

|                                               |       |                                                 |       |
|-----------------------------------------------|-------|-------------------------------------------------|-------|
| ALTERNATOR .....                              | 10-11 | FUEL GAUGE .....                                | 10-56 |
| ASSEMBLY .....                                | 10-18 | OIL & TEMP GAUGES .....                         | 10-55 |
| CLEANING & INSPECTION .....                   | 10-17 | SPEEDOMETER .....                               | 10-57 |
| DISASSEMBLY .....                             | 10-14 | TACHOMETER .....                                | 10-57 |
| INSPECTION .....                              | 10-11 | <b>PRESTOLITE INTEGRAL BREAKERLESS</b>          |       |
| PRECAUTIONS .....                             | 10-11 | <b>INDUCTIVE DISTRIBUTOR (BID) SYSTEM</b> ..... | 10-45 |
| REMOVAL & INSTALLATION .....                  | 10-14 | DESCRIPTION .....                               | 10-45 |
| TESTING .....                                 | 10-11 | DISTRIBUTOR .....                               | 10-47 |
| <b>BATTERY</b> .....                          | 10-8  | DISTRIBUTOR CAP .....                           | 10-46 |
| CABLES .....                                  | 10-10 | IGNITION COIL .....                             | 10-49 |
| CHARGERS .....                                | 10-9  | PRIMARY VOLTAGE TEST 10-46                      |       |
| CONSTRUCTION .....                            | 10-8  | SENSOR AIR GAP .....                            | 10-46 |
| DUAL BATTERY INSTALLATION .....               | 10-9  | TROUBLESHOOTING .....                           | 10-46 |
| LOCATION .....                                | 10-8  | VISUAL CHECKS .....                             | 10-46 |
| MARINE .....                                  | 10-8  | VOLTAGE DROP TEST .....                         | 10-46 |
| RATINGS .....                                 | 10-8  | <b>SENDING UNITS AND SWITCHES</b> .....         | 10-58 |
| <b>BREAKER POINT IGNITION SYSTEM</b> .....    | 10-32 | AUDIO WARNING SYSTEM .....                      | 10-58 |
| DESCRIPTION .....                             | 10-32 | IGNITION SWITCH .....                           | 10-59 |
| DISTRIBUTOR .....                             | 10-35 | OIL PRESSURE SENDING UNIT .....                 | 10-58 |
| DISTRIBUTOR CAP & ROTOR .....                 | 10-34 | WATER TEMPERATURE SENDER .....                  | 10-58 |
| GENERAL TESTS .....                           | 10-32 | SOLENOID .....                                  | 10-30 |
| IGNITION COIL .....                           | 10-36 | REMOVAL & INSTALLATION .....                    | 10-30 |
| IGNITION VOLTAGE TESTS .....                  | 10-33 | <b>SPECIFICATIONS</b> .....                     | 10-89 |
| TROUBLESHOOTING .....                         | 10-32 | ALTERNATOR .....                                | 10-89 |
| <b>CHARGING SYSTEM</b> .....                  | 10-10 | STARTER .....                                   | 10-90 |
| ALTERNATOR .....                              | 10-11 | <b>SPITFIRE/ELECTRONIC ENGINE</b>               |       |
| ASSEMBLY .....                                | 10-18 | <b>MANAGEMENT (EMM) SYSTEM</b> .....            | 10-49 |
| CLEANING & INSPECTION .....                   | 10-17 | COIL MODULE .....                               | 10-50 |
| DISASSEMBLY .....                             | 10-14 | DESCRIPTION & OPERATION .....                   | 10-49 |
| GENERAL INFORMATION .....                     | 10-10 | DISTRIBUTOR .....                               | 10-50 |
| PRECAUTIONS .....                             | 10-11 | EEM MODULE .....                                | 10-51 |
| REMOVAL & INSTALLATION .....                  | 10-14 | KNOCK SENSOR .....                              | 10-51 |
| SYSTEM INSPECTION .....                       | 10-11 | SYSTEM COMPONENTS .....                         | 10-50 |
| TESTING .....                                 | 10-11 | TIMING RING .....                               | 10-51 |
| TROUBLESHOOTING .....                         | 10-10 | TIMING SENSOR .....                             | 10-51 |
| DISTRIBUTOR .....                             |       | STARTER .....                                   | 10-20 |
| BID .....                                     | 10-47 | DISASSEMBLY & ASSEMBLY .....                    | 10-24 |
| BREAKER POINT .....                           | 10-35 | PINION CLEARANCE .....                          | 10-30 |
| DI .....                                      | 10-42 | REMOVAL & INSTALLATION .....                    | 10-23 |
| EEM .....                                     | 10-50 | TESTING .....                                   | 10-22 |
| EST .....                                     | 10-42 | FORD .....                                      | 10-22 |
| SPITFIRE .....                                | 10-50 | GM .....                                        | 10-22 |
| TFI-IV .....                                  | 10-52 | TROUBLESHOOTING .....                           | 10-21 |
| <b>ELECTRONIC SPARK TIMING</b>                |       | <b>STARTER CIRCUIT</b> .....                    | 10-19 |
| <b>(EST) SYSTEM</b> .....                     | 10-39 | DESCRIPTION AND OPERATION .....                 | 10-19 |
| <b>DISTRIBUTOR IGNITION (DI) SYSTEM</b> ..... | 10-39 | DISASSEMBLY & ASSEMBLY .....                    | 10-24 |
| DESCRIPTION .....                             | 10-39 | PINION CLEARANCE .....                          | 10-30 |
| DISTRIBUTOR .....                             | 10-42 | PRECAUTIONS .....                               | 10-21 |
| DISTRIBUTOR CAP .....                         | 10-42 | REMOVAL & INSTALLATION .....                    | 10-23 |
| IGNITION COIL .....                           | 10-45 | SOLENOID .....                                  | 10-30 |
| IGNITION MODULE .....                         | 10-42 | STARTER MOTOR .....                             | 10-20 |
| INDUCTOR .....                                | 10-42 | TESTING .....                                   | 10-22 |
| PICK-UP COIL .....                            | 10-42 | FORD .....                                      | 10-22 |
| TROUBLESHOOTING .....                         | 10-39 | GM .....                                        | 10-22 |
| VISUAL CHECKS .....                           |       | TROUBLESHOOTING .....                           | 10-20 |
| <b>FORD THICK FILM INTEGRATED IGNITION</b>    |       | <b>UNDERSTANDING AND TROUBLESHOOTING</b>        |       |
| <b>SYSTEM (TFI-IV)</b> .....                  | 10-51 | <b>ELECTRICAL SYSTEMS</b> .....                 | 10-2  |
| DESCRIPTION & OPERATION .....                 | 10-51 | BASIC ELECTRICAL THEORY .....                   | 10-2  |
| DISTRIBUTOR .....                             | 10-52 | ELECTRICAL COMPONENTS .....                     | 10-2  |
| DISTRIBUTOR CAP .....                         | 10-52 | TEST EQUIPMENT .....                            | 10-4  |
| E-CORE COIL .....                             | 10-54 | TROUBLESHOOTING .....                           | 10-6  |
| STATOR .....                                  | 10-53 | WIRE AND CONNECTOR REPAIR .....                 | 10-7  |
| TFI MODULE .....                              | 10-55 | <b>WIRING DIAGRAMS</b> .....                    | 10-59 |
| <b>IGNITION SYSTEM</b> .....                  | 10-31 | INDEX .....                                     | 10-59 |
| APPLICATIONS .....                            | 10-31 | ENGINE .....                                    | 10-60 |
| <b>INSTRUMENTS AND GAUGES</b> .....           | 10-55 | MAIN HARNESS .....                              | 10-86 |
| BATTERY GAUGE .....                           | 10-57 |                                                 |       |

# 10

## IGNITION AND ELECTRICAL SYSTEMS

|                                        |       |
|----------------------------------------|-------|
| <b>UNDERSTANDING AND</b>               |       |
| <b>TROUBLESHOOTING ELECTRICAL</b>      |       |
| <b>SYSTEMS</b> .....                   | 10-2  |
| <b>BATTERY</b> .....                   | 10-8  |
| <b>CHARGING SYSTEM</b> .....           | 10-10 |
| <b>STARTER CIRCUIT</b> .....           | 10-19 |
| <b>IGNITION SYSTEM</b> .....           | 10-31 |
| <b>BREAKER POINT</b>                   |       |
| <b>IGNITION SYSTEM</b> .....           | 10-32 |
| <b>ELECTRONIC SPARK TIMING</b>         |       |
| <b>(EST) SYSTEM</b> .....              | 10-39 |
| <b>DISTRIBUTOR IGNITION</b>            |       |
| <b>(DI) SYSTEM</b> .....               | 10-39 |
| <b>PRESTOLITE INTEGRAL BREAKERLESS</b> |       |
| <b>INDUCTIVE DISTRIBUTOR</b>           |       |
| <b>(BID) SYSTEM</b> .....              | 10-45 |
| <b>SPITFIRE/ELECTRONIC ENGINE</b>      |       |
| <b>MANAGEMENT (EMM) SYSTEM</b> ..      | 10-49 |
| <b>FORD THICK FILM INTEGRATED</b>      |       |
| <b>IGNITION SYSTEM (TFI-IV)</b> .....  | 10-51 |
| <b>INSTRUMENTS AND GAUGES</b> .....    | 10-55 |
| <b>SENDING UNITS AND SWITCHES</b> ..   | 10-58 |
| <b>WIRING DIAGRAMS</b> .....           | 10-59 |
| <b>SPECIFICATIONS</b> .....            | 10-89 |

## UNDERSTANDING AND TROUBLESHOOTING ELECTRICAL SYSTEMS

### Basic Electrical Theory

#### ◆ See Figure 1

For any 12 volt, negative ground, electrical system to operate, the electricity must travel in a complete circuit. This simply means that current (power) from the positive terminal (+) of the battery must eventually return to the negative terminal (-) of the battery. Along the way, this current will travel through wires, fuses, switches and components. If for any reason the flow of current through the circuit is interrupted, the component(s) fed by that circuit will cease to function properly.

Perhaps the easiest way to visualize a circuit is to think of connecting a light bulb (with two wires attached to it) to the battery—one wire attached to the negative (-) terminal of the battery and the other wire to the positive (+) terminal. With the two wires touching the battery terminals, the circuit would be complete and the light bulb would illuminate. Electricity would follow a path from the battery to the bulb and back to the battery. It's easy to see that with longer wires on our light bulb, it could be mounted anywhere. Further, one wire could be fitted with a switch so that the light could be turned on and off.

The normal marine circuit differs from this simple example in two ways. First, instead of having a return wire from each bulb to the battery, the current travels through a single ground wire, which handles all the grounds for a specific circuit. Secondly, most marine circuits contain multiple components, which receive power from a single circuit. This lessens the amount of wire needed to power components.

### HOW ELECTRICITY WORKS: THE WATER ANALOGY

Electricity is the flow of electrons—the sub-atomic particles that constitute the outer shell of an atom. Electrons spin in an orbit around the center core of an atom. The center core is comprised of protons (positive charge) and neutrons (neutral charge). Electrons have a negative charge and balance out the positive charge of the protons. When an outside force causes the number of electrons to unbalance the charge of the protons, the electrons will split off the atom and look for another atom to balance out. If this imbalance is kept up, electrons will continue to move and an electrical flow will exist.

Many people have been taught electrical theory using an analogy with water. In a comparison with water flowing through a pipe, the electrons would be the water and the wire is the pipe.

The flow of electricity can be measured much like the flow of water through a pipe. The unit of measurement used is amps, frequently abbreviated as amps (a). You can compare amperage to the volume of water flowing through a pipe. When connected to a circuit, an ammeter will measure the actual amount of current flowing through the circuit. When relatively few electrons flow through a circuit, the amperage is low. When many electrons flow, the amperage is high.

Water pressure is measured in units such as pounds per square inch (psi), electrical pressure is measured in units called volts (v). When a voltmeter is connected to a circuit, it is measuring the electrical pressure. When electrical pressure is low, then voltage is considered to be low. When electrical pressure is high, then voltage is considered to be high.

The actual flow of electricity depends not only on voltage and amperage but also on the resistance of the circuit—the higher the resistance, the higher the force necessary to push the current through the circuit. The standard unit for measuring resistance is an ohm ( $\Omega$ ). Resistance in a circuit varies depending on the amount and type of components used in the circuit and the overall condition of the components and wires. If we assume that everything in our circuit is new, then, the main factors which determine resistance are:

- **Material**—some materials have more resistance than others. Those with high resistance are said to be insulators. Rubber materials (or rubber-like plastics) are some of the most common insulators used, as they have a very high resistance to electricity. Very low resistance materials are said to be conductors. Copper wire is among the best conductors. Silver is actually a superior conductor to copper and is used in some relay contacts but its high cost prohibits its use as common wiring. Most marine wiring is made of copper.
- **Size**—the larger the wire size being used, the less resistance the wire will have. This is why components that use large amounts of electricity usually have large wires supplying current to them.

- **Length**—for a given thickness of wire, the longer the wire, the greater the resistance. The shorter the wire, the less the resistance. When determining the proper wire for a circuit, both size and length must be considered to design a circuit that can handle the current needs of the component.
- **Temperature**—with many materials, the higher the temperature, the greater the resistance (positive temperature coefficient). Some materials exhibit the opposite trait of lower resistance with higher temperatures (negative temperature coefficient). These principles are used in many of the sensors on the engine.

### OHM'S LAW

There is a direct relationship between current, voltage and resistance that can be summed up by a statement known as Ohm's law.

- Voltage (E) is equal to amperage (I) times resistance (R):  $E = I \times R$
- Other forms of the formula are  $R = E/I$  and  $I = E/R$

In each of these formulas, E is the voltage in volts, I is the current in amps and R is the resistance in ohms. The basic point to remember is that as the resistance of a circuit goes up, the amount of current that flows in the circuit will go down, if voltage remains the same.

The amount of work that the electricity can perform is expressed as power. A unit of power is known as a watt (W). There is a direct relationship between power, voltage and current that can be summed up by the following formula:

- Power (W) is equal to amperage (I) times voltage (E):  $W = I \times E$

**This formula is only true for direct current (DC) circuits. The alternating current formula is a tad different but since the electrical circuits in most boats are DC type, we need not get into AC circuit theory.**

### Electrical Components

#### POWER SOURCE

#### ◆ See Figure 2

Power is supplied to the boat by two devices: The battery and the alternator. The battery supplies electrical power during starting or during periods when the current demand of the boat's electrical system exceeds the output capacity of the alternator. The alternator supplies electrical current when the engine is running. The alternator does not just supply the current needs of the boat but it also recharges the battery.

In most modern boats, the battery is a lead/acid electrochemical device consisting of six 2 volt subsections (cells) connected in series, so that the unit is capable of producing approximately 12 volts of electrical pressure. Each subsection consists of a series of positive and negative plates held a short distance apart in a solution of sulfuric acid and water.

The two types of plates are of dissimilar metals, thus setting up a chemical reaction inside the battery case. It is this reaction that produces current flow from the battery when its positive and negative terminals are connected to an electrical load. The alternator, restoring the battery to its original chemical state replaces the power removed from the battery.

The following is a brief description of how the system works:

The battery stores electricity and acts as a "sponge" for the whole system. It mops up generated

current until it's fully charged and it releases energy on demand.

Permanent magnets that create the moving magnetic field. If your engine has good spark, you can take it for granted that the magnets are in working order because the ignition and charging systems share the same magnets.

The alternator windings are the stationary coils of wire that the magnets rotate around. They produce the electrical charge. Simply put, the more windings in your stator, the greater the potential output in amps your charging system you'll have.

The rectifier consists of a series of diodes or electrical one-way valves. The rectifier overcomes one of the disadvantages of a current-generating system using permanent magnets and stator windings, which is that the current produced within the windings is alternating current (AC). You can't use AC to charge batteries. They accept only direct current (DC). So the rectifier is designed to convert AC current to a usable form of DC current simply called "rectified AC."

All engines covered here utilize a voltage regulator; either combined with the rectifier or standing alone. The regulator automatically reduces the output of generated current as the battery becomes fully charged.

## GROUND

All boats use some sort of a ground return circuit. Direct ground components are grounded to an electrically conductive metal component through their mounting points. These electrically conductive metal components are then grounded to the battery.

All other components use some sort of ground wire which leads directly back to the battery. The electrical current runs through the ground wire and returns to the battery through the ground (-) cable. If you look, you'll see that the battery ground cable connects between the battery and a heavy gauge ground wire.

■ It should be noted that a good percentage of electrical problems can be traced to bad or loose grounds.

## PROTECTIVE DEVICES

+ See Figure 3

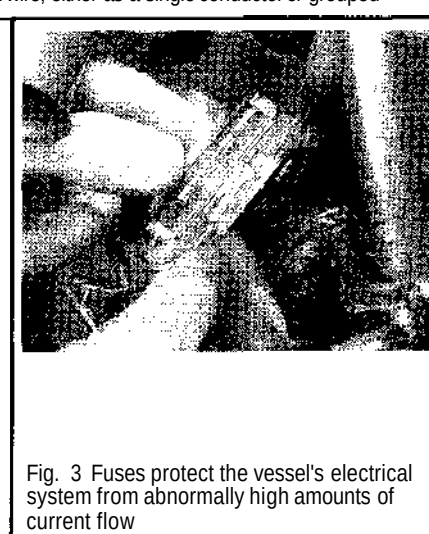
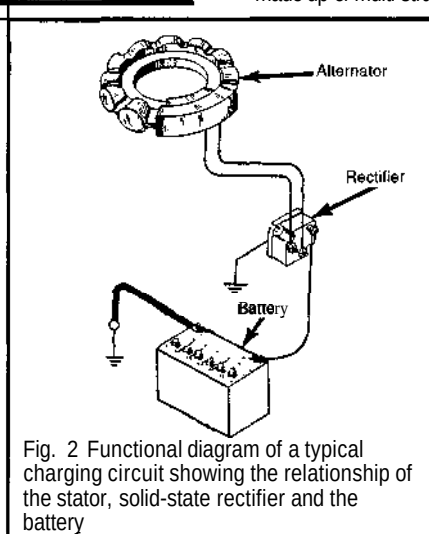
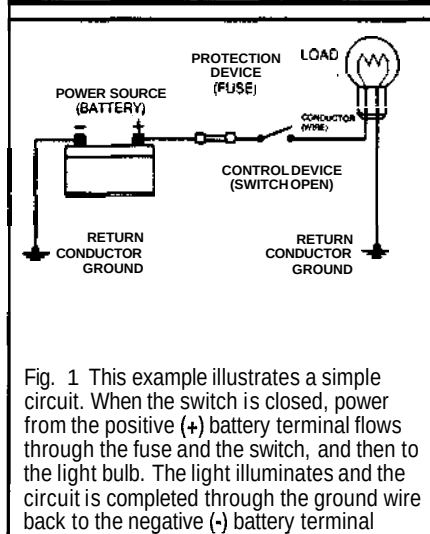
It is possible for large surges of current to pass through the electrical system of your boat. If this surge of current were to reach components in the circuit, the surge could burn them out or severely damage them. Surges can also overload the wiring, causing the harness to get hot and melt the insulation. To prevent this, fuses, circuit breakers and/or fusible links are connected into the supply wires of the electrical system. These items are nothing more than a built-in weak spot in the system. When an abnormal amount of current flows through the system, these protective devices work as follows to protect the circuit:

- Fuse—when an excessive electrical current passes through a fuse, the fuse "blows" (the conductor melts) and opens the circuit, preventing the passage of current.
- Circuit Breaker—a circuit breaker is basically a self-repairing fuse. It will open the circuit in the same fashion as a fuse but when the surge subsides, the circuit breaker can be reset and does not need replacement.
- Fusible Link—a fusible link (fuse link or main link) is a short length of special, high temperature insulated wire that acts as a fuse. When an excessive electrical current passes through a fusible link, the thin gauge wire inside the link melts, creating an intentional open to protect the circuit.

To repair the circuit, the link must be replaced. Some newer type fusible links are housed in plug-in modules, which are simply replaced like a fuse, while older type fusible links must be cut and spliced if they melt. Since this link is very early in the electrical path, it's the first place to look if nothing on the boat works, yet the battery seems to be charged and is properly connected.

## ✱✱ CAUTION

Always replace fuses, circuit breakers and fusible links with identically rated components. Under no circumstances should a component of higher or lower amperage rating be substituted.



## SWITCHES & RELAYS

◆ See Figure 4

Switches are used in electrical circuits to control the passage of current. The most common use is to open and close circuits between the battery and the various electric devices in the system. Switches are rated according to the amount of amperage they can handle. If a switch rated for the sufficient amperage is not used in a circuit, the switch could overload and cause damage.

Some electrical components which require a large amount of current to operate use a special switch called a relay. Since these circuits carry a large amount of current, the thickness of the wire in the circuit is also greater. If this large wire were connected from the load to the control switch, the switch would have to carry the high amperage load and the space needed for wiring in the boat would be twice as big to accommodate the increased size of the wiring harness. To prevent these problems, a relay is used.

Relays are composed of a coil and a set of contacts. When the coil has a current passed through it, a magnetic field is formed and this field causes the contacts to move together, completing the circuit. Most relays are normally open, preventing current from passing through the circuit but they can take any electrical form depending on the job they are intended to do. Relays can be considered "remote control switches." They allow a smaller current to operate devices that require higher amperages. When a small current operates the coil, a larger current is allowed to pass by the contacts. Some common circuits that may use relays are horns, lights, starter, electric fuel pumps and other high draw circuits.

## LOAD

Every electrical circuit must include a "load" (something to use the electricity coming from the source). Without this load, the battery would attempt to deliver its entire power supply from one pole to another. This would result in a "short circuit" of the battery. All this electricity would take a short cut to ground and cause a great amount of damage to other components in the circuit by developing a tremendous amount of heat. This condition could develop sufficient heat to melt the insulation on all the surrounding wires and reduce a multiple wire cable to a lump of plastic and copper.

## WIRING & HARNESSES

The average boat contains miles of wiring, with hundreds of individual connections. To protect the many wires from damage and to keep them from becoming a confusing tangle, they are organized into bundles, enclosed in plastic or taped together and called wiring harnesses. Different harnesses serve different parts of the boat. Individual wires are color coded to help trace them through a harness where sections are hidden from view.

Marine wiring can either be single strand wire, multi-strand wire or printed circuitry. Single strand wire has a solid metal core and is usually used inside such components as alternators, motors, relays and other devices. Multi-strand wire has a core made of many small strands of wire twisted together into a single conductor. Most of the wiring in a marine electrical system is made up of multi-strand wire, either as a single conductor or grouped

## 10-4 IGNITION AND ELECTRICAL SYSTEMS

together in a harness. All wiring is color coded on the insulator, either as a solid color or as a colored wire with an identification stripe. A printed circuit is a thin film of copper or other conductor that is printed on an insulator backing. Occasionally, a printed circuit is sandwiched between two sheets of plastic for more protection and flexibility. A complete printed circuit, consisting of conductors, insulating material and connectors is called a printed circuit board. Printed circuitry is used in place of individual wires or harnesses in places where space is limited, such as behind instrument panels.

Since marine electrical systems are very sensitive to changes in resistance, the selection of properly sized wires is critical when systems are repaired. A loose or corroded connection or a replacement wire that is too small for the circuit will add extra resistance and an additional voltage drop to the circuit.

The wire gauge number is an expression of the cross-section area of the conductor. Boats from countries that use the metric system will typically describe the wire size as its cross-sectional area in square millimeters—when this method, the larger the wire, the greater the number. Another common system for expressing wire size is the American Wire Gauge (AWG) system. As gauge number increases, area decreases and the wire becomes smaller. An 18 gauge wire is smaller than a 4 gauge wire. A wire with a higher gauge number will carry less current than a wire with a lower gauge number. Gauge wire size refers to the size of the strands of the conductor, not the size of the complete wire with insulator. It is possible, therefore, to have two wires of the same gauge with different diameters because one may have thicker insulation than the other.

It is essential to understand how a circuit works before trying to figure out why it doesn't. An electrical schematic shows the electrical current paths when a circuit is operating properly. Schematics break the entire electrical system down into individual circuits. In a schematic, usually no attempt is made to represent wiring and components as they physically appear on the boat, switches and other components are shown as simply as possible. Face views of harness connectors show the cavity or terminal locations in all multi-pin connectors to help locate test points.

### CONNECTORS

- ◆ See Figures 5, 6, 7 and 8

Weatherproof connectors are most commonly used where the connector is exposed to the elements. Terminals are protected against moisture and dirt by sealing rings that provide a weather tight seal. All repairs require the use of a special terminal and the tool required to service it.

Unlike standard blade type terminals, these weatherproof terminals cannot be straightened once they are bent. Make certain that the connectors are properly seated and all of the sealing rings are in place when connecting leads.

### Test Equipment

Pinpointing the exact cause of trouble in an electrical circuit is most times accomplished by the use of special test equipment. The following sections describe different types of commonly used test equipment and briefly explain how to use them in diagnosis. In addition to the information covered below, the tool manufacturer's instruction manual (provided with most tools) should be read and clearly understood before attempting any test procedures.

### JUMPER WIRES

- ◆ See Figure 9

#### ⚠ CAUTION

Never use jumper wires made from a thinner gauge wire than the circuit being tested. If the jumper wire is of too small a gauge, it may overheat and possibly melt. Never use jumpers to bypass high resistance loads in a circuit. Bypassing resistances, in effect, creates a short circuit. This may, in turn, cause damage and fire. Jumper wires should only be used to bypass lengths of wire or to simulate switches.

Jumper wires are simple, yet extremely valuable, pieces of test equipment. They are basically test wires that are used to bypass sections of a circuit. Although jumper wires can be purchased, they are usually fabricated from lengths of standard marine wire and whatever type of connector (alligator clip, spade connector or pin connector) that is required

for the particular application being tested. In cramped, hard-to-reach areas, it is advisable to have insulated boots over the jumper wire terminals in order to prevent accidental grounding.

It is also advisable to include a standard marine fuse in any jumper wire. This is commonly referred to as a "fused jumper". By inserting an in-line fuse holder between a set of test leads, a fused jumper wire can be used for bypassing open circuits. Use a 5-amp fuse to provide protection against voltage spikes.

Jumper wires are used primarily to locate open electrical circuits. If an electrical component fails to operate, connect the jumper wire between the component and a good ground. If the component operates only with the jumper installed, the ground circuit is open.

If the ground circuit is good but the component does not operate, the circuit between the power feed and component may be open. By moving the jumper wire successively back from the component toward the power source, you can isolate the area of the circuit where the open is located. When the component stops functioning or the power is cut off, the open is in the segment of wire between the jumper and the point previously tested.

You can sometimes connect the jumper wire directly from the battery to the "hot" terminal of the component but first make sure the component uses 12 volts in operation. Some electrical components, such as fuel injectors or sensors are designed to operate on about 4 to 5 volts and running 12 volts directly to these components will cause damage.

### TEST LIGHTS

- ◆ See Figure 10

The test light is used to check circuits and components while electrical current is flowing through them. It is used for voltage and ground tests. To use a 12-volt test light, connect the ground clip to a good ground and probe wherever necessary with the pick. The test light will illuminate when voltage is detected. This does not necessarily mean that 12 volts (or any particular amount of voltage) is present, it only means that some voltage is present.

It is advisable before using the test light to touch its ground clip and probe across the battery posts or terminals to make sure the light is operating properly.

#### ⚠ WARNING

Do not use a test light to probe electronic ignition, spark plug or coil wires. Never use a pick-type test light to probe wiring on electronically controlled systems unless specifically instructed to do so. Any wire insulation that is pierced by the test light probe should be taped and sealed with silicone after testing.

Like the jumper wire, the 12V test light is used to isolate opens in circuits. But, whereas the jumper wire is used to bypass the open to operate the load, the 12V test light is used to locate the presence of voltage in a circuit. If the test light illuminates, there is power up to that point in the circuit, if the test light does not illuminate, there is an open circuit (no power). Move the test light in successive steps back toward the power source until the light in the handle illuminates. The open is between the probe and a point that was previously probed.

The self-powered test light is similar in design to the 12V test light but contains a 1.5V penlight battery in the handle. It is most often used in place of a multi-meter to check for open or short circuits when power is isolated from the circuit (continuity test).

The battery in a self-powered test light does not provide much current. A weak battery may not provide enough power to illuminate the test light even when a complete circuit is made (especially if there is high resistance in the circuit). Always make sure that the test battery is strong. To check the battery, briefly touch the ground clip to the probe, if the light glows brightly, the battery is strong enough for testing.

#### ⚠ WARNING

A self-powered test light should not be used on any electronically controlled system or component. The small amount of electricity transmitted by the test light is enough to damage many electronic marine components.

