Chapter Nine

Electrical System

All engines covered in this manual are equipped with a 12-volt, negative-ground electrical system. Many electrical problems can be traced to a simple cause such as a blown fuse, a loose or corroded connection, a loose alternator drive belt or a frayed wire. While these are easily corrected problems that may not appear to be important, they can quickly lead to serious difficulty if allowed to go uncorrected.

Complete overhaul of electrical components, such as the alternator or starter motor, may not be practical or economical. In some cases, the necessary bushings, bearings or other worn parts are not available for individual replacement.

If tests indicate a unit with problems other than those discussed in this chapter, replace it with a new or rebuilt marine unit. Make certain, however, that the new or rebuilt part is an exact replacement for the defective one removed. Also be sure to isolate and correct the cause of the failure before installing a replacement. For example, an uncorrected short in an alternator circuit will most likely burn out a new alternator as quickly as it damaged the old one. If in doubt, always consult an expert.

This chapter provides service procedures for the battery, charging system, starting system and switches. Wiring diagrams are included at the end of this book. **Table 1** and **Table 2** are located at the end of this chapter.

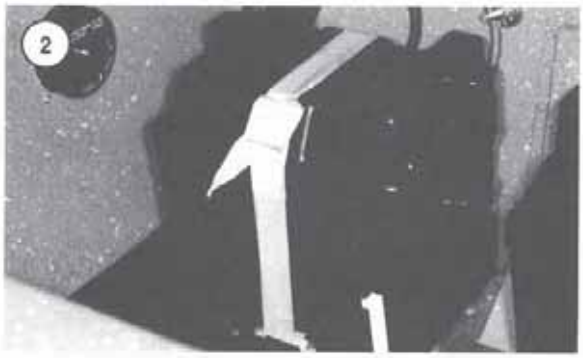
NOTE

Except where specified, F and D series engines are included when a basic model number is specified. For example, if model 3GM is called out in a procedure, the procedure also applies to 3GMD and 3GMF.

BATTERY

Because batteries used in marine applications endure far more rigorous treatment and are often used differently than those used in an automotive charging system, they are constructed differently. However, battery advancements developed for automotive batteries have been applied to marine batteries. This has resulted in new battery designs that provide the boater with more choices. A battery may be selected that better accommodates the electrical requirements for the engine and the boat's accessories than the typical older, wet-cell battery designs.

If buying a new battery, consult with a marine dealership that sells a full line of marine batteries. To obtain the best advice, provide the engine model and a list of electri-



cal devices that will be powered by the battery and how they will be used.

Automotive batteries should be used *only* in an emergency situation when a suitable marine battery is not available. If used, the automotive battery should be replaced with a suitable marine battery as soon as possible.

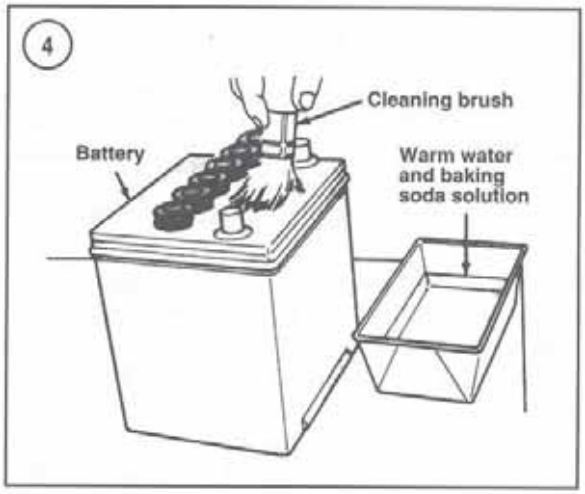
Refer to **Table 1** for recommended battery capacity.

Safety Precautions

When working with batteries, use extreme care to avoid spilling or splashing the electrolyte. This solution contains sulfuric acid, which can ruin clothing and cause serious chemical burns. If any electrolyte is spilled or splashed on clothing or skin, immediately neutralize with a solution of baking soda and water, then flush the area with an abundance of clean water.

WARNING

Electrolyte splashed into the eyes is extremely dangerous. Always wear safety glasses while working with batteries. If electrolyte is splashed into the eyes, call a physician immediately, force the eyes open and flood with cool, clean water for approximately five minutes.



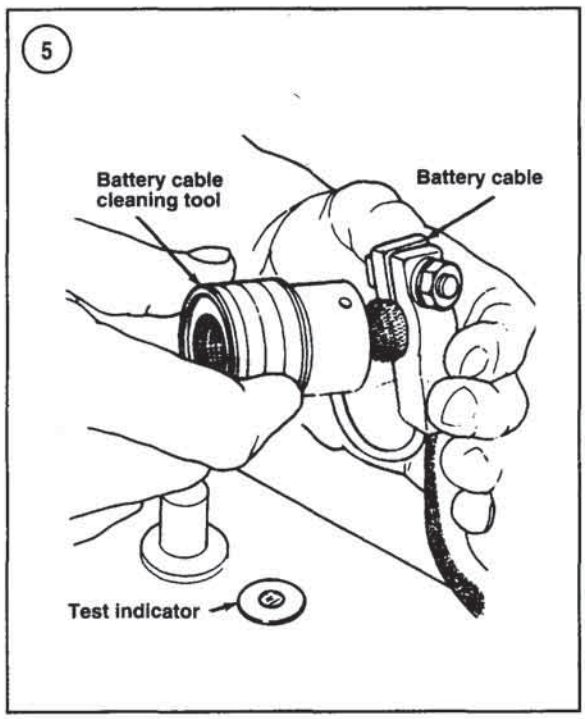
If electrolyte is spilled or splashed onto any surface, it should be immediately neutralized with baking soda and water solution and then rinsed with clean water. While batteries are being charged, highly explosive hydrogen gas forms in each cell. Some of this gas escapes through filler cap openings and may form an explosive atmosphere in and around the battery. This condition can exist for several hours. Sparks, an open flame or a lighted cigarette can ignite this gas, causing an internal battery explosion and possible serious personal injury.

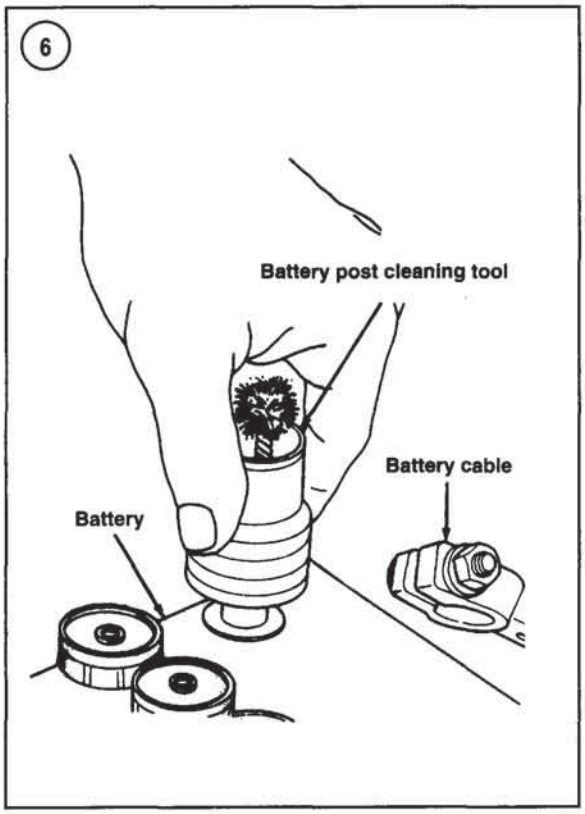
Take the following precautions to prevent injury.

1. Do not smoke or permit any open flame near any battery being charged or that has been recently charged.

2. Do not disconnect live circuits at battery terminals, since a spark usually occurs when a live circuit is broken.

3. Take care when connecting or disconnecting any battery charger. Make sure its power switch is off before





making or breaking any connection. Poor connections are a common cause of electrical arcs that cause explosions.

