1040		37	5.2	.2047			....	.3320		Q	17.86	.7031	45/64
....	.0350		65	2.7	.1063			....	.2055		5	8.5	.3346			18.0	.7087	
.9	.0354			....	.1065		36	5.25	.2067			8.6	.3386			18.26	.7187	23/32
....	.0360		64	2.75	.1082			5.3	.2086			....	.3390		R	18.5	.7283	
....	.0370		63	2.78	.1094	7/64	....	....	.2090		4	8.7	.3425			18.65	.7344	47/64
.95	.0374			....	.1100		35	5.4	.2126			8.73	.3437	11/32	....	19.0	.7480	
....	.0380		62	2.8	.1102			...	.2130		3	8.75	.3445			19.05	.7500	3/4
....	.0390		61	....	.1110		34	5.5	.2165			8.8	.3465			19.45	.7656	49/64
1.0	.0394			....	.1130		33	5.56	.2187	7/32	....	....	.3480		S	19.5	.7677	
....	.0400		60	2.9	.1141			5.6	.2205			8.9	.3504			19.84	.7812	25/32
....	.0410		59	....	.1160		32	....	.2210		2	9.0	.3543			20.0	.7874	
1.05	.0413			3.0	.1181			5.7	.2244			....	.3580		T	20.24	.7969	51/64
....	.0420		58	....	.1200		31	5.75	.2263			9.1	.3583			20.5	.8071	
....	.0430		57	3.1	.1220			....	.2280		1	9.13	.3594	23/64	....	20.64	.8125	13/16
1.1	.0433			3.18	.1250	1/8	....	5.8	.2283			9.2	.3622			21.0	.8268	
1.15	.0452			3.2	.1260			5.9	.2323			9.25	.3641			21.04	.8218	53/64
....	.0465		56	3.25	.1279			....	.2340		A	9.3	.3661			21.43	.8437	27/32
1.19	.0469	3/64	...	....	.1285		30	5.95	.2344	15/64	....	....	.3680		U	21.5	.8465	
1.2	.0472			3.3	.1299			6.0	.2362			9.4	.3701			21.83	.8594	55/64
1.25	.0492			3.4	.1338			....	.2380		B	9.5	.3740			22.0	.8661	
1.3	.0512			....	.1360		29	6.1	.2401			9.53	.3750	3/8	....	22.23	.8750	7/8
....	.0520		55	3.5	.1378			....	.2420		C	....	.3770		V	22.5	.8858	
1.35	.0513			....	.1405		28	6.2	.2441			9.6	.3780			22.62	.8906	57/64
....	.0550		54	3.57	.1406	9/64	...	6.25	.2460		D	9.7	.3819			23.0	.9055	
1.4	.0551			3.6	.1417			6.3	.2480			9.75	.3838			23.02	.9062	29/32
1.45	.0570			....	.1440		27	6.35	.2500	1/4	E	9.8	.3858			23.42	.9219	59/64
1.5	.0591			3.7	.1457			6.4	.2520			....	.3860		W	23.5	.9252	
....	.0595		53	....	.1470		26	6.5	.2559			9.9	.3839			23.81	.9375	15/16
1.55	.0610			3.75	.1476			....	.2570		F	9.92	.3906	25/64	....	24.0	.9449	
1.59	.0625	1/16	...	....	.1495		25	6.6	.2598			10.0	.3937			24.21	.9531	61/64
1.6	.0629			3.8	.1496			....	.2610		G	....	.3970		X	24.5	.9646	
....	.0635		52	....	.1520		24	6.7	.2638			....	.4040		Y	24.61	.9687	31/32
1.65	.0649			3.9	.1535			6.75	.2657	16/64	....	10.32	.4062	13/32	....	25.0	.9843	
1.7	.0669				[illegible]		23	6.75	.2657			....	.4130		Z	25.03	.9844	63/64
....	.0670		51					....	.2660		H	10.5	.4134			25.4	1.0000	1

MODEL	CYL	HP	MFG	CHAMP	AC	GAP	IDLE SPEED	GAP	DWELL	MFD.	TIMING MARKS DEGREE	FUEL PUMP PRESS.
1964												
CU/CUE/12M/SU/SUE/13E	4	110	Chev.	N12Y	46N	.035	500-600	.016	30"	.18-.23	4° (3)	3.5-4.5
HU/HUE/12M	V6	150	Kaiser	J1OY	M43S	.035	550-650	.016	30"	.18-.23	5" (2)	4--5-3/4
1965												
CU/CUE/SU/SUE/13E	4	120	Chev.	N6	C44N	.035	500-600	.019	31"	.18-.23	4° (3)	3.5-4.5
HU/HUE/13E/HU/13EM	V6	150	Kaiser	J10Y	M43S	.035	550-650	.016	30"	.18-.23	5° (2)	4--5-3/4
1966												
CU/CUE/14D/SU/SUE/14D	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HU/HUE/14D	V6	150	Kaiser	J10Y	M43S	.035	550-650	.016	30"	.18-.23	5° (2)	4--5-3/4
TU/TUE/14D	V8	200	Buick	J10Y	M43S	.035	550-650	.018	30"	.18-.23	2.5° (2)	4--5-3/4
1967												
CU/CUE/15S	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HU/HUE/15S	V6	155	Kaiser	JIOY	M43S	.035	550-650	.016	30°	.18-.23	5° (2)	4--5-3/4
KU/KUE/15S	V8	185	Chev.	UJ6	C43	.035	550-650	.020	29°	.27-.29	8° (2)	7.9
TU/TUE/15S	V8	200	Buick	J IOY	M43S	.035	550-650	.018	30°	.18-.23	2.5° (2)	4--5-3/4
1968												
NU-1OS,NUE-1OS	4	80	Ford	N9Y	R43N	.025	580-650	.025	39°	.21-.25	8° (2)	1-2
CU/CUE/16C	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HU/HUE/16C	V6	155	Kaiser	J IOY	M43S	.035	550-650	.016	30°	.18-.23	5° (2)	4--5-3/4
KU/KUE/16C	V8	185	Chev.	UJ6	C43	.035	550-650	.020	29°	.27-.29	8° (2)	7.9
TU/TUE/16C	V8	210	Qhev.	UJ6	C43	.035	550-650	.018	30°	.27-.29	8° (2)	7.9

MODEL	CYL	HP	MFG	CHAMP	AC	GAP	IDLE SPEED	GAP	DWELL	MFD.	TIMING MARKS DEGREE	FUEL PUMP PRESS.
1969												
CUFR/CUFM/CUTR/CUTM/69	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HUFR/HUFM/HUTR/HUTM/69	V6	155	Kaiser	J10Y	M43S	.035	550-650	.016	30°	.18-.23	5° (2)	4--5-3/4
TUFR/TUFM/69	V8	210	Chev.	UJ6	C43	.035	550-650	.018	30°	.27-.29	10° (2)	7-9
1970												
MUFM/NUFR/69R or 12A	4	90	Ford	N9Y	R43N	.025	580-650	.025	39°	.21-.25	8° (2)	1-2
CUFR/CUFM/CUTR/CUTM/19E	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HUFR/HUFM/HUTR/HUTM/19E	V6	155	Kaiser	J10Y	M43S	.035	550-650	.016	30°	.18-.23	5° (2)	4--5-3/4
TUFRITUFMI19E	V8	210	Chev.	J6	CR43K	.035	550-650	.018	30°	.27-.29	10° (2)	7-9
1971												
NUFMINUFRI13M or 12AX	4	90	Ford	N9Y	R43N	.025	580-650	.025	39°	.21-.25	8° (2)	1-2
CUFM/CUTM/CUFR/20D or 19EX	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HUFM/HUTM/HUFR/HUTR/20/19	V6	155	Kaiser	J10Y	M43S	.035	550-650	.016	30°	.18-.23	5° (2)	4--5-3/4
TUFM/TUFR/20D or 19X	V8	215	Chev.	J6	CR43K	.035	550-650	.018	30°	.27-.29	10° (2)	7-9
XUVM/XUFM/20C	V8	235	Chev.	J6	CR43K	.035	600-650	.018	30°	.27-.29	3° (2)	7-9
1972												
LUFM/10S/LUFM/10C	4	100	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
VUFMI10S/10C/GUFM/10C/10S	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
HUTM/HUFM/21S or 21C	V6	155	Kaiser	J10Y	M43S	.035	550-650	.016	30°	.18-.23	5° (2)	4--5-3/4
JUFMI10S or 10C	6	165	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	6° (3)	3.5-4.5
TUFM/21C/21S	V8	225	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	10° (2)	7-9
XUFM/21R/21A	V8	245	Chev.	RBL8	MR43T	.035	600-650-	.018	30°	.27-.29	10° (2)	7-9

MODEL	CYL	HP	MFG	CHAMP	AC	GAP	IDLE SPEED	GAP	DWELL	MFD.	TIMING MARKS DEGREE	FUEL PUMP PRESS.
1973												
990206S	4	100	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990207S/990215S	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990216S/990217S	4	140	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990210S/990218S	6	165	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	6° (3)	3.5-4.5
990211S	V8	225	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	10° (2)	7-9
990212S	V8	245	Chev.	RBL8	MR43T	.035	600-650-	.018	30°	.27-.29	10° (2)	7-9
1974												
990207R/990215R	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990216FF/R	4	140	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990221R	V8	170	Ford	RBL8	MR43T	.030	500-600	.019	31°	.21-.25	10° (3)	5-6
990210R/990218R	6	165	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	6° (3)	3.5-4.5
990220R	V8	190	Ford	RBL8	MR43T	.030	500-600	.019	31°	.21-.25	10° (3)	5-6
990211R	V8	225	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	10° (2)	7-9
990212R	V8	245	Chev.	RBL8	MR43T	.035	600-650-	.018	30°	.27-.29	10° (2)	7-9
1975												
990224A/990223A	4	120	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990226A/990225A	4	140	Chev.	N6	C44N	.035	500-600	.019	31°	.18-.23	4° (3)	3.5-4.5
990227A990228A	6	165	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	6° (3)	3.5-4.5
990229A	V8	175	Ford	RBL8	MR43T	.030	500-600	.019	31°	.21-.25	10° (3)	5-6
990220R2/99231A	V8	190	Ford	RBL8	MR43T	.030	500-600	.019	31°	.21-.25	10° (3)	5-6
990211A	V8	225	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	10° (2)	7-9
990241A	V8	235	Ford	RBL8	MR43T	.030	500-600	.019	31°	.21-.25	10° (3)	5-6
990212A	V8	245	Chev.	RBL8	MR43T	.035	600-650-	.018	30°	.27-.29	10° (2)	7-9

MODEL	CYL	HP	MFG	CHAMP	AC	GAP	IDLE SPEED	GAP	DWELL	MFD.	TIMING MARKS DEGREE	FUEL PUMP PRESS.
1976												
990223A11/990224A11 990234M/990235M	4	120	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
990225A11/99026A11 990236M/990237M	4	140	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
990228A11/990239M 990236M	6	165	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	6° (3)	3.5-4.5
990230A11/990230M 990229A11/990229M	V8	175	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	10° (2)	7-9
990232A11/990232M 990231A11/990231M	V8	190	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	10° (2)	7-9
990211A11/990211M	V8	225	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	10° (2)	7-9
990240A11/990240M 990241A11/990241M	V8	235	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	10° (2)	7-9
1977												
990235E/990235E1 990234E/990234E1	4	120	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
990237E/990237E1 990236E/990236E1	4	140	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
990230E/990230G 990229E/990229G	V8	175	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	10° (2)	7-9
990232E/990232G 990231E/990231G	V8	190	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	10° (2)	7-9
990240E/990240G 990241E/990241G	V8	235	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	10° (2)	7-9

MODEL	CYL	HP	MFG	CHAMP	AC	GAP	IDLE SPEED	GAP	DWELL	MFD.	TIMING MARKS DEGREE	FUEL PUMP PRESS.
1978												
99024/3D/3H/3HI 99024/2D/2H/2HI	4	120	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
99024/5D/5H/5HI 99024/4D/4P/4H/4HI	4	140	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
99025/2D/2H/2J/ 99025/3D/3H/3J	V8	185	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	7° (2)	7-9
99025/4D/4H/4J 99025/5D/5H/5J	V8	225	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	7° (2)	7-9
990250/D/P/H/N/J/U/ 990251/D/H/N/J/U	V8	240	Ford	RBL8	MR43T	.035	500-600	.019	31°	.25-.28	6° (2)	7-9
1979												
990242/990243	4	120	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
990244/990245	4	140	Chev.	RBL8	MR43T	.035	500-600	.019	31°	.18-.23	4° (2)	4--5-3/4
990252/990253	V8	185	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	7° (2)	7-9
990266/990267	V8	200	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	7° (2)	7-9
990254/990255	V8	230	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	7° (2)	7-9
990251	V8	250	Ford	RBL8	MR43T	.030	500-600	.017	29°	.25-.28	6° (2)	7-9
990256/990257	V8	260	Chev.	RBL8	MR43T	.035	550-650-	.018	30°	.27-.29	10° (2)	7-9

MODEL	CYL	HP	MFG	CHAMP	AC	GAP	IDLE SPEED	GAP	DWELL	MFD.	TIMING MARKS DEGREE	FUEL PUMP PRESS.
1980												
990242C, 2CI 990243C, 3CI	4	120	Chev	RBL-8	MR43T	.035	500-600	.019	31°-34°	.18-.23	4°(2)	3.5-6
990244C, 4CI 990245C, 5CI	4	140	Chev	RBL-8	MR43T	.035	500-600	.019	31°-34°	.18-.23	4°(2)	3.5-6
990252C, 2K 990253C, 3K	V8	185	Chev	RBL-8	MR44T	.035	500-600	.018	28°32°	.25-.29	13°(2)	5.75-7
990266C, 6K 990267C, 7K 990260C, 0K	V8	200	Chev	RBL-8	MR44T	.035	500-600	.018	28°-32°	.25-.29	13°(2)	5.75-7
990254C, 4CK 990255C, 5CK 990261C, 1CK	V8	230	Chev	RBL-8	MR44T	.035	500-600	.018	28°-32°	.25-.29	13°(2)	5.75-7
990256C, 6CK 990257C, 7CK 990262C, 2CK	V8	260	Chev	RBL-8	MR43T	.035	500-600	.018	28°-32°	.27-.29	10°(2)	5.75-7

(1) Flywheel and distributor pulley

(2) Harmonic balancer

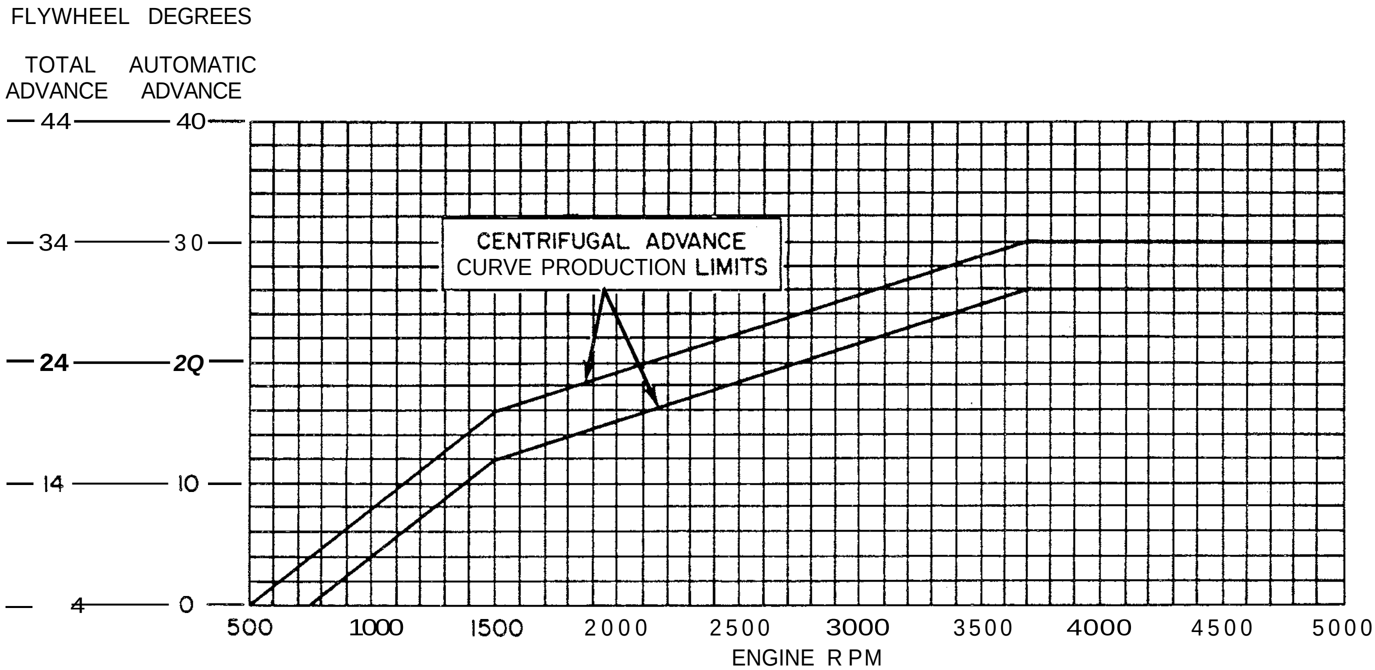
(3) Crankshaft pulley

(4) Mix oil with gasoline -- two stroke cycle engine

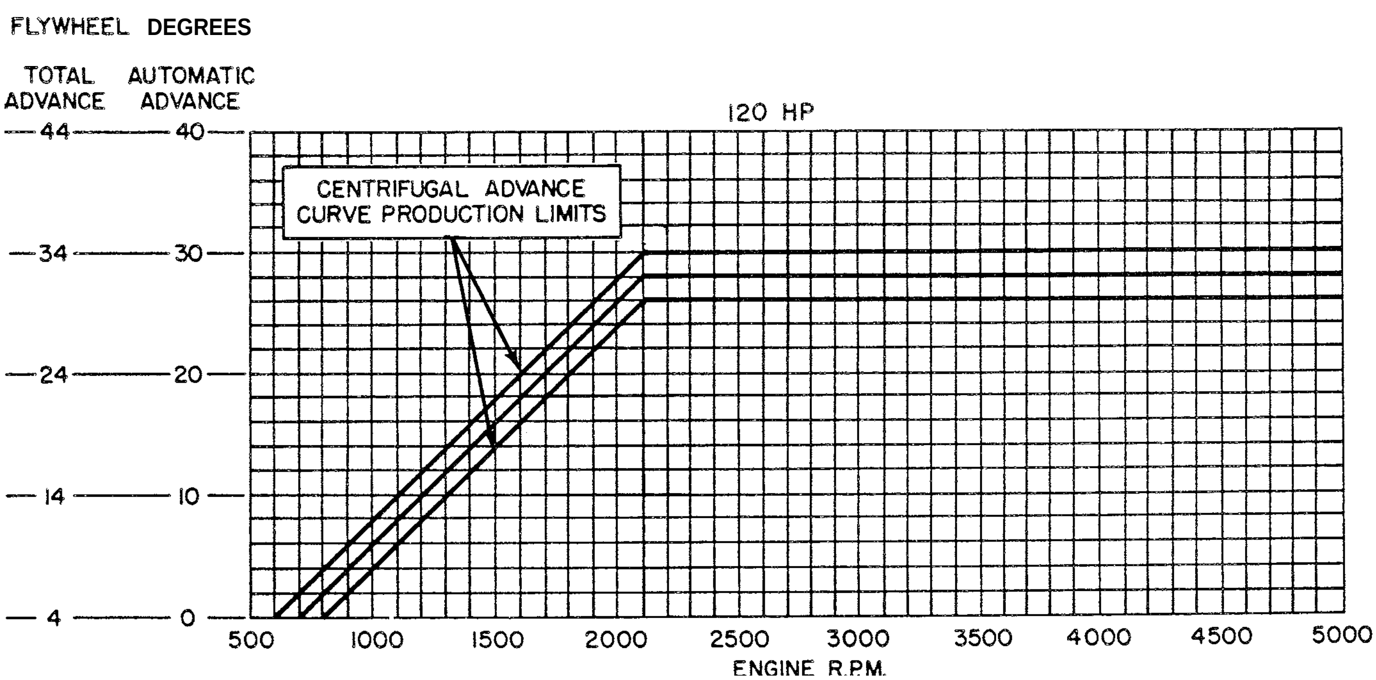
ENGINE	CID	MFG	CYL	CHAMP PLUG	AC PLUG	PLUG GAP	POINT GAP	DWELL	TIMING	FUEL PRESS	IDLE RPM	WOT RPM
		1981					1981					
2.5 Litre	153	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3.5 to 6 PSI	500-600	4200-4600
3.0 Litre	181	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3.5 to 6 PSI	500-600	4200-4600
3.8 Litre	229	GMC	V6	RBL-8	MR44T	.035"	.019"	37-41°	10°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
5.0 Litre	305	GMC	V8	RBL-8	MR44T	.030"	.018"	28-32°	13°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
5.7 Litre	350	GMC	V8	RBL-8	MR43T	.030"	.018"	28-32°	10°BTDC	5-3/4 to 7 PSI	500-600	4000-4400
		1982					1982					
2.5 Litre	153	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3.5 to 6 PSI	500-600	4200-4600
3.0 Litre	181	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3.5 to 6 PSI	500-600	4200-4600
3.8 Litre	229	GMC	V6	RBL-8	MR44T	.035"	.018"	37-41°	10°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
5.0 Litre	305	GMC	V8	RBL-8	MR44T	.030"	.018"	28-32°	13°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
5.7 Litre	350	GMC	V8	RBL-8	MR43T	.030"	.018"	28-32°	10°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
		1983					1983					
2.5 Litre	153	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3.5 to 6 PSI	500-600	4200-4600
3.0 Litre	181	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3.5 to 6 PSI	500-600	4200-4600
3.8 Litre	229	GMC	V6	RBL-8	MR44T	.035"	.018"	37-41°	10°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
5.0 Litre	305	GMC	V8	RBL-8	MR44T	.030"	.018"	28-32°	13°BTDC	5-3/4 to 7 PSI	500-600	4200-4600
5.7 Litre	350	GMC	V8	RBL-8	MR43T	.030"	.018"	28-32°	10°BTDC	5-3/4 to 7 PSI	500-600	4200-4600

TUNE-UP SPECIFICATIONS

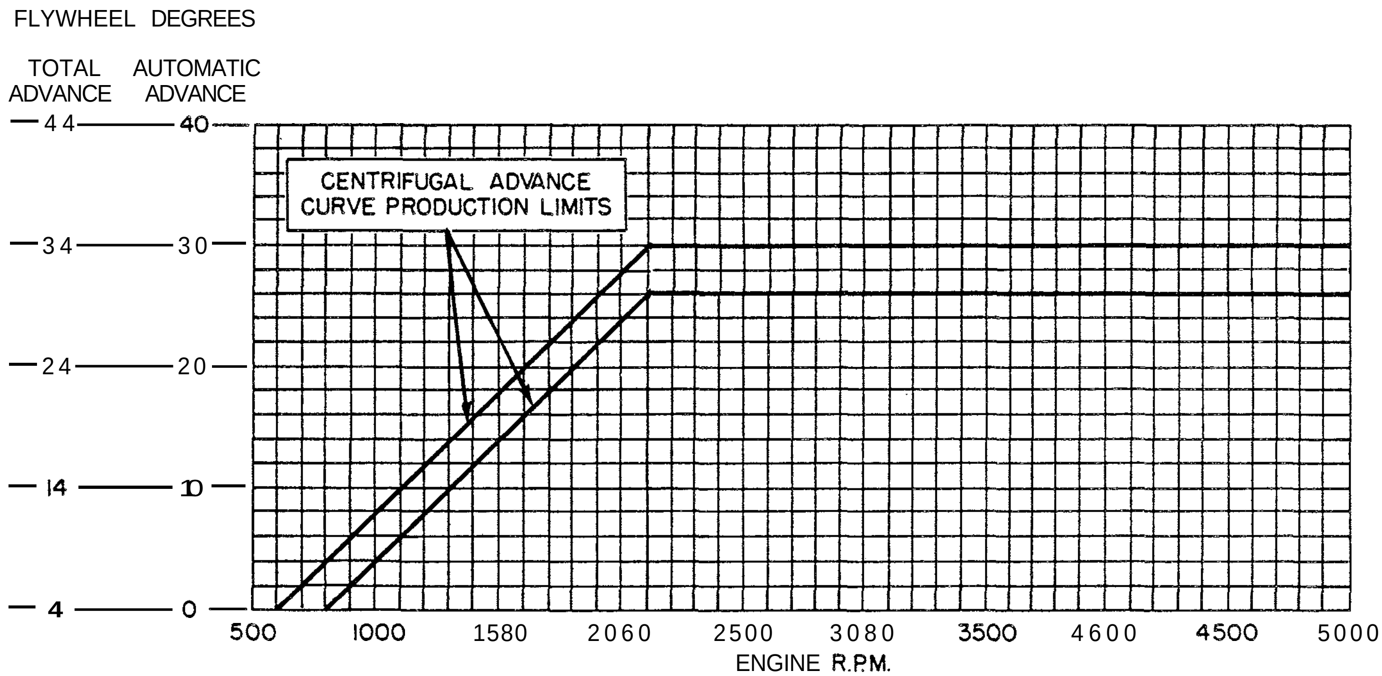
ENGINE	CID	MFG	CYL	CHAMP PLUG	AC PLUG	PLUG GAP	POINT GAP	DWELL	TIMING	FUEL PRESS	IDLE RPM	WOT RPM
		1984					**1984**					
2.5 Litre	153	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4°BTDC	3-1/2 to 6 **PSI**	500-600	4200-4600
3.0 Litre	181	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4° BTDC	3-1/2 tp 6 **PSI**	500-600	4200-4600
3.8 Litre	229	GMC	V6	RBL-8	MR43T	.035"	.018"	34-38'	10° BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
5.0 Litre	305	GMC	V8	RBL-8	MR43T	.035"	.018"	28-32'	13° BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
5.7 Litre	350	GMC	V8	RBL-8	MR43T	.035"	.018"	28-32'	10° BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
		1985					**1985**					
2.5 Litre	153	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4° BTDC	3-1/2 to 6 **PSI**	500-600	4200-4600
3.0 Litre	181	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	4° BTDC	3-1/2 to 6 **PSI**	500-600	4200-4600
3.8 Litre	229	GMC	V6	RBL-8	MR43T	.035"	.018"	34-38'	10° BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
5.0 Litre	305	GMC	V8	RBL-8	MR43T	.035"	.018"	28-32'	13° BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
5.7 Litre	350	GMC	V8	RBL-8	MR43T	.035"	.018"	28-32'	10° BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
		1986					**1986**					
2.5 Litre	153	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	1°BTDC	3-1/2 to 6 PSI	500-60G	4200-4600
3.0 Litre	181	GMC	4	RBL-8	MR43T	.035"	.019"	31-34°	1°BTDC	3-1/2 to 6 PSI	500-600	4200-4600
4.3 Litre	262	GMC	V6	RBL-8	MR43T	.035"	.018"	37-41°	1°BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
5.0 Litre	305	GMC	V8	RBL-8	MR43T	.035"	.018"	28-32'	8°BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600
5.7 Litre	350	GMC	V8	RBL-8	MR43T	.035"	.018"	28-32'	5°BTDC	5-3/4 to 7 **PSI**	500-600	4200-4600



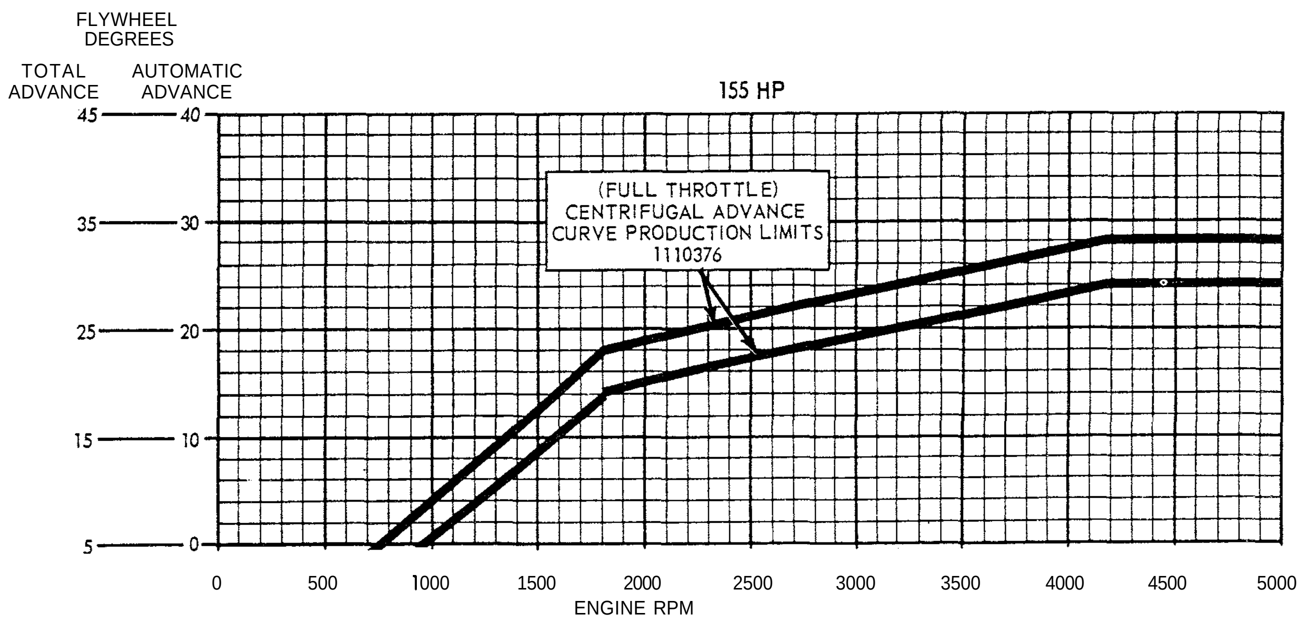
Centrifugal Advance -- *120 hp* -- 1965-70
Start Advance 1^{o}-5^{o} *at* 800 *rpm.*
Maximum Advance 20^{o}-30^{o} *at* 3700 *rpm.*



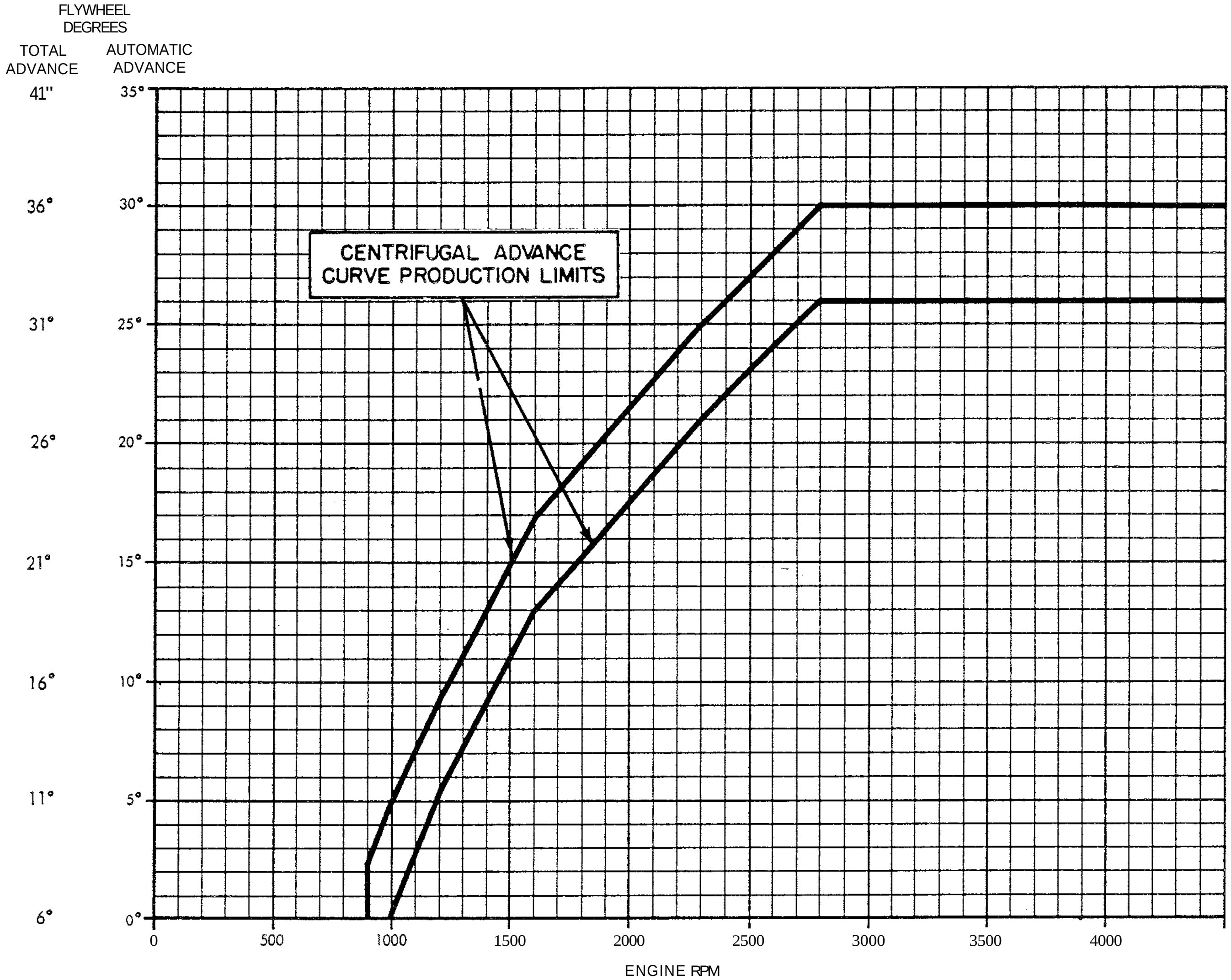
Centrifugal Advance -- 120 hp -- 1971-72
Start Advance 0^{o}-2^{o} *at* 700 *rpm.*
Maximum Advance 26^{o}-30^{o} *at 2100 rpm.*



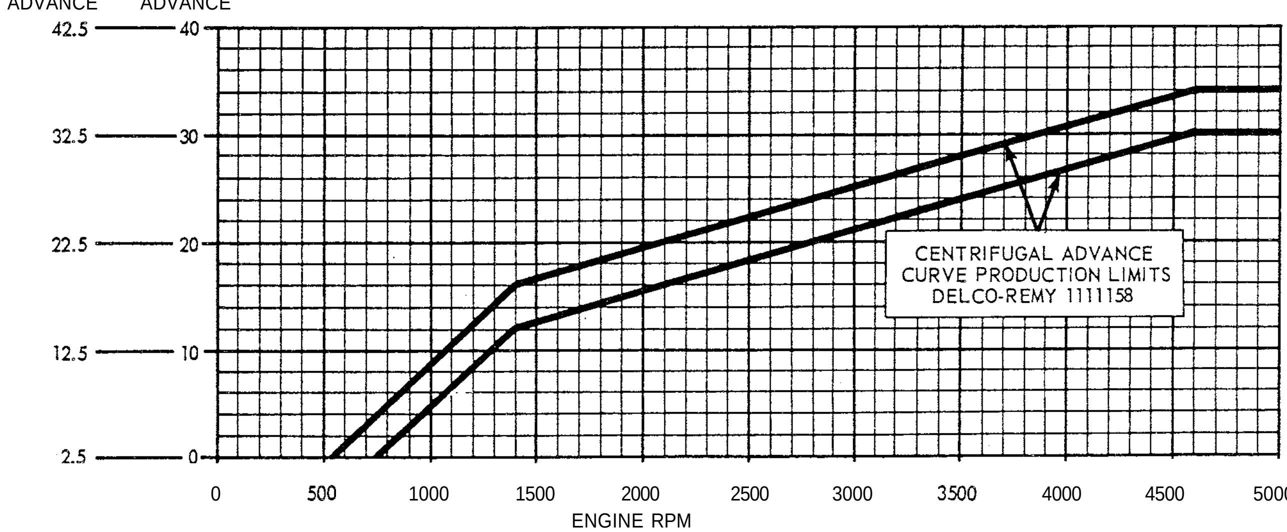
Centrifugal Advance
120 hp and 140 hp -- 1973-81
2.5 and 3.0 Litre -- 1982 and on
Start Advance 0^{o} - 2^{o} at 700 rpm
Maximum Advance 26^{o} - 30^{o} at 2100 rpm



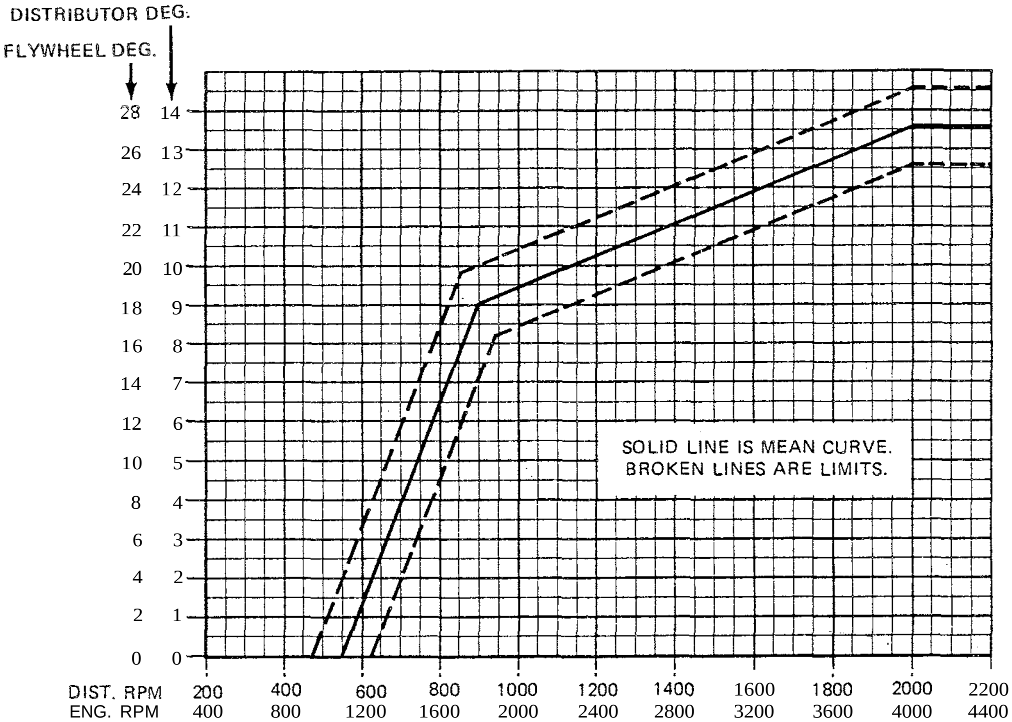
Centrifugal Advance -- 150 and 155 hp -- 1964-72
Start Advance 4^{o}-5^{o} at 1000 rpm.
Maximum Advance 24^{o}-28^{o} at 4200 rpm.