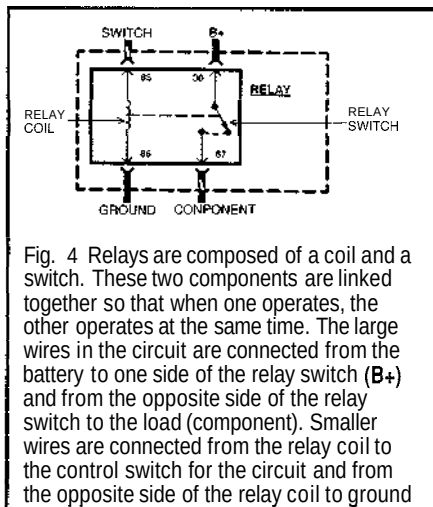


Fig. 4 Relays are composed of a coil and a switch. These two components are linked together so that when one operates, the other operates at the same time. The large wires in the circuit are connected from the battery to one side of the relay switch (B+) and from the opposite side of the relay switch to the load (component). Smaller wires are connected from the relay coil to the control switch for the circuit and from the opposite side of the relay coil to ground



Fig. 5 Bullet connectors are some of the more common electrical connectors found on an engine

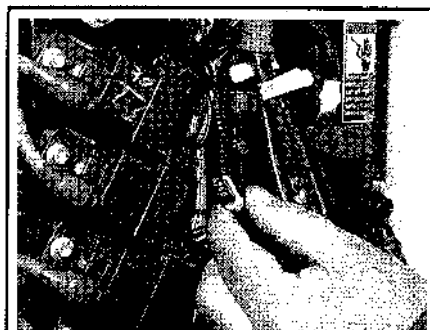


Fig. 6 A typical weatherproof electrical connector

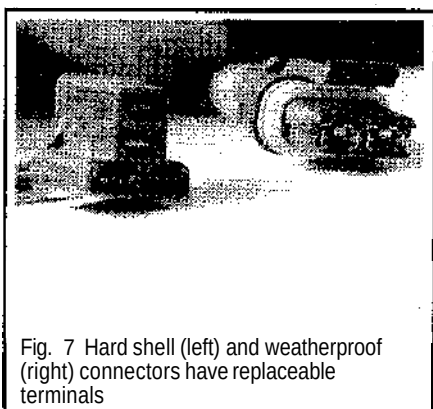


Fig. 7 Hard shell (left) and weatherproof (right) connectors have replaceable terminals

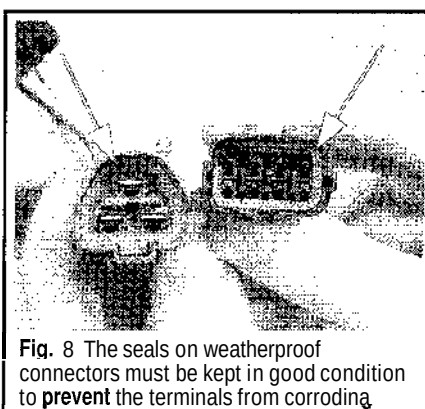


Fig. 8 The seals on weatherproof connectors must be kept in good condition to prevent the terminals from corroding

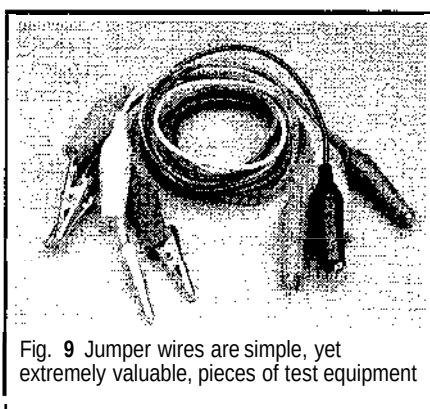


Fig. 9 Jumper wires are simple, yet extremely valuable, pieces of test equipment

## MULTI-METERS

### ◆ See Figure 11

Multi-meters are an extremely useful tool for troubleshooting electrical problems. They can be purchased either in analog or digital form and have a price range to suit any budget. A multi-meter is a voltmeter, ammeter and multi-meter (along with other features) combined into one instrument. It is often used when testing solid-state circuits because of its high input impedance (usually 10 mega-ohms or more). A brief description of the multi-meter main test functions follows:

- **Voltmeter**—the voltmeter is used to measure voltage at any point in a circuit or to measure the voltage drop across any part of a circuit. Voltmeters usually have various scales and a selector switch to allow the reading of different voltage ranges.

The voltmeter has a positive and a negative lead. To avoid damage to the meter, always connect the negative lead to the negative (-) side of the circuit (to ground or nearest the ground side of the circuit) and connect the positive lead to the positive (+) side of the circuit (to the power source or the nearest power source).

■ The negative voltmeter lead will always be Black and the positive voltmeter will always be some color other than Black (usually Red).

- **Multi-meter**—the multi-meter is designed to read resistance (measured in ohms) in a circuit or component. Most multi-meters will have a selector switch which permits the measurement of different ranges of resistance (usually the selector switch allows the multiplication of the meter reading by 10, 100, 1,000 and 10,000). Some multi-meters are "auto-ranging" which means the meter itself will determine which scale to use.

Since an internal battery powers the meters, the multi-meter can be used like a self-powered test light. When the multi-meter is connected, current from the multi-meter will flow through the circuit or component being tested. Since the multi-meter's internal resistance and voltage are known values, the amount of current flow through the meter depends on the resistance of the circuit or component being tested.

The multi-meter can also be used to perform a continuity test for suspected open circuits. In using the meter for making continuity checks, do not be concerned with the actual resistance readings. Zero resistance (or any ohm reading) indicates continuity in the circuit. Infinite resistance indicates an opening in the circuit. A high resistance reading where there should be none indicates a problem in the circuit.

Checks for short circuits are made in the same manner as checks for open circuits, except that the circuit must be isolated from both power and normal ground. Infinite resistance indicates no continuity, while zero resistance indicates a dead short.

### ✱✱WARNIN

Never use a multi-meter to check the resistance of a component or wire while there is voltage applied to the circuit.

- **Ammeter**—an ammeter measures the amount of current flowing through a circuit in units called amps (amps). At normal operating voltage, most circuits have a characteristic amount of amps, called "current draw" which can be measured using an ammeter. By referring to a specified current draw rating, then measuring the amps, and comparing the two values; one can determine what is happening within the circuit to aid in diagnosis.

For example, an open circuit will not allow any current to flow, so the ammeter reading will be zero. A damaged component or circuit will have an increased current draw, so the reading will be high.

The ammeter is always connected in series with the circuit being tested.

All of the current that normally flows through the circuit must also flow through the ammeter, if there is any other path for the current to follow, the ammeter reading will not be accurate. The ammeter itself has very little resistance to current flow and, therefore, it will not affect the circuit but it will measure current draw only when the circuit is closed and electricity is flowing. Excessive current draw can blow fuses and drain the battery, while a reduced current draw can cause motors to run slowly, lights to dim and other components to not operate properly.

## Troubleshooting the Electrical System

When diagnosing any electrical problem organized troubleshooting is a must. The complexity of electrical systems on modern boats and their power plants demands that you approach any problem in a logical organized manner. There are certain troubleshooting techniques, which are standard:

- Establish when the problem **occurs**—Does the problem appear only under certain conditions? Were there any noises, odors or other unusual symptoms?
- Check for obvious problems—Problems such as broken wires and loose or dirty connections can cause major problems. Always check the obvious before assuming something complicated (or expensive) is the cause.

Experience has shown that most problems tend to be the result of a fairly simple and obvious cause, such as loose or corroded connectors, bad grounds or damaged wire insulation, which causes a short. This makes careful visual inspection of components during testing essential to quick and accurate troubleshooting.

- Isolate the problem area—Make some simple tests and observations, then eliminate the systems that are working properly. Test for problems systematically to determine the cause once the problem area is isolated. Are all the components functioning properly? Is there power going to electrical switches and motors. Performing careful, systematic checks will often turn up most causes on the first inspection, without wasting time checking components that have little or no relationship to the problem.
- Verify all systems after repairs are completed—Some causes can be traced to more than one component, so a careful verification of repair work is important in order to pick up additional malfunctions that may cause a problem to reappear or a different problem to arise. A blown fuse, for example, is a simple problem that may require more than another fuse to repair. If you don't look for a problem that caused a fuse to blow, a shorted wire (for example) may go undetected.

### VOLTAGE

◆ See Figure 12



This test determines voltage available from the battery and should be the first step in any electrical troubleshooting procedure after visual inspection. Many electrical problems, especially on electronically controlled systems, can be caused by a low state of charge in the battery. Excessive corrosion at the battery cable terminals can cause poor contact that will prevent proper charging and full battery current flow.

1. Set the voltmeter selector switch to the 10-volt position.
2. Connect the multi-meter negative lead to the battery's negative (-) terminal and the positive lead to the battery's positive (+) terminal.
3. Turn the battery (ignition) switch ON to provide a load.
4. A well-charged battery should register over 12 volts. If the meter reads below 11.5 volts, the battery power may be insufficient to operate the electrical system properly.
5. Charge the battery and retest.

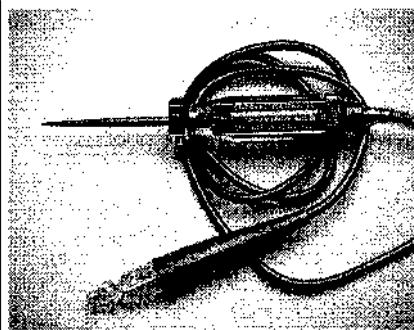


Fig. 10 A test light is used to detect the presence of voltage in a circuit

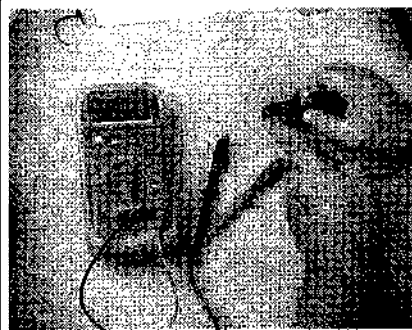


Fig. 11 Multi-meters are essential for diagnosing faulty wires, switches and other electrical components

### VOLTAGE DROP

◆ See Figure 13



When current flows through a load, the voltage beyond the load drops. This voltage drop is due to the resistance created by the load and also by small resistances created by corrosion at the connectors and damaged insulation on the wires. The maximum allowable voltage drop under load is critical, especially if there is more than one load in the circuit, since all voltage drops are cumulative.

1. Set the voltmeter selector switch to the 10-volt position.
2. Connect the multi-meter negative lead to the battery negative (-) terminal or another good ground.
3. Touch the multi-meter positive lead to the battery's positive (+) terminal to determine battery voltage.
4. Operate the circuit and check the voltage prior to the first component (load).
5. There should be little or no voltage drop (from battery voltage) in the circuit prior to the first component. If a voltage drop exists, the wire or connectors in the circuit are suspect.
6. While operating the first component in the circuit, probe the ground-side of the component with the positive (+) meter lead and observe the voltage readings. A small voltage drop should be noticed. The resistance of the component causes this voltage drop.
7. Repeat the test for each component (load) down the circuit.
8. If a large voltage drop is noticed, the preceding component, wire or connector is suspect.

### RESISTANCE

◆ See Figures 14 and 15



### ⚠️WARNING

Never use a multi-meter with power applied to the circuit. The multi-meter is designed to operate on its own power supply. The normal 12-volt electrical system voltage can damage the meter!

1. Isolate the circuit from the boat's power source.
2. Ensure that the battery (ignition) switch is OFF.
3. Isolate at least one side of the circuit to be checked, in order to avoid reading parallel resistances. Parallel circuit resistances will always give a lower reading than the actual resistance of either of the branches.
4. Connect the meter leads to both sides of the circuit (wire or component) and read the actual resistance measured in ohms on the meter scale. Make sure the selector switch is set to the proper ohm scale for the circuit being tested, to avoid misreading the multi-meter test value.
5. Compare this reading to the resistance specification for the component or formulate the theoretical resistance using Ohms Law.

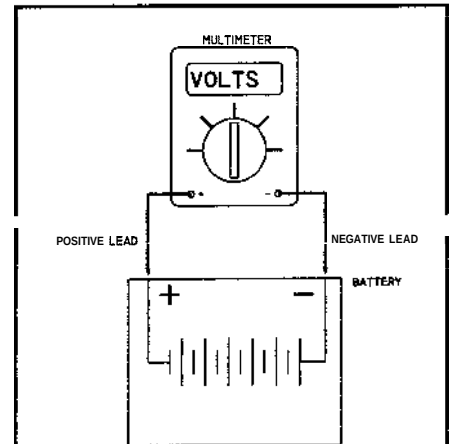


Fig. 12 The voltage test determines voltage available from the battery and should be the first step in any electrical troubleshooting procedure after visual inspection

## OPEN CIRCUITS



◆ See Figures 16 and 17

This test already assumes the existence of an open in the circuit and it is used to help locate the open portion.

1. Isolate the circuit from power and ground.
2. Connect the self-powered test light or multi-meter ground clip to the ground-side of the circuit and probe sections of the circuit sequentially.
3. If the light is out or there is infinite resistance, the open is between the probe and the circuit ground.
4. If the light is on or the meter shows continuity, the open is between the probe and the end of the circuit toward the power source.

## SHORT CIRCUITS



◆ See Figure 18

❑ Never use a self-powered test light to perform checks for opens or shorts when power is applied to the circuit under test. The test light can be damaged by outside power.

1. Isolate the circuit from power and ground.
2. Connect the self-powered test light or multi-meter ground clip to a good ground and probe any easy-to-reach point in the circuit.
3. If the light comes on or there is continuity, there is a short somewhere in the circuit.

4. To isolate the short, probe a test point at either end of the isolated circuit (the light should be on or the meter should indicate continuity).
5. Leave the test light probe engaged and sequentially open connectors or switches, remove parts, etc. until the light goes out or continuity is broken.
6. When the light goes out, the short is between the last two circuit components, which were opened.

## Wire and Connector Repair

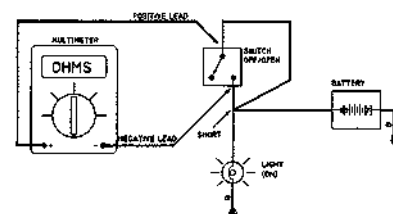
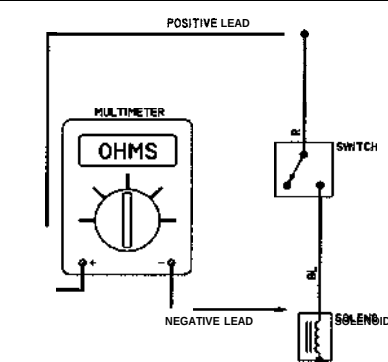
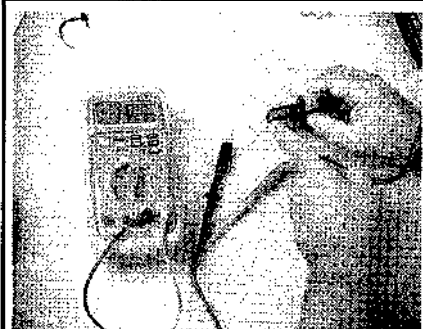
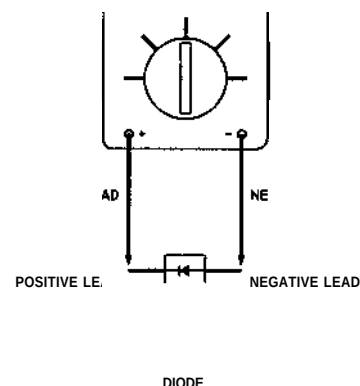
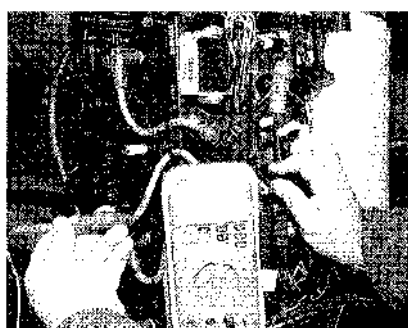
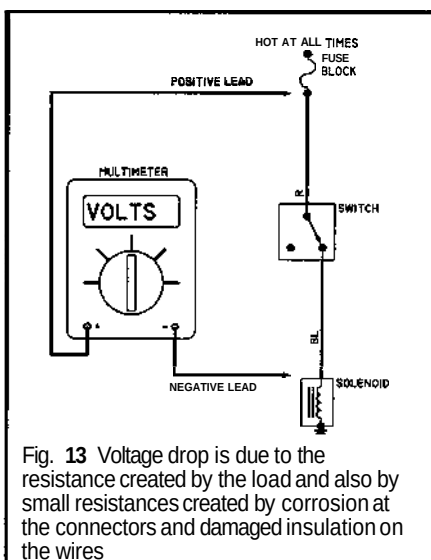


Almost anyone can replace damaged wires, as long as the proper tools and parts are available. Wire and terminals are available to fit almost any need. Even the specialized weatherproof, molded and hard shell connectors are now available from aftermarket suppliers.

Be sure the ends of all the wires are fitted with the proper terminal hardware and connectors. Wrapping a wire around a stud is never a permanent solution and will only cause trouble later. Replace wires one at a time to avoid confusion. Always route wires in the same manner of the manufacturer.

When replacing connections, make absolutely certain that the connectors are certified for marine use. Automotive wire connectors may not meet United States Coast Guard (USCG) specifications.

If connector repair is necessary, only attempt it if you have the proper tools. Weatherproof connectors require special tools to release the pins inside the connector. Attempting to repair these connectors with conventional hand tools will damage them.



# 10-8 IGNITION AND ELECTRICAL SYSTEMS

## BATTERY

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 and electrical accessories.

Because of its job and the consequences (failure to perform in an emergency), the best advice is to purchase a well-known brand, with an extended warranty period, from a reputable dealer.

The usual warranty covers a pro-rated replacement policy, which means the purchaser is entitled to consideration for the time left on the warranty period if the battery should prove defective before the end of the warranty.

Many manufacturers have specifications on the size and type of battery to use for their engines. If in doubt as to how large a battery the boat requires, make a liberal estimate and then purchase the one with the next higher amp rating.

■ Please refer to the Maintenance section for all procedures on cleaning, testing, storage and maintenance.

### BATTERY CONSTRUCTION

◆ See Figure 19

A battery consists of a number of positive and negative plates immersed in a solution of diluted sulfuric acid. The plates contain dissimilar active materials and are kept apart by separators. The plates are grouped into elements. Plate straps on top of each element connect all of the positive plates and all of the negative plates into groups.

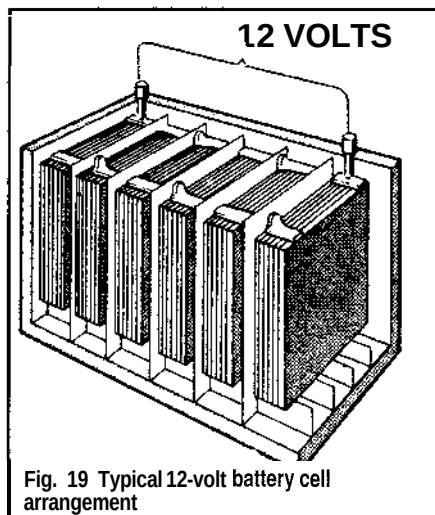
The battery is divided into cells holding a number of the elements apart from the others. The entire arrangement is contained within a hard plastic case. The top is a one-piece cover and contains the filler caps for each cell. The terminal posts protrude through the top where the battery connections for the boat are made. Each of the cells is connected to its neighbor in a positive-to-negative manner with a heavy strap called the cell connector.

### MARINE BATTERIES

◆ See Figure 20

Because marine batteries are required to perform under much more rigorous conditions than automotive batteries, they are constructed 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 are thicker and each plate is securely anchored within the battery case to ensure extended life. The caps are spill proof to prevent acid from spilling into the bilge 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 intended for automotive use.



## ✱✱WARNING

Never use a maintenance-free battery with an engine that is not voltage regulated. The charging system will continue to charge as long as the engine is running and it is possible that the electrolyte could boil out if periodic checks of the cell electrolyte level are not done.

### BATTERY RATINGS

◆ See Figure 21

Three different methods are used to measure and indicate battery electrical capacity:

- Amp/hour rating
- Cold cranking performance
- Reserve capacity

The amp/hour rating of a battery refers to the battery's ability to provide a set amount of amps for a given amount of time under test conditions at a constant temperature. Therefore, if the battery is capable of supplying 4 amps of current for 20 consecutive hours, the battery is rated as an 80 amp/hour battery. The amp/hour rating is useful for some service operations, such as slow charging or battery testing.

Cold cranking performance is measured by cooling a fully charged battery to 0°F (-17°C) and then testing it for 30 seconds to determine the maximum current flow. In this manner the cold cranking amp rating is the number of amps available to be drawn from the battery before the voltage drops below 7.2 volts.

The illustration depicts the amount of power in watts available from a battery at different temperatures and the amount of power in watts required of the engine at the same temperature. It becomes quite obvious—the colder the climate, the more necessary for the battery to be fully charged.

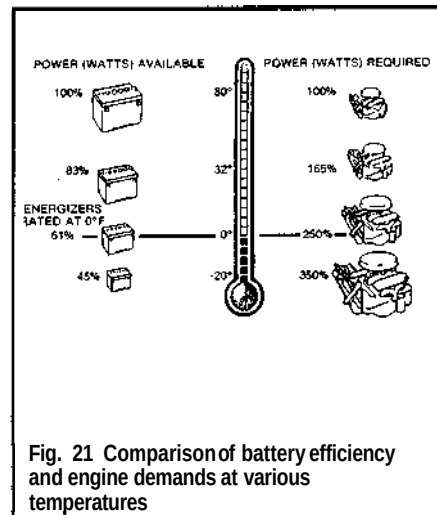
Reserve capacity of a battery is considered the length of time, in minutes, at 80°F (27°C), a 25 amp current can be maintained before the voltage drops below 10.5 volts. This test is intended to provide an approximation of how long the engine, including electrical accessories, could operate satisfactorily if the stator assembly or lighting coil did not produce sufficient current. A typical rating is 100 minutes.

■ If possible, the new battery should have a power rating equal to or higher than the unit it is replacing.

### BATTERY LOCATION

✚ See Figure 22

Every battery installed in a boat must be secured in a well protected, ventilated area. If the battery area lacks adequate ventilation, hydrogen gas, which is given off during charging, is very explosive. This is especially true if the gas is concentrated and confined.



## DUAL BATTERY INSTALLATION

† See Figure 23, 24, 25 and 26

Three methods are available for utilizing a dual-battery hook-up

1 A high-capacity switch can be used to connect the two batteries. The accompanying illustration details the connections for installation of such a switch. This type of switch installation has the advantage of being simple, inexpensive, and easy to mount and hookup. However, if the switch is 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 terminal. When connected in this manner, while the engine is being cranked, the relay is open, but when the engine is running with the ignition switch in the normal position, the relay is closed, and the second battery is being charged at the same time as the starting battery.

3 A heavy duty switch installed as close to the batteries as possible can be connected between them. If such an arrangement is used it must meet the standards of the American Boat and Yacht Council, or the Fire Protection Standard for Motor Craft, N.F.P.A. No. 302.

## BATTERY CHARGERS

◆ See Figure 27

Before using any battery charger, consult the manufacturer's instructions for its use. Battery chargers are electrical devices that change Alternating Current (AC) to a lower voltage of Direct Current (DC) that can be used to charge a marine battery. There are two types of battery chargers—manual and automatic.

A manual battery charger must be physically disconnected when the battery has come to a full charge. If not, the battery can be overcharged and possibly fail. Excess charging current at the end of the charging cycle will heat the electrolyte, resulting in loss of water and active material, substantially reducing battery life.

**As a rule, on manual chargers, when the ammeter on the charger registers half the rated amperage of the charger, the battery is fully charged. This can vary and it is recommended to use a hydrometer to accurately measure state of charge.**

Automatic battery chargers have an important advantage—they can be left connected (for instance, overnight) without the possibility of overcharging the battery. Automatic chargers are equipped with a sensing device to allow the battery charge to taper off to near zero as the battery becomes fully charged. When charging a low or completely discharged battery, the meter will read close to full rated output. If only partially discharged, the initial reading may be less than full rated output, as the charger responds to the condition of the battery. As the battery continues to charge, the sensing device monitors the state of charge and reduces the charging rate. As the rate of charge tapers to zero amps, the charger will continue to supply a few milliamps of current—just enough to maintain a charged condition.

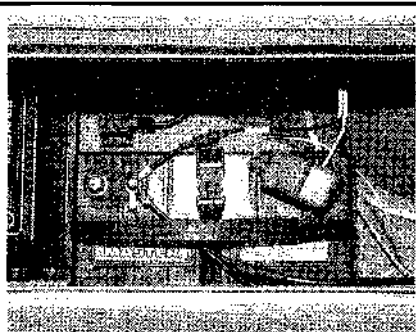


Fig. 22 A good example of a secured, well protected and ventilated battery area

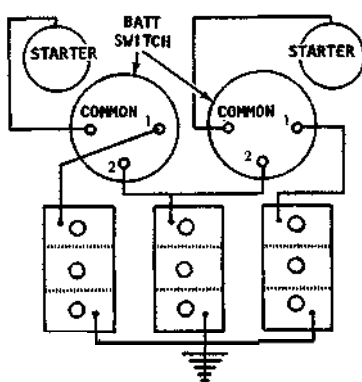


Fig. 23 Schematic diagram for a typical three battery, two engine hookup.

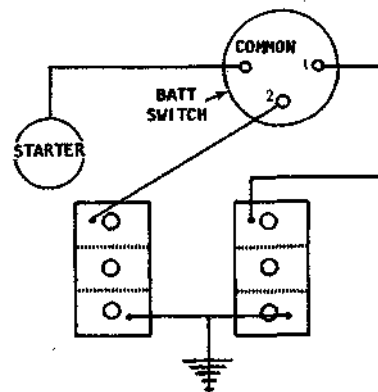


Fig. 24 Schematic diagram for a typical two battery, one engine hookup.

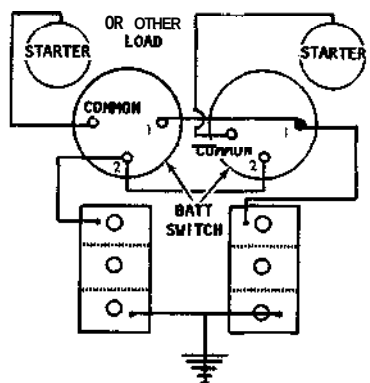


Fig. 25 Schematic diagram for a typical two battery, two engine hookup.

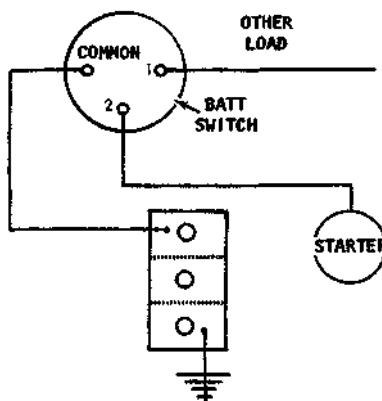


Fig. 26 Schematic diagram for a typical single battery, one engine hookup.

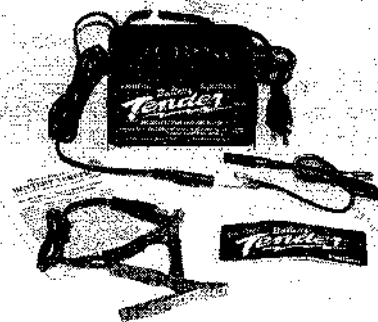


Fig. 27 Automatic chargers, such as the Battery Tender® from Deltran, are equipped with a sensing device to allow the battery charge to taper off to near zero as the battery becomes fully charged

# 10-10 IGNITION AND ELECTRICAL SYSTEMS

## BATTERY CABLES

Battery cables don't go bad very often but like anything else, they can wear out. If the cables on your boat are cracked, frayed or broken, they should be replaced.

When working on any electrical component, it is always a good idea to disconnect the negative (-) battery cable. This will prevent potential damage to many sensitive electrical components.

Always replace the battery cables with one of the same length or you will increase resistance and possibly cause hard starting. Smear the battery posts with a light film of dielectric grease or a battery terminal protectant-spray once you've installed the new cables. If you replace the cables one at a time, you won't mix them up.

## CHARGING SYSTEM

□ For additional, and model specific, electrical schematics of the charging system, please refer to the Wiring Diagrams section.

### General Information

The charging system provides electrical power for operation of the vessel's ignition system, starting system and all electrical accessories. The battery serves as an electrical surge or storage tank, storing (in chemical form) the energy originally produced by the engine driven alternator. The system also provides a means of regulating output to protect the battery from being overcharged and to avoid excessive voltage to the accessories.

The storage battery is a chemical device incorporating parallel lead plates in a tank containing a sulfuric acid/water solution. Adjacent plates are slightly dissimilar, and the chemical reaction of the two dissimilar plates produces electrical energy when the battery is connected to a load such as the starter motor. The chemical reaction is reversible, so that when the alternator is producing a voltage (electrical pressure) greater than that produced by the battery, electricity is forced into the battery, and the battery is returned to its fully charged state.

Newer engines use alternating current alternators, because they are more efficient, can be rotated at higher speeds, and have fewer brush problems. In an alternator, the field usually rotates while all the current produced passes only through the stator winding. The brushes bear against continuous slip rings. This causes the current produced to periodically reverse the direction of its flow. Diodes (electrical one way valves) block the flow of current from traveling in the wrong direction. A series of diodes is wired together to permit the alternating flow of the stator to be rectified back to 12 volts DC for use by the vessel's electrical system.

The voltage regulating function is performed by a regulator. The regulator is often built into the alternator; this system is termed an integrated or internal regulator.

An alternator differs from a DC shunt generator in that the armature is stationary, and is called the stator, while the field rotates and is called the rotor. The higher current values in the alternator's stator are conducted to the external circuit through fixed leads and connections, rather than through a rotating commutator and brushes as in a DC generator. This eliminates a major point of maintenance.

The rotor assembly is supported in the drive end frame by a ball bearing and at the other end by a roller bearing. These bearings are lubricated during assembly and require no maintenance. There are six diodes in the end frame assembly. These diodes are electrical check valves that also change the alternating current developed within the stator windings to a Direct Current (DC) at the output (BAT) terminal. Three of these diodes are negative and are mounted flush with the end frame while the other three are positive and are mounted into a strip called a heat sink. The positive diodes are easily identified as the ones within small cavities or depressions.

The alternator charging system is a negative (-) ground system which consists of an alternator, a regulator, a charge indicator, a storage battery and wiring connecting the components, and fuse link wire.

