COOLING SYSTEMS 1C

INDEX

GENERAL

The cooling system regulates engine operating temperature by allowing the engine to reach normal operating temperature as quickly as possible, maintaining normal operating temperature and preventing overheating (figs. 1C-1, 1C-2 and 1C-3). The cooling system also provides a means of heating the passenger compartment and cooling the automatic transmission fluid.

The cooling system is pressurized and uses a centrifugal water pump to circulate coolant throughout the system.

COOLING SYSTEM OPERATION

On four-cylinder engines (with the engine operating), the belt-driven water pump forces coolant into the front of the cylinder block where water jackets route it around all the cylinders. The coolant then passes upwards through holes in the cylinder head gasket and into the head. Coolant flows out the rear of the intake manifold to the heater core. The coolant returns to the water pump from the heater core.

Below 195°F (90°C) coolant does not flow through the thermostat but flows to the front of the intake manifold and returns to the cylinder head. Above 195°F (90°C) part of the coolant flows through the thermostat to the radiator and returns to the pump inlet.

Heat from the coolant is used to warm the intake manifold to prevent fuel condensation.

NOTE: *The EGR CTO valve and spark CTO valve are located in the intake manifold coolant passages.*

On six-cylinder engines, coolant is forced directly into the cylinder block water jackets surrounding the cylinders. It travels up through passages in the head gasket and cylinder head, around the combustion chambers and valves, through intake manifold and forward to the front of the cylinder head. Below 195°F (90°C), the thermostat is closed and coolant flows through the bypass port in the cylinder head, down through the block and back to the water pump where it is recirculated. A bypass port in the thermostat housing allows coolant flow to the heater core.

On eight-cylinder engines, coolant is forced from center of the engine timing case cover through side outlets into both banks of the cylinder block. It flows through the water jackets around all cylinders and up through holes in the block and head gaskets into the cylinder heads to cool the combustion chambers and valves. Coolant then flows through the heads to passages at the front of the heads and through the intake manifold to the thermostat. In the right head, coolant is forced into an intake manifold passage at the rear corner and out to the heater core, through the heater core, and back to the water pump. Below 195°F (91°C), the thermostat is closed and coolant flows out the bypass port through the hose to the water pump, where it is recirculated.

On all engines, the recirculation cycle continues until the coolant temperature reaches the thermostat calibration temperature and the thermostat begins to open. Some coolant then flows to the radiator inlet tank, through the cooling tubes and into the outlet tank. The radiator fan and vehicle motion cause air to flow past

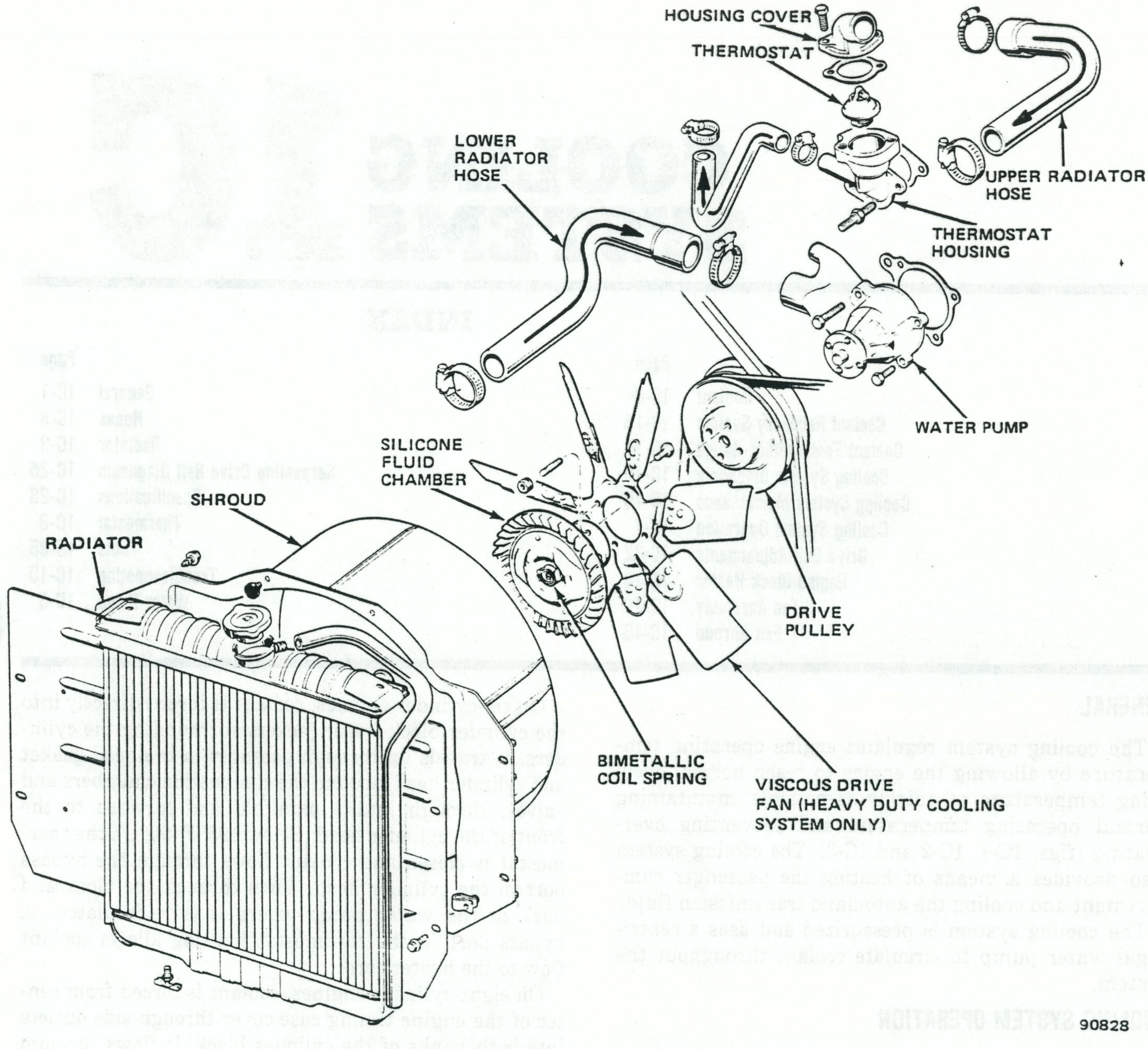

Fig. 1C-1 Four-Cylinder Engine Cooling System Components

the cooling fins to remove heat from the coolant. As the coolant flows through the outlet tank, it passes the automatic transmission fluid cooler, if equipped, and cools the automatic transmission fluid. Coolant is then drawn through the lower radiator hose into the water pump inlet to restart the cycle.

As the thermostat continues to open, it allows more coolant flow to the radiator. When it reaches its maximum open position, maximum coolant flows through the radiator.

Heat causes the coolant to expand and increase the system pressure, which raises the boiling point of the coolant. The pressure cap maintains pressure up to 15 psi (103 kPa). Above 15 psi (103 kPa), the relief valve in the cap allows pressurized coolant to escape through the filler neck overflow tube to the coolant recovery system bottle or to the road.

NOTE: *Immediately after shutdown, the engine enters a condition known as heat soak. This is when the coolant is no longer circulating but engine temperature is still high. If coolant temperature rises above the boiling point, expansion and pressure may force some coolant out of the radiator overflow tube. Normal engine operation will not usually cause this to happen.*

As engine temperature drops, the coolant loses heat and contracts, forming a partial vacuum in the system.

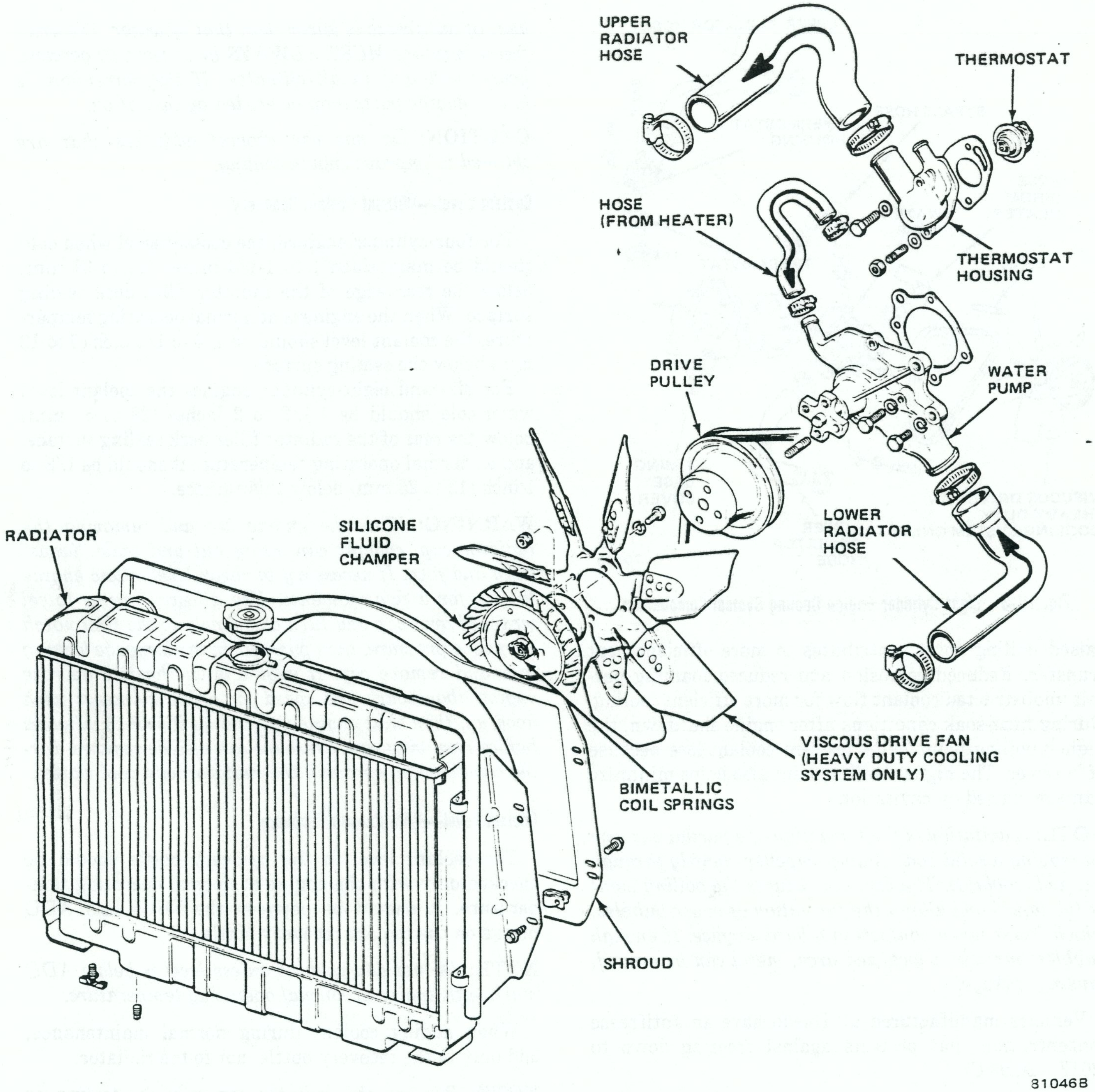

Fig. 1C-2 Six-Cylinder Engine Cooling System Components

The radiator cap vacuum valve allows atmospheric pressure to enter the system to equalize the pressure.

During operation, the coolant temperature is detected by the temperature sending unit. The sending unit electrical resistance varies as temperature changes, causing the temperature gauge to indicate accordingly.

The sender responds to temperature changes and with heavy load operation or on hot days, the coolant will be hotter and the gauge will indicate a higher engine temperature. Unless the gauge pointer moves past the high end of the band or coolant loss occurs, this is normal.

COOLANT

The coolant is a mixture of low mineral content water and ethylene glycol-based antifreeze. The addition of antifreeze to water alters several physical characteristics of water that are important to cooling system performance. The freezing point is lowered, the boiling point is raised and tendencies for corrosion and foaming are reduced. The lowered freezing point protects the engine and cooling system components from damage caused by the expansion of water as it freezes. The

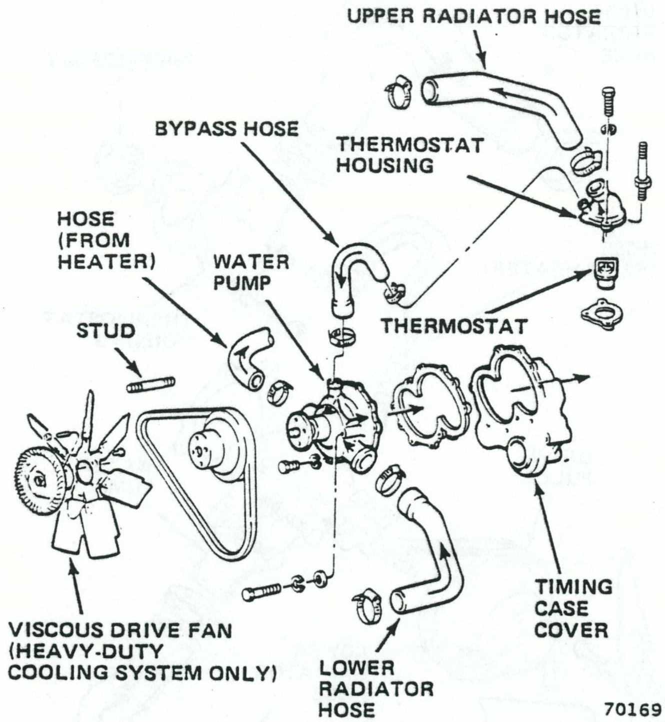

Fig. 1C-3 Eight-Cylinder Engine Cooling System Components

raised boiling point contributes to more efficient heat transfer. Reduced corrosion and reduced foaming permit unobstructed coolant flow for more efficient cooling. During heat-soak conditions after engine shutdown, the higher boiling point helps prevent coolant loss because of boilover. The higher boiling point also helps minimize damage caused by cavitation.

NOTE: *Cavitation is the formation of a partial vacuum by moving a solid body (pump impeller) swiftly through a liquid (coolant). The vacuum reduces the boiling point of the liquid and allows the formation of vapor bubbles, which burst when contacting a hard surface. If enough bubbles burst in a localized area, metal can be eroded, causing leakage.*

Vehicles manufactured at Toledo have an antifreeze concentration that protects against freezing down to -20°F (-28.9° C).

Coolant Level

Maintain the coolant level with a mixture of ethylene glycol based antifreeze and low mineral content water.

CAUTION: *The antifreeze mixture should always be maintained to satisfy local climatic requirements, or 50 percent, whichever is greater. Maximum protection against freezing is provided with a 68 percent antifreeze mixture, which prevents freezing down to -90°F (-68°C). A higher percentage will freeze at a warmer temperature. For example, pure antifreeze freezes at -8°F (-22°C). In addition, a higher percentage of antifreeze can cause the engine to overheat because the specific heat of antifreeze is lower than that of water. The antifreeze mixture MUST ALWAYS be at least 50 percent, year-round and in all climates. If the percentage is lower, engine parts may be eroded by cavitation.*

CAUTION: *Do not use coolant additives that are claimed to improve engine cooling.*

Coolant Level—Without Coolant Recovery

For four-cylinder engines, the coolant level when cold should be maintained 1 to 1-1/4 inches (25 to 32 mm) below the rear edge of the radiator filler neck sealing surface. When the engine is at normal operating temperature, the coolant level should be 1/4 to 1/2 inch (6 to 13 mm) below the sealing surface.

For six- and eight-cylinder engines the coolant level when cold should be 1-1/2 to 2 inches (38 to 51 mm) below the rear of the radiator filler neck sealing surface, and at normal operating temperature it should be 1/2 to 1 inch (13 to 25 mm) below this surface.

WARNING: *With the engine hot and removing the radiator cap, coolant can spray out and scald hands, body and face. If necessary to check level, allow engine to idle for a few moments. Use a heavy rag or towel wrapped over cap and turn cap slowly to the first notch to relieve pressure, then push down to disengage locking tabs and remove cap. If engine is overheated, operate engine above curb idle speed for a few moments with hood up, then shut engine Off and let it cool 15 minutes before removing cap. Pressure can also be reduced during cooldown by spraying the radiator with cool water.*

Coolant Level—With Coolant Recovery

The coolant level in the recovery bottle should be checked only with the engine at normal operating temperature. It should be between the FULL and ADD marks on the coolant recovery bottle.

NOTE: *Do not add coolant unless level is below ADD mark with engine at normal operating temperature.*

When adding coolant during normal maintenance, add only to the recovery bottle, not to the radiator.

NOTE: *Remove the radiator cap only for testing or when refilling the system after service. Removing the cap unnecessarily can cause loss of coolant and allow air to enter the system, which produces corrosion.*

Draining Coolant

NOTE: *DO NOT WASTE reusable coolant. If solution is clean and is being drained only to service the engine or cooling system, drain coolant into a clean container for reuse.*

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

Drain the coolant from the radiator by loosening the draincock on the bottom tank.

On four-cylinder engines, drain the cylinder block by removing the drain plug at the left-rear of the cylinder block.

On six-cylinder engines, drain the coolant from the cylinder block by removing the two drain plugs located on the left side of the block (plugs may have been replaced by one or two CTO valves).

On eight-cylinder engines, drain the coolant from the cylinder block by removing the centrally located plugs on each side of the block.

Replacing Coolant

Before filling, tighten radiator draincock and all drain plugs. Add the proper mixture of coolant to satisfy local climatic requirements for freeze and cooling protection.

CAUTION: *The antifreeze mixture must always be at least 50 percent, year-round and in all climates. If percentage is lower, engine parts may be eroded by cavitation.*

Fill the radiator to the correct coolant level. On vehicles with a coolant recovery system, fill the radiator to the top and install the radiator cap. Add sufficient coolant to the recovery bottle.

After refilling the system or when air pockets are suspected, purge the cooling system of excess air.

Purging Air from Cooling System

Trapped air will hamper or stop coolant flow, or cause burping of engine coolant out of the radiator overflow tube.

Move the heater control to the HEAT position and the heater temperature control to the full WARM or HIGH position.

On vehicles without a coolant recovery system, purge air by operating the engine (with a properly filled cooling system) with the radiator cap off until coolant has completely circulated throughout the engine, or until normal operating temperature is attained. Add coolant if necessary, and install radiator cap.

On vehicles with a coolant recovery system, fill the system with coolant and operate the engine with all coolant caps in place. After coolant has reached normal operating temperature, shut engine off and allow to cool. Add coolant to recovery bottle as necessary.

NOTE: *This procedure may have to be repeated several times to maintain the correct coolant level at normal operating temperature.*

NOTE: *With some models, it may be necessary to remove a heater hose to provide an escape for trapped air when filling the system.*

Coolant Freezing Point Test

Check coolant freezing point, or freeze protection, with an antifreeze hydrometer to determine protection level.

Removing Coolant from Crankcase

If coolant leaks into the lubricating system, **it will clog the oil passages and cause the pistons to seize. Severe damage to the engine will result.** If coolant has leaked into the lubricating system, locate the source of the coolant leaks, such as a faulty head gasket or cracked block, and make the necessary repairs. After repairing the leaks, use Jeep Crankcase Cleaner, or equivalent, to flush engine.

WATER PUMP

A centrifugal water pump circulates the coolant through the water jackets, passages, radiator core, hoses of the system and heater core. The pump is driven from the engine crankshaft by a V-type belt or belts (some eight-cylinder engines). A single serpentine drive belt is used for six-cylinder engines manufactured for sale in California. The water pump impeller is pressed onto the rear of a shaft that rotates in bearings pressed into the housing. The housing has a small hole to allow seepage to escape. The water pump seals are lubricated by the antifreeze in the coolant. No additional lubrication is necessary.

Water Pump Pulley Replacement

(1) Disconnect fan shroud from radiator, if equipped.

(2) Remove fan or Tempatrol drive attaching screws.

(3) Remove fan and spacer or Tempatrol fan and drive. Remove shroud. Refer to Fan Replacement.

(4) Loosen all belts routed around water pump pulley.

(5) Remove pulley.

(6) Install pulley.

(7) Position fan, spacer and shroud.

(8) Install and tighten belts. Refer to Drive Belt Adjustments.

(9) Install fan attaching screws and tighten.

(10) Install shroud attaching screws and tighten.

Water Pump Replacement

The water pump impeller is pressed on the rear of the pump shaft and bearing assembly. The water pump is serviced only as a complete assembly.

NOTE: *DO NOT WASTE reusable coolant. If solution is clean and being drained only to service the cooling system, drain into a clean container for reuse.*

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

Removal—Four-Cylinder Engine

(1) Drain coolant. Observe WARNING and NOTE stated above.

(2) Remove drive belt and fan. Refer to Fan Replacement.

(3) Disconnect lower radiator and heater hoses from pump.

(4) Remove pump attaching bolts and water pump.

Installation—Four-Cylinder Engine

(1) Scrape and clean gasket surface area on block.

(2) Position replacement gasket.

(3) Install water pump on block. Tighten bolts with 25 foot-pounds (30 N•m) torque.

(4) Connect lower radiator and heater hoses.

(5) Install coolant. Use correct mixture.

(6) Install fan and drive belt. Tighten drive belt. Refer to Drive Belt Adjustments.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

NOTE: *The fan assembly and pulley must be installed with the drive belt in position on the pulley. Tighten attaching nuts with 18 foot-pounds (34 N•m) torque.*

(7) Operate engine and check for leaks.

Removal—Six-Cylinder Engine

The following procedure applies to all vehicles with or without power steering, air injection and air conditioning.

(1) Drain cooling system. Observe WARNING and NOTE stated above.

(2) Disconnect radiator and heater hoses from pump.

(3) Remove drive belts.

(4) Remove fan shroud attaching screws from radiator, if equipped.

(5) Remove fan assembly and remove fan shroud. Refer to Fan Replacement.

NOTE: *On some models, fan removal may be easier if the fan shroud is rotated 1/2 turn.*

(6) Remove water pump and gasket.

Installation—Six-Cylinder Engine

CAUTION: *Six-cylinder engines (California) with a serpentine (single) drive belt have a reverse rotating water pump and viscous (Tempatrol) fan drive assembly. The components are identified by the words "REVERSE" stamped on the cover of the viscous drive and inner side of the fan, and "REV" cast into the water pump body. Do not install components that are intended for non-serpentine drive belts.*

Before installing pump, clean gasket mating surfaces and (if original pump) remove deposits and other foreign material from impeller cavity. Inspect block surface for erosion or other faults.

(1) Install replacement gasket and water pump. Tighten bolts with 13 foot-pounds (18 N•m) torque. Rotate shaft by hand to ensure it turns freely.

(2) Position shroud against front of engine, if removed, and install fan and hub assembly. Tighten screws with 18 foot-pounds (24 N•m) torque.

(3) Install fan shroud on radiator.

(4) Install drive belts and tighen to specified tension with Tension Gauge J-23600. Refer to Drive Belt Adjustments.

(5) Connect hoses to water pump.

(6) Fill system with coolant. Use correct mixture.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(7) Operate engine with heater control valve open and radiator cap off until thermostat opens to purge air from cooling system.

(8) Check coolant level and add as required.

Removal—Eight-Cylinder Engine

(1) Disconnect battery negative cable.

WARNING: *DO NOT remove block drain plugs with system under pressure because serious scalding from coolant can occur.*

(2) Drain radiator and disconnect upper radiator hose at radiator.

(3) Loosen all drive belts.

(4) If vehicle is equipped with radiator shroud, separate shroud from radiator.

(5) Install one radiator/shroud screw to retain radiator.

(6) Remove fan and hub from water pump. Remove fan and shroud, if equipped, from engine compartment.

(7) If vehicle is equipped with air conditioning, install double nut on air conditioning compressor bracket-to-water pump stud and remove stud (fig. 1C-4).

NOTE: *Removal of this stud eliminates the necessity of removing compressor mounting bracket.*

(8) Remove alternator and mount bracket assembly and place aside. Do not disconnect wires.

(9) If equipped with power steering, remove two nuts that attach power steering pump to rear half of pump mounting bracket.

(10) Remove two screws that attach front half of bracket to rear half.

(11) Remove remaining upper screw from inner air pump support brace, loosen lower bolt and drop brace away from power steering front bracket (fig. 1C-4).

(12) Remove front half of power steering bracket from water pump mounting stud.

(13) Disconnect heater hose, bypass hose and lower radiator hose at water pump.

(14) Remove water pump and gasket from timing case cover.

(15) Clean all gasket material from gasket mating surface of timing case cover.

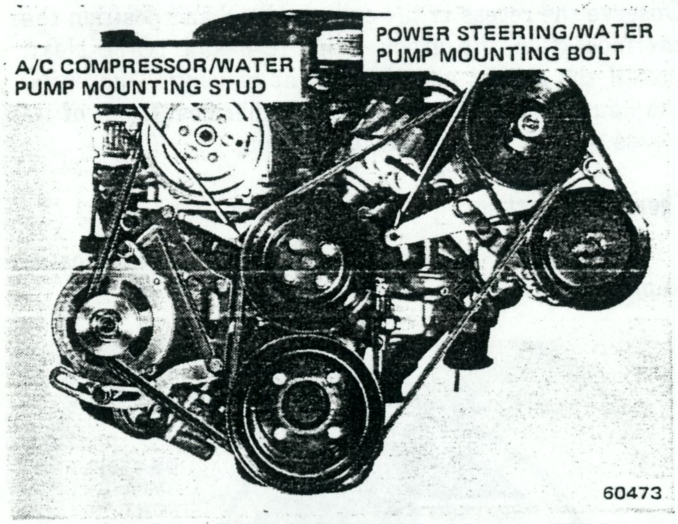

Fig. 1C-4 Water Pump Removal—Eight-Cylinder Engine

Installation—Eight-Cylinder Engine

NOTE: *Check timing case cover for erosion damage caused by cavitation.*

(1) Install water pump and replacement gasket on timing case cover.

(2) Tighten retaining screws to specified torque.

(3) If removed, install front section of power steering mount bracket, power steering pulley and drive belt.

(4) Tighten drive belt to specified tension, then tighten pulley retaining nut to 55 to 60 foot-pounds (75 to 81 N•m) torque.

(5) Install air pump drive belt, if removed, and tighten to specified tension.

(6) Install alternator and mount bracket assembly.

(7) Connect heater hose, bypass hose and lower radiator hose to water pump.

CAUTION: *Check and ensure the wire coil is installed in the lower radiator hose. Failure to install this coil will result in the hose collapsing during high engine rpm.*

(8) Position shroud against front of engine and install engine fan and hub assembly. Tighten retaining screws to specified torque.

(9) Position shroud on radiator and install with attaching screws.

(10) Install alternator drive belt and tighten to specified tension.

(11) Connect upper radiator hose to radiator.

(12) Connect battery negative cable.

(13) Fill cooling system with a mixture of 50 percent Jeep All-Season Coolant, or equivalent, and 50 percent water. Operate engine with heater control valve open until thermostat opens. Shut off engine, recheck coolant level and add as necessary.

(14) Reset clock, if equipped.

Water Pump Tests

Loose Impeller

NOTE: *DO NOT WASTE reusable coolant. If solution is clean and is being drained only to service the cooling system, drain coolant into a clean container for reuse.*

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(1) Drain cooling system.

(2) Loosen fan belt.

(3) Disconnect lower radiator hose from water pump.

(4) Bend stiff clothes hanger or welding rod (fig. 1C-5).

(5) Position rod in water pump inlet and attempt to hold impeller while turning fan blades. If impeller is loose and can be held with rod while fan blades are turning, pump is defective. If impeller turns, pump is OK.

NOTE: *If equipped with a Tempatrol fan, turn water pump shaft with socket and breaker bar attached to a mounting flange nut.*

(6) Connect hose and install coolant, or proceed with further repairs.

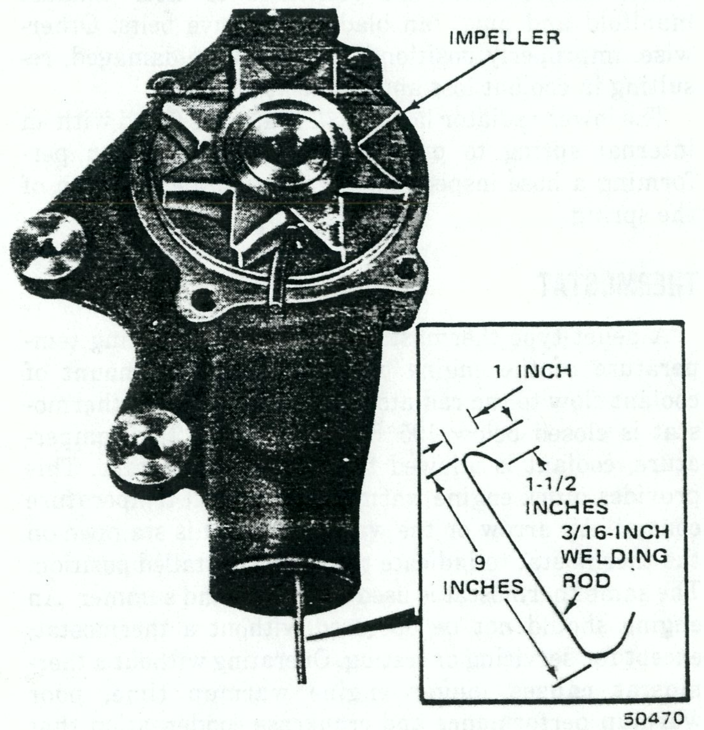

Fig. 1C-5 Testing Water Pump for Loose Impeller—Typical

Inspecting for Inlet Restrictions

With six- and eight-cylinder engines, poor heater performance may be caused by a casting restriction in the water pump heater hose inlet.

NOTE: *This procedure does not apply to the four-cylinder engine.*

(1) Drain sufficient coolant from radiator to permit removal of heater hose from water pump.

(2) Remove heater hose.

(3) Check inlet for casting flash or other restrictions.

NOTE: *Remove pump from engine before removing restriction to prevent contamination of coolant with debris. Refer to Water Pump Removal.*

HOSES

Rubber hoses route coolant to and from the radiator core and heater core. A coolant control valve is installed in the heater core inlet hose to control coolant flow to the heater core.

The lower radiator hose on all engines is spring-reinforced to prevent collapse caused by water pump suction.

Hose Inspection

Inspect hoses at regular intervals. Replace hoses that are cracked, feel brittle when squeezed or swell excessively when under pressure.

In areas where specific routing clamps are not provided, ensure hoses are positioned to clear exhaust manifold and pipe, fan blades and drive belts. Otherwise, improperly positioned hoses will be damaged, resulting in coolant loss and overheating.

The lower radiator hose on all engines is fitted with an internal spring to prevent hose collapse. When performing a hose inspection, check for proper position of the spring.

THERMOSTAT

A pellet-type thermostat controls the operating temperature of the engine by controlling the amount of coolant flow to the radiator. On all engines, the thermostat is closed below 195°F (90°C). Above this temperature, coolant is allowed to flow to the radiator. This provides quick engine warmup and overall temperature control. An arrow or the words TO RAD is stamped on the thermostat to indicate the proper installed position. The same thermostat is used for winter and summer. An engine should not be operated without a thermostat, except for servicing or testing. Operating without a thermostat causes longer engine warmup time, poor warmup performance and crankcase condensation that can result in sludge formation.

Thermostat Replacement

On four-cylinder engines, install the thermostat with the pellet inside the thermostat housing. Insert replacement gasket between thermostat and housing cover.

On six- and eight-cylinder engines, install the thermostat so that the pellet, which is encircled by a coil spring, faces the engine. All thermostats are marked on the outer flange to indicate the proper installed position. Observe the recess in the cylinder head and position the thermostat in the groove (fig. 1C-6 and 1C-7). Next, install the gasket and thermostat housing. Tightening the housing unevenly or with the thermostat out of its recess will result in a cracked housing.

Thermostat Testing

(1) Remove thermostat. Refer to Thermostat Replacement.

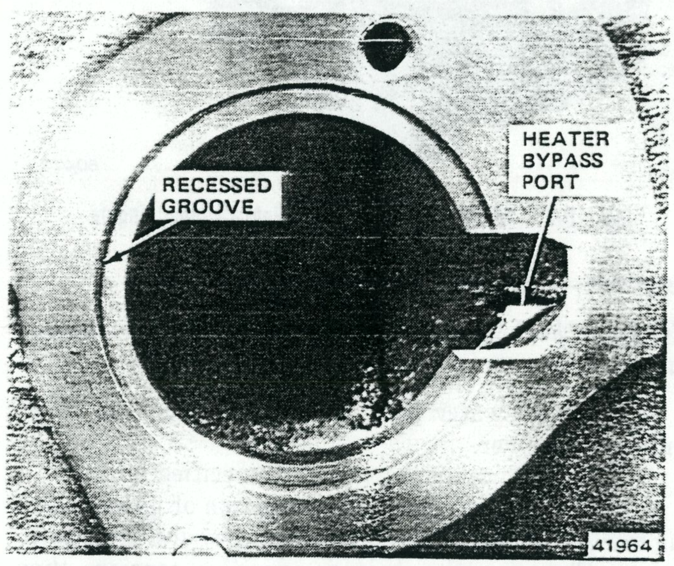

Fig. 1C-6 Thermostat Recess—Six-Cylinder Engine

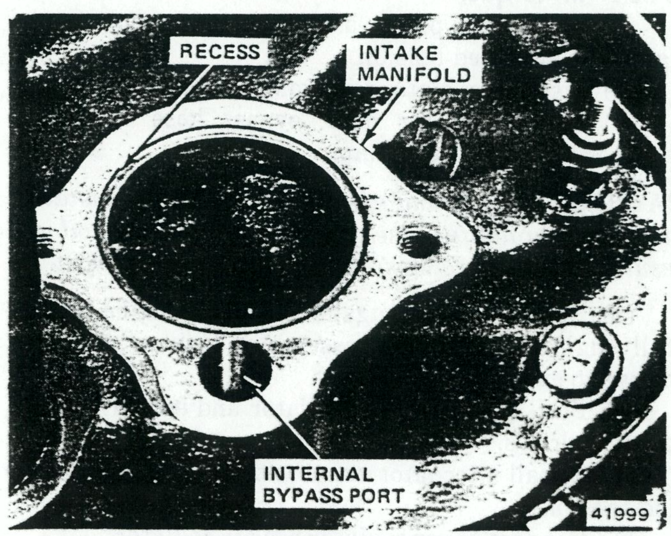

Fig. 1C-7 Thermostat Recess—Eight-Cylinder Engine

(2) Insert 0.003-inch (0.076-mm) feeler gauge, with wire or string attached, between valve and seat (fig. 1C-8).

WARNING: *Antifreeze is poisonous. Keep out of reach of children.*

(3) Submerge thermostat in container of pure antifreeze and suspend it so that it does not touch sides or bottom of container.

(4) Suspend thermometer in solution so that is does not touch container.

WARNING: *Do not breathe fumes.*

(5) Heat solution.

(6) Apply slight tension on feeler gauge while solution is heated. When valve opens 0.003-inch (0.076-mm), feeler gauge will slip free from valve. Note temperature. Refer to Thermostat Calibrations chart below. If faulty, replace thermostat.

(7) Install thermostat.

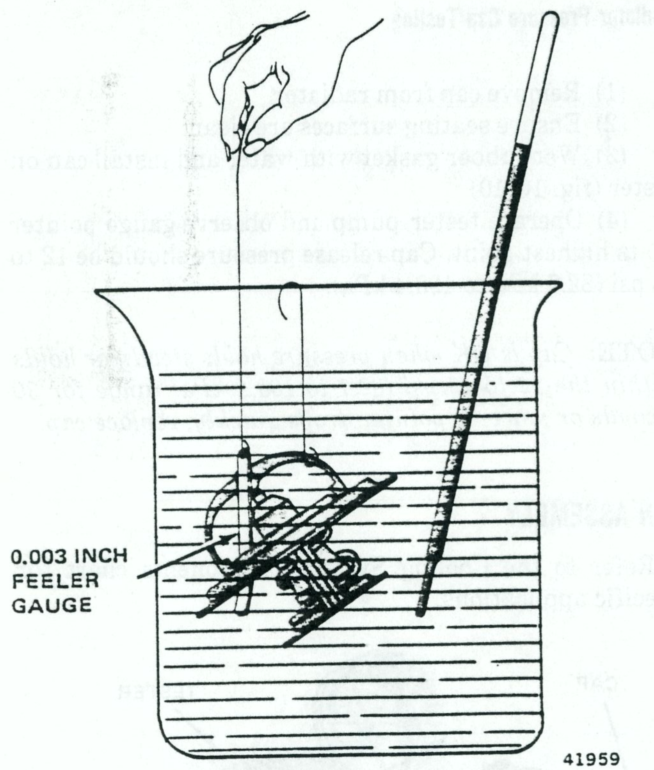

Fig. 1C-8 Testing Thermostat

Thermostat Calibrations

	4-, 6- and 8-Cyl
Must Be Open 0.003-Inch (0.076 mm)	90°C 195°F
Must Be Fully Open	103°C 218°F

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RADIATOR

The radiator, a tube and spacer type, is composed of two tanks soldered to the cooling tubes. The filler neck has an overflow tube that routes excess coolant to the road or to the coolant recovery bottle, if equipped.