Centrifugal Advance -- 165 hp -- 1972-76
Start Advance 0°-2.5° at 900 rpm.
Maximum Advance 26°-30° at 2800 rpm.



Centrifugal Advance -- 200 and 210 hp -- 1966-68
Start Advance 1°-5° at 800 rpm.
Maximum Advance 30°-34° at 4600 rpm.

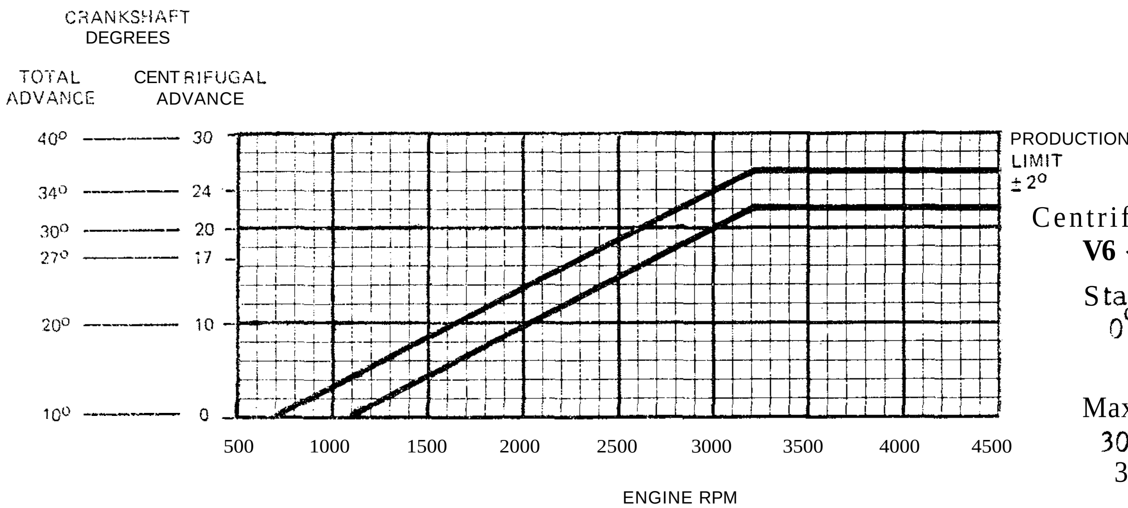


Centrifugal Advance

170 hp -- 1975
175 hp -- 1975-77
190 hp -- 1974-77
235 hp -- 1975-77
240 hp -- 1978
250 hp -- 1979

Distributor -- Start 0^{o} at 550 rpm, Max. 13.5^{o} at 2000 rpm

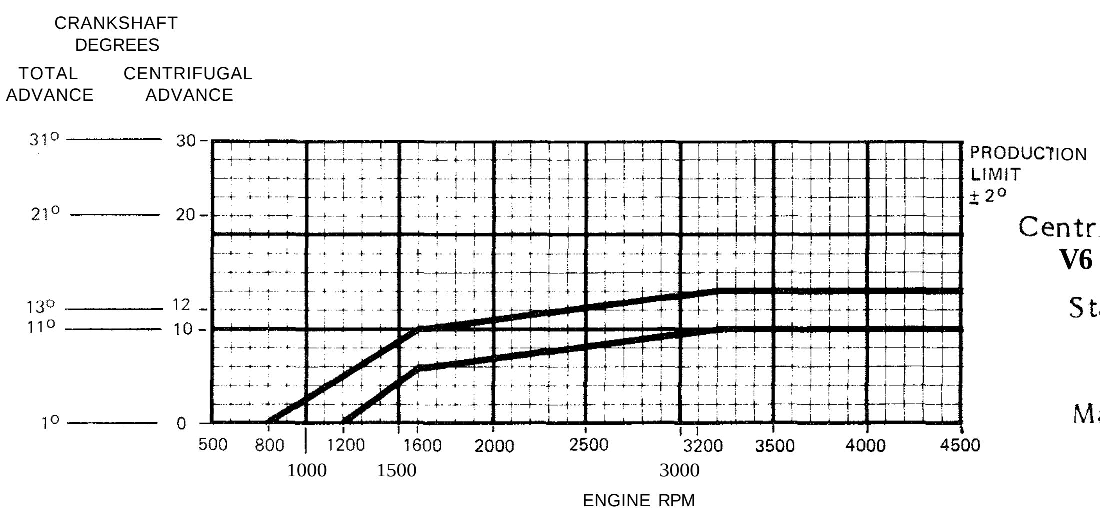
Engine -- Start 0^{o} at 1100 rprn Max. 27^{o} at 4000 rpm



Centrifugal Advance
V6 -- 1981-85

Start Advance 0^{o} - 10^{o} at 800 rpm

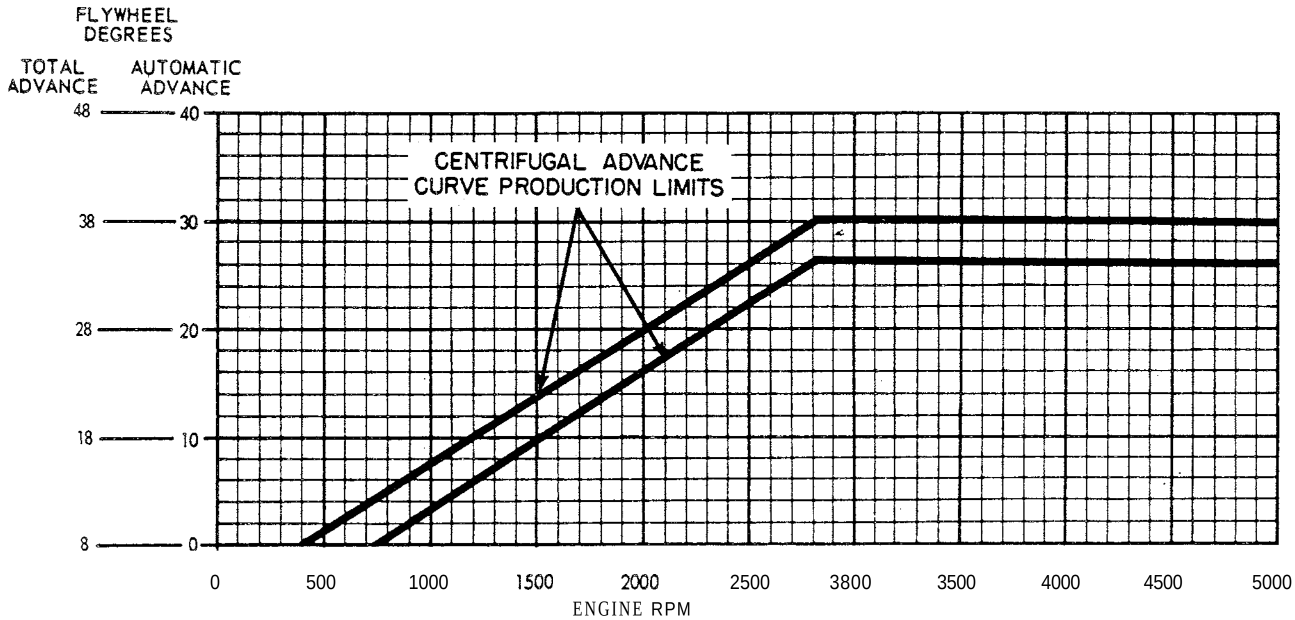
Max. Advance 30^{o}-34^{o} at 3200 rprn



Centrifugal Advance
V6 1986 and on

Start Advance 0^{o}-8^{o} at 1000 rprn

Max. Advance 12^{o}-20^{o} at 3200 rpm



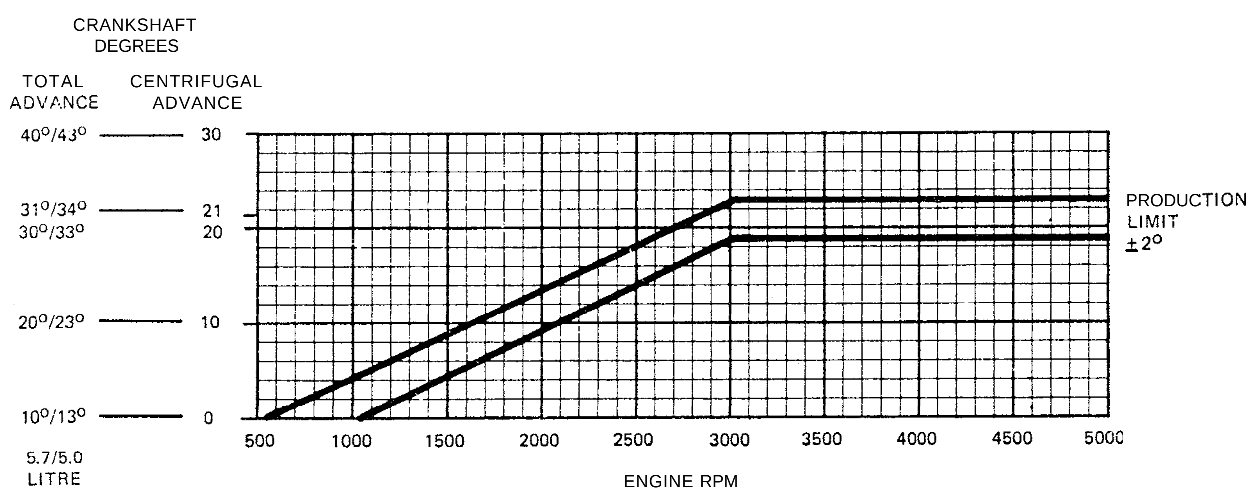
Centrifugal Advance

185 hp -- 1967-68
210 hp -- 1969-70
215 hp -- 1971

235 hp -- 1971
225 hp -- 1972-76
245 hp 1972-76

185 hp -- 1978
225 hp -- 1978
All V8 -- 1980-82

185, 200, 230, and 260 hp -- 1979
Start Advance 0° - 4° at 800 rpm
Maximum Advance 20° - 30° at 2800 rprn



Centrifugal Advance

All V8 -- 1983 and on
Start Advance 0° at 800 rprn
Maximum Advance 19° - 23° at 3000 rpm

RBS CARBURETOR SPECIFICATIONS

Models

100 hp	1972-73
120 hp	1965-71
150 hp	1966

Throttle bore .... 1-7/16"
Main venturi .... 1-1/4"
Low speed circuit:
Jet .... 0.0292" (No. 69 Dr.)
By-pass .... 0.052" (No. 55 Dr.)
Economizer .... 0.0453"
Air bleed .... 0.0492" (1.25 mm Dr.)
Idle port .... Length 0.143" — Width 0.030"
Idle port locations .... 0.143" — 0.148"
above tightly closed valve
Main nozzle .... Installed permanently,
Nozzle bleed .... 0.028" (No. 70 Dr.)
Step-up rod assembly:
Economy step .... 0.063"
Power step .... 0.060"
Step-up rod jet ...... 0.089", Installed permanently
Accelerating pump jet .... 0.0292" (No. 69 Dr.)
Float level adjustment .... 15/32"
Choke setting .... On Index mark
Choke suction hole .... 0.070" (No. 50 Dr.)
Choke unloader adjustment .... 7/64"
Initial idle mixture .... 1 to 2 turns out
Initial idle speed .... 1-1/2 to 3 turns out

2GV CARBURETOR SPECIFICATIONS

Models

90 hp	
120 hp	1972-75
140 hp	1973-75
155 hp	1967-72
165 hp	1972-75
185 hp	1967-68

Float level .... 19/32"
Float drop .... 1-29/32"
Pump rod adjustment .... 1-1/8"
Choke unloader adjustment .... 0.080"
Choke setting .... Index
Initial idle mixture .... 1 turn out

2GC CARBURETOR SPECIFICATIONS

Models

120, 140, & 165 hp	1976-78
200 hp	1966-67

Float level .... 19/32"
Float level (90 Hp only) .... 27/64" or 0.421"
Float drop .... 1-29/32"
Pump rod adjustment .... 1-5/32"
Choke unloader adjustment .... 0.110"
Choke setting .... Index
Initial idle mixture .... 1 turn out

2GC CARBURETOR SPECIFICATIONS

Models

185 hp 1978

Float level	5/8"
Float drop	1-31/32"
Pump rod adjustment	1-7/32"
Choke unloader adjustment	5/16"
Choke setting	Index
Initial idle mixture	1-1/2 turns out

2GC CARBURETOR SPECIFICATIONS

Models

120 & 140 hp	1979 -- 81
2.5 & 3.0 Litre	1982 and on

Float level	1/2"
Float drop	1-314"
Pump rod adjustment	1-5/32"
Choke unloader adjustment	0.1 10"
Choke setting	Index
Initial idle mixture	2 turns out

2GC CARBURETOR SPECIFICATIONS

Model

4.3 Litre 1986 and on

Float level	17/32"
Float drop	1-314"
Pump rod adjustment	1-15/16"
Choke unloader adjustment	5/16"
Choke setting	Index
Initial idle mixture	2-1/2 turns out

2GC CARBURETOR SPECIFICATIONS

Models

185 & 200 hp	1979 -- 81
5.0 Litre	1982 and on

Float level	17/32"
Float drop	1-3/4"
Pump rod adjustment	1-7/32"
Choke unloader adjustment	5/16"
Choke setting	Index
Initial idle mixture	1-1/2 turns out

4MV CARBURETOR SPECIFICATIONS

Models

210 hp	1968–70
215 hp	1971
225 hp	1972–76
235 hp	1973

Float level	1/4"
Pump rod location	Inner hole
Pump rod adjustment	9/32"
Choke unloader adjustment	0.300"
Choke setting	Index
Initial idle mixture	1 turn out

4MV CARBURETOR SPECIFICATIONS

Models

225 hp	1978
230 hp	1979 -- 81
260 hp	1979 -- 81
3.8 Litre	1982 -- 85
5.0, 5.7 Litre	1982 and on
4.3 Litre	1986 and on

Float level	5/16"
Pump rod location	inner hole
Pump rod adjustrnent	5/16"
Choke unloader adjustinent	15/64"
Choke setting	Index
Initial idle mixture	3-1/2 turns out
Vacuum break adjustrnent	1/8"
Secondary air valve spring tension	1/2 turn after contact

HOLLEY 2V CARBURETOR SPECIFICATIONS

Models

170, 175, & 190 hp	1974–77

Pump lever clearance	0.015" minimum
Choke unloader adustment	0.300"
Choke setting	1 notch lean
Initial idle mixture	1-1/2 turns out
Bore	1-1/2"
Venturi	1-3/16"
Main jet	No. 60
Power valve	No. 50

HOLLEY 4V CARBURETOR SPECIFICATIONS

Models

235 hp	1975–76

Pump lever clearance	0.015" minimum
Choke unloader adjustment	0.300"
Choke setting	1 notch lean
Initial idle mixture	1-1/2 turns out
Bore	1-9/16" primary & secondary
Venturi	1-1/4" primary; 1-5/16" secondary
Main jet	No. 64
Power valve	No. 50
Secondary throttle setting	1/2 turn beyond contact

WOLLEY 4V CARBURETOR SPECIFICATIONS

Models

235,240 & 250 hp	1977–79

Pump lever clearance	
Choke unloader adjustment	0.300"
Choke setting	Index
Initial idle mixture	1-1/2 turns out
Bore	
Primary	1-9/16"
Secondary	1-9/16"
Venturi	
Primary	1-1/4"
Secondary	1-5/16"
Main jet	No. 66
Power valve	No. 25
Secondary throttle setting	1/2 turn beyond contact
Float setting	

Dry: Float parallel to fuel bowl when bowl is inverted.

GMC IN-LINE	100 hp 1972 120 hp 1965-72 120 hp 1976-81 2.5 Litre 1982 & on	100 hp 1973 110 hp 1964 120 hp 1973-75	140 hp 1973-81 3.0 Litre 1981 & on
Type - No. of Cylinder	4-In-line	4-In-line	4-In-line
Valve Arrangement	In head	In head	In Head
Bore and Stroke	3.875" x 3.250"	3.875" x 3.250"	4.000" x 3.60"
Piston Displacement	153 Cubic Inches	153 Cubic Inches	181 Cubic Inches
No. System (front to rear)	1-2-3-4	I-2-3-4	I-2-3-4
Firing Order	I-3-4-2	I-3-4-2	I-3-4-2
Compression Ratio	8.3 to 1	8.5 to I	8.4 to I
Compression Pressure	130 PSI*	130 PSI*	130 PSI*

* At cranking speed with throttle wide open

Water Temperature Control	Thermostat	Thermostat	Thermostat
Thermostat Opens at	160" F	160° F	160° F

Alternator Belt Adjustment. 1/4-3/8" Give with Finger Pressure
Full Throttle Operating Range 4000 - 4400 RPM

These dimensions, fits and adjustments apply to new parts only.

Pistons:			
Type	Flat - Notched head	Flat - Natched head	Flat - Sump head
Clearance Limit at Top Land	.0245" - .0335"	.0345" - .0435"	.0255" - .0345"
Clearance Limit at Skirt	.0005" - .0015"	.005" - .0011"	.0025" - .0035"
Compression Ring Groove Depth	.200" - .208"	.200" - .208"	.209" - .211"
Oil Ring Groove Depth	.194" - .202"	.194" - .202"	.190" - .199"
Piston Rings:			
Compression Ring			
Material	Cast Iron	Cast Alloy Iron	Cast Iron
Type	Taper Face (Upper and Lower)	One Piece Inside Bevel	Radius Face (Upper) Taper Face (Lower)
Coating - Upper Ring	Flash Chrome Plate	Flash Chrome Plate	Molybdenum
Coating - Lower Ring	Wear Resistant	None	Wear Resistant
Width	.0775" - .0780"	.0775" - .0780"	.0775" - .0780"
Gap	.010" - .020"	.010' - .020"	.010"-.020" (Upper) .013"-.025" (Lower)
Oil Ring			
Material	Flat Spring Steel	Steel	Flat Spring Steel
Type	Rail Expander and Spacer	Rail Expander andSpacer	Rail Expander and Spacer
Coating (rail)	Chrome	Chrome	Chrome
Width (Piston Groove)	.188" - .189"	.184" - 188"	.188" - 189"
Gap (Ring)	.015" - 055"	0.015" - 0.055"	0.015" - 0.055"
Width (Ring)	0.150"-0.156"	0.150"-0.156"	0.154"-0.160"
Expanders	Expander-Spacer	Expander-Spacer	Expander-Spacer
Piston Pins:			
Length	2.990" - 3.010"	2.990" - 3.010'	2.990" - 3.010"
Diameter	.9270" - .9273"	.9270" - .9273"	.9270" - .9273"
Clearance in Piston (new)	.00015" - .00025"	.00015" - .00025"	.0003" - .0004"
Wear Limit in Piston	.001"	.001"	.001"
Clearance in Rod	Press .0008" - .0021"	Press .0008" - .0021"	Press .0008" - .0021"
Connecting Rods:			
Material	Drop Forged Steel	Drop Forged Steel	Drop Forged Steel
Length (c/1 to c/1)	5.700"	5.700"	5.700"
Connecting 120 Hp. (1967) through 1972,	.0085" - .0135"		
Material	M400	Durex (M-100)	M400
Effective Length	.797" - .807"	.797" - .807"	.792" - .822"
Clearance	.0007" - .0027"	.0007" - .0028"	.00085" - .00135"
End Play	.008" - .015"	.008" - .014"	.008" - .015"

GMC IN-LINE	100 hp 1972 120 hp 1965-72 120 hp 1976-81 2.5 Litre 1982 & on	100 hp 1973 110 hp 1964 120 hp 1973-75	140 hp 1973-81 3.0 Litre 1981 & on
Crankshaft:			
Material	Nodular Cast iron	Forged Steel	Nodular Cast Iron
End Play	.002" - .006"	.002" - .006"	.002" - .006"
End Thrust Taken By	Rear Main Bearing	Rear Main Bearing	Rear Main Bearing
Crankpin Journal Diameter	1.999" - 2.000"	1.999" - 2.000"	2.099" - 2.100"
Main Bearing*			
Type	Precision Removable	Precision Removable	Precision Removable
Journal Diameter	2.2983" - 2.2993"	2.2983" - 2.2993"	2.2983" - 2.2993"
Length	.822" (rear) .802" (others)	1.000" (rear) .802" (others)	.822" (rear) .830" (others)
Clearance	.0003" - .0029"	.0003" - .0029"	.0003" - .0029"

* NOTE: On the 1964 110 hp.

Main Bearing Journal Diameter .... 2.2978" - 2.2988"

Main Bearing Clearance .... .0008" - .0024" (rear)
.0003" - .0019" (others)

Camshaft:			
Camshaft Bearing			
Material	Steel Backed Babbit	Steel Backed Babbit	Steel Backed Babbit
Journal Diameter x Bearing Length	1.8687" x .860"	1.8687" x .860"	1.8687" x .860"
Bearing Outer Diameter - Nos. 1 and 2	1.999" - 2.0011"	1.999" - 2.1"	1.999" - 2.1"
Bearing Outer Diameter - No. 3	2.009" - 2.011"	2.009" - 2.011"	2.009" - 2.011"
Type of Drive	Gear	Gear	Gear
Crankshaft Gear Material	Nodular Cast Iron	Steel	Nodular Cast Iron
Camshaft Gear Material	Bakelite and Fabric Composition	Fiber	Bakelite and Fabric Compostion
Valve Systems:			
Lifter Type	Hydraulic	Hydraulic	Hydraulic
Rocker Arm Ratio	1.75 to 1	1.75 to I	1.75 to I
Valve Lash Adjustment —			
Intake and Exhaust (hot)	1 Turn Down From "Zero Lash" Point	1 Turn Down From "Zero Lash" Point	1 Turn Down From "Zero Lash" Point
Valve Face Angle	45"	45°	45'
Valve Seat Angle	46"	46°	46°
Stem to Guide Clearance - Intake Valve	.0010" - .0027"	.0010" - .0027"	.0010" - .0027"
Stem to Guide Clearance - Exhaust Valve	.0015" - .0032"	.0015" - .0032"	.0010" - .0027"
Recommended Valve Seat Width			
Intake	1/32" to 1/16"	1/32" to 1/16"	1/32" to 1/16"
Exhaust	1/16" to 3/32"	1/16" to 3/32"	1/16" to 3/32"
Outer Valve Spring Free Length	2.08"	2.08"	2.08"
Outer Valve Spring Pressure			
Lb. @ In.	78-86 @ 1.66"	78-86 @ 1.66"	78-86 @ 1.66"
Lb. @ In.	170-180 @ 1.26"	170-180 @ 1.26"	170-180 @ 1.26"
NOTE: On the 1965 120 Hp., the springs are different:			
Lb. @ In.	56-64 @ 1.66"	—	—
Lb. @ In.	170-184 @ 1.33"	—	—
Outer valve spring free length	1.90"	—	—
Engine Lubrication:			
Type Oil Pump	Gear	Gear	Gear
Normal Oil Pressure	40 PSI @ 2000 RPM	35 PSI @ 2000 RPM	40 PSI @ 2000 RPM
Oil Filter - Make and Type	AC Type PF-25 or PER-49	AC Type PF-12 or	AC Type PF-25 or PER-49
Crankshaft Capacity - Quarts	3-1/2 (4 with new filter)	3-1/2 (4 with new filter)	3-1/2 (4 with new filter)
Oil Grade Recommended			
32 Degrees F. and Above	SAE 30	SAE 30	SAE 30
0 Degrees F. to 32 Degrees F.	SAE 20W	SAE 20W	SAE 20W
Below 0 Degrees F.	SAE 10W	SAE 10W	SAE 10W

KAISER V6 (GMC V6)	155 hp 1967-72	150 hp 1965-66	150 hp 1964
Type - No. of Cylinders	90" V-6	90° V-6	90" V-6
Valve Arrangement	In Head	In Head	In Head
Bore and Stroke	3.750" x 3.400"	3.750" x 3.400"	3.750" x 3.400"
Piston Displacement	225 Cubic Inches	225 Cubic Inches	225 Cubic Inches
Compression Ratio	9.0 to 1	9.0 to I	9.0 to I
Octane Requirement	84 Motor/93 Research	84 Motor/93 Research	84 Motor/93 Research
Cylinder Numbers - Front to Rear			
Starboard Bank	2-4-6	2-4-6	2-4-6
Port Bank	1-3-5	1-3-5	1-3-5
Firing Order	1-6-5-4-3-2	1-6-5-4-3-2	1-6-5-4-3-2
Oiling System Type	Forced Feed	Forced Feed	Forced Feed
Type of Lubrication To:			
Crankshaft Bearings	Pressure	Pressure	Pressure
Camshaft Bearings	Pressure	Pressure	Pressure
Connecting Rods	Pressure	Pressure	Pressure
Piston Pins	Splash	Splash	Splash
Cylinder Walls	Splash and Nozzle	Splash and Nozzle	Splash and Nozzle
Timing Chain	Splash and Nozzle	Splash and Nozzle	Splash and Nozzle
Normal Oil Pressure	40 Pounds @ 2400 RPM	30 Pounds @ 2400 RPM	30 Pounds @ 2400 RPM
Oil Reservoir Capacity - Quarts	4 (5 with dry filter)	4 (5 with dry filter)	4 (5 with dry filter)
Oil Filter Make and Type	AC Type PF-7 or Purolator PER-5	AC Type PF-10	AC Type PF-7
Water Temperature Control	Thermostat	Thermostat	Thermostat
Thermostat Opens at	160° F.	160° F.	160° F.

These dimensions, fits and adjustments apply to new parts only.

Pistons:			
Material	Cast Aluminum Alloy	Cast Aluminum Alloy	Aluminum Alloy
Type	Divorced Skirt		
Finish	Cam Ground		
Piston Pin Offset	.040"	.040"	.040"
Piston Clearance Limits			
Top Land	.0265" - ,0345"	.0215" - .0295"	NA
Skirt - Top	.0011" - .0017"	.0005" - .0011"	NA
Skirt - Bottom	.0011" - .0027"	.0005" - .0021"	NA
Ring Groove Depth			
#1 - Compression Ring	.1855" - .1930"	.1880" - .1955"	NA
#2 - Compression Ring	.188" - .1955"	.1905" - .1980"	NA
#3 - Oil Ring	.188" - .1955"	.1905" - .1980"	NA
Piston Rings:			
Compression Rings, Material and Surface Treatment			
Number 1	Cast Iron - Chrome Plated	Iron - Chrome Plated	Iron - Chrome Plated
Number 2	Cast Iron - Lubrited	Iron - Lubrited	Lubrited
Ring Width			
#1 - Compression Ring	.0785" - .0789"	.0785" - .0790"	NA
#2 - Compression Ring	.0770" - .0780"	.0770" - .0780"	NA
#3 - Oil Ring	.181" - .187"	.181" - .187	NA
Compression Ring Gap in Bore	.010" - .020"	.010" - .020"	.010" - .020"
Oil Ring - Type	Steel Rail With Spacer	Steel Rail With Spacer	Steel Rail With Spacer
Oil Ring Expander	Steel Humped Type	Steel Humped Type	Steel Humped Type
Oil Ring Gap in Bore	.015" - .035"	.015" - .035"	.015" - .035"

KAISER V6 (GMC V6)	155 hp 1967-72	150 hp 1965-66	150 hp 1964
Piston Pins:			
Length	3.060″	3.060″	2.960″
Diameter	.9394″ - .9397″	.9394″ - .9397″	.9394″ - .9397″
Fit in Piston	,00005″ - .0001″	.00005″ - .0001″	.0001″
Fit in Connecting Rod	.0007″ - .0015″ Press	.0007″ - .0015″ Press	.0007″ - .0015″ Press
Connecting Rods:			
Material	Pearlitic Malleable Iron	Pearlitic Malleable Iron	NA
Bearings - Type	Removable Steel Backed	Removable Steel Backed	4 Replaceable Liners
Bearings - Material	M/400 Aluminum	M/400 Aluminum	Durex 100A
Bearing Length	.737″	.737	.820″
Bearing Clearance	.0002″ - .0023″	.0002″ - .0023″	NA
End Play	.006″ - .014″	.006″ - .014″	.005″ - .012″
Crankshaft:			
Material	Nodular Iron	Pearlitic Malleable Iron	NA
Main Bearing Journal Diameter	2.4995"	2.4995"	2.2992″
Crankpin Journal Diameter	2.000"	2.000″	2.000″
Bearings - No. and Type	4 - Replaceable Liners	4 - Replaceable Liners	4 Steel Backed Babbit
Bearings - Material	M-400 Aluminum (#1, #2, #3)	M/400 Aluminum (#1, #2, #3)	NA
	M-100 Durex (#4 Lower)	Durex 100A (#4)	NA
End Thrust Taken By	No. 2 Bearing	No. 2 Bearing	No. 2 Bearing
End Play at Thrust Bearing	.004″ - .008″	.004″ - .008″	.004″ - .008″
Main Bearing Effective Length			
Number 1	.864″	.864″	.864″
Number 2	1.057″	1.057″	1.057″
Number 3	.864″	.864″	.864″
Number 4	.864″	.864″	.864″
Main Bearing Clearance	.0004" - .0015″	.0004″ - .0018″	.0005″ - .0021″
Camshaft:			
Material	Cast Alloy Iron	Cast Alloy Iron	Cast Alloy Iron
Type of Drive	Chain	Chain	Chain
No. of Links	54	54	NA
Crankshaft Sprocket	Sintered Iron	Sintered Iron	NA
Camshaft Sprocket	Nylon Coated Aluminum	Nylon Coated Aluminum	NA
Bearings - Number and Type	4 - Steel Backed Babbit	4 - Steel Backed Babbit	NA
Bearing Journal Diameter			
Number 1	1.755" - 1.756"	1.755″ - 1.756"	1.755" - 1.756″
Number 2	1.725″ - 1.726″	1.725" - 1.726″	1.725″ - 1.726″
Number 3	1.695" - 1.696"	1.695" - 1.696"	1.695" - 1.696″
Number 4	1.665" - 1.666"	1.665" - 1.666"	1.665" - 1.666″
Journal clearance in Bearings	.0015″ - .004″	.0015″ - .004″	.0005″ - .0035″
Valve System:			
Lifter Type	Hydraulic	Hydraulic	Hydraulic
Lifter Diameter	.8422″ - .8427″	.8422″ - .8427″	.8422″ - .8427″
Lifter Clearance	.0015″ - .003″	.0015″ - .003″	.0015″ - .003″
Lifter Leakdown Rate, in Test Fixture	12 to 60 Seconds	12 to 60 Seconds	12 to 60 Seconds
Rocker Arm Ratio	1.6 to 1	1.6 to I	1.6 to I
Rocker Arm Clearance on Shaft	.0017″ - .0032″	.0017″ - .0032″	.0017″ - .0032″
Valve Head Diameter, Inlet	1.625"	1.625"	1.625″
Valve Head Diameter, Exhaust	1.375"	1.375"	1.3125"
Valve seat Angle, Inlet and Exhaust	45°	45°	45°
Valve Seat Width, Inlet and Exhaust	1/16"	1/16″	1/16"

KAISER V6 (GMC V6)	155 hp 1967-72	150 hp 1965-66	150 hp 1964
Valve Stem Diameter			
Inlet	.3412" Top - .3407" Bottom	.3412" Top - .3407" Bottom	.3412" Top - .3407" Bottom
Exhaust	.3407" Top .3402" Bottom	.3407" Top - .3402" Bottom	.3407" Top - .3402" Bottom
Stem to Guide Clearance			
Inlet	.0012" - .0032"	Top .001" - .003" Bottom .0015" - .0035"	Top .001" - .003" Bottom .0015" - .0035"
Exhaust	Top .0015" - .0035" Bottom .002" - .004"	Top .0015" - .0035" Bottom .002" - .004"	Top .0015" - .0035" Bottom .002" - .004"
Valve Spring Type	Single Helical	Single Helical	Single Helical
Valve Spring Pressure			
Lb. @ In.	64 + 5 @ 1.727"	64 @ 1.640"	64 @ 1.640"
Lb. @ In.	164 + 5 @ 1.327"	168 @ I.260"	168 @ I.260"
Alternator Belt Adjustment	1/4-3/8" Give with Finger Pressure	60 + 5 With Gauge J-7316	60 + 5 With Gauge J-7316

GMC *SIX-CYLINDER EN-LINE* 1972-76

Type - No. of Cylinder. . . . . 6 - In-line
Valve Arrangement . . . . In head
Bore and Stroke . . . . 3.875" x 3.530"
Piston Displacement . . . . 250 Cubic Inches
No. System (front to rear). 1-2-3-4-5-6
Firing Order 1-5-3-6-2-4
Compression Ratio 8.02:1
Compression Pressure . . . . 130 PSI*
Octane Requirement . . . . 84 Motor/93 Research
Water Temperature Control . . . . Thermostat
Thermostat Opens at . . . . 160° F.
Alternator Belt Adjustment. . . . . . 1/4-3/8" Give With Finger Pressure

* At cranking speed with throttle wide open

2. Engine Dimensions, Fits and Adjustments

Pistons:
Type . . . . Flat - Notched head
Clearance Limit - Production . . . . .0005" - .0015"
- Service. . . . . .0025" Max.