The alternator is belt-driven from the engine. Energy is supplied from the alternator/regulator system to the rotating field through two brushes to two slip-rings. The slip-rings are mounted on the rotor shaft and are connected to the field coil. This energy supplied to the rotating field from the battery is called excitation current and is used to initially energize the field to begin the generation of electricity. Once the alternator starts to generate electricity, the excitation current comes from its own output rather than the battery.

The alternator produces power in the form of alternating current. The alternating current is rectified by 6 diodes into direct current. The direct current is used to charge the battery and power the rest of the electrical system.

■ Anytime you disconnect the battery cables, it is recommended that you disconnect the negative (-) battery cable first. This will prevent you from accidental grounding the positive (+) terminal when disconnecting it; thereby preventing damage to the electrical system,

Before you disconnect the cable(s), first turn the ignition to the OFF position. This will prevent a draw on the battery that could cause arcing. When the battery cable(s) are reconnected (negative cable last), be sure to check all electrical accessories are all working correctly.

When the ignition key is turned to the ON position, current flows from the battery, through the charging system indicator light, to the voltage regulator, and on to the alternator. When the engine is started, the alternator begins to produce current. As the alternator turns and produces current, the current is divided in two ways: part to the battery (to charge the battery and power the electrical components of the vessel), and part is returned to the alternator (to enable it to increase its output). In this situation, the alternator is receiving current from the battery and from itself. A voltage regulator is wired into the current supply to the alternator to prevent it from receiving too much current, which would cause it to put out too much current. Conversely, if the voltage regulator does not allow the alternator to receive enough current, the battery will not be fully charged and will eventually go dead.

The battery is connected to the alternator at all times, whether the ignition key is turned ON or not. If the battery were shorted to ground, the alternator would also be shorted. This would damage the alternator. To prevent this, a fuse link is installed in the wiring between the battery and the alternator. If the battery is shorted, the fuse link melts, protecting the alternator.

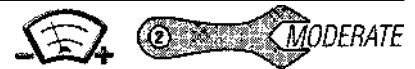
An alternator is better than a conventional, DC shunt generator because it is lighter and more compact, because it is designed to supply the battery and accessory circuits through a wide range of engine speeds, and because it eliminates the necessary maintenance of replacing brushes and servicing commutators.

### General System Troubleshooting

□ For additional, and model specific, electrical schematics of the charging system, please refer to the Wiring Diagrams section.

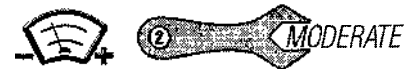
The following symptoms and possible corrective actions will be helpful in restoring a faulty charging system to proper operation.

#### ALTERNATOR FAILS TO CHARGE



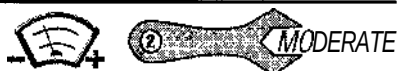
1. Drive belt loose or broken. Replace and/or adjust drive belt.
2. Corroded or loose wires or connection in the charging circuit. Inspect, clean, and tighten.
3. Worn brushes or slip rings. Replace as necessary.
4. Sticking brushes.
5. Open field circuit. Trace and repair.
6. Open charging circuit. Trace and repair.
7. Open circuit in the stator windings.
8. Open rectifier. Replace the unit.
9. Defective regulator. Replace as necessary.

#### ALTERNATOR CHARGES LOW OR UNSTEADY



1. Drive belt loose or broken. Replace and/or adjust drive belt.
2. Battery charge too low. Charge or replace the battery.
3. Defective regulator. Replace as necessary.
4. High resistance, at the battery terminals. Remove the cables, clean the 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 the ground circuit. Trace and repair.

## ALTERNATOR OUTPUT LOW & LOW BATTERY



1. Drive belt slipping. Adjust or replace belt.
2. High resistance in the charging circuit. Trace and repair.
3. Shorted or open circuit in rectifier. Replace as necessary.
4. Grounded stator windings. Replace alternator.

## ALTERNATOR OUTPUT TOO HIGH—BATTERY OVERCHARGED



1. Faulty voltage regulator. Replace as necessary.
2. Regulator base not grounded properly. Correct condition to make good ground.
3. Faulty ignition switch. Replace switch.

## 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 and stator leads or rectifier leads. Check and correct.
5. Rotor or fan damaged. Replace.
6. Open or shorted rectifier. Replace.
7. Open or shorted winding in stator. Replace.

## AMMETER FLUCTUATES CONSTANTLY



1. High resistance connection in the alternator or voltage regulator circuit. Trace and repair.

## Alternator

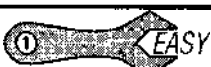
For additional, and model specific, electrical schematics of the charging system, please refer to the Wiring Diagrams section.

## PRECAUTIONS

Several precautions must be observed when performing work on alternator equipment.

- If the battery is removed for any reason, make sure that it is reconnected with the correct polarity. Reversing the battery connections may result in damage to the one-way rectifiers.
- Never short across or ground any of the alternator terminals unless specifically mentioned in a particular test procedure.
- Never operate the alternator with the main circuit broken. Make sure that the battery, alternator, and regulator leads are not disconnected while the engine is running.
- Never attempt to polarize an alternator.
- When charging a battery that is installed in the vessel, disconnect the battery cables.
- When arc (electric) welding is to be performed on any part of the vessel, disconnect the negative battery cable and alternator leads.
- Never disconnect the battery cables while the engine is running

## CHARGING SYSTEM INSPECTION



1. Make sure the battery connections are clean and tight and that the battery is in good condition and fully charged.
2. Check the drive belt for damage or looseness.
3. Check the wiring harness at the alternator. The harness connector should be tight and latched. Make sure that the output terminal of the alternator is connected to the vessel battery positive lead.
4. Verify that all charging system related fuses and electrical connections are tight and free of damage.

5. Check the mounting bolts for proper torque.

The alternator does not require periodic lubrication. The rotor shaft is mounted on bearings at the drive end and the slip ring end. Each bearing contains its own permanent grease supply.

## TESTING



Many times the alternator is suspected of being defective when the battery is not receiving a charge and is constantly being depleted of its energy. Most of the time a heavily corroded wire terminal, broken wire or worn out battery is the actual problem. Perform the preliminary checks listed above to eliminate any problem areas in the charging circuitry before performing the output tests.

If the battery is constantly undercharged, verify all accessories are being switched off when the engine is not running. Check to see if a new accessory (fish finder, live bait tank, etc.) has been added which will place a heavy ampere draw on the battery when operating at low speeds. The battery may be drained when operating at slow speeds for long periods of time.

Check the physical condition and charge state of the battery. The battery should be 75% (1.230 specific gravity) of a full charge. If one or more cells in the battery are defective, the battery should be replaced.

Inspect the alternator system wiring for corroded or loose terminals, damaged or frayed wiring and/or loose wire harness connectors. Check the drive belt for physical condition and proper tension.

If the charging system has passed all the above visual checks, perform the output tests to determine if the alternator is defective.

The following tests require the use of a voltmeter/multi-meter capable of reading 0-20 volts DC. These tests will determine if the alternator and other components within the alternator circuit are in satisfactory working condition.

## Alternator Output Test

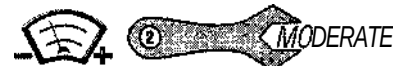


- ◆ See Figures 28, 29 and 30

Always perform the following test prior to any others so that you can first confirm that a charging problem exists.

1. Slide off the rubber boot and disconnect the orange lead at the **POS+** terminal (1986-96), or **B** terminal (1997-98), on the rear of the alternator. Connect and ammeter in series between the terminal and the orange lead—positive probe to terminal and negative probe to lead.
2. Connect a multi-meter between the **POS+**, or **B**, terminal and an engine ground—positive probe to terminal and negative probe to ground.
3. Connect a carbon pile (or Stevens LB-85 Load Bank) across the battery.
4. Start the engine and allow it to idle. Run the engine to 2000 rpm (1986), 650 and 1700 rpm (1991-92), or 650, 1500 and 2000 or higher rpm (1987-90 and 1993-98). Check the meter readings at each benchmark. Compare them to the minimum output and voltage range numbers given for your alternator in the Alternator Test Specifications at the end of this section.
5. If a battery overcharge condition is indicated by excessive water usage, the meter's showing consistent charge or the alternator output at idle (no load) exceeding 14.7V (15.2V on 1986, 14.8V for the 1993-96 65 amp alternator and 15 V on 1997-98); check voltage at the purple lead connected to the **S** terminal on the alternator—low voltage, or no voltage, will cause overcharging. If voltage is OK, there is a short at the voltage regulator and it should be replaced.
6. If a battery undercharge condition is indicated (or no charge at all), perform the following tests in order.

## Battery Charging Circuit Test



- ◆ See Figures 31, 32 and 33

1. Slide the rubber boot off of the **POS+** (1987-96), or **B** terminal (1997-98), terminal. Connect the positive lead of a multi-meter to the orange lead (still connected) and the negative lead to an engine ground. The meter should show normal battery voltage (approx. 12V).

# 10-12 IGNITION AND ELECTRICAL SYSTEMS

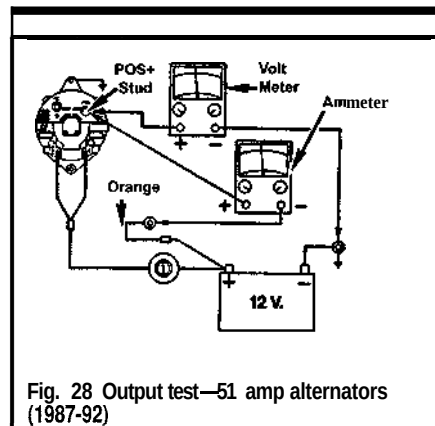


Fig. 28 Output test—51 amp alternators (1987-92)

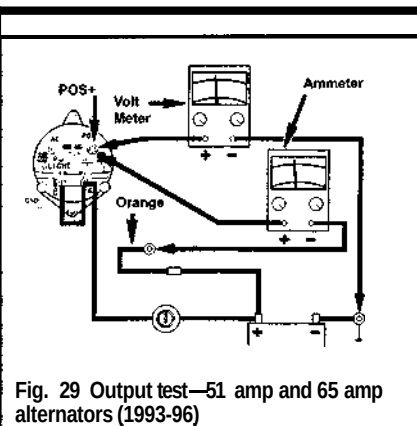


Fig. 29 Output test—51 amp and 65 amp alternators (1993-96)

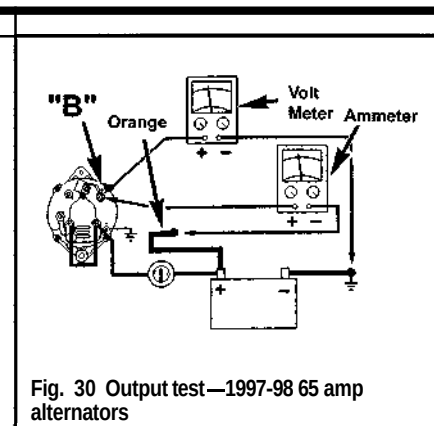


Fig. 30 Output test—1997-98 65 amp alternators

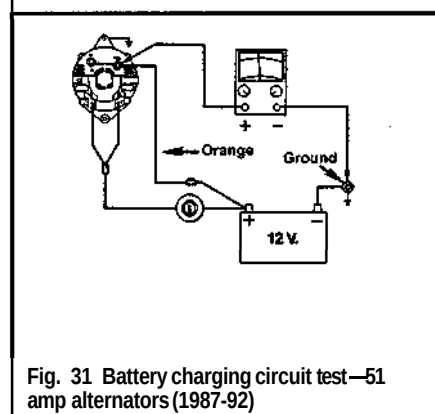


Fig. 31 Battery charging circuit test—51 amp alternators (1987-92)

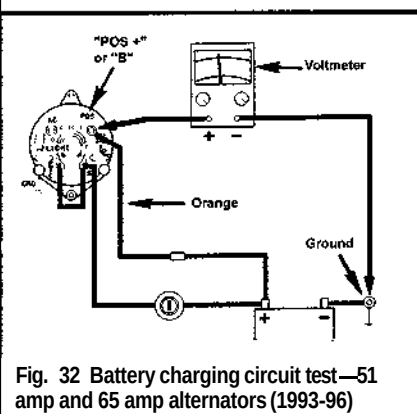


Fig. 32 Battery charging circuit test—51 amp and 65 amp alternators (1993-96)

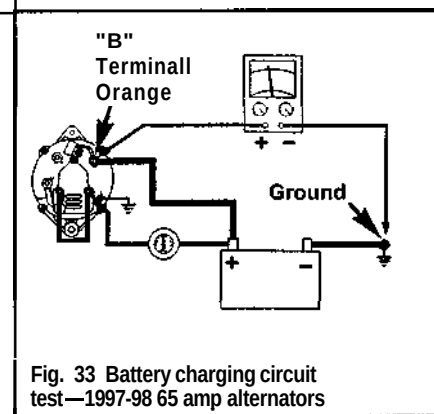


Fig. 33 Battery charging circuit test—1997-98 65 amp alternators

2. If voltage is not within 1V of battery voltage, check the circuit between the orange lead and the circuit breaker, and then the red lead to the starter assist solenoid and then repeat the Output Test.

3. If no voltage is shown, check for an open circuit and repeat the Output Test.

4. If the reading is within specification, move to the next test if working on a 1987-96 51/65 amp alternator, or the Ignition Circuit Test if working on the 1997-98 65 amp alternator.

## Red/Purple "EX Or "EXC Lead Test



1987-96 51/65Amp Alternators Only

◆ See Figures 34 and 35

1. Disconnect the red/purple lead at the EX or EXC terminal on the back of the alternator.

2. Connect a multi-meter between the lead and an engine ground—positive probe to the lead and negative probe to ground.

3. Turn the ignition switch to the ON position but do not start the engine. The meter should show normal battery voltage (approx. 12V). If it does, move on to the next test.

4. If the meter indicates less than battery voltage, check the purple wire circuit between the alternator and the ignition switch for corrosion or bad connections. Repair and then repeat the Output Test.

5. If the meter indicates an open circuit (OV), check and repair the purple wire circuit and then repeat the Output Test.

6. If the meter reading is OV and the fuse or circuit breaker blows each time the ignition switch is turned ON, the purple wire is grounded against another wire or component. Repair the ground and then repeat the Output Test.

## Purple "S" Lead Test



1986 42 Amp Alternators Only

1. Disconnect the purple lead at the terminal on the back of the alternator.

2. Connect a multi-meter between the lead and an engine ground—positive probe to the lead and negative probe to ground.

3. Turn the ignition switch to the ON position but do not start the engine. The meter should show normal battery voltage (approx. 12V). If it does, check the battery.

4. If the meter indicates less than battery voltage, check the purple circuit between the alternator and the ignition switch for corrosion or bad connections. Repair and then repeat the Output Test.

5. If all wiring is OK, check the battery again; perform a specific gravity test and a load test. A fully charged battery, or a sulfated one, would make the alternator show normal voltage but still be low on amperage.

1987-96 51/65Amp Alternators Only

◆ See Figures 36 and 37

1. Disconnect the purple lead at the S terminal on the back of the alternator.

2. Connect a multi-meter between the lead and an engine ground—positive probe to the lead and negative probe to ground.

3. Turn the ignition switch to the ON position but do not start the engine. The meter should show normal battery voltage (approx. 12V). If it does, move on to the Excite/Sense Circuit Test.

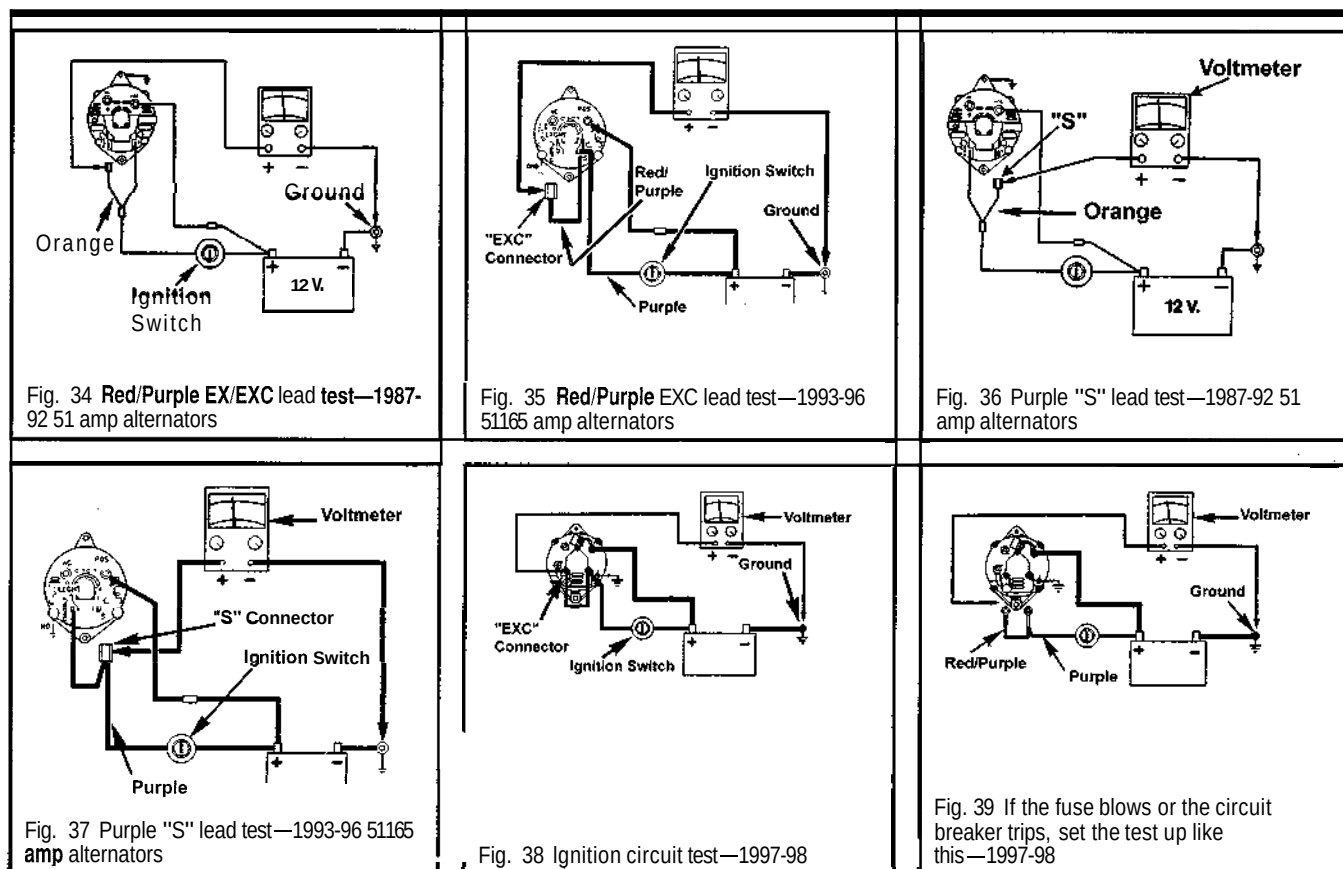
4. If the meter indicates less than battery voltage, check the purple circuit between the alternator and the ignition switch for corrosion or bad connections. Repair and then repeat the Output Test.

5. If the meter indicates an open circuit (OV), check and repair the circuit and then repeat the Output Test.

6. If the meter reading is OV and the fuse or circuit breaker blows each time the ignition switch is turned ON, the purple wire is grounded against another wire or component. Repair the ground and then repeat the Output Test.

7. If all wiring is OK, check the battery again; perform a specific gravity test and a load test. A fully charged battery, or a sulfated one, would make the alternator show normal voltage but still be low on amperage.

8. If everything is still OK, move to the Excite/Sense Circuit Test.



## Ignition Circuit Test



### 1997-98 Alternators Only

◆ See Figures 38 and 39

1. Connect a multi-meter between the EXC lead and an engine ground—positive probe to the lead and negative probe to ground.
2. Turn the ignition switch to the ON position, but do not start the engine. The meter should show normal battery voltage (approx. 12V). If it does, move on to the Excite!Sense Circuit Test.
3. If the meter indicates less than battery voltage (1 or more volts less), disconnect the purple and red/purple leads, connect an ohmmeter and check continuity back to the ignition switch. Repair and then repeat the Output Test.
4. If the meter indicates an open circuit (0 V), disconnect the purple and red/purple leads and repeat the voltage check.
5. If the meter reading is 0V and the fuse or circuit breaker blows each time the ignition switch is turned ON, disconnect the purple and red/purple leads and repeat the voltage check in Steps 1-2. If the fuse/breaker doesn't blow (or trip), the circuit is grounding through the alternator and you will need to replace it. If they do blow, there's a problem in the ignition switch circuit—find it and correct it. Repeat the Output Test.
6. If all wiring is OK, check the battery again; perform a specific gravity test and a load test. A fully charged battery, or a sulfated one, would make the alternator show normal voltage but still be low on amperage.
7. If everything is still OK, move to the Excite!Sense Circuit Test.

## Excite!Sense Circuit Test



### 1987-98 Engines Only

◆ See Figures 40, 41 and 42

1. Connect a multi-meter between the Light stud (1987-96), or L2 terminal (1997-98), on the rear of the alternator and ground—positive lead to the stud, negative lead to ground. There should not be a wire connected to the stud.

■ On many models (particularly those with a mechanical fuel pump), you will need to unscrew the protective cap on the stud.

2. Turn the ignition switch to the ON position but do not start the engine. The meter should read 1.5-3.0 V on 1987-96 models, or 1-2 V on 1997-98 models. If it does, move on to the Diode-Trio Test on 1987-96 models; if not, replace the voltage regulator.

3. If on replacing the regulator, the alternator continues to fail to produce the specified voltage and amperage, disassemble the alternator and perform the internal tests detailed later.

## Diode-Trio Test



### 1987-96 Alternators Only

◆ See Figures 43 and 44

1. Bypass the diode-trio by connecting a jumper wire between the POS+ terminal and the LIGHT stud on the back of the alternator.

■ On models with a mechanical fuel pump, you will need to unscrew the protective cap on the Light stud.

2. Connect a multi-meter between the POS+ terminal stud and an engine ground—positive lead to the stud, negative to the ground.
3. Start the engine and allow it to idle. If you detect charging voltage at the POS+ terminal stud, replace the diode-trio.
4. If your alternator passed both the Excite!Sense Test and this test, replace the voltage regulator. If on replacing the regulator, the alternator continues to fail to produce the specified voltage and amperage, disassemble the alternator and perform the internal tests detailed later.

# 10-14 IGNITION AND ELECTRICAL SYSTEMS

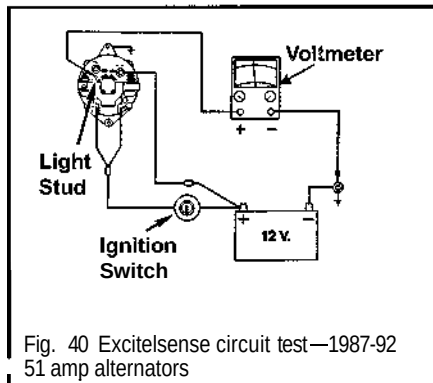


Fig. 40 Excitesense circuit test—1987-92 51 amp alternators

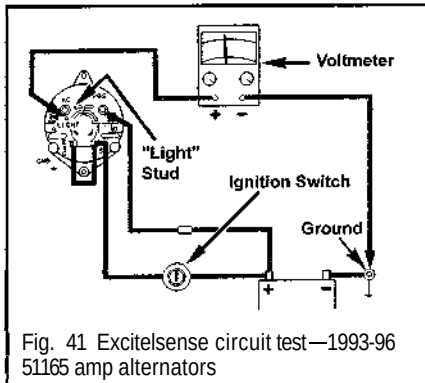


Fig. 41 Excitesense circuit test—1993-96 51165 amp alternators

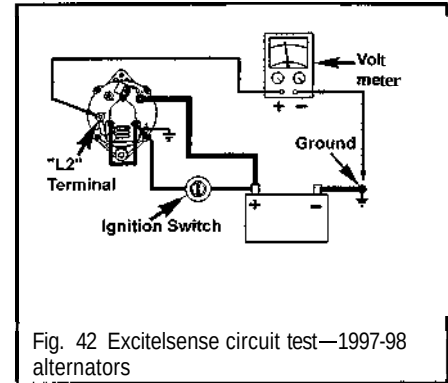


Fig. 42 Excitesense circuit test—1997-98 alternators

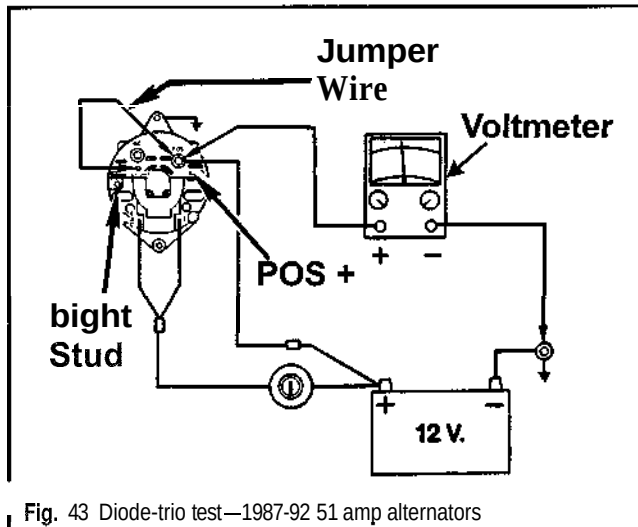


Fig. 43 Diode-trio test—1987-92 51 amp alternators

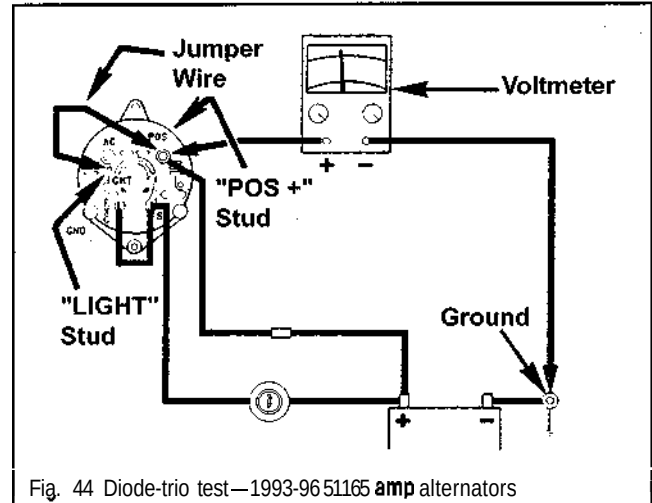


Fig. 44 Diode-trio test—1993-96 51165 amp alternators

## REMOVAL & INSTALLATION

◆ See Figures 45 and 46



1. Disconnect both the negative and positive battery cables from the battery terminal posts. On the back of the alternator, tag and disconnect all electrical leads from the terminals at the rear of the alternator. Although you can always refer to the wiring schematics on installation, we strongly suggest making good notes of which terminal each lead was connected to.

2. Loosen the alternator pivot and belt adjustment bolt(s). Pivot the alternator inward and remove the alternator drive belt from the pulley.

3. Remove the alternator mounting bolt(s) and nut(s)—drive belt models use a mounting bolt and a pivot bolt. Lift the alternator free of the engine.

To Install:

4. Install the alternator into the mounting bracket with the bolt, washers, spacer (if equipped) and nuts. Do not tighten the bolts yet; just leave them finger tight.

5. Reconnect all leads to their original terminals. Coat the purple and red/purple leads with Liquid Neoprene. Make sure that the rubber boots or plastic caps are positioned correctly so they cover the connection fully.

6. Install the drive belt and adjust it as detailed in the Maintenance section and then tighten the bolts securely.

7. Reconnect the battery cables.

## DISASSEMBLY

■ As expressed earlier in this manual, some times the equipment, small parts and experience required to repair the alternator will suggest that it is more cost effective if the alternator is taken to a shop which specializes in alternator rebuilding. Be sure to inform the shop that the alternator is for a marine application, to ensure the terminal ends and covers are installed properly.

If a specialty shop is not available, use the following instructions and exploded diagram to disassemble the alternator.

## 1986 Alternators



1. Remove the alternator.
2. Carefully position the alternator into a soft-jawed vise and then scribe or paint reference marks across the two housing halves.
3. Loosen and remove the 4 housing bolts. Pry the metal tabs away from the rubber plug and then lift off the end screen.
4. Remove the small rubber connector from the housing.
5. Position a 5116 in. Allen wrench in vise. Slide the alternator shaft onto the wrench and then remove the end nut with a 15116 in. wrench. Remove the washer, pulley, fan and collar from the rotor shaft.
6. Carefully pull the rotor assembly up and off the end of the slip ring frame, being very careful to not lose the brush springs. Its not a bad idea to cover the end frame with a piece of tape to keep any dirt out of the bearing.
7. Remove the diode trio screw and insulating washer holding it to the regulator. Now remove the 3 nuts securing the trio to the rectifier bridge and lift out the trio and the stator

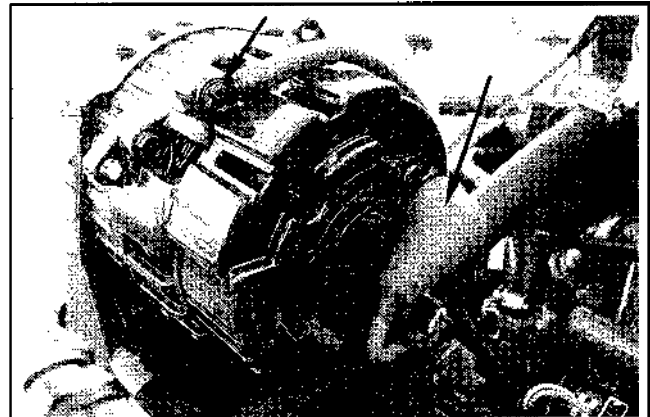


Fig. 45 Disconnect all electrical leads at the rear of the alternator...

