Chapter Two

Troubleshooting

Every internal combustion engine requires an uninterrupted supply of fuel, air, ignition and adequate compression. If any of these are lacking, the engine will not run.

Troubleshooting is a relatively simple matter if it is done logically. The first step in any troubleshooting procedure is to define the symptoms as fully as possible and then localize the problem. Subsequent steps involve testing and analyzing those areas that could cause the symptoms. A haphazard approach may eventually solve the problem, but it can be costly in terms of wasted time and unnecessary parts replacement.

When all else fails, go back to basics—simple solutions often solve complex-appearing problems.

Never assume anything. Do not overlook the obvious. If the engine suddenly quits when running or refuses to start, check the easiest and most accessible areas first. Make sure there is fuel in the tank and that the wiring is properly connected.

Be familiar with the engine compartment and engine components so a quick visual check is possible. Learning to recognize and describe symptoms accurately will make repairs easier. If a technician is required, saying that it will not run is not the same as saying that it quit at full throttle and would not restart.

Identify as many symptoms as possible to aid in diagnosis. Note whether the engine lost power gradually or all at once, what color smoke (if any) came from the exhaust, etc.

After defining the symptoms, test and analyze those areas that could cause the problem(s). Many problems can be analyzed without expensive test equipment. A few simple checks can keep a small problem from turning into a large one. They can also avoid a large repair bill and time lost while the boat sits in a shop's service department.

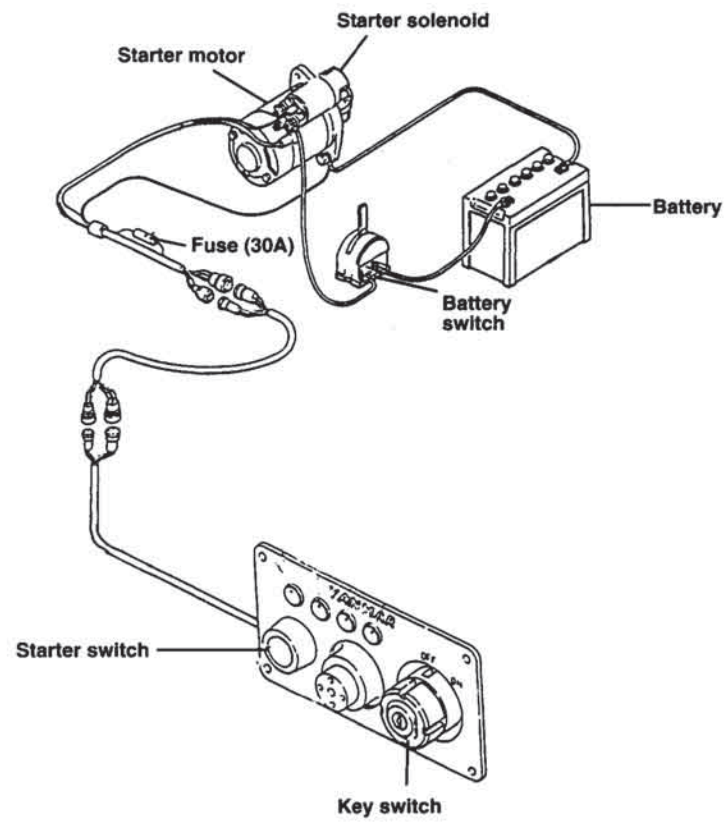
On the other hand, be realistic and do not attempt repairs beyond your abilities or with makeshift tools. Marine service departments also tend to charge heavily for putting together a disassembled engine or other components that may have been abused. Some shops will not even accept such a job. Use common sense and do not get in over your head or attempt a job without the proper tools.

Proper lubrication, maintenance and periodic tune-ups as described in Chapter Three will reduce the necessity for troubleshooting. Even with the best care, however, every marine engine is prone to problems that will eventually require troubleshooting.

If installing replacement parts, do not use automotive parts. While marine components, such as starters and alternators, may appear to be the same as automotive components, they are not. Marine components have been designed to withstand the unique requirements of marine

1

STARTING CIRCUIT (TYPICAL)



service, as well as to provide a measure of safety that is not required of automotive service. For example, a marine starter is flashproofed to prevent possible ignition of fuel vapor in the bilge. The use of an automotive starter as a replacement can result in an explosion or fire, which may cause death, serious injury or boat damage.

This chapter contains brief descriptions of each major operating system and troubleshooting procedures to be used. The troubleshooting procedures analyze common symptoms and provide logical methods of isolation. These are not the only methods. There may be several approaches to a problem, but all methods used must have one thing in common to be successful—a logical, systematic approach.

Troubleshooting diagrams for individual systems are provided within this chapter. A master troubleshooting chart (**Table 1**) is provided at the end of this chapter.

STARTING SYSTEM

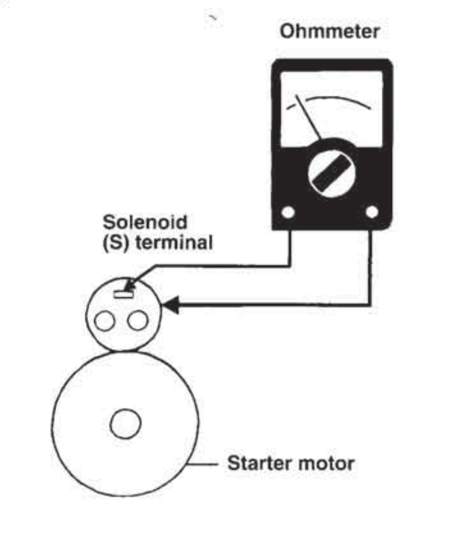
The starting system consists of the battery, starter motor, starter solenoid, starter switch, key switch, fuse and connecting wiring. See **Figure 1**, typical.

Starting system problems are relatively easy to find. In many cases, the trouble is a loose or dirty connection.

Starting System Operation

The battery switch, if used, and the key switch must be in the ON positions so battery current is available to the starter circuit. When the start switch on the instrument panel is pushed, battery current flows to the starter solenoid, which mechanically engages the starter with the engine flywheel. The solenoid also directs current to the starter motor, which rotates the engine flywheel to start

2



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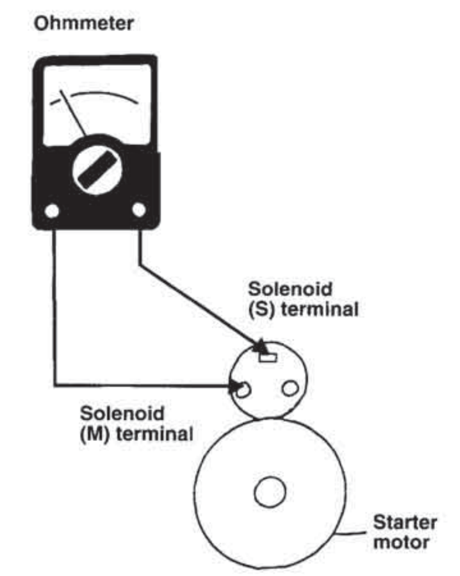

the engine. Once the engine has started and the start switch is released, the slave solenoid is de-energized. Without current to hold the solenoid in position, the starter motor overrunning clutch disengages the starter pinion from the flywheel.