Piston Rings:
Compression Rings
Production Groove Clearance - Top . . . . .0012" - .0027"
- 2nd . . . . .0012" - .0032"
Service Groove Clearance . . . . Hi Limit Production +.001"
Gap, Production - Top. . . . . .010" - .020"
- 2nd . . . . .010" - .020"
Gap, Service . . . . Hi Limit Production +.010"

Oil Ring
Production Groove Clearance . . . . .005" Max.
Service Groove Clearance . . . . Hi Limit Production +.001"
Gap - Production . . . . .015" - .0055"
Gap - Service. . . . . Hi Limit Production +.010"

GMC SIX-CYLINDER IN-LINE 1972-76

Piston Pins:	
Diameter	.9270" - .9273"
Clearance in Piston (new)	.00015" - .00025"
Wear Limit in Piston	.001" Max.
Clearance in Rod	Press .0008" - .0016"
Connecting Rods:	
Clearance	.0007" - .0027"
Side Clearance	.009" - .014"
Crankshaft:	
End Play	.002" - .006"
Crankpin Journal Diameter	1.999" - 2.000"
Crankpin Taper - Production	.0003" Max.
- Service	.001" Max.
Out of Round - Production	.0002" Max.
- Service	.001" Max.
Main Bearing	
Type	Precision Removable
Journal Diameter	2.2983" - 2.2993"
Taper - Production	.0002" Max.
- Service	.001" Max.
Out of Round - Production	.0002" Max.
- Service	.001" Max.
Clearance - Production	.0003" - .0029"
- Service	#1-.002" Max. All Others .0035" Max.
Camshaft:	
Journal Diameter	1.8682 - 1.8692
Camshaft Runout	.0015" Max.
Lobe Lift - Exhaust, Intake	.2297 ± .002"
Valve Systems:	
Lifter Type	Hydraulic
Rocker Arm Ratio	1.75 to 1
Valve Lash Adjustment - Intake and Exhaust (hot)	1 Turn Down From "Zero Lash" Point
Valve Face Angle	45°
Valve Seat Angle	46°
Stem to Guide Clearance - Intake Valve - Production	.0010" - .0027"
Stem to Guide Clearance - Exhaust Valve - Production	.0015" - .0032"
Service	Hi Limit Production +.001" Intake - +.002" Exhaust
Recommended Valve Seat Width	
Intake	1/32" to 1/16"
Exhaust	1/16" to 3/32"
Seat Runout - Intake and Exhaust	.002" Max.
Outer Valve Spring Free Length	1.90"
Installed Height ±1/32"	1-21/32"
Outer Valve Spring Pressure	
Lb.@ In. - Closed	55-64 @ 1.66"
Lb.@ In. - Open	180-192 @ 1.27"
Engine Lubrication:	
Type Oil Pump	Gear
Normal Oil Pressure	35 PSI @ 2000 RPM
Oil Filter - Make and Type	AC Type PF-25 or Purolator PER-49
Crankcase Capacity - Quarts	4 (4.5 with new filter)
Oil Grade Recommended	
32 Degrees F. and Above	SAE 30
0 Degrees F. to 32 Degrees F.	SAE 20W
Below 0 Degrees F.	SAE 10W

GMC V8	200 hp 1966-67	185 hp 1967-68 210 hp 1968
Type - No. of Cylinders	90° V-8	90° V-8
Valve Arrangement	In Head	In Head
Bore and Stroke	3.750" x 3.400"	3.875" x 3.000"
Piston Displacement	300 Cubic Inches	283 Cubic Inches
Compression Pressure	150 psi*	150 psi*
* At cranking speed with throttle wide open	200 hp. 1965 110 psi*	
Compression Ratio	9.0 to 1	9.0 to 1
Octane Requirement	84 Motor/93 Research	84 Motor/93 Research
Cylinder Numbers - Front to Rear		
Starboard Bank	2-4-6-8	2-4-6-8
Port Bank	1-3-5-7	1-3-5-7
Firing Order	I-8-4-3-6-5-7-2	I-8-4-3-6-5-7-2
Engine Manifold Vacuum @ Idle	14 Inches Minimum	NA
Oiling System Type	Forced Feed	Forced Feed
Type of Lubrication To:		
Crankshaft Bearings	Pressure	Pressure
Camshaft Bearings	Pressure	Pressure
Connecting Rods	Pressure	Pressure
Piston Pins	Splash	Splash
Cylinder Walls	Splash and Nozzle	Splash and Nozzle
Timing Chain	Splash and Nozzle	Splash and Nozzle
Normal Oil Pressure	33 Pounds @ 2400 RPM	35 Pounds @ 2400 RPM
NOTE: 1967 200 hp. 40 Pounds @ 2400 rpms		
Oil Reservoir Capacity - Quarts	4 (5 with dry filter)	4 (5 with dry filter)
Oil Filter Make and Type	AC Type PF-10	AC-PF 25
Water Temperature Control	Thermostat	Thermostat
Thermostat Opens at	160° F.	160° F.

These dimensions, fits and adjustments apply to new parts only

Pistons:		
Material and Surface Treatment Cast Aluminum Alloy - Tin Plated		
Piston Pin Offset	.040″	NA
Piston Clearance Limits		
Top Land	.0265″ - .0345″	.0345″ - .0435″
Skirt - Top	.0005″ - .OOll″	.0005″ - .0011″
Skirt - Bottom	.0005″ - .0021″	NA
	NOTE: 1967,200 hp. Skirt Top .0011″ - .0017″ Skirt bottom .0011″ - .0017″	
Ring Groove Depth		
#1 - Compression Ring	.1855″ - .1930″	.200″ - .208″
#2 - Compression Ring	.188″ - .1955″	.200″ - .208″
#3 - Oil Ring	.188″ - .1955″	.194″ - .202″
Piston Rings:		
Compression Rings, Material and Surface Treatment		
Number 1	Cast Iron - Chrome Plated	NA
Number 2	Cast Iron - Lubrited	NA
Ring Width		
#1 - Compression Ring	.0785″ - .0790″	.0775″ - .0780″
#2 - Compression Ring	.0770″ - .0780″	.0775″ - .0780″
#3 - Oil Ring	.181″ - .187″	.184″ - .188″
Compression Ring Gap in Bore	.010″ - .020″	.010″ - .020″

GMC V8	200 hp 1966-67	185 hp 1967-68 210 hp 1968
Oil Ring -Type	Dual Steel Rail With Spacer	NA
Oil Ring Expander	Steel Humped Type	NA
Oil Ring Gap in Bore	.015" - .035"	.015" - .055"
Piston Pins:		
Length	3.060"	2.990" - 3.010"
Diameter	.9394" - .9397"	.9270" - .9273"
Fit in Piston	.0001" - .0004" NOTE: 1967 200 hp. .0001" - .0005"	.00015" - .00025"
Fit in Connecting Rod	.0007" - .0015" Press	Press .0008" - .0016"
Connecting Rods:		
Material	Pearlitic Malleable Iron	NA
Bearings - Type	Removable Steel Backed	NA
Bearings - Material	M/400 Aluminum	NA
Bearing Length	.737"	NA
Bearing Clearance	.0020" - .0023"	.0007" - .0027"
End Play	.006" - .014" (total both rods)	.009" - .013"
Crankshaft:		
Material	Pearlitic Malleable Iron	Precision Removable
Main Bearing JournalDiameter	2.4995"	No. 1 - 2.2984" - 2.2993" Nos. 2. 3.4 - 2.2983" - 2.2993" No. 5 - 2.2978" - 2.2988"
Crankin Journal Diameter	2.000"	1.999" - 2.000"
Bearings - No. and Type	5 - Replaceable Steel Backed	NA
Bearings - Material	M-400 Aluminum (#1, #2, #3, #4) M-100 Durex (#5)	NA
End Thrust Taken By	No. 3 Bearing	Rear Main Bearing
End Play at Thrust Bearing	.004" - .008"	.003" - .011"
Main Bearing Effective Length		
Number 1	.864"	NA
Number 2	.864"	NA
Number 3	I.057"	NA
Number 4	.864"	NA
Number 5	.864"	NA
Main Bearing Clearance	.0004" - .0015"	No. I - .0008" - .0020" Nos. 2, 3, 4 - .0018" - .0020" No. 5 - .0010" - .0038"
Camshaft:		
Material	Cast Alloy Iron	NA
Type of Drive	Chain	NA
No. of Links	54	NA
Crankshaft Sprocket	Sintered Iron	NA
Camshaft Sprocket	Nylon Coated Aluminum	NA
Bearings - Number and Type	5 - Steel Backed Babbit	NA
Bearing JournalDiameter		
Number 1	1.785" - 1.786"	1.8682"-1.8692"
Number 2	1.755" - 1.756"	1.8682"
Number 3	1.725" - 1.726"	1.8682"
Number 4	1.695" - 1.696"	1.8682"
Number 5	1.665" - 1.666"	I.8682"
JournalClearance in Bearings	.0005" - .0025" (#1) .0005"-.0035" (#2, #3, #4, #5)	NA
Valve System:		
Lifter Type	Hydraulic	Hydraulic
Lifter Diameter	.8422" - .8427"	NA

GMC V8	200 hp 1966-67	185 hp 1967-68 210 hp 1968
Lifter Clearance	.0015" - .003"	NA
Lifter Leakdown Rate, in Test Fixture	12 to 60 Seconds	NA
Rocker Arm Ratio	1.6 to 1	1.5 to 1
Rocker Arm Clearance on Shaft	.0017" - .0032"	NA
Valve Head Diameter, Inlet	1.8125"	NA
Valve Head Diameter, Exhaust	1.375"	NA
Valve Seat Angle, inlet and Exhaust	4	45"
Valve Seat Width, Inlet	NA	1/32" to 1/16"
and Exhaust	1/16"	1/16" to 3/32"
Valve Lash Adjustment - intake and Exhaust (Hot)	NA	1 Turn Down From "Zero Lash" Point
Valve Stem Diameter		
Inlet	.3415" Top - .3412" Bottom	NA
Exhaust	.3402" Top - .3412" Bottom	NA
Stem to Guide Clearance		
Inlet	.0012" - .0032" W/.0003" Max. Taper	.0010" - .0027"
Exhaust	Top .0015" - .0035" Bottom .0021" - .004"	
Valve Spring Type	Sine Helical	NA
Valve Spring Pressure		
Lb. @ In.	64 ± 5 @ 1.727"	78-86 @ 1.66"
Lb. @ In.	164 ± 5 @ 1.340"	170-180 @ 1.260"
Alternator Belt Adjustment	60 ± 5 With Cage J-7316	75 ± 5 with gage J-7316

GMC V8	225 hp 1972-76 245 hp 1972-75	210 hp 1969-70 215 hp 1971 235 hp 1971
Type - No. of Cylinders	90" - V-8	90° - V-8
Valve Arrangement	In head	In head
Bore and Stroke	3.875" x 3.250"	3.875" x 3.250"
Piston Displacement	307 Cubic Inches	307 Cubic Inches
Cylinder Numbers - Front to Rear		
Starboard Bank	2-4-6-8	2-4-6-8
Port Bank	1-3-5-7	1-3-5-7
Firing Order	1-8-4-3-6-5-7-2	1-8-4-3-6-5-7-2
Compression Ratio	8.2 to 1	8.5 to 1
Compression Pressure	165 PSI*	165 PSI*
* At cranking speed with throttle wide open.		
Octane Requirement	84 Motor/93 Research	84 Motor/93 Research
Water Temperature Control	Thermostat	Thermostat
Thermostat Opens at	160° F.	[illegible] F.
Alternator Belt Adjustment	1/4-3/8" give with finger pressure	1/4-1/2" give with finger pressure
These dimensions, fits and adjustments apply to new parts only.		
Pistons:		
Clearance Limit at Top Land	.0029" - .0036"	.0345" - .0435"
Clearance Limit at Top Land 1974, 225 & 245 Hp.	.0235" - .0325"	
Clearance Limit at Skirt	.0005" - .0011"	.0005" - .0011"
Compression Ring Groove Depth	.2025" - .2035"	.200" - .208"

GMC V8	225hp 1972-76 245 hp 1972-75	210 hp 1969-70 215 hp 1971 235 hp 1971
Oil Ring Groove Depth	.1965″ - .1975″	.194″ - .202″
Piston Rings:		
Compression Ring		
Width	.0775″ - .0780″	.0775″ - .0780″
Gap	.010″ - .020″	.010″ - .020″
Oil Ring		
Width of Rails	.028″ Max	N A
Width of Spacer	.184″ - .188″	N A
Width of Spacer	1974-225-245hp .177″ - .182″	
Width	NA	.184" - .188″
Gap	NA	.015″ - .055″
Piston Pins:		
Length	2.990" - 3.010"	2.990" - 3.010"
Diameter	.9270″ - .9273″	.9270″ - .9273″
Clearance in Piston (new)	.00015″ - .00025″	.00015″ - .00025″
Wear Limit in Piston	.001″	.001″
Clearance in Rod	Press .0008″ - .0016″	Press .0008″ - .0016″
Connecting Rods:		
Connecting Rod Bearing		
Clearance	.0011″ - .0032″	.0007″ - .0027″
End Play	.008″ - .014″	.009″ - .013″
Crankshaft:		
End Play	.002″ - .006″	.003″ - .011″
End Thrust Taken By	No. 5 Main Bearing	Rear Main Bearing
Crankpin Journal Diameter	2.100"	1.999″-2.000″
Main Bearing		
Type	Precision Removable	Precision Removable
Journal Diameter	2.4490″	No. 1, 2.2984"-2.2993" Nos. 2, 3, 4 - 2.2983" - 2.2993" No. 5 - 2.2978" - 2.2988″
Clearance	No. 1-4 - .0006″ - .0018″ No. 5 - .0017" - .0033″	No. 1 - .0008″ - .0020″ Nos. 2, 3, 4 - .0018″ - .0020″ No. 5 - ,0010"- .0036″
Camshaft:		
Cast-In Identification No. 6930	225 HP	215 HP
No. 3125	245 HP	235 HP
Camshaft Bearing Journal		
Diameter & Length	1.8682" x 1.8962"	1.8682″ x 1.8692"
Type of Drive	Double Row Roller Chain	Chain
Valve Systems:		
Lifter Type	Hydraulic	Hydraulic
Rocker Arm Ratio	1.5 to I	1.5 to I
Valve Lash Adjustment -		
Intake and Exhaust (hot)	3/4 to 1 Turn Down From "Zero Lash" Point	3/4 to 1 Turn Down From "Zero Lash" Point
Valve Face Angle	4	45"
Valve Seat Angle	46°	46°
Stem to Guide Clearance - Intake	.0010″ - .0027″	.0010″ - .0027″
Stem to Guide Clearance - Exhaust	.0010″ - .0027″ top .0020″ - .0037″ bottom	.0010″ - .0027″
Recommended Valve Seat Width		
Intake	1/32″ to 1/16″	1/32" to 1/16″
Exhaust	1/16" to 3/32"	1/16″ to 3/32"
Outer Valve Spring Free Length	2.03″	2.08"

GMC V8	225hp 1972-76 245 hp 1972-75	210 hp 1969-70 215 hp 1971 235 hp 1971
Outer Valve Spring Pressure		
Lb. @ In. Closed	76-84 @ 1.70"	78-86 @ 1.66"
Lb. @ In. Open	194-206 @ 1.25"	170-180 @ 1.260"
Engine Lubrication:		
Type Oil Pump	Gear	Gear
Oil Filter - Type	Purolator PER-40 or AC PF-35	Purolator PER-40 or AC PF-29
Crankcase Capacity - Quarts	5 (6 with new filter)	5 (6 with new filter)
Oil Grade Recommended		
32 Degrees F. and Above	SAE 30	SAE 30
0 Degrees F. to 32 Degrees F	SAE 20W	SAE 20W
0 Degrees F.	SAE 10W	SAE 10W
Fuel Grade Recommendation	93 Octane Leaded, 91 Octane Low Lead	

We recommend OMC PREMIUM 4 CYCLE MOTOR OIL specially formulated for heavy duty marine use. Ideal for OMC Stern Drive and Inboard engines. Provides better anti-wear qualities, especially during long high speed operation. Neutralizes acids caused in all internal combustion engines, offers superior corrosion protection. Formulated to offer better resistance to oxidation and high temperature sludge formation.

GMC V8 ENGINES	305 CID 185 hp 1978-79 200 hp 1979 225 hp 1978 230 hp 1979

ENGINE BLOCK

GENERAL SPECIFICATIONS

Type - No. of cylinders	90° - V-8
Valve arrangement	In head
Bore & stroke	3.736 x 3.480
Displacement cu. in.	305
Cylinder number, front to rear	
Starboard bank	2-4-6-8
Port bank	1-3-5-7
Firing order	1-8-4-3-6-5-7-2
Compression ratio	8.4: 1
Compression pressure	125 psi (1)
Water temp. control	Thermostat
Thermostat opens at	160° F
Alternator belt adjustment give with finger pressure	1/4-3/8"
Full throttle operating range	4000-4400 rpm

FITS AND ADJUSTMENTS

Pistons	
Production clearance	.00007-.0017
Service clearance	.0027 max.
Piston rings - compression	
Groove clearance	
Production - top	.0012-.0032
Production - 2nd	.0012-.0027
Service - hi limit	+.001
Gap	
Top	.010-.020
2nd	.010-.025
Service - hi limit	+.010
Piston rings - oil	
Groove clearance	.005 max.
Service	
Production plus	.001
Gap	
Production	.015-.055
Service	
Production plus	.010
Piston pins	
Diameter	.09270-.09273

GMC V8 ENGINES	305 CID 200 hp 1979 225 hp 1978 230 hp 1979
Clearance	
Production	.00025-.00035
Service	.001 max.
Fit in rod	
Interference	.008-.0016
Connecting rods	
Bearing clearance	
Production	.0013-.0035
Service	.0035 max.
Side-clearance	.008-.014
Crankshaft	
End play	.002-.006
Main journal diameter	
No. 1	2.4484-2.4493
No. 2, 3, 4	2.448 1-2.4490
No. 5	2.4479-2.4488
Taper	
Production	.0002 max.
Service	.001 max.
Out-of-round	
Production	.0002
Service	.001 max.
Main bearing clearance Production	
No. 1	.0019-.0031
No. 2, 3, 4	.0013-.0025
No. 5	.0023-.0033
Main bearing clearance Service	
No. 1	.002 max.
All others	.0035 max.
Crankpin diameter	2.099-2.100
Taper	
Production	.0003 max.
Service	.001 max.
Out-of-round	
Production	.0002 max.
Service	.001 max.
Camshaft	
Cast-in ident. No.	2944
Bearing journal dia.	1.8682- 1.8692
Runout	.015 max.
Type of drive	Double row roller chain

GMC V8 ENGINES

305 CID
200 hp 1979
225 hp 1978
230 hp 1979

CYLINDER HEAD

Valve system	
Lifter type	Hydraulic
Rocker arm ratio	1.5: 1
Valve lash adjustment	
Intake & exhaust	3/4 turn down from "zero lash" point
Valve face angle	45°
Valve seat angle	46°
Stem to guide clearance	
Intake & exhaust	.0010-.0027
Exhaust, service	.0027 + .002
Intake, service	.0027 + .001
Valve seat width	
Intake	1/32-1116
Exhaust	1/16-1/32
Valve spring	
Free length	2.03
Pressure ft-lbs	
Closed	76-84 @ 1.70
Open	194-206 @ 1.25

GMC V8 ENGINES

305 CID
200 hp 1979
225 hp 1978
230 hp 1979

ENGINE LUBRICATION

Oil pump type	Gear
Crankcase capacity	
225 and 230 hp	Approx. 5 qts
New filter, add	1 qt
185 and 200 hp	Approx. 4 qts
New filter, add	1 qt
Oil filter	
OMC Part No.	173233
Purolator	PER-40
AC	PF35
Oil grade recommended	
32 degrees F. & above	SAE 30
0 degrees F. to 32 F	SAE 20W
Below 0 degrees F.	SAE 10W

SPECIFICATIONS

GMC V8 ENGINES	305 CID 185 hp 1980-81 200 hp 1980-81 230 hp 1980-81 350 CID 1979-81 5.0 Litre 1982 & on 5.7 Litre 1982 & on
ENGINE BLOCK	
GENERAL SPECIFICATIONS	
Type - No. of cylinders	90° - V-8
Valve arrangement	In head
Bore & stroke	
305 CID	3.736 x 3.480
350 CID	4.000 x 3.480
Displacement	
305 CID	305 cu. in.
350 CID	350 cu. in.
Cylinder number, front to rear	
Starboard bank	2-4-6-8
Port bank	1-3-5-7
Firing order	1-8-4-3-6-5-7-2
Compression ratio	
305 CID	8.4:1
350 CID	9.0:1
Compression pressure	
305 CID	125 psi
350 CID	135 psi
Water temp. control	Thermostat
Thermostat opens at	160° F
Alternator belt adjustmet, give with finger pressure	1/4-3/8"
Full throttle operating range -- 185 hp	4000-4400 rpm
200, 230, & 260 hp	4200-4600 rpm
5.0 & 5.7 Litre	4200-4600
FITS AND ADJUSTMENTS	
Pistons	
Production clearance	.00007-.0017
Service clearance	.0027 max.
Piston rings - compression	
Groove clearance	
Production - top	.0012-.0032
Production - 2nd	.0012-.0032
Service - hi limit	+.001
Gap	
Top	.010-.020
2nd	.010-.025
Service - hi limit	+.010
Piston rings - oil	
Groove clearance	.005 max.
5.0 & 5.7 Litre	.002-.007 max.

GMC V8 ENGINES	305 CID 185 hp 1980-81 200 hp 1980-81 230 hp 1980-81 350 CID 1979-81 5.0 Litre 1982 & on 5.7 Litre 1982 & on
Service	
Production plus	.001
Gap	
Production	.015-.055
Service	
Production plus	.010
Piston pins	
Diameter	.09270-.09273
Clearance	
Production	.00025-.00035
Service	.001 max.
Fit in rod	
Interference	.008-.0016
Connecting rods	
Bearing clearance	
Production	.0013-.0035
Service	.0035 max.
Side clearance	.008-.014
Crankshaft	
End play	.002-.006
Main journal diameter	
No. 1	2.4484-2.4493
No. 2, 3, 4	2.4481-2.4490
No. 5	2.4479-2.4488
Taper	
Production	.0002 max.
Service	.001 max.
Out-of-round	
Production	.0002
Service	.001 max.
Main bearing clearance Production	
No. 1	.0008-.0020
No. 2, 3, & 4	.0011-.0023
No. 5	.0017-.0032
Main bearing clearance Service	
No. 1	.0010-.0015
No. 2, 3, & 4	.0010-.0023
5.0 & 5.7 Litre	.0010-.0025
No. 5	.0017-.0032
5.0 & 5.7 Litre	.0025-.0035

SPECIFICATIONS

GMC V8 ENGINES	305 CID 185 hp 1980-81 200 hp 1980-81 230 hp 1980-81 350 CID 1979-81 5.0 Litre 1982 & on 5.7 Litre 1982 & on
Crankpin diameter	2.0986-2.0998
Taper	
Production	.005 max.
Service	.001 max.
Out-of-round	
Production	.0005 max.
Service	
All models	.001 max.
Camshaft	
Cast-in ident. No.	2944
Bearing journal dia.	1.8682-1.8692
Runout	.0015 max.
Type of drive	Double row roller chain
CYLINDER HEAD	
Valve system	
Lifter type	Hydraulic
Rocker arm ratio	1.5:1
Valve lash adjustment	
Intake & exhaust	3/4 turn down from "zero lash" point
Valve face angle	45°
Valve seat angle	46°
Stem to guide clearance	
Intake & exhaust	.0010-.0027
Exhaust, service	.0027 + .002
Intake, service	.0027 + .001

GMC V8 ENGINES	305 CID 185 hp 1980-81 200 hp 1980-81 230 hp 1980-81 350 CID 1979-81 5.0 Litre 1982 & on 5.7 Litre 1982 & on
Valve seat width	
Intake	1/32-1116
Exhaust	1/16-3/32
Valve spring	
Free length	2.03
Pressure ft-lbs	
Closed	76-84 @ 1.70
Open	194-206 @ 1.25
ENGINE LUBRICATION	
Oil pump type	Gear
Crankcase capacity	
185 and 200 hp	Approx. 4 qts
New filter, add	1 qt
230, 260 hp; 5.0 & 5.7 Litre	5 qts
New filter, add	1 qt.
Oil filter	
OMC Part No.	173233
Purolator	PER-40
AC	PF35
Oil grade recommended	
32 degrees F. & above	SAE 30
0 degrees F. to 32 F	SAE 20W
Below 0 degrees F.	SAE 10W

SPECIFICATIONS

GMC V-6 ENGINES	229 CID 3.8 Litre 1981-82
ENGINE BLOCK	
GENERAL SPECLFICATIONS	
Type - No. of cylinder	90^{o} - V-6
Valve arrangement	In head
Bore & stroke	3.800 x 3.400
Displacement cu. in.	229
Litres	3.8
Cylinder number, front to rear	
Starboard bank	2-4-6
Port bank	1-3-5
Firing order	1-6-5-4-3-2
Compression ratio	8.0: 1
Compression pressure	130 psi (1)
Water temp. control	Thermostat
Thermostat opens at	160^{o} F
Alternator belt adjustmet, give with finger pressure	1/4-3/8"
Full throttle operating range	4200-4600 rpm
FITS AND ADJUSTMENTS	
Pistons	
Production clearance	.0008-.0020
Piston rings - compression	
Groove clearance	
Production - top	.003-.005
Production - 2nd	.003-.005
Gap	
Top	.010-.020
2nd	.010-.020
Piston rings - oil	
Groove clearance	.0035 max.
Gap -- Production	.015-.035
Piston pins	
Diameter	.9391-.9394
Clearance Production	.0004-.0007
Fit in rod	
Interference	.0007-.0017
Connecting rods	
Bearing clearance	
Production	.0005-.0026
Side clearance	.006-.0027
Crankshaft	
End play.	004-.008

GMC V-6 ENGINES	229 CID 3.8 Litre 1981-82
Vain journal diameter	
All	2.4995
Out-of-round	
Production	.0015 max.
Main bearing clearance	
Production	
All	.004-.0015
Crankpin diameter	2.2495-2.2487
Camshaft	
Bearing journal dia.	1.785-1.786
Type of drive	Double row roller chain
CYLINDER HEAD	
Valve system	
Lifter type	Hydraulic
Rocker arm ratio	1.55:1
Valve lash adjustment	
Intake & exhaust	Non Adjust.
Valve face angle	45^{o}
Valve seat angle	45^{o}
Stem to guide clearance	
Intake & Exhaust	.0015-.0032
Valve seat width	
Intake	1/16
Exhaust	3/32
Valve spring	
Pressure ft-lbs	
Closed	59-69 @ 1.727
Open	162-174 @ 1.327
ENGINE LUBRICATION	
Oil pump type	Gear
Crankcase capacity	
170 hp -- 3.8 Litre	4 qts
New filter, add	1/2 qt
Oil filter	
OMC Part No.	173834
Purolator	PER-173
AC	PF-51
Oil grade recommended	
32 degrees F. & above	SAE 30
0 degrees F. to 32 F	SAE 20W
Below 0 degrees F.	SAE 10W

SPECIFICATIONS

GMC V6 ENGINES	229 & 262 CID 3.8 & 4.3 Litre 1983 and on
ENGINE BLOCK	
GENERAL SPECIFICATIONS	
Type - No. of cylinder	90° - V6
Valve arrangement	In head
Bore & stroke (3.8 Lt)	3.736 x 3.480
(4.3 Lt)	4.000 x 3.480
Cylinder number, front to rear	
Starboard bank	2-4-6
Port bank	1-3-5
Firing order	1-6-5-4-3-2
Compression ratio (3.8 Lt)	8.6: 1
(4.3 Lt)	9.3: 1
Compression pressure (3.8 Lt)	125 psi
(4.3 Lt)	167 psi
Water temp. control	Thermostat
Thermostat opens at	160° F
Alternator belt adjustment, give with finger pressure	1/4-3/8"
Full throttle operating range	4200-4600 rpm
FITS AND ADJUSTMENTS	
Pistons	
Production clearance	.0007 - .00 17
Piston rings - compression	
Groove clearance	
Production - top	.0012-.0032
Production - 2nd	.0012-.0032
Gap	
Top	.010-.020
2nd	.010-.025
Piston rings - oil	
Groove clearance	.002-.007 max.
Gap -- Production	.015-.055
Piston pins	
Diameter	.9270-.9273
Clearance Production	.00025-.00035
Fit in rod	
Interference	.008-.0016
Connecting rods	
Bearing clearance	
Production	.0013-.0035
Side clearance	.008-.014
Crankshaft	
End play.	.002-.006
Main journal diameter	
No.1	2.4484-2.4493

GMC V6 ENGINES	229 & 262 CID 3.8 & 4.3 Litre 1983 and on
No. 2, 3, 4	2.448 1-2.4490
No. 5	2.4479-2.4488
Out-of-round	
Production	,0002 max.
Main bearing clearance	
Production	
No. 1	.0008-.0020
No. 2, 3, 4	.0011-.0023
No. 5	.0017-.0032
Crankpin diameter	2.0986-2.0998
Camshaft	
Bearing journal dia.	1.8682-1.8692
Type of drive	Morse silent chain
CYLINDER HEAD	
Valve system	
Lifter type	Hydraulic
Rocker arm ratio	1.5:1
Valve lash adjustment	
Intake & exhaust	(Hot) One turn down from zero lash.
Valve face angle	45°
Valve seat angle	46°
Stem to guide clearance	
Intake & Exhaust	.0010-.0027
Valve seat width	
Intake	1/32 to 1/16
Exhaust	1/16 to 3/32
Valve spring	
Pressure ft-lbs	
Closed	76-84 @ 1.70"
Open	194-206 @ 1.25
ENGINE LUBRICATION	
Oil pump type	Gear
Crankcase capacity	
170 hp -- 3.8 Litre	4 qts
New filter, add	1/2 qt
Oil filter	
OMC Part No.	173834
Purolator	PER-173
AC	PF-51
Oil grade recommended	
32 degrees F. & above	SAE 30
0 degrees F. to 32 F	SAE 20W
Below 0 degrees F.	SAE 10W

FORD V-8	302 CID 175 HP 1977-79	302 CID 190 HP 1977-79	351 CID 235 HP 1977	351 CID 240 HP '78 250 HP '79
ENGINE BLOCK				
Compression Ratio	8.4 to 1	8.4 to 1	8.3 to 1	8.3 to 1
Bore and Stroke	4.00 x 3.00	4.00 x 3.00	4.00 x 3.50	4.00 x 3.50
Compression Pressure PSI (Sea Level) @ Cranking Speed	When checking compression, take the highest reading and compare it to the lowest reading. The lowest reading must be within 75% of the highest.			
Oil Pressure Hot @ 2000 RPM	35-60	35-60	35-60	35-60
Cylinder Designation				
Starboard Bank	1234	1234	1234	1234
Port Bank	5678	5678	5678	5678
Firing Order	15426378	13726548	13726548	13726548
Belt Tension (Lbs.)	75 + 15	75 + 15	75 + 15	75 + 15
CYLINDER HEAD				
Combustion Chamber Volume	67.5-70.5	58.9-61.9	67.5-70.5	67.5-70.5
Valve Guide Bore Diameter (Standard Intake & Exhaust)	← 0.3433 - 0.3443 →			
Valve Seat Width				
Intake	← 0.060 - 0.0.80 →			
Exhaust	← 0.060 - 0.080 →			
Valve Seat Angle	← 45° →			
Valve Seat Runout (Maximum)	← 0.015 →			
Valve Arrangement	← Left E-I-E-I-E-I-E-I →			
(Front to Rear)	← Right I-E-I-E-I-E-I-E →			
Rocker Arm Stud Bore Dia. Std.	← 0.3680 - 0.3695 →			
Gasket Surface Flatness	← 0.003" in any six-inches 0.007" overall →			
CYLINDER BLOCK				
Cylinder Bore Diameter	4.000-4.0052	4.000-4.0052	4.0004-4.0048	4.000-4.0048
Maximum out of round	← 0.001 →			
Wear Limit	← 0.005 →			
Cylinder bore surface RMS	← 15 - 35 →			

FORD *V-8*	*302* CID 175 HP *1977-79*	*302* CID 190 HP *1977-79*	*351* CID *235* HP *1977*	*351* CID *240* HP *'78* *250* HP *'79*
Maximum Taper	← 0.001 →			
Wear Limit	← 0.010 →			
Lifter Bore Diameter	← 0.8752-0.8767 →			
Main Bearing Bore Diameter Cylinder Block	2.4412-2.4420	2.4412-2.4420	3.1922-3.1930	3.1922-3.1930
Distributor Shaft Bearing Bore Diameter	0.04525-0.4541	0.4525-0.4541	0.5155-0.5171	0.5155-0.5171
Head Gasket Surf. Flatness	← Head gasket surface finish RMS 60-150 → ← 0.003" in any 6-inches or 0.006" overall →			
Crankshaft to rear face of block runout TIR Max.	← 0.010 →			
VALVE ROCKER ARMS, PUSH RODS AND TAPPETS				
Rocker Arm Lift Ratio	← 1.61:1 →			
Valve Push Rod (Max. Runout)	← 0.015 →			
Valve Lifter Std. Diameter	← 0.8740-0.8745 →			
Clearance to bore	← 0.0007-0.0027 →			
Wear Limit	← 0.005 →			
Hydraulic Lifter Leakdown rate	5-50 sec. max. measurement at 1/16 plunger travel			
Collapsed Tappet Gap Allowable	0.090-0.190	0.106-0.206	0.106-0.206	0.106-0.206
Desired	0.090-0.140	0.106-0.156	0.106-0.156	0.106-0.156
VALVES				
Valve Stem to Valve Guide Clearance Intake	← 0.0010-0.0027 →			
Exhaust	← 0.0015-0.0032 →			

FORD V-8	302 CID 175 HP 1977-79	302 CID 190 HP 1977-79	351 CID 235 HP 1977	351 CID 240 HP '78 250 HP '79
Wear Limit		0.0055		
Valve Head Diameter				
Intake	1.773-1.791	1.834-1.852	1.834-1.852	1.773-1.791
Exhaust	1.442-1.460	1.533-1.548	1.533-1.548	1.442-1.460
Valve Face Angle	←	44°	→	→
Valve face Runout Maximum	←	0.002	→	→
Valve Stem Diameter				
Standard				
Intake	←	0.3416-0.3423	→	→
Exhaust	←	0.3411-0.3418	→	→
0.003 Oversize				
Intake	←	0.3446-0.3453	→	→
Exhaust	←	0.3441-0.3448	→	→
0.015 Oversize				
Intake	←	0.3566-0.3573	→	→
Exhaust	←	0.3561-0.3568	→	→
0.030 Oversize				
Intake	←	0.3716-0.3723	→	→
Exhaust	←	0.3711-0.3718	→	→

VALVE SPRINGS

Valve Spring Press. Lbs @ Spec. Length Intake-exhaust	76-84@1.69 190-210@1.31	71-79@1.790 190-210@1.34	71-79@1.790 190-210@1.34	71-79@1.790 190-210@1.34
Wear limit Intake-exhaust	68@1.69 171@1.31	64@1.790 171@1.34	64@1.790 171@1.34	64@1.790 171@1.34
Valve Spring Free Length (Approximate) Intake-exhaust	1.94	2.06	2.06	2.06
Valve Spring Assembled Ht. pad to retainer Intake-exhaust	1-43/64 to 1-45/64	1-49/64 to 1-13/16	1-49/64 to 1-13/16	1-49/64 to 1-13/16
Valve Spring Out-of-square (Max.)	←	0.078	→	→

FORD V-8	302 CID 175 HP 1977–79	302 CID 190 HP 1977–79	351 CID 235 HP 1977	351 CID 240 HP '78 250 HP '79
CAMSHAFT				
Lobe Lift				
Intake	0.237	0.260	0.278	0.278
Exhaust	0.247	0.278	0.283	0.283
Max. allowable lift loss	←	0.005	→	→
Theoretical Valve Lift				
Intake	0.381	0.419	0.448	0.448
Exhaust	0.398	0.448	0.456	0.456
Camshaft End Play	←	0.005-0.0055	→	→
Wear limit	←	0.007	→	→
Camshaft Journal to Bearing Clearance	←	0.001-0.003	→	→
Wear limit	←	0.006	→	→
Timing Chain Deflection (Maximum)	←	0.500	→	→
Camshaft Journal Dia. Standard				
No. 1 Bearing	←	2.0805-2.0815	→	→
No. 2 Bearing	←	2.0655-2.06665	→	→
No. 3 Bearing	←	2.0505-2.0515	→	→
No. 4 Bearing	←	2.0355-2.0365	→	→
No. 5 Bearing	←	2.0205-2.0215	→	→
Camshaft journal maximum runout	←	0.005	→	→
Camshaft journal max. out-of-roung	←	0.0005	→	→
Camshaft Bearings Inside Diameter				
No. 1 Bearing	←	2.0825-2.0835	→	→
No. 2 Bearing	←	2.0675-2.0685	→	→
No. 3 Bearing	←	2.0525-2.0535	→	→
No. 4 Bearing	←	2.0375-2.0385	→	→
No. 5 Bearing	←	2.0225-2.0235	→	→