Care and Inspection

The following battery maintenance information applies to unsealed, wet-cell batteries. Although some of the procedures also apply to other types of batteries, consult the battery manufacturer for specific recommendations.

1. Disconnect both battery cables (negative first, then positive) and remove the battery hold-down or retainer clamp. See **Figure 1** for a typical open installation and **Figure 2** for a typical enclosed installation.

NOTE

*Some batteries have a carry strap built in for use in Step 2. See **Figure 3**.*

2. Attach a battery carrier or carrier strap to the terminal posts and lift the battery from the battery tray. Remove the battery from the engine compartment.
3. Check the entire battery case for cracks or other damage.
4. If the battery has removable vent caps, cover the vent holes in each cap with small pieces of masking tape.

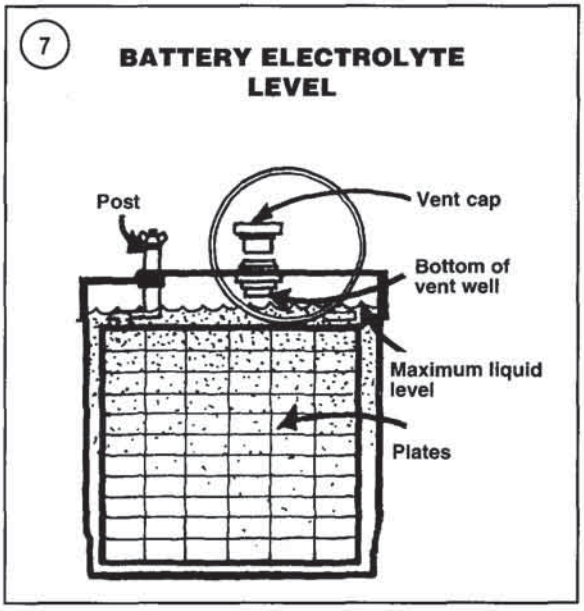
NOTE

Keep cleaning solution out of the battery cells in Step 5, or the electrolyte will be seriously weakened.

5. Scrub the top of the battery with a stiff bristle brush, using a baking soda and water solution (**Figure 4**). Rinse the battery case with clear water and wipe it dry with a clean cloth or paper towels. Remove the masking tape from the filler cap vent holes, if so equipped.
6. Inspect the battery tray or container in the engine compartment for corrosion. Remove and clean it, if necessary, with the baking soda and water solution. Rinse it with clear water and wipe it dry, then reinstall.
7. Clean the battery cable clamps with a stiff wire brush or one of the many tools made for this purpose (**Figure 5**). The same tool is used for cleaning the battery posts (**Figure 6**).
8. Reposition the battery on the battery tray or container and remove the carrier or strap. Install and tighten the hold-down device.
9. Reinstall the positive battery cable, then the negative battery cable.

CAUTION

Be sure the battery cables are connected to their proper terminals. Reversing the polarity can damage the alternator.



10. Tighten the battery cable connections to 9 ft.-lb. (12 N•m). Overtightening the connections can cause damage to the battery case. Coat the connections with petroleum jelly, or a light mineral grease. Aerosol anti-corrosion sprays can also be used.

NOTE

Do not overfill the battery cells in Step 11. The electrolyte expands due to heat from charging and may overflow if the level is more than 1/4 in. (6 mm) above the battery plates.

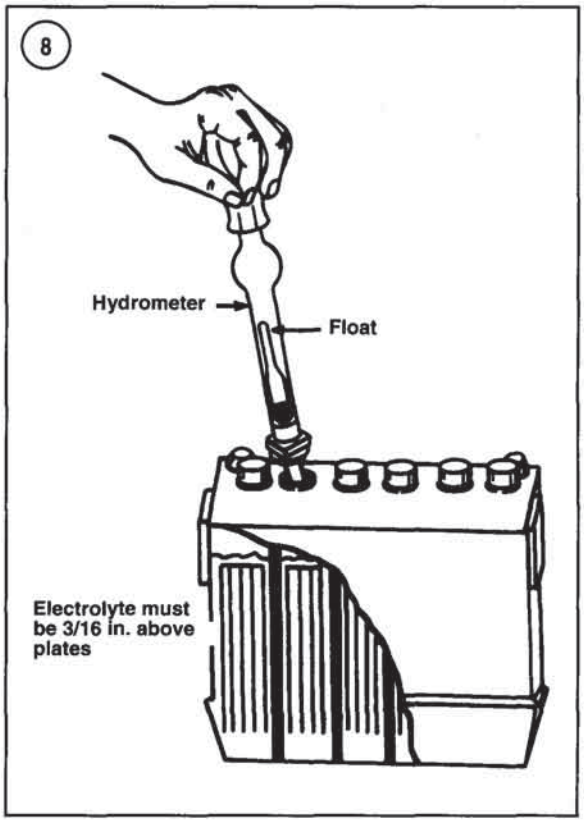
11. Remove the filler caps and check the electrolyte level. The electrolyte should cover the battery plates by at least 3/16 in. (4.8 mm). See **Figure 7**. Top off with distilled water to the bottom of the fill ring in each cell, if necessary.

Battery Testing

Hydrometer testing is the best way to check battery condition. Use a hydrometer with numbered graduations from 1.100-1.300 rather than one with color-coded bands. To use the hydrometer, squeeze the rubber ball, insert the tip in a cell and release the ball (**Figure 8**).

NOTE

Do not attempt to test a battery with a hydrometer immediately after adding water to the cells. Run the engine or charge the battery for 15-20 minutes prior to testing.



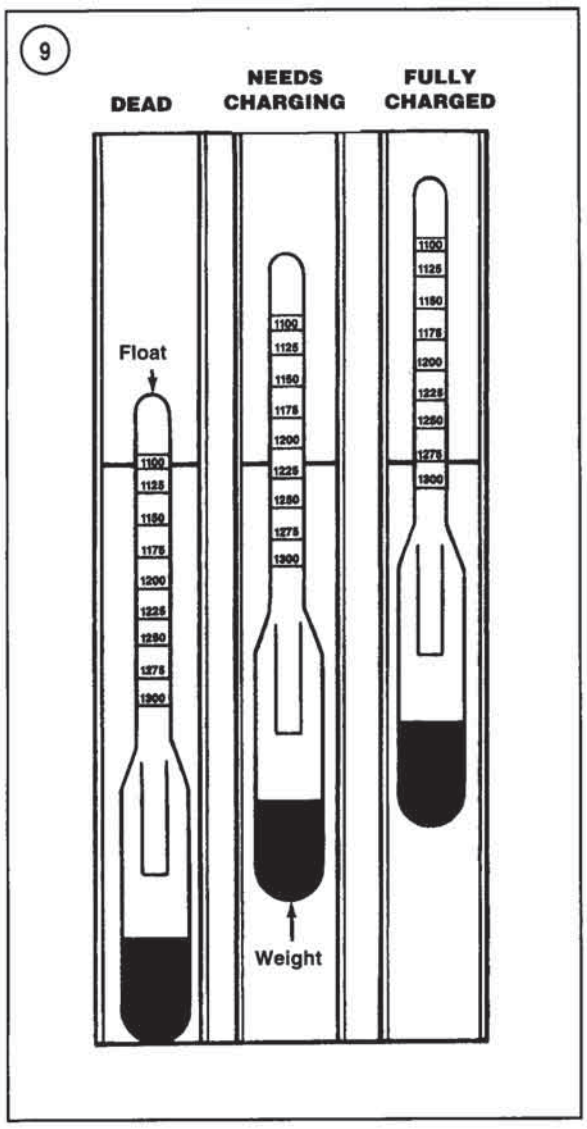
Draw enough electrolyte to float the weighted float inside the hydrometer. When using a temperature-compensated hydrometer, release the electrolyte and repeat this process several times to make sure the thermometer has adjusted to the electrolyte temperature before taking the reading.