On-Boat Testing

Two of these procedures require a fully charged 12-volt battery, to be used as a booster, and a pair of jumper cables. Use the jumper cables as outlined in *Jump Starting*, Chapter Nine, following all of the precautions noted. Disconnect the wiring harness and leads at the rear of the alternator before connecting a booster battery for these tests. This will protect the alternator from possible damage.

Slow running starter

1. Connect the 12-volt booster battery to the engine's battery with jumper cables. Listen to the starter running speed as the engine is cranking. If the starter running speed sounds normal, check the battery for loose or corroded connections or a low charge. Clean and tighten the connections as required. Recharge the battery if necessary.
2. If starter running speed does not sound normal, clean and tighten all starter solenoid connections and the battery ground on the engine.
3. Repeat Step 1. If the starter running speed is still too slow, replace the starter.

Starter solenoid clicks, starter does not run

1. Clean and tighten all starter and solenoid connections. Make sure the terminal eyelets are securely fastened to the wire strands and are not corroded.
2. Remove the battery terminal clamps. Clean the clamps and battery posts. Reinstall the clamps and tighten them securely.
3. If the starter still does not run, connect the 12-volt booster battery to the engine's battery with the jumper cables. If the starter still does not run, replace it.

Starter solenoid chatters (no click), starter does not run

1. Check the S terminal wire connection at the starter solenoid. Clean and tighten if necessary.
2. Disconnect the S terminal wire at the starter solenoid. Connect a jumper wire between this terminal and the positive battery post.
3. Try starting the engine. If the engine starts, check the key switch, starter switch and the system wiring for an

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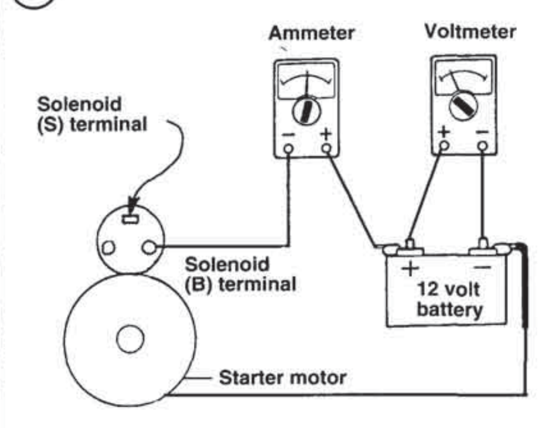


open circuit or a loose connection. If the engine does not start, replace the starter solenoid.

Starter spins but does not rotate flywheel

1. Remove the starter. See Chapter Nine.
2. Check the starter pinion gear. If the teeth are chipped or worn, inspect the flywheel ring gear for the same problem. Replace the starter and/or ring gear as required.
3. If the pinion gear is in good condition, disassemble the starter and check the armature shaft for corrosion. See *Brush Replacement*, Chapter Nine, for the disassembly procedure. If no corrosion is found, the starter drive mechanism is slipping. Replace the starter with a new or rebuilt marine unit.

Starter will not disengage when start switch is released

This problem is usually caused by a sticking solenoid or defective start switch, but the pinion may jam on the flywheel ring gear on an engine with many hours of operation.

NOTE
A low battery or loose or corroded battery connections can also cause the starter to remain engaged with the flywheel ring gear. Low voltage at the starter can cause the contacts inside the solenoid to chatter and weld together, resulting in the solenoid sticking in the ON position.

Loud grinding noises when starter runs

This can be caused by improper meshing of the starter pinion and flywheel ring gear or by a broken overrunning clutch mechanism.

1. Remove the starter. See Chapter Nine.
2. Check the starter pinion gear. If the teeth are chipped or worn, inspect the flywheel ring gear for the same problem. Replace the starter and/or ring gear as required.
3. If the pinion gear is in good condition, the overrunning clutch mechanism in the starter may be defective. Replace the starter with a new or rebuilt marine unit.

Starter Solenoid Resistance Tests

Check the starter solenoid using the following resistance tests:

CAUTION
Disconnect the negative battery cable before performing resistance tests.

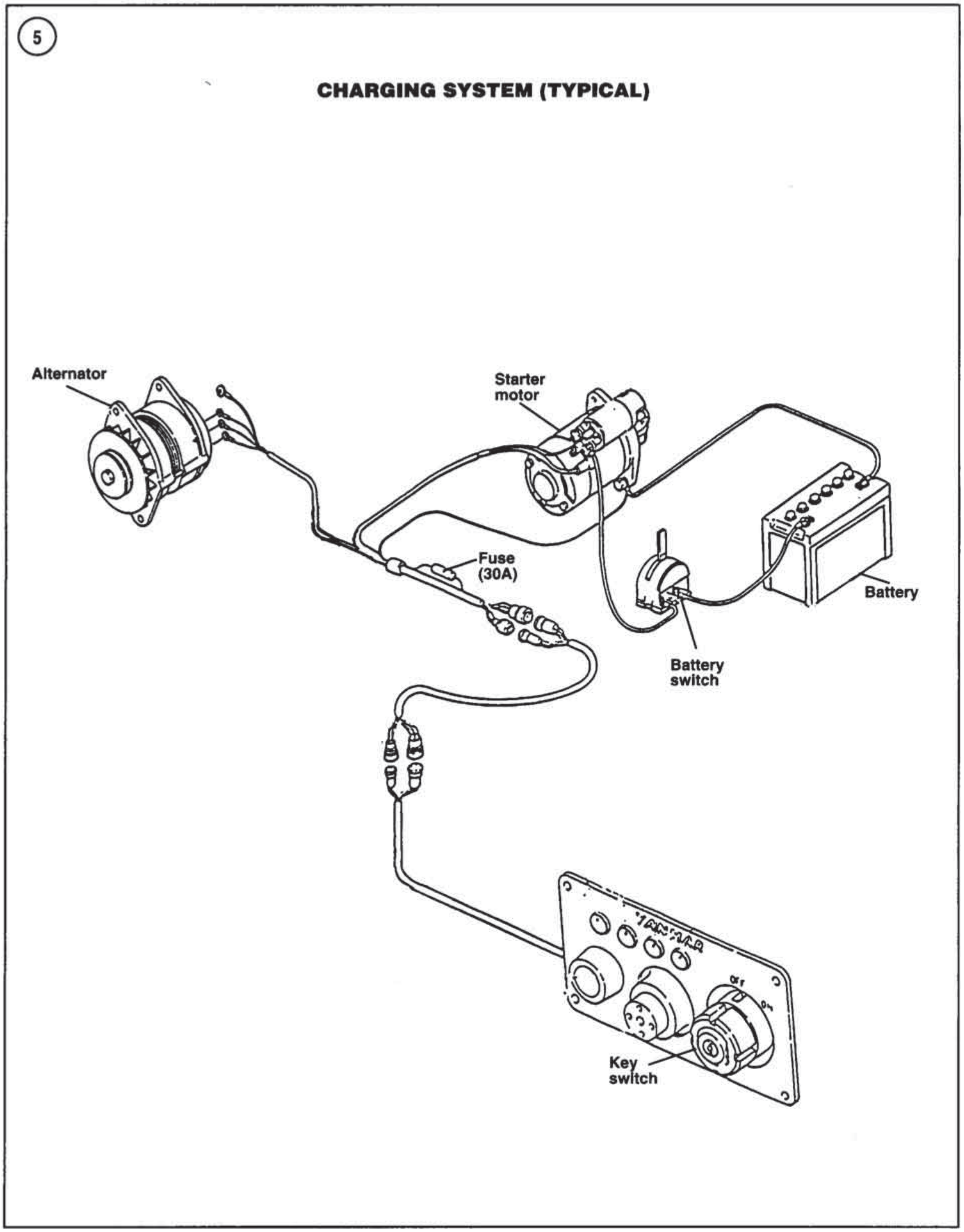
1. Refer to **Figure 2** and connect an ohmmeter lead to the S terminal of the solenoid. Connect the remaining ohmmeter lead to the metal body of the solenoid. The ohmmeter should indicate approximately one ohm or less. Replace the solenoid if the ohmmeter indicates infinite resistance (no continuity).
2. Refer to **Figure 3** and connect an ohmmeter lead to the S terminal of the solenoid. Connect the remaining ohmmeter lead to the M terminal of the solenoid. The ohmmeter should indicate approximately one ohm or less. Replace the solenoid if the ohmmeter indicates infinite resistance (no continuity).