FORD V-8	302 CID 175 HP 1977-79	302 CID 190 HP 1977-79	351 CID 235 HP 1977	351 CID 240 HP '78 250 HP '79
Camshaft Bearing				
No. 1 bearing	← 0.0050-0.0200 →			
Location	Distance in inches that the front edge of the bearing is installed towards the rear from the front face of the cylinder block.			
CRANKSHAFT BEARINGS				
Connecting Rod Bearings To Crankshaft Clearance				
Desired	0.0008-0.00 15 →			
Allowable	← 0.0008-0.0026 →			
Wall Thickness Std.	0.0572-0.0577 0.002 U.S. thickness and 0.0010 to std. thickness			
Main Bearings To Crankshaft Clearance				
No. 1 desired	0.0001	0.0001		
No. 1 allowable	0.0001 to 0.0020	0.0001 to 0.0020		
All others desired	0.0005 to 0.0015	0.0005 to 0.0015		
All others allowable	0.0005 to 0.0024	0.0005 to 0.0024		
All bearings desired			0.0008 to 0.0015	0.0008 to 0.0015
All bearings allowable			0.0008 to 0.0026	0.0008 to 0.0026
Wall Thickness Std. No. 1 bearing	0.0961 to 0.0966	0.0961 to 0.0966		
All others	0.0955 to 0.0958	0.0955 to 0.0958		
All bearings			0.0955 to 0.0958	0.0957 to 0.0960
Wall thickness	0.002" U.S. thickness add 0.00 10 to standard thickness.			
CRANKSHAFT AND FLYWHEEL				
Main Bearing Journal Diameter	2.2482 to 2.2490	2.2482 to 2.2490	2.9994 to 3.0002	2.9994 to 3.0002
Main Journal max. out-of-round	← 0.0004 →			

FORD V-8	***302 CID 175 HP 1977-79***	***302 CID 190 HP 1977-79***	***351 CID 235 HP 1977***	***351 CID 240 HP '78 250 HP '79***
Main Bearing Journal Runout (Maximum)	←	0.002		→
Wear limit	←	0.005		→
Main Bearing Journal Thrust Face Runout	←	0.002		→
Main Bearing Journal Taper (Maximum)	←	0.004		→
Thrust Bearing Journal Length	←	1.137-1.139		→
Main Bearing Surface Finish RMS Maximum Journal	←	12		→
Thrust Face	←	35 front -- 25 rear		→
Connecting Rod Journal Diameter	2.1228 to 2.1236	2.1228 to 2.1236	2.3103 to 2.3111	2.3103 to 2.3111
Connecting rod journal out-of-round (maximum)	←	0.0004		→
Connecting Rod Bearing Journal Maximum Taper	←	0.0004 per inch		→
Crankshaft Free End Play	←	0.004 to 0.008		→
Wear limit	←	0.012		→
PISTONS				
Diameter	Measure at the piston pin bore. Centerline at 90° to the pin bore.			
Coded Red	3.9984 to 3.9990	3.9984 to 3.9990	3.9978 to 3.9984	3.9978 to 3.9984
Coded Blue	3.9996 to 4.0002	3.9996 to 4.0002	3.9990 to 3.9996	3.9990 to 3.9996
0.003 Oversize	4.0008 to 4.0014	4.0008 to 4.0014	4.0002 to 4.0008	4.0002 4.0008
Piston to Cylinder Bore Clearance	←	0.0018 0.0026		→
Piston Pin Bore Diameter	0.9123 to 0.9126	0.9123 to 0.9126	0.9124 to 0.9127	0.9124 to 0.9127

FORD V-8	302 CID 175 HP 1977–79	302 CID 190 HP 1977–79	351 CID 235 HP 1977	351 CID 240 HP '78 250 HP '79
Ring Groove Width				
Upper and lower compression ring	←	0.080-0.081		→
Oil Ring	←	0.1880-0.1890		→
PISTON PIN				
Length	←	3.010-3.040		→
Diameter				
Standard	←	0.9120-0.9123		→
0.001 Oversize	←	0.9130-0.9133		→
To Piston Clearance	0.0002 to 0.0004	0.0002 to 0.0004-	0.0003 to 0.0005	0.0003 to 0.0005
To Connecting Rod Clearance	←	Interference fit		→
PISTON RINGS				
Ring Width				
Compression Ring				
Top & bottom	0.077	0.077	0.078	0.078
Side Clearance				
Compression Ring				
Top & bottom	0.002	0.002	0.004	0.004
Wear limit		0.006		
Oil Ring	←	Snug		→
Ring Gap Width				
Compression Ring				
Top & bottom	0.010	0.010	0.020	0.020
Oil Ring	0.015	0.015	0.015	0.055
Steel ring	←	All		→
CONNECTING ROD				
Piston Pin Bore or Bushing ID	←	0.9104-0.9112		→
Connecting Rod Bearing Bore Diameter	←	2.2390-2.2398		→
Connecting Rod Bearing Bore Max. out-of-round and taper	←	0.0004		

FORD V-8	302 CID 175 HP 1977–79	302 CID 190 HP 1977–79	351 CID 235 HP 1977	351 CID 240 HP '78 250 HP '79
Connecting Rod Length Center-to-Center	5.0885 to 5.0915	5.0885 to 5.0915	5.9545 to 5.9575	5.9545 to 5.9575
Connecting Rod Alignment Max. Total Difference	Pin bushing and crankshaft bearing bore must be parallel and in the same vertical plane within the specified total difference at ends of 8-inch long bar measured 4" on each side of the rod.			
Twist	← 0.012 →			
Bend	← 0.0004 →			
Connecting Rod Assy. Assembled to Crankshaft Side Clearance	← 0.010–0.020 →			
Wear Limit	← 0.023 →			

OIL PUMP

Rotor-Type Oil Pump Relief Valve Spring Tension Lbs. @ Spec. Length	10.6–12.2 @ 1.704	10.6–12.2 @ 1.704	18.2–20.2 @ 2.49	18.2–20.2 @2.49
Driveshaft to Housing Bearing Clearance	← 0.0015–0.0029 →			
Relief Valve Clearance	← 0.0015–0.0029 →			
Rotor Assembly End Clearance	← 0.001–0.004 →			
Outer Race to Housing (Radial Clearance)	← 0.006–0.013 →			

ENGINE OIL PAN CAPACITIES

U.S. Measure (Add 1 qt. with oil filter replacement)	← 5 qts →			
Imperial Measure (Add 1 qt. with oil fitler replacement)	← 4 qts →			

FORD V-8	302 CID 175 HP 1974-76	302 CID 190 HP 1974-75	351 CID 235 HP 1974-76	302 CID 190 HP 1976
ENGINE BLOCK				
Compression Ratio	8.0 to 1	7.9 to 1	8.0 to 1	8.0 to 1
Bore and Stroke	4.00 x 3.00	4.00 x 3.00	4.00 x 3.50	4.00 x 3.00
Compression Pressure FSI (Sea Level) @ Cranking Speed	When checking compression, take the highest reading and compare it to the lowest reading. The lowest reading must be within 75% of the highest.			
Oil Pressure Hot @ 2000 RPM	40-60	40-60	40-60	35-60
Cylinder Designation				
Starboard Rank	1234	1234	1234	1234
Port Bank	5678	5678	5678	5678
Firing Order	15426378	13726548	13726548	13726548
Belt Tension (Lbs.)	75 + 15	75 + 15	75 + 15	75 + 15
CYLINDER HEAD				
Combustion Chamber Volume	56.7 - 59.7	58.9 - 61.9	58.9 - 61.9	58.9 - 61.9
Valve Guide Bore Diameter (Standard Intake & Exhaust)	← 0.3433 - 0.3443 →			
Valve Seat Width				
Intake	← 0.060 - 0.0.80 →			
Exhaust	← 0.060 - 0.080 →			
Valve Seat Angle	← 45° →			
Valve Seat Runout (Maximum)	← 0.015 →			
Valve Arrangement	← Left E-I-E-I-E-I-E-I →			
(Front to Rear)	← Right I-E-I-E-I-E-I-E →			
Rocker Arm Stud Bore Dia. Std.	← 0.3680 - 0.3695 →			
Gasket Surface Flatness	← 0.003" in any 6-inches, 0.007" overall →			
CYLINDER BLOCK				
Cylinder Bore Diameter	4.0004-4.0040 4.0004-4.0052	4.0004-4.0040 1976 only	4.000-4.0036 4.000-4.0048	4.000-4.0052
Maximum out of round	← 0.001 →			
Wear Limit	← 0.005 →			
Cylinder bore surface RMS	← 15 - 35 →			

FORD V-8	302 CID 175 HP 1974-76	302 CID 190 HP 1974-75	351 CID 235 HP 1974-76	302 CID 190 HP 1976
Maximum Taper	←	0.001	→	→
Wear Limit	←	0.010	→	→
Lifter Bore Diameter	←	0.8752-0.8767	→	→
Main Bearing Bore Diameter	2.4412-2.4420	2.4412-2.4420	3.1922-3.1930	2.4412-2.4420
Cylinder Block Distributor Shaft Bearing Bore Diameter	0.04525-0.4541	0.4525-0.4541	0.5155-0.5171	0.4525-0.4541
Head Gasket Surf. Flatness	+Head gasket surface finish RMS 60-150 ←0.003" in any 6-inches or 0.006" overall			→ →
Crankshaft to rear face of block runout TIR Max.	←	0.010	→	→

VALVE ROCKER ARMS, PUSH RODS AND TAPPETS

Rocker Arm Lift Ratio	←	1.61:1	→	→
Valve Push Rod (Max. Runout)	←	0.015	→	→
Valve Lifter Std. Diameter	←	0.8740-0.8745	→	→
Clearance to bore	←	0.0007-0.0027	→	→
Wear Limit	←	0.005	→	→
Hydraulic Lifter Leakdown Rate	5-50 seconds maximum measurement at 1/16 plunger travel			
Collapsed Tappet Gap Allowable	0.090-0.190	0.106-0.206	0.106-0.206	0.106-0.206
Desired	0.090-0.140	0.106-0.156	0.106-0.156	0.106-0.156

VALVES

Valve Stem to Valve Guide Clearance Intake	←	0.0010-0.0027	→	→
Exhaust	←	0.0015-0.0032	→	→

FORD V-8	302 CID 175 HP 1974–76	302 CID 190 HP 1974–75	351 CID 235 HP 1974-76	302 CID 190 HP 1976
Wear Limit		0.0055		
Valve Head Diameter				
Intake	1.773- 1.791	1.834- 1.852	1.834- 1.852	1.834- 1.852
Exhaust	1.442- 1.460	1.533- 1.548	1.533- 1.548	1.533- 1.548
Valve Face Angle	←	44°	→	
Valve face Runout Maximum	←	0.002	→	
Valve Stem Diameter				
Standard				
Intake	←	0.3416-0.3423	→	
Exhaust	←	0.3411-0.3418	→	
0.003 Oversize				
Intake	←	0.3446-0.3453	→	
Exhaust	←	0.3441-0.3448	→	
0.015 Oversize				
Intake	←	0.3566-0.3573	→	
Exhaust	←	0.3561-0.3568	→	
0.030 Oversize				
Intake	←	0.3716-0.3723	→	
Exhaust	←	0.3711-0.3718	→	
VALVE SPRINGS				
Valve Spring Press. Lbs @ Spec. Length Intake-exhaust	76-84@1.69 190-210@1.31	71-79@1.790 190-210@1.34	71-79@1.790 190-210@1.34	71-79@1.790 190-210@1.34
Wear limit Intake-exhaust	68@1.69 171@1.31	64@1.790 171@1.34	64@1.790 171@1.34	64@1.790 171@1.34
Valve Spring Free Length (Approximate) Intake-exhaust	1.94	2.07	2.07	2.07
Valve Spring Assembled Ht. pad to retainer Intake-exhaust	1-43/64 to 1-45/64	1-49/64 to 1-13/16	1-49/64 to 1-13/16	1-13/16 to 1-27/32
1976 only	1-21/32 to 1-23/32		1-13/16 to 1-27/32	
Valve Spring Out-of-square (Max.)	←	0.078	→	

FORD V–8	302 CID 175 HP 1974-76	302 CID 190 HP 1974–75	351 CID 235 HP 1974–76	302 CID 190 HP 1976
CAMSHAFT				
Lobe Lift				
Intake	0.2303	0.260	0.260	0.260
Exhaust	0.2375	0.278	0.278	0.278
Max. allowable lift loss	←	0.005	→	
Theoretical Valve Lift				
Intake	0.3707	0.418	0.418	0.418
Exhaust	0.3823	0.448	0.448	0.448
Camshaft End Play	←	0.005–0.0055	→	
Wear limit	←	0.007	→	
Camshaft Journal to Bearing Clearance	←	0.001–0.003	→	
Wear limit	←	0.006	→	
Timing Chain Deflection (Maximum)	←	0.500	→	
Camshaft Journal Dia. Standard				
No. 1 Bearing	←	2.0805–2.0815	→	
No. 2 Bearing	←	2.0655–2.06665	→	
No. 3 Bearing	←	2.0505–2.0515	→	
No. 4 Bearing	←	2.0355–2.0365	→	
No. 5 Bearing	←	2.0205–2.0215	→	
Camshaft journal maximum runout	←	0.005	→	
Camshaft journal max. out-of-roung	←	0.0005	→	
Camshaft Bearings Inside Diameter				
No. 1 Bearing	←	2.0825–2.0835	→	
No. 2 Bearing	←	2.0675–2.0685	→	
No. 3 Bearing	←	2.0525–2.0535	→	
No. 4 Bearing	←	2.0375–2.0385	→	
No. 5 Bearing	←	2.0225–2.0235	→	

FORD V-8	302 CID 175 HP 1974–76	302 CID 190 HP 1974–75	351 CID 235 HP 1974–76	302 CID 190 HP 1976
Camshaft Bearing No. 1 bearing	← 0.0050-0.0200 →			
Location	Distance in inches that the front edge of the bearing is installed towards the rear from the front face of the cylinder block.			
CRANKSHAFT BEARINGS				
Connecting Rod Bearings To Crankshaft Clearance Desired	← 0.0008–0.0015 →			
Allowable	← 0.0008–0.0026 →			
Wall Thickness Std.	0.0572–0.0577 thickness	0.002 U.S. thickness and 0.0010 to std.		
Main Bearings To Crankshaft Clearance No. 1 desired	0.0001	0.0001		0.0001
No. 1 allowable	0.0001 to 0.0020	0.0001 to 0.0020		0.0001 to 0.0020
All others desired	0.0005 to 0.0015	0.0005 to 0.0015		0.0005 to 0.0015
All others allowable	0.0005 to 0.0024	0.0005 to 0.0024		0.0005 to 0.0024
All bearings desired			0.0008 to 0.0015	
All bearings allowable			0.0008 to 0.0026	
Wall Thickness Std. No. 1 bearing	0.0961 to 0.0966	0.0961 to 0.0966		0.0961 to 0.0966
All others	0.0955 to 0.0958	0.0955 to 0.0958		0.0955 to 0.0958
All bearings			0.0955 to 0.0958	
Wall thickness	0.002" U.S. thickness add 0.0010 to standard thickness.			
CRANKSHAFT AND FLYWHEEL				
Main Bearing Journal Diameter	2.2482 to 2.2490	2.2482 to 2.2490	2.9994 to 3.0002	2.2482 to 2.2490
Main Journal max. out-of-round	← 0.0004 →			

FORD V-8	302 CID 175 HP 1974-76	302 CID 190 HP 1974-75	351 CID 235 HP 1974-76	302 CID 190 HP 1976
Main Bearing Journal Runout (Maximum)	← 0.002 →			
Wear limit	← 0.005 →			
Main Bearing Journal Thrust Face Runout	← 0.002 →			
Main Bearing Journal Taper (Maximum)	← 0.004 →			
Thrust Bearing Journal Length	← 1.137-1.139 →			
Main Bearing Surface Finish RMS Maximum				
Journal	← 12 →			
Thrust Face	← 35 front -- 25 rear →			
Connecting Rod Journal Diameter	2.1228 to 2.1236	2.1228 to 2.1236	2.3103 to 2.3111	2.1228 to 2. 1236
Connecting rod journal out-of-round (maximum)	← 0.0004 →			
Connecting Rod Bearing Journal Maximum Taper	← 0.0004 per inch →			
Crankshaft Free End Play	← 0.004 0.008 →			
Wear limit	← 0.012 →			

PISTONS

Diameter	Measure at the piston pin bore. Centerline at 90° to the pin bore.			
Coded Red	3.9984 to 3.9990	3.9984 to 3.9990	3.9978 to 3.9984	3.9984 to 3.9990
Coded Blue	3.9996 to 4.0002	3.9996 to 4.0002	3.9990 to 3.9996	3.9996 to 4.0002
0.003 Oversize	4.0008 to 4.0014	4.0008 to 4.0014	4.0002 to 4.0008	4.0008 to 4.0014
Piston to Cylinder Bore Clearance	← 0.0018 0.0026 →			
Piston Pin Bore Diameter	0.9123 to 0.9126	0.9123 to 0.9126	0.9124 to 0.9127	0.9123 to 0.9126

FORD V-8	302 CID 175 HP 1974-76	302 CID 190 HP 1974-75	351 CID 235 HP 1974-76	302 CID 190 HP 1976
Ring Groove Width				
Upper and lower compression ring	←	0.080-0.081	→	
Oil Ring	←	0.1880-0.1890	→	
PISTON PIN				
Length	←	3.010-3.040	→	
Diameter Standard	←	0.9120-0.9123	→	
0.001 Oversize		0.9130-0.9133		
To Piston Clearance	0.0002 to 0.0004	0.0002 to 0.0004	0.0003 to 0.0005	0.0002 to 0.0004
To Connecting Rod Clearance	←	Interference fit	→	
PISTON RINGS				
Ring Width				
Compression Ring Top & bottom	0.077	0.077	0.078	0.077
Side Clearance				
Compression Ring Top & bottom	0.002	0.002	0.004	0.002
Wear limit	←	0.006	→	
Oil Ring	←	Snug	→	
Ring Gap Width				
Compression Ring Top & bottom	0.010	0.010	0.020	0.010
Oil Ring	0.015	0.015	0.055	0.015
Steel ring	←	All	→	
CONNECTING ROD				
Piston Pin Bore or Bushing ID	←	0.9104-0.9112	→	
Connecting Rod Bearing Bore Diameter	←	*2.2390-2.2398*	→	
Connecting Rod Bearing Bore Max. out-of-round and taper	←	*0.0004*	→	

FORD V-8	302 CID 175 HP 1974–76	302 CID 190 HP 1974–75	351 CID 235 HP 1974–76	302 CID 190 HP 1976
Connecting Rod Length Center-to-Center	5.0885 to 5.0915	5.0885 to 5.0915	5.9545 to 5.9575	5.0885 to 5.0915
Connecting Rod Alignment Max. Total Difference	Pin bushing and crankshaft bearing bore must be parallel and in the same vertical plane within the specified total difference at ends of 8-inch long bar measured 4" on each side of the rod.			
Twist	← 0.012 →			
Bend	← 0.0004 →			
Connecting Rod Assy. Assembled to Crankshaft Side Clearance	← 0.010-0.020 →			
Wear Limit	← 0.023 →			

OIL PUMP

Rotor-Type Oil Pump Relief Valve Spring Tension Lbs. @ Spec. Length	11.15-11.75 @ 1.704	11.15-11.75 @ 1.704	18.2-20.2 @ 2.49	10.6-12.2 @ 1.704
Driveshaft to Housing Bearing Clearance	← 0.0015-0.0029 →			
Relief Valve Clearance	← 0.0015-0.0029 →			
Rotor Assembly End Clearance	← 0.001-0.004 →			
Outer Race to Housing (Radial Clearance)	← 0.006-0.013 →			

ENGINE OIL PAN CAPACITIES

U.S. Measure (Add 1 qt. with oil filter replacement)	← 5 qts →			
Imperial Measure (Add 1 qt. with oil fitler replacement)	← 4 qts →			

TORQUE SPECIFICATIONS FOR THE 110,120, AND 140 Hp ENGINES

PART	APPLICATION	THREAD	FT. LBS.	IN. LBS.
Bolt	Camshaft Thrust Plate	1/4-20		72-90
Nut	Connecting Rod	11/32-24	30-35	
Screw	Coupling, Flywheel to Crankshaft	7/16-20	60-65	
Plug	Crankcase Drain	1/2-20	15-20	
Bolt	Cylinder Head	1/2-13	90-100	
Screw	Engine Mount to Cylinder Block	3/8-16	20-24	
Screw	Fill and Drain Oil Plug (outdrive)	3/8-16	4-5	
Setscrew	Gear to Clutch Spring	10-32		30-35
Screw	Gearcase to Exhaust Tube	5/16-18	16-18	
Screw	Impeller Housing to Gear Housing	3/8-16	30-36	
Bolt	Main Bearing Cap (oiled)	7/16-14	60-70	
Screw	Manifold to Cylinder Head	3/8-16	20-25	
Filter	Oil	1/2-20	Hand Tight	
Bolt	Oil Pan (end)	5/16-18		120-130
Bolt	Oil Pan (side)	1/4-20		72-90
Bolt	Oil Pan (to front cover)	1/4-20		50-60
Screw	Oil Pump Cover to Body	1/4-20		65-75
Bolt	Oil Pump Mounting	5/16-18		110-120
Nut	Pinion (elastic stop nut)	3/4-16	70-80	
Screw	Pulley to Balancer Hub (1)	5/16-24	15-20	
	(2)	3/8-24	15-20	
Screw	Rocker Arm Cover	1/4-20		50-60
Nut	Shaft and Ball Gear Assembly (upper gear box)		60-70	
Plug	Spark	14 MM	35	
Screw	Cover to Intermediate Hsg.	10-24		42-54
Bolt	Timing Gear Cover to Block	1/4-20		72-90
Screw	Water Passage Cover	1/4-20	3-7	
Bolt	Water Pump to Block	5/16-18	13-17	

Use a reliable torque wrench to tighten the parts listed to prevent straining or distorting them or possibly damaging the threads. These specifications are for clean threads only. Dirty threads produce friction which prevents accurate measurements. It is important that these torque specifications be strictly observed. Overtightening to any extent can damage threads, thus preventing proper torque frorn being obtained, requiring replacement or repair of damaged parts.

The following specifications are for screw sizes not shown otherwise:

SCREW SIZE	FT. LBS.	IN. LBS.
#6	---	7-10
#10	2-3	25-35
#12	3-4	35-45
1/4	5-7	60-80
5/16	10-12	120-140
3/8	18-20	220-240

TORQUE VALUES FOR 150, 160, 165 HP ENGINES

Size	Usage	
1/4-20	Camshaft Thrust Plate	80 lb. in.
	Crankcase Front Cover	80 lb. in.
	Flywheel Housing Pans	80 lb. in.
	Oil Pan (To Crankcase)	80 lb. in.
	Oil Pan (To Front Cover)	50 lb. in.
	Oil Pump Cover	70 lb. in.
	Rocker Arm Cover	45 lb. in.
11/32-24	Connecting Rod Cap	35 lb. ft.

TORQUE VALUES FOR 150, 160, 165 HP ENGINES (Continued)

5/16-18	Oil Pan (To Crankcase)	75 lb. in.
	Oil Pump	115 lb. in.
	Push Rod Cover	50 lb. in.
	Water Pump	15 lb. in.
3/8-16	Distributor Clamp·	20 lb. ft.
	Flywheel Housing	30 lb. ft.
	Manifold Clamp (L6 Outer)	20 lb. ft.
	Manifold Clamp (All Others)	30 lb. ft.
	Thermostat Housing	30 lb. ft.
7/16-14	Main Bearing Cap	65 lb. ft.
7/16-20	Flywheel	60-65 lb. ft.
1/2-13	Cylinder Head	95 lb. ft.
1/2 -14	Temperature Sending Unit	20 lb. ft.
1/2-20	Oil Filter	Hand Tight
14mm 5/8	Spark Plug	15 Ib. ft.

TORQUE VALUES FOR V6 150 AND 155 HP ENGINES

PART	APPLICATION	THREAD	TORQUE FT. LBS.
Nut	Connecting Rod Bolt	11/32-24	30-40
Screw	Coupling, Flywheel to Crankshaft	7/16-20	45-50
Plug	Crankcase Drain	1/2-20	25-35
Bolt	Crankshaft Bearing Cap to Crankcase	1/2-13	95-120
Bolt	Cylinder Head to Block	7/16-14	65-80
Bolt	Distributor Holddown Clamp	3/8-16	10-15
Bolt	Engine Mount to Cylinder Block	7/16-14	40-45
Screw	Fill and Drain Oil Plug (outdrive)	3/8-16	4-5
Bolt	Fuel Pump Eccentric and Timing Chain Sprocket to Camshaft	7/16-20	40-55
Bolt	Fuel Pump to Timing Chain Cover	5/16-18	20-25
Set Screw	Gear to Clutch Spring	10-32	30-35 In. Lbs.
Screw	Gearcase to Exhaust Tube	5/16-18	16-18
Bolt	Harmonic Balancer to Crankshaft	5/8-18	140-Minimum
Screw	Impeller Housing to Gear Housing	3/8-16	30-36
Screw	Intake Manifold to Cylinder Head	3/8-16	45-55
Screw	Mount Bracket to Front Lateral Support		60-65
Filter	Oil		10-15
Bolt	Oil Pan to Block	5/16-18	9-13
Screw	Oil Pump Cover Assembly to Timing Chain Cover	1/4-20	8-12
Bolt	Oil Screen Housing Pipe and Flange Assembly to Block	1/4-20	6-9
Nut	Pinion (Elastic Stop Nut)	3/4-16	70-80
Bolt	Pulley and Reinforcement to Harmonic Balancer	5/16-18	18-25
Bolt	Pulley to Water Pump Hub	5/16-24	17-23
Screw	Rear Support Bracket to Adapter		20-24
Screw	Rocker Arm Cover to Cylinder Head	1/4-20	3-5
Bolt	Rocker Arm Shaft Bracket to Cylinder Head	3/8-16	25-35
Nut	Shaft and Ball Gear Assembly (upper gear box)		60-70

TORQUE VALUES FOR 198,228 250 260 HP GM ENGINES

PART	APPLICATION	TORQUE FT. LBS.	TORQUE IN. LBS.
Bolt	Camshaft Sprocket	15-20	
Nut	Connecting Rod	45	
Screw	Coupling, Flywheel to Crankshaft	60-65	
Plug	Crankcase Drain	20-25	
Bolt	Cylinder Head	60-70	
Screw	Distributor Clamp	8-12	
Screw	Engine Mount to Cylinder Block	35-45	
Screw	Fill and Drain Oil Plug (outdrive)	4-5	
Setscrew	Gear to Clutch Spring		30-35
Screw	Gearcase to Exhaust Tube	16-18	
Screw	Impeller Housing to Gear Housing	30-36	
Bolt	Main Bearing Cap (oiled)	75-85	
Screw	Intake Manifold	25-35	
Filter	Oil	tighten snug and add 1/3 turn	
Bolt	Oil Pan 5/16-18		60-70
Bolt	Oil Pan 1/4-20		72-96
Screw	Oil Pump Cover to Body		72-96
Bolt	Oil Pump Mounting	60-70	
Nut	Pinion (elastic stop nut)	70-80	
Screw	Pulley to Balancer Hub	15-20	
Screw	Rocker Arm Cover		45
Nut	Shaft and Ball Gear Assembly (upper gear box)	60-70	
Plug	Spark	15	
Screw	Cover to Intermediate Housing		42-54
Bolt	Timing Chain Cover to Block		72-90
Screw	Water Passage Cover	3-7	
Bolt	Water Pump to Block	25-35	

TORQUE VALUES FOR 188, 225,233 HP FORD ENGINES

Item	Engine 175,190 HP	Engine 235 HP	Item	Engine 175, 190 HP	Engine 235 HP
Cylinder Head Bolts			**Oil Inlet Tube to Oil Pump**	**10-15**	
Step 1	50	85	**Oil Pump Cover Plate**	**6-9**	
Step 2	60	95	**Oil Filter Insert to Block**	**20-30**	**20-30**
Step 3	65-72	105-112	**Oil Filter to Block Cartridge Type**	**With grease on gasket surface, hand-tighten until gasket contacts adapter face then** tighten **1/2 turn** more.	
Oil Pan to Cylinder Block	9-11 (5/16 x 18) 7-9 (1/4 x 20)				
Intake Manifold Bolts	23-25		Cylinder Front Cover	12-15	
			Water Pump Bolts	12-15	
Exhaust Manifold Bolts	20-25		Camshaft Sprocket to camshaft-	40-45	
			Camshaft Thrust Plate to Block	9-12	
Water Pump Housing	12-15		Vibration Damper to Crankshaft	70-90	100-130
			Crankshaft Pulley to Vibration Damper	35-50	
Flywheel to Crankshaft	75-85		Connecting Rod Nuts	19-24	40-45
Main Bearing Cap Bolts	60-70	95-105	Valve Rocker Arm Cover	3-5	
			Fuel Pump to Cylinder Front Cover	17-27	
Oil Pan Drain Plug	7-9		Rocker Arm Stud Nut	17-23 Ft-Lbs After Nut Contacts Shoulder	
Oil Pump to Cylinder Block	22-32				
			Alternator Pivot Bolt	45-57	
Engine Block Spacer Bolts	50-55		Water Pump Pulley Screw	14-20	
Fuel Pump Screw	18-20		Adapter Housing to Spacer Nuts	22-24	
Starter Motor Screw	24-30				

TORQUE SPECIFICATIONS

3.8, 4.3, 5.0, AND 5.7 LITRE MODELS

SIZE	USAGE	ALL MODELS
1/4"-20	Crankcase Front Cover	80 lb. in.
	Oil Filter Bypass Valve	80 lb. in.
	Oil Pan To Crankcase	80 lb. in.
	Oil Pump Cover	80 lb. in.
	Rocker Arm Cover	45 lb. in.
5/16"-18	Camshaft Sprocket	30 lb. ft.
	Oil Pan To Crankcase	265 lb. in.
3/8"-16	Distributor Clamp	20 lb. ft.
	Adaptor Housing	30 lb. ft.
	Intake Manifold	30 lb. ft.
	Water Pump	30 lb. ft.
3/8"-24	Connecting Rod Cap	45 lb. ft.
7/16"-14	Cylinder Head	65 lb. ft.
	Main Bearing Cap	70 lb. ft.
	Oil Pump	65 lb. ft.
7/16"-20	Flywheel	60 lb. ft.
	Harmonic Balancer	60 lb. ft.
1/2"-24	Temperature Sending Unit	20 lb. ft.
1/2"-20	Oil Filter	25 lb. ft.
14 mm	Spark Plug	15 lb. ft.