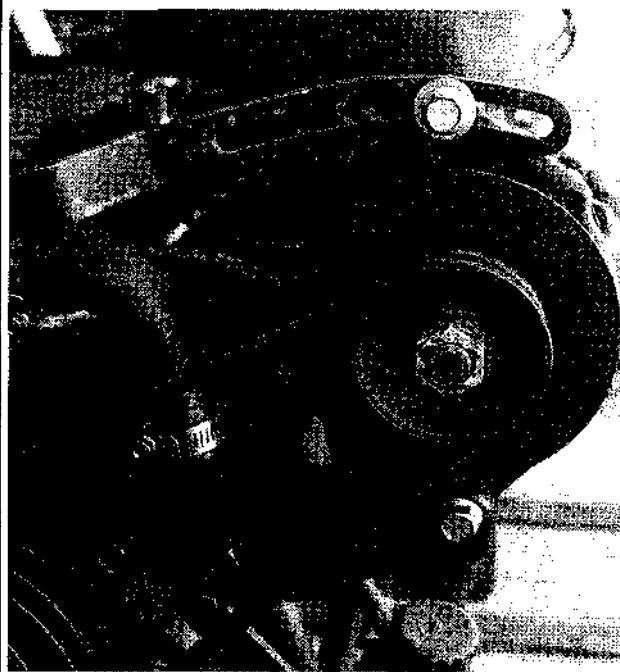


Fig. 46 ...and then remove the mounting and pivot bolt (typical installation shown)

## 1987-96 Alternators

◆ See Figures 47, 48 and 49



1. Remove the alternator.
2. Run an oversize drive belt around the pulley and then clamp it into a vise so that the belt protects the pulley/alternator. Loosen the pulley nut.
3. Lift the assembly out of the vise and place it carefully on a clean workbench. Remove the pulley nut, pulley, fan, woodruff key and the spacer.
4. If equipped, remove the protective cap, from the LIGHT stud. Remove any nuts, washers and insulators from the remaining studs or terminals; remember to make note of which hardware came from which stud.
5. Remove the two screws in the center and pry off the rear cover.
6. Remove the two nuts holding down the brush holder, but do not pull it off yet.

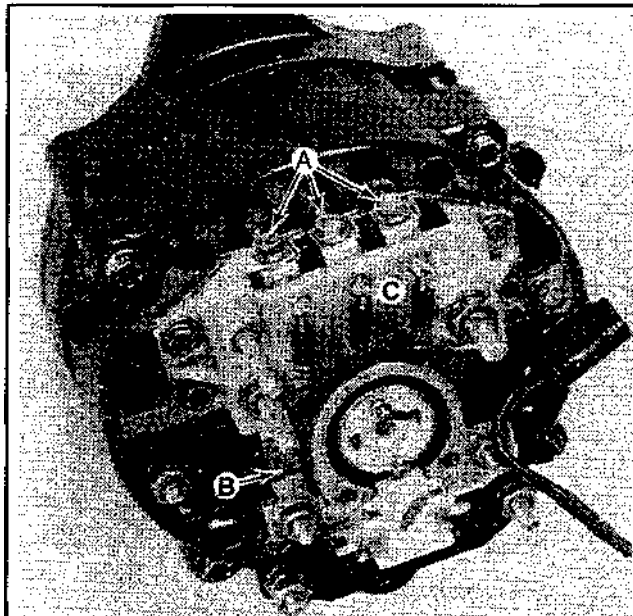


Fig. 47 Disconnect the three stator wires and the strap

7. Tag and disconnect the three stator wires on top of the rectifier bridge. Unscrew the locknut on the POS+ terminal and remove the capacitor lead (if equipped). Lift off the small bracket connecting the left stator terminal to the AC stud. Remove the 4 mounting screws, straighten out the POS+ strap and lift off the diode triolrectifier assembly.

□ The rectifier bridge will most likely be stuck to the rear housing; carefully pry it loose.

8. Slide the brush holder out of the housing, making sure that the brushes don't snap out as they clear the slip rings.

9. Remove the 2 regulator mounting screws and lift off the regulator. Make sure you don't lose the two fiber washers that most units have underneath the regulator!

10. Scribe (or paint) a mark across the front and rear housings, loosen the four screws and separate the pieces. Inserting 2 small prybars at points 180° apart (there should be slots) and using them carefully as levers will make this much easier. Make sure that you don't insert the bars any more than 1/16 in. into the slots

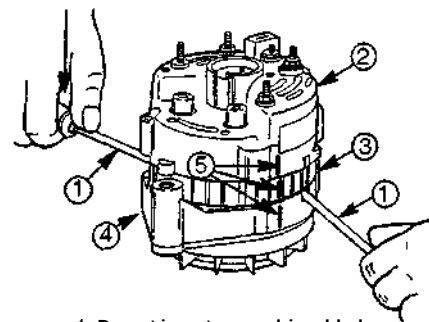
11. If the rotor/stator assembly didn't come out when you separated the housings, use the prybars again to lever the assembly up and out of the housing.

## 1997-98 Alternators

◆ See Figure 50



1. Remove the alternator.
2. Run an oversize drive belt around the pulley and then clamp it into a vise so that the belt protects the pulley/alternator. Loosen the pulley nut.
3. Lift the assembly out of the vise and place it carefully on a clean workbench. Remove the pulley nut, pulley, fan, woodruff key and the spacer.
4. Remove the protective cap from the L2 terminal.
5. Remove the 2 flange nuts and 1 screw and then lift off the regulator cover.
6. Remove the two mounting screws and lift out the regulator/brush holder assembly.
7. Disconnect and remove the capacitor (1 nut).
8. Remove the insulators from the three remainina terminals (L2, P and B).
9. Scribe a mark on both housings and matching marks on the stator, as an aid to properly assemble the alternator frame later on.
10. Remove the four thru-bolts. Separate the rear housing and stator from the front housing and rotor by carefully inserting 2 small prybars no more than 1/16 in. into the slots on opposite sides of the stator frame; UNDER the stator but not into the windings. Pry the rear housing stator up and separate them. Never pry anywhere except at the slot or the castings will be damaged.
11. Install the rotor/front housing assembly in a soft-jawed vise; clamping it very carefully around the rotor armature. Grab the front housing and pull it upwards while tapping the end of the rotor shaft with a plastic mallet. Lift out the spacer.



- 1- Do not insert screwdriver blades more than 1/16 in. (1.5 mm) into slots
- 2- Rear end frame
- 3- Stator
- 4- Front end frame
- 5- Scribe marks

Fig. 48 Use two screwdrivers to separate the frames

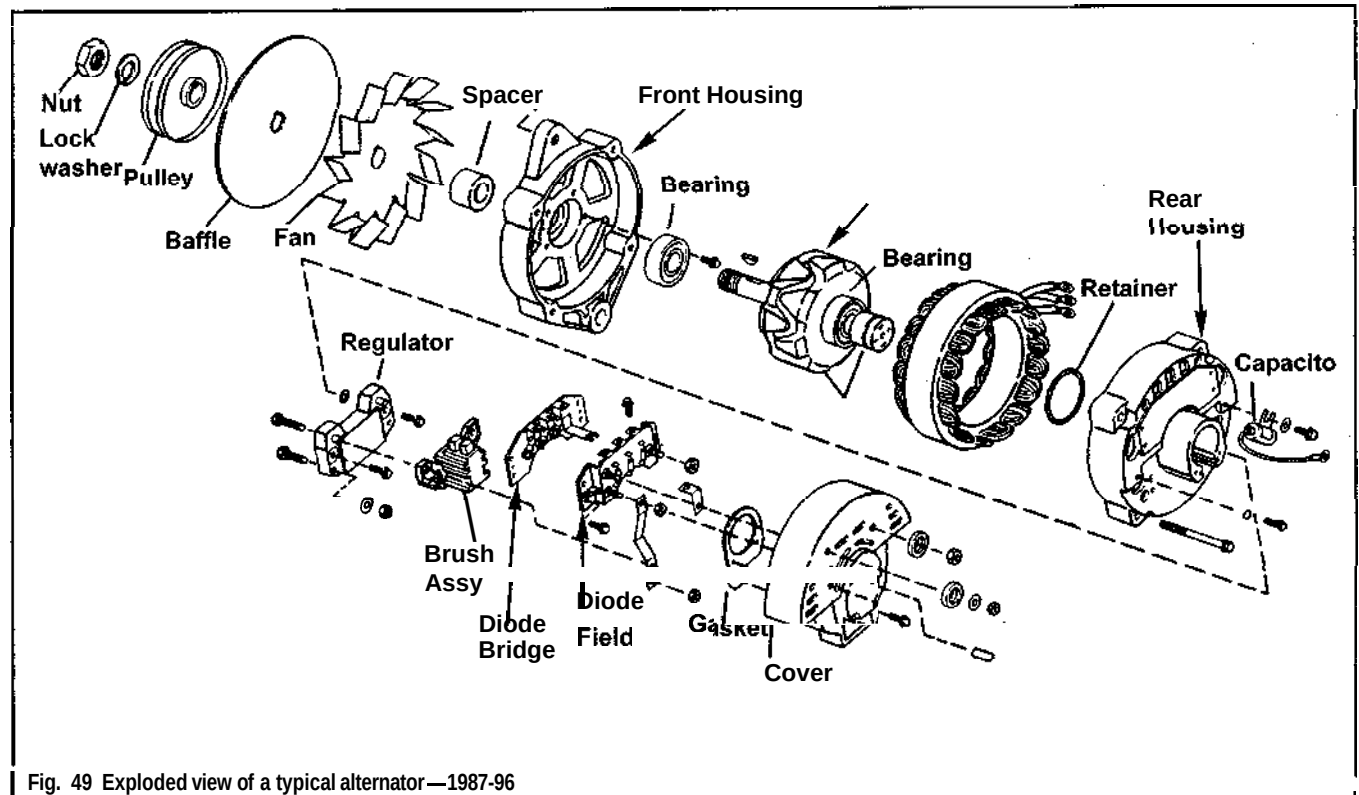


Fig. 49 Exploded view of a typical alternator—1987-96

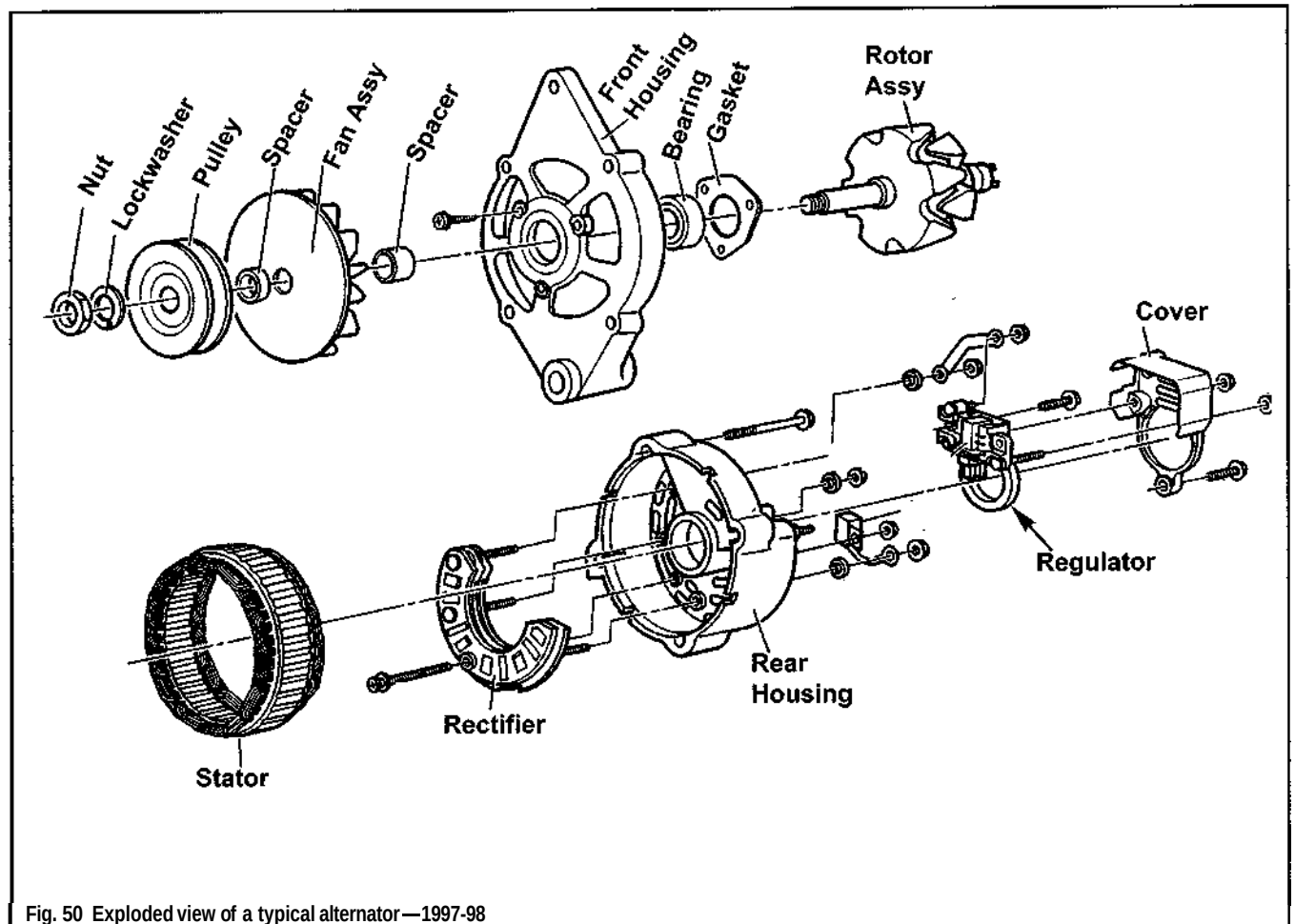


Fig. 50 Exploded view of a typical alternator—1997-98

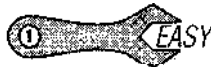
12. Remove the 3 bearing retainer screws from the front housing and press out the bearing.
13. Lay the stator/rear housing assembly on its back and unsolder the 3 stator leads while holding the corresponding rectifier lead with needle nose pliers to dissipate the heat. Remove the stator from the housing.
14. Remove the center mounting screw and lift out the rectifier.

## CLEANING & INSPECTION

The following components are to be visually inspected for serviceability. Electrical checks and tests are detailed previously in this section.

Use a clean soft and wipe any dirt or debris off the parts. Do not clean electrical components with solvent, because such action may damage the item.

### Brush



Inspect the brush casing for cracks or damaged brush leads. Check the brush leads for poor solder connections and damaged leads. Check for broken springs and excessive brush wear. If the brushes are worn to less than 3/16 in. (5mm).

### Rotor



Inspect the end of the rotor shaft for stripped or damaged threads. Check the pole piece fingers for damage caused by worn bearings. Inspect the rear bearing for smooth quiet rolling action. If the threads cannot be repaired or the bearing is defective, the entire rotor assembly must be replaced.

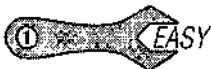
Clean the rotor slip rings with 400 grit sand paper. Blow off any dust using compressed air and inspect the rotor slip rings for grooves, pits, flat spots or out-of-round more than 0.002 in. (0.051mm). If any of the above conditions are found, the rotor assembly must be replaced.

### Stator



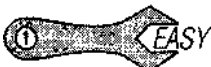
Inspect the insulating enamel for heat discoloration because discoloration is an indication of a shorted diode or grounded winding. Check the stator for damaged insulation and wires from contact with the rotor. Replace the stator if any of the above defects are obvious.

### End Frames (Housings)



Inspect the end frames for cracks, distortion, stripped threads or worn bearing bore (bearing seized on shaft and spinning in bore). If any of the above damage is obvious the end frame must be replaced.

### Fan and Pulley



Inspect the fan for bent or cracked fins, broken welds or worn mounting hole. Check the pulley sheaves for trueness, excessive wear, grooves, pits, nicks and corrosion. If the pulley sheave damage cannot be repaired with a file or wire brush, the pulley must be replaced or drive belt wear will be accelerated.

### Diode Trio Test



#### 1986 Engines

Obtain an ohmmeter and select the Rx1000 scale. Attach one ohmmeter lead (red) to the regulator arm of the diode. Attach the other meter lead (black) to any one of the three stator terminals. Observe the meter reading, and then move the black lead to each of the 2 remaining terminals. Now reverse the meter leads and repeat the procedure. The ohmmeter should indicate continuity in one direction and a high resistance, when the meter leads are reversed. If any one of the three terminals fail the test, the diode trio, as an assembly, must be replaced.

#### 1987-96 Engines

Obtain an ohmmeter and select the Rx1000 scale. Attach one ohmmeter lead to any one of the three small tabs. Attach the other meter lead to the **LIGHT** terminal (the terminal with the metal strap). Observe the meter reading, and then reverse the meter leads and again observe the reading. The ohmmeter should indicate continuity in one direction and a high resistance, when the meter leads are reversed. Test the other two small tabs in the same manner. If any one of the three tabs fail the test, the diode trio, as an assembly, must be replaced.

#### 1997-98 Engines

##### ◆ See Figure 51

1. Connect an ohmmeter. Connect one meter lead to the common side of the diode. Connect the other meter lead to the opposite end of the diode and note the meter reading.
2. Reverse the meter leads and again note the meter reading. The meter should indicate a high resistance in one direction and continuity in the other when the leads are reversed.
3. Repeat this procedure for the remaining diodes.
4. Each diode must show continuity and high resistance in the same direction as the others. If not, replace the rectifier assembly.

### Rectifier Bridge Positive Diode Test



#### 1986 Engines

Connect an ohmmeter and set it to the Rx100 scale. Connect one lead to the grounded heat sink and the other to one of the 3 terminals. Note the reading on the meter, reverse the leads and note the reading again. If both readings are zero, or very high, replace the rectifier bridge. If one reading is zero and the other is very high, the bridge is OK.

Now repeat the tests between the grounded heat sink and the other 2 terminals.

#### 1987-96 Engines

Attach one ohmmeter lead to the **POS+** terminal strap. Attach the other meter lead to one of the three stator attachment terminals. As in the previous test, the ohmmeter should indicate continuity in one direction and a high resistance when the meter leads are reversed. Test the other two stator attaching terminals in the same manner. If any one of the three stator attaching terminals fails the test, the entire rectifier bridge assembly must be replaced.

#### 1997-98 Engines

##### ◆ See Figure 52

1. Obtain an ohmmeter and connect the negative lead of the meter to the rectifier diode heat sink. Connect the other meter lead to one of the rectifier diode terminal and note the reading. If the meter does not indicate continuity, the diode is open and the rectifier must be replaced. Repeat the procedure for each of the diodes.

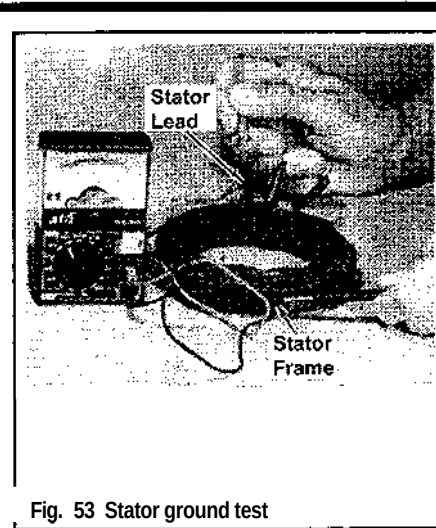
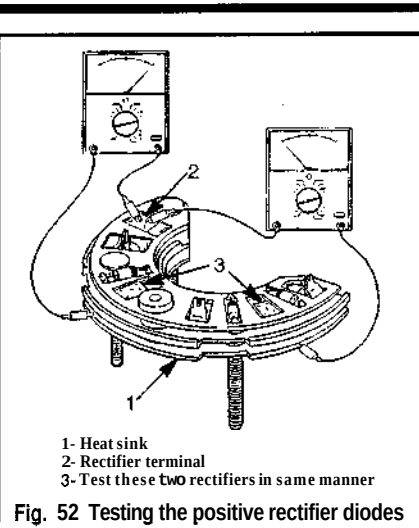
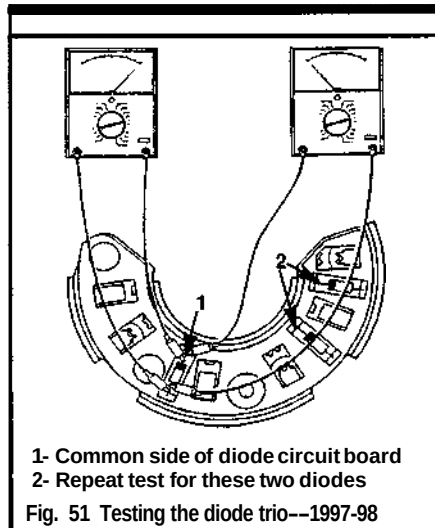
2. Now reverse the probes and check each diode in the opposite direction. The meter should indicate no continuity; if any continuity is present, replace the rectifier.

### Rectifier Bridge Negative Diode Test



#### 1987-96 Engines

Attach one ohmmeter lead to the rectifier bridge body. Attach the other meter lead to one of the three stator attachment terminals. As in the previous two tests, the ohmmeter should indicate continuity in one direction and a high resistance when the meter leads are reversed. Test the other two stator attaching terminals in the same manner. If any one of the three stator attaching terminals fail the test, the entire rectifier bridge assembly must be replaced.



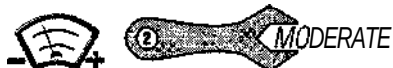
## 1997-98 Engines

### ◆ See Figure 50

1. Obtain an ohmmeter and connect the positive lead of the meter to the rectifier diode heat sink. Connect the other meter lead to one of the rectifier diode terminal and note the reading. If the meter does not indicate continuity, the diode is open and the rectifier must be replaced. Repeat the procedure for each of the diodes.
2. Now reverse the probes and check each diode in the opposite direction. The meter should indicate no continuity; if any continuity is present, replace the rectifier.

### Stator Ground Test

### ◆ See Figure 53



Select the Rx1000 scale on the ohmmeter. Make contact with one meter lead to the stator frame. Make contact with the other meter lead to one of the stator leads. The meter must indicate infinity, or no continuity. Repeat this test for the other two stator leads. If any one lead fails the test, the stator assembly must be replaced.

### Stator Open Circuit Test

### ◆ See Figure 54



Select the lowest possible scale on the ohmmeter. Make contact with the meter leads to the first and second stator leads (from the left). The meter should register approximately 0.1 ohms on 1987-96 alternators, or 0.2 ohms on 1997-98 alternators. Repeat this test with the first and third stator leads, and then the second and third stator leads. In each test, the resistance value should be the same. If the results vary, the stator assembly must be replaced.

### Rotor Ground Test

### ◆ See Figure 55



Select the Rx1000 scale on the ohmmeter. Make contact with one meter lead to any one of the two slip rings. Make contact with the other meter lead to the rotor body. The meter should indicate infinity, or no continuity. Any other reading would indicate the rotor assembly is grounded and therefore must be replaced.

### Rotor Open/Short Circuit

### ◆ See Figure 56



Select the Rx10 scale on the ohmmeter. Make contact with one meter lead to one slip ring, and the other slip ring with the second meter lead. The meter should indicate 2.6 ohms on 1998 engines, 3.5-4.7 ohms on 1987-92 engines or 4.1-4.7 ohms on 1993-96 engines. A lower reading indicates shorted windings. A higher reading indicates an excessive resistance. An infinite reading indicates an open circuit. If the reading is not within specification, the rotor assembly must be replaced.

## ASSEMBLY

### 1986 Engines

1. Clean the brushes with a soft cloth and a mild solvent.
2. Press both brushes into the holder and then insert a toothpick through the hole in the rear of the alternator housing to hold them in place during the rest of the procedure.

### ✖ \*WARNING

Never use a metal pick to hold the brushes in place.

3. Check to see if there is a small dab of sealer in the recess on the edge of the stator frame. If not, squeeze a small amount of RTV silicone sealer into the recess.
4. Position the stator into the housing and rotate it until the notches in the frame are aligned with the holes in the housing.
5. Position the diode trio and install the special insulated screw.
6. Move the stator terminal onto the rectifier bridge, thread on the 3 nuts and tighten them securely.
7. Clean the rotor slip rings with mild solvent. Line up the reference marks on the housings and connect them so that they fit snugly over the stator frame.
8. Remove the toothpick.
9. Press the rubber plug into the voltage regulator until it is snug.
10. Slide the screen over the unit and then install the housing bolts. Tighten the bolts to 35-50 inch lbs. (46-68 Nm).

### 1987-96 Engines

### ◆ See Figure 47



1. Position the stator/rotor assembly into the front housing so that the three terminals are just under the upper mounting boss on the housing. Make sure that the indents in the frame of the stator line up over each of the thru-bolt holes.
2. Position the rear housing over the assembly and then feed the stator leads through the slots in the back of the housing. Set the cover onto the stator assembly so that the alignment marks made during disassembly line up, install the 4 bolts and tighten them to 50-60 inch lbs. (5.6-6.8 Nm).

□ Spin the rotor shaft to ensure that the rotor rotates freely within the assembly.

3. Lay the fiber washers over the regulator mounting bolt holes and install the regulator. Tighten the screws securely.

4. Position the brush holder over the regulator so that the banded surface is facing away from the regulator. Squeeze the brushes with your fingers and slide the holder into the grooves at the of the housing. Tighten the right nut finger tight and leave the left one loose.
5. Straighten the **B+** strap from the rectifier, swab a little heat sink compound over the mounting surface and place the diode/rectifier bridge in position on the rear housing.
6. Feed the strap through the slot in the diode trio body and position the unit onto the bridge. Tighten the mounting screws securely.
7. Bend the strap into place so that it fits against base of the diode trio output stud. Slide the condenser lead over the output stud and tighten the lock nut securely.
8. Slide the small bracket into position over the **AC** stud and the terminal and then reconnect the 3 stator leads to the diode trio.
9. Make sure the strap from the **LIGHT** terminal is positioned over the left stud on the brush holder and then install the final holder mounting nut. Tighten both nuts securely.
10. Position a new felt gasket into the slip ring pocket on the inside of the rear cover. Position the cover over the regulator/brush holder, install the screws and tighten them securely.
11. Reinstall all hardware to the rear terminals and studs.
12. Install the spacer, woodruff key, fan and pulley and then tighten the nut finger tight. Place the assembly back in a vise with the drive belt around the pulley and tighten the nut to 35-50 ft. lbs. (48-68 Nm).
13. Install the alternator and connect the electrical leads.

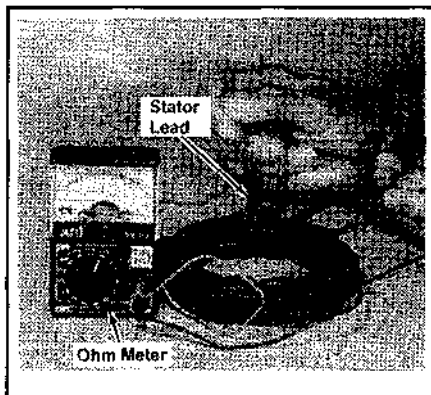


Fig. 54 Stator open circuit test

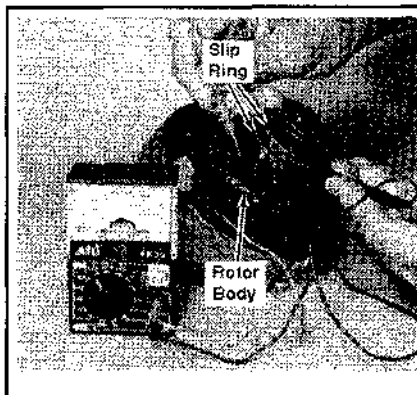


Fig. 55 Performing the rotor ground test.

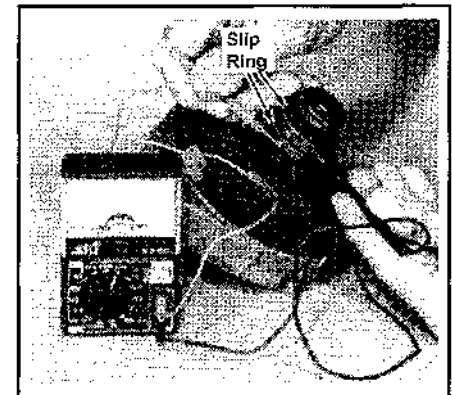


Fig. 56 Rotor open/short circuit test

1997-98 Engines

◆ See Figure 50



1. Position a new bearing into the front housing bearing bore. Position the front end frame into an arbor press. Using the appropriate size mandrel, press the bearing into the bore until the bearing contacts the end frame. Place the bearing retainer plate over the bearing and secure with 3 screws and washers.
2. Position the rotor into a soft jawed vise with the pulley shaft upwards. Install the front housing over the shaft. Slide the short spacer over the shaft, the fan (blades down), the tall spacer and then the pulley. Install the washer and nut and tighten it to 47 ft. lbs. (63 Nm).
3. Position the rectifier into the rear housing and tighten the retaining screw securely. Slide in the stator and then re-solder the three electrical leads.
4. Position the rear housing assembly over the rotor so that the terminal studs on the rear are on the upper pivot boss side and the marks made earlier are in alignment. Press the frames together and then install the screws, tightening them securely.
5. Push the brushes down so they are flush with the top of the holder and then insert a #54 (0.050 in./1mm) drill bit into the hole in the holder so they stay compressed. Position the brush/regulator in the cavity on the back of the rear end frame and tighten the two mounting screws to 42 inch lbs. (4.2 Nm). Pull out the drill bit so that the brushes release against the slip rings.
6. Install the strap to the L2 stud and tighten the nut securely.
7. Install the cover. Tighten the 2 nuts to 51 inch lbs. (5.8 Nm) and the screw to 30 inch lbs. (3.4 Nm). Pop on the insulator caps.
8. Install the alternator.