All vehicles have downflow type radiators. A top tank and a bottom tank are soldered to vertical cooling tubes. The radiator cap and filler neck are located on the inlet tank. The bottom, or outlet, tank contains the draincock. It also contains the transmission fluid cooler for vehicles with an automatic transmission.

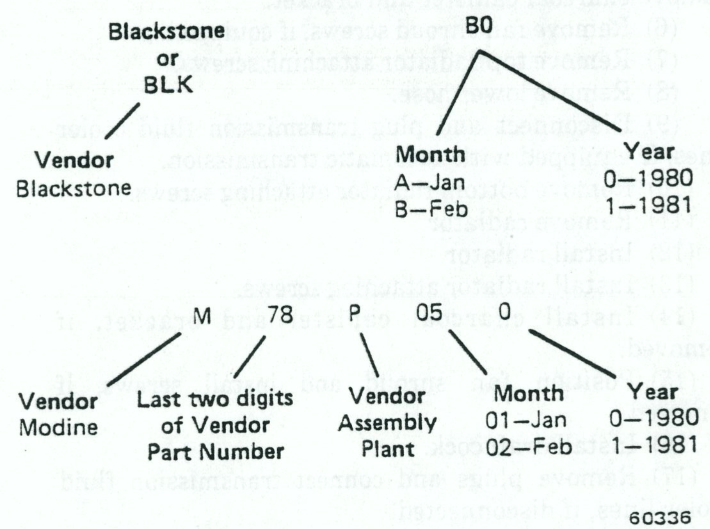
Some radiators have a plastic shroud attached to funnel air more directly through the radiator for improved engine cooling during idle and low rpm speeds.

Some vehicles are equipped with air seals between the radiator and various body structures. This prevents air from flowing forward around the radiator and recirculating through the core.

Radiator Identification

Radiators are identified by a Jeep part number and the vendor build code number embossed on the upper tank. Some Cherokees, Wagoneers and Trucks have the code located at the radiator right side support.

Radiator Identification



Radiator Maintenance

NOTE: *To test radiator for leaks or pressure loss, refer to Troubleshooting—Cooling System Leakage.*

The radiator should be free from any obstruction of airflow. This includes bugs, clogged bug screens, leaves, mud, emblems, flags, fog lamps, improperly mounted license plates, large nonproduction bumper guards or collision damage.

NOTE: *Remove dirt and other debris by blowing compressed air from the engine side of the radiator through the fins.*

Several problems may affect radiator performance:
- bent or damaged tubes,
- corrosive deposits restricting coolant flow,
- tubes blocked because of improper soldering.

Repair damaged tubes that affect proper operation. Leaks can be detected by applying 3 to 5 psi (21 to 34 kPa) air pressure to the radiator while it is submerged in water. Repair tubes with solder. Clean a clogged radiator with solvent or by reverse flushing. Refer to Cooling System Maintenance.

Replacement—All Models

NOTE: *DO NOT WASTE reusable coolant. If solution is clean and is being drained only to service the cooling system, drain into a clean container for reuse.*

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(1) Position drain pan under radiator and remove draincock. Observe WARNING above.
(2) Remove radiator cap.
(3) Disconnect upper radiator hose.
(4) Disconnect coolant recovery hose, if equipped.
(5) On air-conditioned, four-cylinder engine models, remove charcoal canister and bracket.
(6) Remove fan shroud screws, if equipped.
(7) Remove top radiator attaching screws.
(8) Remove lower hose.
(9) Disconnect and plug transmission fluid cooler lines, if equipped with automatic transmission.
(10) Remove bottom radiator attaching screws.
(11) Remove radiator.
(12) Install radiator.
(13) Install radiator attaching screws.
(14) Install charcoal canister and bracket, if removed.
(15) Position fan shroud and install screws, if removed.
(16) Install draincock.
(17) Remove plugs and connect transmission fluid cooler lines, if disconnected.
(18) Install lower radiator hose using replacement clamp.
(19) Install upper hose using replacement clamp.
(20) Install coolant. Use correct mixture.
(21) Connect coolant recovery hose, if removed.
(22) Install radiator cap.

Radiator Pressure Cap

The radiator cap consists of a pressure valve and a vacuum valve. The cap has several functions (fig. 1C-9):
- prevents coolant loss when the vehicle is in motion;
- prevents impurities from entering the system and this minimizes corrosion;
- allows atmospheric pressure to eliminate the vacuum that occurs in the system during cooldown;
- seals cooling system pressure up to 15 psi (103.4 kPa), which raises the coolant boiling point approximately 2-1/2°F per psi of pressure (0.20°C per kPa).

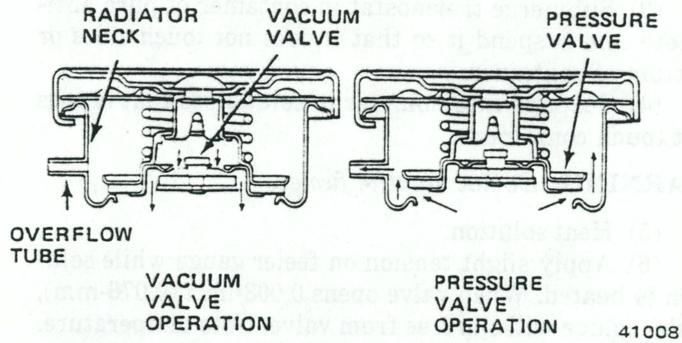


Fig. 1C-9 Radiator Cap Operation

Radiator Pressure Cap Testing

(1) Remove cap from radiator.
(2) Ensure seating surfaces are clean.
(3) Wet rubber gasket with water and install cap on tester (fig. 1C-10)
(4) Operate tester pump and observe gauge pointer at its highest point. Cap release pressure should be 12 to 15 psi (82.7 kPa to 103.4 kPa).

NOTE: *Cap is OK when pressure holds steady or holds within the 12 to 15 psi (82.7 to 103.4 kPa) range for 30 seconds or more. If pointer drops quickly, replace cap.*

FAN ASSEMBLY

Refer to the Cooling System Components chart for specific applications.

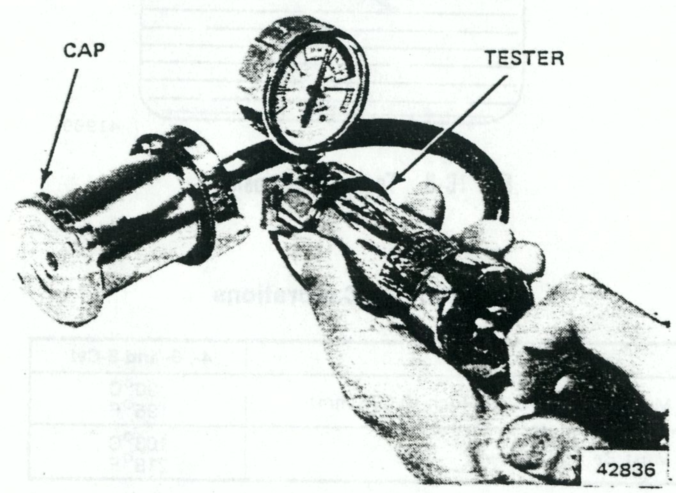


Fig. 1C-10 Radiator Cap Pressure Test

There are several types of metal fans available for all engines. Most engines with standard cooling use a seven-bladed rigid fan. Some engines are fitted with standard-equipment multi-bladed viscous fans for noise reduction. Most air-conditioned vehicles have a viscous (Tempatrol) fan (fig. 1C-11).

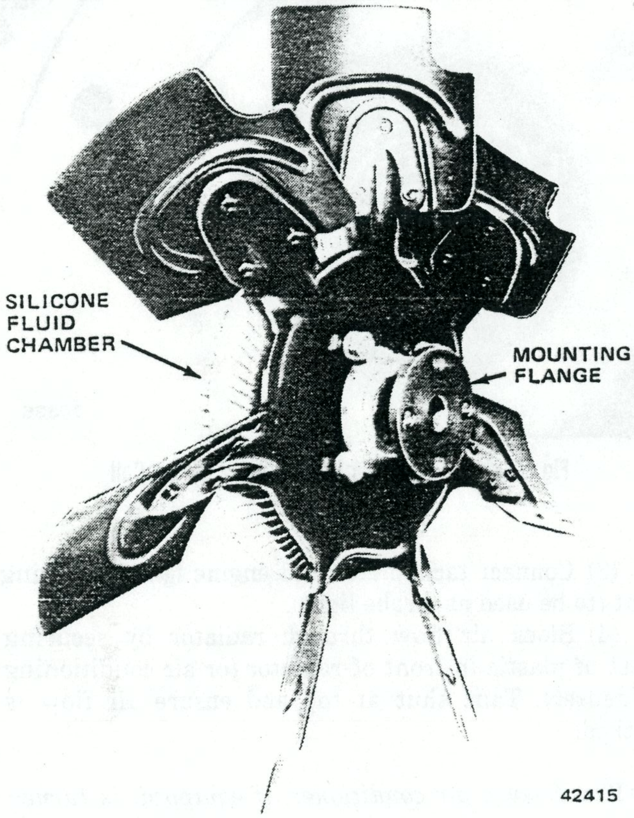


Fig. 1C-11 Tempatrol Fan—Typical

The Tempatrol fan drive is a torque- and temperature-sensitive clutch unit that automatically increases or decreases fan speed to provide proper engine cooling.

The Tempatrol fan drive clutch is essentially a silicone-fluid-filled coupling connecting the fan assembly to the fan/water pump pulley. The coupling allows the fan to be driven in a normal manner at low engine speeds while limiting the top speed of the fan to a predetermined maximum level at higher engine speeds. A bimetallic spring coil is located on the front face. This spring coil reacts to the temperature of the radiator discharge air and engages the drive clutch for higher fan speed if the air temperature from the radiator rises above a certain point. Until additional engine cooling is necessary, the fan will remain at a reduced rpm regardless of the engine speed. Only when sufficient heat is present in the air flowing through the radiator core to cause a reaction from the bimetallic coil will the Tempatrol drive clutch engage and increase fan speed to provide the necessary additional engine cooling.

Once maximum fan speed is attained, the fan will not rotate faster regardless of increased engine speed. When the necessary engine cooling has been accomplished and the degree of heat in the air flowing through the radiator core has been reduced, the bimetallic coil again reacts and the fan speed is reduced to the previous disengaged speed.

Rigid fan blades are fastened by rivets. The fan is mounted on an aluminum spacer to provide the proper distance between the fan and radiator.

WARNING: *Do not stand in direct line with the fan when the engine is operating, particularly at speeds above idle.*

Cherokees, Wagoneers and Trucks equipped with air conditioning (or heavy-duty cooling) are equipped with a Tempatrol (viscous drive) fan assembly. Six-cylinder engines not equipped with air conditioning or heavy-duty cooling have a rigid metal, four-bladed fan. All CJ vehicles with eight-cylinder engines and air conditioning are equipped with a Tempatrol (viscous drive) fan assembly.

Fan blade assemblies are balanced within 0.25 in. oz. and should not be altered in any way. Replace a damaged or bent fan. Do not attempt repair. Refer to the Cooling System Components chart for fan applications.

CAUTION: *Fans are designed to be compatible with certain applications only. DO NOT attempt to increase cooling capacity by installing a fan not intended for a given engine. Fan or water pump damage and noise may result.*

Replacement—All Models

(1) Disconnect fan shroud from radiator, if equipped.

(2) Remove fan attaching bolts.

(3) Remove fan, spacer and shroud.

NOTE: *If equipped with a Tempatrol fan assembly, remove attaching nuts and remove fan and drive as a unit.*

(4) Position fan, spacer and shroud, if equipped.

(5) Install fan attaching bolts (or nuts) and tighten.

(6) Install shroud attaching screws and tighten, if removed.

Tempatrol Fan Blade and Drive Unit Replacement

CAUTION: *Six-cylinder engines (California) with a serpentine (single) drive belt have a reverse rotating water pump and viscous (Tempatrol) fan drive assembly. The components are identified by the words "REVERSE" stamped on the cover of the viscous drive and inner side of the fan, and "REV" cast into the water pump body. Do not install components that are intended for nonserpentine drive belts.*

If it necessary to replace either the Tempatrol fan blade unit or the drive unit separately, use the following procedure.

The Tempatrol drive unit should be replaced if there is an indication of a fluid leak, noise, or if roughness is detected when turning by hand. If the drive cannot be turned by hand, or if the leading edge of the fan can be moved more than 1/4 inch (6.35 mm) front to rear, replace the drive unit.

(1) Remove fan shroud attaching screws.

(2) Remove nuts attaching fan assembly and pulley to water pump. Remove drive belt.

(3) Move shroud rearward and remove fan assembly.

CAUTION: *To prevent silicone fluid from draining into fan drive bearing and contaminating the lubricant, do not place Tempatrol fan unit on work bench with rear mounting flange pointing downward.*

(4) Remove bolts attaching fan blade unit to drive unit.

(5) Attach replacement unit. Tighten bolts with 13 foot-pounds (18 N•m) torque.

(6) Install fan assembly and pulley on water pump. Tighten nuts with 18 foot-pounds (24 N•m) torque.

NOTE: *If a four-cylinder engine, the fan assembly and pulley must be installed with the drive belt in position on pulleys.*

Tempatrol Fan Test

In an engine overheating situation, the Tempatrol drive unit can be statically tested for proper operation by observing movement of the bimetallic spring coil and shaft. To test, disconnect end of bimetallic spring coil from slot (fig. 1C-12) and rotate it counterclockwise until a stop is felt.

NOTE: *Do not force beyond stop.*

Gap between end of coil and clip on housing should be approximately 1/2 inch (13 mm). Replace unit if shaft does not rotate with coil. After test, connect end of coil in slot.

Dynamic Test

CAUTION: *Ensure there is adequate fan blade clearance before drilling.*

(1) Drill 1/8-inch (3.18-mm) diameter hole in top center of shroud.

(2) Insert dial thermometer (0° to 220°F [-18° to 105°C]) with 8-inch stem, or equivalent, through hole in shroud.

NOTE: *Ensure there is adequate clearance from fan blades.*

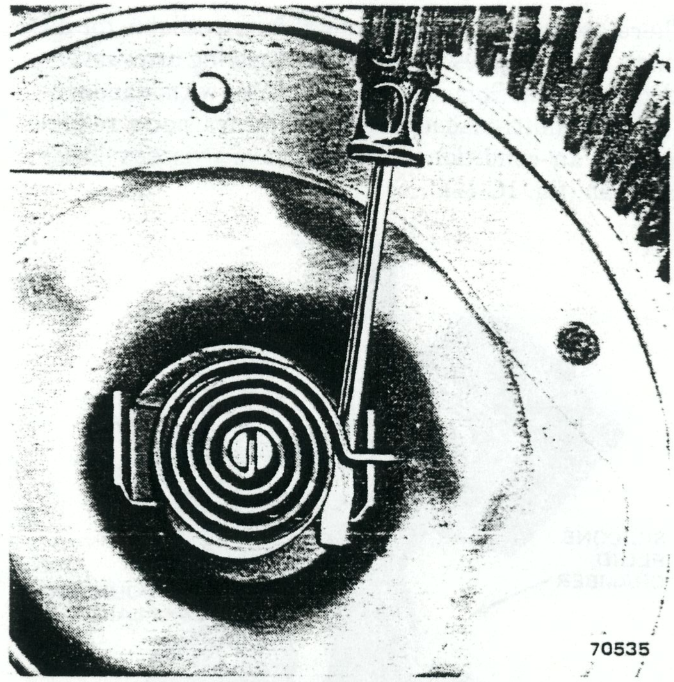


Fig. 1C-12 Disconnecting Tempatrol Spring Coil

(3) Connect tachometer and engine ignition timing light (to be used as strobe light).

(4) Block air flow through radiator by securing sheet of plastic in front of radiator (or air conditioning condenser). Tape shut at top and ensure air flow is blocked.

NOTE: *Ensure air conditioner, if equipped, is turned off.*

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(5) Start engine and operate at 2400 rpm with timing light aimed at fan blades (strobe light).

(6) Within ten minutes air temperature (indicated on dial thermometer) should reach 190°F (88°C). Satisfactory operation of fan drive requires that it engage before or at 200°F (93°C). Engagement is distinguishable by increase in fan roar. Timing light will also indicate increase in speed of fan.

(7) When air temperature reaches 200°F (93°C), remove plastic sheet. Satisfactory operation of Tempatrol fan requires air temperature to drop 20°F (11°C) or more. Definite decrease of audible fan air flow should be noticed. Replace defective fan assemblies.

NOTE: *The cooling system must be in good condition prior to performing the test outlined above to ensure against excessively high coolant temperature.*

FAN SHROUD

In some extreme situations, the engine fan blades may contact the shroud. An examination for proper engine mounting should isolate the problem. If not, examine the shroud position. To compensate for normal engine movement, loosen the shroud attaching screws and reposition shroud to prevent fan-to-shroud contact. Inspect the fan for bent blades and replace fan if necessary.

COOLANT RECOVERY SYSTEM

The coolant recovery system consists of a special pressure radiator cap, an overflow tube and a plastic coolant recovery bottle (fig. 1C-13). Refer to the Cooling System Components chart for specific applications.

The radiator cap used with the recovery system has a gasket to prevent air leakage at the filler neck. The cap has small finger grips (to discourage unnecessary removal) and has a mark on top that aligns with the overflow tube to indicate the proper installed position. The rubber overflow tube fits into the top of the plastic bottle and extends to the bottom. The overflow tube must always be submerged in coolant. The bottle also has a molded-in tube to allow excess coolant to escape. This same tube allows atmospheric pressure to enter the bottle during recovery operation. The bottle is fitted with a plain plastic cap.

Coolant Recovery Operation

As engine temperature increases, the coolant expands. The radiator cap pressure vent valve (normally open) slowly allows transfer of expanding coolant to the coolant recovery bottle. Any air trapped in the system will also be expelled during this period.

If ambient temperature is high, the system continues heating until vapor bubbles form. These vapor bubbles pass rapidly through the radiator cap vent valve, causing it to close. Further expansion of the coolant pressurizes the system up to 15 psi (103.4 kPa). Above 15 psi (103.4 kPa) the relief valve in the cap allows pressurized coolant to escape to the coolant recovery system.

As engine temperature drops, the coolant loses heat and contracts, forming a partial vacuum in the system. The radiator cap vacuum valve then opens and allows atmospheric pressure to force coolant from the recovery bottle into the system to equalize the pressure. Air is not admitted as long as the overflow tube remains submerged in the recovery bottle.

Coolant Recovery Bottle Replacement—All Models

(1) Remove tube from radiator filler neck.
(2) Remove bottle from radiator support panel.
(3) Pour coolant into clean container for reuse.
(4) Remove tube from bottle.
(5) Install tube in replacement bottle.

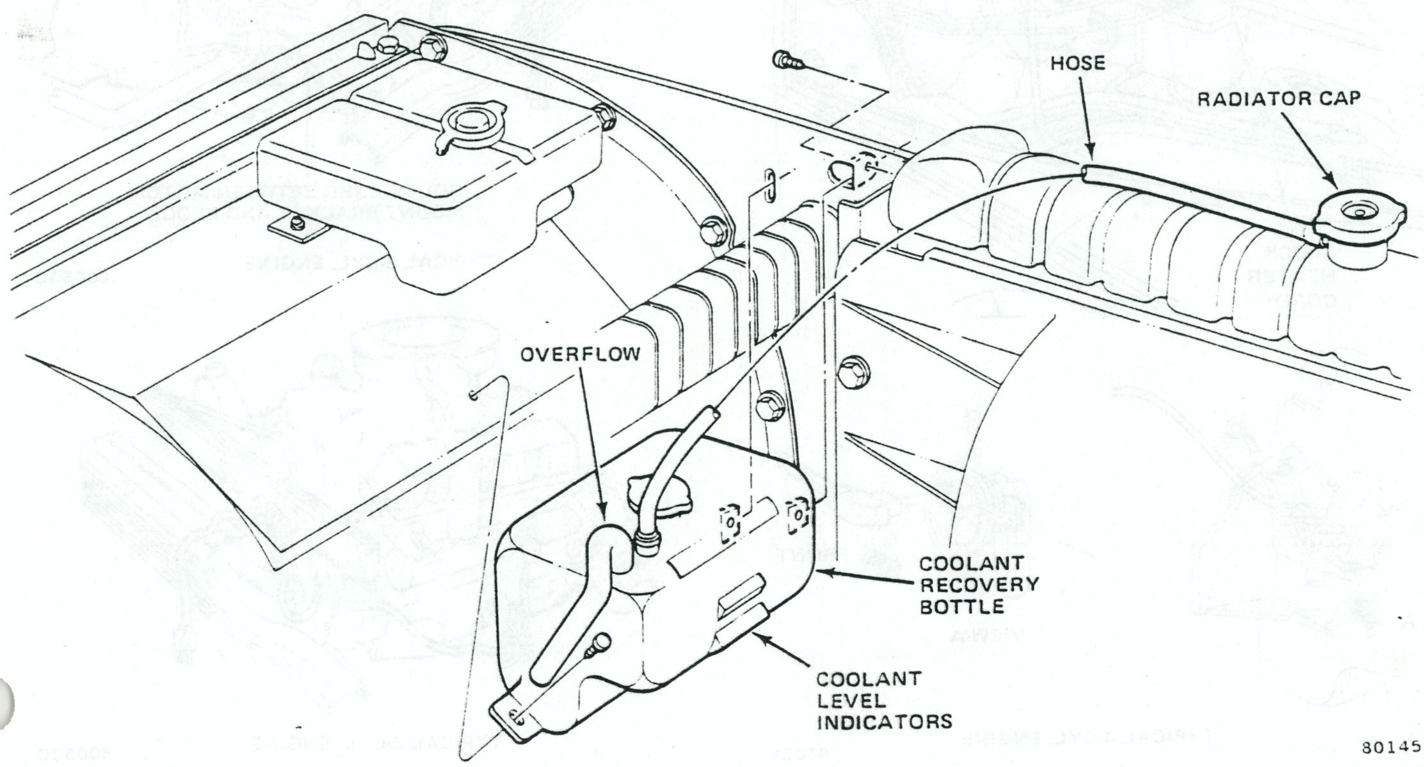


Fig. 1C-13 Coolant Recovery System—Typical

(6) Install bottle on radiator support panel.
(7) Connect tube to radiator filler neck.
(8) Install coolant in bottle. Ensure tube is submerged in coolant.

COOLANT TEMPERATURE GAUGE

All vehicles are equipped with a coolant temperature gauge. Refer to Chapter 1L—Power Plant Instrumentation for operation, diagnosis and repair of the temperature gauge system.

ENGINE BLOCK HEATER

A factory-installed engine block heater is optional. It consists of a 600W, 120V heater element fitted into a core plug hole in the block, a power cord and nylon straps are placed in the glove box for later installation.

Engine Block Heater Installation

NOTE: *DO NOT WASTE reuseable coolant. If solution is clean and is being drained only to service the engine or cooling system, drain coolant into a clean container for reuse.*

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(1) Drain coolant from engine. See NOTE and WARNING above.

(2) Remove core plug and install block heater (fig.1C-14). Tighten T-bolt type with 20 inch-pounds (2.3 N•m) torque. Tighten compression nut type with 10 foot-pounds (14 N•m) torque.

CAUTION: *Use care when tightening block heater attaching parts. Improper tightening may damage seal or allow heater to loosen, resulting in coolant loss and engine damage.*

(3) From front of vehicle, route heater (female) end of power cord through hole in front panel, along wire harness and connect to block heater.

(4) Use nylon straps furnished to tie cord to wire harness and to inside of grille. Allow cord to extend outside of grille.

(5) Install coolant in engine.

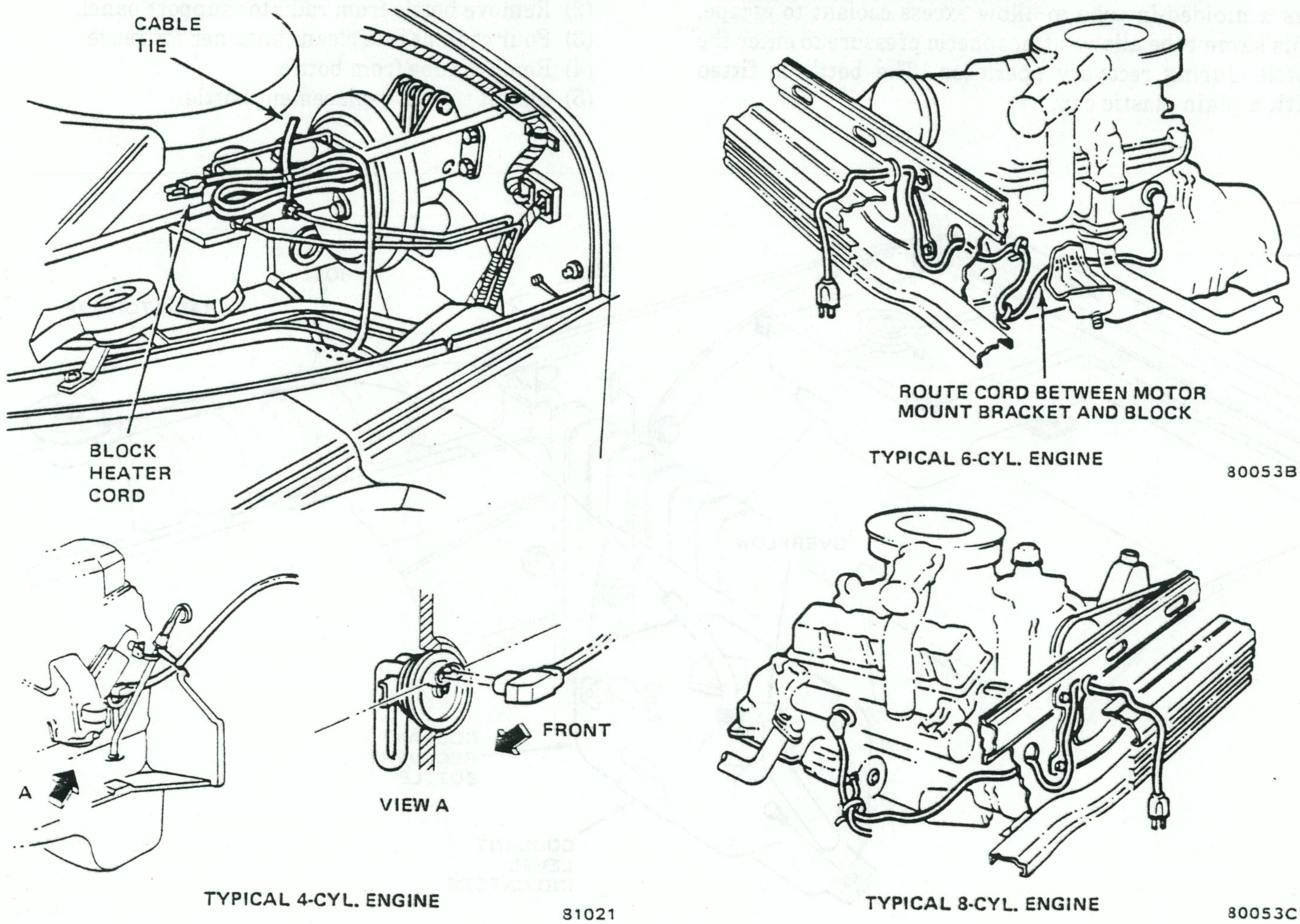


Fig. 1C-14 Engine Block Heater Installation

COOLING SYSTEM MAINTENANCE

Engine Flushing

CAUTION: *The cooling system normally operates at 12 to 15 psi (83 to 103 kPa) pressure. Exceeding this pressure may damage the radiator, heater core, or hoses.*

(1) Remove thermostat housing and thermostat. Install thermostat housing.

(2) Attach flushing gun to upper radiator hose at radiator end.

(3) Attach leadaway hose to water pump inlet.

(4) Connect water supply and air supply hoses to flushing gun.

(5) Allow engine to fill with water.

(6) When engine is filled, apply air in short blasts, allowing system to fill between air blasts. Continue until clean water flows through leadaway hose.

(7) Remove thermostat housing and install thermostat. Install thermostat housing, using a replacement gasket.

(8) Connect radiator hoses.

(9) Refill cooling system with correct antifreeze-water mixture.

Solvent Cleaning

In some instances, the use of a radiator cleaner (Jeep Radiator Kleen, or equivalent) before flushing will soften scale and deposits and aide the flushing operation.

CAUTION: *Ensure instructions on the container are followed.*

Radiator Reverse Flushing

(1) Disconnect radiator hoses.

(2) Attach piece of radiator hose to radiator bottom outlet and insert flushing gun.

(3) Connect water supply hose and air supply line to flushing gun. Note excess pressure caution above.

(4) Allow radiator to fill with water.

(5) When radiator is filled, apply air in short blasts, allowing radiator to refill between blasts.

Continue this reverse flushing until clean water flows through top radiator opening. If flushing fails to clear radiator passages, have the radiator cleaned more extensively by a radiator repair shop.

Transmission Fluid Cooler Repairs

Because of the high pressure applied to the fluid cooler, do not attempt conventional soldering to repair leaks. **All repairs must be silver soldered or brazed.**

Core Plugs

Prior to hot tanking for block boiling, remove casting flash causing hot spots or coolant flow blockage. Remove core plugs with hammer, chisel and prying tool. Apply a sealer to edges of replacement plugs and position plugs with lip to outside of block. Install with hammer and suitable tool. Refer to Core Plug Sizes chart.

Core Plug Sizes

Location	Diameter inches	Diameter mm
Four-Cylinder Head (rear inside water jacket)	0.637	16
Four-Cylinder Head (rear)	1.9	48.5
Four-Cylinder Block (3 on side)	1.6	41.5
Four Cylinder Block (1 on rear)	1.9	48.3
Six-Cylinder Head (3 left side)	0.875	22
Six-Cylinder Head (rear)	2.0	51
Six-Cylinder Block (3 left, 1 rear)	2.0	51
Eight-Cylinder Heads (outer sides, 2 each)	1.0	24.4
Eight-Cylinder Blocks (3 each side)	1.5	38.1
Eight-Cylinder Heads (1 each end)	1.5	38.1

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COOLING SYSTEM DIAGNOSIS

If the cooling system requires frequent addition of coolant to maintain the correct level, inspect all units and connections in the cooling system for evidence of leakage. Perform the inspection with the cooling system cold. Small leaks, which may appear as dampness or dripping, can easily escape detection if they are rapidly evaporated by engine heat. Telltale stains of a grayish white or rusty color, or dye stains from antifreeze, may appear at connecting joints in the cooling system. These stains are almost always a sure indication of small leaks, though there may appear to be no defects.

Air may be drawn into the cooling system through incomplete sealing at the water pump seal or through incomplete sealing in the coolant recovery system. Combustion pressure may be forced into the cooling system through a leak at the cylinder head gasket, though the passage is too small to allow coolant to enter the combustion chamber.

TROUBLESHOOTING

Cooling System Leakage

NOTE: *Engine should be warm. Recheck system cold if cause of coolant loss is not located during warm engine troubleshooting.*

WARNING: *Hot, pressurized coolant can cause injury by scalding.*

Service Diagnosis

Condition	Possible Cause	Correction
HIGH TEMPERATURE INDICATION-OVERHEATING	(1) Coolant level low.	(1) Replenish coolant level.
	(2) Fan belt loose.	(2) Adjust fan belt.
	(3) Radiator hose(s) collapsed.	(3) Replace hose(s).
	(4) Radiator blocked to airflow.	(4) Remove restriction (bugs, fog lamps, etc.)
	(5) Faulty radiator cap.	(5) Replace cap.
	(6) Vehicle overloaded.	(6) Reduce load or shift to lower gear.
	(7) Ignition timing incorrect.	(7) Adjust ignition timing.
	(8) Idle speed low.	(8) Adjust idle speed.
	(9) Air trapped in cooling system.	(9) Purge air.
	(10) Vehicle in heavy traffic.	(10) Operate at fast idle intermittently in neutral gear to cool engine.
	(11) Incorrect cooling system component(s) installed.	(11) Install proper component(s).
	(12) Faulty thermostat.	(12) Replace thermostat.
	(13) Water pump shaft broken or impeller loose.	(13) Replace water pump.
	(14) Radiator tubes clogged.	(14) Flush radiator.
	(15) Cooling system clogged.	(15) Flush system.
	(16) Casting flash in cooling passages.	(16) Repair or replace as necessary. Flash may be visible by removing cooling system components or removing core plugs.
	(17) Brakes dragging.	(17) Repair brakes.
	(18) Excessive engine friction.	(18) Repair engine.
	(19) Antifreeze concentration over 68%.	(19) Lower antifreeze content.
	(20) Missing air seals between hood and radiator.	(20) Replace air seals.

NOTE: *Immediately after shutdown, the engine enters a condition known as heat soak. This is caused by the cooling system being inoperative while engine temperature is still high. If coolant temperature rises above boiling point, expansion and pressure may push some coolant out of the radiator overflow tube. If this does not occur frequently, it is considered normal.*

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Service Diagnosis (Continued)

Condition	Possible Cause	Correction
	(21) Faulty gauge.	(21) Repair or replace gauge.
	(22) Loss of coolant flow caused by leakage or foaming.	(22) Repair leak, replace coolant.
	(23) Tempatrol fan inoperative.	(23) Perform Tempatrol fan test. Repair as necessary.
COOLANT LOSS—BOILOVER	Refer to Overheating Causes in addition to the following:	
	(1) Overfilled cooling system.	(1) Reduce coolant level to proper specification.
	(2) Quick shutdown after hard (hot) run.	(2) Allow engine to run at fast idle prior to shutdown.
	(3) Air in system resulting in occasional "burping" of coolant.	(3) Purge system.
	(4) Insufficient antifreeze allowing coolant boiling point to be too low	(4) Add antifreeze to raise boiling point.
	(5) Antifreeze deteriorated because of age of contamination.	(5) Replace coolant.
	(6) Leaks due to loose hose clamps, loose nuts, bolts, drain plugs, faulty hoses, or defective radiator.	(6) Pressure test system to locate leak then repair as necessary.
	(7) Faulty head gasket.	(7) Replace head gasket.
	(8) Cracked head, manifold, or block.	(8) Replace as necessary.
COOLANT ENTRY INTO CRANKCASE OR CYLINDER	(1) Faulty head gasket.	(1) Replace head gasket.
	(2) Crack in head, manifold or block.	(2) Replace as necessary.
COOLANT RECOVERY SYSTEM INOPERATIVE	(1) Coolant level low.	(1) Replenish coolant to FULL mark.
	(2) Leak in system.	(2) Pressure test to isolate leak and repair as necessary.
	(3) Pressure cap not tight or gasket missing or leaking.	(3) Repair as necessary.