Torque Specifications

2.5 AND 3.0 LITRE MODELS

PART	APPLICATION	THREAD	TORQUE FT. LES.	TORQUE IN. LBS.
Bolt	Camshaft Thrust Plate	1/4-20		72-90
Nu:	Connecting Rod	11/32-24	35	
Screw	Coupling, Flywheel to Crankshaft	7/16-20	60-65	
Bolt	Cylinder Head	1/2-13	90-100	
Screw	Engine Mount to Cylinder Block	3/8-16	20-24	
Bolt	Main Bearing Cap (oiled)	7/16-14	60-70	
Screw	Manifold to Cylinder Head	3/8-16	20-25	
Filter	Oil	1/2-20	Hand Tight	
Bolt	Oil Pan (end	5/16-18		75
Bolt	Oil Pan (side)	1/4-20		80
Screw	Oil Pump Cover to Body	1/4-20		65-75
Bolt	Oil Pump Mounting	5/16-18		110-120
Screw	Pulley to Balancer Hub (1)	5/16-24	15-20	
	(2)	3/8-24	15-20	
Screw	Rocker Arm Cover	1/4-20		45
Plug	Spark	14 MM	15	
Bolt	Timing Gear Cover to Block	1/4-20		72-90
Bolt	Water Pump to Block	5/16-18	13-17	
Bolt	Temp Sending Unit	1/2-14	20	
Bolt	Push Rod Cover	5/16-18		50
Bolt	Distributor Clamp	3/8-16	20	
Bolt	Flywheel Housing to Engine	3/8-16	35-40	
Screw	Alternator Bracket to Engine		26-30	

ENGINE MODEL – GEAR RATIOS – OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

HP	ENGINE MODEL	UPPER	GEAR RATIOS LOWER	TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	OUNCES LOWER
	1964						
88	DU-11C & 11R, DU & DUE-11A	25.25	20.23	.87	1.15	18.25	17.5
110	CU & CUE-12M	25.25	20.23	.87	1.15	18.25	17.5
150	HU & HUE-12M, -12B	25.25	16.28	.57	1.76	18.25	37.2
	1965						
90	DU & DUE-12M	25.25	20.23	.87	1.15	18.25	17.5
120	CU & CUE-13E	25.25	20.23	.87	1.15	18.25	17.5
	SU & SUE-13E	25.25	16.28	.57	1.76	18.25	37.2
150	Note 3HU & HUE-13E (Early)	25.25	16.28	.57	1.76	18.25	37.2
	HU & HUE-13E (Late)	25.25	19.29	.65	1.54	18.25	37.2
	1966						
90	DU & DUE-13B	25.25	20.23	.87	1.15	18.25	17.5
120	CU & CUE-14D	25.25	20.23	.87	1.15	18.25	17.5
150	HU & HUE-14D	25.25	15.23	.65	1.54	18.25	37.2
200	Note 4TU & TUE-14D (Early)	24.18	15.23	.87	1.15	18.25	37.2
200	TU & TUE-14D (Late)	24.18	19.29	.87	1.54	18.25	37.2
	1967						
90	DU & DUE-14D, -15S	25.25	20.23	.87	1.15	18.25	17.5
120	CU & CUE-15S	25.25	15.23	.65	1.54	18.25	37.2
	CU & CU-16C	19.20	15.23	.62	1.61	18.25	37.2
155	HU & HU-15S	25.25	15.23	.65	1.54	18.25	37.2
	HU & HUE-16C	19.20	15.23	.62	1.61	18.25	37.2
185	KU & KUE-15S	24.18	15.23	.87	1.15	18.25	37.2
200	TU & TUE-15S	24.18	15.23	.87	1.15	18.25	37.2
	TU TUE-16C	21.16	15.23	.86	1.16	18.25	37.2

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

		GEAR RATIOS				GEAR OIL CAPACITY	
HP	ENGINE MODEL	UPPER	LOWER	TOTAL	OVERALL	OUNCES UPPER	OUNCES LOWER
	1968						
80	NU & NUE-10S	16.28	20.23	.49	2.04	18.25	17.5
90	DU & DUE-15S	19.20	20.23	.82	1.22	18.25	17.5
120	CU & CUE-16C	19.20	15.23	.62	1.61	18.25	37.2
155	HU & HUE-16C	19.20	15.23	.62	1.61	18.25	37.2
185	KU & KUE-16C	21.16	15.23	.86	1.16	18.25	37.2
200	TU & TUE-16C	21.16	15.23	.86	1.16	18.25	37.2
210	TU & TUE-17R	21.16	15.23	.86	1.16	18.25	37.2
	1969						
80	NU & NUE-10S	16.28	20.23	.49	2.04	18.25	17.5
120	CUTR-69M, CUFR-69M CUTM-69M, CUFM-69M	19.20	15.23	.62	1.61	18.25	33.9
155	HUTR-69M, HUFR-69M HUTM-69M, HUFM-69M	19.20	15.23	.62	1.61	18.25	33.9
210	TUFR-69M, TUFM-69M	21.16	15.23	.86	1.16	18.25	33.9
	1970						
90	NUFR-12A	16.28	20.23	.49	2.04	18.25	17.5
120	CUTR-19E, CUFR-19E, CUTM-19E, CUFM-19E, CUFR-19EB	19.20	15.23	.62	1.61	18.25	33.9
155	HUTR-19E, HUFR-19E, HUTM-19E, HUFM-19E, HUFR-19EB	19.20	15.23	.62	1.61	18.25	33.9
210	TUFR-19R, TUFM-19E, TUFR-19EB	21.16	15.23	.86	1.16	18.25	33.9

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE *A-69*

HP	ENGINE MODEL	GEAR RATIOS UPPER	GEAR RATIOS LOWER	GEAR RATIOS TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	GEAR OIL CAPACITY OUNCES LOWER
	1971						
90	NUFM-12AX, 13M; NUFR-12AX, 13M	16.28	20.23	.49	2.04	18.25	17.5
120	CUTR-19EX, 20D; CUFR-19EX, 20D;						
	CUTM-19EX, 20D; DUFM-19EX, 20D	19.20	15.23	.62	1.61	18.25	33.9
155	HUTR-19EX, 20D; HUFR-19EX, 20D;						
	HUTM-19EX, 20D; HUFM-19EX, 20D	19.20	15.23	.62	1.61	18.25	33.9
215	TUFR-19EX, 20D; TUFM-19EX, 20D	21.16	15.23	.86	1.16	18.25	33.9
235	XUFR-20S, 20C; XUFM-20S, 20C	21.16	15.23	.86	1.16	18.25	33.9
	1972						
100	LUFR-10S, LUFM-10S	19.20	15.23	.62	1.61	13.50	33.9
	LUFR-10C, LUFM-10C, LUFP-10C	16.20	15.23	.52	1.92	13.50	33.9
120	GUFM-10S, VUFM-10S,						
	GUFR-10S, VUFR-10S	19.20	15.23	.62	1.61	13.50	33.9
	GUFR-10C, VUFR-10C,						
	GUFM-10C, VUFM-10C						
	GUFP-10C, VUFP-10C	16.20	15.23	.52	1.92	13.50	33.9
155	HUTR, P, M-21S, 21C						
	HUFR, P, M-21S, 21C	19.20	15.23	.62	1.61	18.25	33.9
165	JUFR, P, M-WUFP-10S, 10C	21.19	15.23	.72	1.39	13.50	33.9
225	TUFR, P, M-21S, 21C	21.16	15.23	.86	1.16	18.25	33.9
245	XUFR, P, M-21R, 21A	21.16	15.23	.86	1.16	18.25	33.9
	1973						
100	990206S, F	16.20	15.23	.52	1.92	13.50	33.9
120	990215S, F; 990207S, F	16.20	15.23	.52	1.92	13.50	33.9
140	990217S, F; 990216S, F	19.20	15.23	.62	1.61	13.50	33.9
165	990218S, F; 990210S, F	21.19	15.23	.72	1.39	13.50	33.9
225	990211S, F	21.16	15.23	.86	1.16	18.25	33.9
245	990212S, F	21.16	15.23	.86	1.16	18.25	33.9

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

		GEAR RATIOS				GEAR OIL CAPACITY	
HP	ENGINE MODEL	UPPER	LOWER	TOTAL	OVERALL	OUNCES UPPER	OUNCES LOWER
	1974						
120	990207R, 990215R	16.20	15.23	.52	1.92	13.50	33.9
140	990216FF, R	19.20	15.23	.62	1.61	13.50	33.9
165	990210R, 990218R	21.19	15.23	.72	1.39	13.50	33.9
170	990221R	21.19	15.23	.72	1.39	13.50	33.9
190	990220R	21.19	15.23	.72	1.39	13.50	33.9
225	990211R	21.16	15.23	.86	1.16	18.25	33.9
245	990212R	21.16	15.23	.86	1.16	18.25	33.9
	1975						
120	990224A (Selec Trim)	16.20	15.23	.52	1.92	13.50	33.9
120	990223A (Manual Trim)	16.20	15.23	.52	1.92	13.50	33.9
140	990226A (Selec Trim)	19.20	15.23	.62	1.61	13.50	33.9
	990225A (Manual Trim)	19.20	15.23	.62	1.61	13.50	33.9
165	990210R2 (Selec Trim)	21.19	15.23	.72	1.39	13.50	33.9
	990228A (Selec Trim)	21.19	15.23	.72	1.39	13.50	33.9
	990218R2 (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
	990227A (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
175	990229A (Fixed Mount)	21.19	15.23	.72	1.39	13.50	33.9
190	990220R2 (Fixed Mount)	21.19	15.23	.72	1.39	13.50	33.9
	990231A (Fixed Mount)	21.19	15.23	.72	1.39	13.50	33.9
225	990211R11 (Fixed Mount)	21.16	15.23	.86	1.16	18.25	33.9
	990211A (Fixed Mount)	21.16	15.23	.86	1.16	18.25	33.9
235	990240A (Fixed Mount)	21.16	15.23	.86	1.16	13.50	33.9
	990241A (SelecTrim)	21.16	15.23	.86	1.16	13.50	33.9
245	990212A (Fixed Mount)	21.16	15.23	.86	1.16	18.25	33.9

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

HP	ENGINE MODEL	GEAR RATIOS UPPER	LOWER	TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	OUNCES LOWER
	1976						
120	990224A11 (SelecTrim)	16.20	15.23	.52	1.92	13.50	33.9
	990235M (SelecTrim	16.20	15.23	.52	1.92	13.50	33.9
	990223A11 (Manual Trim)	16.20	15.23	.52	1.92	13.50	33.9
	990234M (Manual Trim)	16.20	15.23	.52	1.92	13.50	33.9
140	990226A11 (SelecTrim)	19.20	15.23	.62	1.61	13.50	33.9
	990237M (SelecTrim)	19.20	15.23	.62	1.61	13.50	33.9
	990225A11 (Manual Trim)	19.20	15.23	.62	1.61	13.50	33.9
	990236M (Manual Trim)	19.20	15.23	.62	1.61	13.50	33.9
165	990228A11 (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990239M (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990227A11 (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
	990238M (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
175	990230A11 (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990230M (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990229A11 (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
	990229M (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
190	990232A11 (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990232M (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990231A11 (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
	990231M (Manual Trim)	21.19	15.23	.72	1.39	13.50	33.9
225	990211A11 (Fixed Mount)	21.16	15.23	.86	1.16	18.50	33.9
	990211M (Fixed Mount)	21.16	15.23	.86	1.16	18.50	33.9
235	990240A11 (Manual Trim)	21.16	15.23	.86	1.16	13.50	33.9
	990240M (Manual Trim)	21.16	15.23	.86	1.16	13.50	33.9
	990241A11 (SelecTrim)	21.16	15.23	.86	1.16	13.50	33.9
	990241M (SelecTrim)	21.16	15.23	.86	1.16	13.50	33.9

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

HP	ENGINE MODEL	GEAR RATIOS UPPER	LOWER	TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	OUNCES LOWER
	1977						
120	990235E (SelecTrim)	16.20	15.23	.52	1.92	13.50	33.9
	990234E (Manual Trim)	16.20	15.23	.52	1.92	13.50	33.9
140	990237E (SelecTrim)	19.20	15.23	.62	1.61	13.50	33.9
	990236E (Manual Trim)	19.20	15.23	.62	1.61	13.50	33.9
175	990230E (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990229E (Fixed Trim)	21.19	15.23	.72	1.39	13.50	33.9
190	990232E (SelecTrim)	21.19	15.23	.72	1.39	13.50	33.9
	990231E (Fixed Trim)	21.19	15.23	.72	1.39	13.50	33.9
235	990240E (Fixed Trim)	21.16	15.23	.86	1.16	13.50	33.9
	990241E (SelecTrim)	21.16	15.23	.86	1.16	13.50	33.9
	1978						
120	990243D & H (SelecTrim)	21.18	13.26	.61	1.64	13.50	33.8
	990242D & H (Fixed Trim)	21.18	13.26	.61	1.64	13.50	33.8
	990245D & H (SelecTrim)	21.18	13.26	.61	1.64	13.50	33.8
140	990244D & H (Fixed Trim)	21.18	13.26	.61	1.64	13.50	33.8
	990253D & H (SelecTrim)	21.17	14.26	.67	1.49	13.50	33.8
185	990252D & H (Fixed Trim)	21.17	14.26	.67	1.49	13.50	38.4
	990255D & H (SelecTrim)	21.16	14.26	.71	1.41	13.50	38.4
225	990254D & H (SelecTrim)	21.16	14.26	.71	1.41	13.50	38.4
	990251D (SelecTrim)	21.16	14.26	.71	1.41	13.50	38.4
240	990250D (Fixed Trim)	21.16	14.26	.71	1.41	13.50	38.4

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

HP	ENGINE MODEL	GEAR RATIOS UPPER	GEAR RATIOS LOWER	GEAR RATIOS TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	GEAR OIL CAPACITY OUNCES LOWER
	1979						
120	990243 (SelecTrim)	21.18	13.26	.61	1.64	13.50	33.8
	990242 (Fixed Trim)	21.18	13.26	.61	1.64	13.50	33.8
140	990245 (SelecTrim)	21.18	13.26	.61	1.64	13.50	33.8
	990244 (Fixed Trim)	21.18	13.26	.61	1.64	13.50	33.8
185	990253 (SelecTrim)	21.17	14.26	.67	1.49	13.50	38.4
	990252 (Fixed Trim)	21.17	14.26	.67	1.49	13.50	38.4
200	990267 (SelecTrim)	21.17	14.26	.67	1.49	13.50	38.4
	990266 (Fixed Trim	21.17	14.26	.67	1.49	13.50	38.4
230	990255 (SelecTrim)	21.16	14.26	.71	1.41	13.50	38.4
	990254 (Fixed Trim)	21.16	14.26	.71	1.41	13.50	38.4
250	990251 (SelecTrim)	21.16	14.26	.71	1.41	13.50	38.4
260	990257 (SelecTrim)	21.16	14.26	.71	1.41	13.50	38.4
	990256 (Fixed Trim)	21.16	14.26	.71	1.41	13.50	38.4
	1980						
120	990242C & 2CI (Fixed Trim)	21.18	13.26	.61	1.64	16.6	33.8
	990243C & 3CI (Selec Trim)	21.18	13.26	.61	1.64	16.6	33.8
140	990244C & 4CI (Fixed Trim)	21.18	13.26	.61	1.64	16.6	33.8
	990245C & 5CI (Selec Trim)	21.18	13.26	.61	1.64	16.6	33.8
185	990252C & 2CK (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	990253C & 3CK (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
200	990266C & 6CK (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	990267C & 7CK (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
	990260C & 0CK (SelecTrim w/P.S.)	21.17	14.26	.67	1.49	16.6	38.4
230	990254C & 4CK (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	990255C &5CK (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
	990261C & 1CK (SelecTrim w/P.S.)	21.17	14.26	.67	1.49	16.6	38.4
260	990256C & 6CK (Fixed Trim)	21.16	14.26	.71	1.41	16.6	38.4
	990257C & 7CK (SelecTrim)	21.16	14.26	.71	1.41	16.6	38.4
	990262C & 2CK (SelecTrim w/P.S.)	21.16	14.26	.71	1.41	16.6	38.4

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

HP	ENGINE MODEL	GEAR RATIOS UPPER	GEAR RATIOS LOWER	GEAR RATIOS TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	GEAR OIL CAPACITY OUNCES LOWER
1981							
120	990242C & 2C1 (Fixed Trim)	21.18	13.26	.61	1.64	16.6	33.8
	120FTHRCIS & CIF (Fixed Trim)	21.18	13.26	.61	1.64	16.6	33.8
	990243C & 3CI (SelecTrim)	21.18	13.26	.61	1.64	16.6	33.8
	120STHRCIS & CIF (SelecTrim)	21.18	13.26	.61	1.64	16.6	33.8
140	990244C & 4CI (Fixed Trim)	21.18	13.26	.61	1.64	16.6	33.8
	140FTHRCIS & CIF (Fixed Trim)	21.18	13.26	.61	1.64	16.6	33.8
	993245C & 5CI (SelecTrim)	21.18	13.26	.61	1.64	16.6	33.8
	140STHRCIS & CIF (SelecTrim)	21.18	13.26	.61	1.64	16.6	33.8
	140SPHRCIS & CIF(SelecTrim w/P.S.)	21.18	13.26	.61	1.64	16.6	33.8
170							
3.8 Litre	170STMRCIS (SelecTrim)	21.20	14.26	.57	1.77	16.6	38.4
	170SPMRCIS (SelecTrim w/P.S.)	21.20	14.26	.57	1.77	16.6	38.4
185	990252C & 2CK (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	990253C & 3CK (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
200	990266C & 6CK (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	200FTHRCIS & CIF (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	990267C & 7CK (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
	200STHRCIS & CIF (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
	990260C &0CK(Selec Trim w/P.S.)	21.17	14.26	.67	1.49	16.6	38.4
	200SPHRCIS & CIF(SelecTrim w/P.S.)	21.17	14.26	.67	1.49	16.6	38.4
230	9902546 & 4CK (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	230FTHRCIS & CIF (Fixed Trim)	21.17	14.26	.67	1.49	16.6	38.4
	990255C & 5CK (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
	230STHRCIS & CIF (SelecTrim)	21.17	14.26	.67	1.49	16.6	38.4
	990261C & 1CK (SelecTrim w/P.S.)	21.17	14.26	.67	1.49	16.6	38.4
	230SPHRCIS & CIF(SelecTrim w/P.S.)	21.17	14.26	.67	1.49	16.6	38.4
260	990256C & 6CK (Fixed Trim)	21.16	14.26	.71	1.41	16.6	38.4
	260FTHRCIS & CIF (Fixed Trim)	21.16	14.26	.71	1.41	16.6	38.4
	990257C & 7CK (SelecTrim)	21.16	14.26	.71	1.41	16.6	38.4
	260STHRCIS & CIF (SelecTrim)	21.16	14.26	.71	1.41	16.6	38.4
	990262C & 2cK (SelecTrim w/P.S.)	21.16	14.26	.71	1.41	16.6	38.4
	260SPHRCIS & CIF(SelecTrim w/P.S.)	21.16	14.26	.71	1.41	16.6	38.4

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

			GEAR RATIOS			GEAR OIL CAPACITY	
MODEL	IDENTIFICATION	UPPER	LOWER	TOTAL	OVERALL	OUNCES UPPER	OUNCES LOWER
1982							
2.5 Litre (120 HP)	252FTHRCNC	21:18	13:26	.58	1.71	16.6	Z6.7
	252FPHRCNC (w/P.S.)	21:18	13:26	.58	1.71	16.6	Z6.7
	252STHRCNC (SelecTrim)	21:18	13:26	.58	1.71	16.6	Z6.7
	252SPHRCNC (SelecTrim, w/P.S.)	21:18	13:26	.58	1.71	16.6	Z6.7
3.0 Litre (140 HP)	302FTHRCNC	21:18	13:26	.58	1.71	16.6	Z6.7
	302FPHRCNC (w/P.S.)	21:18	13:26	.58	1.71	16.6	Z6.7
	302STHRCNC (SelecTrim)	21:18	13:26	.58	1.71	16.6	Z6.7
	302SPHRCNC (SelecTrim, w/P.S.)	21:18	13:26	.58	1.71	16.6	Z6.7
3.8 Litre (170 HP) 2 BBL	382STMRCNC (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
	382SPMRCNC (SelecTrim, w/P.S.)	21:20	14:26	.57	1.77	16.6	32.1
	382STMCCNC (SelecTrim, Closed Cool)	21:20	14:26	.57	1.77	16.6	32.1
	382SPMCCNC (SelcTrim, P.S., C.C.)	21:20	14:26	.57	1.77	16.6	32.1
3.8 Litre (170 HP) 4 BBL	384STMRCNC (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
	384SPMRCNC (SelecTrim, P.S.)	21:20	14:26	.57	1.77	16.6	32.1
	384STMCCNC (SelocTrim, Closed Cool)	21:20	14:26	.57	1.77	16.6	32.1
	384SPMCCNC (SelecTrim, P.S., C.C.)	21:20	14:26	.57	1.77	16.6	32.1
5.0 Litre (305 CID) 2 BBL	502STHRCNC (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
	502SPHRCNC (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1
	502STHCCNC (SelecTrim Closed Cool)	21:17	14:26	.67	1.50	16.6	32.1
	502SPHCCNC (SelecTrim, P.S., C.C)	21:17	14:26	.67	1.50	16.6	32.1
	502STMRCNC (S.T., Mid-rise Elbow)	21:17	14:26	.67	1.50	16.6	32.1
	502SPMRCNC (S.T., P.S., Mid-rise)	21:17	14:26	.67	1.50	16.6	32.1
	502STMCCNC (S.T., Mid-rise, C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	502SPMCCNC (S.T., P.S., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1

1982 Continued on Next Page

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PACE A-69

MODEL	IDENTIFICATION	GEAR RATIOS UPPER	LOWER	TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	OUNCES LOWER
	1982 Continued						
5.0 Litre	504STHRCNC (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
(307 CID)	504SPHRCNC (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1
4BBL	504STHCCNC (SelecTrim, Closed Cool)	21:17	14:26	.67	1.50	16.6	32.1
	504SPHCCNC (SelecTrirn, P.S., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	504STMRCNC (S.T., Mid-Rise Elbow)	21:17	14:26	.67	1.50	16.6	32.1
	504SPMRCNC (S.T., P.S., M.R.E.)	21:17	14:26	.67	1.50	16.6	32.1
	504STMCCNC (S.T., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	504SPMCCNC (S.T., P.S., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
5.7 Litre	574STHRCNC (SelecTrim)	21:16	14:26	.71	1.41	16.6	32.1
(350 CID)	574SPHRCNC (SelecTrim, P.S.)	21:16	14:26	.71	1.41	16.6	32.1
	574STHCCNC (SelecTrirn, Closed Cool)	21:16	14:26	.71	1.41	16.6	32.1
	574SPHCCNC (SelecTrim, P.S., C.C.)	21:16	14:26	.71	1.41	16.6	32.1
	574STMRCNC (SelecTrim, M.R.E.)	21:16	14:26	.71	1.41	16.6	32.1
	574SPMRCNC (S.T., P.S., M.R.E.)	21:16	14:26	.71	1.41	16.6	32.1
	574STMCCNC (S.T., M.R.E., C.C.)	21:16	14:26	.71	1.41	16.6	32.1
	574SPMCCNC (S.T., P.S., M.R.E., C.C.)	21:16	14:26	.71	1.41	16.6	32.1
1983							
2.5 Litre	252FTHRCTR	21:18	13:26	.58	1.71	16.6	26.7
(120 HP)	252FPHRCTR (Power Steering)	21:18	13:26	.58	1.71	16.6	26.7
	252STHRCTR (SelecTrim)	21:18	13:26	.58	1.71	16.6	26.7
	252SPHRCTR (SelecTrim, P.5.)	21:18	13:26	.58	1.71	16.6	26.7
3.0 Litre	302FTHRCTR	21:18	13:26	.58	1.71	16.6	26.7
(140 HP)	302FPHRCTR (Power Steering)	21:18	13:26	.58	1.71	16.6	26.7
	302STHRCTR (SelecTrim)	21:18	13:26	.58	1.71	16.6	26.7
	302SPHRCTR (SelecTrim, P.S.)	21:18	13:26	.58	1.71	16.6	26.7

1983 Continued on Next Page

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

MODEL	IDENTIFICATION	GEAR RATIOS UPPER	GEAR RATIOS LOWER	GEAR RATIOS TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	GEAR OIL CAPACITY OUNCES LOWER
	1983 Continued						
3.8 Litre	382STMRCTR (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
(170 HP)	382SPMRCTR (SelecTrim, P.S.)	21:20	14:26	.57	1.77	16.6	32.1
2 BBL	382STMCCTR (SelecTrim, Closed Cool)	21:20	14:26	.57	1.77	16.6	32.1
	382SPMCCTR (SelecTrim, P.S., C.C.)	21:20	14:26	.57	1.77	16.6	32.1
3.8 Litre	384STMRCTR (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
(170 HP)	384SPMRCTR (SelecTrim, P.S.)	21:20	14:26	.57	1.77	16.6	32.1
4 BBL	384STMCCTR (SelecTrim, Closed Cool)	21:20	14:26	.57	1.77	16.6	32.1
	384SPMCCTR (SelecTrim, P.S., C.C.)	21:20	14:26	.57	1.77	16.6	32.1
5.0 Litre	502STHRCTR (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
(305 CID)	502SPHRCTR (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1
2 BBL	502STHCCTR (SelecTrim, Closed Cool)	21:17	14:26	.67	1.50	16.6	32.1
	502SPHCCTR (SelecTrim, P.S., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	502STMRCTR (S.T., Mid-rise Elbow)	21:17	14:26	.67	1.50	16.6	32.1
	502SPMRCTR (S.T., P.S., M.R.E.)	21:17	14:26	.67	1.50	16.6	32.1
	502STMCCTR (S.T., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	502SPMCCTR (S.T., P.S., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
5.0 Litre	504STHRCTR (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
(307 CID)	504SPHRCTR (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1
4 BBL	504STHCCTR (SelecTrim, Closed Cool)	21:17	14:26	.67	1.50	16.6	32.1
	504SPHCCTR (S.T., P.S., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	504STMRCTR (S.T., Mid-rise Elbow)	21:17	14:26	.67	1.50	16.6	32.1
	504SPMRCTR (S.T., P.S., M.R.E.)	21:17	14:26	.67	1.50	16.6	32.1
	504STMCCTR (S.T., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1
	504SPMCCTR (S.T., P.S., M.R.E., C.C.)	21:17	14:26	.67	1.50	16.6	32.1

1983 Continued on Next Page

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

MODEL	IDENTIFICATION	GEAR RATIOS CPPER	LOWER	TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	OUNCES LOWER
	1983 Continued						
5.7 Litre	574STHRCTR (SelecTrim)	21:16	14:26	.71	1.41	16.6	32.1
(350 CID)	574SPHRCTR (SelecTrim, P.S.)	21:16	14:26	.71	1.41	16.6	32.1
	574STHCCTR (SelecTrim, Closed Cool)	21:16	14:26	.71	1.41	16.6	32.1
	574SPHCCTR (S.T., P.S., C.C.)	21:16	14:26	.71	1.41	16.6	32.1
	574STMRCTR (S.T., Mid-rise Elbow)	21:16	14:26	.71	1.41	16.6	32.1
	574SPMRCTR (S.T., P.S., M.R.E.)	21:16	14:26	.71	1.41	16.6	32.1
	574STMCCTR (S.T., W.R.E., C.C.)	21:16	14:26	.71	1.41	16.6	32.1
	574SPMCCTR (S.T., P.S., M.R.E., C.C.)	21:16	14:26	.71	1.41	16.6	32.1
	1984						
2.5 Litre	252FTHRCR (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
(120 HP)	252STHRCR (SelecTrim)	21:18	13:26	.58	1.7 1	16.6	26.7
3.0 Litre	302FTHRCR (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
(140 HP)	302STHRCR (SelecTrim)	21:18	13:26	.58	1.71	16.6	26.7
	302SPHRCR (SelecTrim, P.S.)	21:18	13:26	.58	1.7 1	16.6	26.7
3.8 Litre	382FTMRCR (Preset Trim)	21:20	14:26	.57	1.77	16.6	32.1
(170 HP)	382STMRCR (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
2 BBL	382SPMRCR (SelecTrim P.S.)	21:20	14.26	.57	1.77	16.6	32.1
3.8 Litre	384FTMRCR (Preset Trim)	21:20	14:26	.57	1.77	16.6	32.1
(170 HP)	384STMRCR (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
4 BBL	384SPMRCR (SelecTrim, P.S.)	21:20	14:26	.57	1.77	16.6	32.1
5.0 Litre	502FTHRCR (Preset Trim)	21:17	14:26	.67	1.50	16.6	32.1
(305 CID)	502STHRCR (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
2 BBL	502SPHRCR (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1

1984 Continued on Next Page

ENGINE MODEL – GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A–69

MODEL	IDENTIFICATION	GEAR RATIOS UPPER	LOWER	TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	OUNCES LOWER
	1984 Continued						
5.0 Litre	504FTHRCR (Preset Trim)	21.17	14:26	.67	1.50	16.6	32.1
(307 CID)	504STHRCR (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
4BBL	504SPHRCR (SelecTrim P.S.)	21:17	14:26	.67	1.50	16.6	32.1
5.7 Litre	574FTHRCR (Preset Trim)	21:16	14:26	.71	1.41	16.6	32.1
(350 CID)	574STHRCR (SelecTrim)	21:16	14:26	.71	1.4 1	16.6	32.1
	574SPHRCR (SelecTrim, P.S.)	21:16	14:26	.71	1.4 1	16.6	32.1
	1985						
2.5 Litre	252FTHRCO (Preset Trim)	21:18	13:26	.58	1.7 1	16.6	26.7
(120 HP)	252STHRCO (SelecTrim)	21:18	13:26	.58	1.7 1	16.6	26.7
3.0 Litre	302FTHRCO (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
(140 HP)	302STHRCO (SelecTrim)	21:18	13:26	.58	1.7 1	16.6	26.7
	302SPHRCO (SelecTrim, P.S.)	21:18	13:26	.58	1.7 1	16.6	26.7
3.8 Litre	382FTMRCO (Preset Trim)	21:20	14:26	.57	1.77	16.6	32.1
(170 HP)	382STMRCO (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
2 BBL	382SPMRCO (SelecTrim P.S.)	21:20	14.26	.57	1.77	16.6	32.1
3.8 Litre	384FTMRCO (Preset Trim)	21:20	14:26	.57	1.77	16.6	32.1
(170 HP)	384STMRCO (SelecTrim)	21:20	14:26	.57	1.77	16.6	32.1
4 BBL	384SPMRCO (SelecTrim, P.S.)	21:20	14:26	.57	1.77	16.6	32.1
5.0 Litre	502FTHRCO (Preset Trim)	21:17	14:26	.67	1.50	16.6	32.1
(305 CID)	502STHRCO (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
2 BBL	502SPHRCO (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1

1985 Continued on Next Page

ENGINE MODEL — GEAR RATIOS — OIL CAPACITIES

SEE GENERAL AND SPECIAL NOTES APPENDIX PAGE A-69

MODEL	IDENTIFICATION	GEAR RATIOS UPPER	GEAR RATIOS LOWER	GEAR RATIOS TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	GEAR OIL CAPACITY OUNCES LOWER
	1985 Continued						
5.0 Litre (307 CID) 4 BBL	504FTHRCO (Preset Trim)	21.17	14:26	.67	1.50	16.6	32.1
	504STHRCO (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
	504SPHRCO (SelecTrim P.S.)	21:17	14:26	.67	1.50	16.6	32.1
5.7 Litre (350 CID)	574FTHRCO (Preset Trim)	21:16	14:26	.71	1.41	16.6	32.1
	574STHRCO (SelecTrim)	21:16	14:26	.71	1.41	16.6	32.1
	574SPHRCO (SelecTrim, P.S.)	21:16	14:26	.71	1.41	16.6	32.1
	1986						
2.5 Litre (120 hp)	252FTHRCO (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
	252STHRCO (SelecTrim)	21:18	13:26	.58	1.71	16.6	26.7
	252FTHRCD (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
3.0 Litre (140 hp)	302FTHRCO (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
	302STHRCO (SelecTrim)	21:18	13:26	.58	1.71	16.6	26.7
	302SPHRCO (SelecTrim,P.S.)	21:18	13:26	.58	1.71	16.6	26.7
	302FTHRCD (Preset Trim)	21:18	13:26	.58	1.71	16.6	26.7
4.3 Litre (262 CID) 2BBL	432FTMRCO (Preset Trim)	21:19	14:26	.60	1.68	16.6	32.1
	432STMRCO (SelecTrim)	21:19	14:26	.60	1.68	16.6	32.1
	432SPMRCO (SelecTrim, P.S.)	21:19	14:26	.60	1.68	16.6	32.1
	432FTMRCD (Preset Trim)	21:19	14:26	.60	1.68	16.6	32.1
4.3 Litre (264 CID) 4BBL	434FTMRCO (Preset Trim)	21:19	14:26	.60	1.68	16.6	32.1
	434STMRCO (SelecTrim)	21:19	14:26	.60	1.68	16.6	32.1
	434SPMRCO (SelecTrim, P.S.)	21:19	14:26	.60	1.68	16.6	32.1
	434FTMRCD (Preset Trim)	21:19	14:26	.60	1.68	16.6	32.1

ENGINE MODEL – GEAR RATIOS – OIL CAPACITIES

MODEL	IDENTIFICATION	GEAR RATIOS UPPER	GEAR RATIOS LOWER	GEAR RATIOS TOTAL	OVERALL	GEAR OIL CAPACITY OUNCES UPPER	GEAR OIL CAPACITY OUNCES LOWER
	1986 Continued						
5.0 Litre	502FTHRCO (Preset Trim)	21:17	14:26	.67	1.50	16.6	32.1
(305 CID)	502STHRCO (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
2BBL	502SPHRCO (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1
	502FTHRCD (Preset Trim)	21:17	14:26	.67	1.50	16.6	32.1
5.0 Litre	504FTHRCO (Preset Trim)	21:17	14:26	.67	1.50	16.6	32.1
(307 CID)	504STHRCO (SelecTrim)	21:17	14:26	.67	1.50	16.6	32.1
4BBL	504SPHRCO (SelecTrim, P.S.)	21:17	14:26	.67	1.50	16.6	32.1
	504FTHRCD (Preset Trim)	21:17	14:26	.67	1.50	16.6	32.1
5.7 Litre	574FTHRCO (Preset Trim)	21:16	14:26	.71	1.41	16.6	32.1
(350 CID)	574STHRCO (SelecTrim)	21:16	14:26	.71	1.41	16.6	32.1
	574SPHRCO (SelecTrim, P.S.)	21:16	14:26	.71	1.41	16.6	32.1
	574FTHRCD (Preset Trim)	21:16	14:26	.71	1.41	16.6	32.1

GENERAL NOTES

P.S. = Power Steering **S.T. = SelecTrim** **C.C. = Closed Cooling** **M.R.E. = Mid-rise Elbow**

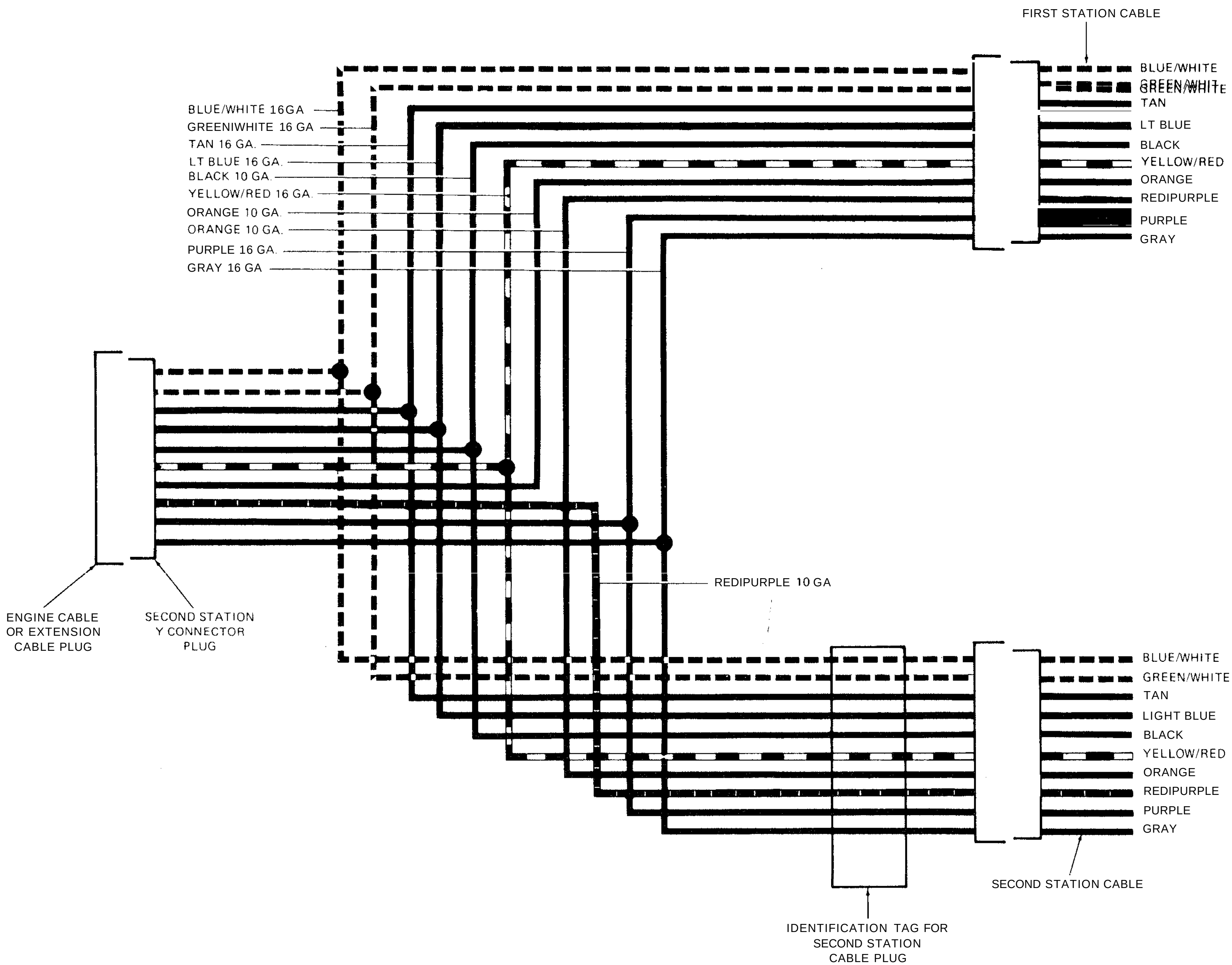
The 19.29 ratio gearcase is marked with an **"H"** on the skeg. The 24.18 unit is marked with a **"T"** on the upper casting. The 15.23 unit is marked with a **"B"** or an **"O"** on the skeg.

SPECIAL NOTES

Gear Ratio Total is the relationship of one revolution of the ball gear shaft (input shaft) and the revolution of the output shaft -- propeller shaft. As an example: one revolution of the input shaft may result in the propeller shaft rotating .52 or approximately 1/2 turn.

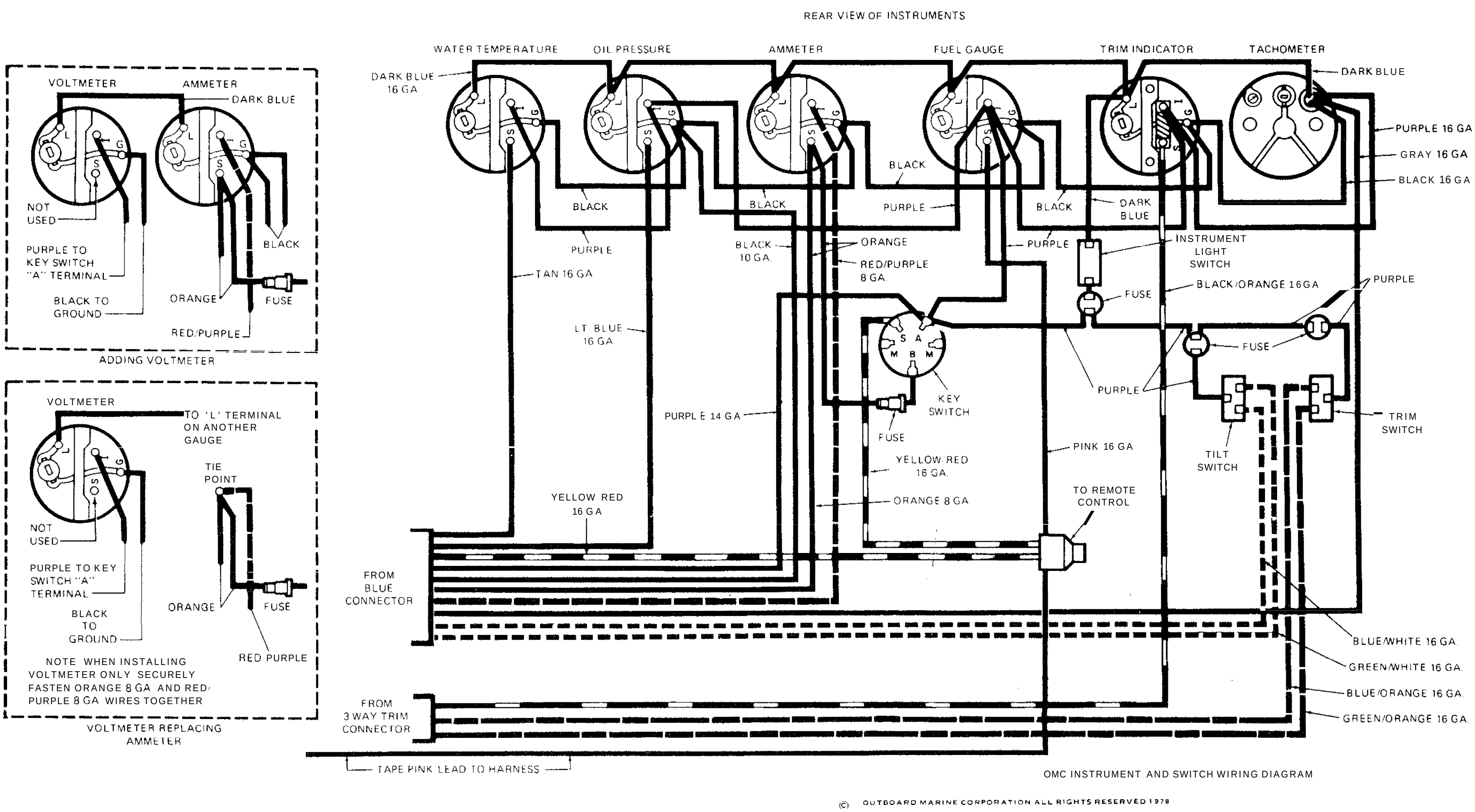
Overall Ratio is the relationship of how much the input shaft must rotate to result in one full revolution of the propeller shaft. Example: one full turn of the propeller shaft resulted in the input shaft rotating 1.92 revolutions.