## STARTER CIRCUIT

### Description and Operation

The cranking system used all OMC engines consists of a 12 V DC cranking motor (starter), a starter-mounted or field housing-mounted solenoid, an assist solenoid or starter relay, a neutral start (safety) switch, the ignition switch, 50 or 60 amp circuit breaker, 20 amp inline fuse and all necessary wiring to complete the circuit.

All engines utilize an electric starter motor coupled with a mechanical gear mesh between the starter motor and the flywheel, similar to the method used to crank an automobile engine.

As the name implies, the sole purpose of the starter motor circuit is to control operation of the starter motor to crank the engine until it is operating. The circuit includes a relay or magnetic switch (solenoid) to connect or disconnect the motor from the battery. The operator controls the switch with a key switch.

A neutral safety switch is installed into the circuit to permit operation of the starter motor only if the shift control lever is in neutral. This switch is a safety device to prevent accidental engine start when the engine is in gear.

The starter motor is a series-wound electric motor that draws a heavy current from the battery. It is designed to be used only for short periods of time to crank the engine for starting. To prevent overheating the motor, cranking should not be continued for more than 30 seconds without allowing

the motor to cool for at least three minutes. Actually, this time can be spent in making preliminary checks to determine why the engine fails to start.

Power is transmitted from the starter motor to the flywheel through a Bendix drive. This drive has a pinion gear mounted on screw threads. When the motor is operated, the pinion gear moves upward and meshes with the teeth on the flywheel ring gear.

When the engine starts, the pinion gear is driven faster than the shaft and as a result, it screws out of mesh with the flywheel. A rubber cushion is built into the Bendix drive to absorb the shock when the pinion meshes with the flywheel ring gear. The parts of the drive must be properly assembled for efficient operation. If the screw shaft assembly is reversed, it will strike the splines and the rubber cushion will not absorb the shock.

The sound of the motor during cranking is a good indication of whether the starter motor is operating properly or not. Naturally, temperature conditions will affect the speed at which the starter motor is able to crank the engine. The speed of cranking a cold engine will be much slower than when cranking a warm engine. An experienced operator will learn to recognize the favorable sounds of the engine cranking under various conditions.

The job of the starter motor relay (or starter assist solenoid) is to complete the circuit between the battery and starter motor. It does this by closing the starter circuit electro-magnetically, when activated by the key switch. This is a completely sealed switch, which meets SAE standards for marine

applications. Do not substitute an automotive-type relay for this application. It is not sealed and gasoline fumes can be ignited upon starting the engine. The relay consists of a coil winding, plunger, return spring, contact disc and four externally mounted terminals. The relay is installed in series with the positive battery cables mounted to the two larger terminals. The smaller terminals connect to the neutral switch and ground.

To activate the relay, the shift lever is placed in neutral, closing the neutral switch. Electricity coming through the ignition switch goes into the relay coil winding which creates a magnetic field. The electricity then goes on to ground in the engine. The magnetic field surrounds the plunger in the relay, which draws the disc contact into the two larger terminals. Upon contact of the terminals, the heavy amperage circuit to the starter motor is closed and activates the starter motor. When the key switch is released, the magnetic field is no longer supported and the magnetic field collapses. The return spring working on the plunger opens the disc contact, opening the circuit to the starter.

When the armature plate is out of position or the shift lever is moved into forward or reverse gear, the neutral switch is placed in the open position and the starter control circuit cannot be activated. This prevents the engine from starting while in gear.

## Troubleshooting the Starting System



If the starter motor spins but fails to crank the engine, the cause is usually a corroded or gummy Bendix drive. The drive should be removed, cleaned and given an inspection.

**1. Before wasting too much time troubleshooting the starter motor circuit, the following checks should be made. Many times, the problem will be corrected.**

- Battery fully charged.
- Shift control lever in neutral.
- Main 20-amp fuse is good (not blown).
- All electrical connections clean and tight.
- Wiring in good condition, insulation not worn or frayed.

**2. Starter motor cranks slowly or not at all.**

- Faulty wiring connection
- Short-circuited lead wire
- Shift control not engaging neutral (not activating neutral start switch)
- Defective neutral start switch
- Starter motor not properly grounded
- Faulty contact point inside ignition switch
- Bad connections on negative battery cable to ground (at battery side and engine side)
- Bad connections on positive battery cable to magnetic switch terminal
- Open circuit in the coil of the magnetic switch (relay)
- Bad or run-down battery
- Excessively worn down starter motor brushes
- Burnt commutator in starter motor
- Brush spring tension slack
- Short circuit in starter motor armature

**3. Starter motor keeps running.**

- Melted contact plate inside the magnetic switch
- Poor ignition switch return action

**4. Starter motor picks up speed, put pinion will not mesh with ring gear.**

- Worn down teeth on clutch pinion
- Worn down teeth on flywheel ring gear

## Starter Motor

### DESCRIPTION & OPERATION

#### Direct Drive--1987-92 Ford Engines

Direct drive 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 and over-running clutch drive mechanism 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 over-running clutch drive arrangement is installed near one end of the starter shaft. This clutch drive assembly contains a pinion that is made to move along the 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 over-running 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 starter is not in use, one of the field coils is connected directly to ground through a set of contacts. When the starter is first connected to the battery, a large current flows through the grounded field coil, actuating a moveable pole shoe. The pole shoe is attached to the starter drive plunger lever and thus the drive is forced into engagement with the flywheel.

When the pole shoe is seated fully, it opens the grounding contacts on the field coil and the starter then moves to normal operation. A holding coil is utilized to keep pole shoe in position during the time that the starter is cranking the engine.

#### Direct Drive—1986-94 GM Engines

Direct drive 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 over-running 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 that is made to move along the 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 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 transferred from the shell to the pinion by the rollers, which are wedged tightly between the pinion and the taper cut into 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 overrun.

#### Gear Reduction—1993-96 Ford Engines And 1995-98 GM Engines

Gear reduction starter motors are small and light weight for the amount of work produced. These starters have small permanent magnets mounted inside the field frame. The placement and strength of these magnets differ between models. Therefore the field frames are not interchangeable.

The permanent magnets take the place of the large current-carrying iron core field-coil magnets previously used on the larger direct drive starter motors. The motor armature is supported on both ends by a permanently lubricated roller or ball bearing assembly to reduce the drag and friction created by the motor speed of approximately 7,000 rpm.

A planetary gear reduction unit is mated between the drive motor armature and the Bendix drive gear. This planetary gear drive results in an over all gear reduction of approximately 4:1. Through the gear reduction, the conversion of motor high speed, low torque is converted to a high torque, low speed gear drive output. The gear reduction results in a final engine cranking speed of approximately 1,750 rpm.

The starter is designed to operate under heavy loads and produce high power for only short periods of time. Therefore, never crank the engine for more than 30 seconds without allowing a minimum cooling off time of two minutes, before attempting to crank the engine again.

As with all marine installations, a safety switch is installed in the remote control shift box. This switch is designed to open the starter circuit to prevent the engine from starting, if the shift lever is in any position other than the neutral position.

The unit has a Bendix follow-thru type drive designed to overcome disengagement of the flywheel ring gear when engine speed exceeds cranking motor speed.

A helical cut shaft is designed to quickly engage and disengage the Bendix drive. An internal one-way clutch in the Bendix allows the motor to drive the Bendix. If the engine should start, and the flywheel begin to drive the Bendix, the one-way clutch will release and allow the drive to overrun and release the cranking motor armature. The helical splined shaft will then disengage the Bendix from the flywheel.

■ As of 1995, OMC suggests that their GM starters are no longer serviceable. No replacement parts are available. Check with your local parts supplier.

## PRECAUTIONS

1. Always make sure that each battery cable is connected to the correct terminal on the battery.
2. Never disconnect the battery while the engine is running.
3. When using a battery charger or booster, always make sure that the positive battery cable on the charger is connected to the positive terminal on the battery. The same goes for the negative side.
4. Always make sure that both battery cables are disconnected prior to connecting a charger or booster.
5. Always make sure the battery is in good operating condition.
6. Always make sure the battery leads and terminals are clean.

## TROUBLESHOOTING

### ◆ See Figures 57 and 58

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.

### ✱✱ CAUTION

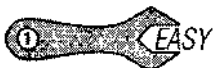
Always take time to vent the bilge when making any of the tests as prevention against igniting any fumes accumulated in that area. As a further precaution, remove the high-tension wire from the center of the distributor cap and ground it securely to prevent sparks.

All cranking motor problems fall into one of three areas:

1. The cranking motor fails to rotate.
2. The cranking motor spins rapidly, but does not crank the engine.
3. The cranking motor cranks the engine, but too slowly to affect engine start.

The following paragraphs provide a logical sequence of tests designed to isolate a problem in the cranking system.

### Battery



1. Turn on several of the cabin lights (or any accessories). Turn the ignition switch to the **ON** position and note the effect on the brightness of the lights. With a properly functioning electrical system, the lights 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.

2. 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.

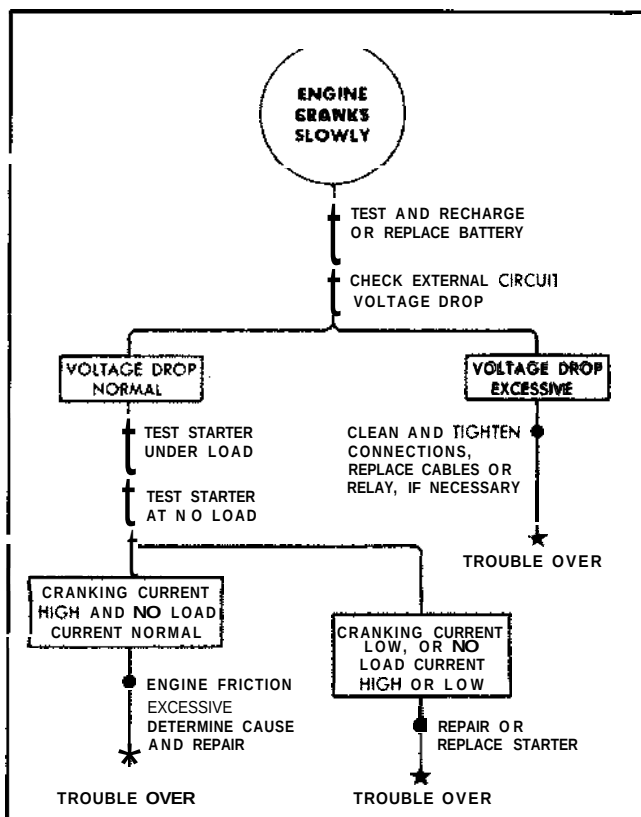


Fig. 57 Engine cranks slowly

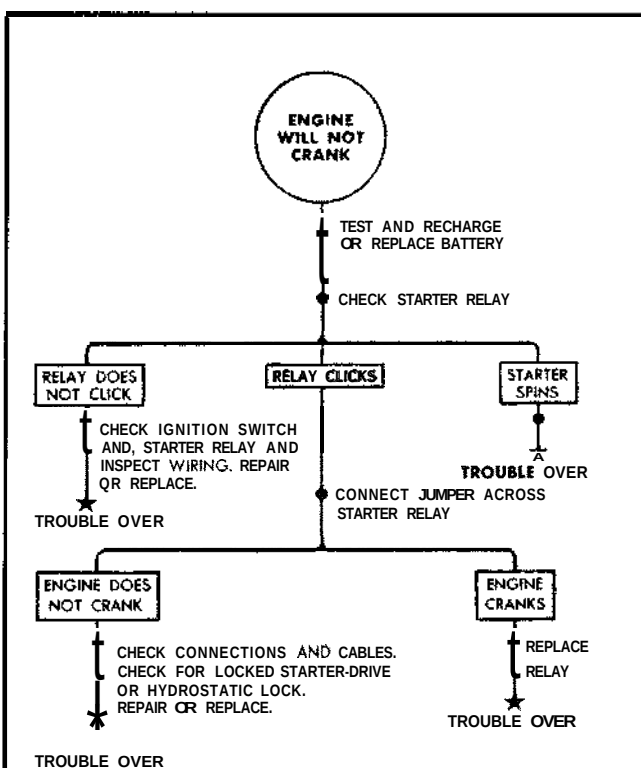


Fig. 58 Engine will not crank

## 10-22 IGNITION AND ELECTRICAL SYSTEMS

3. 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.

4. If the starter spins without cranking the engine, the drive is broken. The starter will have to be removed for repairs.

5. If the lights do not dim, and the starter does not operate, then there is an open circuit. Proceed to the Cable Connection Test.

### Cable Connection



1. 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.

2. First, remove the cables at the battery; clean the connectors and posts; replace the cables; and tighten them securely.

3. 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.

4. 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.

5. If the starter still fails to crank the engine, move on to the Solenoid Test.

### Solenoid



1. The solenoid, commonly called the starter relay, is checked by directly bridging between the terminal from the battery (the large heavy one) to the terminal from the ignition switch.

### CAUTION

Take every precaution to ensure there is no gasoline fumes in the bilge before making these tests.

2. If a bilge blower is installed, operate it for at least five minutes to clear any fumes accumulated in the bilge.

3. Turn the ignition switch to the **ON** position. Now, connect a jumper wire 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 motor still fails to operate, continue with the Current Draw Test.

### Current Draw



Lay an amperage gauge on the cable between the battery and the starter motor. Attempt to crank the engine and note the current draw reading of the amperage gauge under load. The current draw should not exceed 190 amperes.

## TESTING—GM ENGINES

### Starter Circuit Resistance

◆ See Figure 59



■ The battery must be fully charged prior to performing the following test.

1. Start the engine and allow it to run until it reaches normal operating temperature.

2. Shut the engine down and ensure that it will not start during cranking. Make sure that the ignition switch is in the **OFF** position, and, if equipped, run the bilge pump to clear any fumes prior to disconnecting the following wires:

• All models except those listed below: disconnect both 2-wire connectors at the ignition coil.

• 1993 4.3L and 1994 5.7L models (carburetor): disconnect both primary wires at the coil terminals

• 1993-97 7.4L and 8.2L carbureted models: disconnect the engine harness 14-pin connector at the ignition module

3. Connect a voltmeter and connect the positive lead to the lower terminal on the solenoid. Touch the negative terminal to the starter ground so that it grounds.

4. Turn the ignition switch **ON** and crank the engine observing the initial meter reading. If the meter reads more than 9 V at normal cranking speed, the starter and switch are OK. If the cranking speed is low and the meter reads less than 9 V, check your battery, battery terminals and/or the solenoid. Perform the Solenoid Contacts Test.

### CAUTION

Never operate the starter for more than 10 seconds at a time without allowing the motor to cool for at least 3 min.

### Solenoid Contacts Test

+ See Figure 60



1. Connect a voltmeter and switch it to the high scale. Connect the negative lead to the lower solenoid terminal and the positive lead to the upper (BAT) terminal.

2. Turn the ignition switch to the **ON** position and crank the engine. As soon as you begin cranking the engine, flip the meter back to the **low** scale and take note of the reading. Turn the meter back to the high scale and shut off the engine.

3. If the solenoid switch contacts are OK, the meter reading should have been 1110 V or less. Anything above this will necessitate switch repair or replacement.

### Solenoid Amperage Test



◆ See Figure 61

1. Remove the starter from the engine.

2. Remove the screw from the solenoid motor terminal and then bend the field leads slightly until they are clear of the terminal.

3. Connect a heavy gauge jumper wire to the Motor terminal on the solenoid and ground it against the starter body.

4. Connect an ammeter and a carbon pile in series between the **S** terminal on the solenoid (small one) and the positive terminal on a battery. Connect a heavy gauge jumper wire between the starter body and the negative post on the battery.

5. Connect a voltmeter between the base of the solenoid and the **S** terminal on the solenoid.

6. Adjust the resistance on the carbon pile (slowly!) until the voltmeter is showing 10 volts and then check the reading on the ammeter. With the solenoid at room temperature, the reading should be 47-55 amps; showing current draw of both windings in parallel.

7. Remove the jumper between the Motor terminal and the starter body. Readjust the carbon pile until the voltmeter is reading 10 V again. The ammeter should read 15-20 amps; showing the current draw for hold-in winding alone.

8. Any readings outside the ranges given above will necessitate replacement of the solenoid.

## TESTING—FORD ENGINES

### Starter Circuit Resistance



### 1987-92 Engines

◆ See Figure 62

1. With the ignition switch in the **OFF** position, disconnect the distributor primary wire at the ignition coil (negative terminal).

2. Connect a voltmeter and set it to the low scale. Connect the negative lead to the starter terminal and the positive lead to the positive battery terminal. Turn the ignition switch to the **ON** position; the meter should read 0.5V.

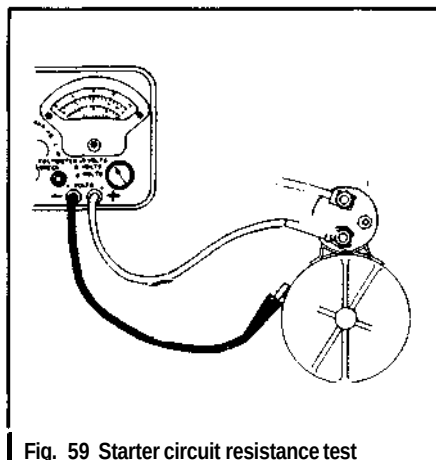


Fig. 59 Starter circuit resistance test

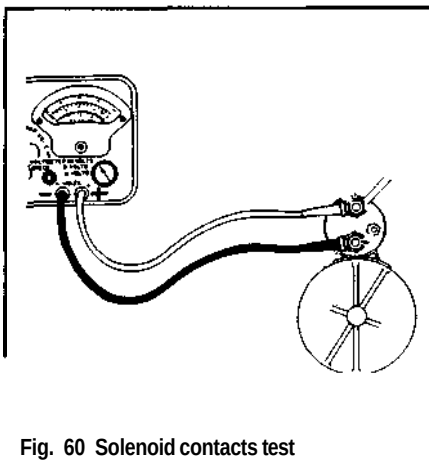


Fig. 60 Solenoid contacts test

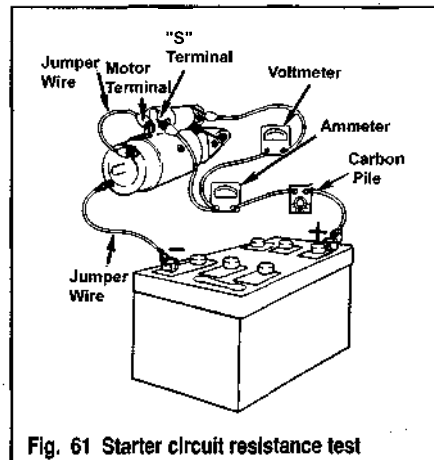


Fig. 61 Starter circuit resistance test

3. Now move the negative lead to the starter terminal on the solenoid and turn the ignition switch back to the **ON** position; the meter should read 0.3V.

4. Now move the negative lead to the battery terminal on the solenoid and turn the ignition switch back to the **ON** position; the meter should read 0.1V.

5. Now move the negative lead to the negative battery terminal on the solenoid and move the positive lead to an engine ground. Turn the ignition switch back to the **ON** position; the meter should read 0.1V.

## 1993-96 Engines

☐ The battery must be fully charged prior to performing the following test.

1. Start the engine and allow it to run until it reaches normal operating temperature.

2. Shut the engine down and ensure that it will not start during cranking. Make sure that the ignition switch is in the **OFF** position, and, if equipped, run the bilge pump to clear any fumes prior to disconnecting the following wires:

- EFI models: disconnect the 3-wire connector at the E-coil.
- Carbureted models: disconnect both primary wires at the ignition coil terminals

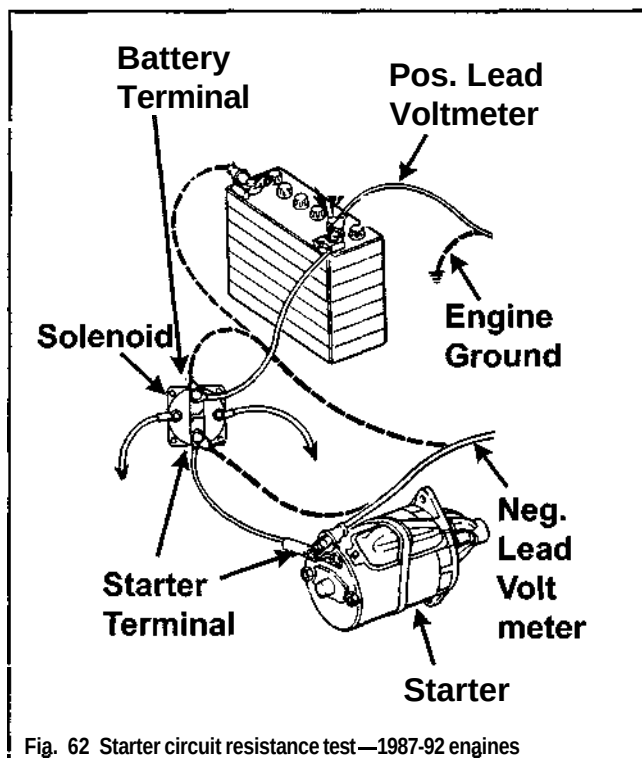


Fig. 62 Starter circuit resistance test—1987-92 engines

3. Connect a voltmeter between the **B+** terminal on the motor and the housing.

4. If battery voltage is not present, check all wires and connections between the battery and the solenoid. Also check all grounds for opens or shorts.

5. If battery voltage is present, connect a remote starter switch between **B+** and **S** terminals. Turn the remote starter **ON**. If the starter does not crank, replace it. If it does crank, check the wires and connections between the solenoid and assist solenoid for opens or shorts.

## ✖ CAUTION

Never operate the starter for more than 10 seconds at a time without allowing the motor to cool for at least 3 min.

## 1993-96 Engines



1. Connect a voltmeter between an engine ground and the **S** terminal on the assist solenoid. Turn the ignition switch to the **START** position and confirm that the meter shows battery voltage.

2. If no voltage is shown, check the assist solenoid ground and then repeat Step 1. If there is still not battery voltage present, check the circuit from the terminal back through the cable connector, neutral safety switch, ignition switch, fuse and circuit breaker—correct any problems found.

3. If voltage is found to be present in Step 1, reconnect the voltmeter to the solenoid output terminal and check for battery voltage. If none is indicated, replace the assist solenoid.

## REMOVAL & INSTALLATION

◆ See Figure 63



1. Disconnect the battery cables.  
2. Tag and disconnect all wires at the starter solenoid. Move them out of the way.

3. Cut the plastic tie holding the drain hose from the flywheel housing.  
4. On GM engines, remove the nut from the support bracket. Remove the ring gear guard at the leading edge of the flywheel housing.

5. Loosen the two mounting bolts and then pull them out of the starter housing. Carefully lift out the starter. Mounting bolts on GM engine run vertically, while mounting bolts on Ford engine run horizontally.

☐ Be aware that some applications will utilize a shim(s) between the motor and cylinder block. Do not lose this shim!

## To Install:

6. Position the shim (if equipped) and then install the starter. Slide in the thru-bolts and tighten them to 30-36 ft. lbs. (41-49 Nm) on GM engines, 20-25 ft. lbs. (27-34 Nm) on 1987-92 Ford engines, or 15-20 ft. lbs. (21-27 Nm) on 1993-96 Ford engines.

7. On GM engines, install the ring gear plate and tighten the bolts to 5-7 ft. lbs. (7-9 Nm).

8. On GM engines, install the support bracket nut and tighten it securely.
9. Reconnect all electrical leads, tightening their nuts securely and coating the solenoid connections with Liquid Neoprene. On Ford engines, tighten the battery cable to 80-120 inch lbs. (9-13 Nm).
10. Reattach the drain hose to the solenoid with a new plastic tie.
11. Connect the battery cables.

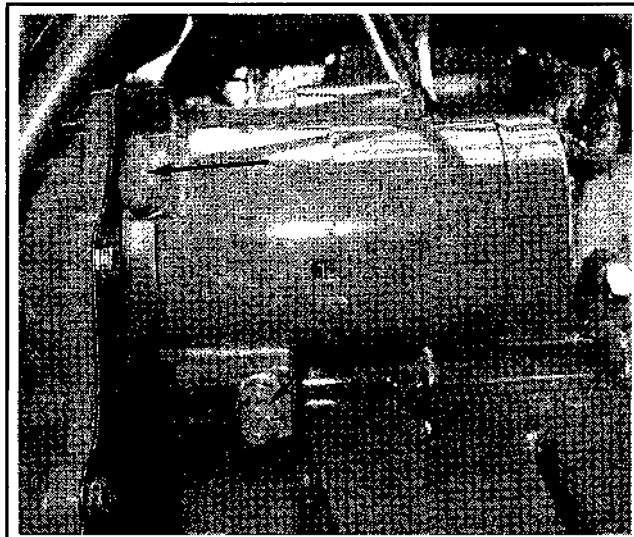


Fig. 63 Starter mounting bolts

## DISASSEMBLY & ASSEMBLY

■ **Before disassembling begins, read these few words first on a time and money saving idea. Most dealers do not find it economical to stock all the small parts or spend the time to service a starter motor. In most cases the labor cost alone will exceed the cost of a new or rebuilt unit.**

Throughout the country, specialty shops may be found specializing in and servicing starter motors, alternators and other electrical assemblies. A customer can usually obtain a new or rebuilt starter for a modest cost usually on the spot or same day service. Some marine dealers even stock new and rebuilt cranking motors ready for installation. This means the repair can be completed and the boat back in service before the end of the day.

If the decision is made to disassemble the unit, check with the marine dealer first for parts availability, order time, and cost compared to a new or rebuilt unit off the shelf. These units usually come with some type of warranty. Therefore, if it fails within the warranty period, additional cost is not involved.

### Direct Drive—1986-94 GM Engines



#### ◆ See Figures 64, 65 and 66

1. Remove the starter.
2. Remove the solenoid.
3. Scribe or paint match-marks across the commutator end plate and frame; and across the frame and drive housing.
4. Loosen and remove the 2 thru-bolts and pull off the end plate.
5. Tap the field frame where it mates with the drive housing a few times with a rubber mallet and then pull off the frame along with the field coil.
6. Pull the brush holder pivot pins out and lift the holders and springs out of the frame. Remove the brush screws and pull the brushes from the holder.
7. Remove the 2 bolts holding the bearing plate to the drive housing and then lift the armature assembly out of the housing.
8. Slide the thrust collar off of the pinion end of the armature shaft and then remove the thrust washer from the opposite end of the armature shaft.
9. Locate a small piece of pipe (1/2 in. I.D.) and slide it over the shaft. Tap it lightly with a hammer until you drive the pinion stop retainer in toward the armature. Remove the snap-ring from its groove and then slide the retainer and armature assembly off of the shaft.

10. Remove the retaining pin from the brush support and holders and then remove them all after disconnecting the leads.

11. Pop off the small retaining ring and pull the pivot pin (lever shaft) out of the drive housing. Lift the lever and plunger assembly from the housing.

#### To assemble:

12. Clean all components thoroughly and inspect them. Perform the previous tests.
13. Coat the shift lever linkage lightly with silicone grease. Position it into the drive housing so the open side is facing out and then slide in the pivot pin. Snap on the retaining ring.
14. Lubricate the drive end of the armature shaft with a thin coating of 10W motor oil or silicone lubricant. Install the bearing plate so the raised side faces the armature and then install the fiber washer. Slide the assist spring and clutch assembly onto the armature shaft so that the pinion is facing outward. Slide the retainer onto the shaft with the cupped surface facing the end of the shaft (away from the pinion).
15. Stand the armature on its end on a wooden surface with the commutator end down. Position the snap ring on the upper end of the shaft and hold it in place with a block of wood. 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.
16. 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.
17. 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.
18. Squirt a few drops of 10W oil into the drive housing bushing and then slide the armature and clutch assembly into place in the drive housing while engaging the shift lever with the clutch.
19. Swivel the assembly until the holes in the center bearing plate line up with the holes in the housing and then install the 2 screws. Tighten them securely.
20. Install the brushes into the brush holders. Assemble the insulated (black) 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, and then rotate the spring to engage the center of the V-spring in the support.
21. Attach the ground wire to the grounded brush and the field lead wire to the insulated brush.
22. Position the field frame over the armature and apply a thin coating of liquid neoprene between the frame and the solenoid case. Expand the brushes until they just clear the commutator. Place the frame in position against the drive housing, rotating it until the dowel engages the hole and seats the frame into the housing. Take care not to damage the brushes and making sure that the previous marks line up.
23. 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 plate onto the shaft so that the match-marks line up. Install the thru-bolts and tighten them securely. Connect the field coil connectors to the motor solenoid terminal.

□ **The thru-bolt with the exposed thread must be at the top of the housing.**

24. Install the solenoid.
25. Check the pinion clearance. Install the starter.

### Direct Drive—1987-92 Ford Engines



#### ◆ See Figure 67, 68, 69 and 70

1. Remove the starter motor.
2. Loosen the clamp screw and remove the starter cover retaining clamp. Remove the remaining mounting screw and lift off the starter cover.
3. Remove the 2 starter motor through bolts.
4. Use a small punch and drive the roll pin out of the starter plunger lever. It is not necessary to drive the pin all of the way out; simply push it through enough so that the lever can be removed, but the pin is still in the remaining housing hinge hole.
5. Carefully lift the brush end plate from the end of the starter frame. Take note of the positioning of all brushes, springs and leads. Remove the 4 brush springs from the holder with needle nose pliers.