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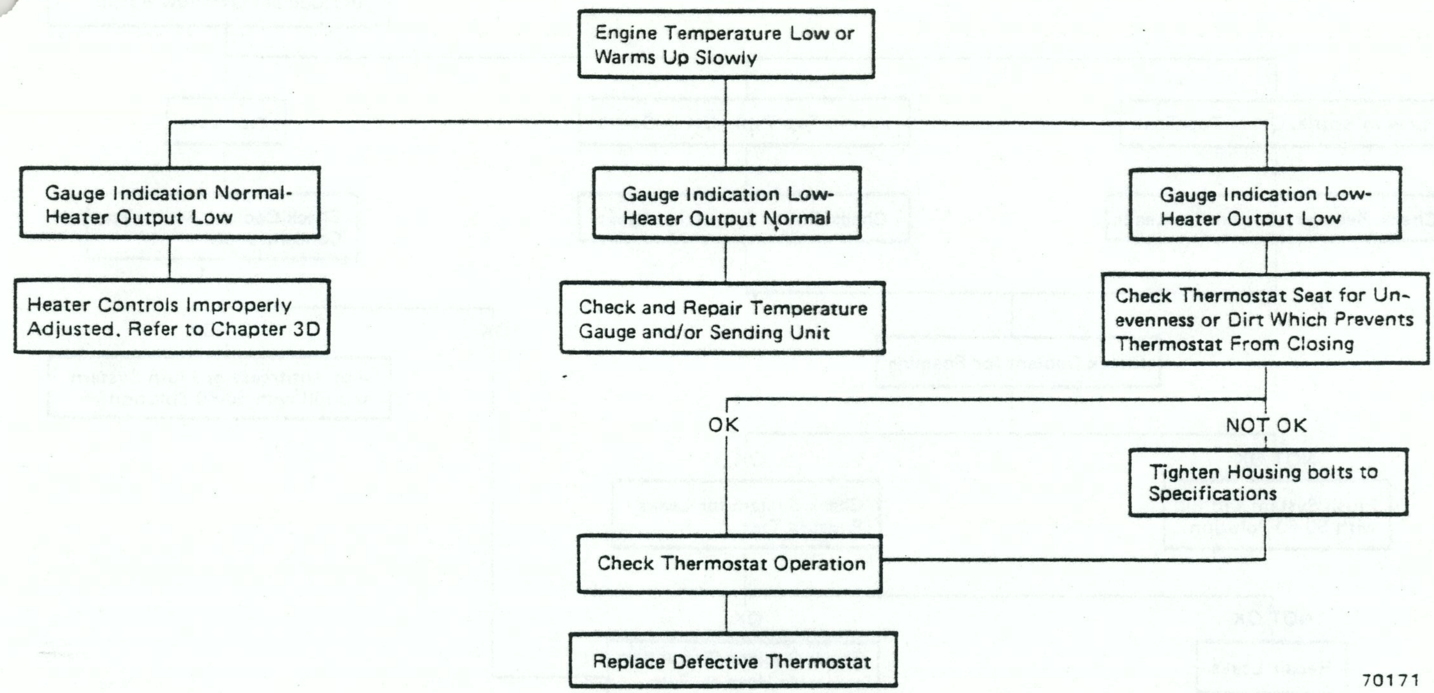
Service Diagnosis (Continued)

Condition	Possible Cause	Correction
	(4) Pressure cap defective.	(4) Replace cap.
	(5) Overflow tube clogged or leaking.	(5) Repair as necessary.
	(6) Overflow tube kinked .	(6) Repair as necessary.
	(7) Recovery bottle vent plugged.	(7) Remove restriction.
NOISE	(1) Fan contacting shroud.	(1) Reposition shroud and check engine mounts.
	(2) Loose water pump impeller.	(2) Replace pump.
	(3) Dry fan belt.	(3) Apply silicone or replace belt.
	(4) Loose fan belt.	(4) Adjust fan belt.
	(5) Rough surface on drive pulley.	(5) Replace pulley.
	(6) Water pump bearing worn.	(6) Remove belt to isolate. Replace pump.
	(7) Belt alignment.	(7) Check for improper pulley locations. Shim power steering pump.
LOW TEMPERATURE INDICATION— UNDERCOOLING	(1) Thermostat stuck open.	(1) Replace thermostat.
	(2) Faulty gauge.	(2) Repair or replace gauge.
	(3) Tempatrol fan drive constantly engaged.	(3) Perform fan test. Repair as necessary.
NO COOLANT FLOW THROUGH HEATER CORE	(1) Plugged return pipe in water pump.	(1) Remove obstruction.
	(2) Heater hose collapsed or plugged.	(2) Remove obstruction or replace hose.
	(3) Plugged heater core.	(3) Remove obstruction or replace core.
	(4) Plugged outlet in thermostat housing.	(4) Remove flash or obstruction.
	(5) Heater bypass hole in cylinder head plugged.	(5) Remove obstruction.
	(6) Heater tubes assembled on core incorrectly.	(6) Mount tubes correctly.

Low Engine Temperature Diagnosis Guide



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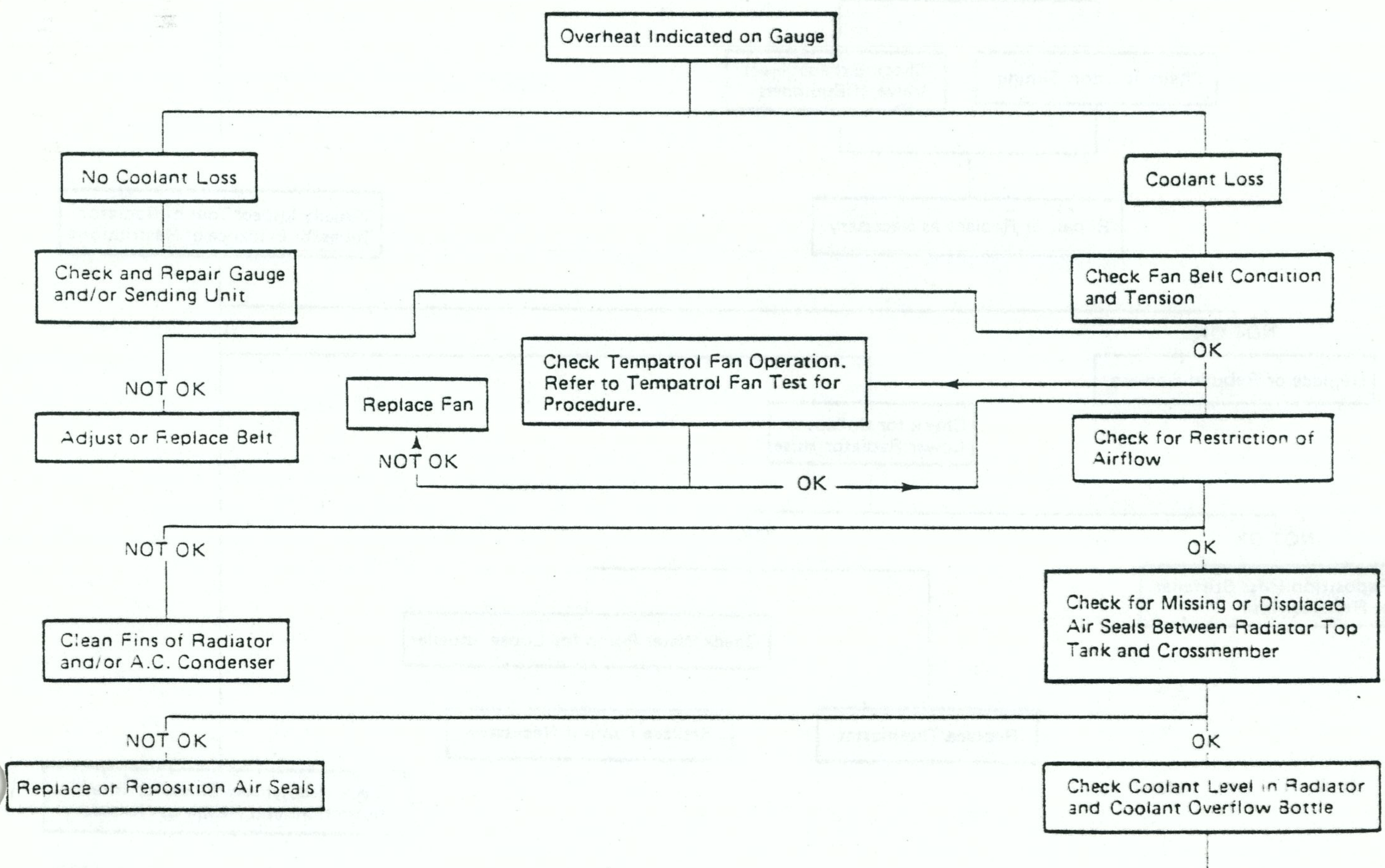
Engine Overheating Diagnosis Guide



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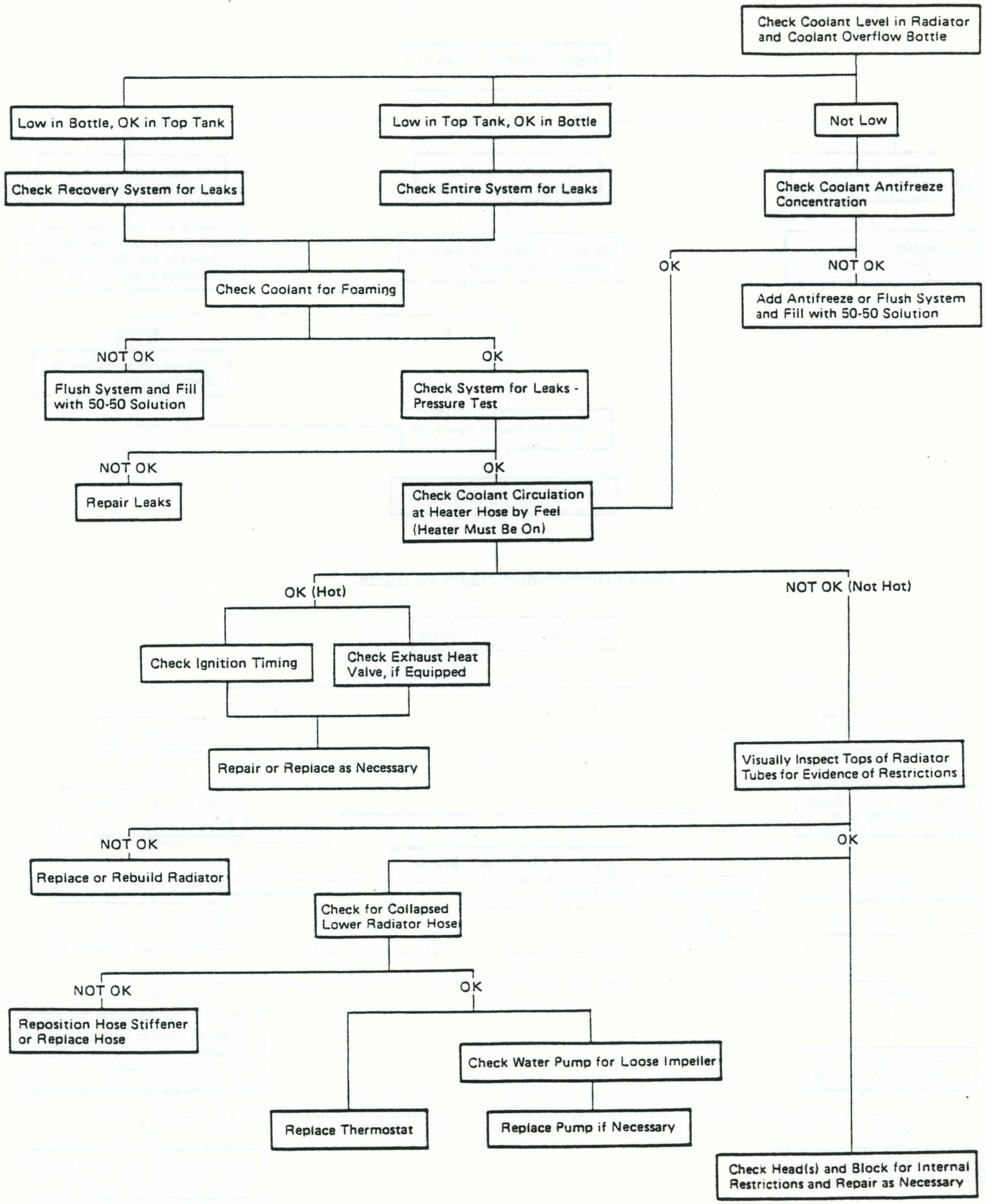
Engine Overheating Diagnosis Guide (Continued)



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(1) Carefully remove radiator pressure cap from filler neck and check coolant level.

NOTE: *Push down on the cap to disengage from the stop tabs.*

(2) Wipe inside of filler neck and examine lower inside sealing seat for nicks, cracks, paint, dirt and solder bumps.

(3) Inspect overflow tube for internal obstructions. Insert a wire through tube to ensure it is clear.

(4) Inspect cams on outside of filler neck. If cams are bent, seating of pressure cap valve and tester seal will be affected. Bent cams can be reformed if done carefully.

(5) Attach pressure tester to filler neck (fig. 1C-15). **Do not force.**

(6) Operate tester pump to apply 15 psi (103.4 kPa) pressure to system. If hoses swell excessively while testing, replace as necessary.

(7) Observe gauge pointer:

(a) **Holds Steady:** If pointer remains steady for two minutes, there are no serious leaks in the system.

NOTE: *There may be an internal leak that does not appear with normal system pressure. If it is certain that coolant is being lost and no leaks can be detected, check for interior leakage or perform Combustion Leakage Test.*

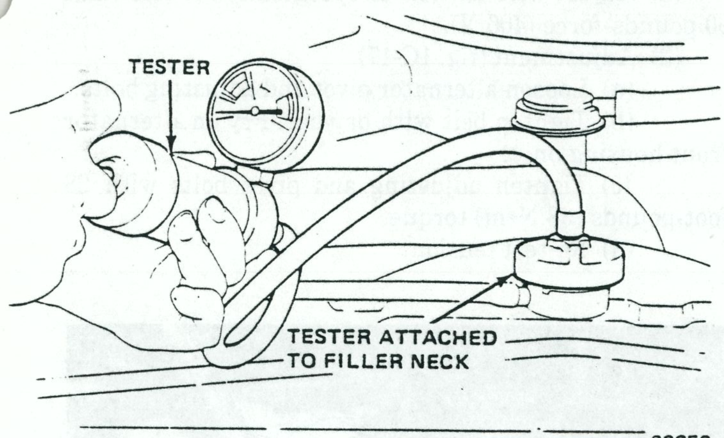

Fig. 1C-15 Cooling System Pressure Test

(b) **Drops Slowly:** Indicates presence of small leaks or seepage. Examine all connections for seepage or slight leakage with a flashlight. Check radiator, hose, gaskets and heater. Seal small leaks with AMC Sealer Lubricant, or equivalent. Repair leaks and recheck system.

(c) **Drops Quickly:** Indicates that serious leakage is present. Examine system for serious external leakage. If no leaks are visible, check for internal leakage.

NOTE: *Large radiator leaks should be repaired by a reputable radiator repair shop.*

Inspecting for Internal Leakage

(1) Remove oil pan drain plug and drain small amount of engine oil (coolant, being heavier, should drain first), or operate engine to churn oil, then examine dipstick for water globules.

(2) Inspect transmission dipstick for water globules.

(3) Inspect transmission fluid cooler for leakage. Refer to Transmission Fluid Cooler Leakage Test.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(4) Operate engine without pressure cap on radiator until thermostat opens.

(5) Attach Pressure Tester to filler neck. If pressure builds up quickly, leak exists as result of faulty head gasket or crack. Repair as necessary.

WARNING: *Do not allow pressure to exceed 15 psi (103.4 kPa). Turn engine Off. To release pressure, rock tester from side to side. When removing tester, do not turn tester more than 1/2 turn if system is under pressure.*

(6) If there is no immediate pressure increase, pump Pressure Tester until indicated pressure is within system range. Vibration of gauge pointer indicates compression or combustion leakage into cooling system.

CAUTION: *Do not disconnect spark plug wires while engine is operating.*

(7) Isolate compression leak by shorting each spark plug. Gauge pointer should stop or decrease vibration when spark plug of leaking cylinder is shorted because of the absence of combustion pressure.

CAUTION: *Do not operate engine with spark plug shorted for more than a minute, otherwise catalytic converter may be damaged.*

Testing for Combustion Leakage (Without Pressure Tester)

NOTE: *DO NOT WASTE reusable coolant. If solution is clean and is being drained only to service the cooling system, drain coolant into a clean container for reuse.*

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(1) Drain sufficient coolant to allow thermostat removal.

(2) Disconnect water pump drive belt.

(3) **Four- and Eight-Cylinder Engine:** Remove thermostat housing cover and remove thermostat.

Six-Cylinder Engine: Disconnect upper radiator hose from thermostat housing, remove thermostat and install thermostat housing on cylinder head.

(4) Add coolant to engine to bring level within 1/4 inch (6.3 mm) of top of thermostat housing.

CAUTION: *Avoid overheating. Do not operate engine for an excessive period of time. Open draincock immediately after test to eliminate boilover.*

(5) Start engine and accelerate rapidly to approximately 3000 rpm three times while observing coolant. If any internal engine combustion leaks to cooling system exist, bubbles will appear in coolant. If bubbles do not appear, there are no internal leaks.

Transmission Fluid Cooler Leakage Test

Transmission Fluid cooler leaks can be detected by the presence of transmission fluid in the coolant. If fluid appears in the coolant, check the fluid level of the automatic transmission. If the fluid level is low, check the fluid cooler as follows:

(1) Remove transmission-to-cooler lines at radiator.

(2) Plug one fitting in cooler.

(3) Remove radiator cap and ensure radiator is filled with coolant.

(4) Apply shop air pressure (50 to 100 psi [344 to 690 kPa]) to other fitting on cooler.

CAUTION: *Because of high fluid pressure, conventional soldering must not be used for fluid cooler repair. All repairs must be silver-soldered or brazed.*

Bubbles in coolant at filler neck indicate a leak in fluid cooler. If a transmission fluid cooler leak is discovered, remove radiator for cooler repair. Unsolder outlet tank for access to fluid cooler.

DRIVE BELT ADJUSTMENTS

General

After the need for adjustment has been determined, drive belts are adjusted by pivoting the driven component in its mount to achieve the desired tension. In some applications, a belt may drive several components or, for California six-cylinder engines, a single serpentine drive belt drives all components. It is necessary to loosen and pivot only one component.

(1) Locate drive belt that is to be tested for correct tension.

(2) Test tension with Gauge J-23600 (fig. 1C-16).

(3) If necessary, adjust drive belt.

(4) Test tension after adjustment.

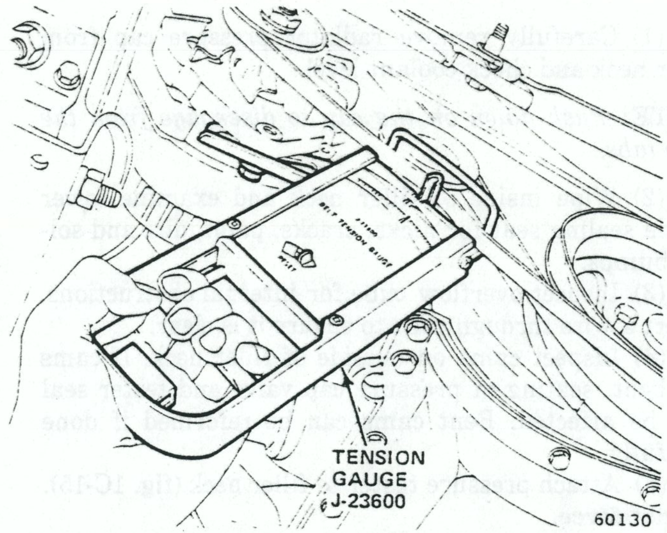

Fig. 1C-16 Testing Drive Belt Tension—Typical

Four-Cylinder Engine

Alternator and Fan (without Air Conditioner)

(1) Position Tension Gauge J-23600 on upper section of belt midway between alternator pulley and fan pulley. Test belt tension according to instructions on gauge.

(2) Adjust belt tension to specification if less than 90 pounds-force (400 N).

(3) Adjustment (fig. 1C-17).

(a) Loosen alternator pivot and adjusting bolts.

(b) Tighten belt with pry bar. Pry on alternator front housing only.

(c) Tighten adjusting and pivot bolts with 28 foot-pounds (38 N•m) torque.

(d) Re-test tension.

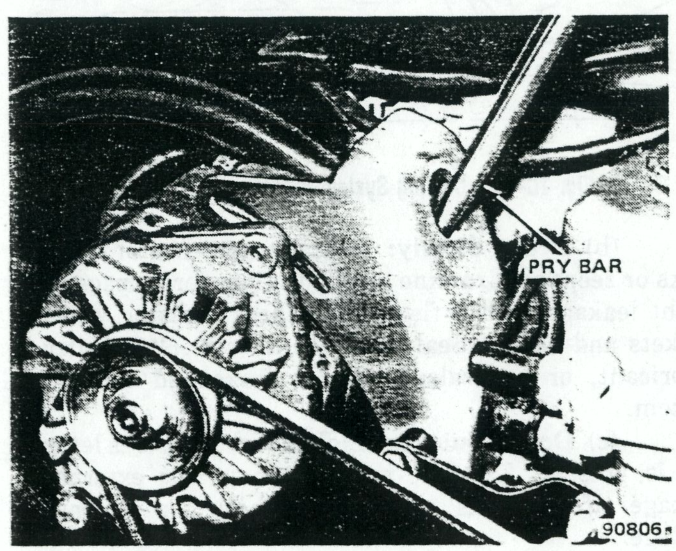

Fig. 1C-17 Four-Cylinder Engine Alternator Drive Belt Adjustment

Power Steering Pump

(1) Position Tension Gauge J-23600 on upper section of belt midway between pump pulley and fan pulley. Test belt tension according to instructions on gauge.

(2) Adjust belt tension to specification if less than 90 pounds-force (400 N).

(3) Adjustment (fig. 1C-18).

(a) Loosen pump-to-mounting bracket locknuts.

(b) Loosen pivot bolts.

(c) Insert drive lug of 1/2-inch drive ratchet into adjustment hole and pivot pump to tighten belt.

(d) Tighen nuts and pivot bolt with 28 foot-pounds (38 N•m) torque.

(e) Re-test tension.

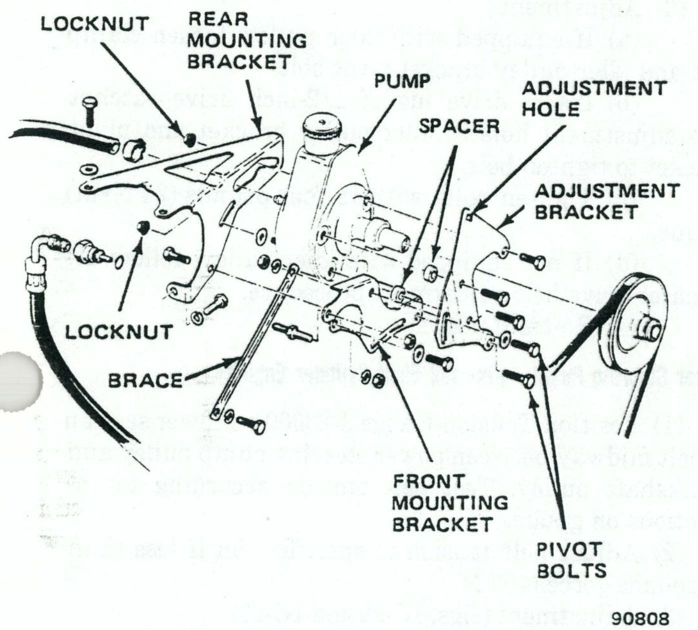

Fig. 1C-18 Four-Cylinder Engine Power Steering Pump Drive Belt Adjustment

Six- and Eight-Cylinder Engine

Alternator and Fan (Six-Cylinder Engine without Air Conditioner and All Eight-Cylinder Engines)

(1) Position Tension Gauge J-23600 on upper section of belt midway between alternator pulley and fan pulley. Test belt tension according to instructions on gauge.

(2) Adjust belt tension to specification if less than 90 pounds-force (400 N).

(3) Adjustment (fig. 1C-19 and 1C-20).

(a) Loosen alternator pivot and adjusting bolts.

(b) Tighten belt with pry bar. Pry on alternator front housing only.

(c) Tighten adjusting bolt with 18 foot-pounds (24 N•m) torque. Tighten pivot bolt with 28 foot-pounds (38 N•m) torque.

(d) Re-test tension.

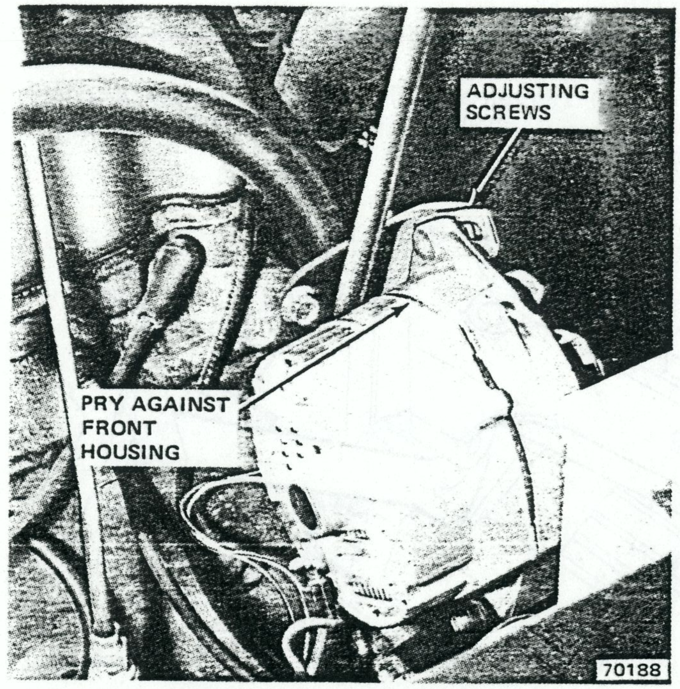

Fig. 1C-19 Six-Cylinder Engine (w/o A/C) Alternator Drive Belt Adjustment

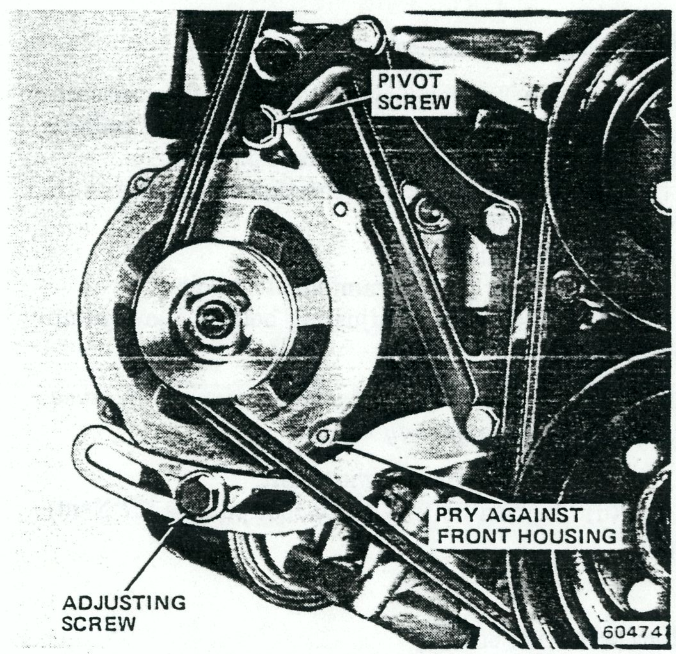

Fig. 1C-20 Eight-Cylinder Engine Alternator Drive Belt Adjustment

Alternator and Fan (Six-Cylinder Engine with Air Conditioner)

(1) Position Tension Gauge J-23600 on section of belt adjacent to inner fender panel. Test belt tension according to instructions on gauge.

(2) Adjust belt tension to specification if less than 90 pounds-force (400 N).

(3) Adjustment (fig. 1C-21).

(a) From underside of engine compartment, loosen lower mounting bracket pivot nut and adjusting bolt.

(b) Insert pry bar into hole in bottom of bracket and pry to tighten belt.

(c) Tighten adjusting bolt with 18 foot-pounds (24 N•m) torque. Tighten pivot nut with 28 foot-pounds (38 N•m) torque.

(d) Re-test tension.

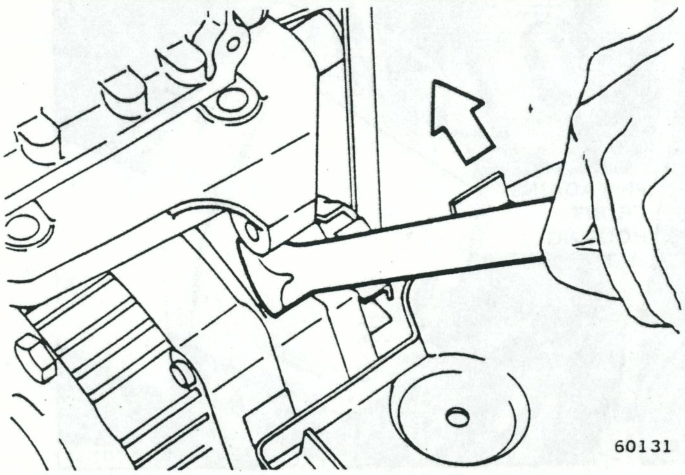

Fig. 1C-21 Six-Cylinder Engine (w/A/C) Alternator Drive Belt Adjustment

Air Pump (without Power Steering)

(1) Position Tension Gauge J-23600 on upper section of belt midway between air pump pulley and fan pulley. Test tension according to instructions on gauge.

(2) Adjust belt tension to specification if less than 60 pounds-force (267 N).

(3) Adjustment.

(a) Loosen lower retaining/pivot bolt.

(b) Loosen upper adjusting bolt to allow pump to be moved.

CAUTION: *Do not pry against sides of pump because internal pump damage may result.*

(c) Raise pump to tighten belt.

(d) Tighten bolts with 20 foot-pounds (27 N•m) torque.

(e) Re-test tension.

Air Pump (with Power Steering)

(1) Remove flexible tube attached to air cleaner snorkel.

(2) Position Tension Gauge J-23600 on outer section of belt (adjacent to inner fender panel) midway between power steering pump pulley and air pump pulley. Test belt tension according to instructions on gauge.

(3) Adjust belt tension to specification if less than 60 pounds-force (267 N).

(4) Adjustment.

(a) Loosen upper adjusting bolt.

(b) Loosen lower pivot nut to allow pump to be moved.

CAUTION: *Do not pry against sides of pump because internal pump damage may result.*

(c) Raise pump to tighten belt.

(d) Tighten adjusting bolt with 20 foot-pounds (27 N•m) torque. Tighten pivot nut with 15 foot-pounds (20 N•m) torque.

(e) Re-test tension.

Air Conditioner Compressor

(1) Position Tension Gauge J-23600 on upper section of belt midway between compressor pulley and either idler pulley or alternator pulley. Test belt tension according to instructions on gauge.

(2) Adjust belt tension to specification if less than 90 pounds-force (400 N).

(3) Adjustment.

(a) If equipped with idler pulley, loosen clamp bolt and idler pulley bracket pivot bolt.

(b) Insert drive lug of 1/2-inch drive ratchet into adjustment hole in idler pulley bracket and pivot bracket to tighten belt.

(c) Tighten bolts with 18 foot-pounds (24 N•m) torque.

(d) If not equipped with idler pulley, follow alternator drive belt adjustment procedure.

(e) Re-test tension.

Power Steering Pump—Six- and Eight-Cylinder Engines

(1) Position Tension Gauge J-23600 on lower section of belt midway between power steering pump pulley and crankshaft pulley. Test belt tension according to instuctions on gauge.

(2) Adjust belt tension to specification if less than 90 pounds-force (400 N).

(3) Adjustment (figs. 1C-22 and 1C-23).

(a) Loosen air pump drive belt (refer to Air Pump Drive Belt Adjustment).

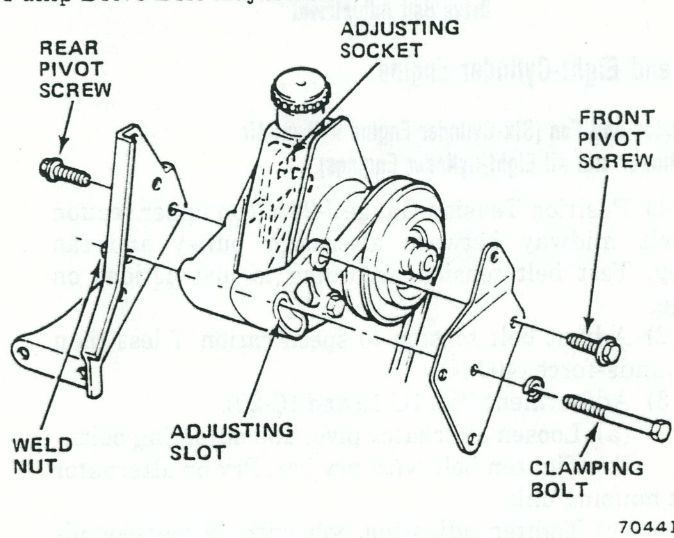

Fig. 1C-22 Six-Cylinder Engine Power Steering Pump Drive Belt Adjustment

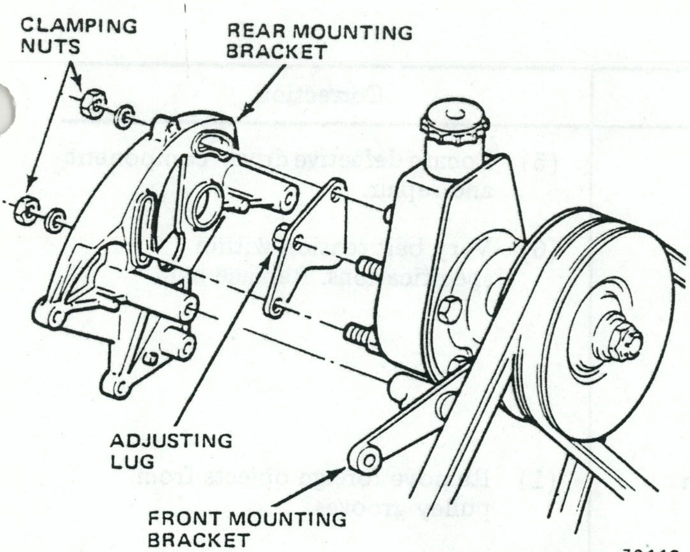

Fig. 1C-23 Eight-Cylinder Engine Power Steering Pump Drive Belt Adjustment

(b) Loosen adjusting bolts that attach power steering pump bracket to adaptor plates.

NOTE: *The bolt that attaches pump bracket to rear adaptor plate is located behind rear adaptor plate flange.*

(c) Insert drive lug of 1/2-inch drive ratchet into adjustment hole in bracket and pivot bracket to tighten belt.

(d) Tighten bolts with 30 foot-pounds (41 N•m) torque.

(e) Re-test tension.

(f) Adjust air pump drive belt (refer to Air Pump Drive Belt Adjustment).

Serpentine Drive Belt (California Only)

(1) Position Tension Gauge J-23600-B on largest accessible span of belt. Test belt tension according to manufacturer's instructions.

(2) Adjust belt tension to specification if less than 140 pounds-force (623 N).

(3) Adjustment.

(a) Loosen alternator adjustment and pivot bolts.

CAUTION: *Maintain a clearance of at least 1.2 inches (30.5 mm) between power steering pump body and air pump body. A 1.2-inch (30.5 mm) block gauge may prove useful to rapidly establish clearance between pumps. Do not use power steering pump to increase belt tension.*

(b) Tighten belt with pry bar. Pry on alternator front housing only.

(c) Tighten adjustment and pivot bolts with 28 foot-pounds (38 N•m) torque.

(d) Re-test tension.

NOTE: *Because of the higher tension required for serpentine drive belts, a helper may be necessary for belt adjustment.*

SERPENTINE DRIVE BELT DIAGNOSIS

Refer to diagnosis chart when servicing serpentine drive belts.

Serpentine Drive Belt Diagnosis

Condition	Possible Cause	Correction
TENSION SHEETING FABRIC FAILURE (WOVEN FABRIC ON OUTSIDE CIRCUMFERENCE OF BELT HAS CRACKED OR SEPARATED FROM BODY OF BELT)	(1) Grooved or backside idler pulley diameters are less than minimum recommended.	(1) Replace pulley(s) not conforming to specification.
	(2) Tension sheeting contacting stationary object.	(2) Correct rubbing condition.
	(3) Excessive heat causing woven fabric to age.	(3) Replace belt.
	(4) Tension sheeting splice has fractured.	(4) Replace belt.
NOISE (OBJECTIONAL SQUEAL, SQUEAK, OR RUMBLE IS HEARD OR FELT WHILE DRIVE BELT IS IN OPERATION)	(1) Belt slippage.	(1) Adjust belt.
	(2) Bearing noise.	(2) Locate and repair.
	(3) Belt misalignment.	(3) Align belt/pulley(s).
	(4) Belt-to-pulley mismatch.	(4) Install correct belt.

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Condition	Possible Cause	Correction
NOISE (OBJECTIONAL SQUEAL, SQUEAK, OR RUMBLE IS HEARD OR FELT WHILE DRIVE BELT IS IN OPERATION) (Continued)	(5) Driven component induced vibration.	(5) Locate defective driven component and repair.
	(6) System resonant frequency induced vibration.	(6) Vary belt tension within specifications. Replace belt.
RIB CHUNKING (ONE OR MORE RIBS HAS SEPARATED FROM BELT BODY)	(1) Foreign objects imbedded in pulley grooves.	(1) Remove foreign objects from pulley grooves.
	(2) Installation damage.	(2) Replace belt.
	(3) Drive loads in excess of design specifications.	(3) Adjust belt tension.
	(4) Insufficient internal belt adhesion.	(4) Replace belt.
RIB OR BELT WEAR (BELT RIBS CONTACT BOTTOM OF PULLEY GROOVES)	(1) Pulley(s) misaligned.	(1) Align pulley(s).
	(2) Mismatch of belt and pulley groove widths.	(2) Replace belt.
	(3) Abrasive environment.	(3) Replace belt.
	(4) Rusted pulley(s).	(4) Clean rust from pulley(s).
	(5) Sharp or jagged pulley groove tips.	(5) Replace pulley.
	(6) Rubber deteriorated.	(6) Replace belt.
LONGITUDINAL BELT CRACKING (CRACKS BETWEEN TWO RIBS)	(1) Belt has mistracked from pulley groove.	(1) Replace belt.
	(2) Pulley groove tip has worn away rubber to tensile member.	(2) Replace belt.
BELT SLIPS	(1) Belt slipping because of insufficient tension.	(1) Adjust tension.
	(2) Belt or pulley subjected to substance (belt dressing, oil, ethylene glycol) that has reduced friction.	(2) Replace belt and clean pulleys.
	(3) Driven component bearing failure.	(3) Replace faulty component bearing.
	(4) Belt glazed and hardened from heat and excessive slippage.	(4) Replace belt.