Hold the hydrometer vertically and note the number aligned with the surface of the electrolyte (**Figure 9**). This is the specific gravity for the cell. Return the electrolyte to the cell from which it came.

The specific gravity of the electrolyte in each battery cell is an excellent indicator of that cell's condition. A fully charged cell will read 1.260 or more at 80° F (27° C). If the cells test below 1.220, the battery must be recharged. Charging is also necessary if the specific gravity varies more than 50 points from cell to cell.

NOTE

If a temperature-compensated hydrometer is not used, add 0.004 to the specific gravity reading for every 10° above 80° F (27° C).



For every 10° below 80° F (27° C), subtract 0.004.

Charging

Maintain batteries used for starting in a good state of charge. Check the battery with a voltmeter as shown in **Figure 10**. Recharge any battery that cannot deliver at least 9.6 volts under a starting load. If recharging does not bring it up to strength or if it does not hold the charge, replace the battery.

A cold battery will not accept a charge readily. If the temperature is below 40° F (5° C), allow the battery to warm up to room temperature before charging. The battery does not have to be removed from the boat before charging, but it is a recommended procedure since a charging battery gives off highly explosive hydrogen gas. In many boats, the area around the battery is not well ventilated and the gas may remain in the area for several hours after the charging procedure has been completed. Sparks or flames occurring near the battery can cause it to explode, spraying battery acid over a wide area.

Disconnect the negative battery cable first, then the positive battery cable. Make sure the electrolyte is full. Remove the vent caps and place a folded paper towel over the vent openings to absorb any electrolyte that may splatter as the battery charges.

Connect the charger to the battery; negative to negative, positive to positive. If the charger output is variable, select a 10-12 amp setting. Set the voltage selector to 12 volts and plug the charger in. Once the battery starts to accept a charge, reduce the charge rate to a level that will prevent excessive gassing.

The length of time required to recharge a battery depends upon its rating, state of charge and temperature. Generally speaking, the current input time should equal the battery amp-hour rating. For example, a 45 AH battery will require a 9-amp charging rate for five hours (9 × 5 = 45) or a 15-amp charging rate for three hours (15 × 3 = 45). Check charging progress with the hydrometer.

Jump Starting

If the battery becomes discharged, it is possible to start and run the engine by jump starting it from another battery.

Before jump starting a battery when temperatures are 32° F (0° C) or lower, check the condition of the electrolyte. If it is not visible or if it appears to be frozen, do *not* attempt to jump start the battery, as the battery may explode or rupture.

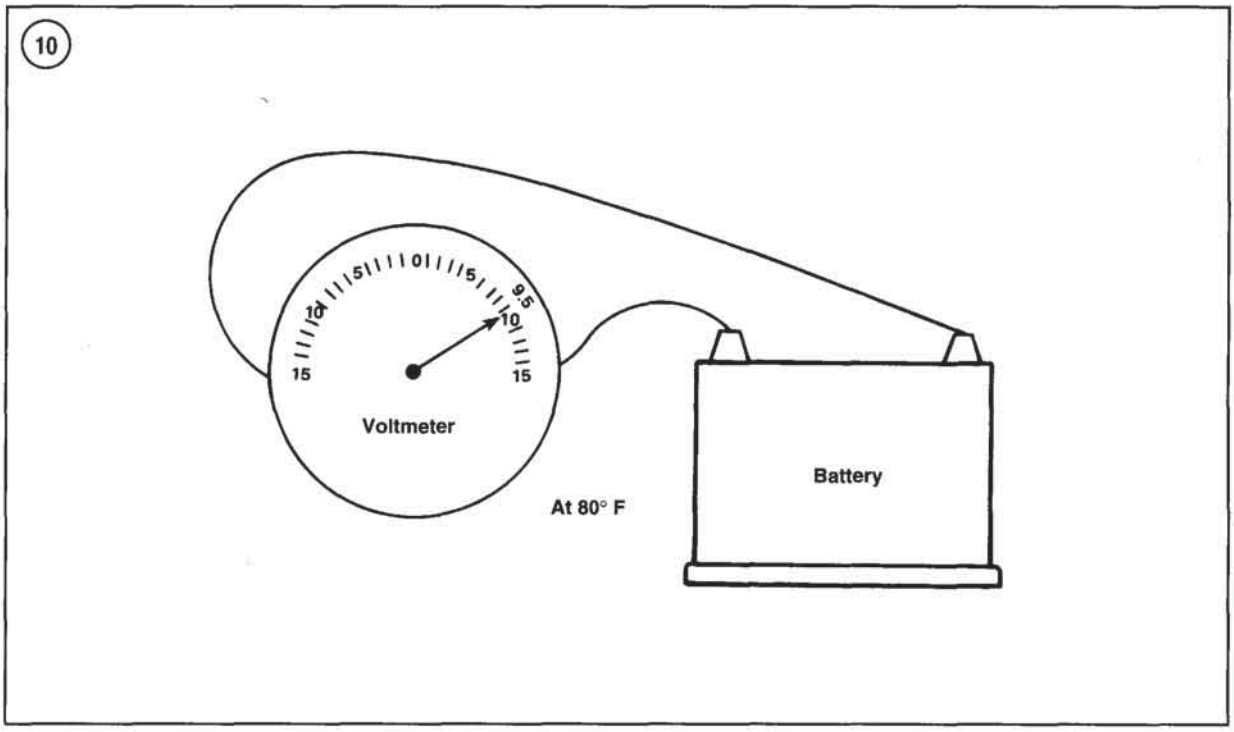
WARNING

Use extreme caution when connecting a booster battery to one that is discharged to avoid personal injury or damage to the system.

1. Connect the jumper cables in the order and sequence shown in **Figure 11**.

WARNING

An electrical arc may occur when the final connection is made. This could cause an explosion if it occurs near the battery. For this reason, the final connection should be made

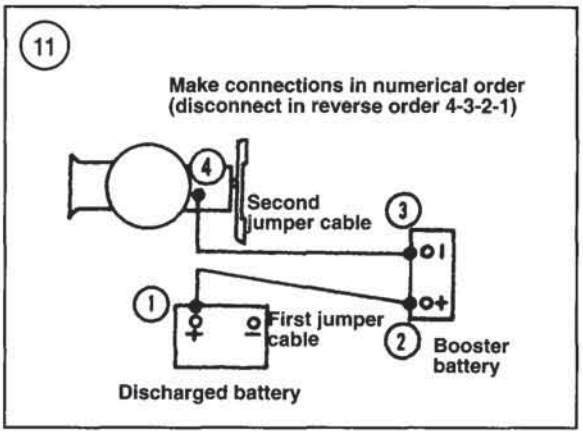


to the alternator mounting bracket or another good engine ground and not the battery itself.

2. Check that all jumper cables are out of the way of moving parts on both engines.
3. Start the engine with the good battery and run at a moderate speed.
4. Start the engine with the discharged battery. Once it starts, run it at a moderate speed.

CAUTION
Racing the engine may damage the electrical system.

5. Remove the jumper cables in the exact reverse order shown in **Figure 11**. Begin at point 4, then disconnect at points 3, 2 and 1.