Starter Motor No-Load Current Draw Test

If troubleshooting indicates that the starter motor may be defective, use the following starter motor no-load current draw test to determine if the starter motor is in acceptable operating condition.

To perform the test, the following equipment is needed: an ammeter capable of measuring 0-100 amps, a voltmeter, a vibration tachometer and a fully charged 12-volt battery. Minimum battery capacity is 70 amp-hours for one- and two-cylinder engines and 100 amp-hours for three-cylinder engines.

1. Remove the starter motor from the engine. Securely fasten the motor in a vise or other suitable holding fixture.
2. Using a heavy gauge jumper cable, connect the ammeter in series with the positive battery terminal (**Figure 4**). Connect a voltmeter to the battery.


5
CHARGING SYSTEM (TYPICAL)
Alternator
Starter motor
Fuse (30A)
Battery
Battery switch
Key switch

3. Hold a vibration-type tachometer against the starter frame.
4. To operate the starter motor, connect a wire between the positive battery terminal and the S terminal on the starter solenoid.
5. Note the starter rpm, current draw and battery voltage while the motor is running, then disconnect the wire to the S terminal on the solenoid.
6. If the starter motor does not perform within the specifications listed in **Table 3**, repair or replace the motor as described in Chapter Nine.

CHARGING SYSTEM

The charging system consists of the alternator, voltage regulator, battery, key switch, instrument panel warning light, connecting wiring and fuse.

A belt driven by the engine crankshaft pulley turns the alternator, which produces electrical energy to charge the battery. As engine speed varies, the voltage output of the alternator varies. The regulator maintains the voltage to the electrical system within safe limits. The warning light on the instrument panel signals if charging is not taking place.

All models use a Hitachi alternator with an internal transistorized voltage regulator attached to the rear alternator housing. Alternator output is 35 amps (model LR135-05) or 55 amps (model LR155-20). **Figure 5** shows components of the charging circuit.

Charging system troubles are generally caused by a defective alternator, voltage regulator, battery or an inoperative charge lamp. They may also be caused by something as simple as incorrect drive belt tension.

The following are symptoms of problems that may be encountered.

1. *Battery discharges frequently*—This can be caused by a drive belt that is slightly loose. Grasp the alternator pulley with both hands and try to turn it. If the pulley can be turned without moving the belt, the drive belt is too loose. As a rule, keep the belt tight enough so that it can be deflected only about 1/2 in. under moderate thumb pressure applied between the pulleys. The battery may also be at fault; test the battery condition as described in Chapter Nine.
2. *Charging system warning lamp does not light when key switch is turned ON*—This may indicate a defective key switch, battery, voltage regulator or warning lamp. Try to start the engine. If it doesn't start, check the key switch and battery. If the engine starts, remove and test the warning lamp bulb. If the problem persists, the alternator brushes may not be making contact. Perform the System Circuitry Test in this chapter.
3. *Charging system warning lamp flashes on and off*—This usually indicates that the charging system is working intermittently. Check drive belt tension first, then check all electrical connections in the charging circuit. As a last resort, check the alternator.
4. *Charging system warning lamp comes on and stays on*—This usually indicates that no charging is taking place. First check drive belt tension, then the battery condition. Check all wiring connections in the charging system. If this does not locate the problem, check the alternator and voltage regulator as described in this chapter.
5. *Battery requires frequent addition of water or lamp requires frequent replacement*—The alternator is probably overcharging the battery. The voltage regulator is most likely at fault.
6. *Excessive noise from the alternator*—Check for loose mounting brackets and bolts. The problem may also be worn bearings or, in some cases, lack of lubrication. If an alternator whines, a shorted diode may be the problem.

CHARGING SYSTEM TESTS

The alternator is equipped with an internal transistorized regulator. The transistorized regulator contains excitation and sensing circuits. The regulator controls output voltage by switching the alternator rotor current on and off. A rectifier consisting of a set of diodes converts alternating current to direct current.

Alternator Regulated Voltage Test

This test checks the regulated voltage output of the alternator. All wires connected to the alternator for normal operation must be connected.

1. Check the alternator drive belt tension. See Chapter Three.
2. Check the battery terminals and cables for corrosion and/or loose connections. Disconnect the negative battery cable, then the positive battery cable. Clean the cable clamps and battery terminals, if necessary, then reconnect the cables.
3. Check all wiring connections between the alternator and engine to make sure they are clean and tight.
4. Connect the positive lead of a voltmeter to the BAT terminal of the alternator. Connect the negative voltmeter lead to the E terminal of the alternator. See **Figure 6.**
5. Move the engine wire harness back and forth while observing the voltmeter scale. The meter should indicate a steady battery voltage reading (approximately 12 volts).