81102B

Condition	Possible Cause	Correction
"GROOVE JUMPING" (BELT DOES NOT MAINTAIN CORRECT POSITION ON PULLEY, OR TURNS OVER AND/OR RUNS OFF PULLEYS)	(1) Insufficient belt tension.	(1) Adjust belt tension.
	(2) Pulley(s) not within design tolerance.	(2) Replace pulley(s).
	(3) Foreign object(s) in grooves.	(3) Remove foreign objects from grooves.
	(4) Excessive belt speed.	(4) Avoid excessive engine acceleration.
	(5) Pulley misalignment.	(5) Align pulley(s).
	(6) Belt-to-pulley profile mismatched.	(6) Install correct belt.
	(7) Belt cordline is distorted.	(7) Replace belt.
BELT BROKEN (NOTE: IDENTIFY AND CORRECT PROBLEM BEFORE NEW BELT IS INSTALLED)	(1) Excessive tension.	(1) Replace belt and adjust tension to specification.
	(2) Tensile members damaged during belt installation.	(2) Replace belt.
	(3) Belt turnover.	(3) Replace belt.
	(4) Severe misalignment.	(4) Align pulley(s).
	(5) Bracket, pulley, or bearing failure.	(5) Replace defective component and belt.
CORD EDGE FAILURE (TENSILE MEMBER EXPOSED AT EDGES OF BELT OR SEPARTED FROM BELT BODY)	(1) Excessive tension.	(1) Adjust belt tension.
	(2) Drive pulley misalignment.	(2) Align pulley.
	(3) Belt contacting stationary object.	(3) Correct as necessary.
	(4) Pulley irregularities.	(4) Replace pulley.
	(5) Improper pulley construction.	(5) Replace pulley.
	(6) Insufficient adhesion between tensile member and rubber matrix.	(6) Replace belt and adjust tension to specifications.
SPORADIC RIB CRACKING (MULTIPLE CRACKS IN BELT RIBS AT RANDOM INTERVALS)	(1) Ribbed pulley(s) diameter less than minimum specification.	(1) Replace pulley(s).
	(2) Backside bend flat pulley(s) diameter below minimum.	(2) Replace pulley(s).
	(3) Excessive heat condition causing rubber to harden.	(3) Correct heat condition as necessary.
	(4) Excessive belt thickness.	(4) Replace belt.
	(5) Belt overcured.	(5) Replace belt.
	(6) Excessive tension.	(6) Adjust belt tension.

81102C

SPECIFICATIONS

Cooling System Specifications

	Four-Cylinder Engine		Six-Cylinder Engine		Eight-Cylinder Engine	
	USA	Metric	USA	Metric	USA	Metric
Radiator Cap Relief Pressure	15 psi	103 kPa	15 psi	103 kPa	15 psi	103 kPa
Thermostat						
Rating	195°F	91°C	195°F	91°C	195°F	91°C
Must be open 0.003 inch (0.076mm) at	192°-198°F	89°-92°C	192-198°F	89-92°C	192-198°F	89-92°C
Fully open	218°F	103°C	218°F	103°C	218°F	103°C
Water Pump						
Type	Centrifugal		Centrifugal		Centrifugal	
Drive	V-Belt		V-Belt*		V-Belt	
Radiator						
Type	Tube & Spacer		Tube & Fin		Tube & Fin	
Cooling System Capacities (includes 1 quart for heater)	7.8 qts.	7.1 liters	10.5 qts.	9.9 liters	13.0 qts. (11.6 imp. qts.) 304 CID engine 14.0 qts. (10.8 imp. qts.) 360 CID engine	12.3 liters 13.2 liters
Fan						
Number of Blades			Refer to Cooling System Components Chart			
Diameter			Refer to Cooling System Components Chart			
Drive Belt						
Angle of V	36°		38°		38°	
Width—top of groove	0.38 in.	9.65mm	0.391-0.453 in.	9.931-11.506 mm	0.391-0.453 in.	9.931-11.506 mm
Type (plain or cogged)	plain		plain		plain	
Serpentine						
Number of Ribs			6			
Rib Angle			40°			
Rib Width			0.14 in.	3.56mm		

* California: Serpentine Drive Belt

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Cooling System Components

Model	Cooling Package			Engine				Transmission		Radiator		Fan				Shroud
	STD	HD	AC	151	258	304	360	Man.	Auto.	Fins Per Inch	Rows of Tubes	Diam. (Inches)	No. of Blades	Spacer (Inches)	Tempa-trol	
	●				●			●		8	2	16.25③	4	0.88		
	●				●				●①	9	2	16.25③	4	0.88		
		●②			●			●		15	2	15.62	7	1.22		●
CJ-5		●②			●				●①	15	2	15.62	7	1.22		●
85			●②		●			●		15	2	15.62	7	1.22		●
			●②		●				●①	15	2	15.62	7	1.22		●
CJ-7	●					●		●		10.5	2	19.00	4	1.50		
87	●					●			●①	12	2	19.00	4	1.50		
		●	●			●		●		16	2	19.50	7		●	●
		●	●			●			●①	16	2	19.50	7		●	●
	●			●					●①	13	2	15.00	4	1.70		●
		●		●					●①	16	2	16.00	7		●	●
	●			●				●		11	2	15.00	4	1.70		●
		●		●				●		13	2	16.00	7		●	●
	●				●			●		9	2	16.25③	4	0.88		
	●				●				●	10	2	16.25③	4	0.88		
Wagoneer		●			●			●		15	2	19.50③	7		●	●
15		●			●				●	15	2	19.50③	7		●	●
			●		●			●		15	2	19.50③	7		●	●
Cherokee			●		●				●	15	2	19.50③	7		●	●
16, 17, 18	●						●	●		11.5	2	19.50	7		●	
	●						●		●	12.5	2	19.50	7		●	
Truck		●					●	●		16	2	19.50	7		●	●
25, 26, 27		●					●		●	16	2	19.50	7		●	●
			●				●	●		16	2	19.50	7		●	●
			●				●		●	16	2	19.50	7		●	●

NOTE: All radiator caps are rated at 15 psi (103 kPa)
① Not applicable to CJ-5 vehicles
② Not available in California
③ California: Reverse Rotation

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Engine Drive Belt Tension

	Initial Pounds-Force New Belt	Reset Pounds-Force Used Belt	Initial Newtons New Belt	Reset Newtons Used Belt
Air Conditioner				
All	125-155	90-115	556-689	400-512
Air Pump				
All except six-cylinder w/PS	125-155	90-115	556-689	400-512
Six-Cylinder w/PS (3/8-inch belt)	65-75	60-70	289-334	267-311
Fan And Alternator	125-155	90-115	556-689	400-512
Power Steering Pump	125-155	90-115	556-689	400-512
Serpentine Drive Belt (Six-cylinder engine California)	180-200	140-160	800-890	623-712

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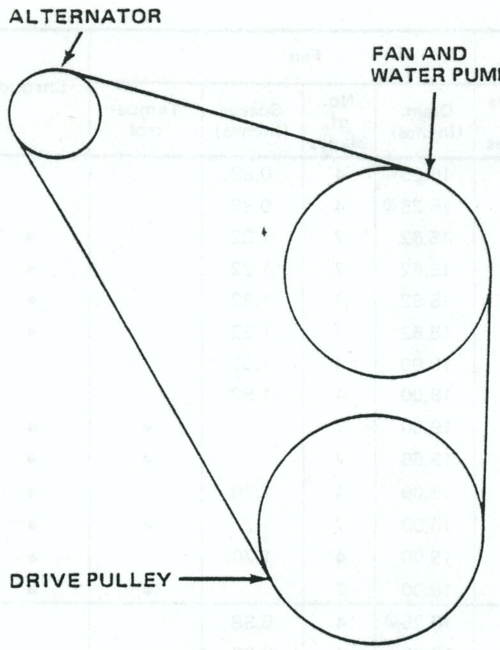
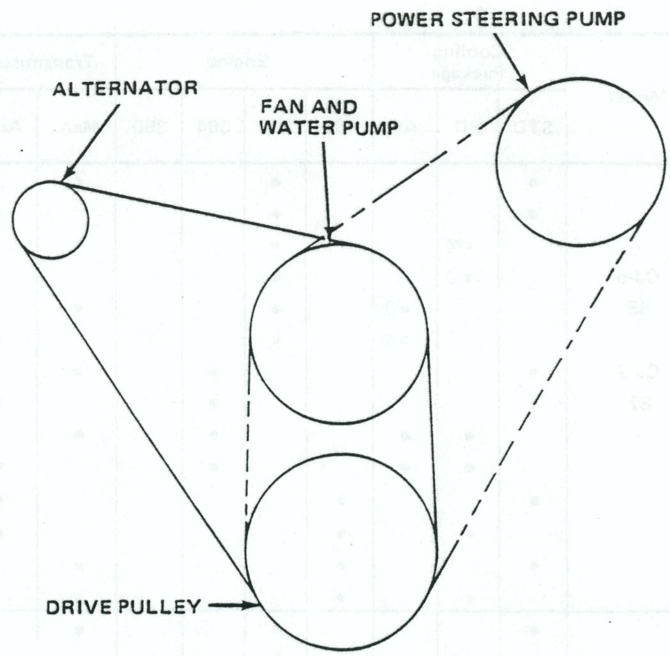
Engine Drive Belt Arrangements



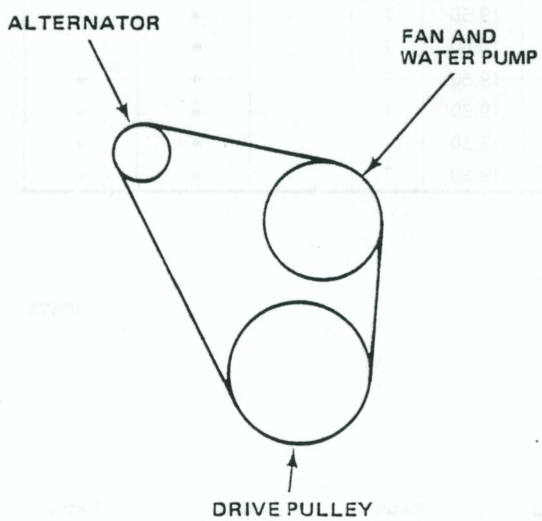
FOUR-CYLINDER ENGINE
BASIC BELT ARRANGEMENT

70708A



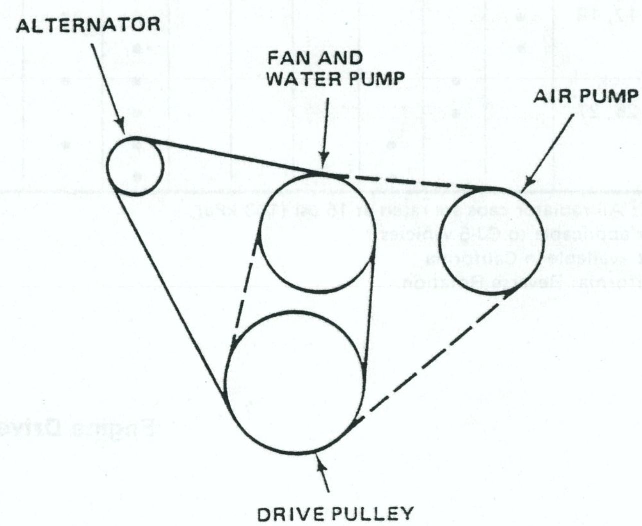
FOUR-CYLINDER ENGINE WITH
ALTERNATOR AND POWER STEERING

70708B



SIX-CYLINDER ENGINE
BASIC BELT ARRANGEMENT

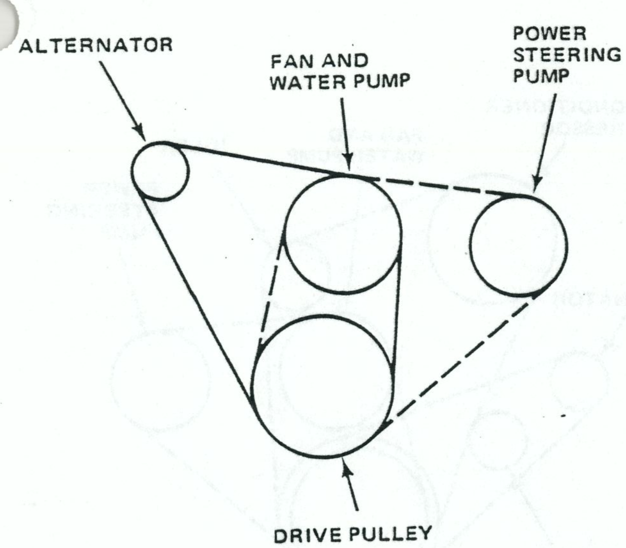
80415A



SIX-CYLINDER ENGINE WITH
ALTERNATOR AND AIR PUMP

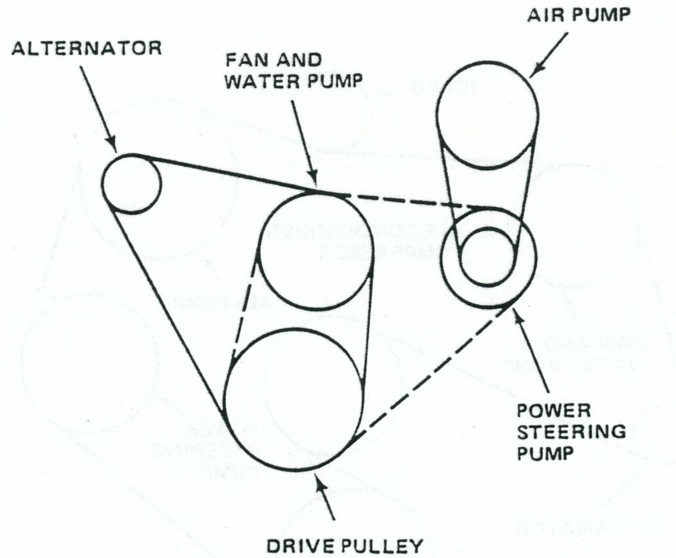
80415B

LEGEND
FRONT BELT ————
MIDDLE BELT — — —
REAR BELT – – – – –



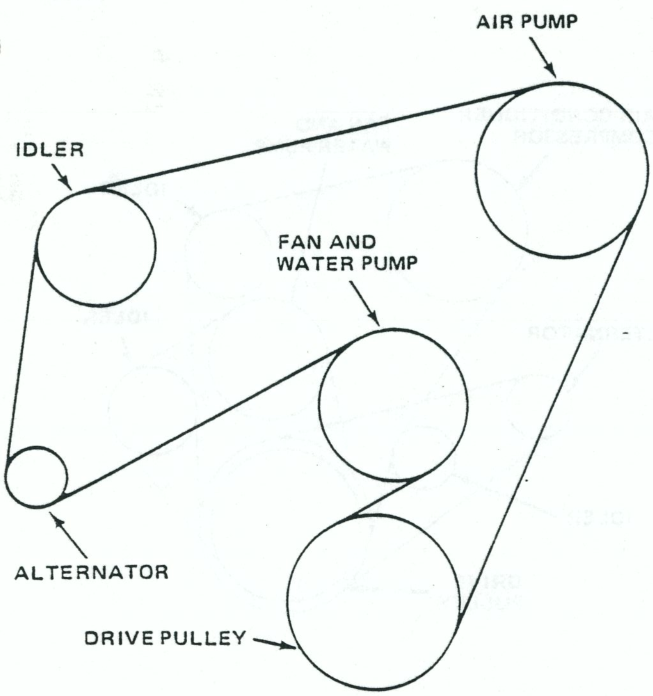
SIX-CYLINDER ENGINE WITH ALTERNATOR
AND POWER STEERING

80415C



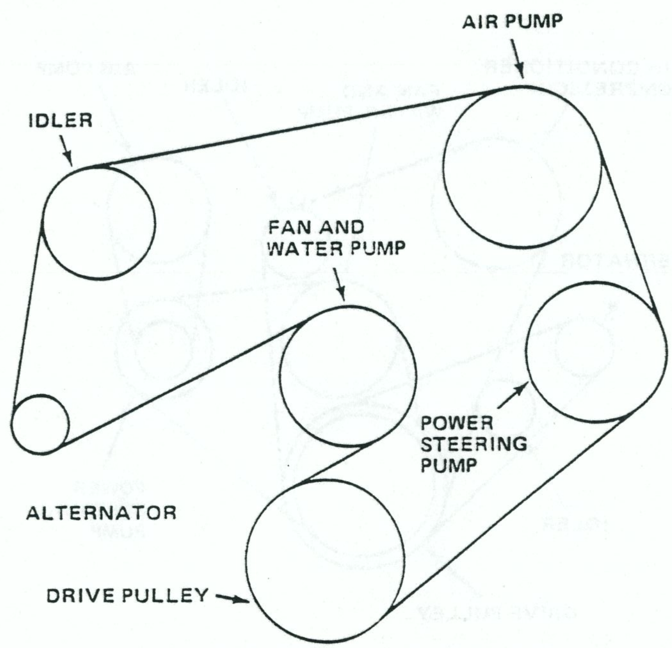
SIX-CYLINDER ENGINE WITH ALTERNATOR
POWER STEERING AND AIR PUMP

80415D



SIX-CYLINDER ENGINE WITH
SERPENTINE DRIVE, ALTERNATOR
AND AIR PUMP

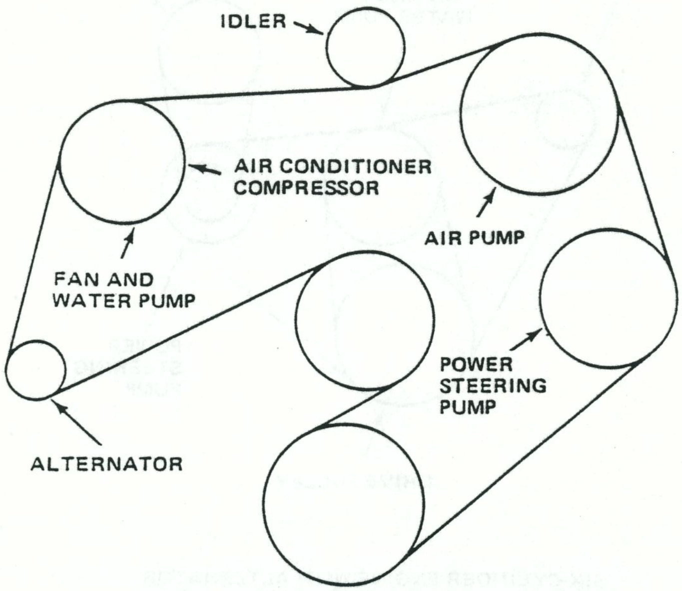
80415J



SIX-CYLINDER ENGINE WITH
SERPENTINE DRIVE, ALTERNATOR,
POWER STEERING AND AIR PUMP

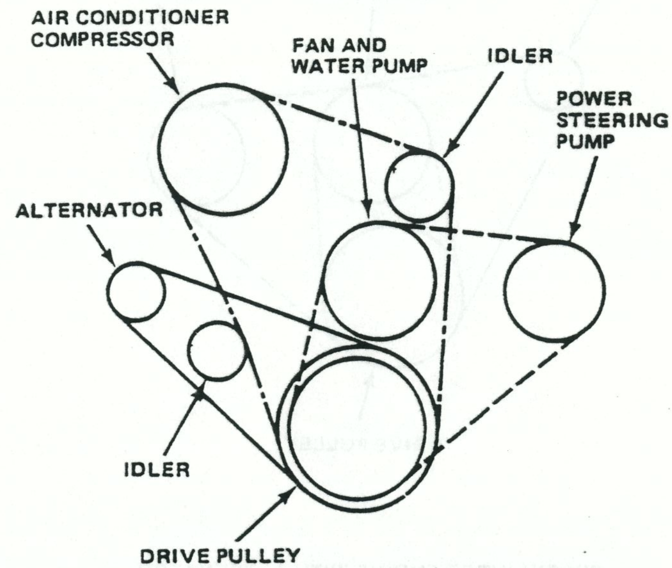
80415K

LEGEND
FRONT BELT ————
MIDDLE BELT —·—·—
REAR BELT — — — —



SIX-CYLINDER ENGINE WITH SERPENTINE DRIVE, ALTERNATOR, AIR CONDITIONING, POWER STEERING AND AIR PUMP

80415M



SIX-CYLINDER ENGINE WITH ALTERNATOR, AIR CONDITIONING AND POWER STEERING

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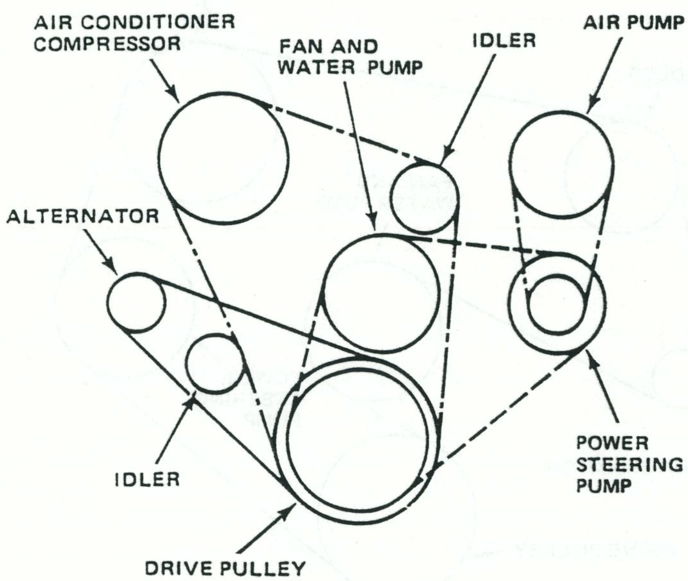

SIX-CYLINDER ENGINE WITH ALTERNATOR, POWER STEERING, AIR PUMP AND AIR CONDITIONING

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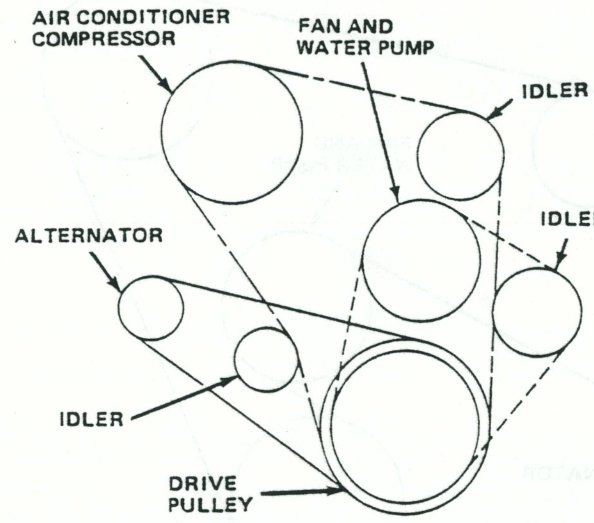

SIX-CYLINDER ENGINE WITH ALTERNATOR AND AIR CONDITIONER

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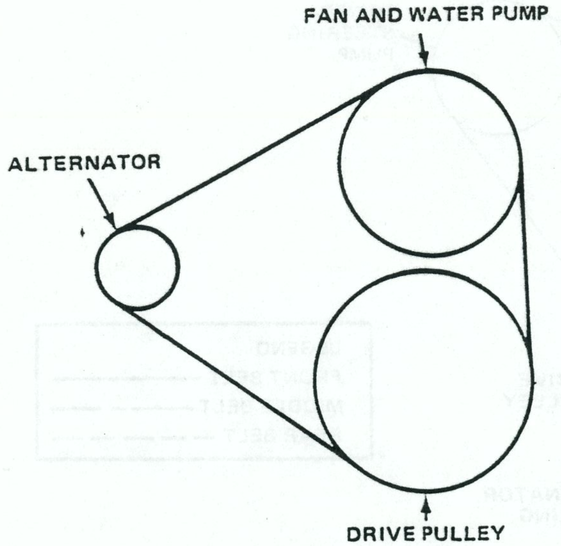
LEGEND
FRONT BELT ————
MIDDLE BELT —— - ——
REAR BELT — — — —



EIGHT-CYLINDER ENGINE
BASIC BELT ARRANGEMENT

NOTE: 10 SI ALTERNATOR – 1 BELT
15 SI ALTERNATOR – 2 BELTS

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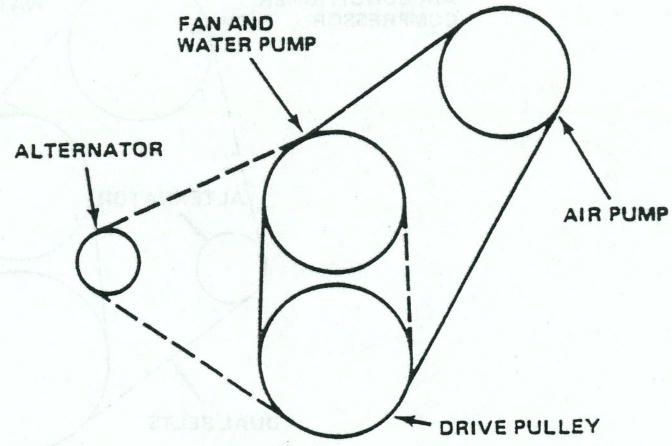

EIGHT-CYLINDER ENGINE WITH
ALTERNATOR AND AIR PUMP

NOTE: 10 SI ALTERNATOR – 1 BELT
15 SI ALTERNATOR – 2 BELTS

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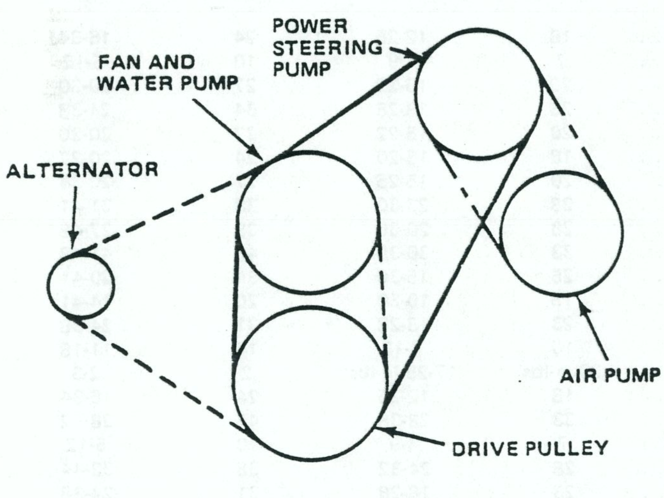

EIGHT-CYLINDER ENGINE WITH ALTERNATOR,
AIR PUMP AND POWER STEERING

NOTE: 10 SI ALTERNATOR – 1 BELT
15 SI ALTERNATOR – 2 BELTS

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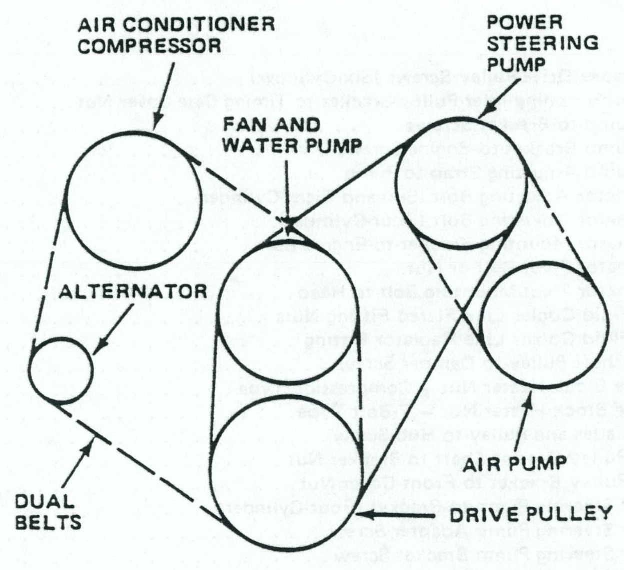
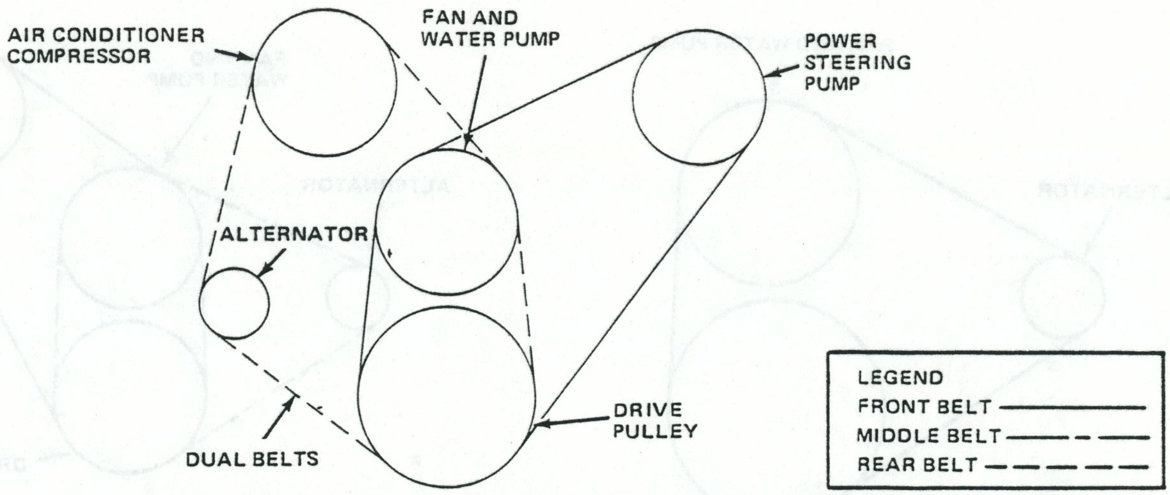


EIGHT-CYLINDER ENGINE WITH ALTERNATOR,
AIR PUMP, AIR CONDITIONING, AND POWER STEERING

90977G

LEGEND
FRONT BELT ————
MIDDLE BELT — — —
REAR BELT — — — — —



EIGHT-CYLINDER ENGINE WITH ALTERNATOR, AIR CONDITIONING AND POWER STEERING

90977H

Torque Specifications

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-tightened item.

	USA (ft-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	Service Set-To Torque	Service In-Use Recheck Torque
Accessory Drive Pulley Screws (Six-Cylinder)	18	12-25	24	16-34
Air Conditioning Idler Pulley Bracket to Timing Case Cover Nut	7	4-9	10	5-12
Air Pump-to-Bracket Screws	20	15-22	27	20-30
Air Pump Bracket-to-Engine Screws	25	18-28	34	24-38
Air Pump Adjusting Strap to Pump	20	15-22	27	20-30
Alternator Adjusting Bolt (Six- and Eight-Cylinder)	18	15-20	24	20-27
Alternator Adjusting Bolt (Four-Cylinder)	20	15-25	27	20-34
Alternator Mounting Bracket-to-Engine Bolt	28	23-30	38	31-41
Alternator Pivot Bolt or Nut	28	20-35	38	27-48
Alternator Pivot Mounting Bolt to Head	33	30-35	45	41-48
A/T Fluid Cooler Line Flared Fitting Nuts	25	15-30	34	20-41
A/T Fluid Cooler Line Radiator Fitting	15	10-30	20	14-41
Crankshaft Pulley to Damper Screw	23	18-28	31	24-38
Engine Block Heater Nut — Compression Type	10	8-13	14	11-18
Engine Block Heater Nut — T-Bolt Type	20 in-lbs	17-25 in-lbs	2	2-3
Fan Blades and Pulley to Hub Screw	18	12-25	24	16-34
Idler Pulley Bearing Shaft to Bracket Nut	33	28-38	45	38-52
Idler Pulley Bracket to Front Cover Nut	7	4-9	10	5-12
Power Steering Pump-to-Bracket (Four-Cylinder)	28	24-32	38	32-44
Power Steering Pump Adapter Screw	23	18-28	31	24-38
Power Steering Pump Bracket Screw	43	37-47	58	50-64
Power Steering Pump Mounting Screw	28	25-35	38	34-48
Power Steering Pump Pressure Line Nut	30	30-45	41	41-61
Power Steering Pump Pulley Nut	58	40-69	79	54-94
Thermostat Housing (Six- and Eight-Cylinder)	13	10-18	18	14-24
Thermostat Housing (Four-Cylinder)	20	17-23	27	24-30
Timing Case Cover to Block (Eight-Cylinder) (through Water Pump)	25	18-33	34	24-45
Water Pump-to-Block Screws (Six-Cylinder)	13	9-18	18	12-24
Water Pump to Block (Four- and Eight-Cylinder)	25	18-33	34	24-45
Water Pump-to-Timing Case Cover Screen (Eight Cylinder)	48 in-lbs	40-55 in-lbs	5	5-6

All Torque values given in foot-pounds and newton-meters with dry fits unless otherwise specified.

Refer to Standard Torque Specifications and Capscrew Markings Chart in Section A of this manual for any torque specifications not listed above.

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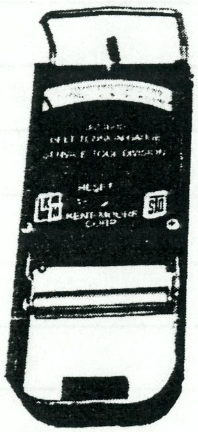
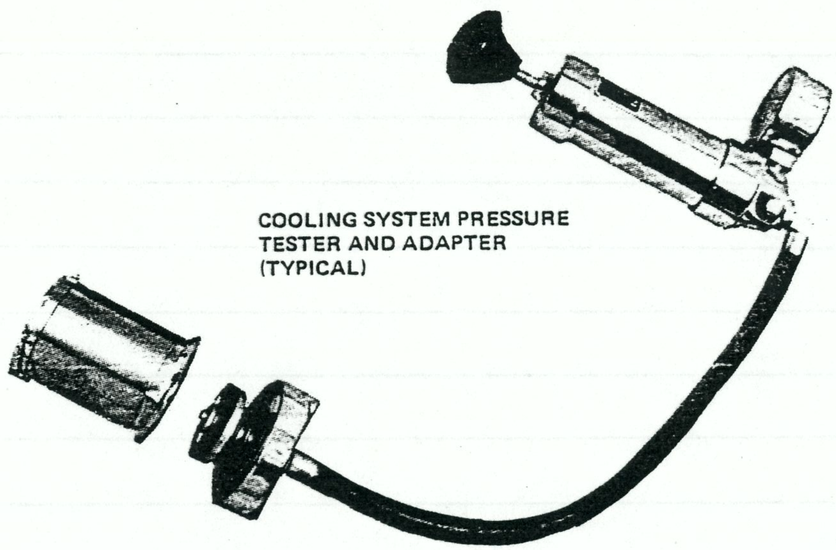
Tools



J-23600
BELT TENSION GAUGE



COOLING SYSTEM PRESSURE
TESTER AND ADAPTER
(TYPICAL)

AJ42005

NOTES

BATTERIES 1D

INDEX

GENERAL

The batteries for 1981 Jeep vehicles are lightweight and have low-antimony/lead compound plates. In addition to helping reduce overall vehicle weight, they require less frequent electrolyte level inspections, have a decreased self-discharge rate from local action and have a longer shelf life. Electrolyte level inspections are required only at the beginning of each winter season and every 15,000 miles (24 000 km).

In addition to the standard equipment 380 cold crank amps battery, a 450 cold crank amps battery is optionally available for vehicles equipped with heavy-duty equipment. Both batteries are 12-volt, lead-acid units.

The vehicle battery tray has a removable spacer that, when removed, will permit the installation of a substitute conventional size group 24 battery in the event a lightweight replacement battery is not available.

NOTE: *A 440 Cold Crank Amps with 135-Minute Reserve Capacity is optionally available for 1981 J-Series vehicles equipped with a Police Package.*

BATTERY CLASSIFICATIONS, RATINGS AND CODES

Group Size Classification

The group size classification provides, by reference to Battery Council International listings or applicable SAE standard, the physical characteristics and electrical criteria for the applicable battery.

Reserve Capacity Minutes Rating

Reserve capacity minutes is defined as the number of minutes a fully charged battery at 80°F (26.7°C) can be discharged at a steady 25 ampere rate until a terminal voltage equivalent to 1.75 volts per cell (10.50 volts total battery voltage) is indicated. The reserve capacity rating for each Jeep battery is either listed on a label or stamped into the battery case. The batteries are also color coded to denote the rating.