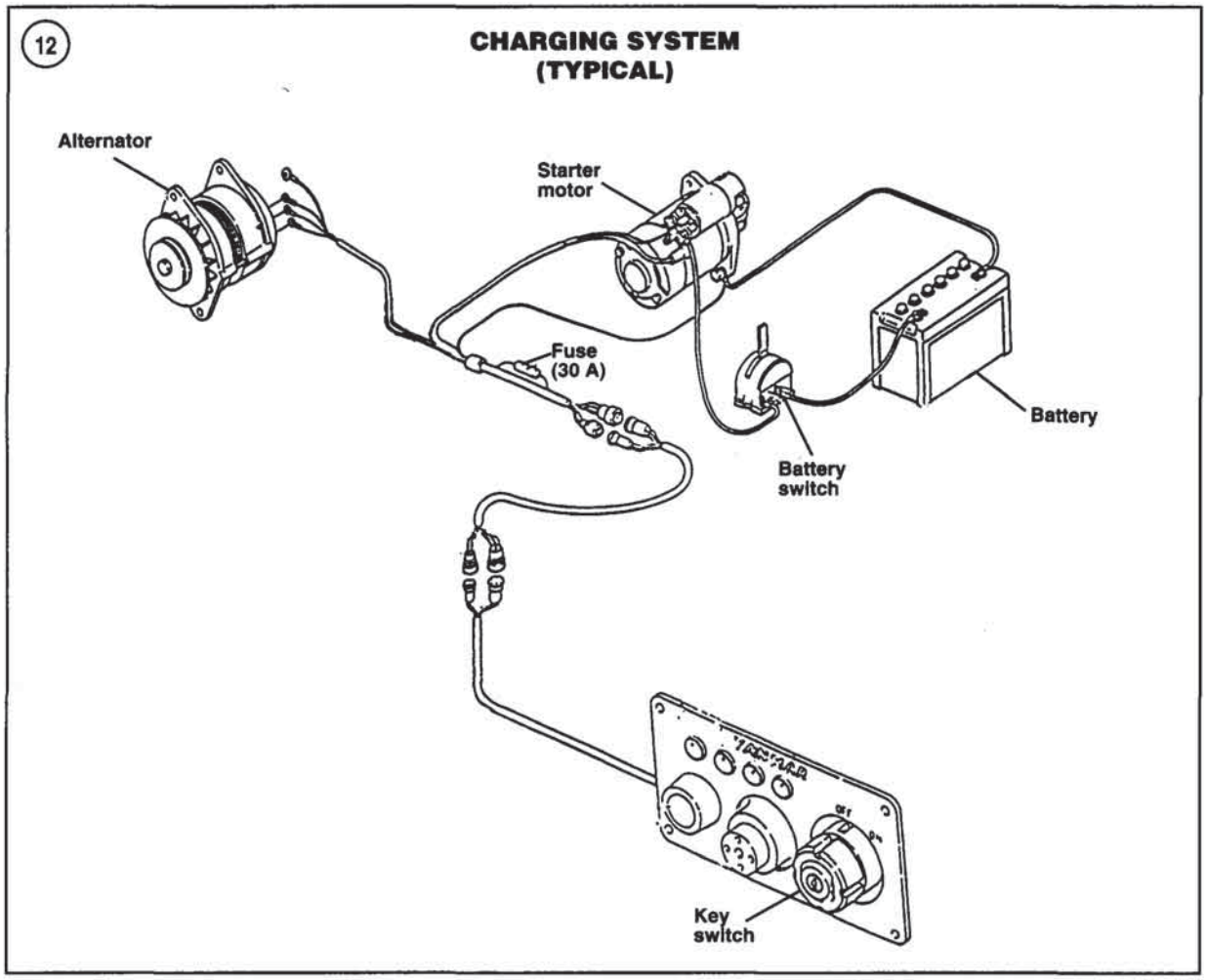


Battery Cables

Poor terminal connections will cause excessive resistance. Defective cable insulation can cause partial short circuits. Both conditions may result in an abnormal voltage drop in the starter motor cable. When this happens, the resulting hard-start condition will place further strain on the battery. Check cable condition and terminal connections periodically.

ELECTRICAL PROTECTION

Some electrical systems are equipped with a battery cutoff switch connected between the positive terminal of the battery and the starter solenoid. The switch provides a means to cut off all circuits from the battery in case of fire



or other electrical emergencies. Using the cutoff switch also prevents any electrical drain on the battery.

All engines are equipped with a 30-amp fuse installed in the wiring harness between the ignition switch and starter motor. If a failure occurs in any part of the electrical system, always check the fuse first to see if it is blown. Usually, the trouble is a short circuit in the wiring. This may be caused by worn insulation or by a wire that has worked its way loose and shorted to ground.

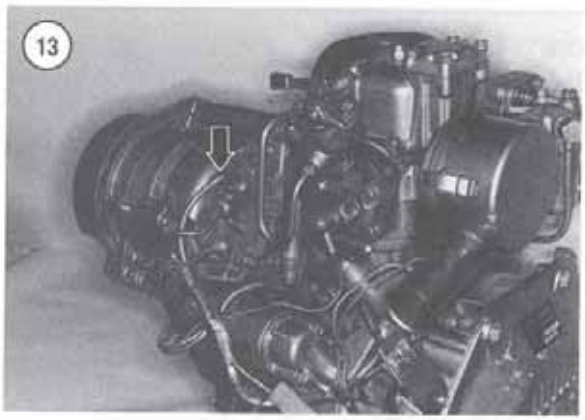
Treat a blown fuse as more than a minor annoyance; it serves as a warning that something is wrong in the electrical system. Before replacing a fuse, determine what caused it to blow and correct the problem. Always carry several spare fuses of the proper amperage values onboard. Never replace a fuse with one of higher amperage rating than that specified for use. Failure to follow these basic rules could result in heat or fire damage to major parts or even the loss of the entire vessel.

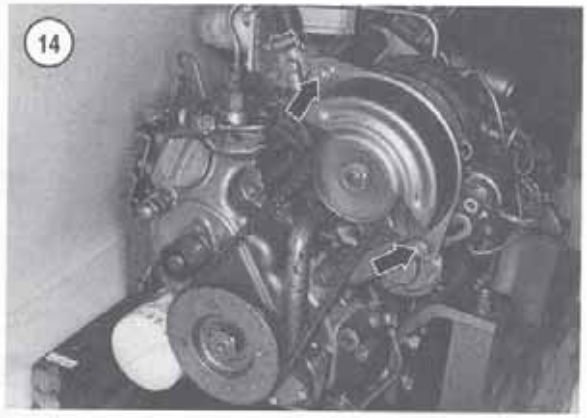
CHARGING SYSTEM

The charging system consists of the battery, alternator, voltage regulator, ignition switch, charge lamp and connecting wiring. All engines are equipped with a Hitachi alternator. Refer to **Figure 12** for a typical charging system.

Preliminary Testing

The first indication of charging system trouble is usually a slow engine cranking speed or running lights that dim as engine speed decreases. This will often occur long before the ammeter or voltmeter indicates that there is a





potential problem. When charging system trouble is first suspected, perform the following:

1. Check the alternator drive belt for correct tension (Chapter Three).
2. Check the battery to make sure it is in satisfactory condition and fully charged and that all connections are clean and secure.
3. Check all connections at the alternator to make sure they are clean and secure.
4. If the charging system is not performing as it should after each of the above points has been carefully checked and any unsatisfactory conditions corrected, refer to Chapter Two and perform the *Charging System Tests*.

Alternator Removal/Installation

This section provides alternator replacement procedures. Complete alternator overhaul is not practical for the home mechanic. In some cases, replacement parts are unavailable.

This procedure is generalized to cover all applications. Access to the alternator is quite limited in some engine compartments and care should be taken to avoid personal injury.

1. Disconnect the negative battery cable.
2. Disconnect all wiring harnesses and leads at the rear of the alternator. See **Figure 13**, typical.

NOTE

When loosening the retaining nut on an alternator terminal, hold the terminal with a wrench to prevent the terminal from rotating.

3. Loosen the alternator adjusting and pivot bolts (**Figure 14**, typical).
4. Swivel the alternator toward the engine and remove the drive belt from the alternator pulley.
5. Support the alternator with one hand and remove the adjusting and pivot bolts, noting the position of any washers or spacers used. Remove the alternator.
6. Installation is the reverse of removal. Tighten fasteners securely and adjust drive belt tension (Chapter Three) before reconnecting wiring harnesses and leads to the rear of the alternator.

NOTE

Make sure the rubber boots at the end of the wires fit snugly over the terminals on the alternator, otherwise, the wire ends and terminals may corrode.