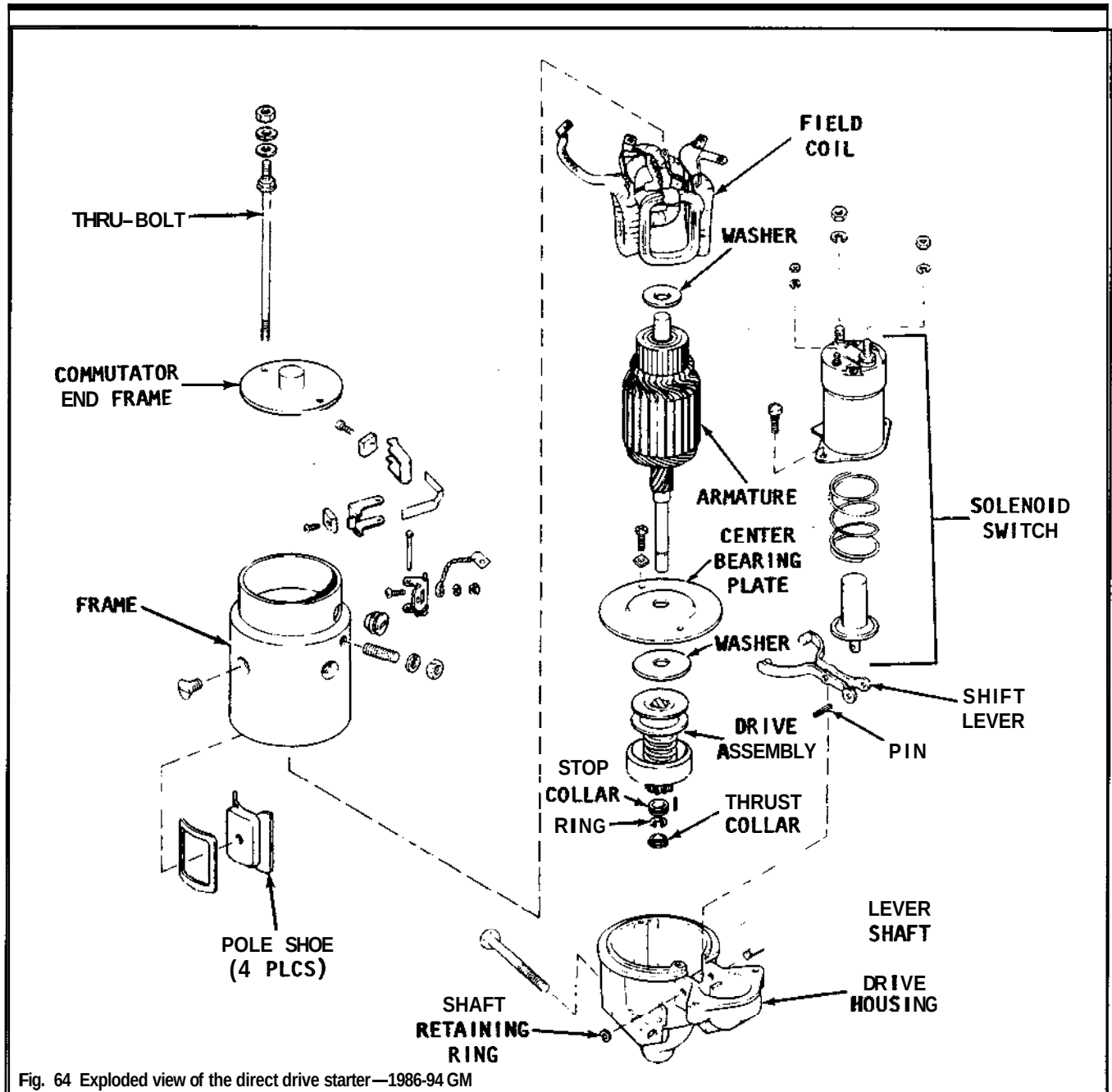


Fig. 64 Exploded view of the direct drive starter—1986-94 GM

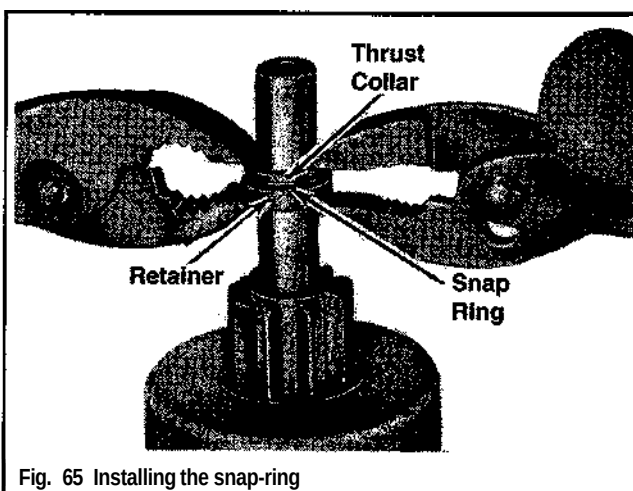


Fig. 65 Installing the snap-ring

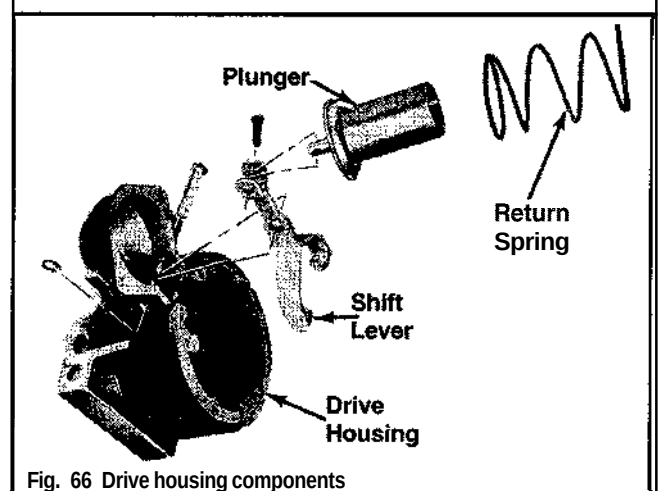


Fig. 66 Drive housing components

6. Separate the frame and armature assembly from the drive housing.
7. Remove the plunger lever return spring from its seat in the housing. Lift out the plunger and lever assembly off of the armature and out of the frame. Remove the armature.
8. Remove the thrust washer, retainer and stop ring from the end of the armature. Slide the starter drive assembly off.
9. Reach under the brush holder at a point that is 180° from the grommet and carefully lift it out of the frame. Never remove the field coils or brushed unless you intend to replace them!
10. Locate the field coil retaining sleeve on the coil that operates the drive gear, bend up the tab and remove the sleeve.
11. Remove the 3 coil retaining screws with the special tool (Owatonna #10044-A) and a press (which actually just prevents the tool from slipping out of the screw head). Unsolder the coil leads and remove the pole shoes and coils from the frame—a 300 watt iron works well for this.
12. Unsolder (or cut) the brush leads from the field coils as close to the connection as possible. Cut the ground brush leads at the frame.

## To assemble:

13. Clean the field coils, armature, armature shaft, commutator, end plate and drive end housing with a soft brush or compressed air. Clean all other components in solvent and dry thoroughly. Remove any residual sealing material.
14. Inspect the armature windings for broken or burned insulation and/or bad connections. Check for open circuits and grounds.
15. Set the commutator in V-blocks and check the run-out. Inspect the shaft and bearing for scoring or excessive wear. If the unit is rough or more than 0.005 in. out-of-round, turn it or replace it.
16. Check the brush holder for any cracks or broken springs. Check the brush spring tension and replace them if tension is not within specifications (40 oz. min.). Replace the holder if cracked or damaged in any way.
17. Replace the brushes if less than 1/4 in. in length.
18. Inspect the field coils for burned or cracked insulation. Check the brush connections and the lead insulation. Brush and contact kits should be available, but everything else will require replacement.
19. Check the starter drive teeth for signs of wear, paying particular attention to the wear pattern. The pinion teeth should penetrate to a depth greater than 1/2 of the ring gear tooth depth so that the risk of early ring gear and starter drive failure is minimized.
20. Position the coils and pole pieces into the housing and then install the retaining screws with the special tool. As you are tightening the screws, tap the frame sharply with a plastic mallet to seat and align the pole shoes. Once finished, stake the screws.
21. Install the solenoid coil and retainer, bending the tabs over the frame.

22. Solder the field coil leads with rosin solder and a 300 watt iron. Always check for continuity before continuing with the assembly.
23. Position new field coil brush leads onto the coil wire and install the clip (provided with the brush). Solder the lead, clip and terminal together.
24. Secure the solenoid coil ground wire under the tab on top of the frame.
25. Solder the ground brush leads to the frame at the point where they were originally cut off.
26. Install the brush springs in the holder so that the flat side is down and they are fully seated.
27. Insert the holder into the frame so that the large lug and notch are located next to the grommet. Make sure that you don't pinch the brush leads between the holder and the frame.
28. Coat the armature splines lightly with Extreme Pressure Grease and slide the starter drive onto the armature. Attach a new stop ring and then slide on a new retainer.
29. Remove all grease from the commutator and then slide the armature into the frame. Install the plunger and lever assembly so that the fingers on the lever engage the collar behind the drive.
30. Coat the drive housing bushing lightly with Extreme Pressure Grease and position the armature thrust washer on the bushing. Install the plunger lever return spring into its seat.
31. Install the armature and frame assembly carefully so that the projection on the plunger lever engages the return spring before the frame seats into the drive housing.
32. Insert a punch into the housing hinge and lever holes and wiggle it until the holes are all in alignment and then drive the pin into place. Depress the plunger and then release it; confirm that the plunger arm makes contact with the copper band, the drive gear extends fully, and the spring returns the plunger and drive gear to the fully disengaged position without any hesitation.
33. Ensure that there is no grease on the brushes. Hold back the spring and push the spring into position. The brush spring should snap into position when it's properly positioned behind the brush. Push down on each spring to make sure they are completely seated. Lay the brush leads into the correct channels.
34. Install the brush end plate and then tighten the thru-bolts to 55-75 inch lbs. (6-8 Nm).
35. Apply a small bead of RTV silicone adhesive around the flange on the starter drive cover. Position the cover over the drive plunger so that it engages the 2 projections on the housing. Tighten the cover screw securely. Slide the retaining clamp over the unit and tighten the screw securely.
36. Install the starter.

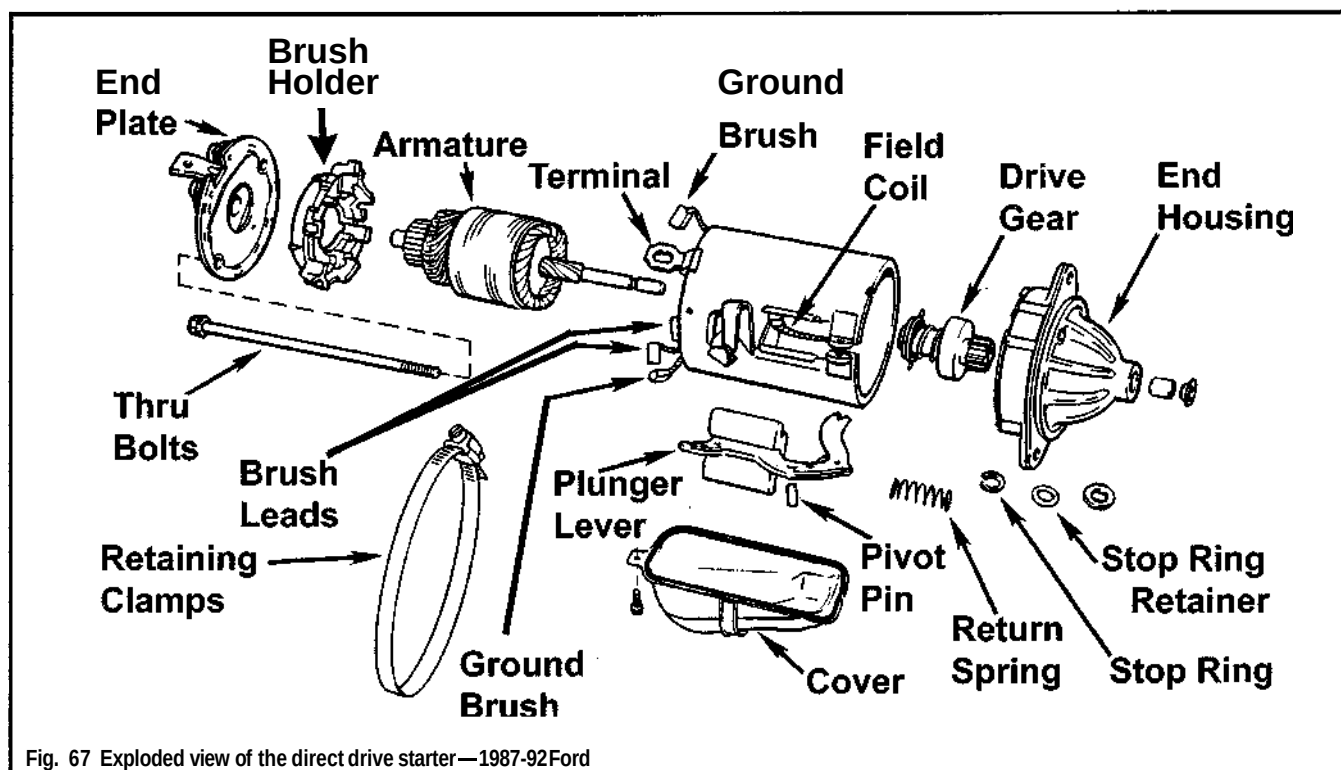


Fig. 67 Exploded view of the direct drive starter—1987-92Ford

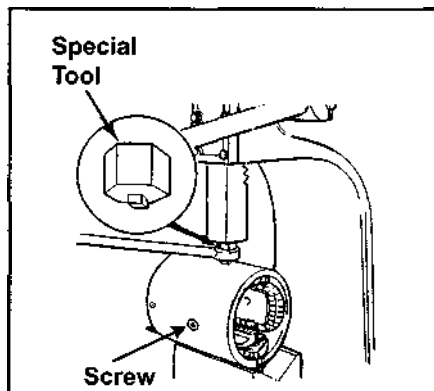


Fig. 68 Removing the coil retaining screws

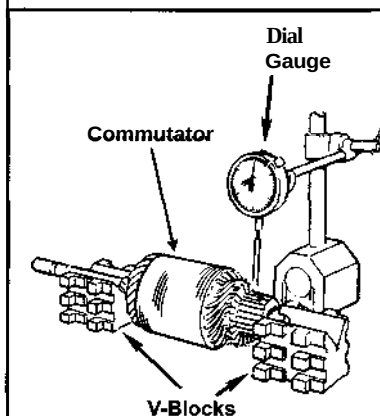


Fig. 69 Checking the commutator

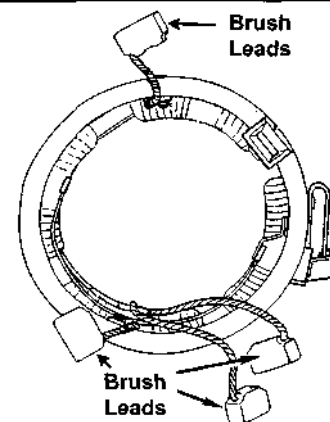


Fig. 70 Installing new brush leads

Gear Reduction—1993-96 Ford Engines And 1995-98 GM Engines



◆ See Figures 71 thru 85

OMC provides no facility for rebuilding the GM starter motor after 1995. Although the following procedure will be very similar for a 1995-98 GM starter motor, we strongly recommend checking with your local OMC retailer to confirm parts availability prior to beginning disassembly on a starter installed on a 1995 and later GM engine.

1. Remove the starter.
2. Disconnect the wire brush lead from the brush block to the solenoid M terminal. Position it out of the way.
3. Remove the 2 solenoid retaining bolts from the inner side of the drive housing. Pull the solenoid out of the housing slowly while unhooking the end of the plunger from the shift lever.
4. Place a scribe mark or a strip of tape (or paint) on the drive housing, field frame and end plate. The tape or scribe marks will assist in the alignment of the drive housing and field frame during the assembling procedures.
5. Remove the two long thru bolts on each side of the motor case. Slide the bolts out from the end plate. Make sure you remove the bolts with the larger heads, the smaller ones are the brush plate screws and should not be removed yet. Pull the drive housing off of the field frame making sure that you save the seal assembly.
6. Carefully pry the ends of the shift lever from the pins on the drive assembly and remove the lever.
7. Remove the retainer and stop ring from the end of the driveshaft and pull the starter drive assembly from the shaft.
8. Press the snap ring off of the driveshaft. Slide off the washer and then remove the gear assembly from the shaft.
9. Tap the retainer off of the stationary gear in such a way that you do not break the 2 pins on the gear. Lift out the 3 planetary gears from the shaft inside the stationary gear. Rotate the assembly so the shaft is vertical and then tap the gear on a hard surface until the armature thrust ball comes free inside the shaft.
10. Mount the end of the shaft in a vise with soft jaws and then use a small prybar to remove the shaft retainer. Slide the thrust washer off of the shaft and then slide the shaft out of the stationary gear.
11. Remove the two bolts securing the end plate to the brush holder. Pull the positive brush lead seal out of the notch in the frame, slide the holder off the end of the commutator and then pull the armature assembly out of the field frame.

The armature will be held in the field frame by permanent magnets.

To assemble:

12. Clean the armature, shaft and brush holder with a brush and compressed air. Do not use a grease dissolving solvent to clean electrical components, planetary gears, or Bendix drive. Solvent will damage wiring insulation and washout the lubricant in bearings and drive gears.

13. Verify the brush holder is not damaged and the brushes are held firmly against the commutator.

14. Inspect the armature commutator for grooves or out of round condition. If the commutator is worn it can be turned down on a lathe. Check the armature for shorts using a growler or test light.

15. Check the commutator for run-out. Inspect the armature shaft and two bearings for scoring or excessive wear with a dial indicator. If the commutator is rough, or more than 0.005 in. (0.12mm) out of round, it must be replaced.

16. Check the roller bearings for wear and rough spots. If there is any roughness or the bearing is stiff, replace the bearing.

17. Check the planetary gear set and the gear teeth for broken or missing teeth. Check to be sure the gears mesh and roll freely without binding or rough spots. If any of these conditions are found, replace the entire planetary gear set.

18. Check the springs in the brush holder to be sure none are broken. Check the spring tension and replace if the tension is not 64 oz. Check the insulated brush holder for cracks that could cause a short. Check the length of each brush; if worn to 0.250 in. (6.35mm) or less, replace them.

19. Coat each end of the armature shaft/splines with a light coating of wheel bearing grease. Slide the armature into the field frame assembly.

20. Install the brush holder assembly into the end of the frame. A brush holder service tool which fits over the end of the commutator while installing the assembly can be fabricated from a piece of scrap wood or metal as shown in the accompanying illustration. Place this tool over the end of the commutator and then slide the holder assembly down over it. As it slides down the tool, the brushes are retracted into the holder. When the holder makes contact with the commutator and is in position, pull out the tool.

- If you can't, or won't, fabricate this tool, position the holder against the commutator so that the positive lead and grommet are aligned with the field frame. Use a small screwdriver to push each brush into the holder while tilting the holder against the commutator; as each brush clears the commutator, remove the screwdriver and the brush will release against the commutator. Guide the lead and grommet into the notch in the field frame.

21. Dab some wheel bearing grease into the bearing bore on the end plate and then install the plate onto the end of the frame. Install the small brush screws and tighten them to 20-30 inch lbs. (2.3-3.4 Nm).

22. Apply a coating of wheel bearing grease to the shaft assembly splines and bearing surfaces, to the stationary gear and planetary gears. Slide the gear shaft through the stationary gear and then position the planetary gears onto the posts on the top of the shaft. Rotate the gears until they are fully seated. Squeeze some grease into the center recess of the shaft assembly and install the thrust ball.

23. Position the gear retainer onto the top of the gear assembly so that it rides in the two pins securely.

24. Slide the armature thrust washer over the other end of the shaft and secure it with the snap ring.

25. Slide the drive assembly over the shaft and into position so that it engages the gear. Slide on the stop ring until it sits in the groove on the shaft, follow it with the retainer—press the retainer down until it rides over the stop ring.

26. Stretch the shift lever over the pins on the side of the drive

## 10-28 IGNITION AND ELECTRICAL SYSTEMS

27. Coat the drive housing bushing lightly with bearing grease. Slide the drive assembly into the drive housing slightly and then insert the seal, small end down, into the housing notch behind the lever. Position the plastic keeper over the small tab on the gear assembly—the longer side fits down into the drive housing.

28. Carefully slide field frame down and into the drive housing so that the match-marks made previously all line up. Feed the two long thru-bolts through and tighten them to 45-84 inch lbs. (5.1-9.5 Nm).

29. Insert the solenoid into the drive housing, attaching the plunger to the shift lever. Rotate the unit so that the M terminal is facing the starter. Tighten the mounting bolts to 45-85 inch lbs. (5.1-9.6 Nm).

30. Attach the positive brush connector to the solenoid terminal and tighten the nut to 80-120 inch lbs. (9-13 Nm).

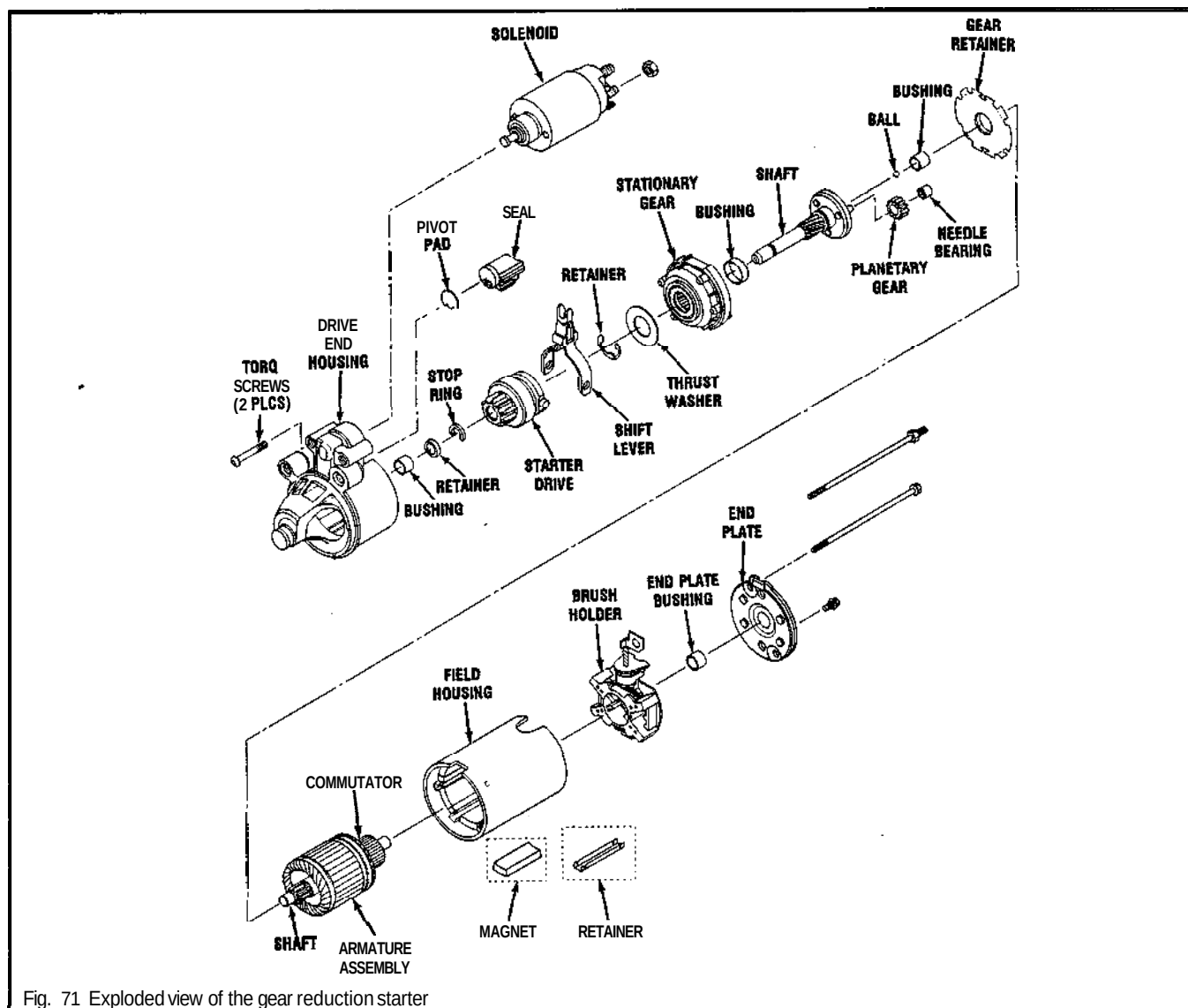


Fig. 71 Exploded view of the gear reduction starter

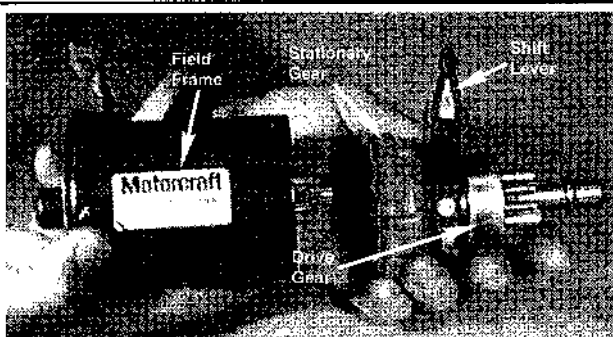


Fig. 72 Removing the gear assembly from the field frame

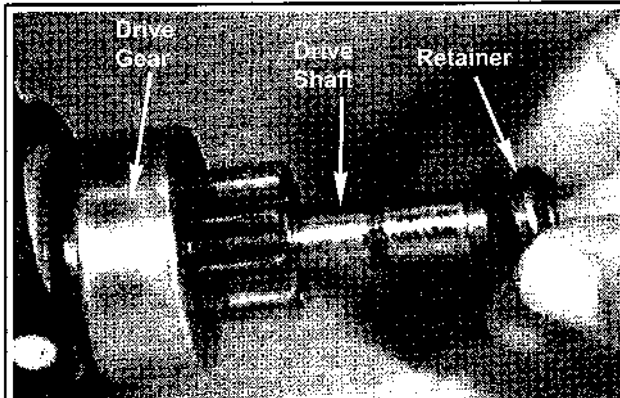


Fig. 73 Slide off the retainer

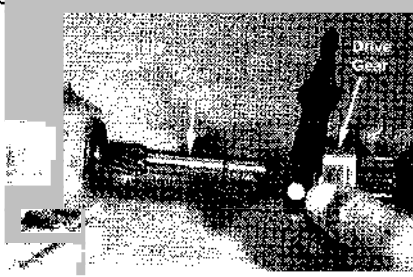


Fig. 74 Pull the drive assembly off of the shaft...

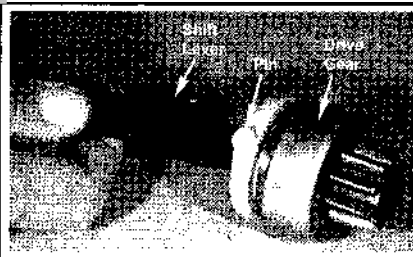


Fig. 75 ...and then remove the shift lever

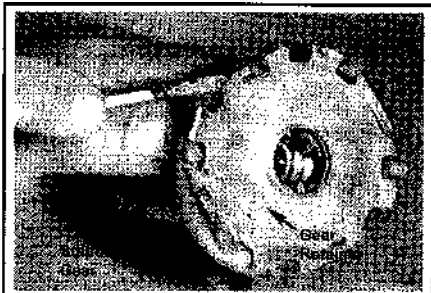


Fig. 76 Pry off the gear retainer...

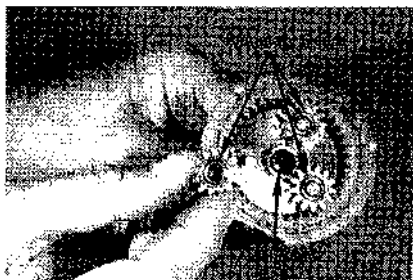


Fig. 77 ...and then remove the planetary gears and thrust ball

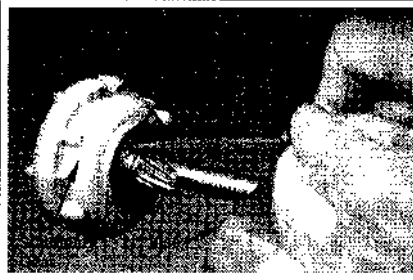


Fig. 78 Pry up the retainer...

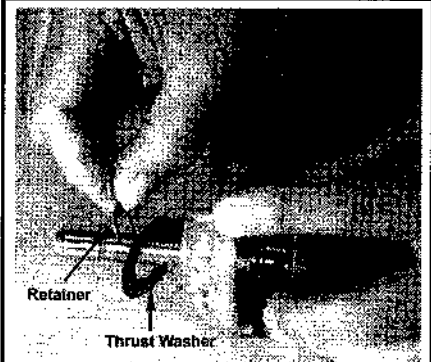


Fig. 79 ...and then remove it and the washer

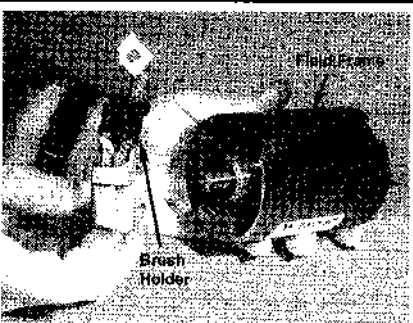


Fig. 80 Lift out the brush holder...