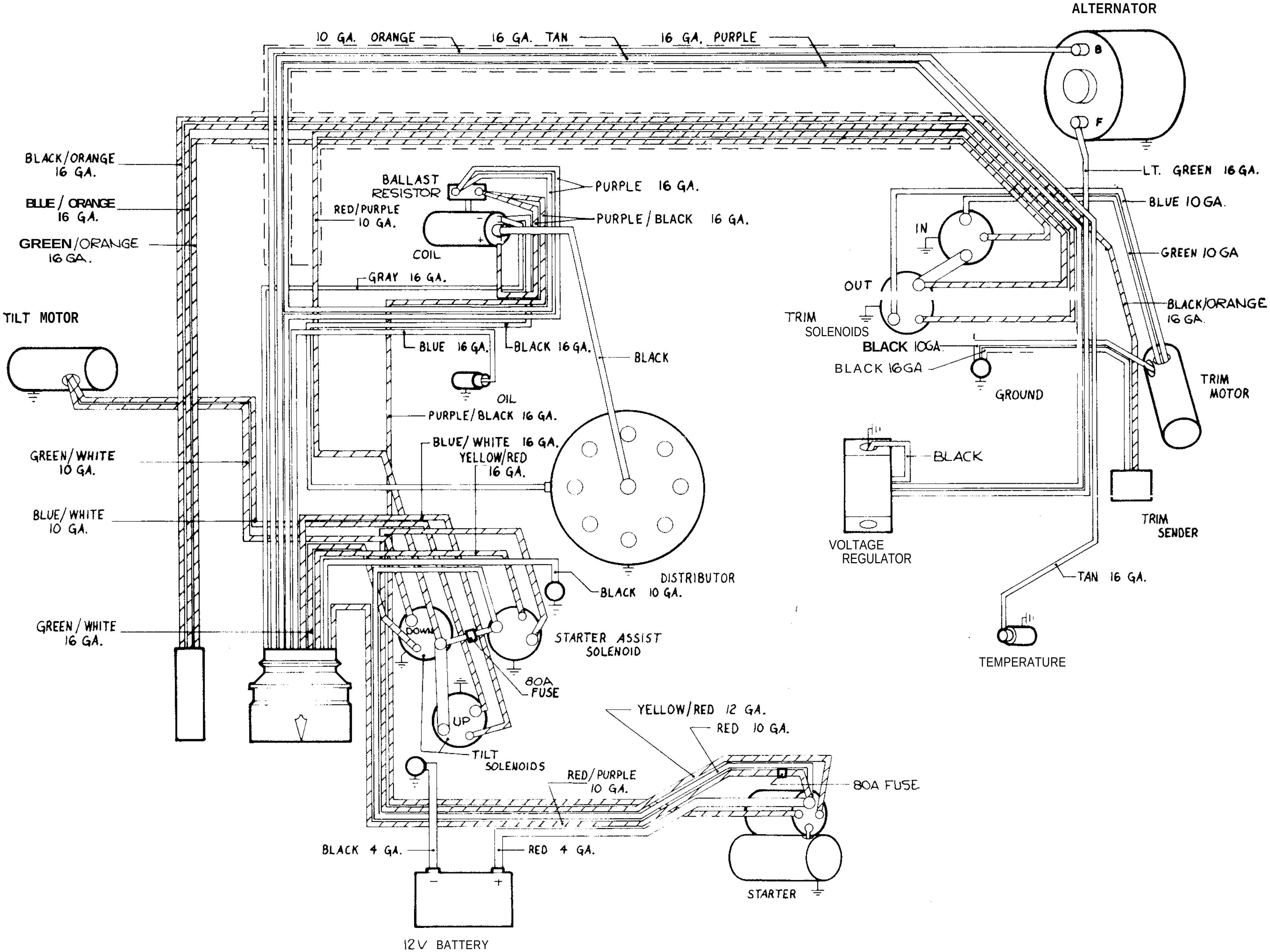
Intermediate Housing: To service the intermediate housing with an oil bath, the lubricant must be siphoned out. A drain plug was not installed until 1980. The intermediate housing oil capacities are: 6.95 ounces, 1968-72; 6.25 ounces, 1973 and on.



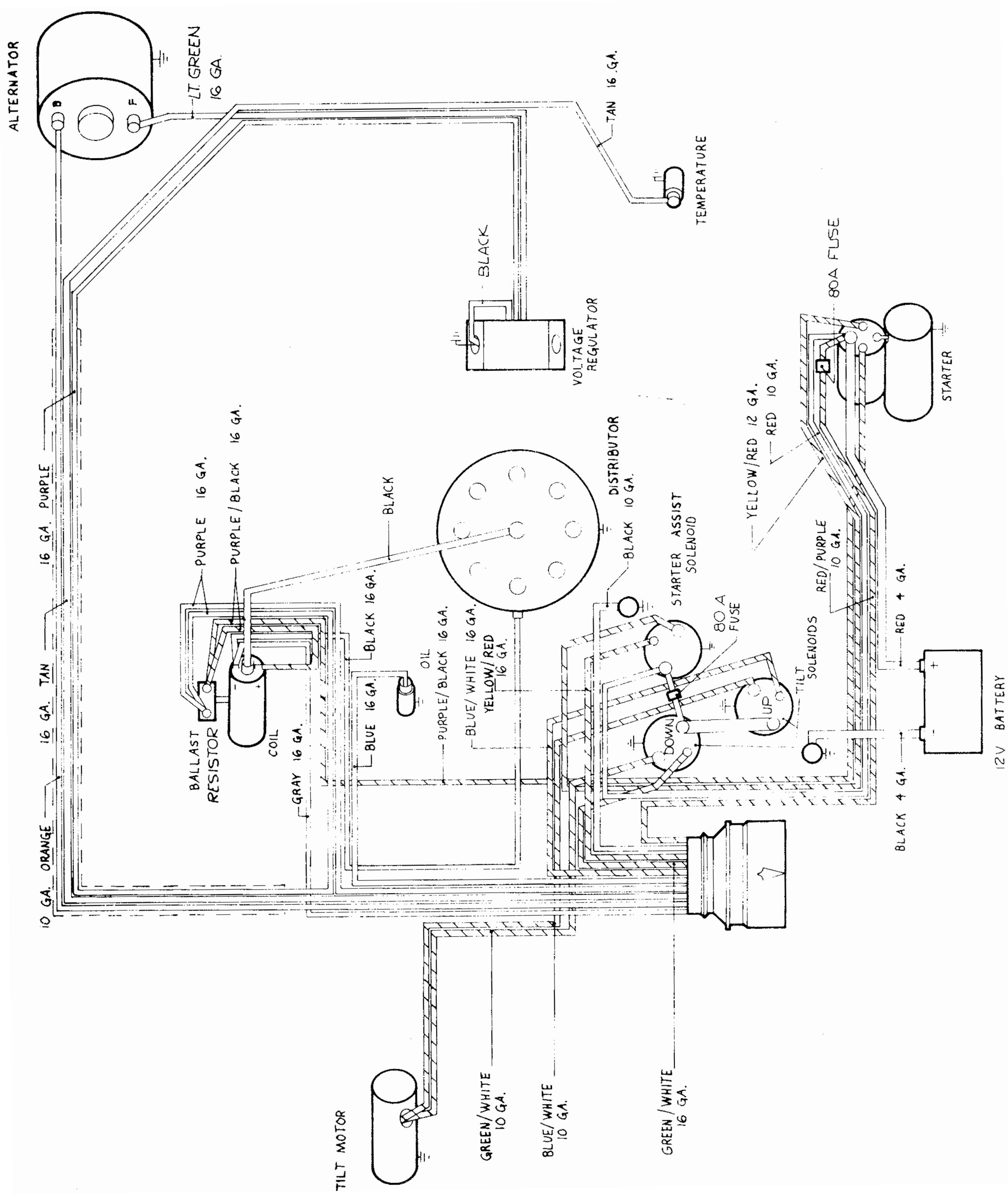
Wire identification for the second station instrument cable connector.

Wiring diagram for the stern drive instrument, cable, and switch.

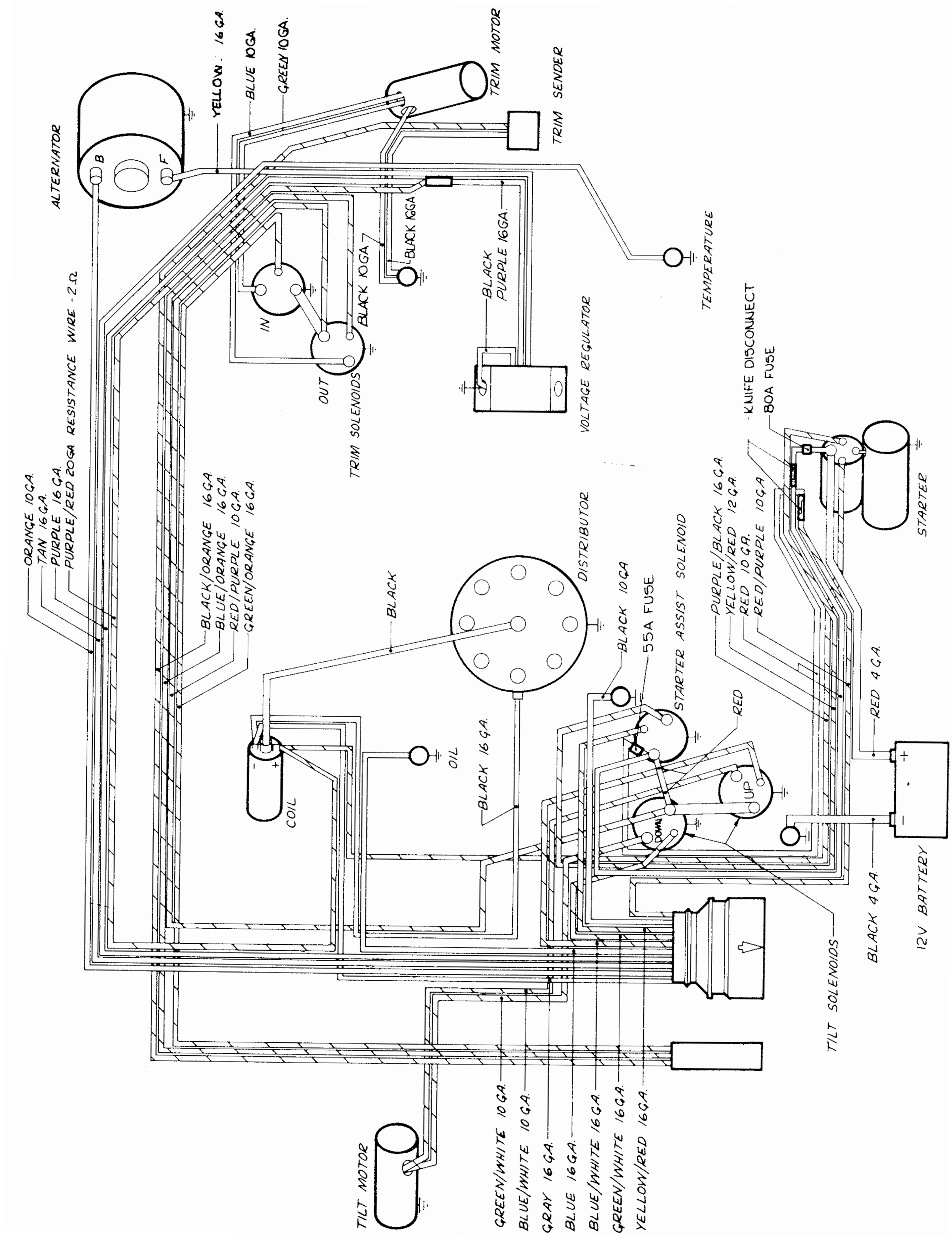




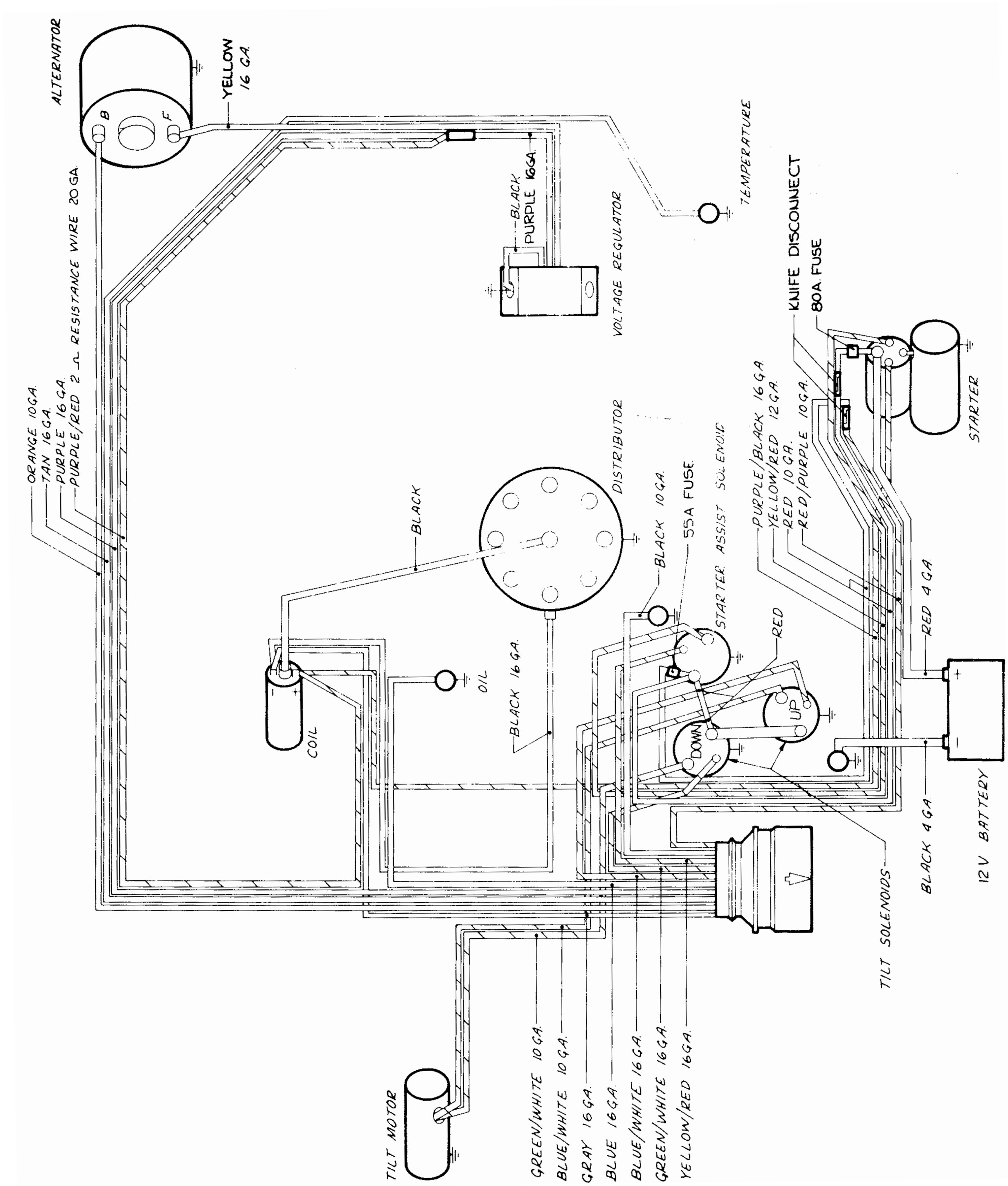
Wire identification for the 185/225 hp SelecTrim Model "D" (with ballast resistor).



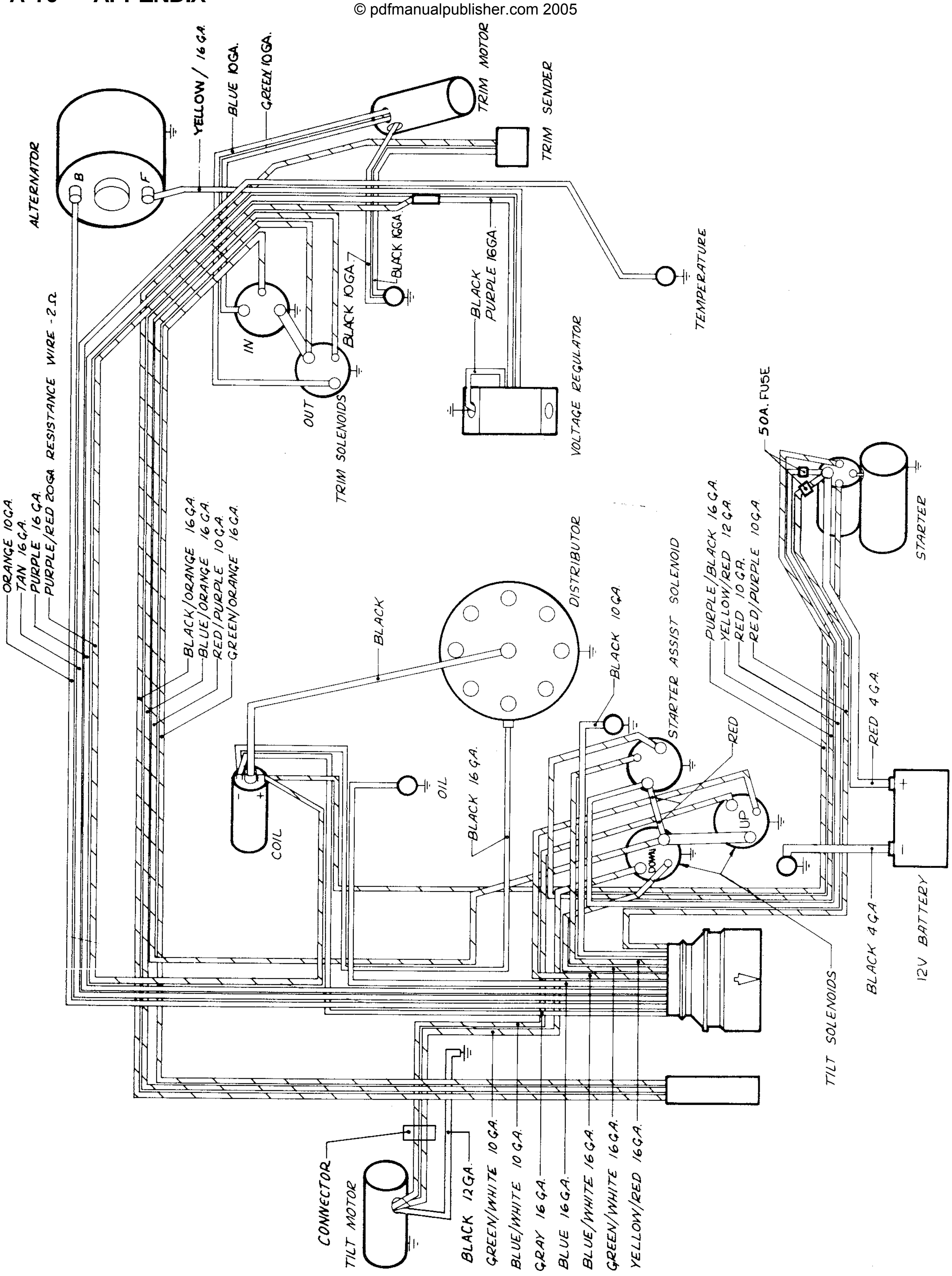
Wire identification for the 185/225 hp pre-set trim Model "D" (with ballast resistor).



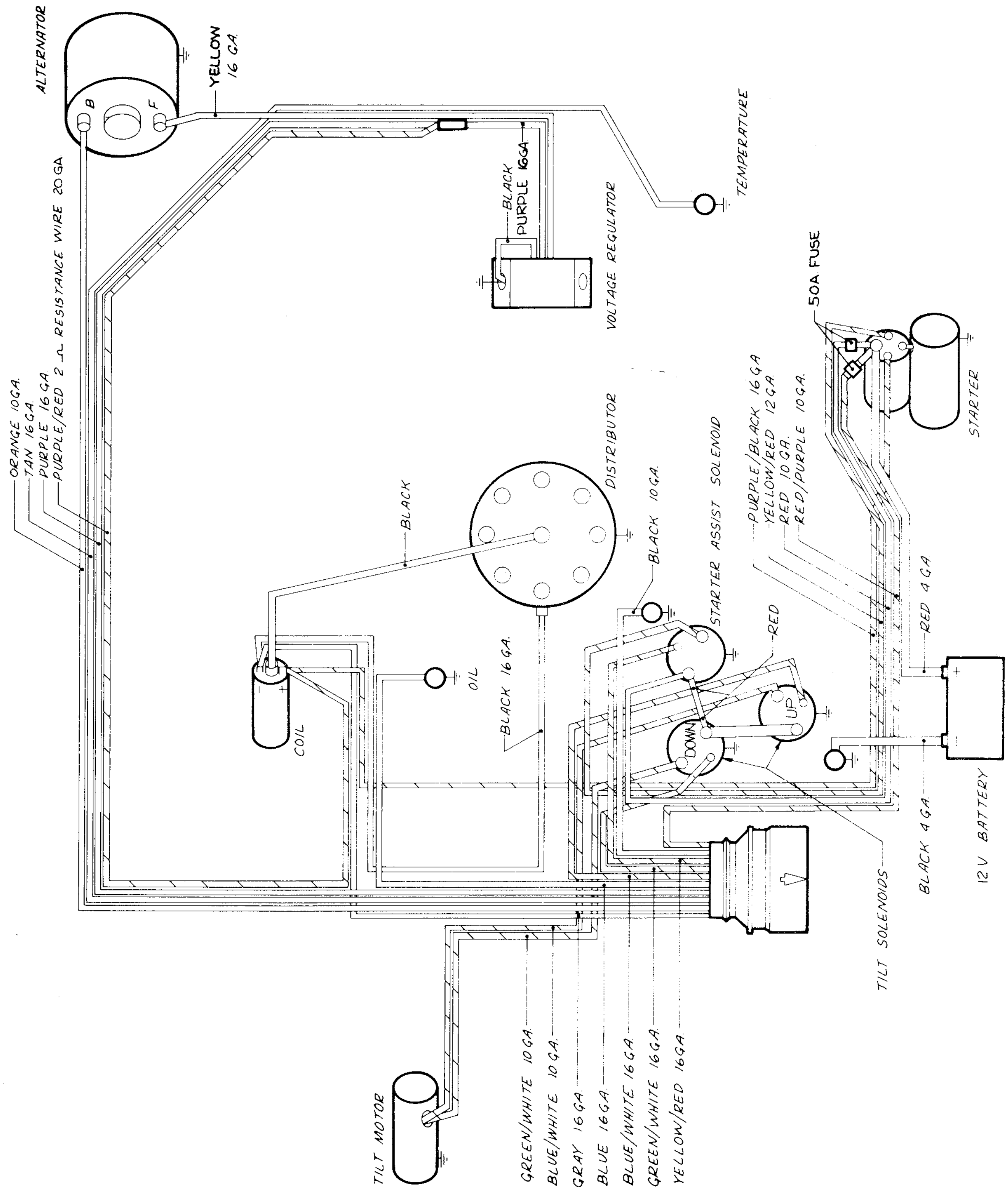
Wire identification for the 185/225 hp SelecTrim Models "H" & "J" (with resistor wire).



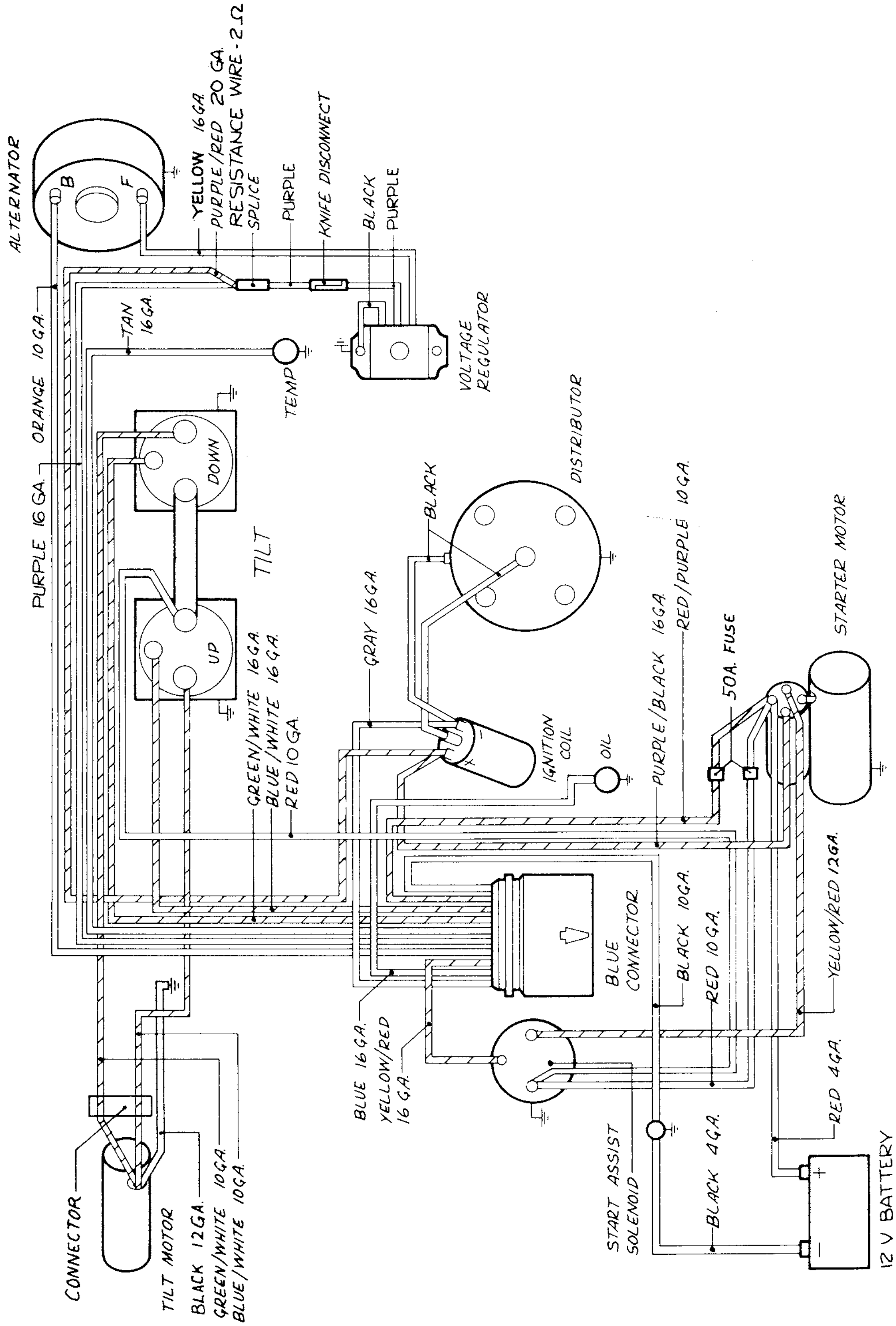
Wire identification for the 185/225 hp pre-set trim Models "H" & "J" (with resistor wire).



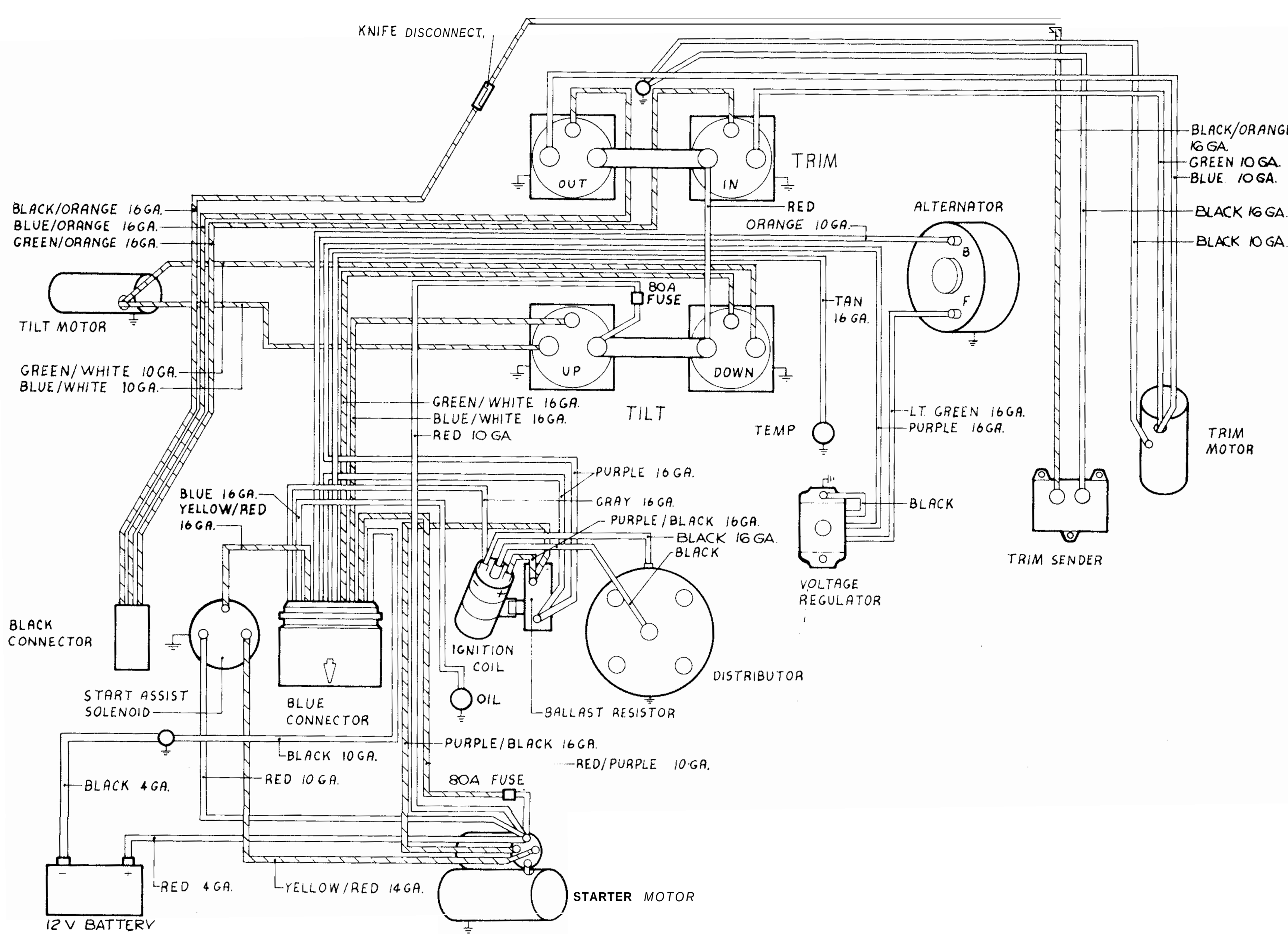
Wire identification for the 185, 200, 230, and 260 hp Selectrim models.



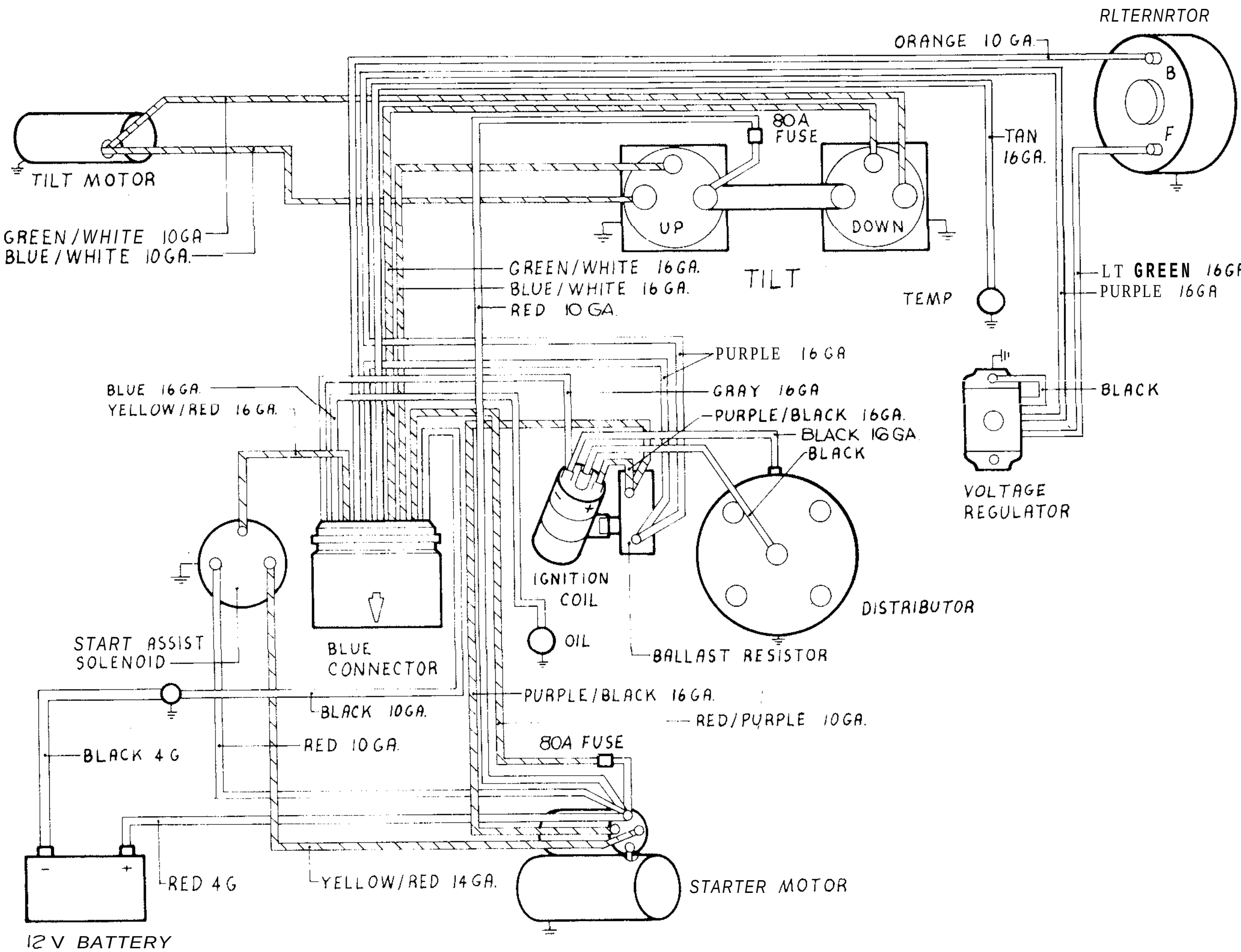
Wire identification for the 185, 200, 230, and 260 hp pre-set trim models.