STARTING SYSTEM

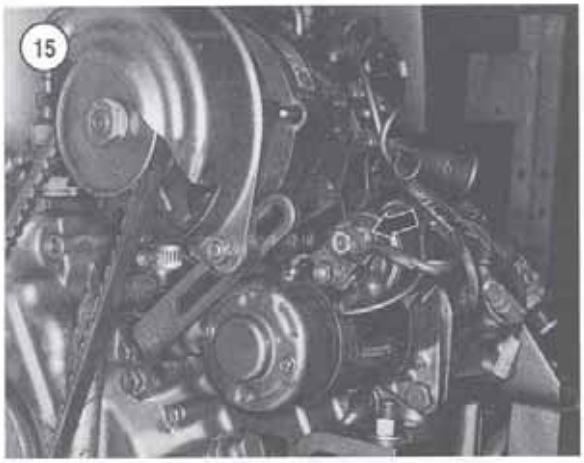
The starting system consists of the battery, starter motor, starter solenoid, starter switch, key switch, fuse and connecting wiring. See **Figure 12**, typical.

Yanmar marine engines are equipped with a Hitachi starter motor. The starter solenoid is enclosed in the drive housing to protect it from exposure to dirt and adverse weather conditions.

Starter service requires experience and special tools. Refer to Chapter Two for troubleshooting procedures. The procedures described below consist of removal, installation and brush replacement. Any repairs inside the unit itself (other than brush replacement) should be performed by a dealer or certified electrical shop. Installation of a professionally rebuilt marine-type unit is generally less expensive and more practical.

Starter Removal/Installation

1. Disconnect the negative battery cable.



2. Disconnect the solenoid terminal wires. See **Figure 15**.
3. Remove the starter motor mounting bolts. Pull the starter motor away from the flywheel and remove it from the engine.
4. Installation is the reverse of removal. Tighten mounting bolts to torque specified in **Table 2**.

Solenoid Removal/Installation

To remove the solenoid it is necessary to partially disassemble the starter. Note that the starter used on series 1GM, 1GM10, 2GM, 2GM20, 3GM and 3GM30 engines are equipped with an antitorque spring that stabilizes the actuating yoke.

1. Remove the starter as previously described.
2. Disconnect the solenoid terminal wires (**Figure 15**).
3. Remove the screws securing the solenoid to the starter. The solenoid will be loose but still attached to the actuating yoke in the starter. It is necessary to partially disassemble the starter to remove the solenoid and yoke.
4. Remove the two throughbolts (29, **Figure 16** or 33, **Figure 17**).

NOTE

Do not allow the armature to move forward because the commutator may slide out of the brushes, which will require disassembly of the rear of the starter to reinstall the brushes.

5. Carefully separate the drive end cover (3, **Figure 16**) from the frame (15 or 22) so the armature shaft withdraws from the drive end housing, but stays in position in the frame.
6. Remove the solenoid with the actuating yoke (6, **Figure 16** or 7, **Figure 17**) and spring, if so equipped.
7. Remove the yoke and spring, if so equipped, from the solenoid.

8A. To install the solenoid on models equipped with an antitorque spring, reverse the disassembly procedure while noting the following:

a. Position the antitorque spring on the solenoid plunger so the spring ends fit in the holes in the solenoid (**Figure 18**).
b. Position the yoke in the solenoid plunger so the notch on the yoke fits against the closed end of the anti-torque spring as shown in **Figure 18**.
c. Make sure the open end of the yoke properly engages the ears on the overrunning clutch body (**Figure 19**).

8B. To install the solenoid on models *not* equipped with an antitorque spring, reverse the disassembly procedure while noting the following:

a. Make sure that the pads on the open end of the yoke properly fit between the flanges on the overrunning clutch body.

Brush Replacement

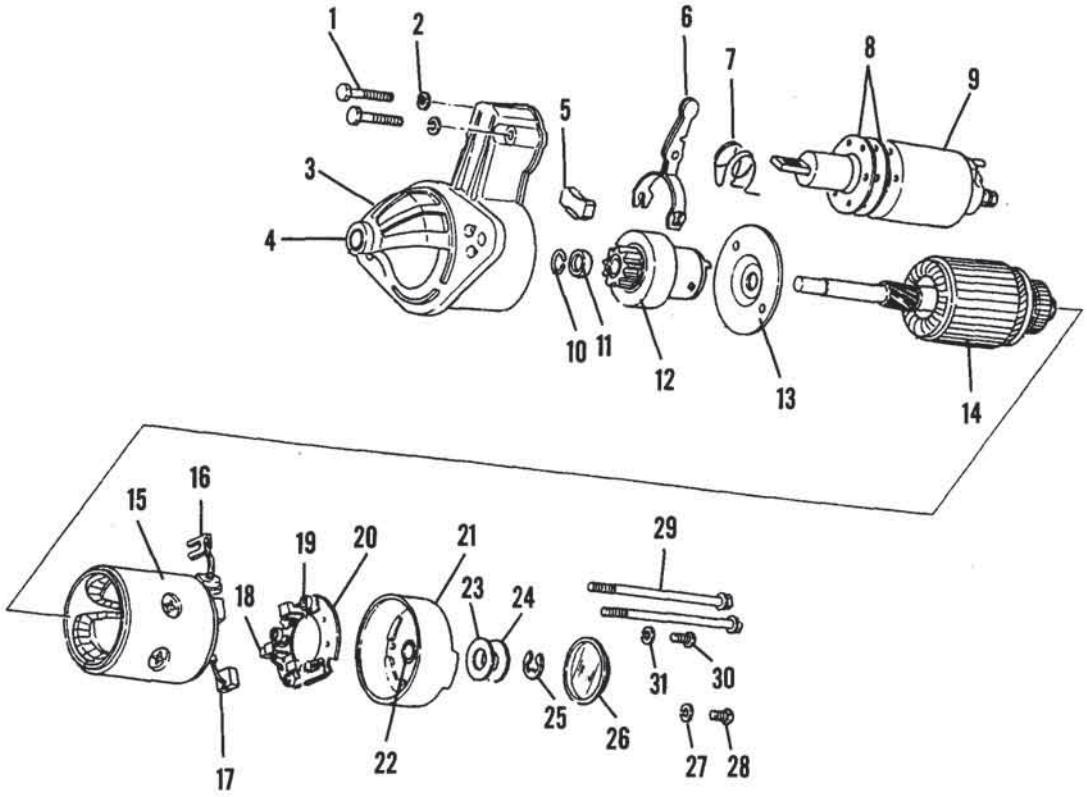
1GM, 1GM10, 2GM, 2GM20, 3GM and 3GM30 models

Brush replacement requires partial disassembly of the starter.

1. Disconnect the positive lead from the solenoid.
2. Remove the cover (26, **Figure 16**) on the end cap.
3. Detach the E-ring (25, **Figure 16**) and remove the washers from the armature shaft.
4. Remove the brush holder retaining screws (30, **Figure 16**).
5. Remove the two throughbolts (29, **Figure 16**).
6. Separate the end cover (21, **Figure 16**) from the starter.
7. Note the position of the brushes in the brush holder. Use a suitable tool to pull back and hold the brush retaining clip, then remove the brush. See **Figure 20**, typical. Repeat this step to remove the remaining brushes.
8. Remove the brush holder from the armature shaft.
9. Use an ohmmeter or self-powered test lamp to check for continuity between the insulated brush holder and the base of the brush holder assembly. See **Figure 21**. If there is continuity, replace the brush holder.
10. Inspect brush and brush spring condition. Measure brush length. Replace all brushes if any are oil-soaked or worn to 12 mm (0.47 in.) or less in length. Replace any broken or distorted brush springs.