Cold Crank Amps Rating

The cold crank amps rating specifies the minimum amps a fully charged battery can deliver at 0°F (-17.7°C) for thirty seconds without the battery terminal voltage dropping below 7.2 volts. The cold crank amps rating is either listed on a label or stamped in the battery case.

Battery Ratings

Group Size	Cold Crank Amps	Reserve Capacity Min.
55-380	380	75
56-450	450	90
24-440	440	135

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Battery Codes

Each battery is date coded at the time of shipment from the manufacturer. This code is stamped into the edge of the plastic case cover (fig. 1D-1). A second code number stamped on the side of the battery case represents manufacturing data and may be ignored.

The date code is decoded as follows:

- **Month:** Jan., Feb., etc.
- **Year:** 80—1980, 81—1981

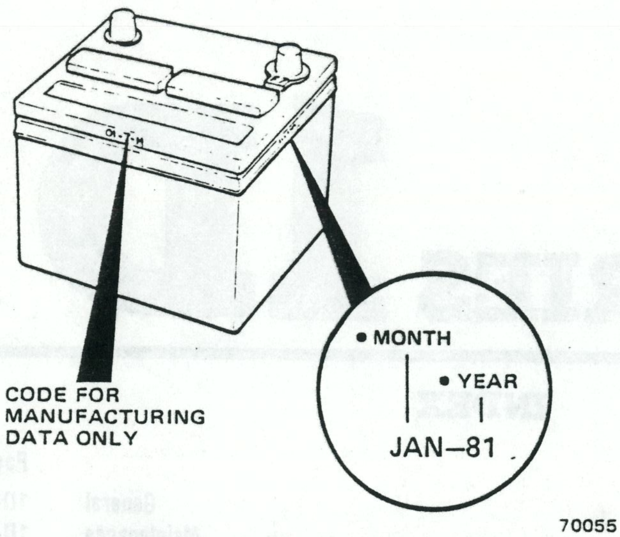

Fig. 1D-1 Date Code Location—Typical

BATTERY REPLACEMENT

Removal

(1) Loosen cable clamps.

(2) Use puller to remove cables if necessary. Remove positive cable first.

WARNING: *Use extreme care to prevent dropping battery and splattering the electrolyte because it can cause severe eye injury and skin burns. Rubber gloves, rubber aprons, protective eye shields and steel-toed shoes will decrease the hazards of this type accident. Immediate first aid is required for electrolyte splashed into the eyes and on the skin. Electrolyte spills should be immediately neutralized with a solution of sodium bicarbonate (baking soda) and water and then thoroughly rinsed with water.*

(3) Loosen holddowns and remove battery.

(4) Inspect cables for corrosion and damage. Remove corrosion using wire brush or post and terminal cleaner and soda solution. Replace cables that have damaged or deformed terminals.

(5) Inspect battery tray and holddowns for corrosion. Remove corrosion using wire brush and soda solution. Paint exposed bare metal. Replace damaged components.

(6) Clean outside of battery case if original battery is to be installed. Clean top cover with a diluted ammonia soda solution to remove acid film. Flush with clean water. Ensure soda solution does not enter cells. Remove corrosion from terminals with wire brush or post and terminal cleaner. Inspect case for cracks or other damage that would result in leakage of electrolyte.

Installation

(1) Refer to Specifications to determine if battery has correct rating for vehicle.

(2) Use hydrometer to test battery electrolyte. Charge if necessary.

CAUTION: *Ensure battery tray is clear of loose hardware or debris that could damage battery case.*

(3) Position battery in tray. Ensure positive and negative terminals are correctly located. Cables must reach their respective terminals without stretching.

(4) Ensure tang at battery base is positioned in tray properly before tightening holddown.

CAUTION: *It is imperative that the cables are connected to the battery positive-to-positive and negative-to-negative. Reverse polarity will damage alternator diodes and radios.*

(5) Connect and tighten positive cable first. Then connect and tighten negative cable.

NOTE: *The tapered positive terminal is 1/16 inch (1.6 mm) larger in diameter than the negative terminal. The opening in the positive cable clamp is correspondingly larger.*

(6) Apply thin coating of petroleum jelly or chassis grease to cable terminals and battery posts.

(7) Inspect negative cable connections on engine and vehicle body for condition, security and electrical continuity.

MAINTENANCE

Always observe the correct polarity when connecting a charger to a battery. Reversed battery connections will damage the alternator diodes and radios. The NEGATIVE battery terminal is grounded to the engine and body.

WARNING: *Explosive gases are present within and around the battery at all times. Avoid open flames and sparks. The danger of battery explosion is compounded by the fact that the acid would be splattered in every direction. Wear protective eye shields and clothing when servicing any battery. Ensure battery has adequate ventilation when charging.*

It is important that the battery be fully charged when a new vehicle is delivered. Maintaining a battery at partial charge could shorten its life.

Inspect electrolyte level in the battery at 15,000 mile (24 000 km) intervals and at the beginning of the winter season. Add distilled water to each cell until the level reaches the bottom of the vent well. DO NOT OVERFILL. Operate the engine immediately after adding water (particularly in cold weather) to assure proper mixing of the water and electrolyte.

Inspect to determine the external condition of the battery and the cables periodically.

The holddown should be tight enough to prevent the battery from vibrating or shifting position and cause damage to the battery case.

CAUTION: *Keep filler caps tight to prevent the neutralizing solution from entering the cells.*

Take particular care to ensure that the top of the battery is free of acid film and dirt between the battery terminals. For best results when cleaning the battery, wash with a diluted ammonia or soda solution to neutralize any acid present and flush with clean water.

To ensure good electrical contact, the battery cables must be tight on the battery posts. Ensure the terminal clamps have not stretched. This could cause the clamp ends to become butted together without actually being tight on the post. If the battery posts or cable terminals are corroded, disconnect the cables by loosening the terminal clamp bolts and remove the terminals with the aid of a puller. Do not twist, hammer or pry on a terminal to free it from the battery post. Clean the terminals and posts with a soda solution and wire brush or post and terminal cleaner. Connect the cable terminal clamps (positive terminal first) to the battery posts and apply a thin coat of petroleum jelly or grease. Inspect the battery negative cable and body ground cable for condition and good electrical continuity with engine and body.

Frozen Electrolyte

WARNING: *Do not attempt to charge or use a booster on a battery with frozen electrolyte. The frozen battery may explode!*

A 75 percent charged battery will not freeze. Maintain batteries at 75 percent charge or more, especially during winter weather.

Replace the battery if the electrolyte becomes either slushy or frozen. A battery in this condition, depending on the severity of the freeze, may accept and retain a charge, and even perform satisfactorily under a load test. However, after 120 to 150 days in service, a reduction in storage capacity and service life will become apparent as the individual plates lose their active material.

Electrolyte Freezing Temperature

Specific Gravity (Corrected to 80° F)	Freezing Temperature
1.270	– 84°F (– 64°C)
1.250	– 62°F (– 52°C)
1.200	– 16°F (– 27°C)
1.150	+ 05°F (– 15°C)
1.100	+ 19°F (– 7°C)

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Battery Storage

All wet cell batteries will discharge slowly from local action when stored. Batteries discharge faster when warm than when cold. For example, at 100°F (37.8°C), a normal self-discharge rate of 0.0024 specific gravity per day can be expected. At 50°F (10°C), a discharge rate of 0.0003 specific gravity per day is normal. Refer to Self-Discharge Rate chart.

Before storage, clean the battery case with a solution of sodium bicarbonate (baking soda) and water, rinse and wipe the case dry. When storing a battery, charge fully (no change in specific gravity after three tests taken at one hour intervals) and store in a cool, dry location. Refer to Charging and Testing.

Fully charge a stored battery before putting it into service. Refer to Charging for procedure. Refer to Battery Replacement for installation procedure.

Self-Discharge Rate

Temperature	Approximate Allowable Self-Discharge Per Day For First Ten Days
100°F (37.8°C)	0.0024 Specific Gravity
80°F (26.7°C)	0.0009 Specific Gravity
50°F (10°C)	0.0003 Specific Gravity

60338

CHARGING

General

A battery stores electrical energy in the form of chemical energy. When it is used to power an electrical device (e.g., a starter motor), the stored energy is released, or discharged, in the form of electrical energy.

The more cells and plate area a battery has, the greater its capacity for storing energy. When the maximum amount of energy is being stored, a battery is commonly said to be "fully charged." The relative amount of charge or stored energy is directly proportional to the specific gravity value of the electrolyte. This allows the use of a hydrometer to determine the state of charge or energy storage level of a battery in relation to the maximum possible charge (full charge).

Dry Charge Battery

WARNING: *Before activating a dry-charged battery, carefully read the instructions and poison/danger warning on the electrolyte carton.*

Do not remove seals until battery is to be activated. Once the seals are removed, the battery must be activated immediately. Discard seals after removal.

Activation Procedure

(1) Fill each cell with battery electrolyte to bottom of well, observing handling precautions listed on electrolyte carton.

(2) After cells are filled, tilt battery from side to side to release air bubbles.

(3) Recheck electrolyte level in each cell and add as necessary.

NOTE: *Uneven filling of cells will affect the battery capacity and service life.*

(4) Install caps supplied with battery.

(5) Inspect battery case for leakage to ensure no damage occurred in handling.

(6) Boost charge battery for 15 minutes at 30 amps or slow charge until battery electrolyte is gassing freely.

(7) Install battery in vehicle. Refer to Battery Replacement-Installation.

NOTE: *Because the apparent state of charge of a battery as indicated by a hydrometer is depressed for the first few cycles, load testing is the only valid test at the time of activation. Hydrometer testing may be used after the battery has been cycled in service.*

The specific gravity of a newly installed Jeep battery will be approximately 1.225 (±0.010). The specific gravity will normally rise to 1.250 to 1.265 after a few days in service.

NOTE: *Electrolyte is composed of sulfuric acid and water. Approximately 35 percent by weight or 24 percent by volume is acid.*

WARNING: *Never add pure acid to a battery.*

Slow Charge

WARNING: *Battery charging generates hydrogen gas, which is highly flammable and explosive. Hydrogen gas is present within and around a battery at all times, even when a battery is in a discharged condition. Keep open flames and sparks (including cigarettes, cigars, pipes) away from the battery. Always wear eye protection when handling, testing or charging a battery.*

Slow charging is the preferred method of recharging a battery. The slow charge method may be safely used, regardless of charge condition of the battery, provided the electrolyte is at the proper level in all cells and is not frozen.

WARNING: *Do not attempt to charge or use a booster on a battery with frozen electrolyte because it can cause the frozen battery to explode.*

The normal charging rate for a lightweight battery is 3 to 5 amps. A minimum period of 24 hours is required when charging at this rate. Charge time is inversely proportional to the temperature of the electrolyte.

A battery may be fully charged by the slow charge method unless it is not capable of accepting a full charge. **A battery is in a maximum charged condition when all cells are gassing freely and three corrected specific gravity tests, taken at one-hour intervals, indicate no increase in specific gravity.**

Fast Charge

CAUTION: *Always disconnect the battery cables before using a fast charger.*

A battery may be charged at any rate that does not cause the electrolyte temperature of any cell to exceed 125°F (51.7°C) and does not cause excessive gassing and loss of the electrolyte.

A fast charger cannot be expected to fully charge a battery within an hour, but will charge the battery sufficiently so that it may be returned to service. The battery will be fully charged by the vehicle charging system, provided the engine is operated a sufficient length of time.

Booster Charging

WARNING: *If the battery electrolyte is not visible or frozen, do not attempt to jump-start because the battery could rupture or explode. The battery must be warmed up to 40°F (4.4°C) and water added if necessary before it can be safely charged or the engine jump-started.*

The correct method for starting an engine with a discharged battery requires either a portable starting unit or a booster battery. When using either method, it is essential that connections be made correctly.

When using a portable starting unit, the voltage must not exceed 16 volts or damage to the battery, alternator, or starter may result. Because of the accompanying high voltage, a fast charger must not be used for jump-starting engines.

(1) Remove vent caps from booster battery and cover cap openings with dampened cloth.

CAUTION: *If the engine is being jump-started with a battery located in another vehicle, the vehicles must not contact each other.*

(2) Connect jumper cable between positive posts of batteries. Positive post has "+" stamped into it. POS is also embossed on battery cover in 1/8-inch letters adjacent to battery post.

(3) Connect one end of second jumper cable to negative terminal of booster battery. NEG is embossed on battery cover in 1/8-inch letters adjacent to battery post. Ensure cable clamps have good electrical contact with posts. **DO NOT CONNECT OTHER END OF JUMPER CABLE TO NEGATIVE TERMINAL OF DISCHARGED BATTERY.** Connect cable to screw, bracket, nut or other good ground connection on engine. Do not connect cable to carburetor, air cleaner or fuel line. Keep cable clear of fan, belts and pulleys.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(4) When engine starts, remove jumper cables. Disconnect cable from engine first.

(5) Discard cloth used to cover cap openings because it has been exposed to sulfuric acid.

(6) Install battery caps.

TESTING

General

NOTE: *A complete battery test includes cleaning the top of the battery case, cleaning posts and cable terminals and performing hydrometer and heavy load tests.*

The condition of a battery may be determined from the results of two tests—state of charge (hydrometer test) and ability to supply current (heavy load test). Refer to Battery Diagnosis and Repair Simplification (DARS) chart.

Perform the hydrometer test first. If specific gravity indicates less than 1.225, the battery must be charged before proceeding to further testing. A battery that will not accept a charge is defective and further testing is not necessary.

NOTE: *A battery with sulfated plates may require an overnight slow charge to determine if the sulfate coating is thin enough to be eliminated by a charge.*

A battery that is fully charged and does not pass the heavy load test is defective.

If a battery discharges and no apparent cause can be found, the battery should be fully charged and allowed to stand on a shelf for three to seven days to determine if the self-discharge is excessive. The Self-Discharge Rate chart lists allowable self-discharge for the first ten days of standing after a battery has been fully charged. A battery is fully charged when all cells are gassing freely and three corrected specific gravity tests, taken at one-hour intervals, indicate no increase in specific gravity.

Hydrometer Test

NOTE: *Periodically disassemble the hydrometer and wash components with soap and water. Inspect the float for possible leaks. If the paper inside has turned brown, the float is defective.*

Prior to testing, visually inspect the battery for any damage (cracked container, cover, loose post, etc.) that would cause the battery to be unserviceable. To interpret the hydrometer correctly, hold it with the top surface of the electrolyte in the hydrometer at eye level (fig. 1D-2). Disregard the curvature of the liquid where the surface rises against the float because of surface cohesion. Draw in only enough electrolyte to keep the float off the bottom of the hydrometer barrel with the bulb released. Keep the hydrometer in a vertical position while drawing in the electrolyte and observing the specific gravity. Exercise care when inserting the tip of the hydrometer into a cell to avoid damage to separators. Damaged separators can result in premature battery failure.

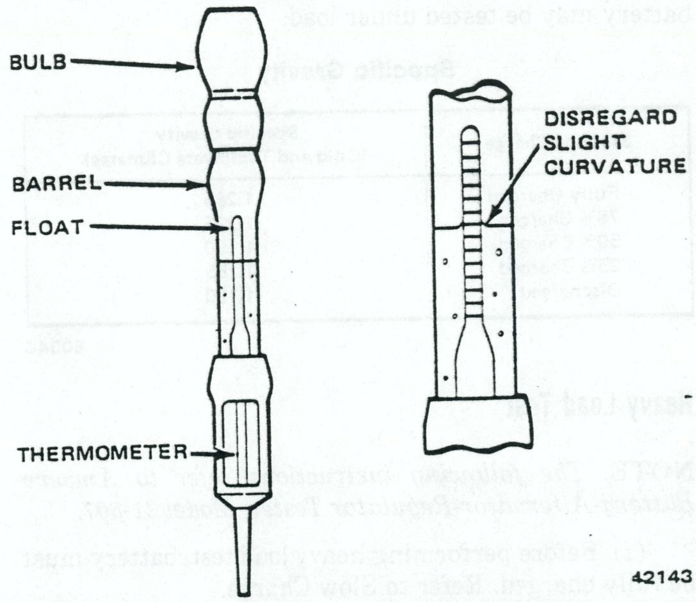

Fig. 1D-2 Hydrometer

Hydrometer floats are generally calibrated to indicate the specific gravity correctly at only one fixed temperature, 80°F (26.6°C). When testing the specific gravity at any other temperature, a correction factor is required. The correction factor is approximately a specific gravity value of 0.004, referred to as 4 points of gravity. For each 10°F above 80°F (5.5°C above 26.6°C), add 4 points. For each 10°F below 80°F (5.5°C below 26.6°C), subtract 4 points. Always correct the specific gravity for temperature variation. Test the specific gravity of the electrolyte in each battery cell.

Example: A battery is tested at 10°F and has a specific gravity of 1.240. The actual specific gravity is determined as follows:

Number of degrees above or below 80°F equals 70 degrees (80 minus 10).

70° divided by 10° (each 10° difference) equals 7.

7 multiplied by 0.004 (temperature correction factor) equals 0.028.

Temperature is below 80°F, therefore temperature correction is subtracted.

Temperature corrected specific gravity is 1.212 (1.240 minus 0.028).

A fully charged battery should have a temperature corrected specific gravity of 1.250 to 1.265.

If the specific gravity of all cells is above 1.235, but the variation between cells is more than 50 points (0.050), it is an indication that the battery is unserviceable. Remove the battery from the vehicle for additional testing.

If the specific gravity of one or more cells is less than 1.235, recharge the battery at a rate of approximately 5 amperes until 3 consecutive specific gravity tests, at one-hour intervals, are constant.

If the cell variation is more than 50 points (0.050) at the end of the charge period, replace the battery.

When the specific gravity of all cells is above 1.235 and variation between cells is less than 50 points, the battery may be tested under load.

Specific Gravity

State of Charge	Specific Gravity (Cold and Temperate Climates)
Fully Charged	1.265
75% Charged	1.225
50% Charged	1.190
25% Charged	1.155
Discharged	1.120

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Heavy Load Test

NOTE: *The following instructions refer to Amserv Battery-Alternator-Regulator Tester, Model 21-307.*

(1) Before performing heavy load test, battery must be fully charged. Refer to Slow Charge.

(2) Turn carbon pile rheostat knob of battery tester to **OFF** position (fig. 1D-3).

(3) Turn selector knob to **AMP** position.

(4) Connect test leads as illustrated in figure 1D-3.

(5) Turn carbon pile rheostat knob clockwise until ammeter indicates correct test amperage:

- 135 amperes for 55-380 battery (75 reserve capacity minutes, 380 cold crank amps).
- 180 amperes for 56-450 battery (90 reserve capacity minutes, 450 cold crank amps).

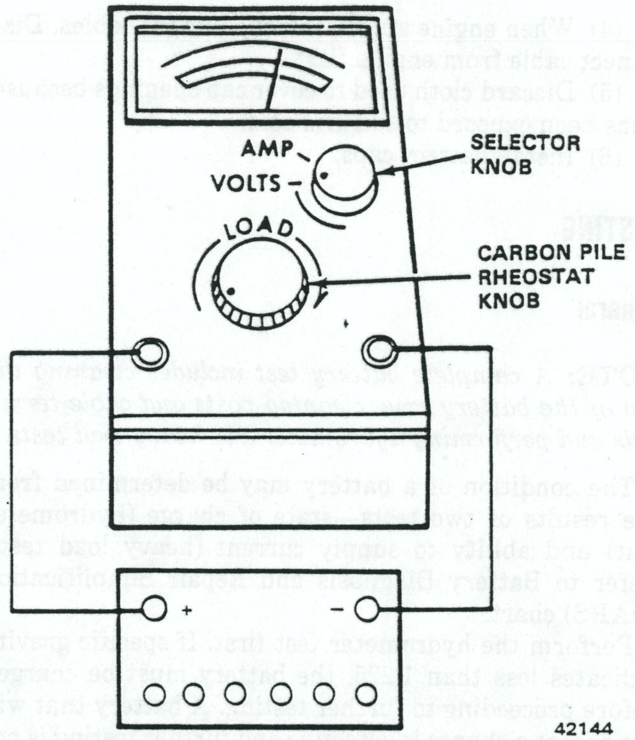


Fig. 1D-3 Heavy Load Test

- 230 amperes for 24-440 battery (135 reserve capacity minutes, 440 cold crank amps).

(6) Maintain load for 15 seconds. Turn selector switch to **VOLTS**, and note voltage.

If the voltmeter indicates 9.6 volts or higher with the battery temperature at a minimum of 70°F (21°C), the battery is in good condition. If less than 9.6 volts, replace the battery.

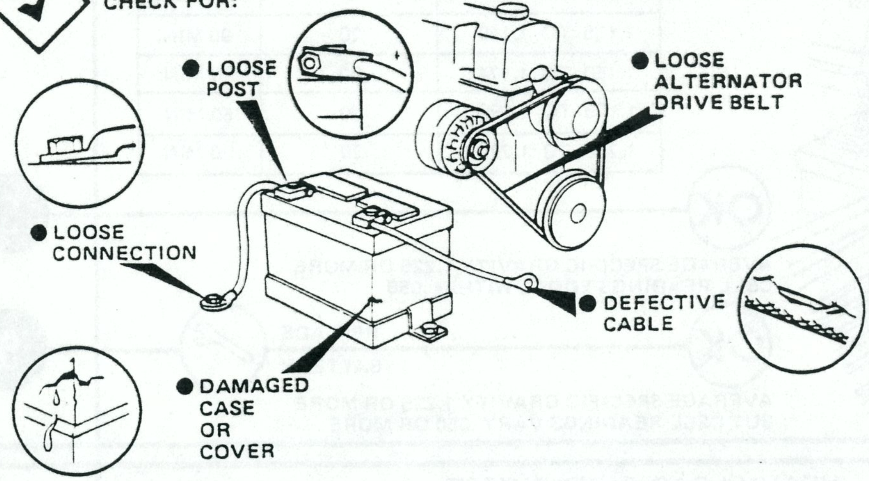
BATTERY DIAGNOSIS AND REPAIR SIMPLIFICATION (DARS) CHART

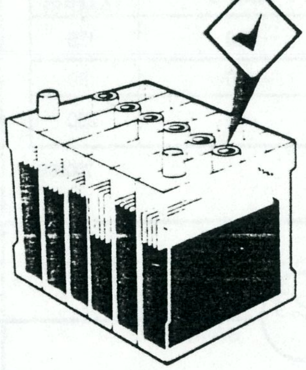
Note: Refer to Chapter A – General Information for details on how to use this DARS chart.

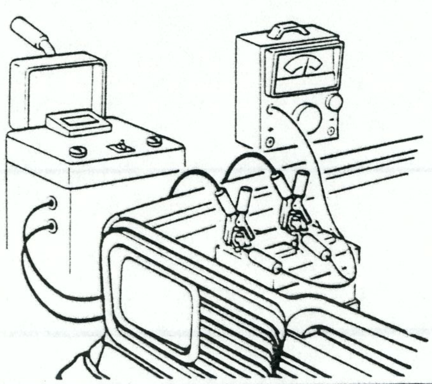
PROBLEM: ENGINE WILL NOT CRANK

Chart 1

STEP	SEQUENCE	RESULT
1	CHECK FOR: ● LOOSE POST ● LOOSE ALTERNATOR DRIVE BELT ● LOOSE CONNECTION ● DEFECTIVE CABLE ● DAMAGED CASE OR COVER → REPAIR OR REPLACE IF NECESSARY	2
2	● CHECK ELECTROLYTE LEVEL AND SPECIFIC GRAVITY IN EACH CELL AND RECORD READINGS. ELECTROLYTE LEVEL TOO LOW FOR SPECIFIC TEST—ADD WATER. CHARGE BATTERY FOR 10 MIN. AT 20 AMPS. MEASURE SPECIFIC GRAVITY.	
	OK: AVERAGE SPECIFIC GRAVITY 1.225 OR MORE CELL READINGS EQUAL WITHIN .050	5
	NOT OK: AVERAGE SPECIFIC GRAVITY 1.225 OR MORE BUT CELL READINGS VARY .050 OR MORE → REPLACE BATTERY	6
	NOT OK: AVERAGE SPECIFIC GRAVITY BELOW 1.225	3
3	● CONNECT BATTERY CHARGER AND VOLTMETER ● CHARGE BATTERY FOR 3 MINUTES AT 40 AMPS ● AT THE END OF 3 MINUTES READ VOLTMETER WHILE CHARGER IS STILL CHARGING	
	OK: VOLTAGE IS 15.5 OR LESS	4
	NOT OK: VOLTAGE ABOVE 15.5 → SLOW CHARGE BATTERY AT 3 TO 4 AMPS FOR 48 TO 72 HOURS	5







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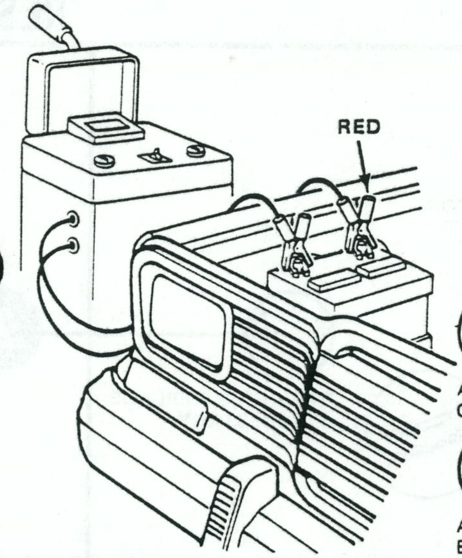
STEP	SEQUENCE	RESULT

4



CHARGE BATTERY AS INDICATED IN CHART, AFTER CHARGE IS COMPLETED, RECHECK SPECIFIC GRAVITY.

AVERAGE SPECIFIC GRAVITY	CHARGE RATE (AMPS)	TIME
LESS THAN 1.125	5	12 HOURS
1.125 TO 1.149	20	90 MIN.
1.150 TO 1.174	20	70 MIN.
1.175 TO 1.199	20	50 MIN.
1.200 TO 1.224	20	30 MIN.

OK → 5
AVERAGE SPECIFIC GRAVITY 1.225 OR MORE
CELL READINGS EQUAL WITHIN .050

NOT OK → REPLACE BATTERY → 6
AVERAGE SPECIFIC GRAVITY 1.225 OR MORE
BUT CELL READINGS VARY .050 OR MORE

5

- CLEAN BATTERY POST AND CABLE ENDS
- CONNECT HEAVY LOAD TESTER
- DETERMINE HEAVY LOAD FROM CHART
- ADJUST TESTER TO LOAD
- HOLD LOAD FOR 15 SECONDS
- READ VOLTMETER

HEAVY LOAD OUTPUT TEST

HEAVY LOAD CHART

GROUP SIZE	COLOR CODE	RESERVE CAPACITY (MINUTES)	COLD CRANK AMPS	HEAVY LOAD (AMPS)
55-380	Green	75	380	135
56-450	Red	90	450	180
24-440	Yellow	135	440	230

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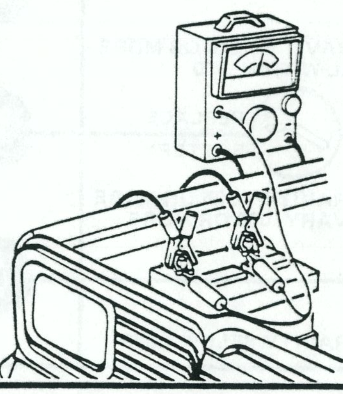

- VOLTAGE READING 9.6 OR MORE → 6
- VOLTAGE READING LESS THAN 9.6 → REPLACE BATTERY → 6

6

OK
ENGINE CRANKS → STOP

NOT OK
ENGINE DOES NOT CRANK → PERFORM STARTER DIAGNOSIS IN STARTER CHAPTER

70060B

SPECIFICATIONS

Battery Specifications

Engine	Group Size	Rating
151, 258, 304, and 360	55-380	380 amps 75 min.
Optional, Factory Installed	56-450	450 amps 90 min.
Optional, Police and Diesel	24-440	440 amps 135 min.

80380

Torque Specifications

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item.

	USA (in-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	Service Set-To Torque	Service In-Use Recheck Torque
Battery Box Screw	145	95-180	16	11-20
Battery Holddown Screw	75	50-95	8	6-11
Battery Cable Clamp	75	60-90	8	7-10

All Torque values given in inch-pounds and Newton-meters with dry fits unless otherwise specified.

Refer to the Standard Torque Specifications and Capscrew Markings Chart in Section A of this manual for any torque specifications not listed above.

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AMA 21-317
CIRCUIT TESTER

CHARGING SYSTEM 1E

INDEX

GENERAL

A Delco charging system is installed on all vehicles. This negative-ground system consists of two primary components: an alternator with an integral regulator and a battery. The non-repairable, non-adjustable regulator is a solid-state device located within the alternator housing.

The standard equipment alternator is rated at 42 amps and the optional, heavy-duty alternators are rated at 55, 63, 70 and 85 amps.

COMPONENTS

Alternator

The alternator (fig. 1E-1) is belt-driven by the engine. Its major components are front and rear housings, stationary windings (stator), rotating field winding (rotor), rectifying diodes and regulator.

The rotor assembly is supported in the front (drive end) housing by a ball bearing and in the rear (slip ring end) housing by a roller bearing. The bearings have sufficient lubricant for the life of the alternator and do

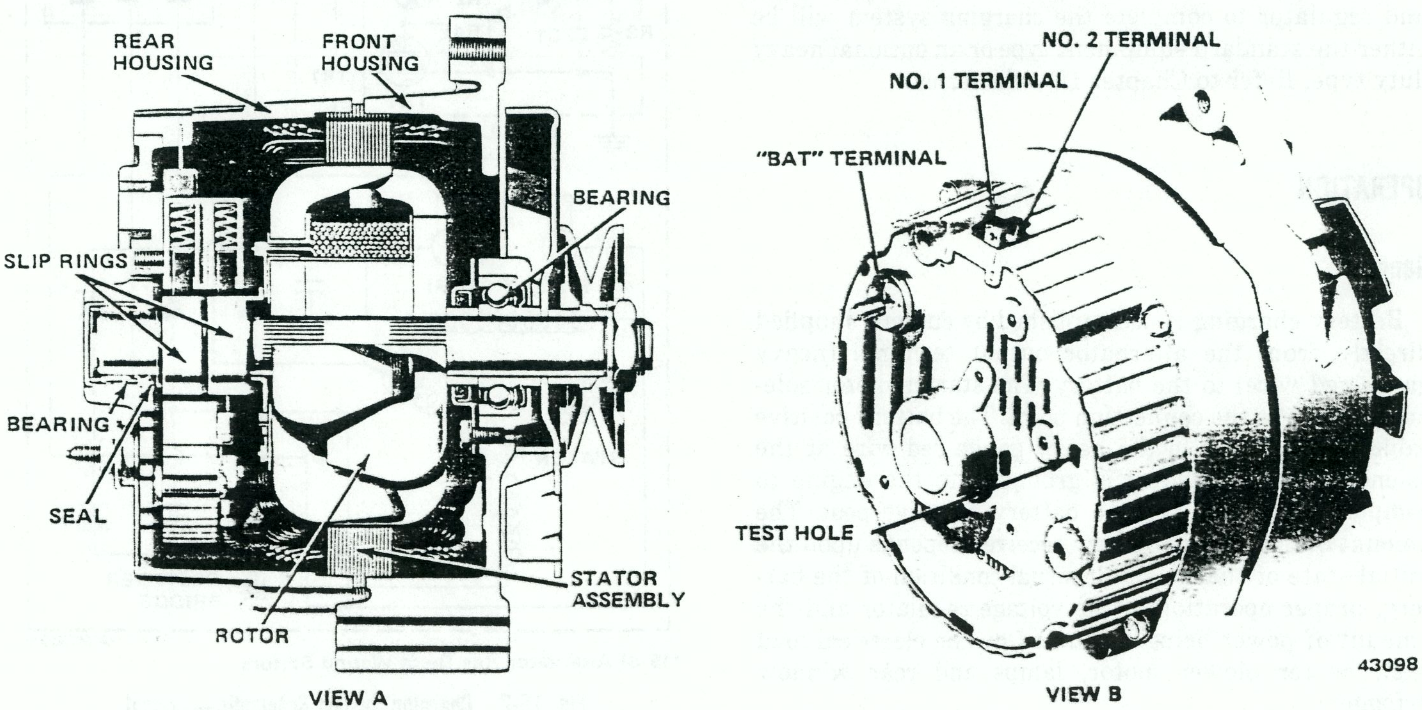


Fig. 1E-1 Delco Alternator—Typical

not require periodic lubrication. Two brushes provide current through two slip rings to and from the field coil. The brushes are designed for long periods of attention-free service. Other than a regularly-scheduled drive belt tension adjustment, the alternator assembly requires no periodic adjustments or maintenance.

The stator windings are wound on the inside of a laminated core that is also part of the alternator frame. The bridge rectifier connected to the stator winding output is comprised of six diodes molded into a single assembly. The bridge rectifier converts the three-phase alternating current output to direct current for the vehicle electrical system.

Battery discharge through the alternator is prevented by the one-way current flow action of the diodes. This eliminates the need for a conventional cutout relay. Alternator field current is supplied through a diode trio that is also connected to the stator windings.

A capacitor, or condenser, located in the end housing, protects the bridge rectifier and diode trio from high surge voltages and suppresses radio interference noise.

NOTE: *All bolt and screw threads are in metric dimensions.*

Voltage Regulator

The voltage regulator utilizes an integrated circuit to regulate the excitation current supplied to the field (rotor) winding. All regulator components are encapsulated in a solid mold and, along with the brush holder assembly, is attached to the rear housing of the alternator. The voltage regulator is not adjustable or repairable.

Battery

The battery used in conjunction with the alternator and regulator to complete the charging system will be either the standard equipment type or an optional heavy duty type. Refer to Chapter 1D—Batteries.

OPERATION

General

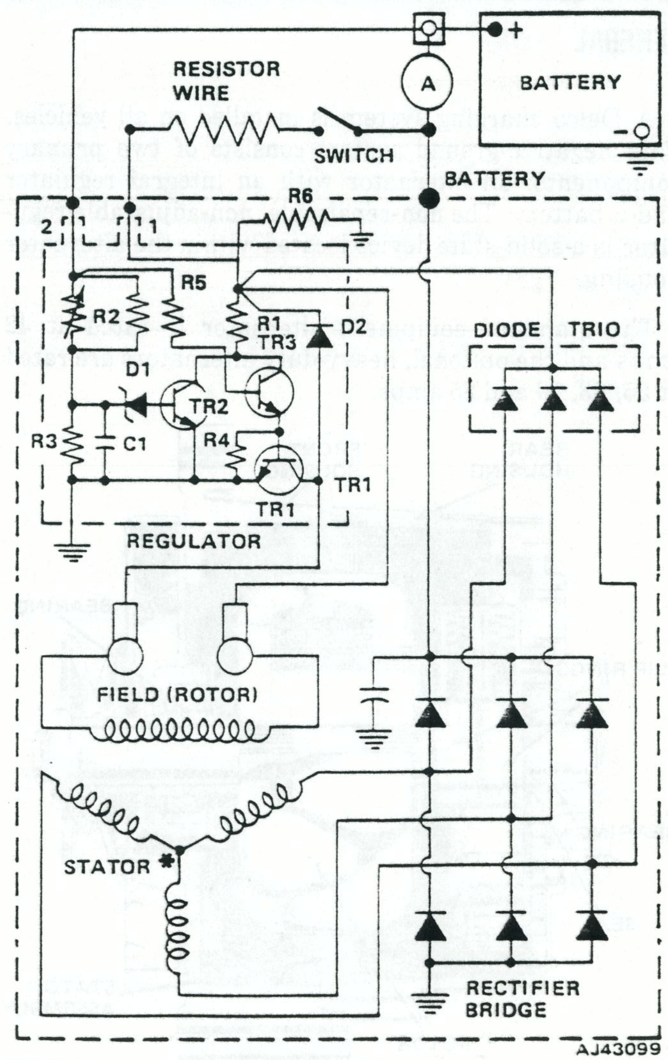
Battery charging is accomplished by current supplied directly from the alternator output terminal (heavy gauge red wire) to the battery. The starter motor solenoid is used as the connection point. The battery positive cable is connected to the heavy gauge red wire at the solenoid. The alternator is grounded to the engine to complete the circuit to the battery negative post. The amount of charge the battery receives depends upon the initial state of charge and internal condition of the battery, proper operation of the voltage regulator and the amount of power being consumed by the electrical load (e.g., heater blower motor, lamps and rear window defogger).

Energizing the System

When the ignition switch is turned to the **On** position (fig. 1E-2), positive battery voltage is applied to the regulator and current flows from ground to the regulator. The regulator controls the amount of excitation current allowed to flow through the field winding. The battery voltage provides the initial excitation that results in a large electromagnetic field around the rotor and a faster build-up of output voltage.