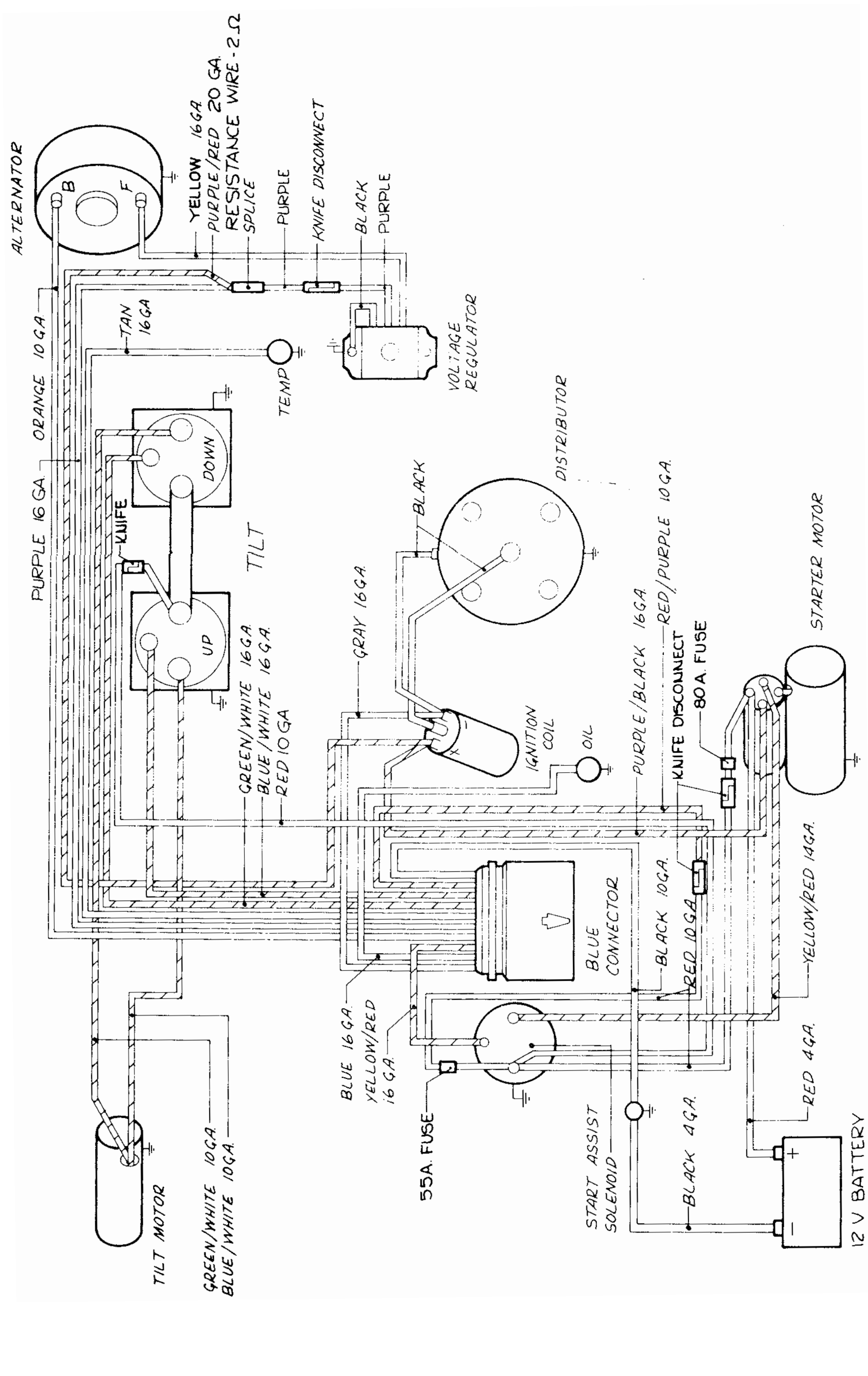
Wire identification for the 120 and 140 hp pre-set trim models.



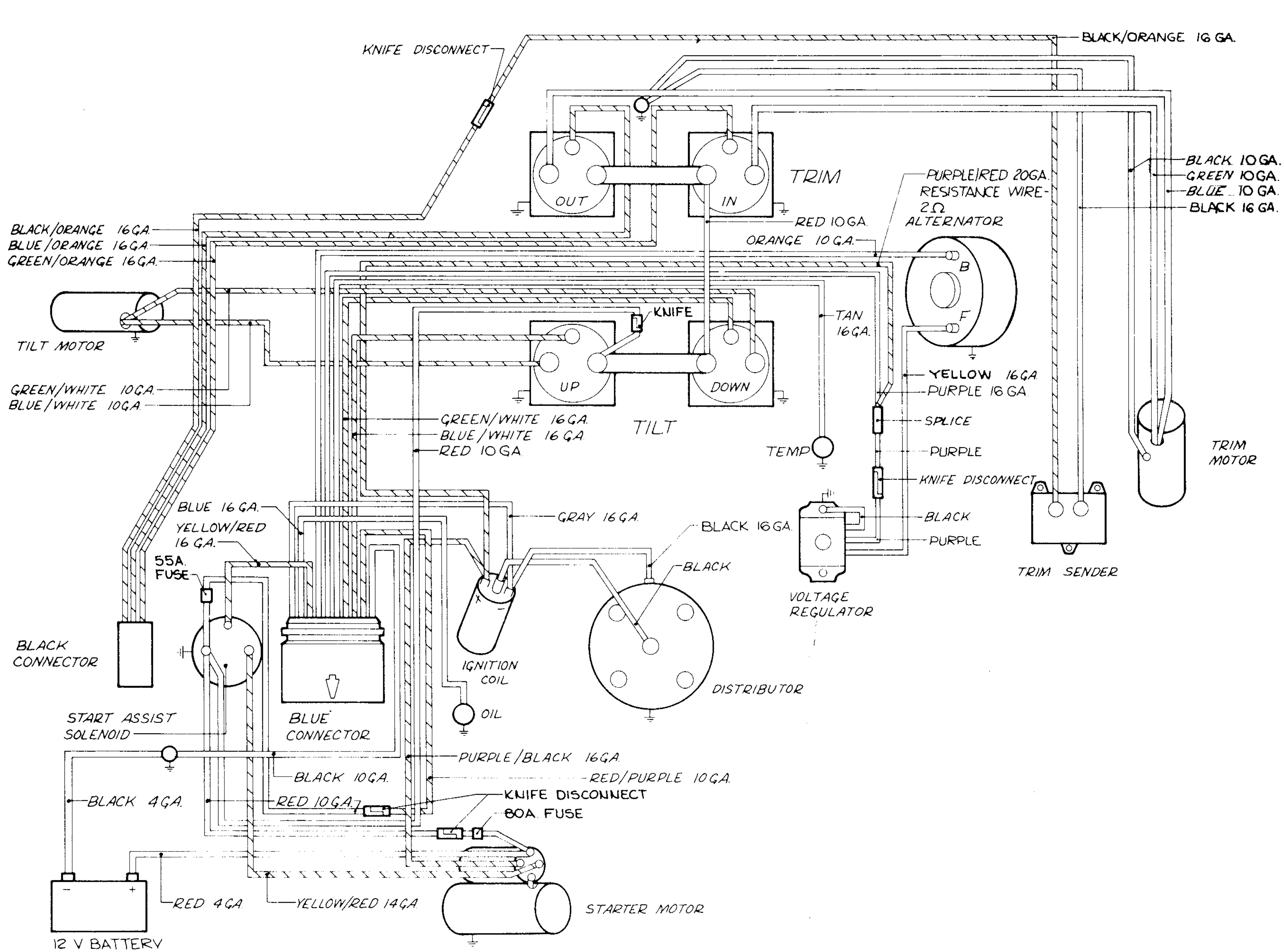
Wire identification for the 120/140 hp SelecTrim Model "D" (with ballast resistor).



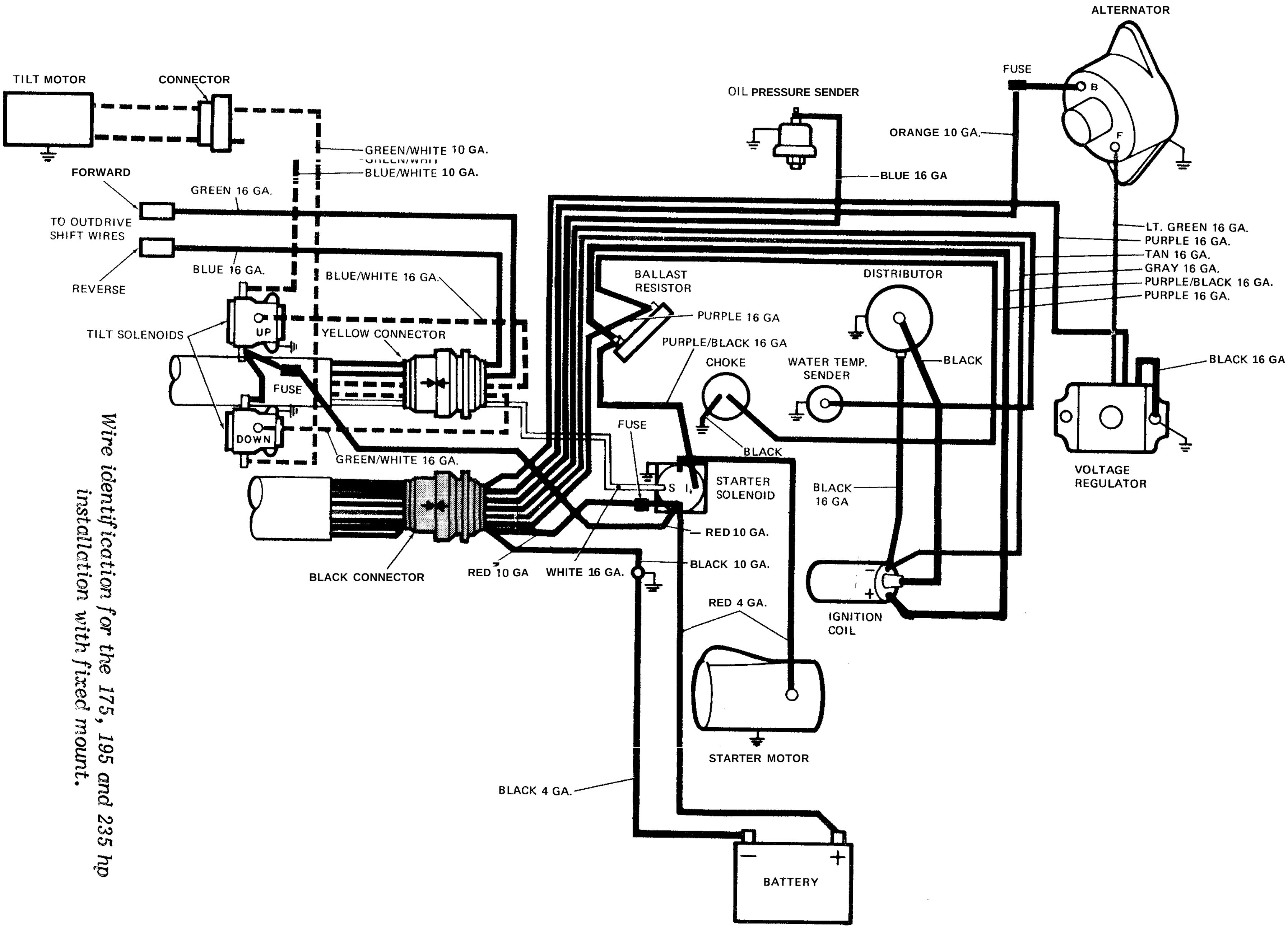
Wire identification for the 120/140 hp pre-set trim Model "D" (with ballast resistor).



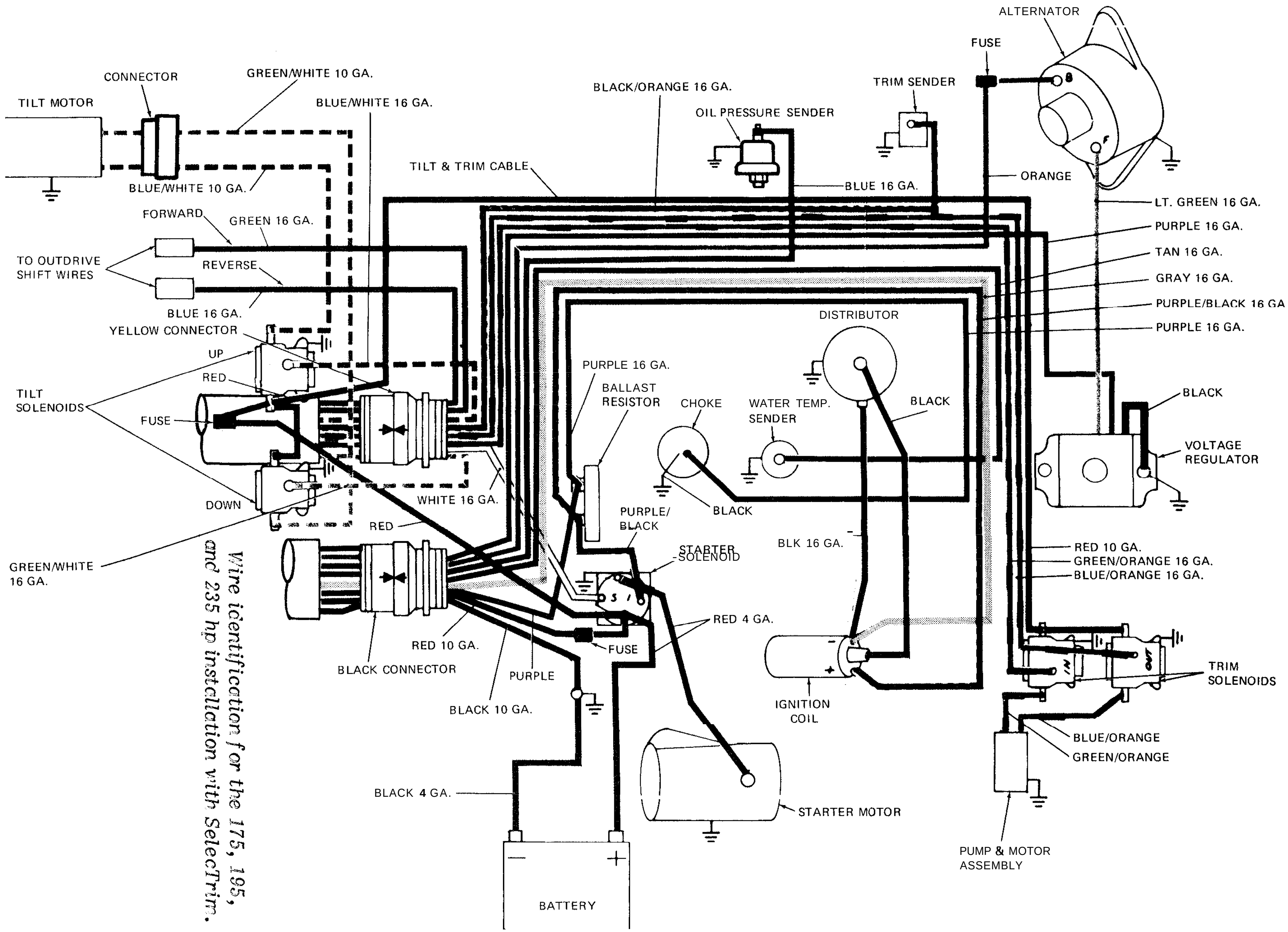
Wire identification for the 120/140 hp pre-set trim Models "H" & "H1" (with resistor wire).



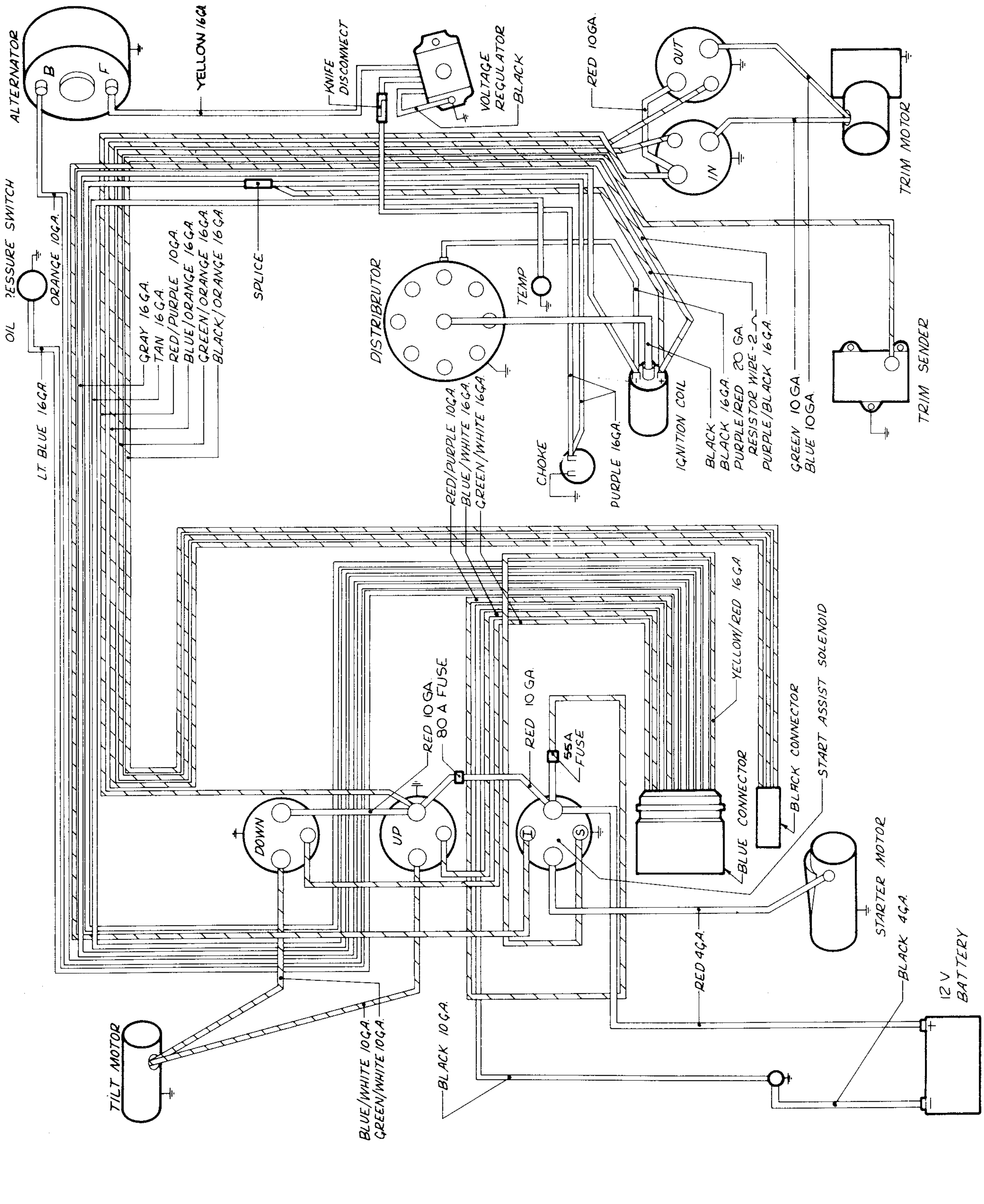
Wire identification for the 120/140 hp SelecTrim Model "H" and "H1" (with resistor wire).



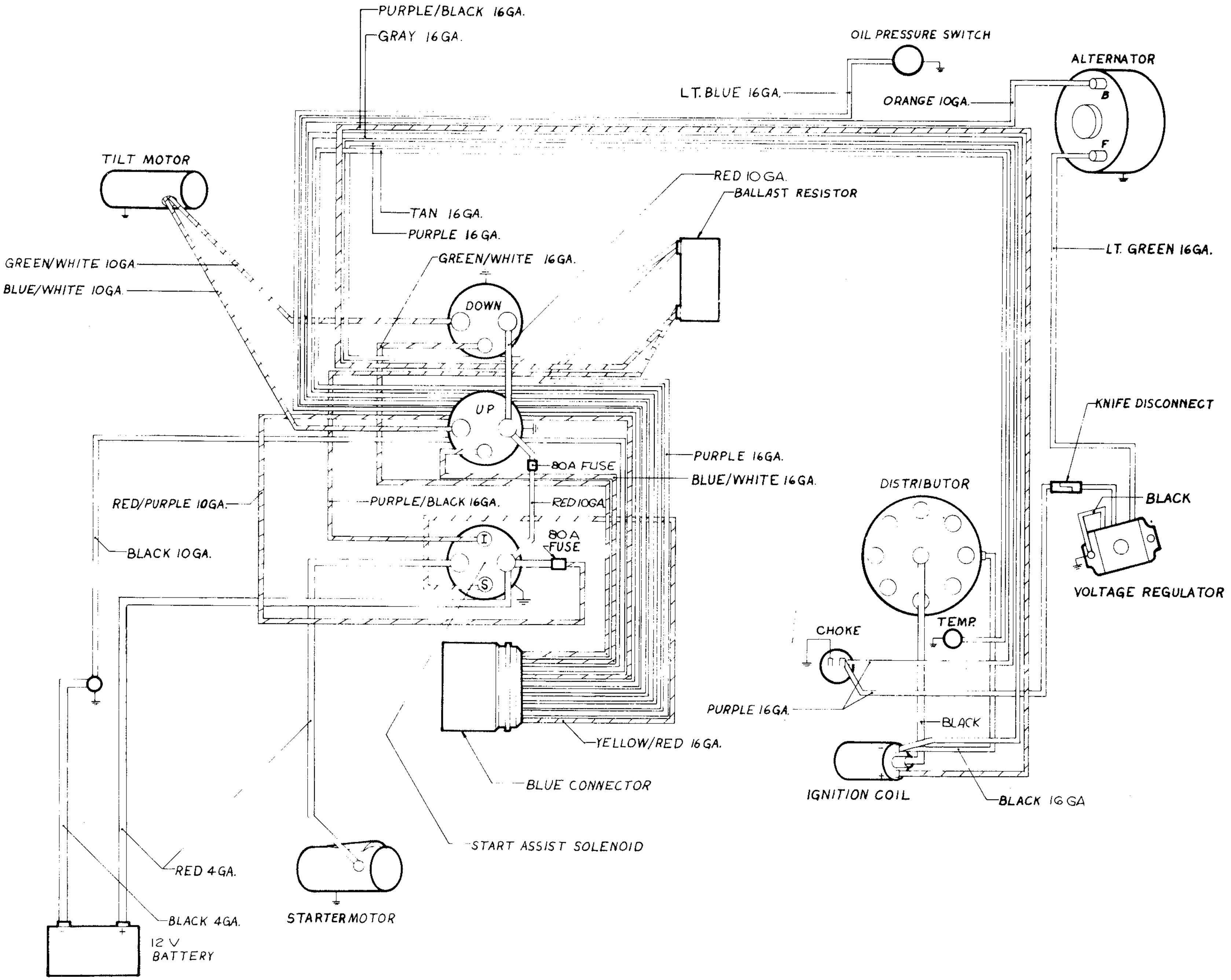
Wire identification for the 175, 195 and 235 hp installation with fixed mount.



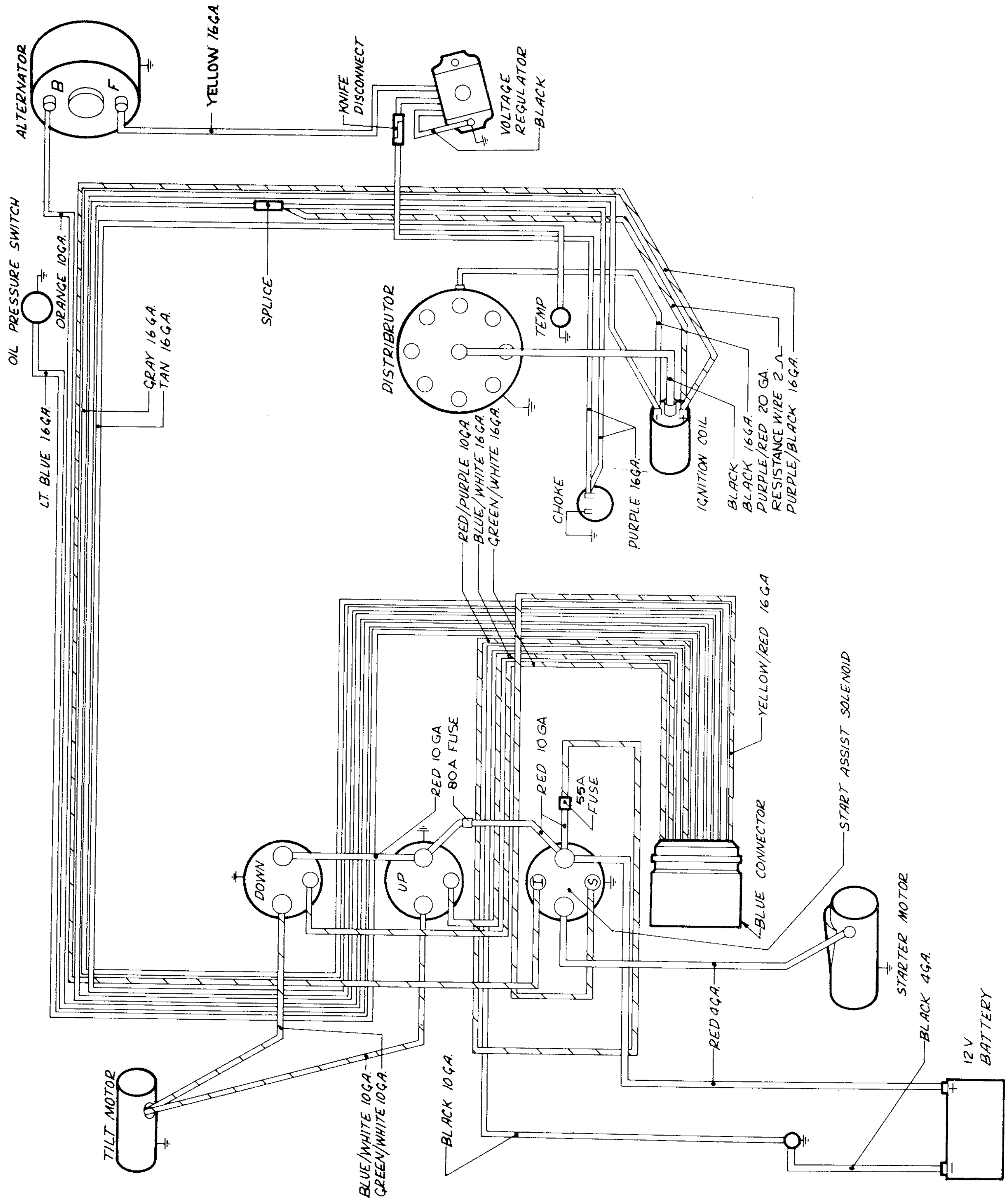
Wire identification for the 175, 195, and 235 hp installation with SelecTrim.



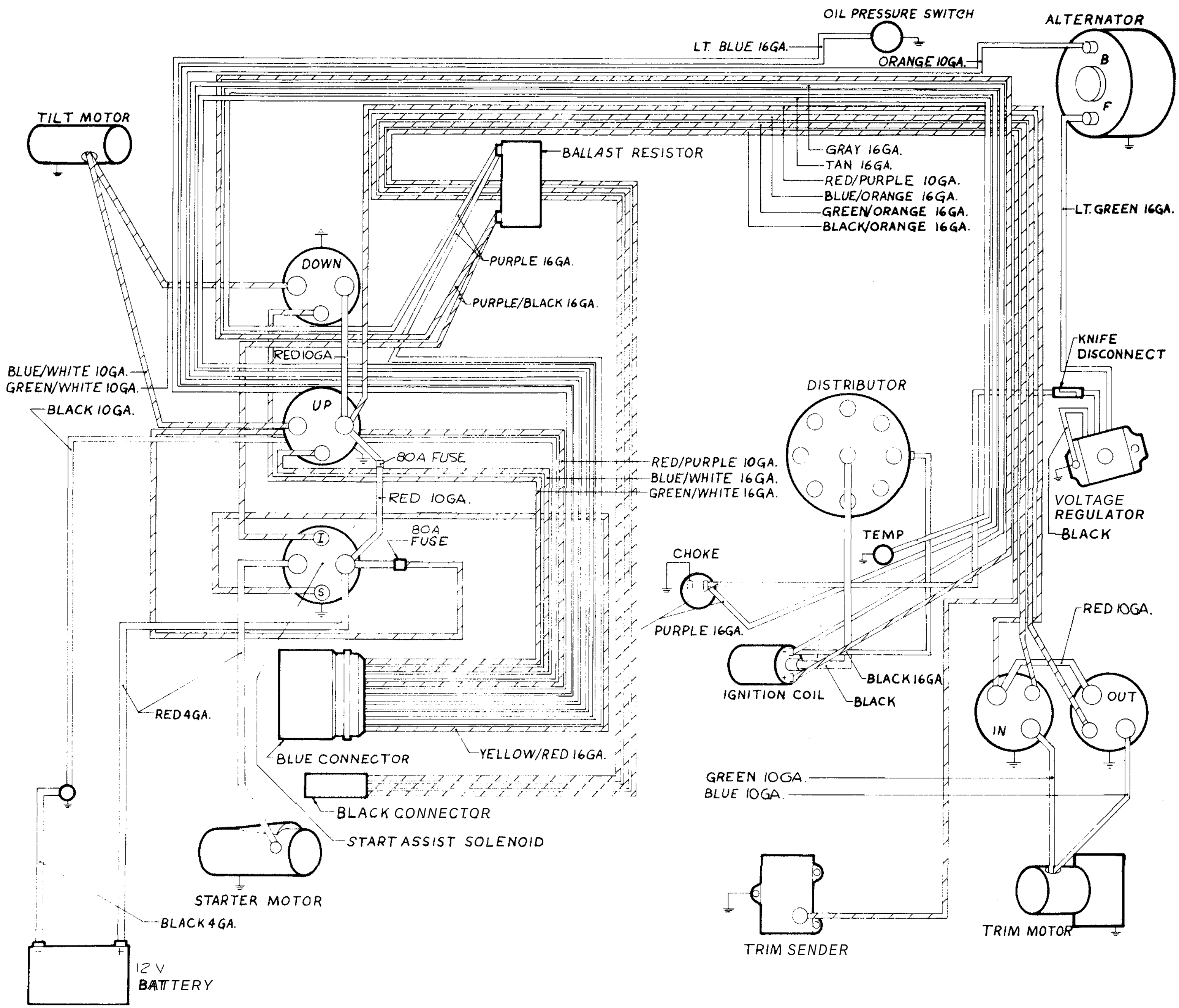
Wire identification for the 240 hp SelecTrim Models "H" and "J" (with resistor wire).



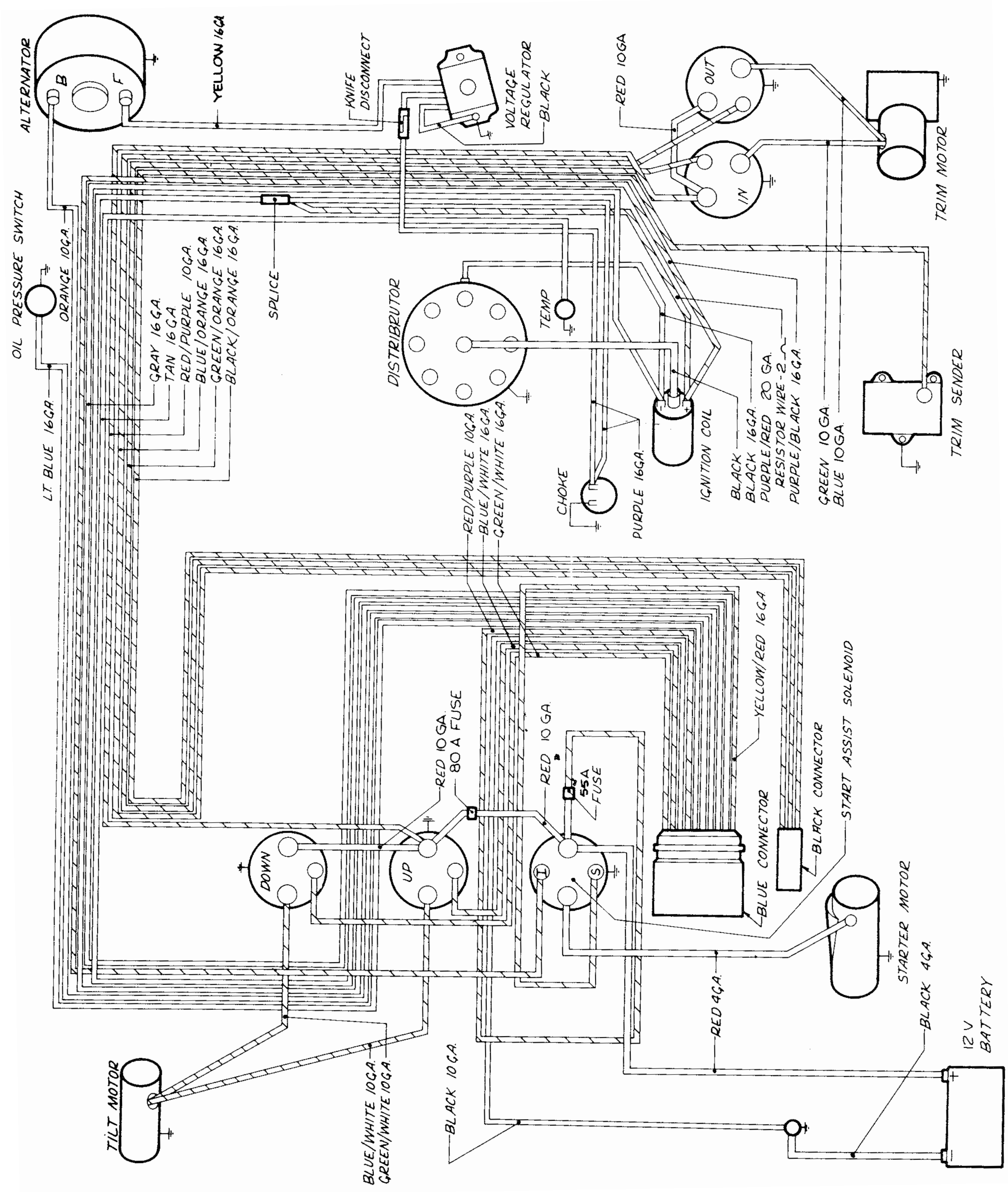
Wire identification for the 240 hp pre-set trim Model "D" (with ballast resistor).