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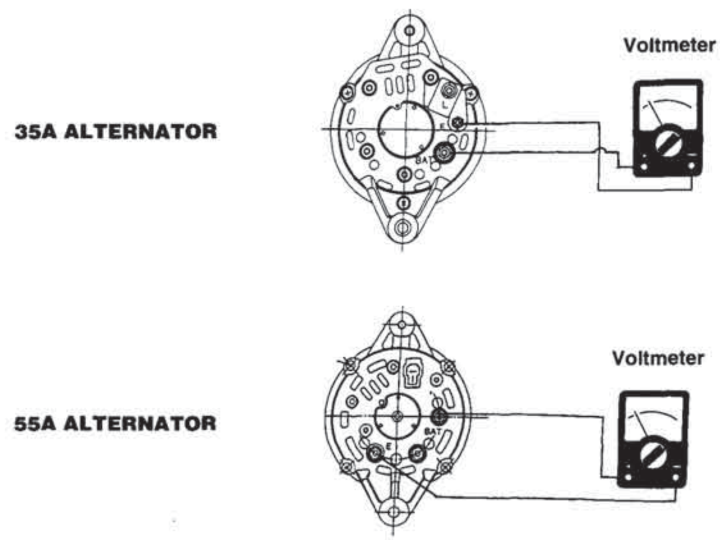
VOLTAGE OUTPUT TEST



If the reading varies or if no reading is obtained, check for poor connections or damaged wiring.

6. Turn the key switch ON. Run the engine from idle up to 2,500 rpm and note the voltmeter reading. If the voltmeter does not indicate 14.2-14.8 volts, remove the alternator and have it bench tested by a dealership or qualified specialist.

Alternator Current Output Test

This test checks the current output of the alternator. All wires connected to the alternator for normal operation must be connected. Refer to **Figure 7** for this procedure.

1. Check the alternator drive belt tension. See Chapter Three.
2. Disconnect the negative battery cable.
3. Disconnect the wire from the BAT terminal on the alternator.
4. Connect the positive lead of a 0-100 amp DC ammeter to the BAT terminal and the negative lead to the disconnected wire.
5. Reconnect the negative battery cable.
6. Make sure the engine control is in the stop position.
7. Turn on all accessories and crank the engine for 15-20 seconds to remove any surface charge from the battery.
8. Turn off all accessories.
9. Connect a tachometer to the engine. Connect a carbon pile load device to the battery terminals.
10. Start the engine and run at 2,500 rpm. Adjust the carbon pile to obtain maximum alternator output. The ammeter should read the rated amperage according to the alternator model identified on the data plate on the alternator (**Figure 8**). Model LR135 alternators should produce 35 amps, and model LR155 alternators should produce 55 amps.

FUEL SYSTEM

Refer to Chapter Seven for a description of fuel system operation. A diagram of a typical fuel system is shown in **Figure 9**.

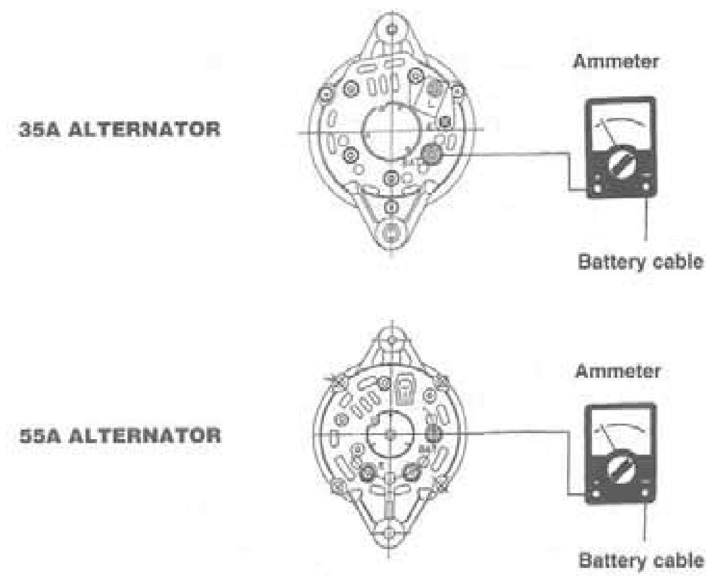
Be aware that diesel fuel injection systems require clean fuel that meets the fuel requirements specified by the engine manufacturer. Many fuel problems are a result of contaminated fuel or fuel not approved by the engine manufacturer. Refer to Chapter Three.

NOTE

Engine components outside the fuel system can also cause some of the following engine symptoms. Be sure to check other engine components that can also cause the symptoms.

7

CURRENT OUTPUT TEST



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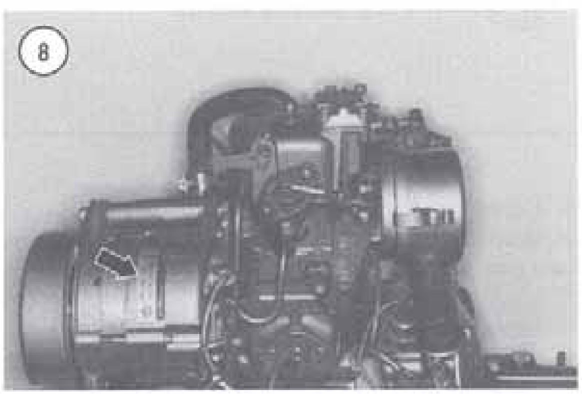

NOTE

If the fuel injection pump or a fuel injector is suspected, have it checked by a diesel engine service shop before purchasing replacement parts.

When troubleshooting the fuel system, refer to the following symptoms and possible causes:

1. *Engine will not start*—Check for an empty fuel tank, incorrect fuel or water in the fuel. Bleed the fuel system as described in Chapter Seven to be sure that fuel is routed to the fuel injection pump and to locate any restrictions, such as the fuel filter, or defective components, such as the fuel transfer pump. Check for proper operation and adjustment of the speed control mechanism, including the stop lever. Refer to Chapter Seven. Check the fuel injection timing as directed in Chapter Seven.
2. *Engine stops suddenly*—Check for an empty fuel tank, incorrect fuel or water in the fuel. Bleed the fuel system as directed in Chapter Seven to be sure that fuel is routed to the fuel injection pump and to locate any restrictions, such as the fuel filter, or defective components, such as the fuel transfer pump. Check for the proper operation and adjustment of the speed control mechanism, including the stop lever.
3. *Engine speed decreases unexpectedly*—Check for water in the fuel. Check for a clogged fuel filter element. Bleed the fuel system as described in Chapter Seven to remove air in the fuel. Check for clogged or defective fuel injection pump or fuel injector.
4. *Engine will not run under full load*—Check for a clogged fuel filter element. Check for a defective fuel transfer pump. Check for a clogged or defective fuel injection pump. Check the speed control mechanism.
5. *Engine misfires*—Check for water in the fuel. Check for a clogged fuel filter element. Bleed the fuel system as