Within the regulator, TR1 and its associated biasing network controls the amount of field excitation current and, in so doing, the amplitude of the output voltage. As long as the rotor is stationary (i.e., no alternator output), all the current flows through the field winding, resistance wire and ammeter to the battery positive terminal. The ammeter will indicate negative (-) current flow (no alternator output).

NOTE: *Sometimes, without a battery installed in a vehicle (or if the battery is completely discharged), there will be no alternator output because there will be no*



*15-SI Alternator Has Delta Wound Stators

Fig. 1E-2 Charging System Schematic—Typical

energizing excitation current. In most instances the rotor will have sufficient residual magnetism to create a magnetic field and induce a voltage into the stator when the rotor is turned.

Voltage Output

When the rotor starts turning, the rotating electromagnetic field is cut by the stator windings. This action induces an AC voltage into the stator windings. The induced stator voltage is higher than the battery voltage and becomes the primary voltage source for excitation current flow through the field winding. The diode trio rectifies the current that flows from ground through TR1 and the field winding to the stator windings.

The six diodes in the bridge rectifier convert the stator AC voltage to DC output voltage. As alternator rotor rpm increases, increased power is generated for charging the battery and operating the electrical accessories. Because the voltage amplitude is higher on the alternator side of the ammeter, the current will flow through the ammeter to the alternator BAT terminal. The ammeter will indicate positive (+) current flow (charge).

Regulation

The No. 2 terminal on the alternator is always connected to the battery, but the discharge current is limited to a negligible value by the high resistances of R2 and R3.

As the alternator rotor rpm and stator voltage increase, the voltage across R3 increases to a level that causes zener diode D1 to conduct. Transistor TR2 is forward biased and conducts, and TR3 is reverse biased Off, which turns TR1 Off. With TR1 Off, the field current and system voltage decrease. When the voltage across R3 decreases, D1 stops conducting. Transistor TR2 is then reverse biased Off and transistors TR3 and TR1 forward biased On. In turn, the field current and output voltage increase. This cycle repeats many times per second to limit the alternator output to a preset value.

Capacitor C1 prevents abrupt voltage changes across R3. R4 prevents excessive back current through TR1 at high temperatures, and D2 protects TR1 by preventing a high induced voltage in the field winding when TR1 is turned Off. Resistor R2 is a thermistor that causes the regulated voltage to vary inversely with temperature, providing the optimum voltage over a wide temperature range for charging the battery.

TROUBLESHOOTING

Close adherence to the following procedures in the order presented will result in locating and correcting charging system malfunctions in the shortest possible time.

Figure 1E-3 depicts a basic wiring diagram for the charging system.

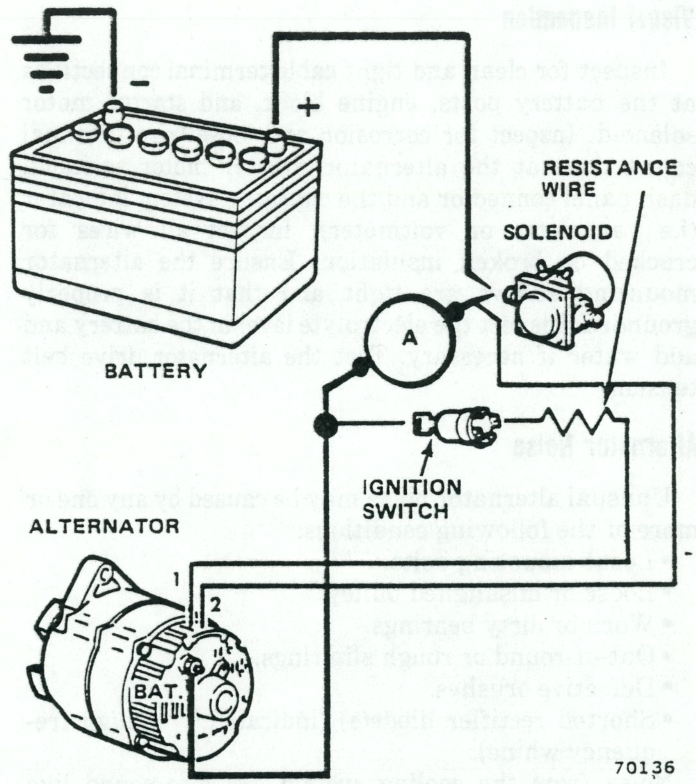


Fig. 1E-3 Basic Wire Connections

To avoid damage to the charging system, always observe the following precautions:

- Do not attempt to polarize the regulator.
- Do not short across or ground any of the terminals in the charging system except as specifically instructed.
- NEVER drive the alternator with the engine when the output terminal circuit is open and No. 1 and No. 2 wire terminals are connected to the alternator.
- Ensure the alternator and battery have the same ground polarity.
- When connecting a charger or a booster battery to the battery, connect negative to negative and positive to positive.

NOTE: *An ammeter is used on Cherokee, Wagoneer and Truck models to indicate the charging rate. CJ models are equipped with a voltmeter.*

Malfunction of the charging system is usually indicated by one or more of the following symptoms:

- Faulty ammeter (or voltmeter) operation.
- An undercharged battery, indicated by slow engine cranking and battery electrolyte having low specific gravity.
- An overcharged battery, indicated by excessive water usage.

Prior to performing any electrical tests, visually inspect all charging system components and wiring for obvious discrepancies.

Visual Inspection

Inspect for clean and tight cable terminal connections at the battery posts, engine block, and starter motor solenoid. Inspect for corrosion and loose wire terminal connections at the alternator, starter motor solenoid, dash panel connector and the charging system indicator (i.e., ammeter or voltmeter). Inspect all wires for cracked or broken insulation. Ensure the alternator mounting screws are tight and that it is properly grounded. Inspect the electrolyte level in the battery and add water if necessary. Test the alternator drive belt tension.

Alternator Noise

Unusual alternator noise may be caused by any one or more of the following conditions:

- Loose mounting bolts.
- Loose or misaligned pulley.
- Worn or dirty bearings.
- Out-of-round or rough slip rings.
- Defective brushes.
- Shorted rectifier diode(s) (indicated by a high frequency whine).

Noise from the cooling system can also sound like alternator noise. Disconnect and plug the heater hoses to eliminate the possibility of the alternator bracket reproducing heater core noises.

Faulty Ammeter or Voltmeter Operation

Diagnosis of the instrumentation circuits is described in Chapter 1L—Power Plant Instrumentation.

Overcharged/Undercharged Battery

For battery undercharged-overcharged diagnosis, refer to DARS charts 1 and 2.

Battery Discharge Through Alternator

If the alternator is suspected of discharging the battery because of excessive current leakage, perform the following test procedure with a No. 158 bulb and bulb socket with attached jumper wires.

WARNING: *Failure to disconnect battery negative cable before disconnecting alternator output wire can result in injury.*

(1) Disconnect battery negative cable. Disconnect output wire (red) from alternator.

(2) Connect test bulb jumper wires in series with output wire and alternator output terminal. Connect battery negative cable. Bulb should not light. If bulb lights (even dimly), replace bridge rectifier.

(3) Disconnect battery negative cable and remove jumper wires.

(4) Disconnect wires from No. 1 and 2 terminals of alternator.

(5) Connect test bulb jumper wires in series with No. 1 terminal at alternator and the battery positive post. Connect battery negative cable. Bulb should not light. If bulb lights (even dimly), test diode trio. If diode trio is not defective, replace voltage regulator.

(6) Connect test bulb jumper wires in series with No. 2 terminal at alternator and battery positive post. Bulb should not light. If bulb lights (even dimly), replace voltage regulator.

TESTING—OFF-VEHICLE

Rotor (Field) Winding Short-to-Ground Test

To perform this test, remove the rotor and front housing assembly from the stator and rear housing assembly. Refer to Alternator Overhaul for procedure. Perform the test with an ohmmeter set for the x1000 ohm scale or with a 110-volt test lamp.

Touch one test lead probe to rotor shaft and touch other probe to one slip ring (fig. 1E-4). Repeat with the other slip ring. In each test, the ohmmeter should indicate infinite resistance (no pointer movement) or the test lamp should not light.

Test Results

If the ohmmeter indicates other than an infinite resistance or test lamp lights, a short to the rotor shaft exists. Inspect the soldered connections at the slip rings to ensure they are secure and not shorted to the rotor shaft, or that excess solder is not shorting rotor winding to the shaft. Replace the rotor if defective.

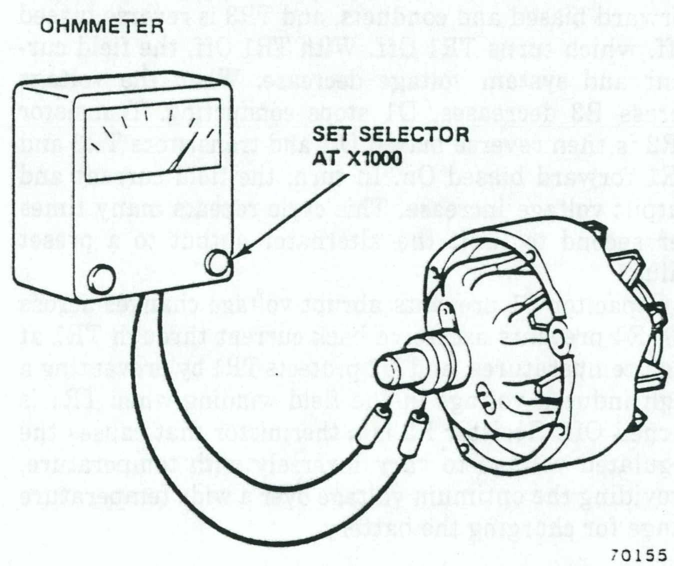


Fig. 1E-4 Rotor (Field) Winding Short-to-Ground Test

Rotor (Field) Winding Open Test

To perform this test, remove the rotor and front housing assembly from the stator and rear housing assembly. Refer to Alternator Overhaul for procedure.

Perform the test with an ohmmeter set for the x1 scale or with a 110-volt test lamp.

Touch one test lead probe to one slip ring and the other test lead probe to the other slip ring (fig. 1E-5). The ohmmeter should indicate 2.2 to 3.0 ohms or test lamp should light.

Test Results

If the ohmmeter indicates infinite resistance or the test lamp fails to light, the rotor winding is open.

Rotor (Field) Winding Internal Short Test

To perform this test, remove the front housing and rotor from the stator and rear housing assembly. Refer to Alternator Overhaul for procedure. This test is performed with a 12-volt battery and an ammeter.

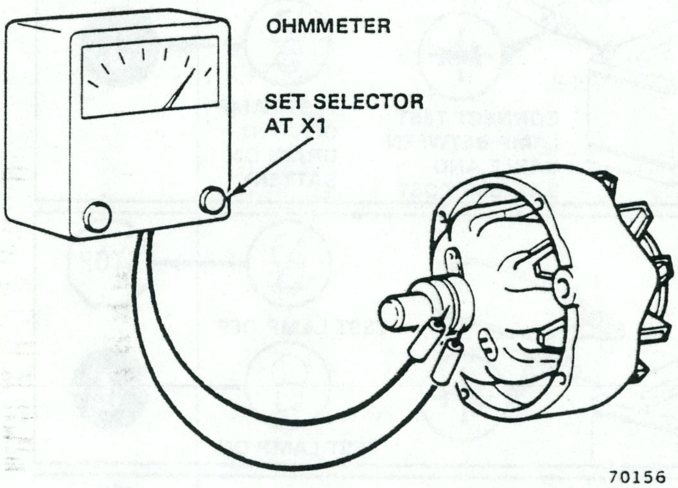


Fig. 1E-5 Rotor (Field) Winding Open Test

Connect battery and ammeter in series with the slip rings (fig. 1E-6). The field current at 12 volts applied at 80°F (27°C) should be between 4.0 and 5.0 amps.

Test Results

Current flow exceeding 5.0 amps indicates a shorted winding.

NOTE: *The winding resistance and ammeter indication will vary slightly with winding temperature changes. A current flow that is less than the specified value indicates excessive winding resistance. An alternate test method is to determine the resistance of the field winding by connecting an ohmmeter to the two slip rings. If the resistance is less than 2.2 ohms at 80°F (27°C), the winding is shorted. If the resistance is more than 3.0 ohms at 80°F (27°C), the winding has excessive resistance.*

Stator Windings Short-to-Ground Test

To perform this test, separate the rear housing and stator from the rotor and front housing assembly. Disconnect the stator windings from the rectifier terminals. Refer to Alternator Overhaul for procedure. The test is performed with an ohmmeter set for the x1000 scale or with a 110-volt test lamp.

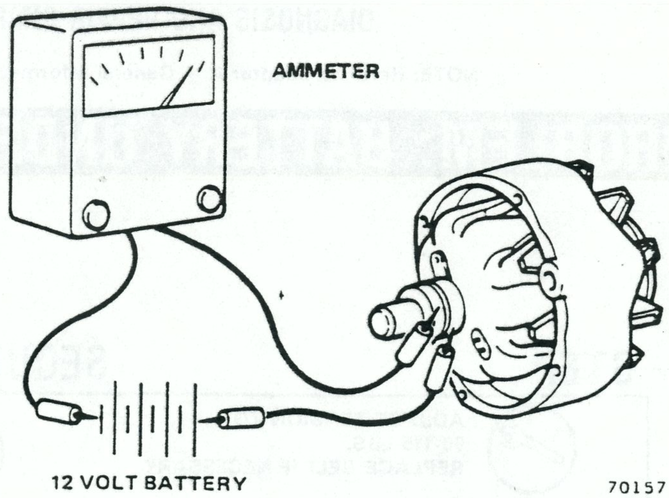


Fig. 1E-6 Rotor (Field) Winding Internal Short Test

Touch one test lead probe to the bare metal surface of the stator core and the other test lead probe to the end of one stator winding (1E-7). Because all three stator windings are soldered together, it is not necessary to test each winding. The ohmmeter should indicate infinite resistance (no pointer movement) or test lamp should not light.

Test Results

If the ohmmeter indicates other than an infinite resistance or test lamp lights, the stator windings are shorted to the core and must be replaced.

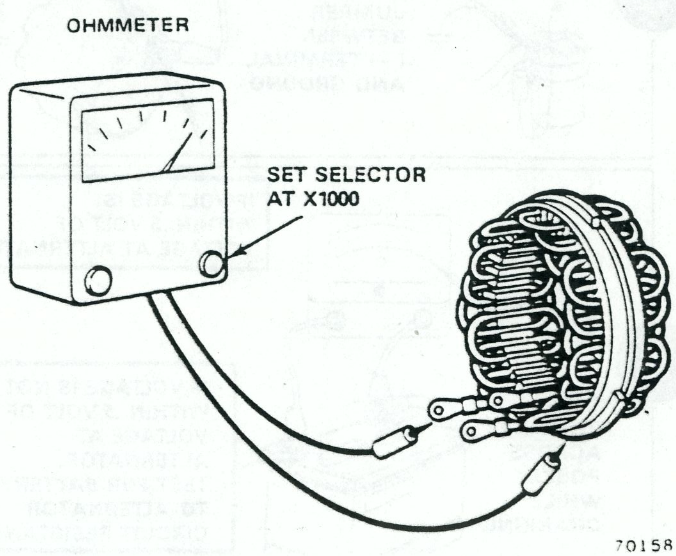


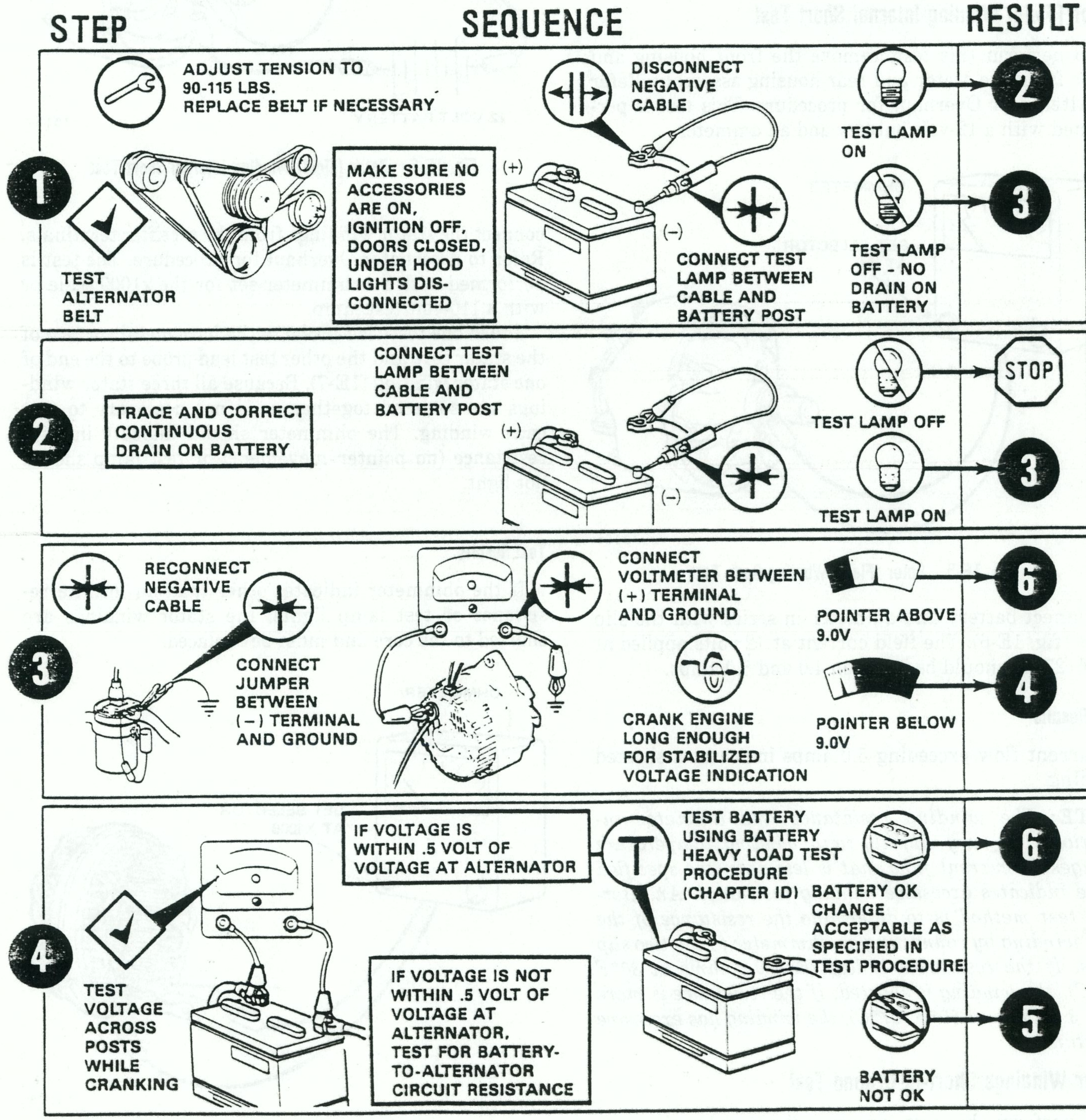
Fig. 1E-7 Stator Windings Short-to-Ground Test

FOUR- AND SIX-CYLINDER ENGINE CHARGING SYSTEM DIAGNOSIS AND REPAIR SIMPLIFICATION (DARS) CHARTS

NOTE: Refer to Chapter A — General Information for details on how to use this DARS chart.

PROBLEM: BATTERY UNDERCHARGED

Chart 1



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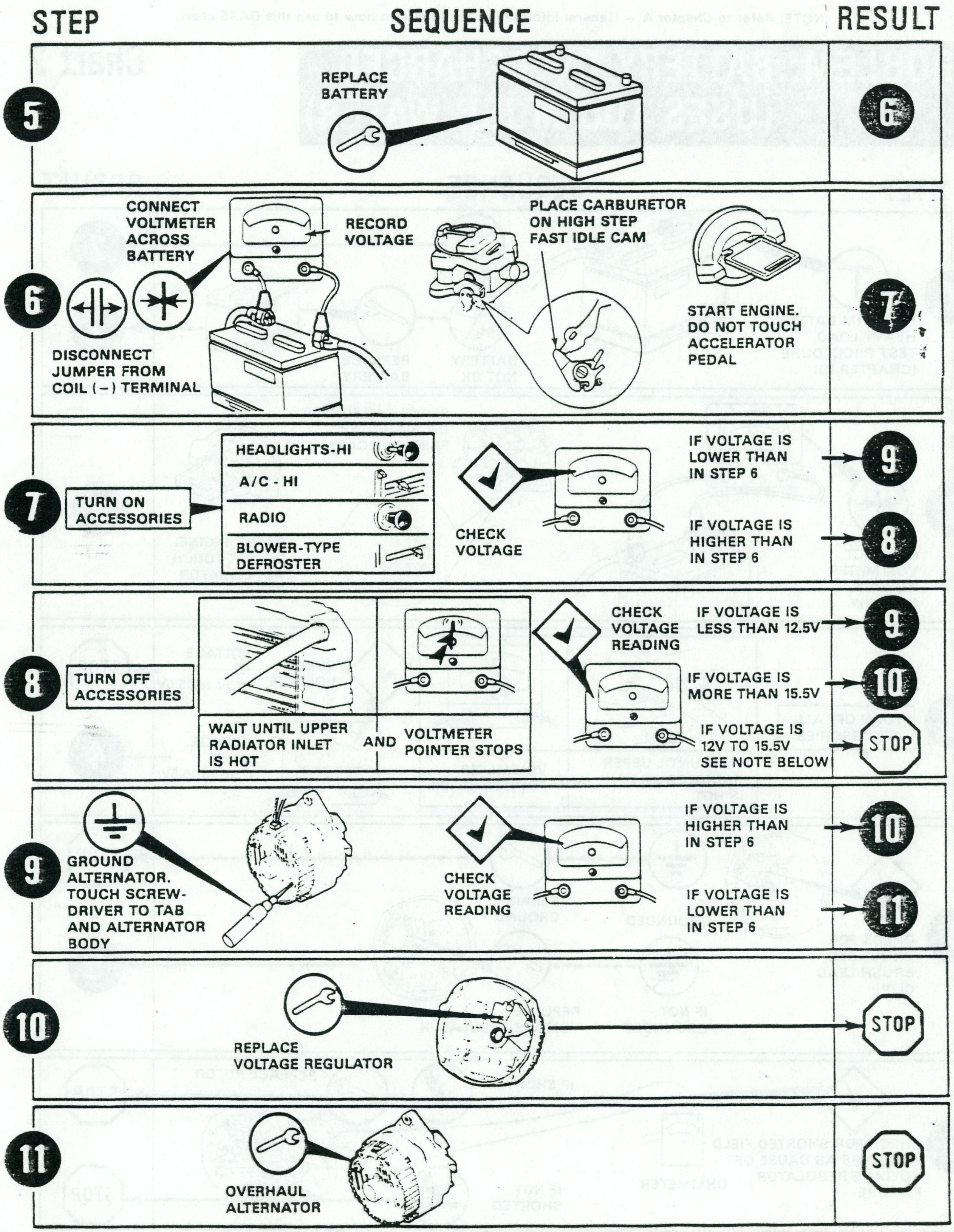

NOTE: IF NO FAULT HAS BEEN FOUND, EXCESSIVE IDLING AND SLOW OR SHORT DISTANCE DRIVING, WITH ALL ACCESSORIES ON, MAY HAVE CAUSED HEAVY DRAIN ON BATTERY – RESULTING IN UNDERCHARGED CONDITION.

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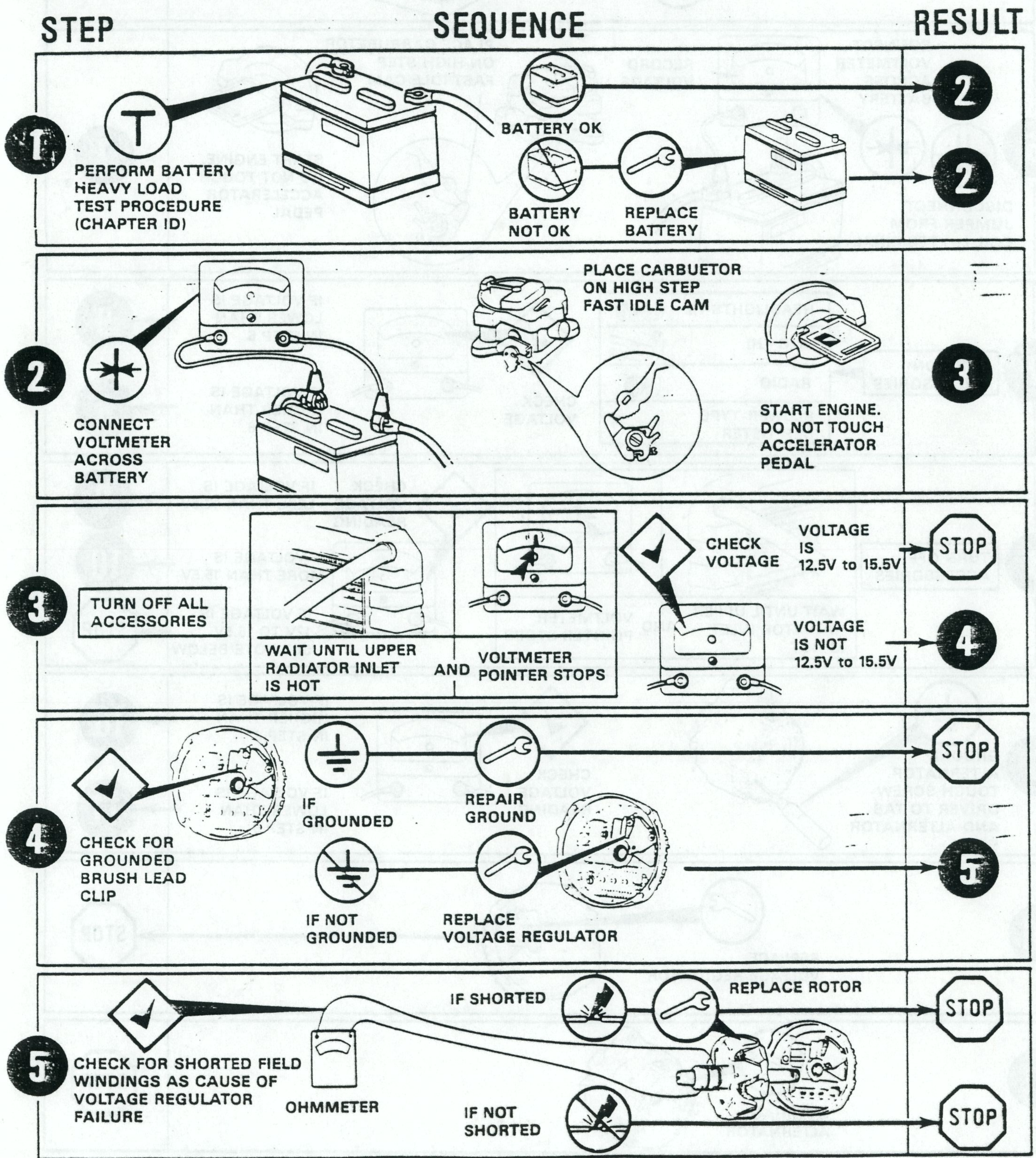
NOTE: Refer to Chapter A — General Information for details on how to use this DARS chart.

PROBLEM: BATTERY OVERCHARGED (USES TOO MUCH WATER)

Chart 2



Stator Windings Continuity Test

NOTE: *The optional 70 and 85 amp alternators (Delco 15-SI) have delta wound stator windings that cannot be tested for open windings with an ohmmeter or test lamp. However, if the results of all other tests are normal and the alternator fails to supply the rated output, open stator windings are probable.*

To perform this test, remove the stator and rear housing assembly from the rotor and front housing assembly. Refer to Alternator Overhaul for procedure. An ohmmeter set for the x1 scale is used to perform the test.

Touch ohmmeter lead probes to any two stator windings and note the resistance (fig. 1E-8). Test all the stator windings in this manner. Equal indications should be obtained for each pair of windings tested.

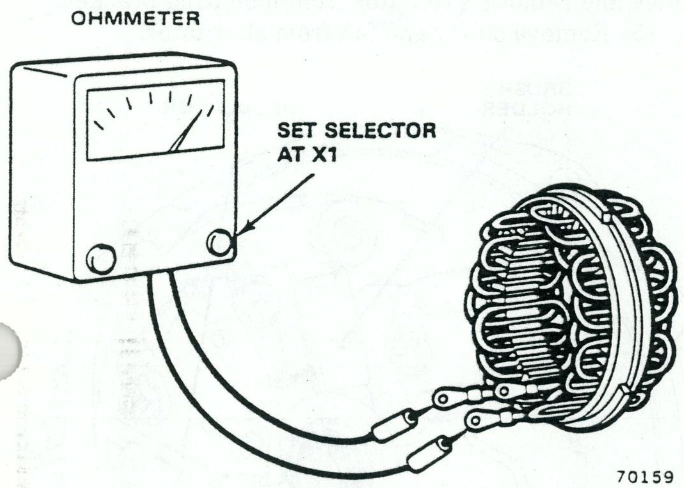


Fig. 1E-8 Stator Windings Continuity Test

Test Results

An infinite resistance (no pointer movement) indicates an open winding. Inspect the neutral junction splice for a poor solder connection. Resolder the connection even if it appears to be good. Retest the continuity. If an open still exists, replace the stator windings.

An indication of more than 1 ohm indicates a possible cold solder joint. Inspect the neutral junction splice and resolder if necessary.

Stator Internal Short Circuit Test

An internal short (e.g., between adjacent windings) is difficult to locate without laboratory test equipment. If all other electrical checks are normal and the alternator fails to supply the rated output, shorted stator windings are probable.

Diode Trio Short Circuit Test

The diode trio is tested in two ways: when installed in the rear housing and when removed from the rear housing.

CAUTION: *Do not use high voltage, such as a 110-volt test lamp, to test the diode trio.*

Test with Diode Trio Installed

(1) Before removing diode trio, connect ohmmeter, with lowest range scale selected, from brush lead clip to rear housing (fig. 1E-9) and note resistance.

(2) Reverse test lead probe connections. If both indications are zero, inspect for grounded brush lead clip caused by absence of insulating washer, absence of insulating sleeve over screw, or damaged insulation (fig. 1E-14).

(3) Remove screws to inspect washers and sleeves. If screw assembly is correct and both ohmmeter observations are same, replace voltage regulator.

Test with Diode Trio Removed

(1) Remove diode trio from rear housing assembly.

(2) Connect ohmmeter having 1-1/2 volt cell to brush terminal and one stator winding terminal (fig. 1E-10). Observe resistance on lowest range scale.

(3) Reverse probes at same two terminals.

(4) Replace diode trio if both resistances are identical. Good diode trio will give one high and one low resistance.

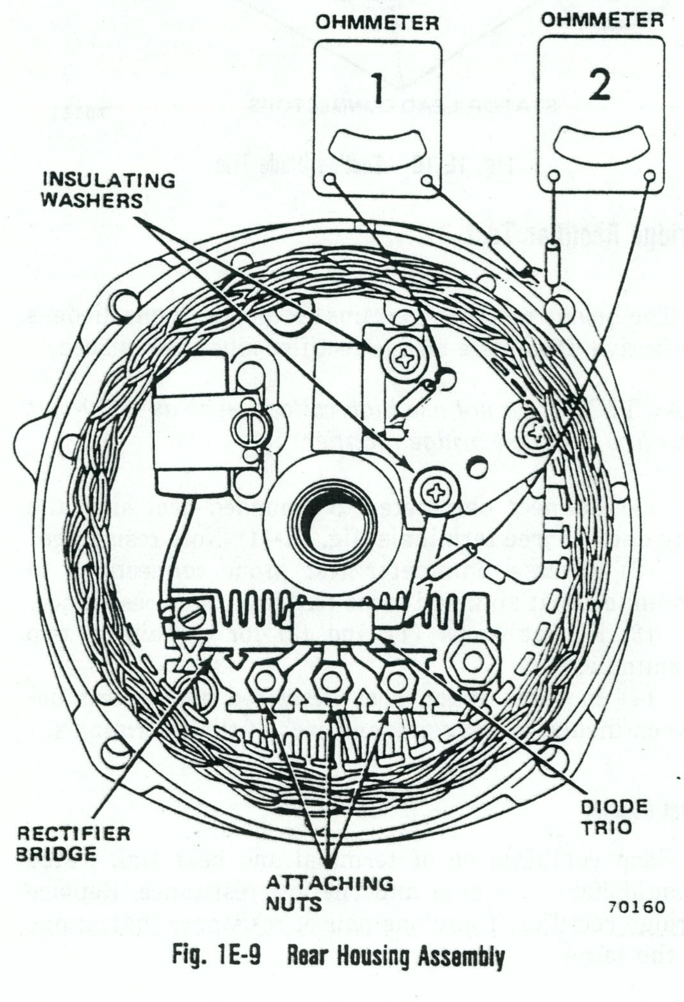


Fig. 1E-9 Rear Housing Assembly

(5) Repeat steps (2), (3), and (4) for each stator winding terminal of diode trio.

(6) Connect ohmmeter to any two stator winding terminals. If resistance is zero, open diode is indicated. Replace diode trio. Repeat test for each combination of stator winding terminals.

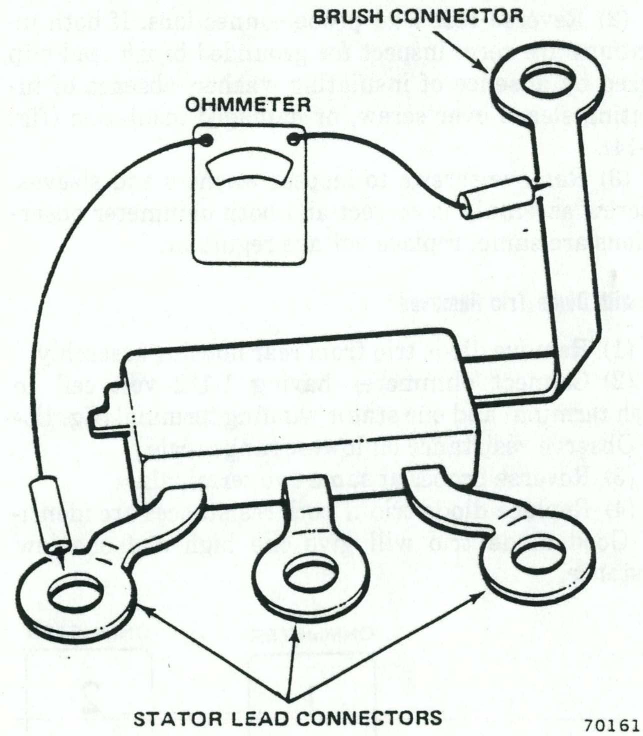


Fig. 1E-10 Testing Diode Trio

Bridge Rectifier Test

The bridge rectifier contains six diodes. If one diode is defective, the entire bridge rectifier must be replaced.

CAUTION: *Do not use high voltage, such as a 110-volt test lamp, to test bridge rectifier.*

(1) Connect ohmmeter to grounded heat sink and any one of three terminals (fig. 1E-11). Note resistance.

(2) Reverse ohmmeter test probe connections to grounded heat sink and same terminal. Note resistance.

(3) Repeat steps (1) and (2) for remaining two terminals.

(4) In same manner as described above, test between insulated heat sink and each of three terminals.

Test Results

Each combination of terminal and heat sink tested should have one high and one low resistance. Replace bridge rectifier if any one pair of resistance indications is the same.

ALTERNATOR REPLACEMENT

Removal

NOTE: *All bolt and screw threads are in metric dimensions.*

WARNING: *Failure to disconnect the battery negative cable before disconnecting the red wire from the alternator can result in injury.*

(1) Disconnect battery negative cable.

(2) Disconnect two-terminal plug and red wire at back of alternator.

(3) Remove mounting and adjusting bolts, washers and nuts.

(4) Remove alternator drive belt from alternator pulley and remove alternator from mounting bracket.

(5). Remove pulley and fan from alternator.