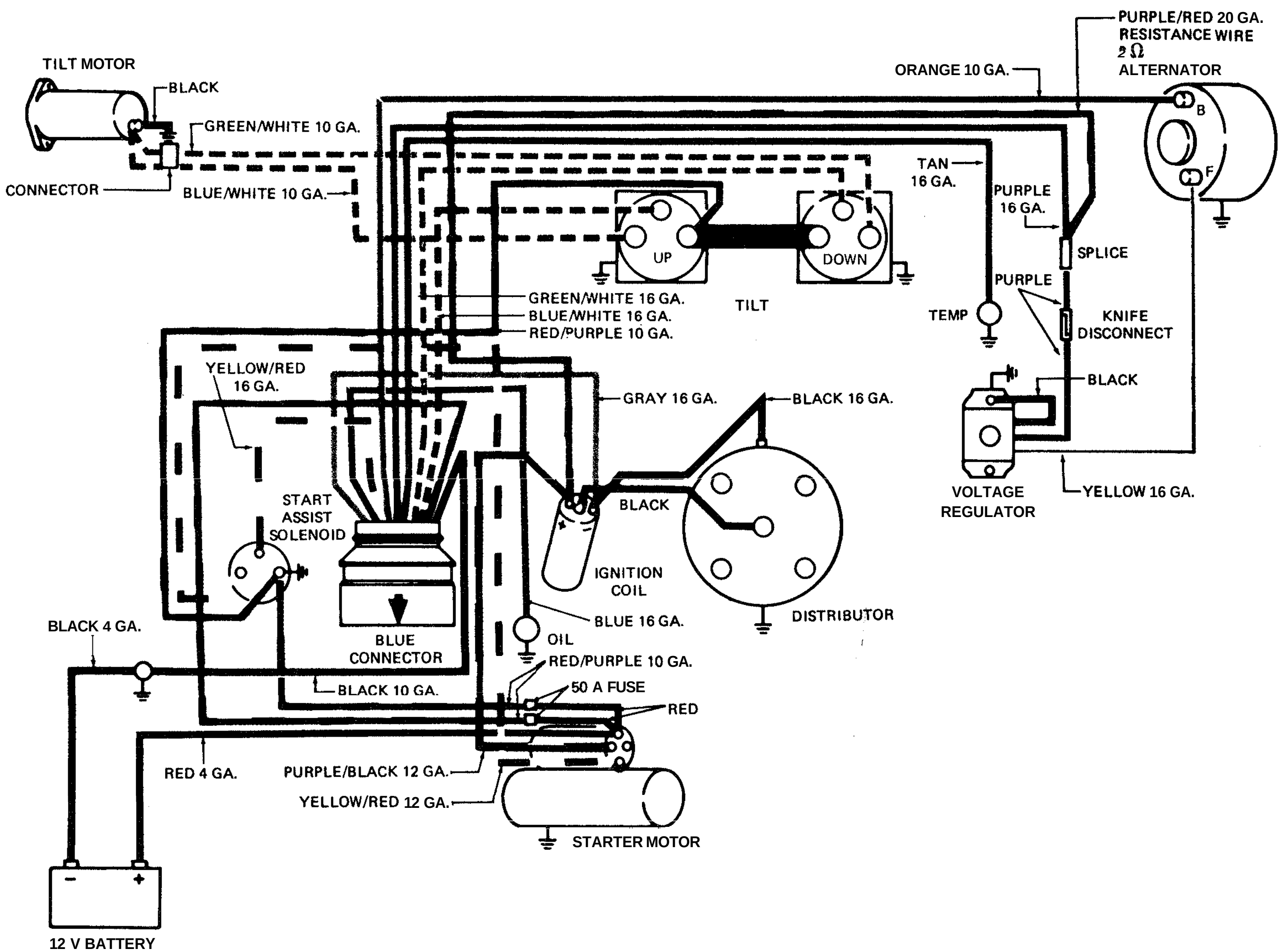
Wire identification for the 240 hp pre-set trim Models "H" and "J" (with resistor wire).



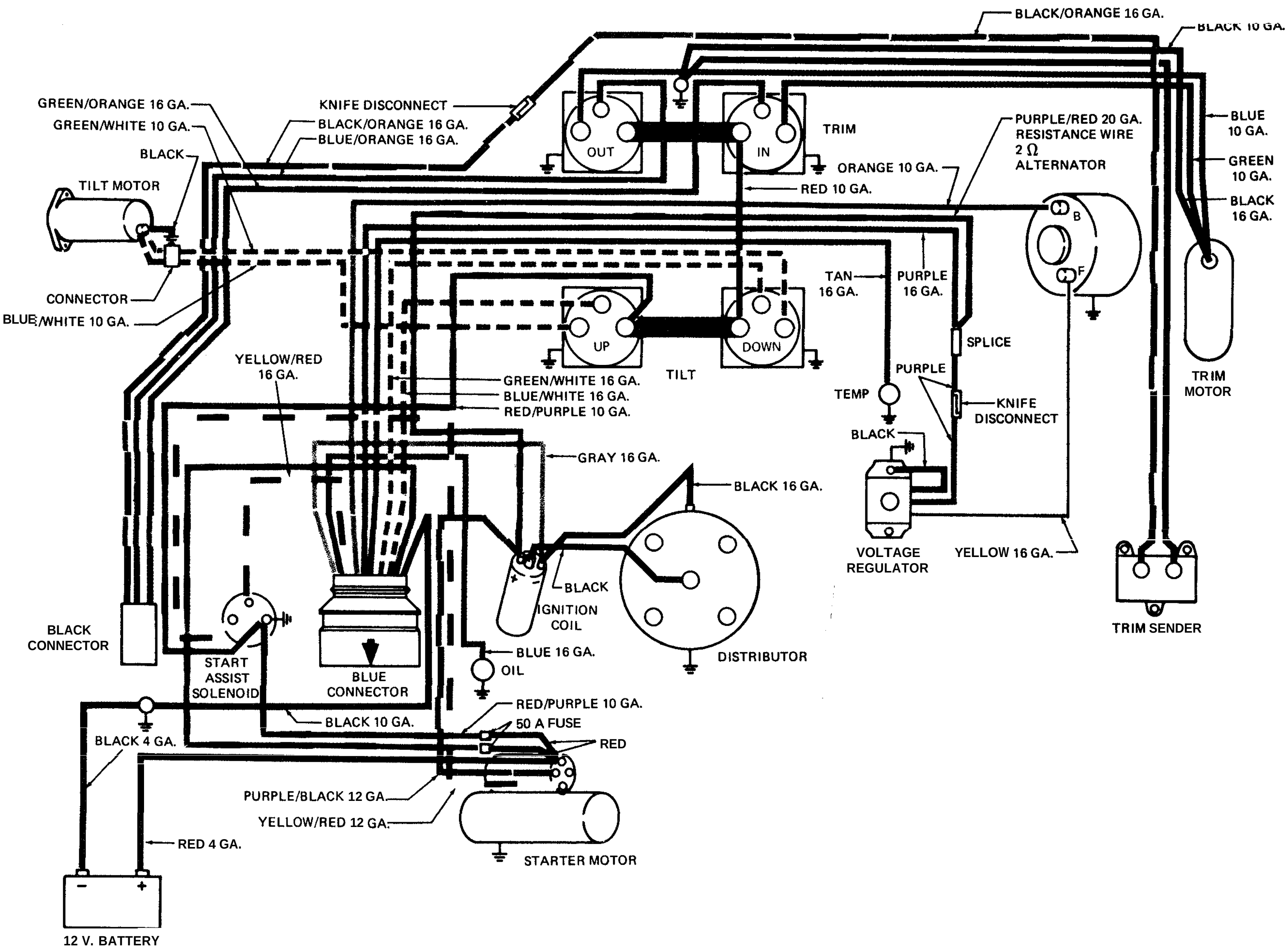
Wire identificaiton for the 240 hp SelecTrim Model "D" (with ballast resistor).



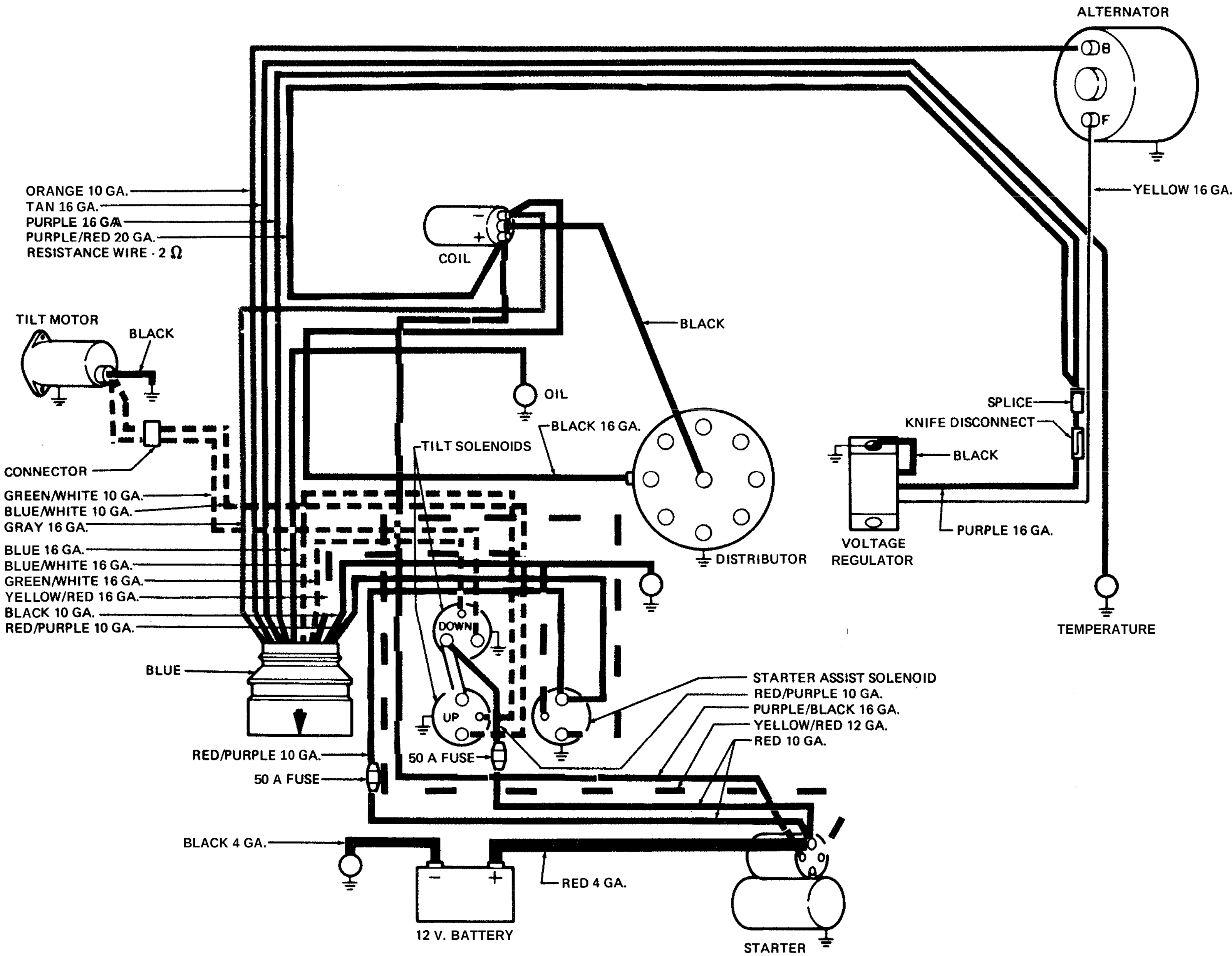
Wire identification for the 250 hp SelecTrim model.



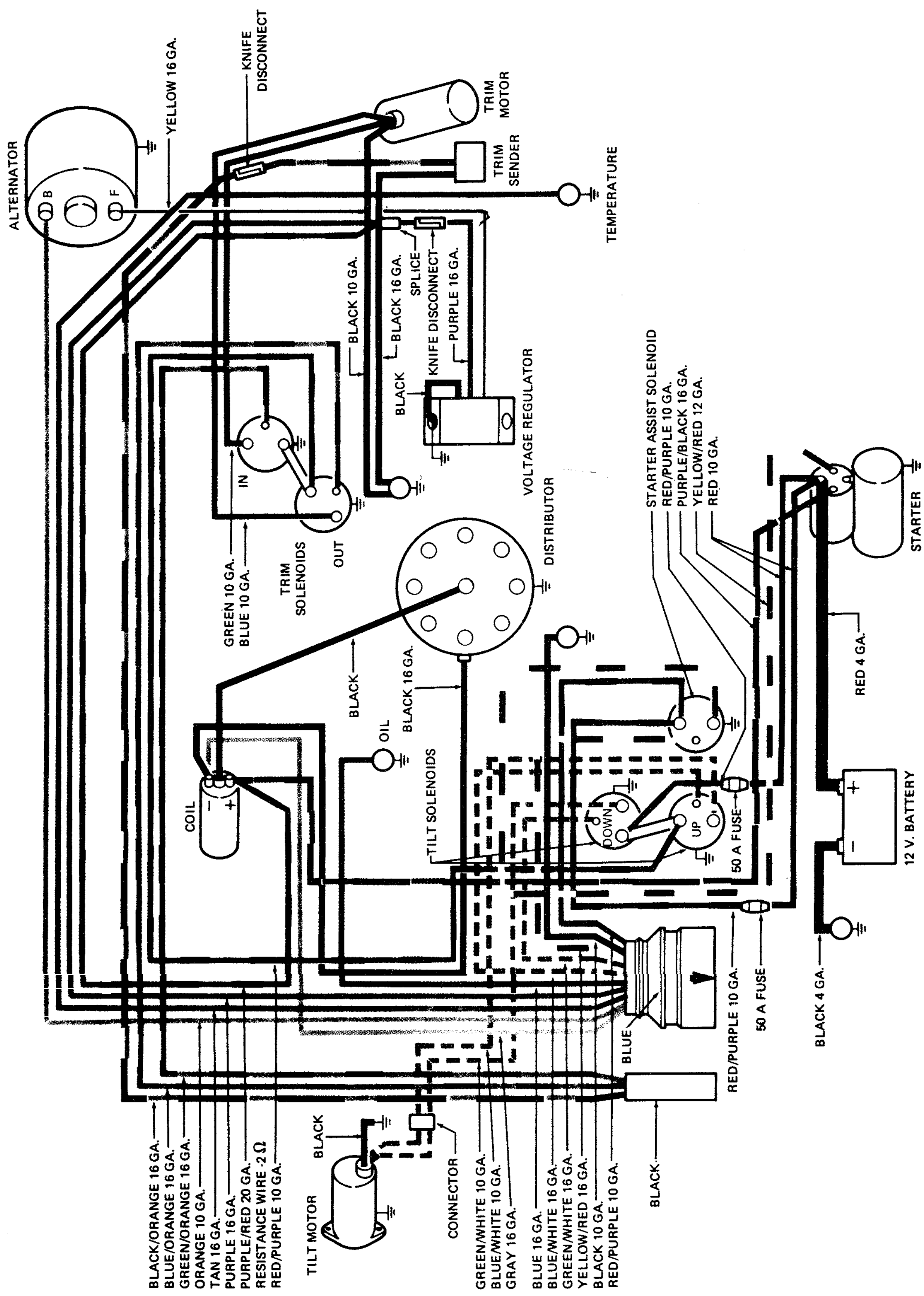
Wire identification for the 120 and 140 hp, also 2.5 and 3.0 Litre with fixed trim — 1980 and on.



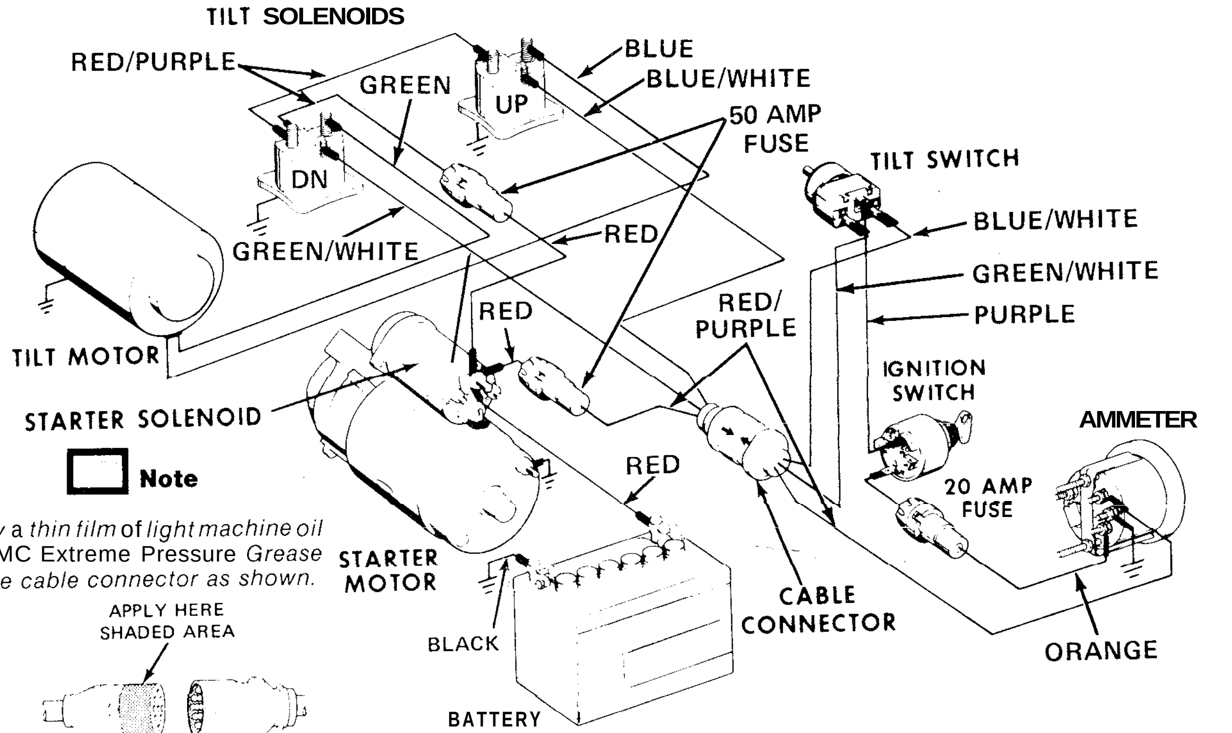
Wire identification for the 120 and 140 hp, also 2.5 and 3.0 Litre with SelecTrim — 1980 and on.



Wire identification for the 200, 230, and 260 hp, also 5.0 and 5.7 Litre — 1980 and on.



Wire identification for the 185, 200, 230, and 260 hp, also 5.0 and 5.7 Litre Models with SelecTrim -- 1980 and on.

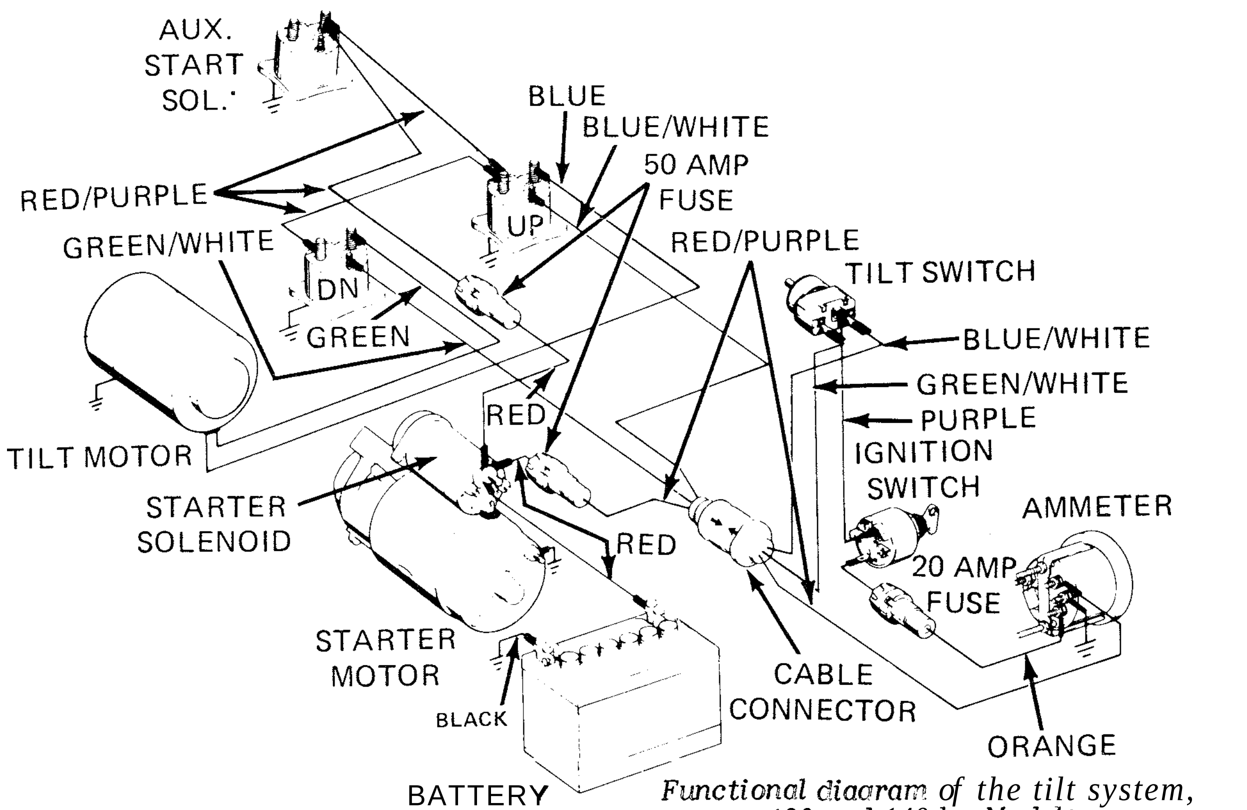


Note

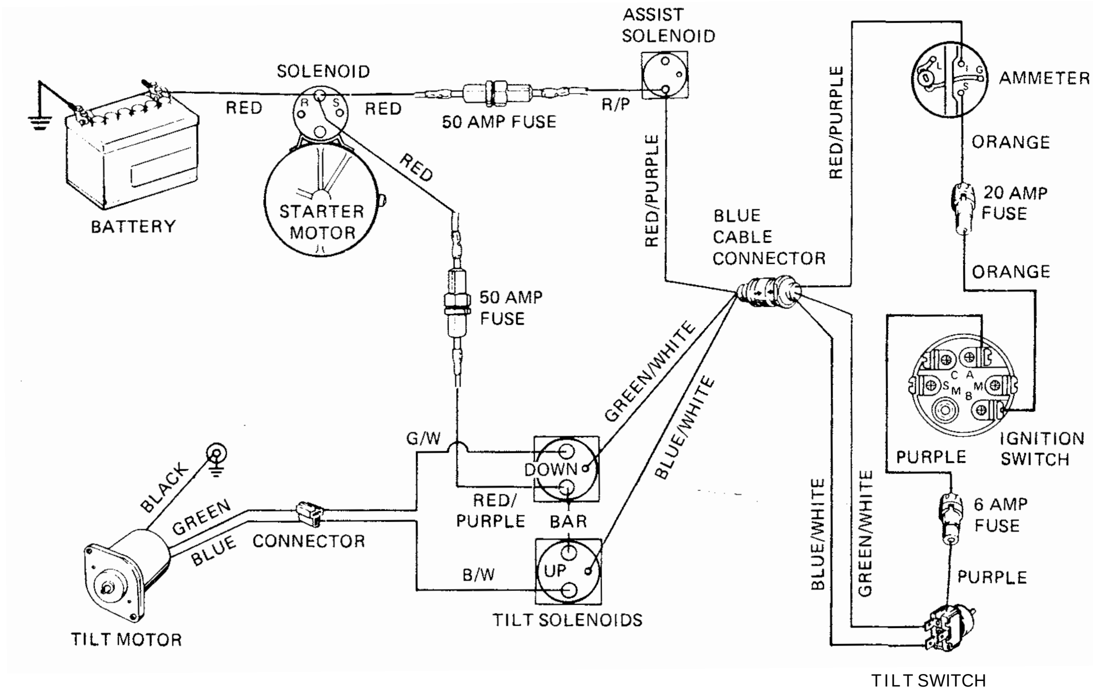
Apply a *thin film* of *light machine oil or* OMC Extreme Pressure *Grease on the cable connector as shown.*

This thin film of lubricant will make the assembly of the connector easier and help prevent corrosion

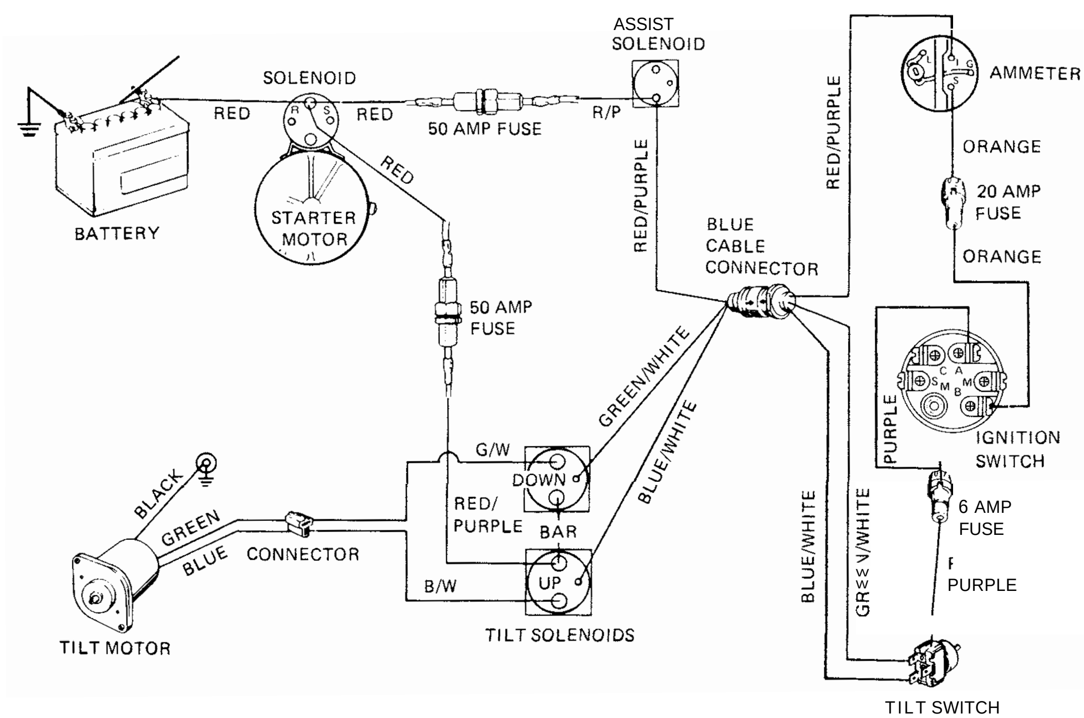
Functional diagram of the tilt system, 185, 200, 230, and 260 hp Models.



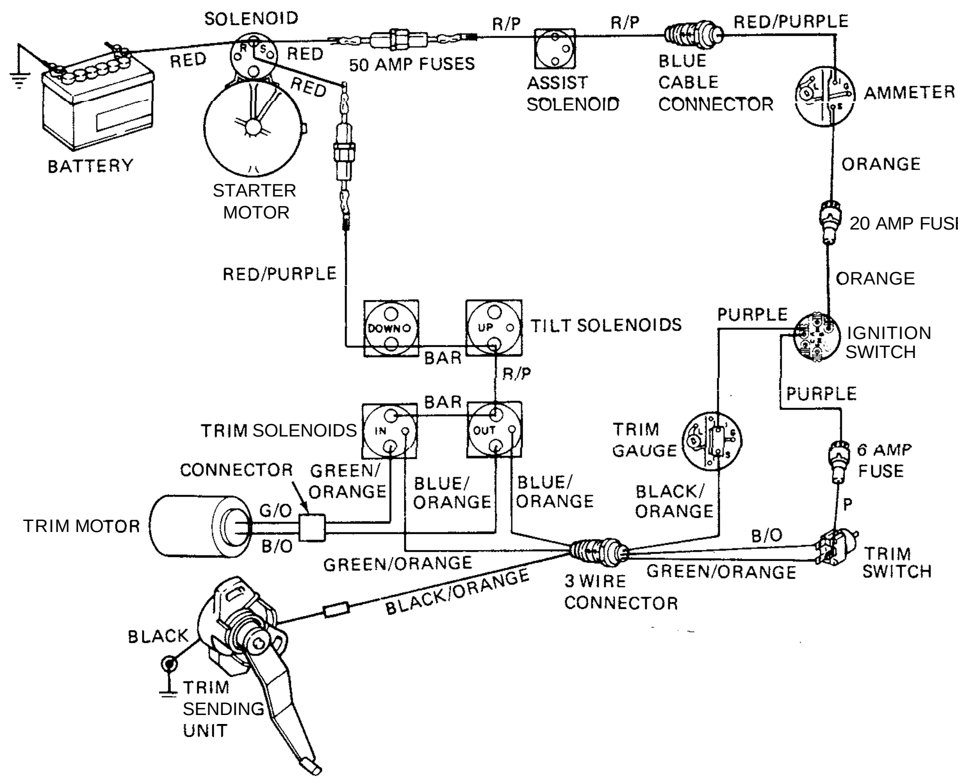
Functional diagram of the tilt system, 120 and 140 hp Models.



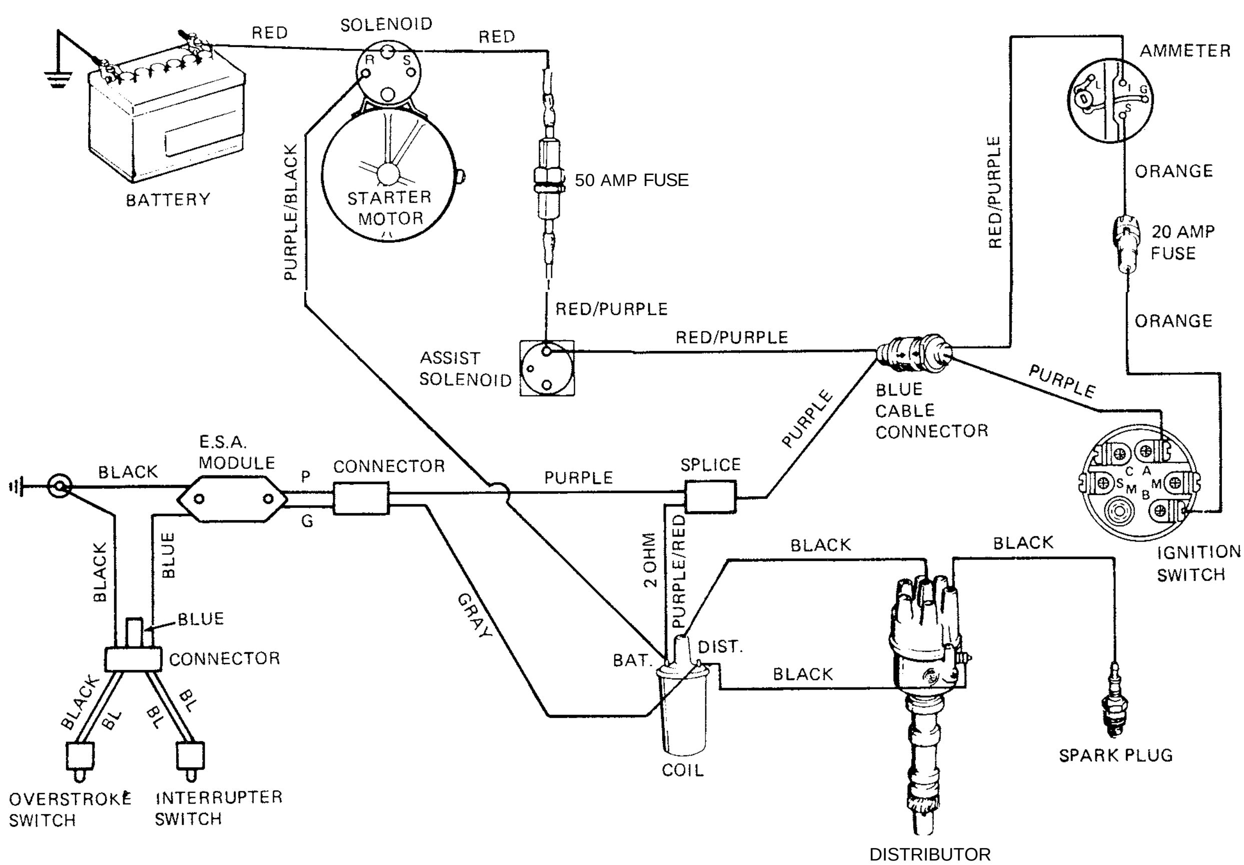
Functional diagram of the tilt circuit, **3.8, 4.3,** *5.0, and 5.7 Litre models.*



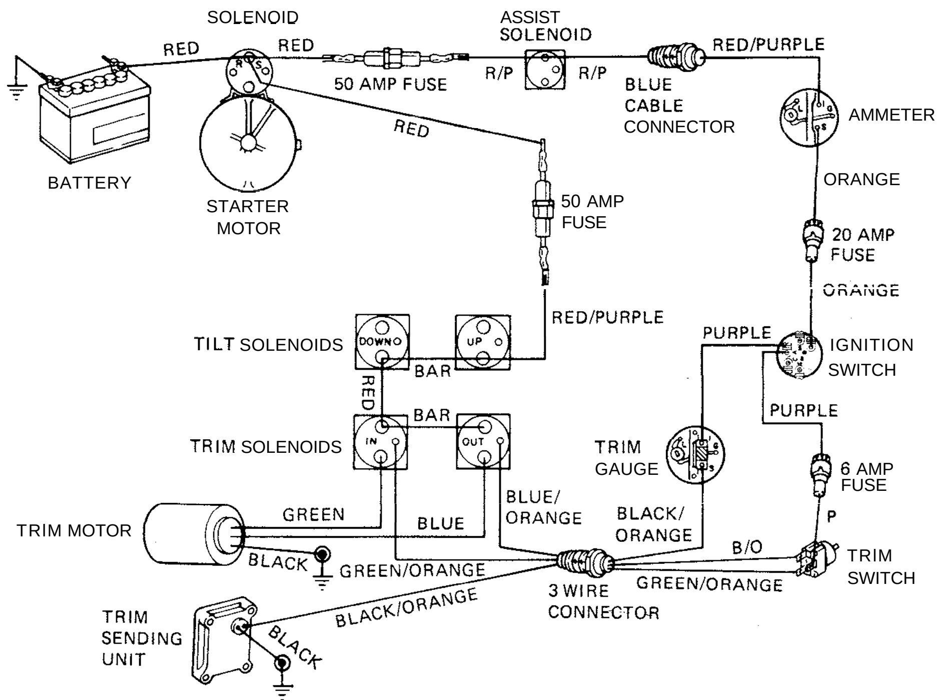
Functional diagram of the tilt circuit, 2.5 and 3.0 Litre Models.



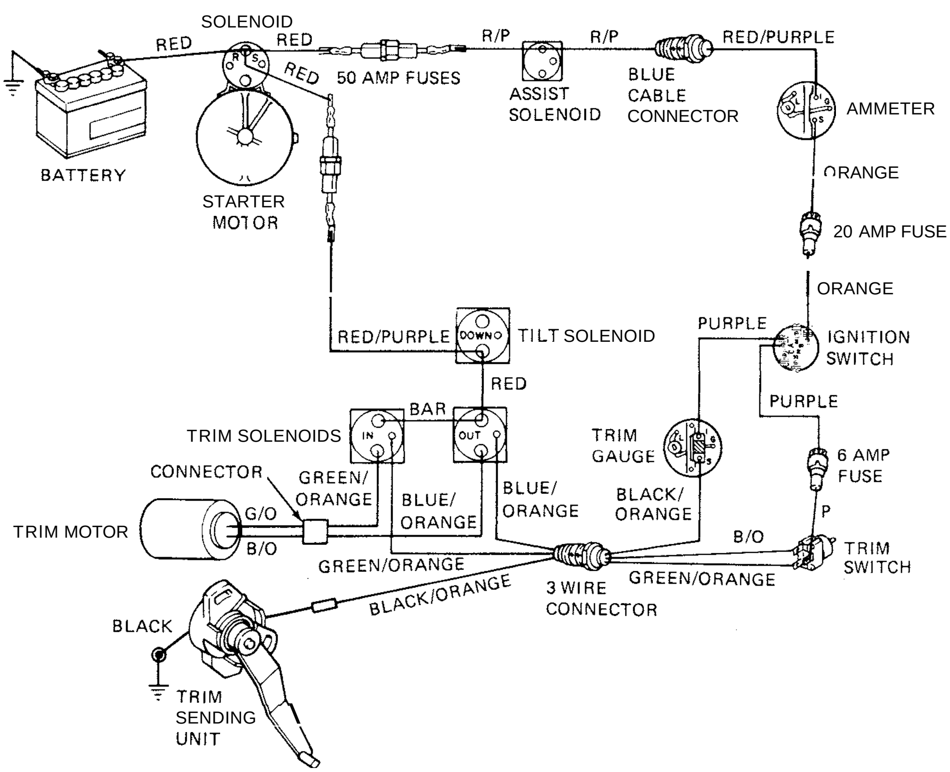
Functional diagram of the trim circuit, 5.0 and 5.7 Litre Models.



Functional diagram of the ignition system, 2.5, 3.0, 3.8, and 4.3 Litre models.



Functional diagram of the trim circuit, 2.5 and 3.0 Litre Models.



Functional diagram of the trim circuit, 3.8, 4.3, 5.0, and 5.7 Litre models.