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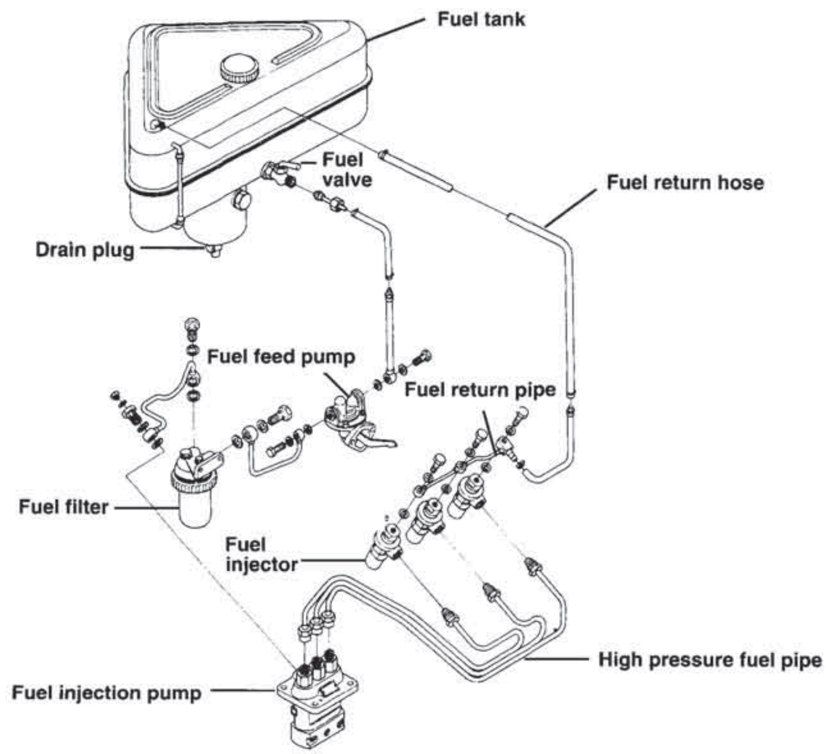
FUEL INJECTION SYSTEM



described in Chapter Seven to remove air in fuel. Check for a clogged or defective fuel injection pump or fuel injector.

WARNING
Wear goggles and protective clothing when performing the next procedure. Diesel injectors can spray with sufficient force to penetrate the skin. Have a fire extinguisher rated for fuel and electrical fires on hand.

To identify a faulty fuel injector on multicylinder engines, loosen the fuel injector fuel line nut with the engine running to reduce fuel pressure (only slight loosening is required). If the engine runs worse, the injector is operating satisfactorily. If the engine runs the same, the injector or the fuel injection pump is not operating properly. If no fuel appears at the fuel line, the fuel injection pump is defective.

6. *Engine knocks*—Check the fuel injection pump timing as described in Chapter Seven. Check for a defective fuel injection pump.

COOLING SYSTEM

The engine may be equipped with a seawater cooling system or freshwater cooling system. Refer to Chapter Eight for identification and description of the cooling system.

Engine Overheating

A problem in the cooling system generally causes engine overheating; however, other engine problems can also cause overheating. Note the possible causes in the following list:

1. *Loose pump drive belt (except 1GM models)*—A loose drive belt prevents the circulating pump from operating at the proper speed.

2. *Loose hose or pipe connections*—Air may be drawn into the suction side of the system.

3. *Worn or defective water pump*—A worn or defective pump may not provide sufficient cooling water.

4. *Dirty cooling system*—Debris in the cooling system prevents adequate heat transfer to the cooling water.

5. *Defective or incorrect thermostat*—A defective thermostat may stay closed or not open sufficiently to allow hot water to leave the engine. An incorrect thermostat may open at a temperature higher than specified, thereby raising the temperature of the cooling water in the engine. Conversely, a thermostat that stays open and doesn't close or opens at a low temperature will cause the engine to run at less than optimum temperature.

ENGINE EXHAUST SMOKE

The engine should emit colorless exhaust smoke or smoke that appears no more than a light haze. If the exhaust smoke is black, white or blue, an engine problem exists.

Blue Smoke

Blue exhaust smoke indicates that oil is burning during the combustion process. Look for a condition that allows oil to enter the combustion chamber, such as a broken piston, broken or stuck piston rings, a damaged cylinder wall, worn valves or guides, a defective crankcase vent, or an overfilled oil sump.

White Smoke

Unburned fuel causes white exhaust smoke. The unburned fuel may be due to retarded fuel injection timing or insufficient compression pressure. Low compression pressure may be caused by a damaged cylinder gasket, broken piston rings, leaking valves or incorrectly adjusted valves. Raw, unburned fuel may be due to incorrect fuel (low cetane rating) or a defective injector.

NOTE

White smoke may also be due to coolant leaking into the combustion chamber.

Black Smoke

Black exhaust smoke results from excess fuel (rich) that forms soot when burned. Either excess fuel or insufficient air can cause black smoke. Some possible causes are a defective fuel injection pump, poor injector spray pattern, low injection opening pressure, clogged air intake, restricted exhaust system or low compression pressure.

ENGINE NOISES

Often the first evidence of an internal engine problem is a strange noise. That knocking, clicking or tapping sound never heard before may be warning of impending trouble.

While engine noises can indicate problems, they are difficult to interpret correctly; inexperienced mechanics can be seriously misled by them.

Remember that diesels are much noisier than gasoline engines and have a normal clatter at idle, especially when cold. It is necessary to become accustomed to these normal noises in order to detect possible problem-associated noises.

Professional mechanics often use a special stethoscope for isolating engine noises. The home mechanic can do nearly as well with a sounding stick, which can be an ordinary piece of dowel, a length of broom handle or a section of small hose. Place one end in contact with the area in question and the other end near the ear to hear sounds emanating from that area. There are many strange sounds coming from even a normal engine. If possible, have an experienced mechanic help sort out the noises.

Clicking or Tapping Noises

Clicking or tapping noises usually come from the valve train and indicate excessive valve clearance. A sticking valve may also sound like a valve with excessive clearance. In addition, excessive wear in valve train components can cause similar engine noises.

Knocking Noises

A heavy, dull knocking is usually caused by a worn main bearing. The noise is loudest when the engine is working hard, such as accelerating at low speed. It is possible to isolate the trouble to a single bearing by disabling the fuel injectors on multicylinder engines one at a time. By disabling the fuel injector nearest the bearing, the knock will be reduced or disappear.

Worn connecting rod bearings may also produced a knock, but the sound is usually more metallic. As with a main bearing, the noise is worse during acceleration. It may increase in transition from acceleration to coasting. Disabling the fuel injectors will help isolate this knock as well.

A double knock or clicking usually indicates a worn piston pin. Disabling fuel injectors on multicylinderengines will isolate this to a particular piston; however, the noise will increase when the affected piston is reached.