(16)

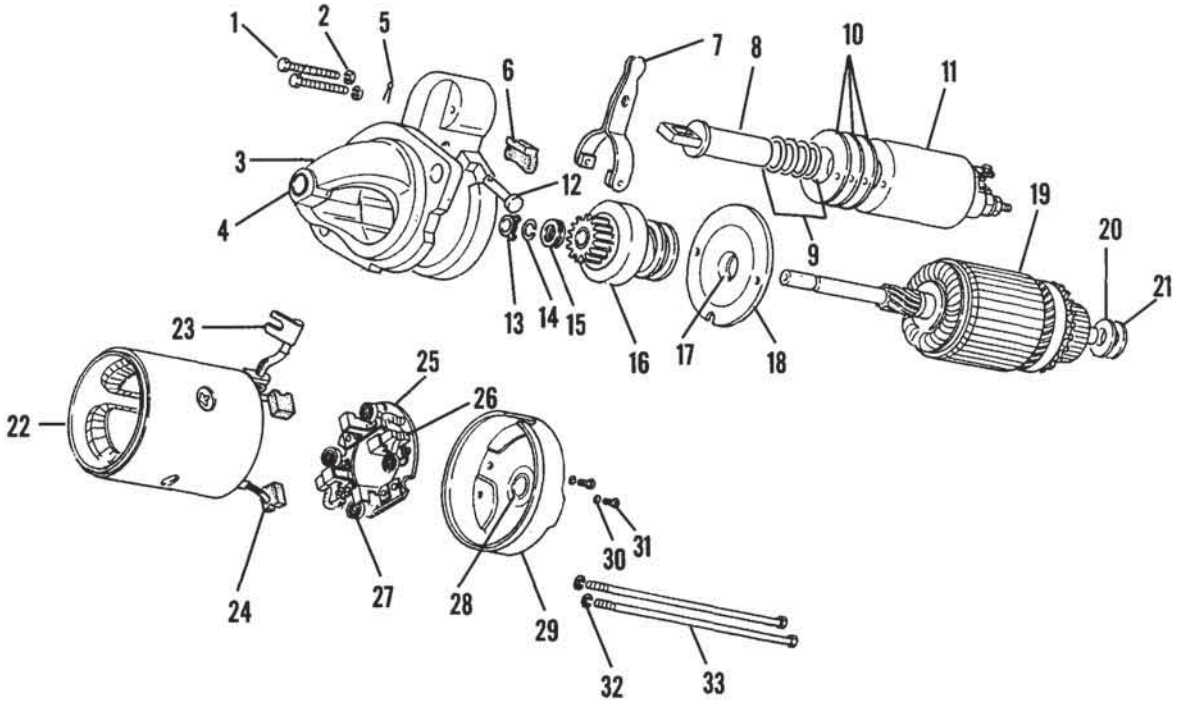
STARTER MOTOR
(EXCEPT 3HM AND 3HM35 MODELS)



1. Bolt
2. Lockwasher
3. Drive end housing
4. Bushing
5. Dust cover
6. Yoke
7. Spring
8. Shims
9. Solenoid
10. Retaining ring
11. Retainer
12. Drive
13. Center plate
14. Armature
15. Frame assembly
16. Positive lead
17. Brush (pos.)
18. Brush (neg.)
19. Brush spring
20. Brush plate
21. Commutator end cover
22. Bushing
23. Washer
24. Washer
25. E-clip
26. Cover
27. Lockwasher
28. Screw
29. Throughbolt
30. Screw
31. Lockwasher

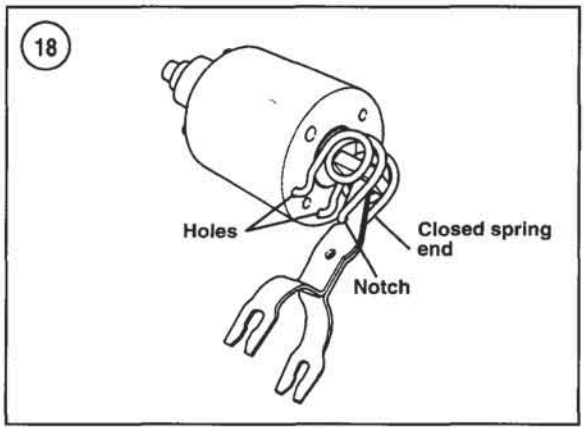
(17)

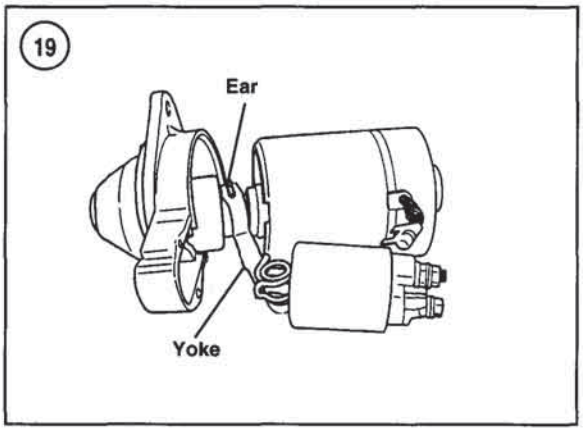
STARTER MOTOR (3HM AND 3HM35 MODELS)



1. Bolt
2. Lockwasher
3. Drive end housing
4. Bushing
5. Clip
6. Dust cover
7. Yoke
8. Actuator
9. Washers
10. Shims
11. Solenoid
12. Pin
13. Stopper washer
14. Circlip
15. Retainer
16. Drive
17. Bushing
18. Center plate
19. Armature
20. Washer
21. Washer
22. Frame assembly
23. Positive lead
24. Positive brush
25. Brush plate
26. Negative brush
27. Brush spring
28. Bushing
29. Commutator end cap
30. Lockwasher
31. Screw
32. Lockwasher
33. Throughbolt

9





11. To replace ground (negative) brushes, remove the brush lead attaching screws from the starter frame. Remove the brushes and install new ones.
12. To replace field coil brushes, cut the insulated brush leads as close as possible to the field coils. Attach new brush leads and solder the connections together with rosin core solder and a 300-watt soldering iron.

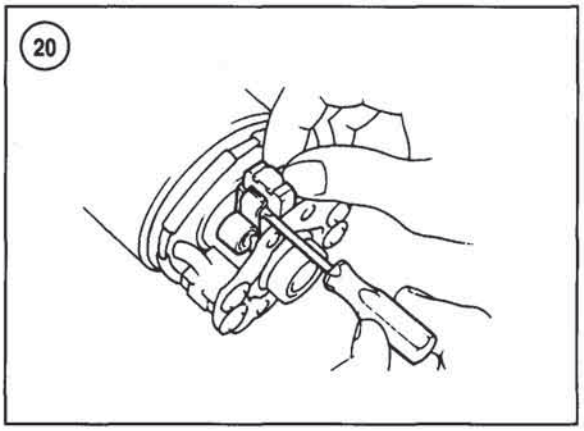
NOTE
Always replace brushes in complete sets.

13. Install the brush end holder.
14. Pull back and hold the brush retaining clip with a wire hook, then install the brush. Repeat this step to install the remaining brushes. Make sure the brush springs rest in the small cutout on top of each brush.
15. Reassembly is the reverse of Steps 1-6.

3HM and 3HM35 models

Brush replacement requires partial disassembly of the starter.

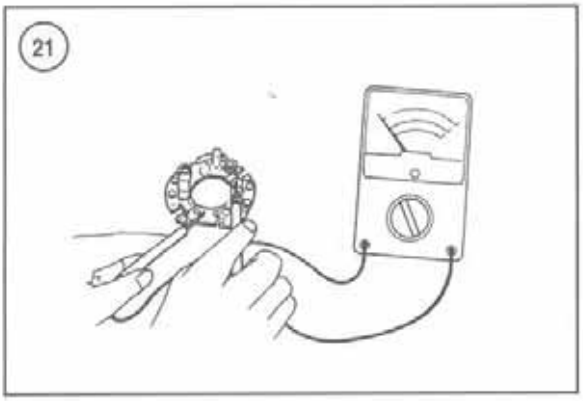
1. Disconnect the positive lead (23) from the solenoid.
2. Remove the brush holder retaining screws (31, **Figure 17**).
3. Remove the two throughbolts (33, **Figure 17**).
4. Separate the end cap (29) from the starter.
5. Note the position of the brushes in the brush holder. Use a suitable tool to pull back and hold the brush retaining clip, then remove the brush. See **Figure 20**, typical. Repeat this step to remove the remaining brushes.
6. Remove the brush holder from the armature shaft.
7. Use an ohmmeter or self-powered test lamp to check for continuity between the insulated brush holder and the base of the brush holder assembly. See **Figure 21**. If there is continuity, replace the brush holder.