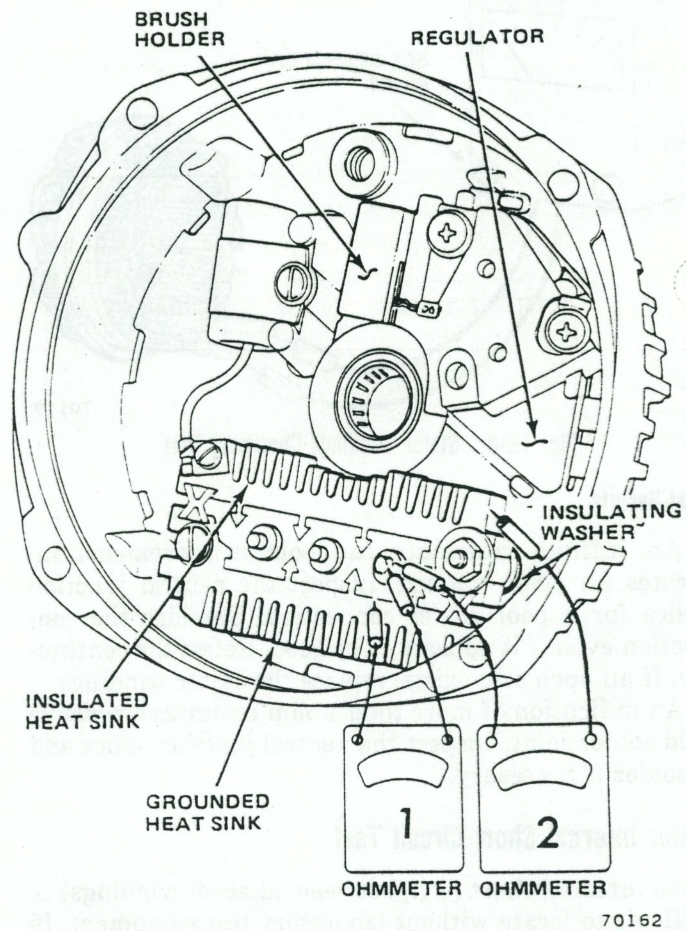


Fig. 1E-11 Testing Bridge Rectifier

Installation

(1) Install original pulley and fan on replacement alternator.

(2) Attach alternator to mounting bracket with washers and bolts. Tighten bolts finger-tight only.

(3) Install alternator drive belt.

(4) Tighten belt to specified tension. Refer to Drive Belt Adjustment for correct belt tightening procedure.

(5) Tighten bolt at sliding slot bracket with 20 foot-pounds (27 N•m) torque. Tighten remaining bolts with 30 foot-pounds (41 N•m) torque.

(6) Install two-terminal plug and red wire on alternator.

(7) Connect battery negative cable.

ALTERNATOR OVERHAUL

Disassembly

CAUTION: *As the rotor and drive end housing assembly is separated from the slip ring housing assembly the brushes will spring out onto the rotor shaft and come in contact with lubricant. Immediately clean brushes that contact shaft to avoid contamination by lubricant, otherwise, they will have to be replaced.*

NOTE: *All bolt and screw threads are in metric dimensions.*

(1) Scribe across front housing, stator frame and rear housing for assembly reference.

(2) Remove four through-bolts that connect rear housing to front housing (fig. 1E-12).

(3) Separate front housing and rotor assembly from rear housing and stator assembly by prying housings apart with screwdriver.

NOTE: *After disassembly, cover the rear housing bearing with tape to prevent entry of dirt and other foreign material. Also, cover the rotor shaft on the slip ring end with tape. Use pressure-sensitive tape and not friction tape, which would leave a gummy deposit on the shaft. If the brushes are to be reused, clean with a soft, dry cloth.*

CAUTION: *Avoid excessive tightening of the rotor in the vise to prevent rotor distortion.*

(4) Place rotor in vise and tighten vise only enough to permit removal of pulley nut.

(5) Alternate pulley nut removal procedure requires use of Allen wrench to prevent rotor from turning while loosening nut with wrench (fig. 1E-13).

(6) Remove pulley nut, lockwasher, pulley, fan, and collar.

(7) Separate front end housing from rotor shaft.

(8) Remove three stator winding attaching nuts and washers and remove stator windings from bridge rectifier terminals.

(9) Separate stator from rear housing.

(10) Remove diode trio strap terminal attaching screw from brush holder and remove diode trio.

(11) Remove capacitor holddown screw.

(12) Disconnect capacitor wire terminal from bridge rectifier. Remove capacitor.

(13) Remove bridge rectifier attaching screws and battery wire terminal screw.

(14) Remove bridge rectifier. Note insulator located between heat sink and rear housing.

(15) Remove two brush holder screws (fig. 1E-14). Note position of all insulator washers to facilitate correct assembly.

(16) Remove brush holder and brushes. Carefully note position of parts for assembly.

(17) Remove voltage regulator.

(18) Remove front bearing retainer plate screws, retainer plate and inner collar.

(19) Press out front bearing and slinger from front housing with suitable tube or collar.

NOTE: *If the bearing is in satisfactory condition, it may be reused.*

(20) Press out rear bearing using tube or collar that fits inside rear housing. Press from inside of housing toward outside.

NOTE: *Replace the bearing in the rear housing if its lubricant supply is exhausted. Do not attempt to lubricate and reuse a dry bearing.*

Cleaning and Inspection

CAUTION: *Do not clean rotor with a degreasing solvent.*

(1) Clean rotor poles by brushing with oleum spirits, or equivalent.

(2) Inspect slip rings for dirt and roughness. Clean with solvent. If necessary, clean and finish slip rings with commutator paper, or 400 grit polishing cloth. **Do not use metal-oxide paper.** Spin rotor in lathe or other support while holding abrasive against rings.

NOTE: *When using an abrasive, support the rotor while spinning to clean slip rings evenly. Cleaning slip rings without support may result in flat spots on slip rings. This will cause brush noise and premature brush wear.*

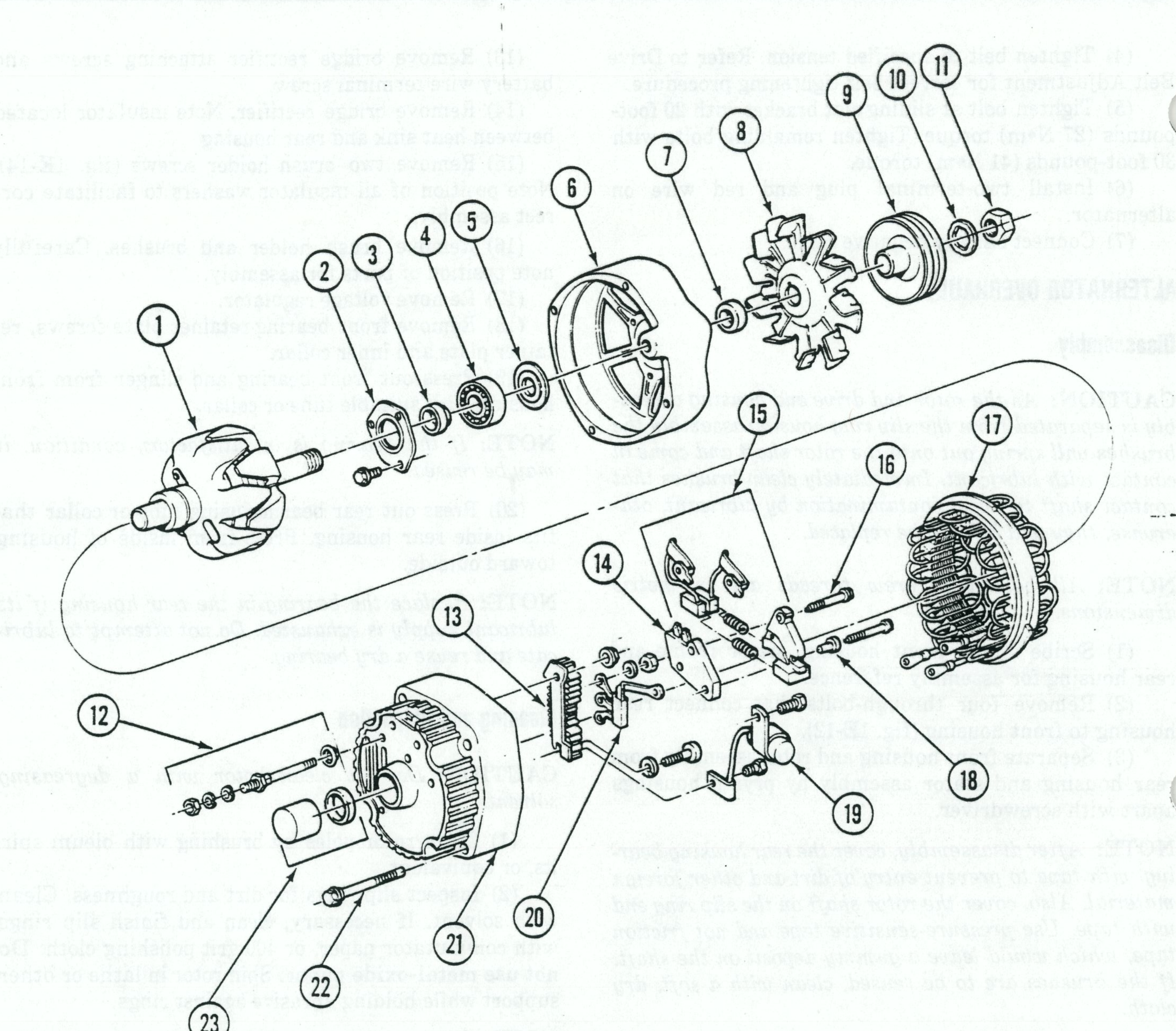
(3) True rough or out-of-round slip rings in lathe to 0.002 inch (0.051 mm) maximum indicator reading. Remove only enough material to make rings smooth and round. Finish with commutator paper, or 400 grit polishing cloth, and blow away all dust.

CAUTION: *Do not clean stator in degreasing solvent.*

(4) Clean stator by brushing with oleum spirits, or equivalent.

(5) Inspect brush springs for evidence of damage or corrosion. Replace springs if there is any doubt about their condition.

(6) Inspect brushes for wear or contamination. If brushes are to be reused, clean with soft, dry cloth until completely free of lubricant.



1. ROTOR
2. FRONT BEARING RETAINER PLATE
3. COLLAR (INNER)
4. BEARING
5. SLINGER
6. FRONT HOUSING
7. COLLAR (OUTER)
8. FAN
9. PULLEY
10. LOCKWASHER
11. PULLEY NUT
12. TERMINAL ASSEMBLY
13. BRIDGE RECTIFIER
14. REGULATOR
15. BRUSH ASSEMBLY
16. SCREW
17. STATOR
18. INSULATING WASHER
19. CAPACITOR
20. DIODE TRIO
21. REAR HOUSING
22. THROUGH-BOLT
23. BEARING AND SEAL ASSEMBLY

Fig. 1E-12 Alternator Components 43105

(7) Inspect condition of brush holder screw insulating washers for broken or cracked insulation (fig. 1E-14).

Assembly

CAUTION: *Overfilling may cause the bearing to overheat.*

(1) Fill cavity between retainer plate and bearing one-quarter full with Delco lubricant 1948791, or equivalent.

(2) Assemble bearing and slinger into front housing (fig. 1E-15).

Fig. 1E-15 Front Housing Bearing Assembly 43111

(3) Press bearing in with suitable tube or collar that fits over outer bearing race.

NOTE: *Install a replacement retainer plate if the felt seal in the retainer plate has hardened.*

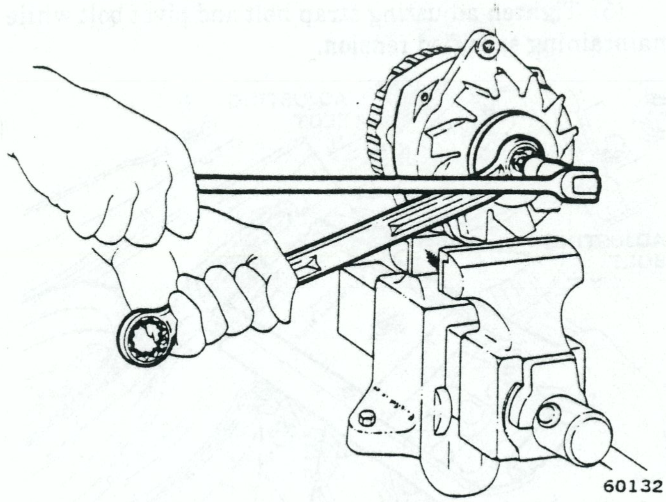


Fig. 1E-13 Removing Pulley Nut

(4) Install inner collars retainer plate and screws.

(5) Position housing, outer collar, fan, pulley and washer on rotor shaft and install pulley nut.

(6) Place rotor in vise. Tighten vise only enough to permit tightening of pulley nut. Tighten nut with 50 foot-pounds (68 N•m) torque.

(7) Alternate method of tightening pulley nut requires use of Allen wrench to prevent rotor from turning while tightening nut with wrench (fig. 1E-16).

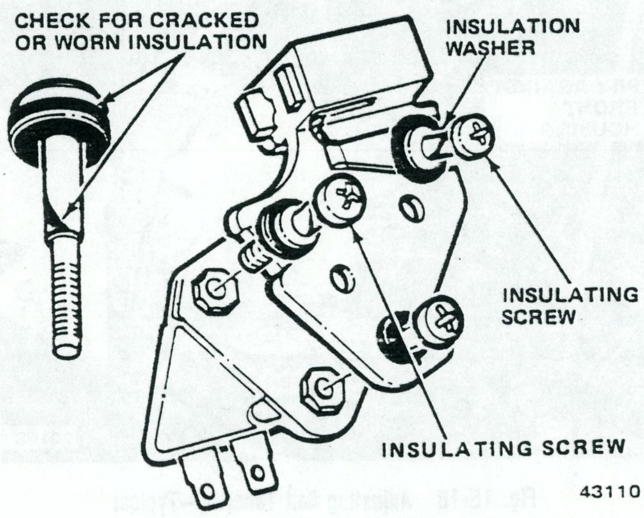


Fig. 1E-14 Brush Holder Assembly

(8) If rear bearing was removed, support inside of rear housing with hollow cylinder.

CAUTION: *Use extreme care to avoid misalignment or placing undue stress on bearing.*

(9) Place flat plate over bearing and press bearing into housing from outside until bearing is flush with housing.

(10) Install replacement bearing seal. Lightly oil lip to facilitate installation of rotor shaft. Press seal in with lip away from bearing.

(11) Install springs and brushes into brush holder. Brushes should slide in and out of brush holder without binding.

NOTE: *Should any of the brush holder assembly parts require replacement, it is necessary to replace the entire brush holder assembly. Individual parts are not serviced.*

(12) Insert straight wooden or plastic toothpick (to prevent scratching brushes) into hole at bottom of holder to retain brushes.

(13) Install voltage regulator.

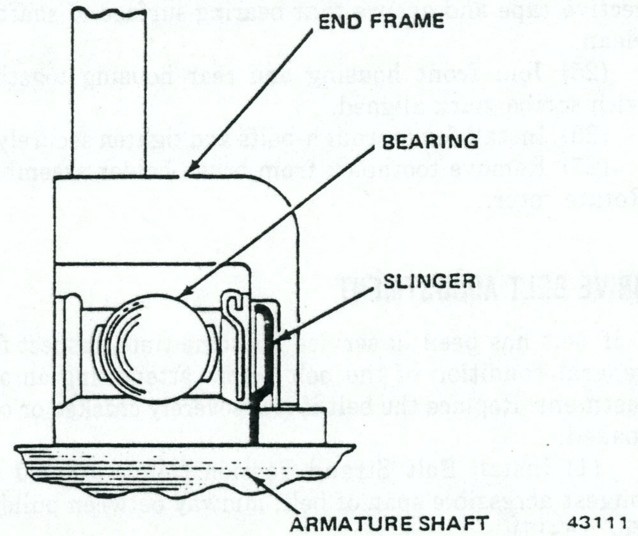


Fig. 1E-15 Front Housing Bearing Assembly

(14) Attach brush holder to rear housing. Carefully note position of insulating washers (fig. 1E-14). Allow toothpick to protrude through hole in rear housing.

(15) Install diode trio terminal strap attaching screw and insulating washer.

(16) Tighten remaining two brush holder screws securely.

(17) Position bridge rectifier on rear housing with insulator inserted between insulated heat sink and rear housing.

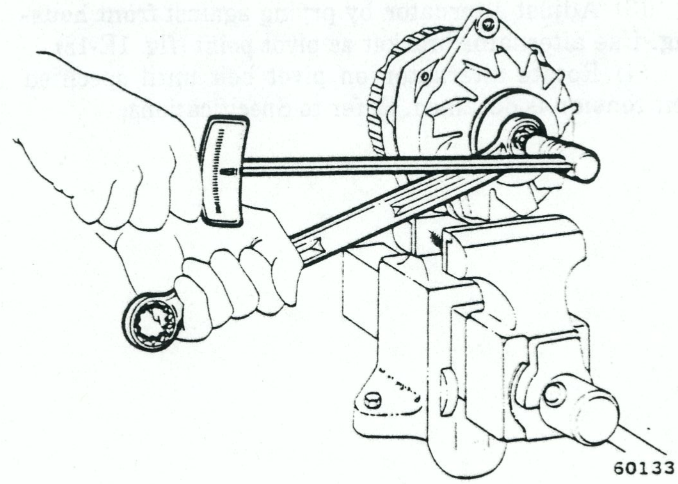


Fig. 1E-16 Tightening Pulley Nut

(18) Install bridge rectifier attaching screw and battery wire terminal screw.

(19) Connect capacitor wire terminal to bridge rectifier and tighten screw securely.

(20) Install capacitor holddown screw.

(21) Position diode trio strap terminals on bridge rectifier terminal studs.

(22) Install stator in rear housing.

(23) Attach stator windings to bridge rectifier terminal studs. Secure with washers and nuts.

(24) Before joining rotor and front housing assembly with stator and rear housing assembly, remove protective tape and ensure that bearing surface of shaft is clean.

(25) Join front housing and rear housing together with scribe mark aligned.

(26) Install four through-bolts and tighten securely.

(27) Remove toothpick from brush holder assembly. Rotate rotor.

DRIVE BELT ADJUSTMENT

If belt has been in service for some time, inspect for general condition of the belt before attempting an adjustment. Replace the belt if it is severely cracked or oil-soaked.

(1) Install Belt Strand Tension Gauge J-23600 on longest accessible span of belt, midway between pulleys (fig. 1E-17).

NOTE: *Eight-cylinder engines with air conditioning use dual drive belts. When testing belt tension, attach Tension Gauge to one belt only. Testing both belts simultaneously will give an inaccurate tension. When using the gauge on a notched belt, position the middle finger of the gauge in the notched cavity of the belt.*

(2) Loosen alternator pivot bolt and adjusting strap bolt.

CAUTION: *Do not pry against the rear housing because the aluminum casting will be damaged.*

(3) Adjust alternator by prying against **front housing**. Use alternator bracket as pivot point (fig. 1E-18).

(4) Rotate alternator on pivot bolt until specified belt tension is obtained. Refer to Specifications.

(5) Tighten adjusting strap bolt and pivot bolt while maintaining specified tension.

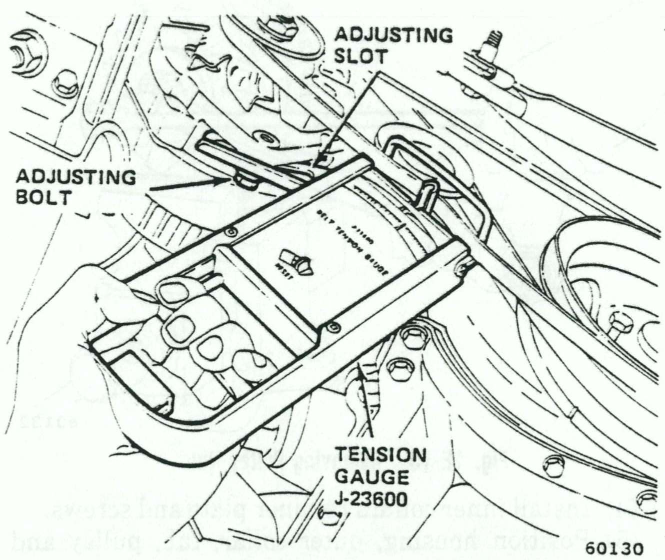


Fig. 1E-17 Testing Belt Tension—Typical

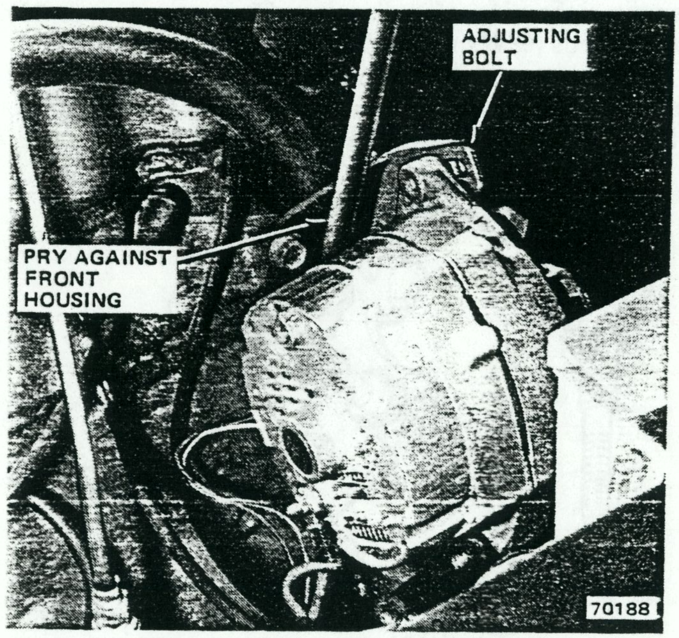


Fig. 1E-18 Adjusting Belt Tension—Typical

SPECIFICATIONS

Delco Charging System Specifications

Alternator

Manufacturer .... Delco
Standard (4, 6 and 8 cyl.) .... 42 amp
Optional (4, 6 and 8 cyl.) .... 63 amp
Optional (6 and 8 cyl.) .... 70 amp
Optional (Police) .... 85 amp
Field Current .... 4.0 to 5.0 amps at 80°F.
Rotation (Viewing Drive End) .... Clockwise
Pulley Size .... 2.43 in. (6.18 cm)
Belt Tension
  New Belt .... Set to 125-155 pounds-force (559-689 newtons)
  Used Belt .... Recheck 90-115 pounds-force (400-512 newtons)
  New Belt .... (6 cyl. Calif. Serpentine Drive) 180-200 pounds-force (800-890 newtons)
  Used Belt .... 140-160 pounds-force (623-712 newtons)

Regulator

Manufacturer .... Delco
Model 1116387
Type .... Solid State
Adjustment .... None

Output Voltage Specifications

Ambient Temperature in Degrees Fahrenheit	Acceptable Voltage Range
0-50	14.3-15.3
50-100	13.9-14.9
100-150	13.4-14.4
150-200	13.0-14.1

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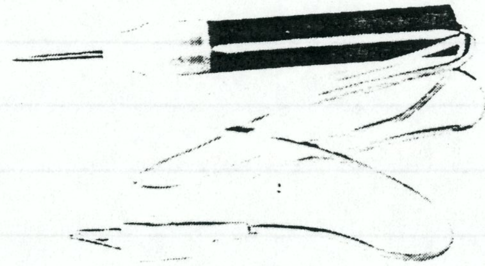
Tools



J-21008
CONTINUITY
LIGHT

70271

Torque Specifications

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item.

	USA (ft-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	Service Set-To Torque	Service In-Use Recheck Torque
Alternator Adjusting Bolt	18	15-20	24	20-27
Alternator Mounting Strap Bolt	28	23-30	38	31-41
Alternator Pivot Bolt or Nut	28	20-35	38	27-47
Pulley Nut	50	45-55	68	58-78

All Torque values given in newton-meters and foot-pounds with dry fits unless otherwise specified.

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NOTES

STARTING SYSTEM 1F

SECTION INDEX

FOUR-CYLINDER ENGINE STARTING SYSTEM

GENERAL

The four-cylinder engine starter motor system consists of a 5MT starter motor, ignition/start switch, battery and related electrical wiring. These components are connected electrically as illustrated in figure 1F-1.

STARTER MOTOR OPERATION

The 5MT starter motor is shown in figure 1F-2. The field windings are permanently mounted in the motor frame. Both the shift lever mechanism and the solenoid plunger are enclosed in the drive housing to protect them from exposure to dirt, icing conditions and water splash.

In the basic circuit illustrated in figure 1F-1, the solenoid is energized when the ignition/starting key switch is closed. The resulting plunger and shift lever movement causes the pinion gear to engage the engine flywheel (or drive plate) ring gear and the solenoid main contacts to close, and engine cranking is initiated. When the engine starts, the pinion gear overrun clutch protects the armature from excessive speed until the switch is opened, at which time the return spring disengages the pinion gear. To prevent excessive overrun, the key switch should be released immediately after the engine starts.

Neutral Safety Switch

The Neutral Safety Switch is a three-connector plunger switch mounted on the automatic transmission case. The outside terminals connect to the back-up lamps, while the center terminal provides a ground path for the starter motor relay circuit. Ground is provided only when the transmission is in Park or Neutral position.

NOTE: *CJ vehicles equipped with a four-cylinder engine and automatic transmission have a starter motor relay that is energized when the ignition key is in the START position, providing the automatic transmission selector is in either the NEUTRAL or PARK position. When the relay is energized, battery voltage is applied to the starter motor pull-in and hold-in windings.*

SERVICE DIAGNOSIS

Before removing any unit from the starter motor system for repair, perform the following inspections.

(1) **Battery:** To determine condition of battery, follow testing procedure outlined in Chapter 1D—Batteries.

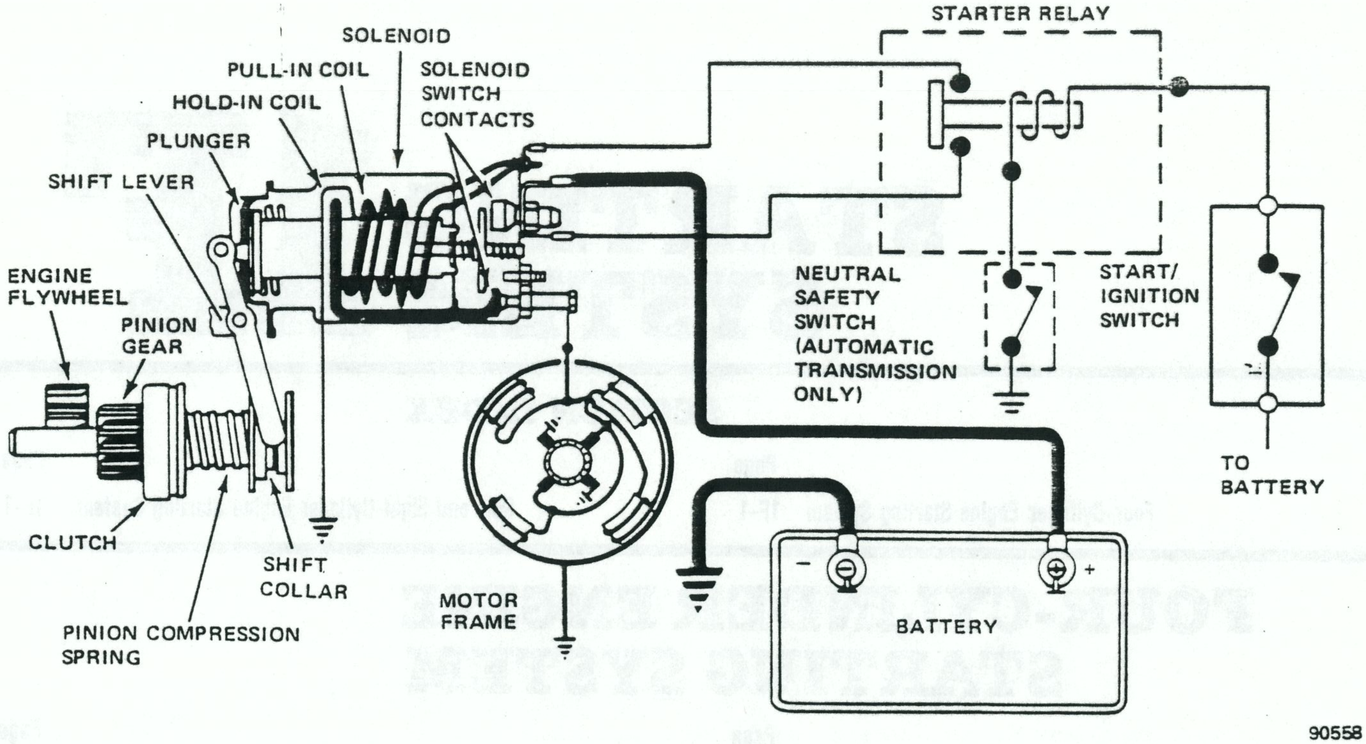

Fig. 1F-1 Four-Cylinder Engine Starter Motor System

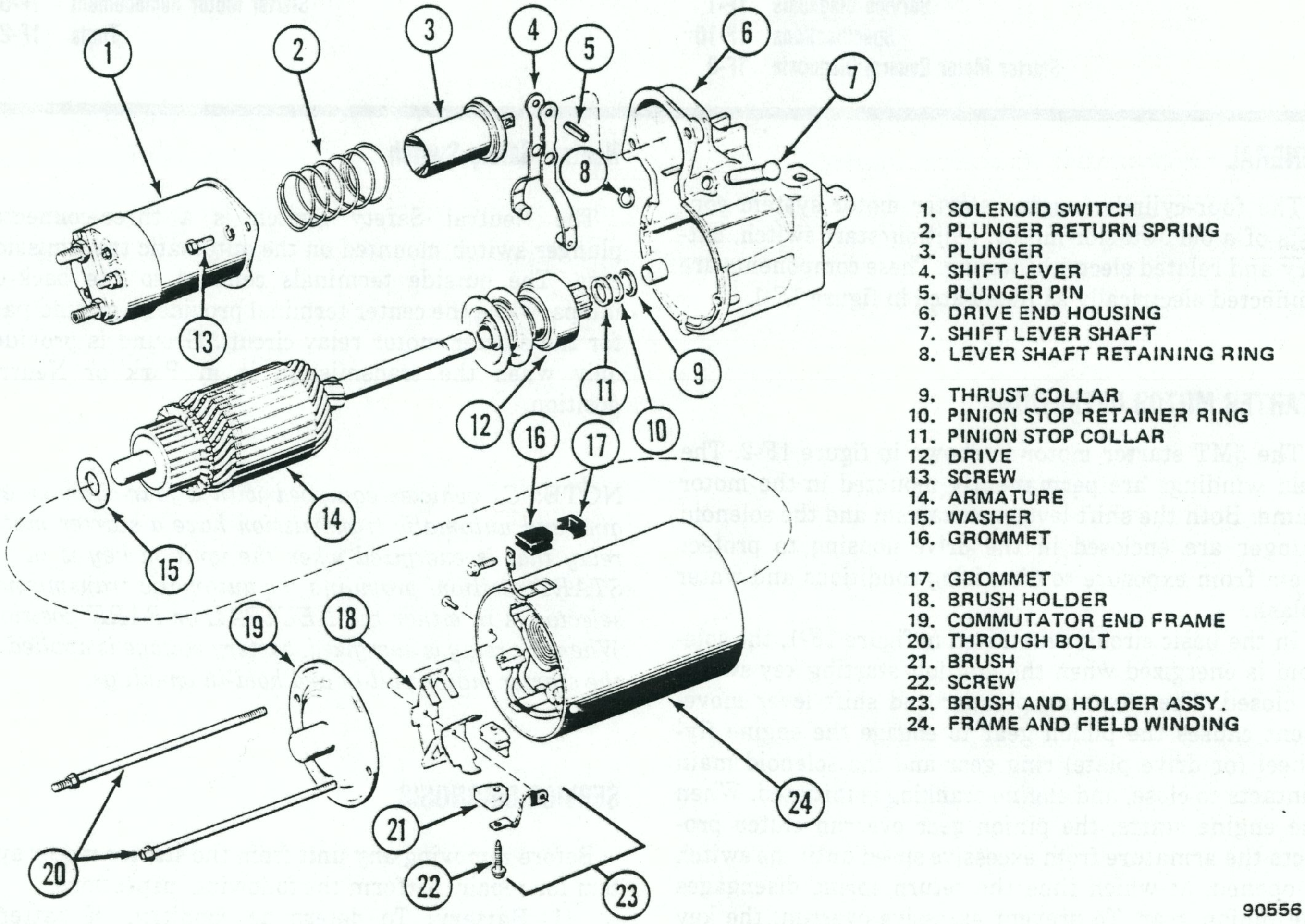

Fig. 1F-2 5MT Starter Motor—Exploded View

(2) **Wiring:** Inspect wiring for damage. Inspect all connections at starter motor solenoid, relay (if equipped), neutral safety switch (if equipped), ignition/start switch, and battery, including all ground connections. Clean and tighten all connections as required.

(3) **Solenoid and Ignition/Start Switch:** Inspect solenoid and switch to determine their condition. Also, if equipped with automatic transmission, inspect condition of starter motor relay.

(4) **Starter Motor Noise:** To correct starter motor noise during starting, use the following procedure:

(a) Refer to Starter Motor Noise Diagnosis Chart to determine problem.

(b) If complaint is similar to first two conditions, correction can be achieved by proper "shimming" as follows.

1. Remove flywheel or drive plate ring gear inspection plate.

2. Inspect flywheel or drive plate and ring gear for damage; i.e., warp, unusual wear and excessive runout. Replace flywheel, ring gear or drive plate as necessary.

3. Disconnect battery negative cable (to prevent inadvertant cranking of engine).

NOTE: *Two shim thicknesses are available. One is 0.015 inch (0.381 mm) and the other 0.045 inch (1.143 mm). If shims are not available, they can be fabricated from plain washers or other suitable material.*

4. If complaint is similar to first condition, starter motor must be moved toward flywheel/drive plate. This can be accomplished by shimming (fig. 1F-3) only outboard starter motor mounting pad. (This is generally condition that causes broken flywheel ring gear teeth or starter motor housings).

5. If complaint is similar to second condition, starter motor must be moved away from flywheel/drive plate. This is accomplished by installing shim(s) (fig. 1F-3). More than one shim may be required.

(c) Conditions 3 and 4 may require starter motor replacement or repair in some instances.

(5) **Starter Motor:** If battery, wiring, switches, solenoid and relay (if equipped) are in satisfactory condition, and engine is known to be functioning properly, remove starter motor and follow test procedures outlined below.

CAUTION: *Never operate the starter motor more than for a 30-second duration without pausing to allow it to cool for at least two minutes. Overheating, caused by excessive cranking, will seriously damage the starter motor.*

Starter Motor Test

A general diagnosis is described at the end of this section. Once a problem has been traced to the starter motor, proceed to the test procedure outlined below.

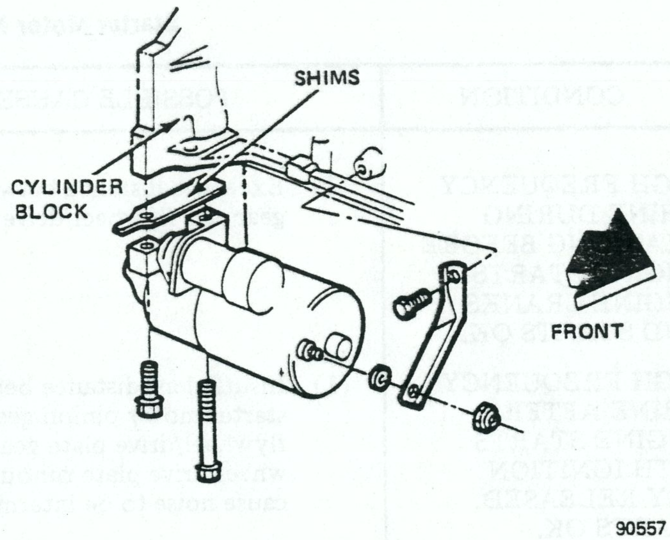

Fig. 1F-3 Starter Motor Shimming and Mounting

Test Procedure

With the starter motor removed from the engine, the pinion gear should be tested for freedom of operation by turning it on the screw shaft. The armature should be tested for freedom of rotation by prying the pinion gear with a screwdriver to engage it with the shaft. Tight bearings, a bent armature shaft, or a bent frame will cause the armature to not rotate freely. If the armature does not rotate freely, the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

No-Load Test

Connect a voltmeter (fig. 1F-4) between the motor terminal and the motor frame, and use a tachometer to measure armature speed. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch (in the open position) from the solenoid battery terminal to the solenoid switch terminal. Close the switch and compare the rpm, current, and voltage with those listed in the specifications. It is not necessary to obtain the exact voltage specified because an accurate interpretation can be made by recognizing that if the voltage is slightly higher, the rpm will be proportionately higher, with the current remaining the same. However, if the exact voltage is desired, a carbon pile rheostat connected across the battery can be used to reduce the voltage to the specified value. The specified current flow includes the solenoid current flow. Make disconnections only with the switch open. Interpret the test results as follows:

(1) Rated current flow and specified no-load speed indicate normal condition of starter motor.