A loose flywheel and excessive crankshaft end play also produce knocking noises. While similar to main bearing noises, they are usually intermittent, not constant, and they do not change when fuel injectors are disabled. If caused by a loose flywheel or coupling, the noise is generally heard at idle or during rapid deceleration. It is a good idea to recheck flywheel/coupler bolt torque whenever accessible.

Some mechanics confuse piston pin noise with piston slap (excessive piston clearance). The double knock will distinguish piston pin noise. Piston slap will always be louder when the engine is cold.

ENGINE TROUBLESHOOTING

These procedures assume the starter cranks the engine over normally. If not, refer to the *Starting System* section of this chapter.

Engine Will Not Start

This can be caused by the fuel system or by insufficient compression pressure. Refer to troubleshooting in the *Fuel System* section of this chapter. Refer to Chapter Three and check valve adjustment. Check for low compression pressure by performing a compression pressure check as described in Chapter Three. Repair the engine as required to obtain the correct compression pressure.

Engine Misses

This can be caused by the fuel system. Refer to troubleshooting in the *Fuel System* section of this chapter. Sticking intake or exhaust valves can also cause the engine to misfire.

Engine Stops Suddenly

This can be caused by engine seizure, a governor malfunction or a problem in the fuel system. Attempt to start the engine to determine if the engine rotates freely. Refer to Chapter Three to check governor adjustment or to Chapter Seven to repair the governor. If a fuel system problem is suspected, refer to troubleshooting in the *Fuel System* section of this chapter.

Engine Will Not Run Under Load

Refer to troubleshooting in the *Fuel System* section in this chapter.

Low Oil Pressure

Low engine oil pressure may be caused by leakage in the oil circuit, excessive bearing clearance, a clogged oil filter, a loose oil regulator valve or incorrect oil viscosity. Low oil pressure may also be caused by engine overheating or oil dilution by fuel in the crankcase.

Verify low oil pressure by performing the oil pressure test described in this chapter.

If the engine is overheating, refer to troubleshooting in the *Cooling System* section in this chapter.

COOLING SYSTEM

The temperature warning lamp should signal cooling system problems before there is any damage. If the engine is stopped at the first indication of trouble, serious damage is unlikely.

With standard cooling systems in which seawater is drawn into the engine, circulated and then expelled, cooling system problems are generally mechanical—a defective pump or thermostat, a loose or broken drive belt or passages plugged with contamination.

Closed cooling systems are more complex in that they use a heat exchanger, which transfers heat from the engine coolant to seawater without the two coming in contact. The closed portion of the cooling system is pressurized (like an automotive cooling system) and uses a 50/50 mixture of ethylene glycol antifreeze and pure soft water. Check this system periodically to make sure it can hold pressure up to 13 psi.

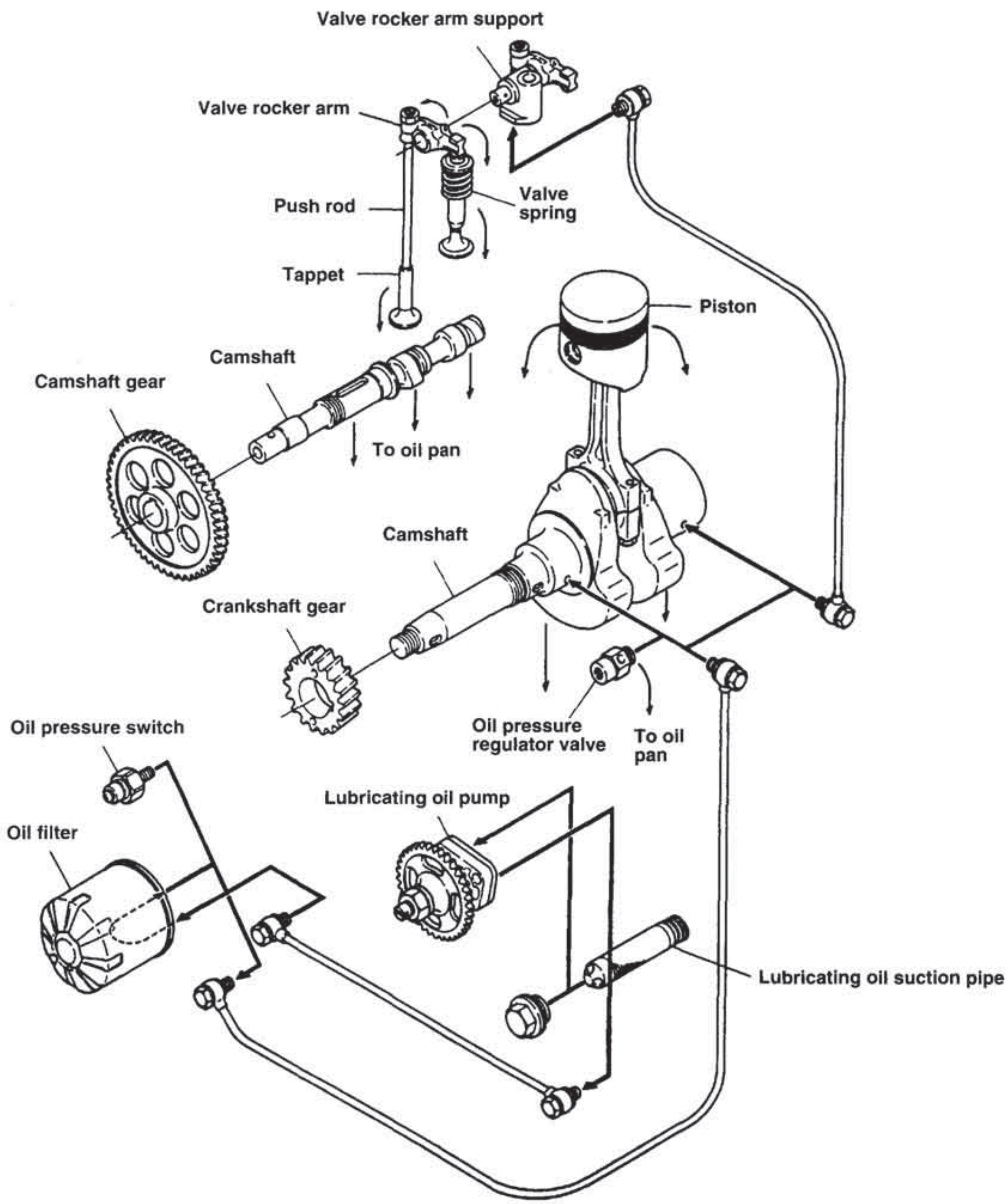
Heat exchangers used in closed cooling systems collect salt, lime and other contaminants in their passages, leading to a gradual decrease in cooling efficiency. For this reason, they should be removed every two years and the seawater passages cleaned with a wire brush and compressed air.