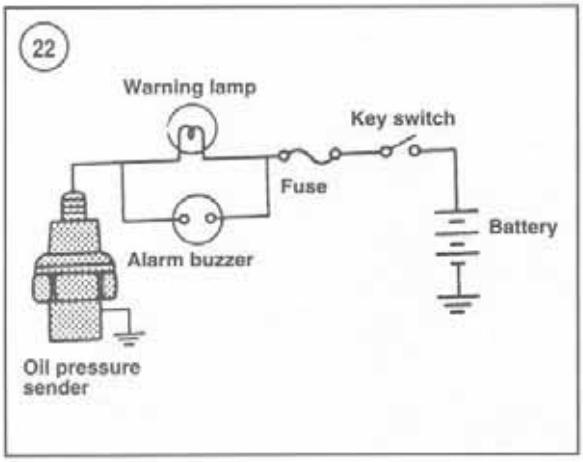


8. Inspect brush and brush spring condition. Measure brush length. Replace all brushes if any are oil-soaked or worn to 14 mm (0.55 in.) or less in length. Replace any broken or distorted brush springs.
9. To replace ground (negative) brushes, remove the brush lead attaching screws from the starter frame. Remove the brushes and install new ones.
10. To replace field coil (positive) brushes, cut the insulated brush leads as close as possible to the field coils. Attach new brush leads and solder the connections together with rosin core solder and a 300-watt soldering iron.

NOTE
Always replace brushes in complete sets.

11. Install the brush end holder.
12. Pull back and hold the brush retaining clip with a wire hook, then install the brush. Repeat this step to install the remaining brushes. Make sure the brush springs rest in the small cutout on top of each brush.
13. Reassembly is the reverse of Steps 1-4.





SWITCHES

The instrument panel is equipped with two switches: a key switch and a start switch. A lighting switch is also used on instrument panels equipped with a tachometer. Most engines are also equipped with a battery cutoff switch. Refer to the following sections to check the operation of these switches. Also refer to the wiring diagrams at the back of this manual.

Key Switch

The key switch is mounted on the instrument panel. When the key is in the ON position, the switch directs current to the circuits it controls.

Perform voltage or resistance checks to determine if the switch is operating properly.

Start Switch

The start switch mounted on the instrument panel is a push-button switch that closes the starter motor circuit when the button is depressed.

Perform voltage or resistance checks to determine if the switch is operating properly.

Battery Cutoff Switch

The battery cutoff switch is connected between the positive terminal of the battery and the starter solenoid. The switch provides a means to cutoff all circuits from the battery in case of fire or other electrical emergencies. Using the cutoff switch also prevents any electrical drain on the battery.

To test the switch, check for voltage at the starter solenoid terminal, or disconnect the positive battery cable and check the switch using an ohmmeter.

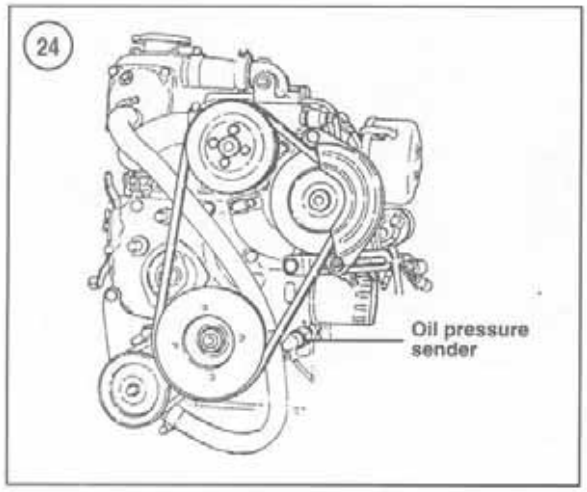
SENDERS

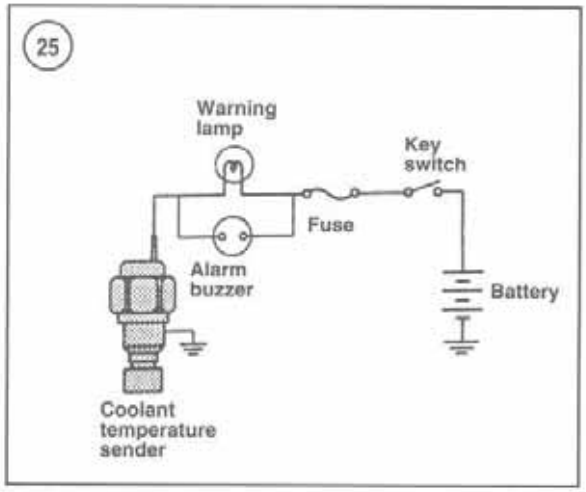
The engine is equipped with senders that trigger warning lights and the alarm buzzer if engine oil pressure or water temperature reaches a dangerous level. The senders are essentially switches that complete an electrical circuit.

Oil Pressure Sender

Refer to the oil pressure circuit in **Figure 22**. The sender is closed at zero oil pressure, which allows current to light the warning lamp and sound the alarm buzzer when the key switch is on. When oil pressure rises above 9.8-29.4 kPa (1.4-4.3 psi), the sender opens, the warning lamp goes out and the alarm buzzer quits.

The oil pressure sender on 1GM and 1GM10 is located on the oil filter adapter as shown in **Figure 23**. The oil





pressure sender on 2GM, 2GM20, 3GM, 3GM30, 3HM and 3HM35 engines is located below the oil filter as shown in **Figure 24**.

To check the oil pressure sender, proceed as follows:

CAUTION
Before checking the oil pressure sender, make sure the engine is filled with oil.

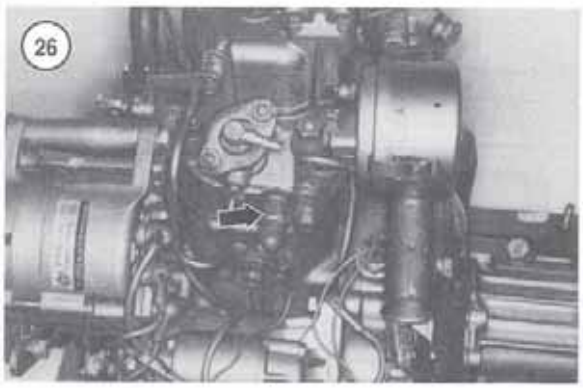
1. Disconnect the wire at the sender terminal.
2. Connect an ohmmeter between the sender terminal and the hex on the base of the sender.
3. With the engine off, the meter should show continuity.
4. Start the engine. As the oil pressure builds above 9.8 kPa (1.4 psi), the meter should switch from continuity to no continuity. If it does not, replace the sender unit.

Coolant Temperature Sender

Refer to the coolant temperature circuit in **Figure 25**. The sender is open at ambient temperature, which prevents current from lighting the warning lamp and activating the alarm buzzer. When coolant rises above the specification, the sender closes, the warning lamp and the alarm buzzer come on.