Fig. 81 ...and then remove the armature assembly

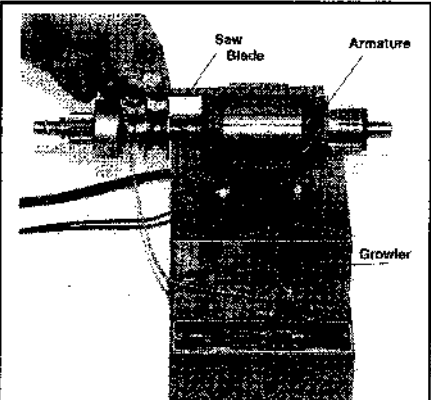


Fig. 82 Testing the armature

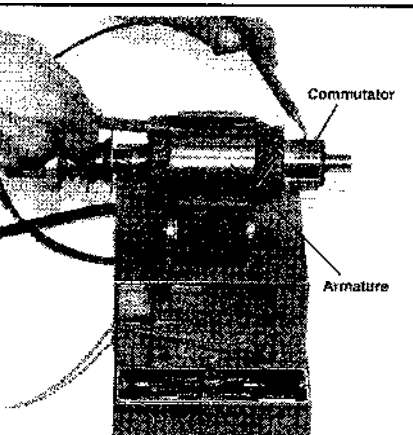


Fig. 83 Testing the armature

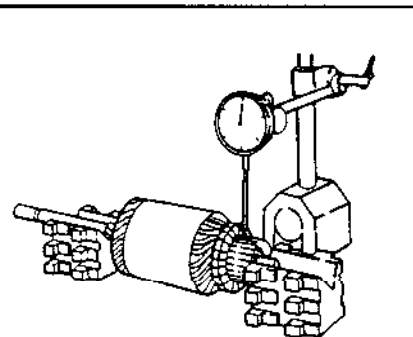


Fig. 84 Checking commutator run-out

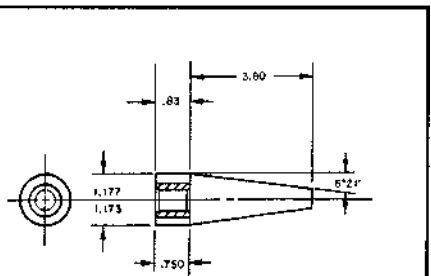
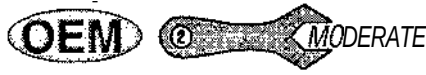


Fig. 85 Fabricating a brush holder installation tool

## PINION CLEARANCE

Direct Drive Only—1986-94 GM Engines

◆ See Figure 86



Pinion clearance should always be checked after reassembly of the starter to insure proper adjustment.

1. Connect a 6V power source between the S terminal on the solenoid and ground.

### ✕ ✕ CAUTION

Never use more than 6V or the starter motor may actually operate.

2. Connect a heavy gauge jumper wire to the solenoid motor terminal and quickly touch the other end to the body of the starter so the solenoid energizes and the pinion moves into the cranking position.

3. Push the pinion back toward the commutator end until there is no slack. Measure the gap between the pinion and the retainer. If not 0.010-0.159 in. (0.25-4.04mm) on direct drive models, the solenoid linkage or shift lever yoke buttons are worn and will require replacement, or the shift lever mechanism has been assembled improperly. No adjustment is possible.

## Solenoid

### REMOVAL & INSTALLATION

GM Direct Drive (1986-94)



1. Remove the starter motor.
2. Remove the screw/washer from the starter connector strap terminal.
3. Remove the two solenoid mounting screws, twist it clockwise until you can remove the flange key from the slot in the starter and then lift off the solenoid. Don't lose the return spring.

To Install:

4. Slide the return spring over the plunger.
5. Position the solenoid at the starter and rotate it until the flange key engages the keyway.
6. Install the two mounting screws and tighten them securely.
7. Install the connector strap and then install the starter.

Ford Direct Drive (1987-92)

1. Disconnect the battery cables.
2. Tag and disconnect the 4 electrical leads at the solenoid. Move them out of the way.
3. Remove the mounting bolts and lift out the solenoid.
4. Install the solenoid and tighten the mounting bolts securely.
5. Reconnect the solenoid leads and the battery cables.

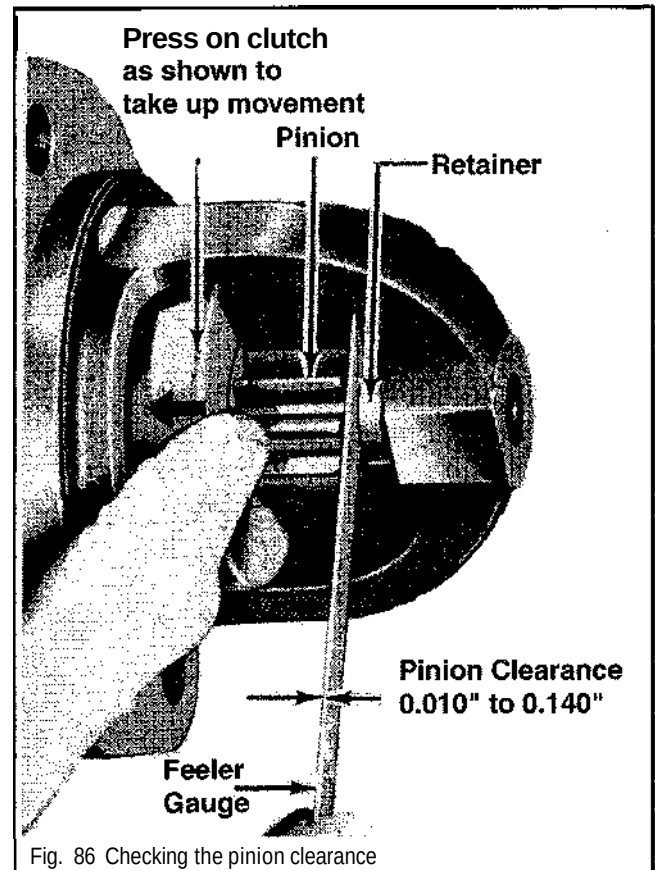


Fig. 86 Checking the pinion clearance

## IGNITION SYSTEM

OMC engines covered in this manual utilize one of six different ignition systems: conventional breaker points, Delco Electronic Spark Timing System (EST), Prestolite Breakerless Inductive Distributor (BID), OMC Spitfire/Electronic Engine Management (EEM), Ford Thick Film Integrated Ignition System (TFI-IV), GM High Energy Ignition System (HEI) and

Distributorless Electronic Ignition (DEI). Please refer to the Application chart for details on your specific engine.

Descriptions of each system, and complete repair procedures are detailed under each of the respective system heads.

### IGNITION SYSTEM APPLICATIONS

| Year | Model       | Displacement<br>L/Cu. In. | Engine<br>Type | Ignition<br>System |
|------|-------------|---------------------------|----------------|--------------------|
| 1986 | 2.5L        | 2.5/153                   | L4             | Breaker Point      |
|      | 3.0L (All)  | 3.0/181                   | L4             | Breaker Point      |
|      | 4.3L (All)  | 4.3/262                   | V6             | Breaker Point      |
|      | 5.0L (All)  | 5.0/305                   | V8             | Breaker Point      |
|      | 5.7L (All)  | 5.7/350                   | V8             | Breaker Point      |
|      | 7.5L        | 7.5/460                   | V8             | Breaker Point      |
| 1987 | 2.3L        | 2.3/140                   | L4             | Breaker Point      |
|      | 3.0L (All)  | 3.0/181                   | L4             | Breaker Point      |
|      | 4.3L (All)  | 4.3/262                   | V6             | Breaker Point      |
|      | 5.0L (All)  | 5.0/305                   | V8             | Breaker Point      |
|      | 5.7L (All)  | 5.7/350                   | V8             | Breaker Point      |
|      | 7.5L        | 7.5/460                   | V8             | Breaker Point      |
| 1988 | 2.3L        | 2.3/140                   | L4             | Breaker Point      |
|      | 3.0L (All)  | 3.0/181                   | L4             | Breaker Point      |
|      | 4.3L (All)  | 4.3/262                   | V6             | Breaker Point      |
|      | 5.0L (All)  | 5.0/305                   | V8             | Breaker Point      |
|      | 5.7L (All)  | 5.7/350                   | V8             | Breaker Point      |
|      | 7.4L 454    | 7.4/454                   | V8             | Breaker Point      |
|      | 7.5L 460    | 7.5/460                   | V8             | Breaker Point      |
|      |             |                           |                |                    |
| 1989 | 2.3L        | 2.3/140                   | L4             | Breaker Point      |
|      | 3.0L (All)  | 3.0/181                   | L4             | Breaker Point      |
|      | 4.3L (All)  | 4.3/262                   | V6             | Breaker Point      |
|      | 5.0L (All)  | 5.0/302                   | V8             | Breaker Point      |
|      | 5.7L (All)  | 5.7/350                   | V8             | Breaker Point      |
|      | 7.5L        | 7.5/460                   | V8             | Breaker Point      |
|      |             |                           |                |                    |
| 1990 | 2.3L        | 2.3/140                   | L4             | Breaker Point      |
|      | 3.0L (All)  | 3.0/181                   | L4             | HEI                |
|      | 4.3L        | 4.3/262                   | V6             | Breaker Point      |
|      | 4.3L HO     | 4.3/262                   | V6             | Spitfire/EEM       |
|      | 5.0L (All)  | 5.0/302                   | V8             | Breaker Point      |
|      | 5.7L        | 5.7/350                   | V8             | Breaker Point      |
|      | 5.7L LE     | 5.7/350                   | V8             | Breaker Point      |
|      | 5.8L        | 5.8/351                   | V8             | Breaker Point      |
|      | 350         | 5.7/350                   | V8             | Spitfire/EEM       |
|      | 454         | 7.4/454                   | V8             | Spitfire/EEM       |
|      | 460         | 7.5/460                   | V8             | Spitfire/EEM       |
|      |             |                           |                |                    |
| 1991 | 3.0L (All)  | 3.0/181                   | L4             | EST                |
|      | 4.3L        | 4.3/262                   | V6             | BID                |
|      | 4.3L HO     | 4.3/262                   | V6             | Spitfire/EEM       |
|      | 5.0L (All)  | 5.0/302                   | V8             | BID                |
|      | 5.7L (All)  | 5.7/350                   | V8             | BID                |
|      | 5.8L (All)  | 5.8/351                   | V8             | BID                |
|      | 350         | 5.7/350                   | V8             | Spitfire/EEM       |
|      | 7.4GL       | 7.4/454                   | V8             | Spitfire/EEM       |
| 1992 | 3.0L (All)  | 3.0/181                   | L4             | EST                |
|      | 4.3L (All)  | 4.3/262                   | V6             | BID                |
|      | 5.0L (All)  | 5.0/302                   | V8             | BID                |
|      | 5.7L (All)  | 5.7/350                   | V8             | BID                |
|      | 5.8L (All)  | 5.8/351                   | V8             | BID                |
|      | 5.8 LE, 351 | 5.8/351                   | V8             | Spitfire/EEM       |
|      | 7.4GL, 454  | 7.4/454                   | V8             | Spitfire/EEM       |
|      | 8.2GL, 502  | 8.2/502                   | V8             | Spitfire/EEM       |

**BID** Breakerless Inductive Distributor  
**EEM** Electronic Engine Management  
**EST** Electronic Spark Timing  
**HEI** High Energy Ignition

Fig. 87

### IGNITION SYSTEM APPLICATIONS

| Year | Model       | Displacement<br>L/Cu. In. | Engine<br>Type | Ignition<br>System |
|------|-------------|---------------------------|----------------|--------------------|
| 1993 | 3.0L (All)  | 3.0/181                   | L4             | EST                |
|      | 4.3L (All)  | 4.3/262                   | V6             | BID                |
|      | 5.0L        | 5.0/302                   | V8             | BID                |
|      | 5.0 EFI     | 5.0/302                   | V8             | TFI-IV             |
|      | 5.8L        | 5.8/351                   | V8             | BID                |
|      | 5.8 LE, 351 | 5.8/351                   | V8             | Spitfire/EEM       |
|      | 5.8 EFI     | 5.8/351                   | V8             | TFI-IV             |
|      | 454, 454 H  | 7.4/454                   | V8             | Spitfire/EEM       |
|      | 8.2GL, 502  | 8.2/502                   | V8             | Spitfire/EEM       |
|      |             |                           |                |                    |
| 1994 | 3.0GL/GS    | 3.0/181                   | L4             | EST                |
|      | 4.3GL       | 4.3/262                   | V6             | EST                |
|      | 5.0FL       | 5.0/302                   | V8             | BID                |
|      | 5.0Fi       | 5.0/302                   | V8             | TFI-IV             |
|      | 5.7GL       | 5.7/350                   | V8             | BID                |
|      | 5.8FL       | 5.8/351                   | V8             | BID                |
|      | 5.8Fi       | 5.8/351                   | V8             | TFI-IV             |
|      | 351 EFI     | 5.8/351                   | V8             | TFI-IV             |
|      | 7.4GL       | 7.4/454                   | V8             | Spitfire/EEM       |
|      |             |                           |                |                    |
| 1995 | 3.0GS       | 3.0/181                   | L4             | EST                |
|      | 4.3GL       | 4.3/262                   | V6             | EST                |
|      | 5.0FL       | 5.0/302                   | V8             | BID                |
|      | 5.0 EFI     | 5.0/302                   | V8             | TFI-IV             |
|      | 5.8FL       | 5.8/351                   | V8             | BID                |
|      | 5.8 EFI/HO  | 5.8/351                   | V8             | TFI-IV             |
|      | 7.4Gi       | 7.4/454                   | V8             | EST-Di             |
|      | 7.4GL       | 7.4/454                   | V8             | Spitfire/EEM       |
|      |             |                           |                |                    |
|      |             |                           |                |                    |
| 1996 | 3.0GS       | 3.0/181                   | L4             | EST                |
|      | 4.3GL/GS    | 4.3/262                   | V6             | EST                |
|      | 4.3Gi       | 4.3/262                   | V6             | EST-DI             |
|      | 5.0FL       | 5.0/302                   | V8             | BID                |
|      | 5.0Fi       | 5.0/302                   | V8             | TFI-IV             |
|      | 5.7Gi       | 5.7/350                   | V8             | EST-DI             |
|      | 5.8FL       | 5.8/351                   | V8             | BID                |
|      | 5.8Fi/FSi   | 5.8/351                   | V8             | TFI-IV             |
|      | 7.4Gi       | 7.4/454                   | V8             | EST-DI             |
|      | 7.4GL       | 7.4/454                   | V8             | Spitfire/EEM       |
| 1997 | 3.0GS       | 3.0/181                   | L4             | EST                |
|      | 4.3GL/GS    | 4.3/262                   | V6             | EST                |
|      | 4.3Gi       | 4.3/262                   | V6             | EST-DI             |
|      | 5.7GL/GS    | 5.7/350                   | V8             | BID                |
|      | 5.7Gi/GSi   | 5.7/350                   | V8             | EST-DI             |
|      | 7.4Gi       | 7.4/454                   | V8             | EST-DI             |
|      | 7.4GL       | 7.4/454                   | V8             | Spitfire/EEM       |
|      |             |                           |                |                    |
| 1998 | 3.0GS       | 3.0/181                   | L4             | EST                |
|      | 4.3GL/GS    | 4.3/262                   | V6             | EST                |
|      | 4.3Gi       | 4.3/262                   | V6             | EST-DI             |
|      | 5.0GL       | 5.0/305                   | V8             | BID                |
|      | 5.7GL       | 5.7/350                   | V8             | BID                |
|      | 5.7GSi      | 5.7/350                   | V8             | EST-DI             |
|      | 7.4Gi/GSi   | 7.4/454                   | V8             | EST-DI             |
|      | 8.2GSi      | 8.2/502                   | V8             | EST-DI             |

**BID** Breakerless Inductive Distributor  
**EEM** Electronic Engine Management  
**EST** Electronic Spark Timing  
**EST-DI** Electronic Spark Timing - Distributor Ignition  
**TFI-IV** Thick Film Integrated - IV

Fig. 88

**BREAKER POINT IGNITION SYSTEM**

❑ Please refer to Maintenance section for complete breaker point gap, dwell and timing adjustment procedures.

**Description**

Used primarily on all engines through 1989, and a few engines in 1990; this ignition system consists of a primary and a secondary circuit. The low-voltage current of the ignition system is carried by the primary circuit. Components 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 that 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 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 takes place is staggering.

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 current 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.

The shift cut-out switch, sometimes referred to as an interrupt 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. 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.

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 power to the piston for the power stroke.

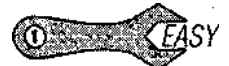
Manual setting and centrifugal advance are the two methods of obtaining the constantly changing demands of the engine. The manual setting is made at idle speed. This setting allows the contact points to open at a specified position of the piston in the same manner as with conventional ignition systems.

**Troubleshooting**

Any problem in the ignition system must first be localized to the primary or secondary circuit before the defective part can be identified.

**GENERAL TESTS**

◆ See Figure 89



Disconnect the ignition coil wire from the center of the distributor cap and hold it about 114 in. from a good engine ground. Turn the ignition switch to the *ON* position, and crank the engine with the starter. If you observe a good spark, go to the Secondary Circuit Test. If you do not have a good spark, go to the Primary Circuit Test.

Primary Circuit Test

◆ See Figure 90



Remove the distributor cap; lift off the rotor; and then turn the crankshaft until the contact points close. Turn the ignition switch to the *ON* position and open and close the contact points using a small screwdriver or a non-metallic object. Hold the high-tension coil wire about 114 in. from a good engine ground. If you notice a good spark jump from the wire to the ground, the primary circuit checks out; proceed to the Secondary Circuit Test. If there is no spark, proceed to the Contact Point Test.

Contact Point Test

◆ See Figure 91



Remove the distributor cap and rotor. Rotate 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 114 in. from a good engine 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, the screwdriver is being used for a set of contact points. If a spark is observed 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, see the Condenser Test.

Condenser Test

◆ See Figure 91



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 movable contact point and the tip making and breaking contact with the contact point base plate. Observe for a low-tension

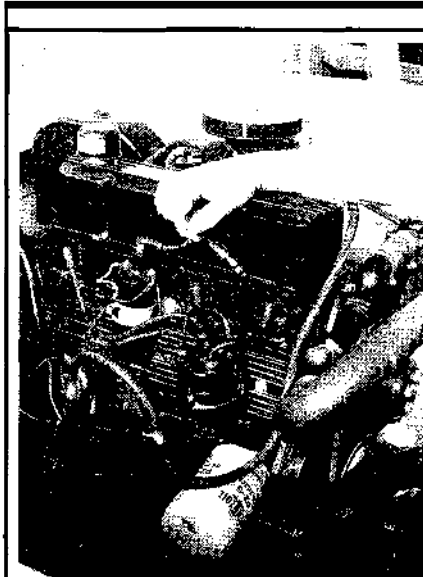


Fig. 89 Testing for spark

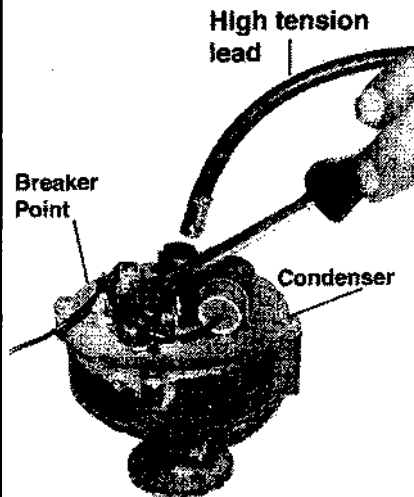


Fig. 90 Checking for spark in the primary circuit

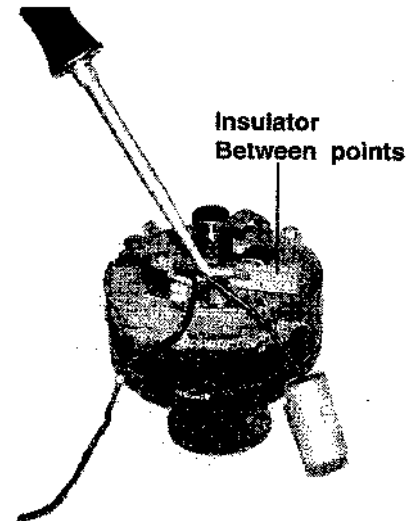


Fig. 91 Testing the points and the condenser

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 primary circuit complete through the neutral-safety switch, the primary side of the ignition coil, the ballast resistor, the shift cut-out switch, and the primary wiring inside the distributor. 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 movable 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.

## Secondary Circuit Test



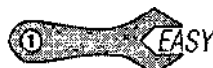
### ◆ See Figure 92

The secondary circuit should not be tested using emergency troubleshooting procedures unless the primary circuit has been tested and proven satisfactory, or any problems discovered in the primary circuit have been corrected.

If the primary circuit tests are satisfactory, use the same procedures as outlined in the Primary Circuit Test to check the secondary circuit. Hold the high-tension coil lead about 1¼ in. 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 lead 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 leads, or the plugs may require attention or replacement. To test the rotor, go to the 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.

## Rotor Test



### ◆ See Figure 93

With the distributor cap removed and the rotor in place on the distributor shaft, hold the high-tension coil lead about 1¼ in. 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 leads (check for poor insulation or replace it), or in the spark plugs (replace them).

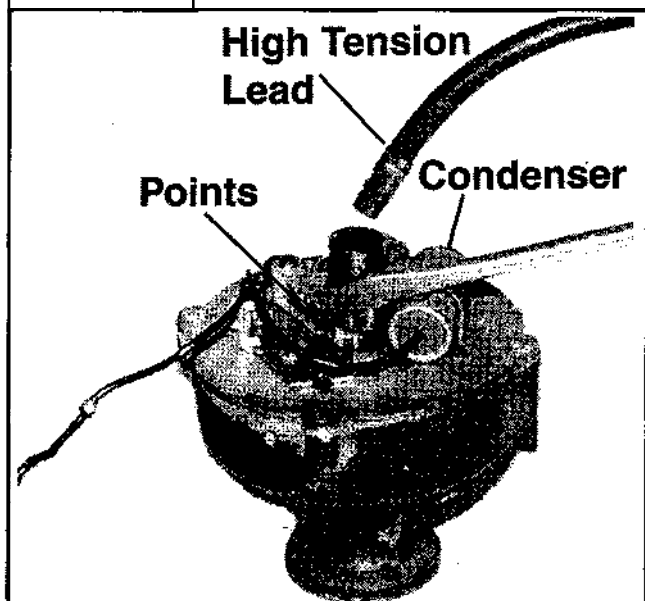


Fig. 92 Testing the secondary circuit

## IGNITION VOLTAGE TESTS

Many times hard starting and mis-firing 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

### ◆ See Figure 94



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 the ON position. The voltage loss should not exceed 3.2 volts. This figure 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.

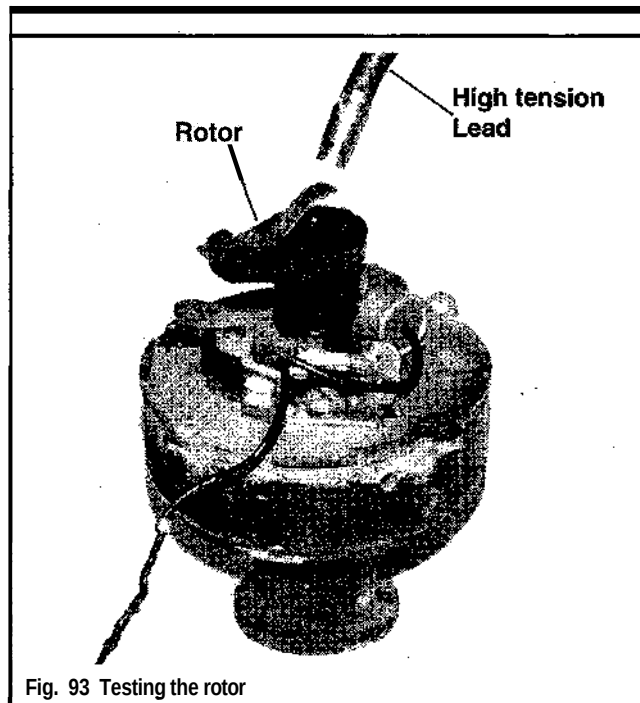


Fig. 93 Testing the rotor

### TEST 2—Cranking System

◆ See Figure 95



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

4 See Figure 96



Measure the voltage between the distributor primary terminal and ground, as shown in the 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

4 See Figure 97



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 the illustration. The specified resistance is between 1.3 and 1.4 ohms. If the reading does not fall within this range, replace the resistor.

### Test 5—Voltage Loss In The Ignition Switch, Ammeter, Or Battery Cable

4 See Figure 98



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 the 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.

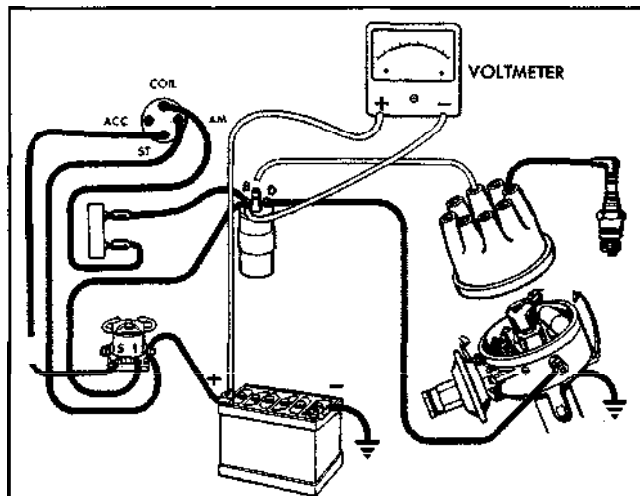


Fig. 94 Voltage test 1

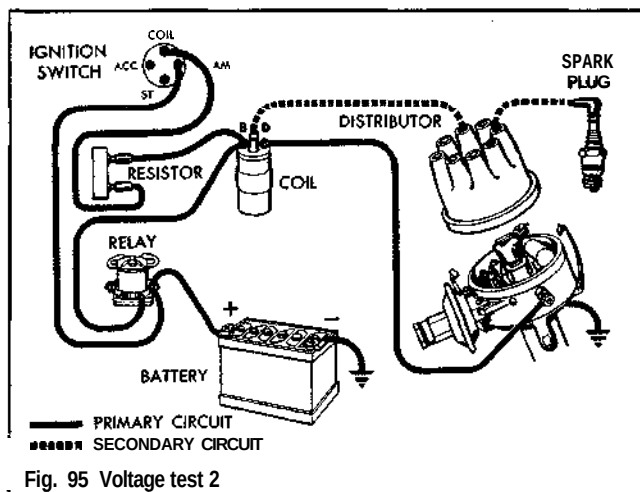


Fig. 95 Voltage test 2

### 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 plug wire of the No. 1 cylinder. In this test, connect the trigger wire to the fifth cylinder in the firing order for a V8 engine.

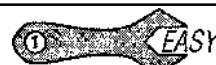
The timing mark and the pointer should align in the same position as it did with the number one cylinder. If there is a variation of a few degrees, the distributor shaft bushings or cam lobes may be worn and the condition will have to be corrected.

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.

## Distributor Cap And Rotor

### REMOVAL & INSTALLATION

◆ See Figures 99 and 100



It is not necessary to remove the spark plug and ignition coil leads to remove the cap. If you do remove them, be sure to carefully mark each lead and tag it for reinstallation in the proper cap socket.

1. Loosen the two cap retaining screws and carefully lift off the cap. It never hurts to paint a small mark across the cap and distributor body to aid in installation. There are a few models out there using only one retaining screw.

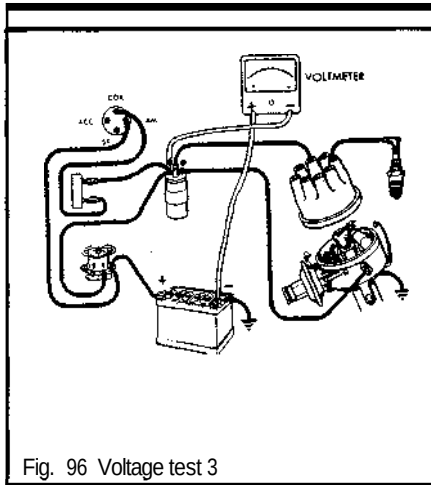


Fig. 96 Voltage test 3

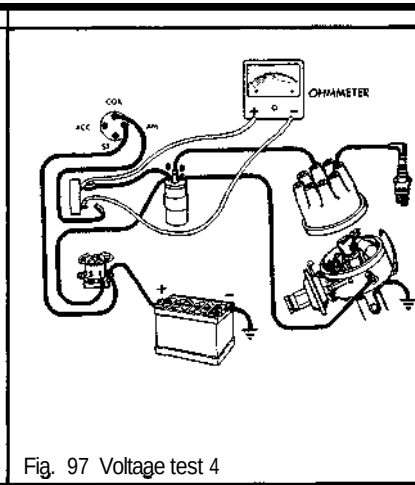


Fig. 97 Voltage test 4

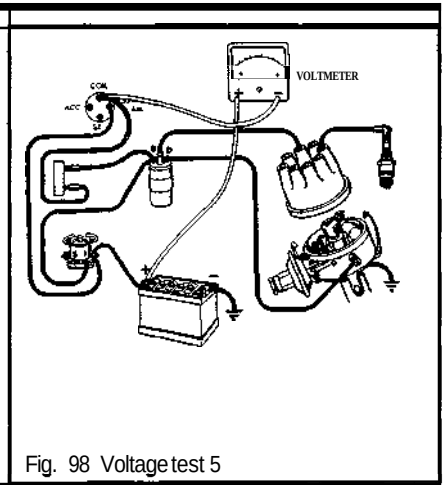


Fig. 98 Voltage test 5

2. Paint a small mark on the distributor body at the end of the rotor and then pull the rotor up and off the shaft.

3. If you have removed the electrical leads from the cap, clean it in warm, soapy water and allow it to dry completely. Check the cap for cracks or other damage. Marine caps should have brass contacts—if yours has aluminum contacts, replace it as someone has previously installed an automotive cap.