LUBRICATION SYSTEM

Refer to **Figure 10, Figure 11** and **Figure 12** for lubrication system diagrams. A rotor type oil pump receives oil

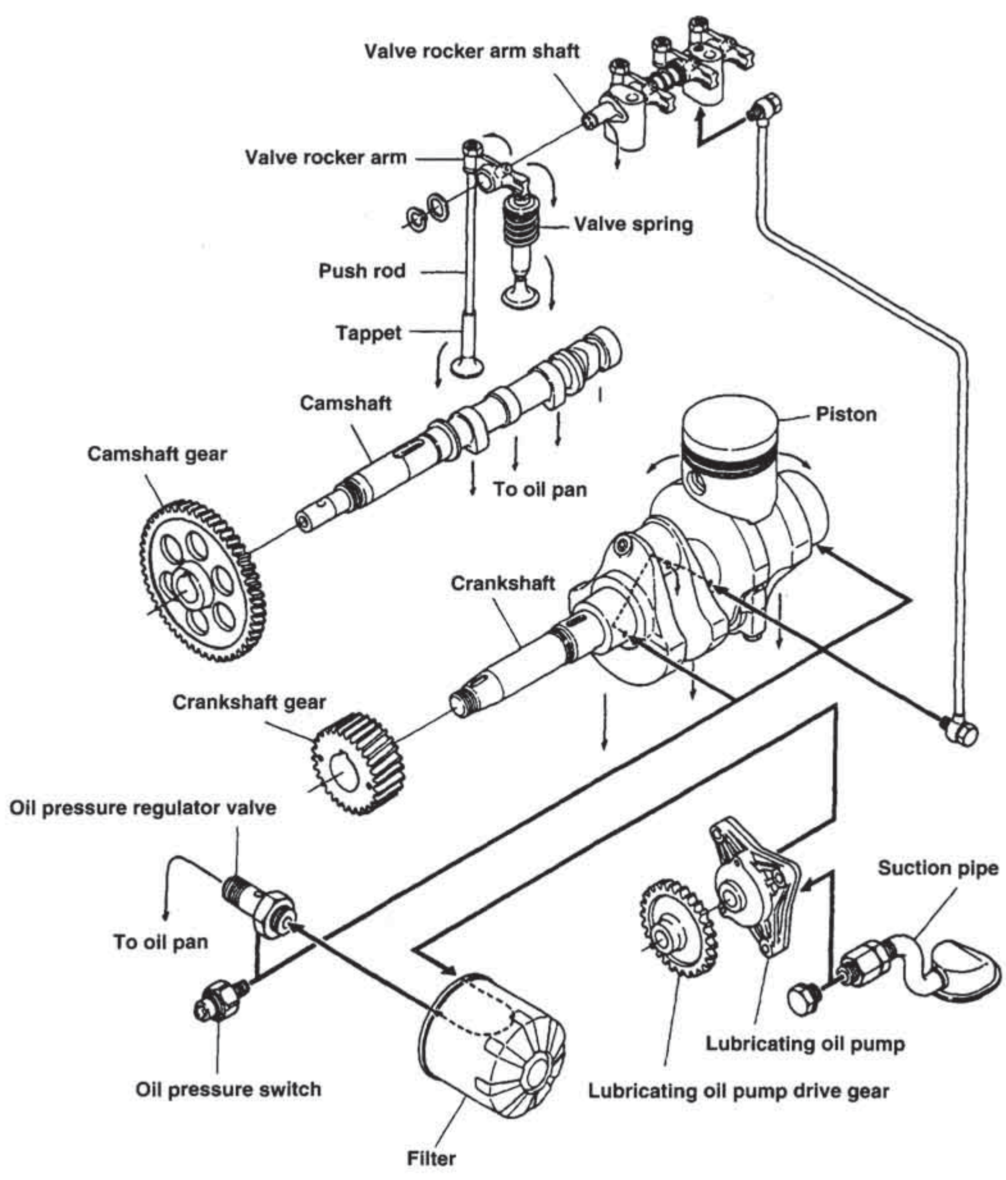
(10)

LUBRICATION SYSTEM (1GM AND 1GM10 MODELS)



(11)

LUBRICATION SYSTEM (2GM AND 2GM20 MODELS)



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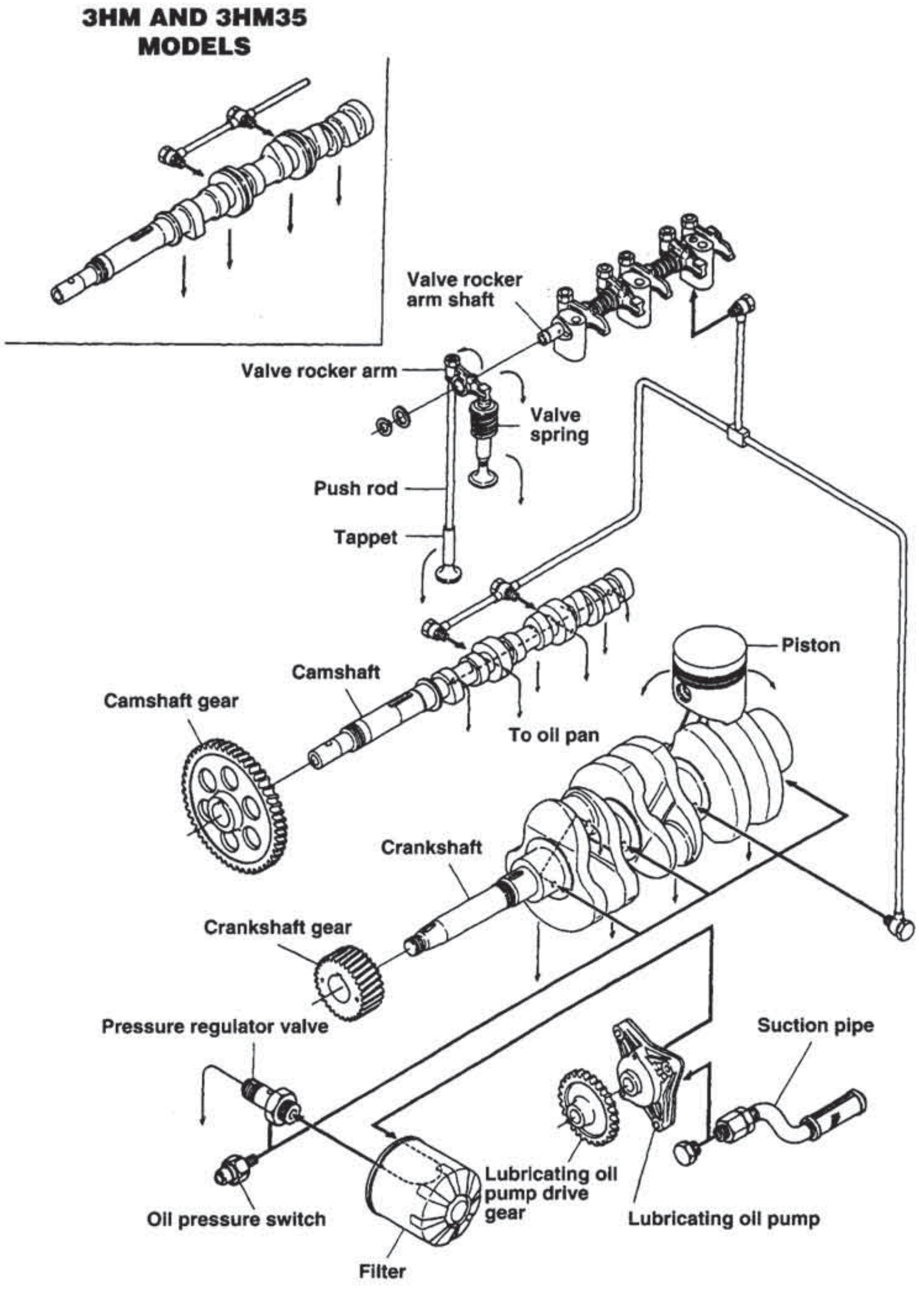
LUBRICATION SYSTEM (3GM, 3GM30, 3HM AND 3HM35 MODELS)