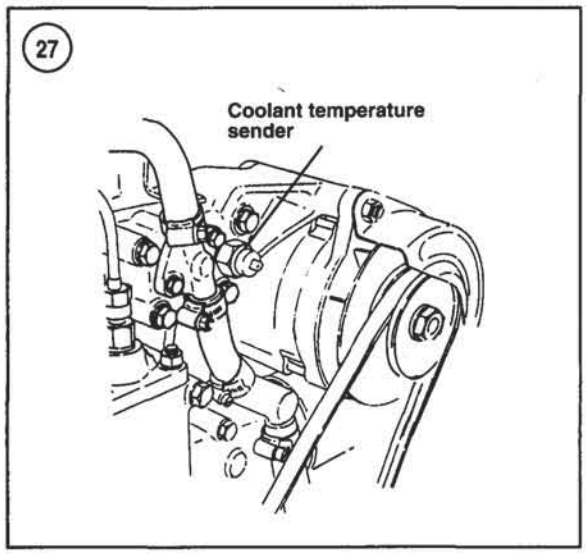
On 1GM and 1GM10 engines, the coolant temperature sensor is located on the cylinder head (**Figure 26**). The coolant temperature sensor on two or three cylinder engines is located on the front or side of the thermostat housing (**Figure 27**, typical).

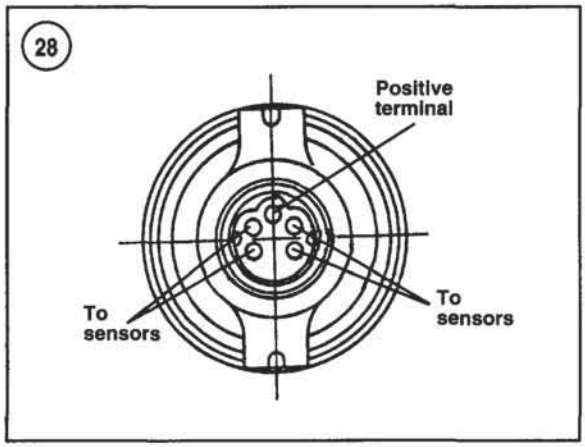
Two different senders may be used depending on the type of cooling system. Engines equipped with seawater cooling are equipped with a sender that is color-coded white and has a closed temperature of 148-154° F (63-67° C). Engines equipped with freshwater cooling are equipped with a sender that is color-coded green and has a closed temperature of 193-202° F (89-95° C).



To check the coolant sender, proceed as follows:

1. Remove the switch from the engine.
2. Connect a digital ohmmeter to the switch.
3. Immerse the sending unit and a cooking thermometer in a container of oil.
4. Heat the container over a flameless heat source and note the ohmmeter reading. The switch should close as follows:
   a. seawater switch (white)—148-154° F (63-67° C).
   b. freshwater switch (green)—193-202° F (89-95° C).
5. Remove the container from the heat and let it cool. The switch should reopen as follows:
   a. seawater switch (white)—136° F (58° C).
   b. freshwater switch (green)—190° F (88° C).
6. Replace the switch if it does not function as specified at each temperature range.





WARNING LAMPS

Engines covered by this manual are equipped with an instrument panel that has three warning lamps. The warning lamps illuminate to indicate high coolant temperature, low oil pressure or insufficient charging current.

Coolant and Oil Pressure Warning Lamps

1. To check the circuit for the coolant or oil pressure warning lamp, detach the lead from the coolant temperature or oil pressure sender.
2. With the key switch ON, ground the sender lead. The warning lamp should come on.
3. To determine if a bulb is defective, substitute a good bulb. All warning lamps use the same type of bulb.

Charging System Warning Lamp

The warning lamp for the charging circuit should illuminate when the key switch is ON and the engine is not running, or when there is a malfunction in the charging circuit.

1. To check the circuit for the charging system warning lamp, detach the lead from the L terminal on the alternator.
2. With the key switch ON, ground the detached lead. The charge system warning lamp should come on.
3. To determine if the charging system bulb is defective, substitute a good bulb. All warning lamps use the same type of bulb.
4. If a good bulb does not light, check the charging system as described in Chapter Two.

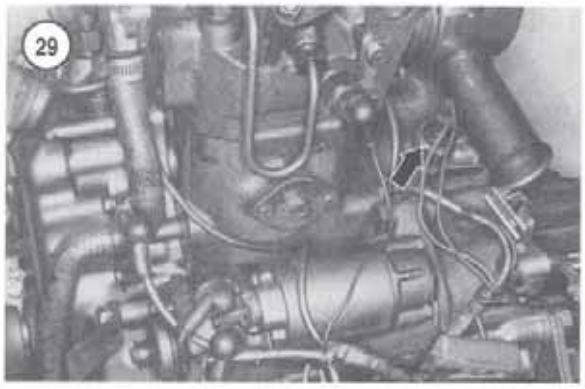
ALARM BUZZER

The alarm buzzer provides an audible warning in addition to the coolant and oil pressure warning lamps. Two types of alarm buzzers are used: a buzzer with two leads and a buzzer with multiple leads. Note the terminal locations in **Figure 28** for the buzzer equipped with multiple leads.

1. Check the alarm buzzer while it is installed.
   a. Detach the lead from the coolant temperature or oil pressure sender.
   b. With the key switch ON, ground the sender lead. The alarm buzzer should come on.
2. Check the alarm buzzer with all leads disconnected from the buzzer or with the buzzer removed from the instrument panel.
   a. On the buzzer with multiple terminals, note the terminal locations in **Figure 28**.
   b. Connect a 12-volt battery to the terminals as follows: Connect a positive battery lead to positive buzzer terminal. Connect the negative battery lead to each of the remaining buzzer terminals. The buzzer should sound; if it does not, replace the buzzer.

TACHOMETER

Some engines may be equipped with a tachometer. A sensor located on the clutch housing (**Figure 29**) provides an electrical signal that drives the tachometer. The electromagnetic sensor counts the teeth on the flywheel ring



gear as it rotates. The sensor sends the resulting electrical signal to the tachometer, which converts it into indicator needle movement.

NOTE

While the sensors for all engines are interchangeable, the tachometers are not. Due to the difference in number of ring gear teeth, the tachometer used on 3HM and 3HM35 engines is not interchangeable with other engines.

Before troubleshooting the tachometer, check for faulty connections, then recheck tachometer operation. If the problem remains, refer to the following sections.

Tachometer Sender

To check the tachometer sender, proceed as follows:

1. Disconnect the leads from the sender (**Figure 29**).
2. With the engine stopped, use an ohmmeter to check the resistance between the sender terminals. Resistance should be 1500-1700 ohms.
3. Run the engine. Measure the alternating current voltage between the sender terminals. The voltage reading should be at least one volt.
4. If the sender fails either test, replace the sender.

Tachometer Gauge

To check the tachometer gauge unit, proceed as follows:

1. Disconnect the red/black and black wire leads from the tachometer. With the key switch ON, measure the voltage between the two wires. There should be 10-16 volts (battery voltage). If not, determine the cause.
2. Disconnect the orange and blue/red wire leads from the tachometer. Run the engine. Measure the alternating current voltage between the orange and blue/red wire leads. The voltage reading should be at least one volt.
3. If the voltage reading in Step 2 is less than one volt, check the wires and connections and check the sender as described in the preceding section.
4. If the voltage readings in Steps 1 and 2 are satisfactory, replace the tachometer.

Table 1 BATTERY CAPACITY (MINIMUM)

Model	Voltage	Battery capacity
1GM, 1GM10	12 V	70 amp-hours
2GM, 2GM20	12 V	70 amp-hours
3GM, 3GM30, 3HM	12 V	70 amp-hours
3HM35	12 V	100 amp-hours

Table 2 ALTERNATOR AND STARTER MOTOR TIGHTENING TORQUES

Model	Alternator mounting bolt	Starter motor mounting bolts
1GM, 1GM10, 2GM, 2GM20, 3GM, 3GM30	22-27 N•m (16-20 ft.-lb.)	45-50 N•m (33-37 ft.-lb.)
3HM, 3HM35	22-27 N•m (16-20 ft.-lb.)	75-80 N•m (55-59 ft.-lb.)