4. Check the rotor for cracks and other damage.

5. Install the rotor onto the shaft so that the end is pointing to the mark on the distributor base made earlier.

6. Install the cap onto the distributor. There should be locating tabs cut into the distributor housing to aid installation; you've also got the mark you made previously. Tighten the retaining screws securely.

## Distributor

### REMOVAL



It is not necessary to remove the spark plug leads to **remove** the cap. If you do remove them, be sure to carefully mark each lead and tag it for reinstallation in the proper cap socket.

1. Disconnect the distributor primary lead at the ignition coil terminal and then remove the cap and rotor.
2. Bump the engine over so that the No. 1 cylinder's piston is at TDC.
3. Scribe or paint a small alignment mark on the distributor body at the rotor notch on the distributor shaft. Scribe or paint a small mark across the distributor housing and cylinder block.
4. Loosen and remove the distributor clamp bolt and then slowly lift the distributor out of the cylinder block.

The distributor will actually rotate slightly as you lift it out, so don't be surprised or concerned.

### INSTALLATION

Engine Not Disturbed



1. Install the rotor onto the shaft so that the marks made earlier align.
2. Install a new gasket on the housing.
3. Grasp the rotor and spin the shaft about 1/8 of a turn, counterclockwise, past the alignment mark (if you are working on a Ford 7.5L (460) engine, position the rotor 118 turn clockwise before the mark). Position the distributor over the hole in the block so that the alignment marks match and then work it down into the hole until it engages completely with the oil pump shaft.

□ It is OK to wiggle the rotor slightly during installation so that the distributor gear meshes properly with the oil pump. It is imperative though that the rotor ends up pointing to the alignment mark made during removal when installation is complete.

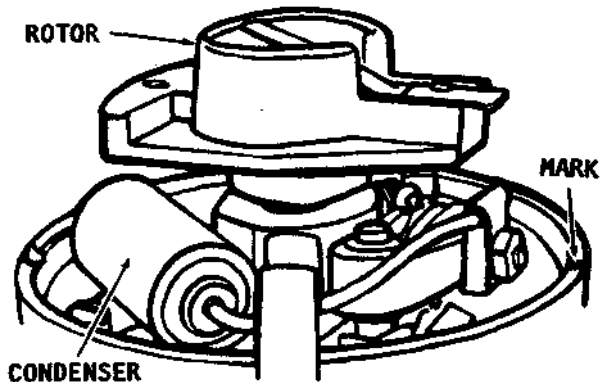


Fig. 99 Paint a small mark on the distributor housing for rotor alignment

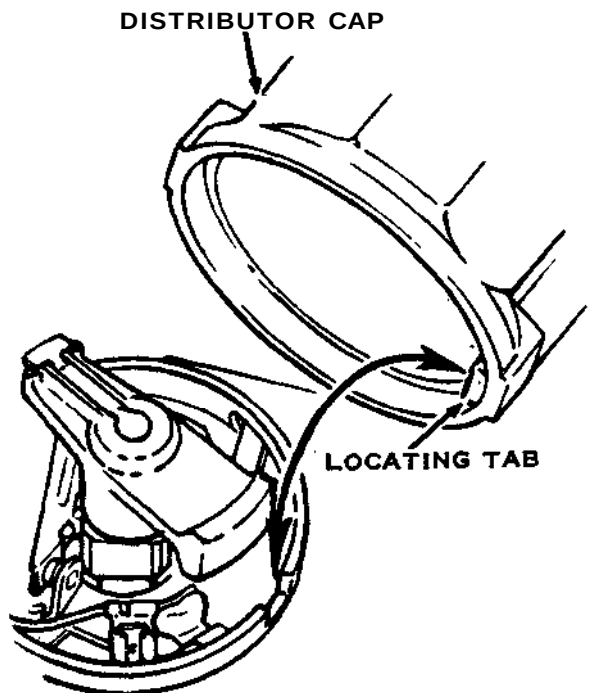


Fig. 100 Most models will have locating tabs cut into the housing to aid in installing the cap

4. Install the clamp bolt and tighten it securely, but no more than 20 ft. lbs. (27 Nm).
5. Check the point gap and dwell as detailed in the Maintenance section and then install the cap and coil lead.
6. Check the ignition timing.

## Engine Disturbed



1. Set the No. 1 piston to TDC. Remove the No. 1 spark plug, put your thumb over the hole and slowly crank the engine until you feel compression on the No. 1 cylinder. Crank the engine a bit more until the pointer lines up with the mark on the scale.
2. Install the rotor onto the shaft so that the marks made earlier align.
3. Install a new gasket on the housing.
4. Grasp the rotor and spin the shaft about 118 of a turn, counterclockwise, past the alignment mark (if you are working on a Ford 7.5L (460) engine, position the rotor 118 turn clockwise before the mark). Position the distributor over the hole in the block so that the alignment marks match and then work it down into the hole until it engages completely with the oil pump shaft.

■ It is OK to wiggle the rotor slightly during installation so that the distributor gear meshes properly with the oil pump. It is imperative though that the rotor ends up pointing to the alignment mark made during removal when installation is complete.

5. Install the clamp bolt and tighten it finger-tight. Rotate the distributor carefully until the breaker points just begin to open and then install the clamp bolt and tighten it securely, but no more than 20 ft. lbs. (27 Nm).
6. Install the distributor cap into position and confirm that the rotor points to the terminal for the No. 1 spark plug lead. If it does, go to the next step; if not, repeat the installation procedure.
7. Check the point gap and dwell as detailed in Maintenance section and then install the cap and coil lead.
8. Check the ignition timing.

## DISASSEMBLY & ASSEMBLY

◆ See Figure 101, 102 and 103



□ Engines using a breaker point ignition system may have been equipped with a Delco, Mallory or a Prestolite distributor.

1. Remove the distributor.
2. 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. On Mallory distributors, you will have to remove the terminal screw running through the side of the housing.
3. Pull the primary lead through the opening in the housing. Scribe a mark across the breaker plate and housing and then remove the two breaker plate attaching screws. Remove the breaker plate. On Mallory models, make sure that you take note of the relationship between the curved notch in the plate and the inside of the housing. On Delco models, there is a small rubber grommet in the plate holding the primary wire — do not disturb this grommet.

■ Further disassembly of the distributor body is not recommended.

4. Remove the thrust washer installed only on certain counterclockwise rotating engines.
5. Remove the weight retainers, and then remove the weights.
6. 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.

### To assemble:

7. 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.
8. 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 in., the shaft and body must be replaced.

9. Inspect the breaker plate assembly for damage and replace it if there are signs of excessive wear.

10. 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.

## ✖✖ WARNING

Marine distributors have a corrosion resistant coating applied to the return spring on top of the breaker plate and on the two small weight springs under the plate. For this reason, as well as other good reasons, automotive parts — point sets, springs, or other distributor parts — should never be used as a replacement.

11. Always replace the points with a new set during a distributor overhaul. The condenser seldom gives trouble, but good shop practice dictates 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.

12. Lubricate the distributor shaft with crankcase oil, and then slide it into the 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.

13. Install the distributor cap clamps. Left-hand rotating engine distributor assemblies may 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 0.001-0.010 in.

14. Install the gear onto the shaft with the marks, on the gear and the shaft 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.

15. 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.

16. 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.

17. 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 marked during disassembly, matched.

18. Place the breaker plate in position and then secure with the attached screws. Remember on Mallory models that the curved notch should be spanning the hole where the terminal screw goes through the housing. On Delco models, make sure that the small rubber grommet is seated correctly in the plate and the notch in the housing.

19. 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. Don't forget the terminal screw on the Mallory! Connect the primary wire and the condenser lead to the breaker point primary terminal.

20. Adjust the point gap and dwell as outlined in the following procedures, then install the distributor.

## Ignition Coil

### REMOVAL & INSTALLATION



1. Disconnect the negative battery cable.
2. Disconnect the high tension lead coming from the distributor.
3. Tag and disconnect the coil electrical leads.
4. Remove the coil mounting bolts/screws and lift out the coil.
5. Install the coil and tighten the mounting hardware securely.
6. Connect the electrical leads and the high tension lead.
7. Connect the battery cable.

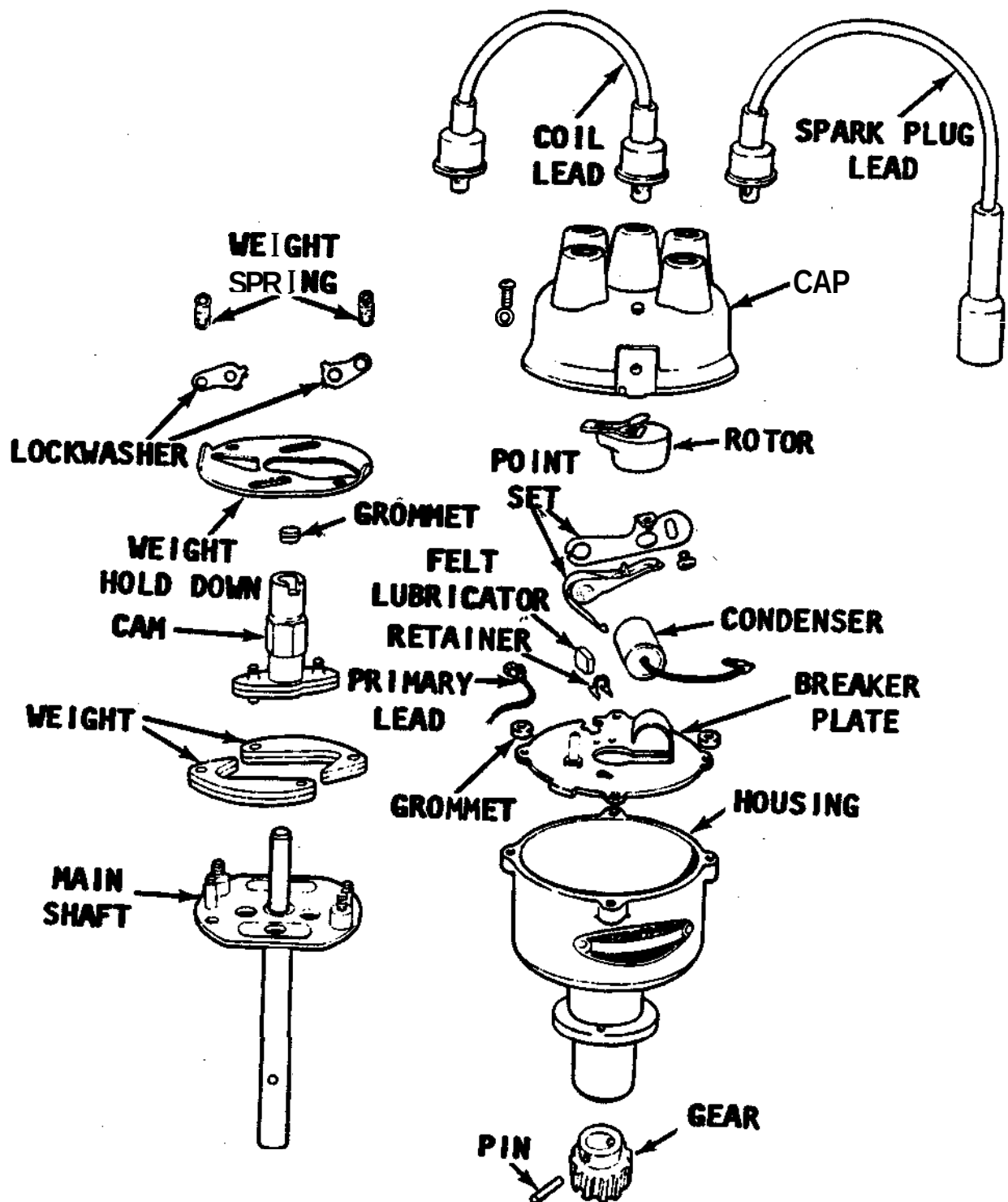
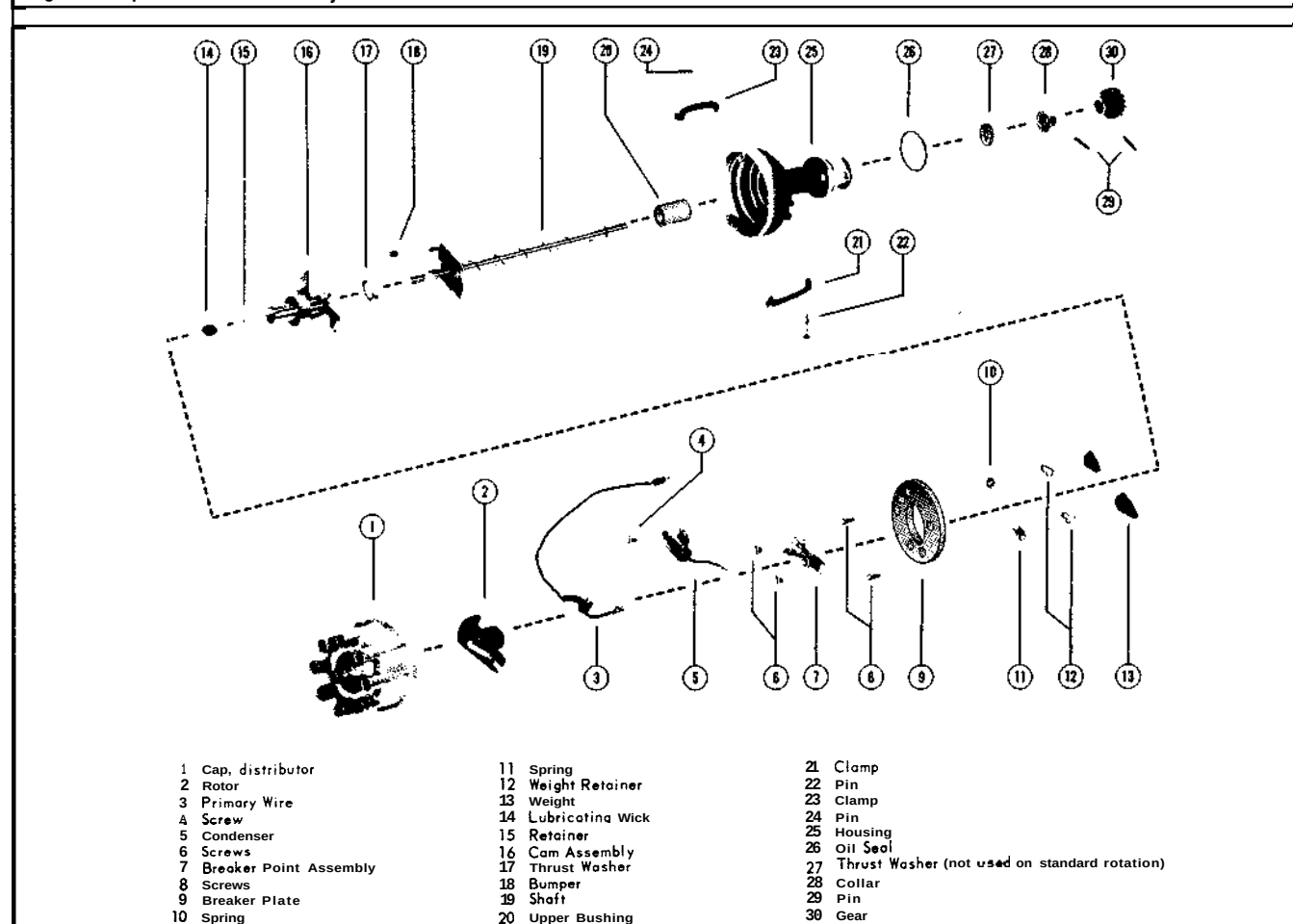
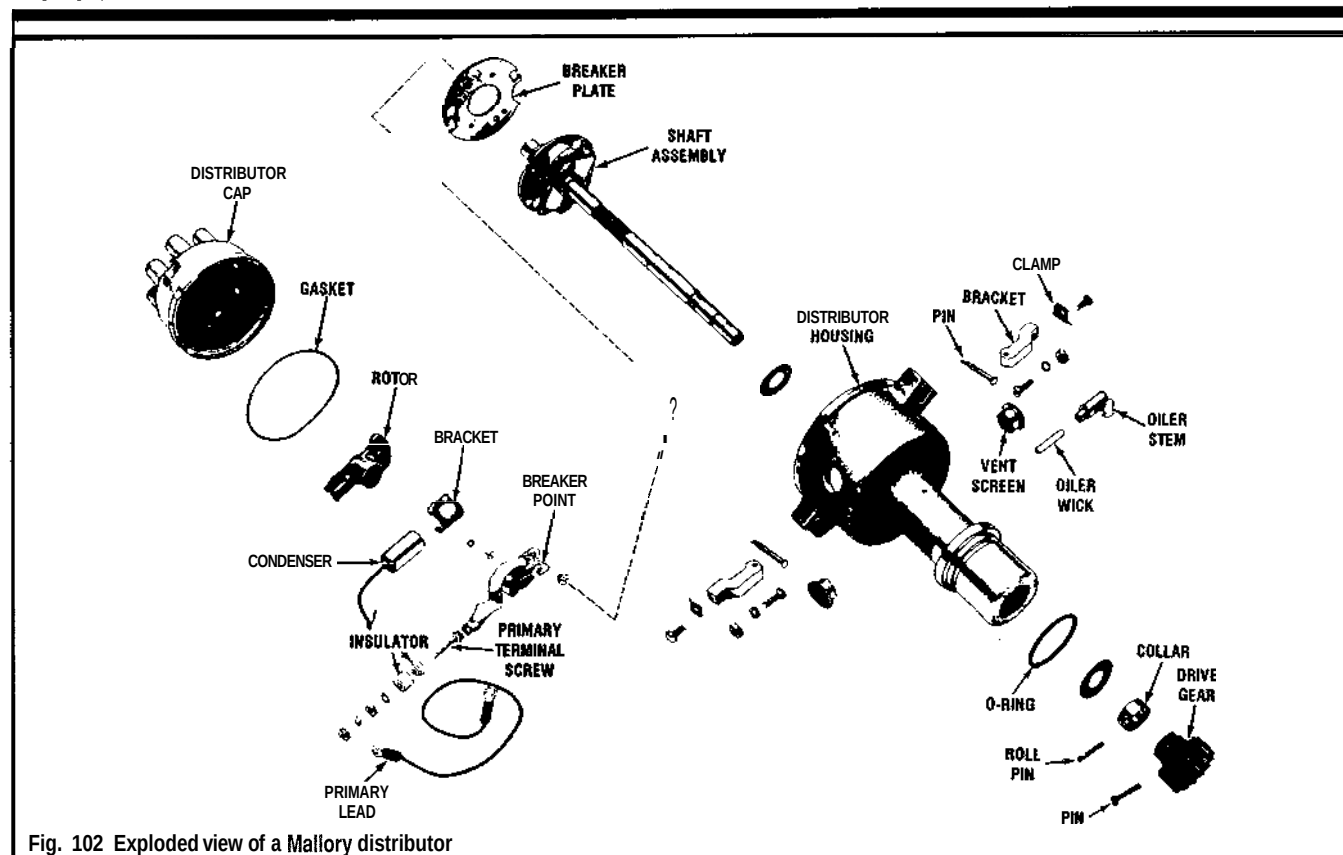


Fig. 101 Exploded view of a Delco distributor



## ELECTRONIC SPARK TIMING (EST) SYSTEM

## DISTRIBUTOR IGNITION (DI) SYSTEM

### Description

#### ◆ See Figures 104, 105 and 106

Basic components of this system include a pointless distributor, a remote ignition coil, an electronic ignition module and a pick-up coil. The distributor does not contain breaker points, a condenser or a centrifugal advance arrangement. As the name of the system implies, spark advance and ignition timing are handled electronically. There are little to no differences between the two systems; EST is used on carbureted engines, while DI is used on EFI engines.

The distributor utilizes an internal magnetic pick-up assembly consisting of a permanent magnet, a pole piece with internal teeth and the actual pick-up coil. The pick-up coil itself is sealed against moisture and electro-mechanical interference. When the rotating teeth of the timer core (which is attached to the top of the distributor shaft) line up with the internal teeth on the pole piece, voltage is induced in the pick-up coil. The coil then sends a signal to the ignition module; thus triggering the primary ignition circuit. Current flow in the primary circuit is interrupted and voltage as high as 35,000 volts is induced in the secondary windings of the ignition coil; this voltage is then through the secondary ignition circuit to fire the spark plugs.

The distributor is connected to the ignition coil by a high tension secondary wire and 2 low voltage primary wires. Because of this high voltage, a special thermoplastic, injection molded, glass-reinforced distributor cap is used.

A timer core (trigger wheel) is mounted near the upper end of the distributor shaft. This "wheel" has "teeth"—the number corresponding to the number of engine cylinders. An ignition module is mounted close to the wheel.

The ignition coil produces greater spark voltage, longer spark, and operates at a much higher rpm than normal. The secondary windings are wrapped around the primary windings, which are in turn wrapped around an iron core. The coil generates a very high secondary voltage of up to 35,000 V when the primary circuit has been broken. There are a pair of 2-wire connectors used for:

- Battery voltage input
- Primary voltage to the ignition module
- Ignition module trigger signal input
- Tachometer output signal

The ignition module is located inside the distributor and is a solid state unit that uses transistorized relays and switches to control any associated circuits. The module serves the following functions:

- Changing the voltage signal from the pick-up coil to a "square" digital signal

- Sending the digital signal as a reference signal (REF HI) for ignition control
- Providing a ground reference signal (REF LO)
- Providing a means to control spark advance (Ignition mode and/or Module mode)
- Providing a trigger signal for the ignition coil

The pick-up coil assembly consists of the stationary pole piece and a pick-up coil and magnet; which rides inside the pole piece. The coil produces an alternating voltage signal as the teeth pass the magnet. A signal is produced for each cylinder of the engine during one complete revolution of the engine. The coil assembly is connected to the ignition module with a 2-wire connector.

### Troubleshooting

#### + See Figure 107 and 108



### ✖✖ WARNING

This Delco EST breakerless ignition system requires the use of a jumper wire—OMC 986662—or one may be fabricated using a six inch piece of 16AWG wire and a male bullet terminal on each end. This jumper is required to shunt (turn off), the electronic spark advance function in the module while setting initial timing.

### ✖✖ CAUTION

Always ground the high tension lead of the coil any time it is disconnected from the distributor. Failure to disconnect the lead could result in fire or an explosion, if gas vapors are present. Reason: A high voltage discharge in the secondary circuit of the coil may occur when the ignition switch is turned to the on and off positions. This high voltage discharge may occur even if the engine is not cranked.

Before spending too much time and money attempting to trace a problem to the ignition system, a compression check of the cylinders should be made. If the cylinders do not have adequate compression, troubleshooting and attempted service of the ignition or fuel system will fail to give the desired results of satisfactory engine performance.

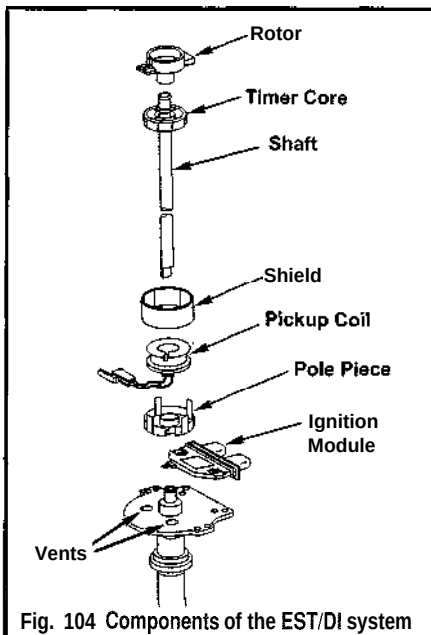


Fig. 104 Components of the EST/DI system

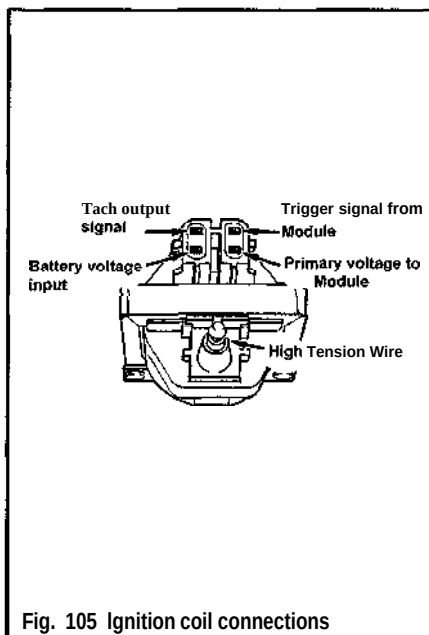


Fig. 105 Ignition coil connections

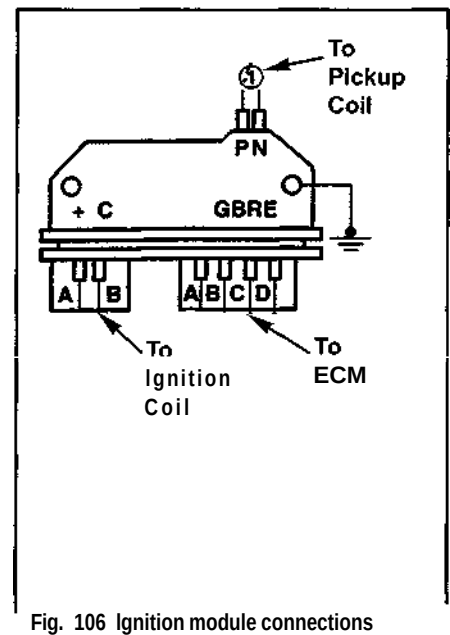


Fig. 106 Ignition module connections

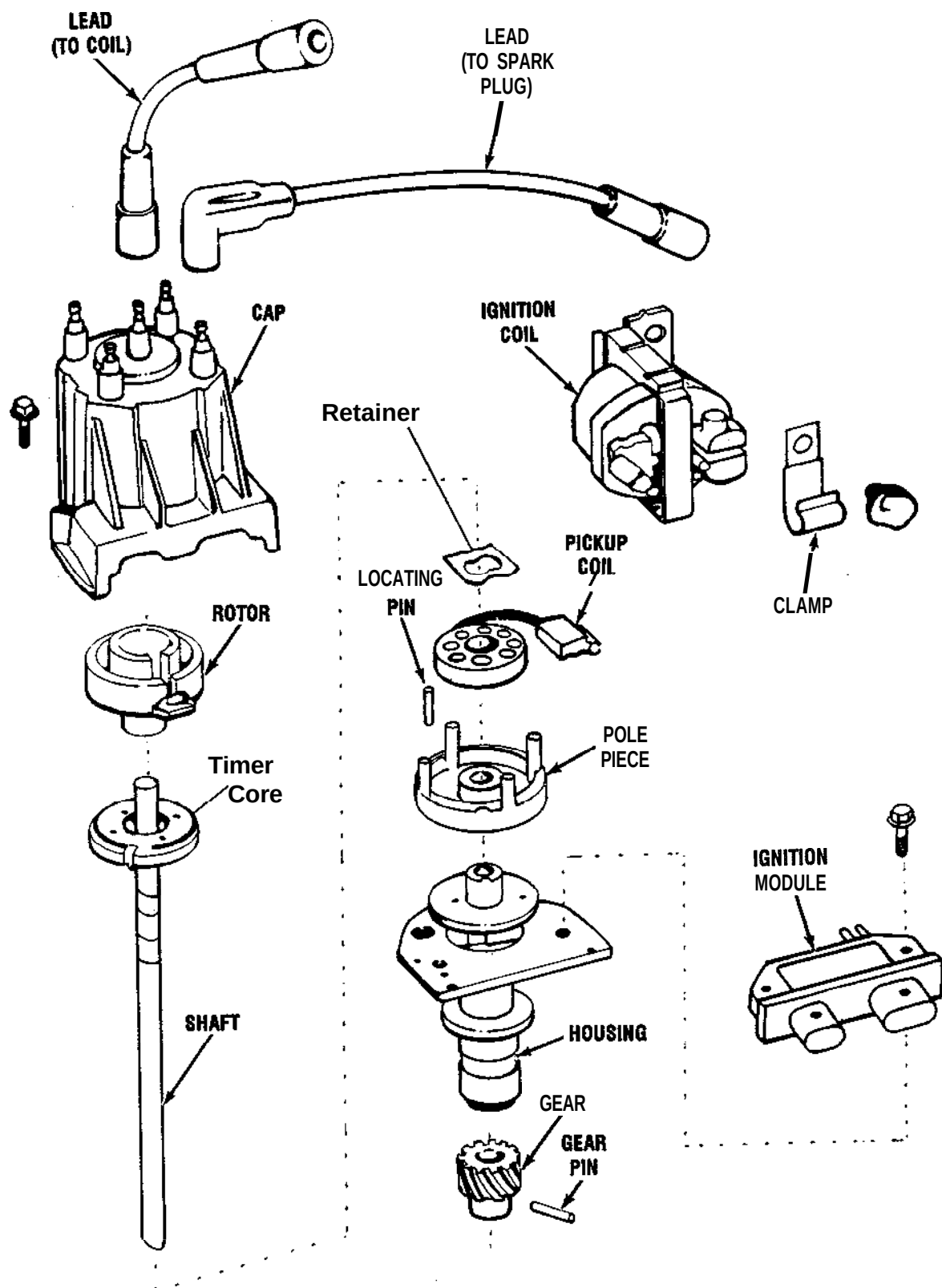


Fig. 107 Exploded view of the typical DI distributor