from a pickup located in the oil pan, then forces oil to the necessary engine components. The oil pump is driven by the crankshaft gear.

An oil pressure relief valve regulates oil pressure at 300-400 kPa (43-57 psi). When oil pressure exceeds the desired pressure, the relief valve opens and expels oil into the timing gearcase. A low oil pressure warning light on the instrument panel and a warning alarm buzzer activate if oil pressure is below 9.8 kPa (1.4 psi).

Refer to Chapters Five, Six and Nine for service procedures.

Oil Pressure Test

The engine is equipped with an oil pressure warning light and alarm that are activated if low oil pressure occurs. To verify low oil pressure, perform the following oil pressure test.

1. Disconnect the wire lead from the oil pressure sender (**Figure 13**, typical).

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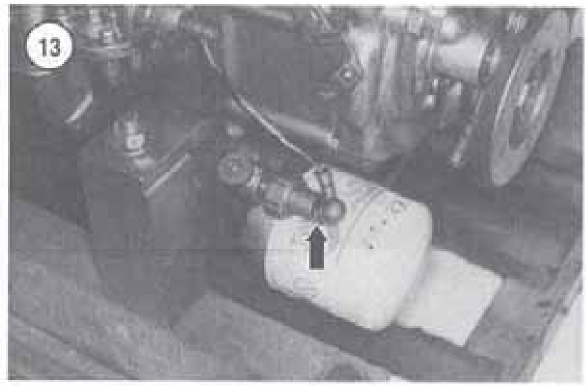

2. Remove the oil pressure sender.
3. Connect a suitable oil pressure gauge.
4. Start the engine and note the oil pressure reading at idle and wide open throttle.
5. Compare the gauge readings with the specifications in **Table 3**.

Table 1 ENGINE TROUBLESHOOTING

Trouble	Probable cause	Correction
Engine cranks slowly	Battery faulty or low charge	Charge or replace battery
	Faulty starter motor	Repair or replace starter motor
	Incorrect engine oil viscosity	Replace with proper engine oil
Engine will not crank	Discharged battery	Charge or replace battery
	Corroded battery terminals	Clean terminals
	Loose connection in starting circuit	Clean and tighten all connections
	Defective starting switch	Replace switch
	Starting motor brushes dirty	Clean or replace brushes
	Jammed starter drive gear	Loosen starter motor to free gear
	Faulty starter motor	Replace motor
	Seized engine	Inspect and repair
Engine will not start	Empty fuel tank	Fill tank with proper fuel
	Dirty or plugged fuel filter	Clean fuel filters
	Air in injection lines	Bleed air in injection lines
	Faulty fuel feed pump	Repair fuel feed pump
	Faulty fuel injection pump	Repair fuel injection pump
	Faulty governor	Repair governor
	Misadjusted controls	Adjust speed and stop controls
	Improper fuel injection timing	Adjust fuel injection timing
	Poor valve seating	Check for broken or weak valve springs, warped stems, carbon and gum deposits and insufficient tappet clearance
	Damaged cylinder head gasket	Check for leaks around gasket when engine is cranked; if a leak is found, replace gasket
	Worn or broken piston rings	Replace worn or broken rings; check cylinders for out-of-round and taper
Engine stops suddenly	Empty fuel tank	Fill fuel tank
	Air in fuel lines	Bleed fuel lines

(continued)

Table 1 ENGINE TROUBLESHOOTING (continued)

Trouble	Probable cause	Correction
Engine stops suddenly (continued)	Governor malfunction	Repair governor
	Engine seized	Inspect and repair
Engine slows unexpectedly	Overload	Locate cause for overload and rectify
	Fuel filter or fuel lines clogged	Inspect and unclog or replace
	Air in fuel system	Bleed air in fuel system
	Water in fuel	Remove water
	Misadjusted governor	Adjust governor
	Piston or bearing seizure	Repair damaged components; determine cause
Engine will not run under full load	Clogged fuel filter	Clean fuel filter
	Faulty fuel feed pump	Repair fuel feed pump
	Worn fuel injection pump	Repair or replace fuel injection pump
Engine knocks	Excessive bearing clearance	Inspect and repair
	Loose rod bolt	Inspect and repair
	Loose flywheel or coupling bolt	Tighten bolt
	Incorrect injection timing	Adjust timing
	Excessive fuel injected into cylinder	Inspect fuel injection pump and injectors
Low oil pressure	Oil leaks	Inspect and repair
	Excessive bearing clearance	Inspect and repair
	Clogged oil filter element	Clean or replace filter element
	Faulty oil pressure regulator valve	Repair oil pressure regulator valve
	Low oil viscosity	Replace oil; check for dilution due to fuel leaking into crankcase
Overheating	Dirty cooling system	Flush cooling system
	Faulty thermostat	Replace thermostat
	Insufficient coolant flow	Check water pump; check for blockage in system
	Insufficent coolant in closed system	Fill with proper coolant
	Air entering system	Check for loose clamps and damaged hoses

Table 2 STARTER MOTOR NO-LOAD SPECIFICATIONS

Model	Volts	Max. amperage	Speed (rpm)
3HM, 3HMF, 3HM35	12	90	4000 or higher
All other models	12	60	7000 or higher

Table 3 OIL PRESSURE

At 850 rpm	
all models	50 kPa (7 psi)
At 3400 rpm	
3HM and 3HM35	300-400 kPa (43-58 psi)
At 3600 rpm	
all models	
except 3HM and 3HM35	300-400 kPa (43-58 psi)