Starter Motor Noise Diagnosis

CONDITION	POSSIBLE CAUSE	CORRECTION
HIGH FREQUENCY WHINE DURING CRANKING BEFORE ENGINE STARTS; ENGINE CRANKS AND STARTS OK.	(1) Excessive distance between pinion gear and flywheel/drive plate gear.	(1) Shim starter motor toward flywheel/drive plate.
HIGH FREQUENCY WHINE AFTER ENGINE STARTS WITH IGNITION KEY RELEASED. STARTS OK.	(1) Insufficient distance between starter motor pinion gear and flywheel/drive plate gear. Flywheel/drive plate runout can cause noise to be intermittent.	(1) Shim starter motor away from flywheel/drive plate. Inspect flywheel/drive plate for damage; bent, unusual wear, and excessive runout. Replace flywheel/drive plate as necessary.
A LOUD "WHOOP" AFTER ENGINE STARTS WHILE STARTER MOTOR IS ENGAGED	(1) Most probable cause is defective overrunning clutch. Clutch replacement normally corrects this condition.	(1) Replace overrunning clutch or drive assembly.
A "RUMBLE", "GROWL" OR "KNOCK" AS STARTER MOTOR COASTS TO STOP AFTER ENGINE STARTS.	(1) Most probable cause is bent or unbalanced starter motor armature. Armature replacement normally corrects this condition.	(1) Replace starter motor armature.

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(2) Low no-load speed and high current flow indicate:

(a) Too much friction—tight, dirty, or worn bearings, bent armature shaft or bent frame causing armature to drag.

(b) Shorted armature winding. This can be further determined on growler after disassembly.

(c) Grounded armature or field windings. Inspect further after disassembly.

(3) No armature rotation and high current flow indicate:

(a) Terminal or field windings shorted to ground.

(b) Seized bearings (this should have been determined by turning armature by hand).

(4) No armature rotation and no current flow indicate:

(a) Open field winding circuit. This can be determined after disassembly by inspecting internal connections and testing circuit with test lamp.

(b) Open armature windings. Inspect commutator for badly burned bars after disassembly.

(c) Broken brush springs, worn brushes, protruding insulation between commutator bars or other causes that would prevent good contact between brushes and commutator.

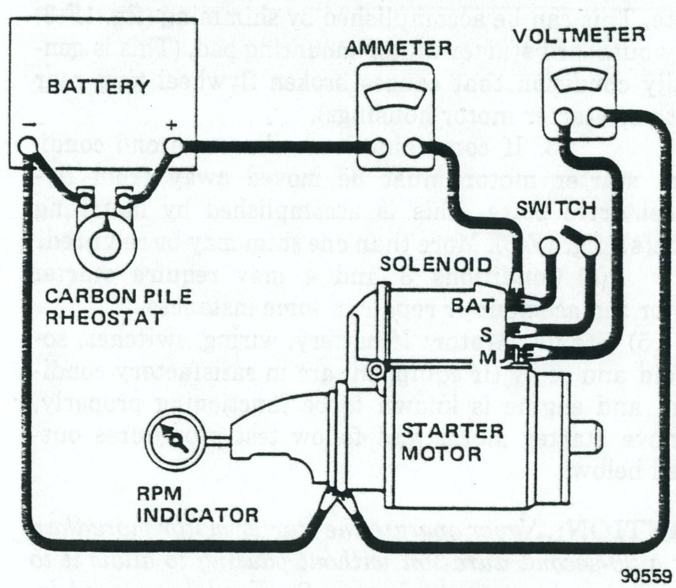


Fig. 1F-4 No-Load Test Connections

(5) Low no-load speed and low current flow indicate high internal resistance because of poor connections, defective wires, dirty commutator and causes listed under step (4) above.

(6) High no-load speed and high current flow usually indicate shorted field windings. If shorted field windings are suspected, replace field winding and frame assembly and retest for improved performance. In some instances, armature winding could also be shorted. Test on growler.

STARTER MOTOR REPLACEMENT

Starter motors do not require lubrication except during overhaul.

When the motor is disassembled for any reason, lubricate as follows:

(1) Armature shaft and drive end and commutator end bushings should be covered with a thin coating of Lubriplate, or equivalent.

(2) Roll type overrunning clutch requires no lubrication. However, drive assembly should be wiped clean. **Do not** clean in degreasing tank or with grease dissolving solvents because this will dissolve lubricant in clutch mechanism. Use silicone grease (General Electric CG321, Dow Corning 33 Medium, or equivalent) on shaft underneath overrruning clutch assembly.

NOTE: *Avoid excessive lubrication.*

Starter Motor Removal

Use the following procedure to remove the starter motor from the engine:

(1) Disconnect battery negative cable at battery.

(2) Remove starter-to-engine brace (fig. 1F-3).

(3) From beneath vehicle, remove two starter motor-to-engine bolts (fig. 1F-3), and allow starter to drop down.

(4) Disconnect solenoid wires and battery cable, and remove starter motor. To replace, reverse procedure outlined above. Replace any shims that were removed.

Solenoid Removal

Use the following procedure to remove the solenoid from the starter motor:

(1) Disconnect field strap.

(2) Remove solenoid-to-drive housing attaching screws, motor terminal bolt, and remove solenoid by twisting.

(3) Replace by reversing procedure outlined above.

NEUTRAL SAFETY SWITCH REPLACEMENT

(1) Disconnect wiring connector and remove switch from transmission. Allow fluid to drain into container.

(2) Move selector lever to Park and Neutral positions. Inspect switch operating lever fingers to ensure they are properly centered in switch opening.

(3) Install switch and seal on transmission case. Tighten switch with 24 foot-pounds (6 N•m) torque.

(4) Test switch continuity.

(5) Correct transmission fluid level as required.

STARTER MOTOR OVERHAUL

If the starter motor does not function correctly (as described in the No-Load Test above), it should be disassembled for further testing of the components. The starter motor should be disassembled only enough to permit repair or replacement of the defective parts. Safety glasses should be worn when disassembling or assembling the starter motor.

Disassembly

The following procedure should be used to disassemble and reassemble the starter motor. Component inspections are also included. Refer to figure 1F-2 and proceed as follows:

(1) Disconnect field winding connection from solenoid terminal.

(2) Remove through-bolts.

(3) Remove commutator end frame and field frame assembly.

(4) Remove armature assembly from drive housing. Remove solenoid and shift lever assembly from drive housing before removing armature assembly.

(5) Remove thrust collar from armature shaft.

(6) Remove pinion gear from armature by sliding metal cylinder onto shaft and by striking metal cylinder against retainer with hammer. Drive retainer toward armature core and off snap ring (fig. 1F-5).

(7) Remove snap ring from groove in armature shaft.

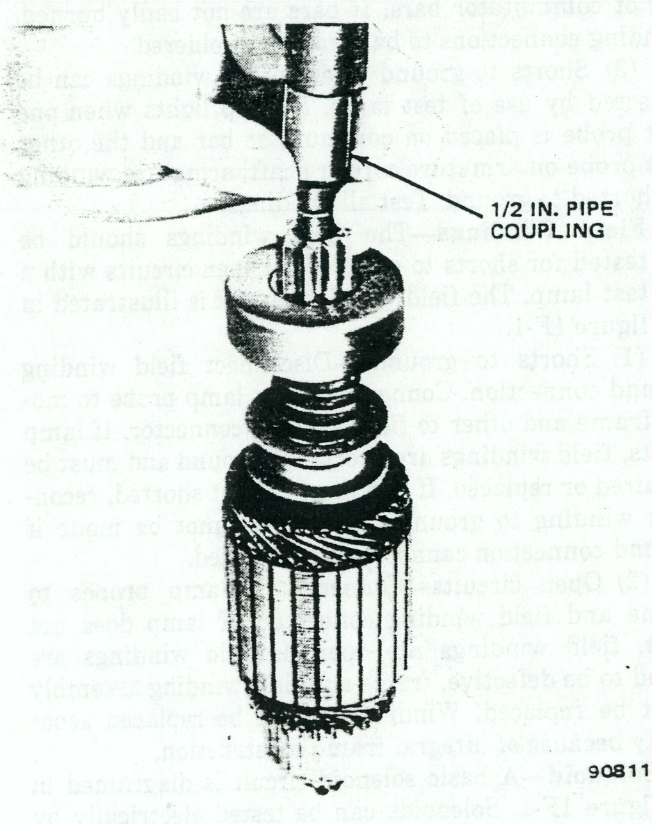


Fig. 1F-5 Removing Retainer From Snap Ring

(8) Roller type clutches are designed to be serviced as a complete unit. Do not disassemble, replace if necessary.

Component Inspection

- **Brushes and Brush Holders**—Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Ensure the brush holders are clean and the brushes are not binding in the holders. The complete brush surface should ride on the commutator for proper operation. Check by hand to ensure that the brush springs are providing firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.
- **Armature Windings**—Commutators should not have the insulation undercut, and out-of-round commutators should **not** be turned in a lathe. The armature windings should be tested for internal short circuits, open circuits, and shorts to ground:

(1) Internal short circuits are located by rotating armature in growler with steel strip (e.g., hacksaw blade) held above armature. Steel strip will vibrate when at area of short circuit. Short circuits between commutator bars are sometimes caused by brush dust or copper imbedded between bars. Cleaning dust and copper out of bars may eliminate short circuits.

(2) Open circuits can be located by inspecting connections joining armature windings to commutator bars for looseness. Loose connections cause arcing and burning of commutator bars. If bars are not badly burned, winding connections to bars can be resoldered.

(3) Shorts to ground in armature windings can be detected by use of test lamp. If lamp lights when one test probe is placed on commutator bar and the other test probe on armature core or shaft, armature winding is shorted to ground. Test all windings.

- **Field Windings**—The field windings should be tested for shorts to ground and open circuits with a test lamp. The field winding circuit is illustrated in figure 1F-1.

(1) Shorts to grounds—Disconnect field winding ground connection. Connect one test lamp probe to motor frame and other to field winding connector. If lamp lights, field windings are shorted to ground and must be repaired or replaced. If windings are not shorted, reconnect winding to ground. This test cannot be made if ground connection cannot be disconnected.

(2) Open circuits—Connect test lamp probes to frame and field winding connector. If lamp does not light, field windings are open. If field windings are found to be defective, frame and field winding assembly must be replaced. Windings cannot be replaced separately because of integral frame construction.

- **Solenoid**—A basic solenoid circuit is diagramed in figure 1F-1. Solenoids can be tested electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings. With all wires disconnected from the solenoid, make test connections to the solenoid switch terminal and to ground to test the hold-in winding (fig. 1F-6). Use the carbon pile rheostat across the battery to decrease the battery voltage to the value listed in specifications. Compare the current flow with the value listed in Specifications. A high current flow indicates a shorted or grounded hold-in winding, and a low current flow indicates excessive resistance.

To test the pull-in winding, connect the battery across the solenoid switch (S) terminal and the Solenoid motor (M) terminal. To reduce the voltage to the specified value, connect the carbon pile rheostat

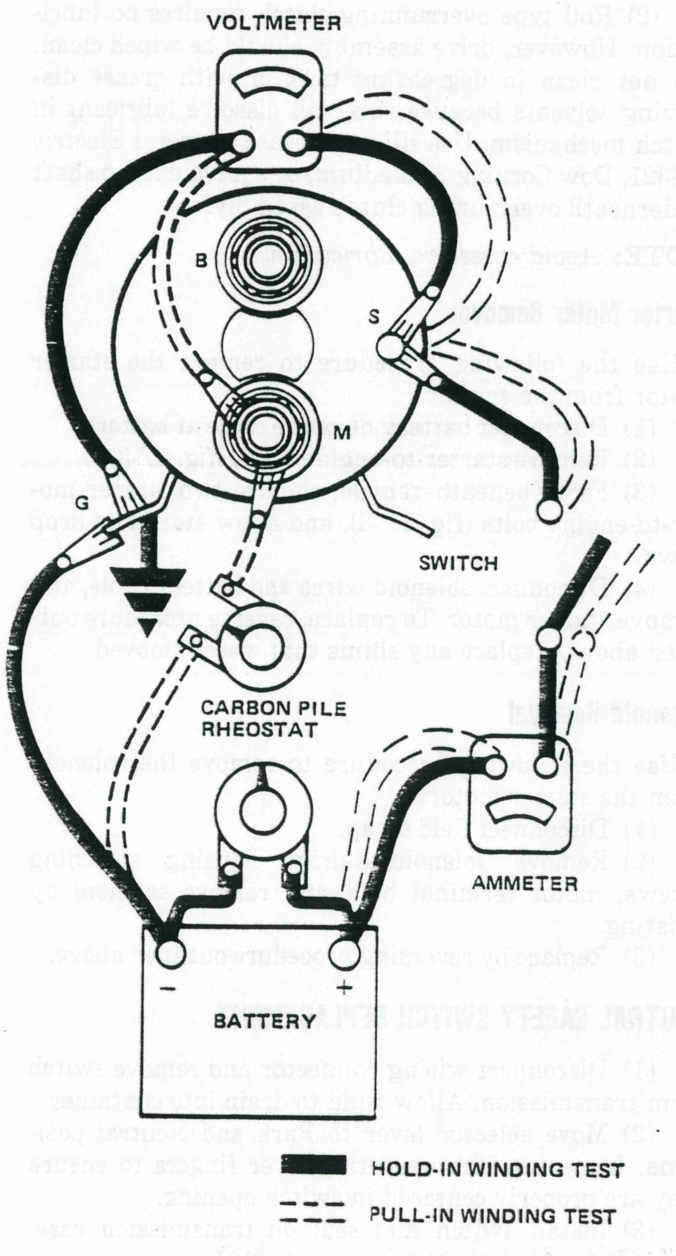


Fig. 1F-6 Solenoid Test Connections

between the battery and M-terminal as shown with dashed lines (fig. 1F-6) instead of across the battery as shown with solid lines. If not needed, connect a jumper directly from the battery to the M-terminal.

CAUTION: *To prevent overheating, do not allow the pull-in winding to be energized more than 15 seconds. The current flow will decrease as the winding temperature increases.*

- **Overrunning Clutch**—Test the overrunning clutch action. The pinion gear should turn freely in the overrunning direction. Inspect the pinion gear teeth to ensure that they have not been chipped, cracked, or excessively worn. Replace assembly if necessary. Badly chipped pinion gear teeth indicate possible chipped teeth on the ring gear. The ring gear should be examined and replaced if necessary.

Test the overrunning clutch for slipping with the clutch attached to the armature. Wrap the armature with a shop towel and clamp in a vise. Using a 12-point deep socket and torque wrench, place the socket on the clutch and turn counterclockwise. The clutch should not slip with up to 50 foot-pounds (68 N•m) torque applied. If it does, replace the clutch.

Reassembly

(1) Position clutch assembly on armature shaft. To replace snap ring and retainer onto armature:

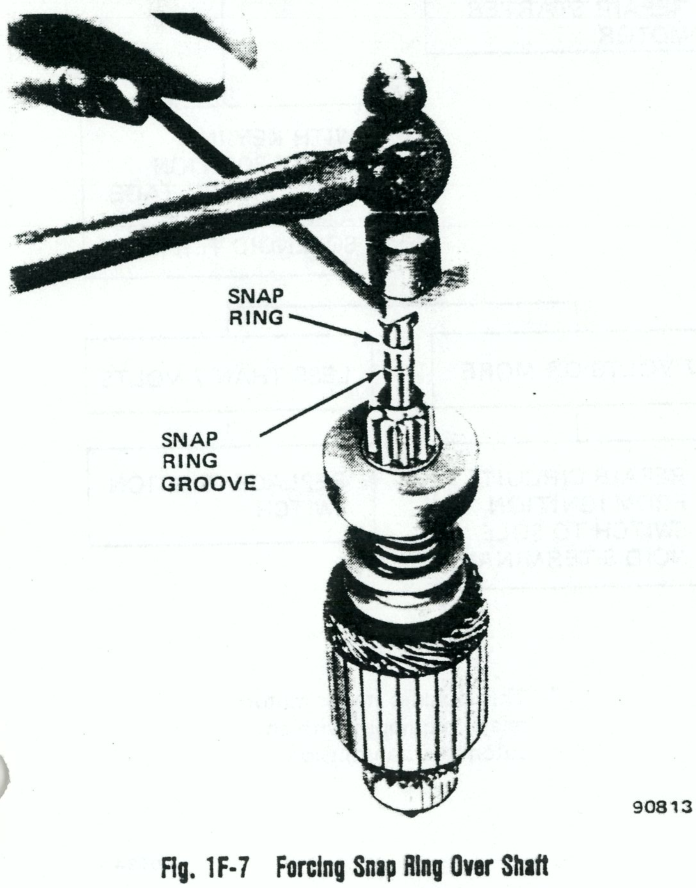


Fig. 1F-7 Forcing Snap Ring Over Shaft

(a) Position retainer on armature shaft with cupped surface facing snap ring groove.

(b) Position snap ring on end of shaft. With piece of wood on top, force ring over shaft and tap in place (fig. 1F-7), then slide ring down into groove.

(c) To force retainer over snap ring, place a suitable washer over shaft and squeeze retainer and washer together with pliers (fig. 1F-8).

(d) Remove washer.

(e) Slide thrust collar over shaft.

(2) Refer to disassembly procedure and follow in reverse order to complete reassembly.

(3) When solenoid is installed, apply sealing compound between motor frame, flange, and solenoid junction.

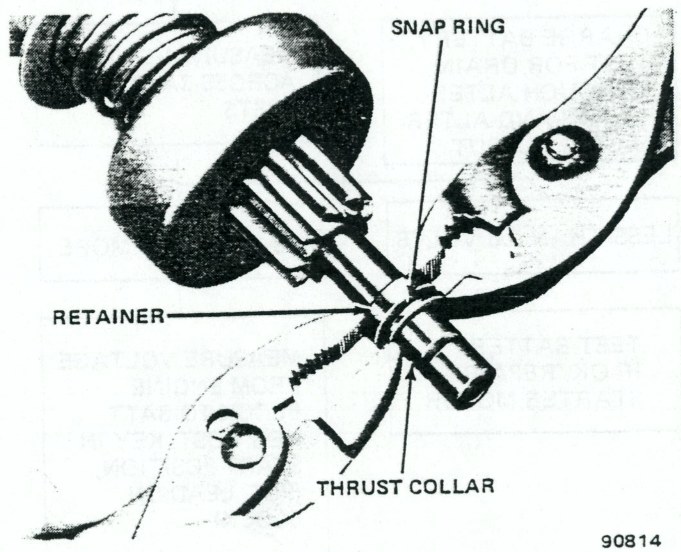


Fig. 1F-8 Forcing Retainer Over Snap Ring

Pinion Gear Clearance Test

The pinion gear clearance cannot be adjusted but should be tested after reassembly of the starter motor to ensure proper clearance. Improper clearance is an indication of worn parts.

To measure pinion gear clearance, follow the steps listed below:

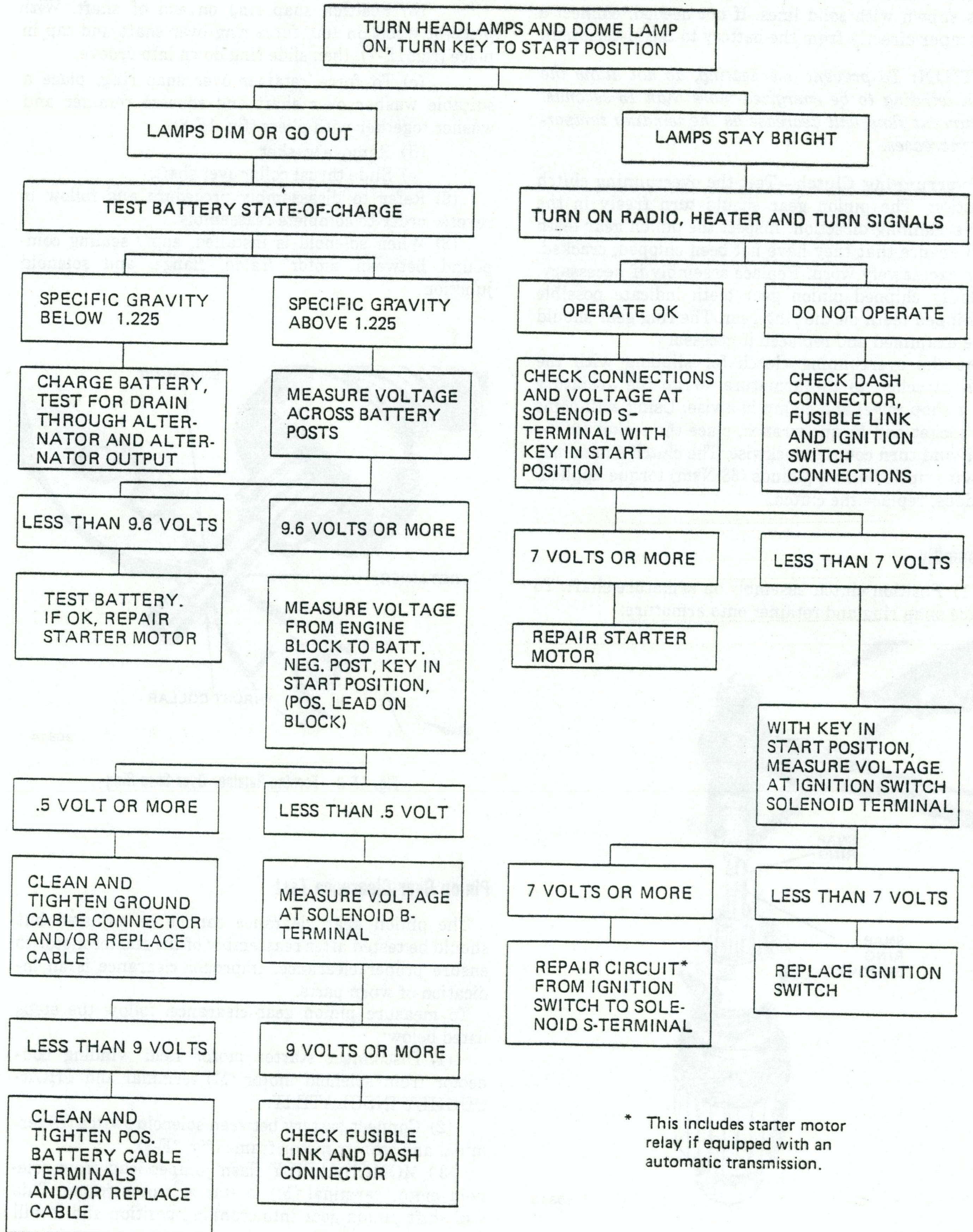
(1) Disconnect starter motor field winding connector from solenoid motor (M) terminal and THOROUGHLY INSULATE IT.

(2) Connect battery between solenoid switch (S) terminal and starter motor frame (fig. 1F-9).

(3) MOMENTARILY flash jumper lead from solenoid motor terminal (M) to starter motor frame. This will shift pinion gear into cranking position and it will remain in this position until battery is disconnected.

Starter Motor General Diagnosis

NO CRANKING, SOLENOID DOES NOT ENERGIZE



* This includes starter motor relay if equipped with an automatic transmission.

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Starter Motor General Diagnosis (Continued)

SLOW CRANKING, SOLENOID CLICKS OR CHATTERS

CHECK: BATTERY CONDITION

VISUAL CONDITION OF BATTERY CABLES AND CONNECTIONS

IF BATTERY NEEDS CHARGING, MAKE ALTERNATOR AND BATTERY DRAIN CHECK, CHARGE BATTERY AND RECHECK CRANKING. IF TROUBLE HAS NOT BEEN FOUND, PROCEED.

↓

REMOVE 12-VOLT LEAD FROM HEI DISTRIBUTOR. MAKE ALL VOLTMETER TESTS WITH KEY IN START POSITION.

↓

MEASURE VOLTAGE ACROSS BATTERY TERMINAL POSTS

- **9.6 VOLTS OR MORE**
  - MEASURE VOLTAGE FROM BATTERY NEGATIVE TERMINAL TO ENGINE BLOCK. (POS. LEAD ON BLOCK)
    - **.5 VOLT OR MORE** → REPAIR GROUND CABLE AND CONNECTIONS
    - **LESS THAN .5 VOLT** → MEASURE VOLTAGE AT SOLENOID B - TERMINAL, CLEAN AND TIGHTEN CONNECTIONS AT STARTER MOTOR
      - **9 VOLTS OR MORE** → REPAIR STARTER MOTOR
      - **LESS THAN 9 VOLTS** → CLEAN AND TIGHTEN POSITIVE CONNECTIONS IF OK, REPLACE CABLE
- **LESS THAN 9.6 VOLTS**
  - CHARGE AND CONNECT TEST BATTERY. MEASURE VOLTAGE
    - **LESS THAN 9.6 VOLTS** → REPAIR STARTER MOTOR
    - **9.6 VOLTS OR MORE** → REPLACE ORIGINAL BATTERY

NOTE: THIS DIAGNOSIS IS DESIGNED FOR USE ON ENGINES AND BATTERIES AT ROOM OR NORMAL OPERATING TEMPERATURES. IT IS ALSO NECESSARY THAT THERE BE NO ENGINE DEFECTS THAT WOULD CAUSE CRANKING PROBLEMS. TO USE IT UNDER OTHER CONDITIONS CAN RESULT IN AN INCORRECT DIAGNOSIS.

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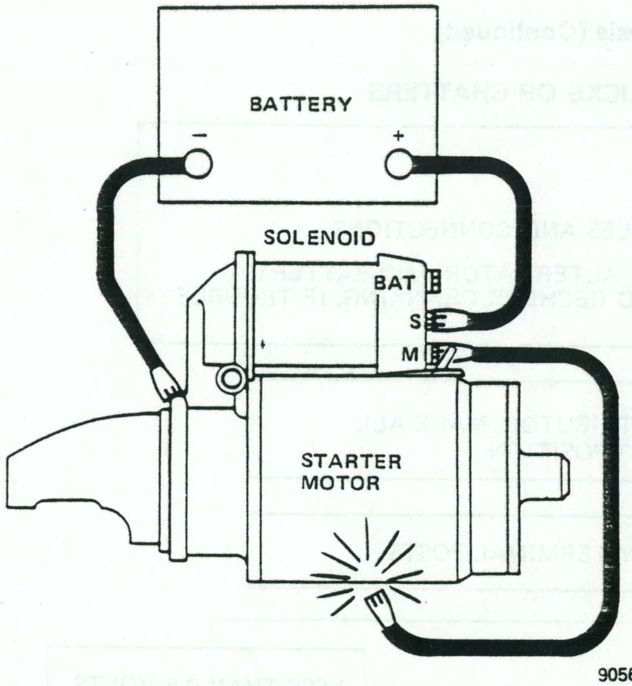

Fig. 1F-9 Pinion Gear Clearance Measurement Test Circuit

(4) Push pinion gear back toward commutator end to eliminate any slack.

(5) Measure distance between pinion gear and pinion gear stop with feeler gauge (fig. 1F-10). Acceptable distance is 0.010 to 0.140 inch (0.0254 to 3.556 mm).

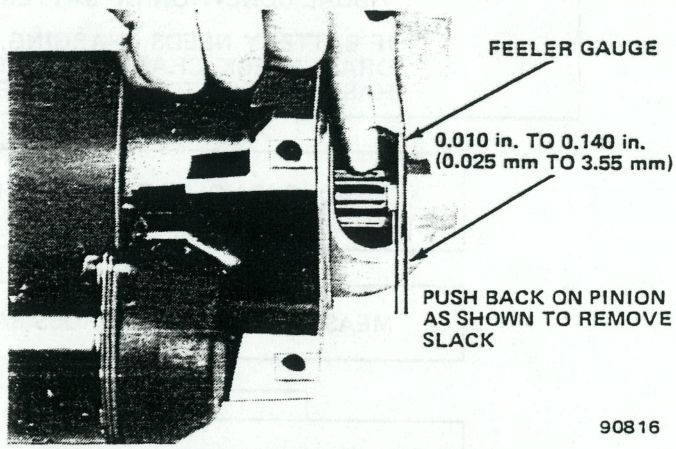

Fig. 1F-10 Measuring Pinion Gear Clearance

SPECIFICATIONS

STARTER MOTOR AND SOLENOID									
ENGINE	STARTER		NO LOAD TEST WITH 9 VOLTS				SOLENOID		
	PART NO.	TYPE	AMPS		RPM•		PART NO.	SPECIFICATIONS	
			MIN.	MAX.	MIN.	MAX.		HOLD-IN WINDING AMPS AT 10V	PULL-IN WINDING AMPS AT 5V
151 (2V)	1109526	5MT	45	70	7000	11,900	1114488	15-20	20-30

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SIX-AND EIGHT-CYLINDER ENGINE STARTING SYSTEM

GENERAL

The starting system used with all Jeep six- and eight-cylinder engines consists of a positive engagement starter motor, a starter motor solenoid, an ignition/start switch, circuits protected by fusible links and the battery. Vehicles equipped with an automatic transmission also have a neutral safety switch. The starter motor has a moveable pole shoe and appropriate linkage to engage the drive mechanism. Inside the drive assembly, an overrunning clutch prevents the starter motor from being driven by the ring gear.

COMPONENTS

Starter Motor

Identification

At the time of manufacture, the starter motor identification code is stamped on the frame adjacent to the Jeep part number. The date is decoded as follows:

- Year (0—1980) (1—1981)
- Month (A—Jan., B—Feb., etc.)
- Week (A—first week in month, B—second week, etc.)

Field Windings

Four field windings are used. Each is wound around an iron pole shoe that concentrates the electromagnetic flux created when current flows through the field winding. Three of the field windings have fixed pole shoes, while the fourth winding has a moveable pole shoe. This fourth winding, located at the top of the starter motor, has an additional, smaller winding wound inside of it. This is the hold-in winding.

Drive Assembly

A pinion gear, driven by the starter motor armature, is forced to move into mesh with the engine flywheel (or drive plate) ring gear when the starter motor is actuated. The movement is accomplished by the action of the moveable pole shoe and its drive yoke (fig. 1F-11). As long as the ignition key is held in the **Start** position, the pinion gear remains in mesh with the ring gear. An overrunning (one-way) clutch in the drive assembly permits the starter motor to drive the ring gear, but after the engine starts, the clutch prevents the engine from driving the starter motor before the key is released to the **On** position.

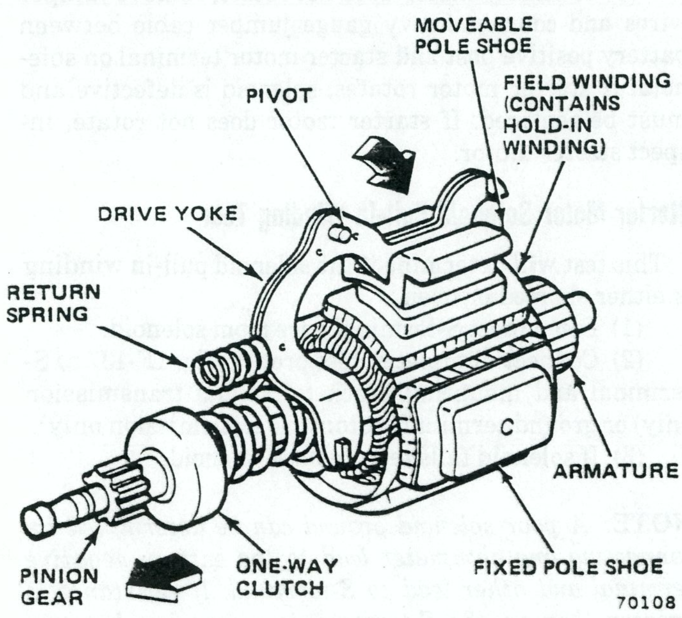

Fig. 1F-11 Moveable Pole Shoe Operation

Starter Motor Solenoid

Two different starter motor solenoids are used, one with manual transmissions and the other with automatic transmissions. The solenoids differ only in the method of providing a ground for the solenoid pull-in winding.

The ground circuit for the solenoid pull-in winding is completed through the solenoid mounting bracket on manual transmission equipped vehicles.

On vehicles equipped with an automatic transmission, the pull-in winding is grounded through an additional terminal on the bottom of the solenoid. A wire connected to this terminal provides a ground path from the neutral safety switch located on the transmission. The pull-in-winding ground circuit is completed at the neutral safety switch only when the automatic transmission gear selector is placed in Neutral or Park.

NOTE: *The neutral safety switch and back-up lamp switch are enclosed in a single housing.*

The starter motor solenoid pull-in winding is energized when battery voltage is applied to the S-terminal of the solenoid and the pull-in winding is grounded. When the solenoid pull-in winding is energized, the contact disc is forced into the closed position. The disc mates with two contacts in the solenoid and this completes the circuit between the battery and the starter motor.

All starter motor solenoids have an I-terminal that is connected to the ignition system. When the starter motor is in operation, the I-terminal provides full battery voltage for the ignition coil. This circuit bypasses the resistance wire that provides voltage for the coil after the engine starts. Refer to Chapter 1G—Ignition Systems for additional information.

CAUTION: *Starter motor solenoids used in previous years (before solid-state ignitions) look similar to the solenoids presently used but are very different internally. Use of the wrong type solenoid can damage the neutral safety switch. Verify the part number stamped on the replacement solenoid before installation.*

CAUTION: *Starter motor solenoids are equipped with both blade terminals and long studs. The blade terminals are attached to the long studs and held in place by retaining nuts. Loosening of the retaining nuts could cause the loss of internal connections and necessitate replacement of the solenoid.*

Neutral Safety Switch

The Neutral Safety Switch is a three-terminal plunger switch mounted on the automatic transmission case. The two outer terminals connect to the back-up lamp circuit, while the center terminal provides a ground path for the starter motor solenoid circuit. Ground is provided only when the automatic transmission is in Park or Neutral position.

Starter System Circuits

The starting system has two electrical circuits, a low current circuit and a high current circuit (fig. 1F-12). The low current circuit is the control circuit. It includes the connections and wires leading from the ignition switch to the S-terminal on the starter motor solenoid, and from the ground terminal of the starter motor solenoid to the neutral safety switch on automatic transmission equipped vehicles. The high current circuit runs from the battery through the starter motor solenoid to the starter motor to ground. This circuit uses heavy gauge cables because of the large current flow required for the starter motor.

Fusible Link

A fusible link is used in the low current starting system circuit (fig. 1F-12). Current flows from the starter motor solenoid battery terminal by cable to the battery positive terminal. From the solenoid battery terminal, voltage is also distributed to other vehicle circuits. A 14-gauge fusible link is connected between the solenoid terminal and the main body wire harness. This fusible link protects the complete vehicle electrical system as well as the solenoid.

Fusible links are covered with a special non-flammable insulation. Each link is manufactured with a specific load rating and is intended for a specific circuit. Replacement links are available from Jeep service parts sources.

OPERATION

The starter motor low current circuit is controlled by the ignition/start switch (fig. 1F-12). The ignition/start switch applies battery voltage to the starter motor solenoid S-terminal when the ignition key is in the **Start** position. This energizes the solenoid pull-in winding, which completes the high current circuit between the battery and the starter motor. The starter motor is then actuated and begins rotating the engine crankshaft.

TROUBLESHOOTING

The Service Diagnosis chart may be used to isolate the source of the problem when the starter motor either rotates the engine too slowly, will not rotate the engine, or has abnormal drive engagement.

If the starter motor rotating speed is normal and the drive pinion gear engages properly with the ring gear but the engine does not start, a problem exists either in the fuel system or ignition system.

ON-VEHICLE TESTING

Starter Motor Will Not Rotate

(1) Verify battery and cable condition as outlined in Chapter 1D—Batteries to assure correct voltage is available.

(2) Inspect and tighten battery and starter motor cable connections at starter motor solenoid terminals.

(3) Disconnect wire at solenoid S-terminal.

WARNING: *Place transmission in Neutral (manual) or Park (automatic) position and apply parking brake before conducting solenoid test.*

(4) Connect jumper wire from battery positive post to solenoid S-terminal. If starter motor rotates, solenoid is not defective. Inspect ignition/start switch circuit.

(5) If starter motor does not rotate, connect another jumper wire from battery negative terminal to solenoid mounting bracket (manual transmission only) or ground terminal (automatic transmission only). Ensure good connection is made. If solenoid energizes, it was not properly grounded. Remove rust or corrosion and attach solenoid to inner-fender panel with cadmium-plated screws (manual transmission only) or test operation of neutral safety switch (automatic transmission only).

(6) If starter motor does not rotate, remove jumper wires and connect heavy gauge jumper cable between battery positive post and starter motor terminal on solenoid. If starter motor rotates, solenoid is defective and must be replaced. If starter motor does not rotate, inspect starter motor.

Starter Motor Solenoid Pull-In Winding Test

This test will determine if the solenoid pull-in winding is either shorted or open.

(1) Disconnect S-terminal wire from solenoid.

(2) Connect ohmmeter test probes (fig. 1F-13) to S-terminal and mounting bracket (manual transmission only) or ground terminal (automatic transmission only).

(3) If solenoid fails test, replace solenoid.

NOTE: *A poor solenoid ground can be determined by connecting one ohmmeter lead to the battery negative terminal and other lead to S-terminal. If resistance is greater than in the S-terminal-to-mount bracket test (fig. 1F-13), the solenoid has a poor ground.*

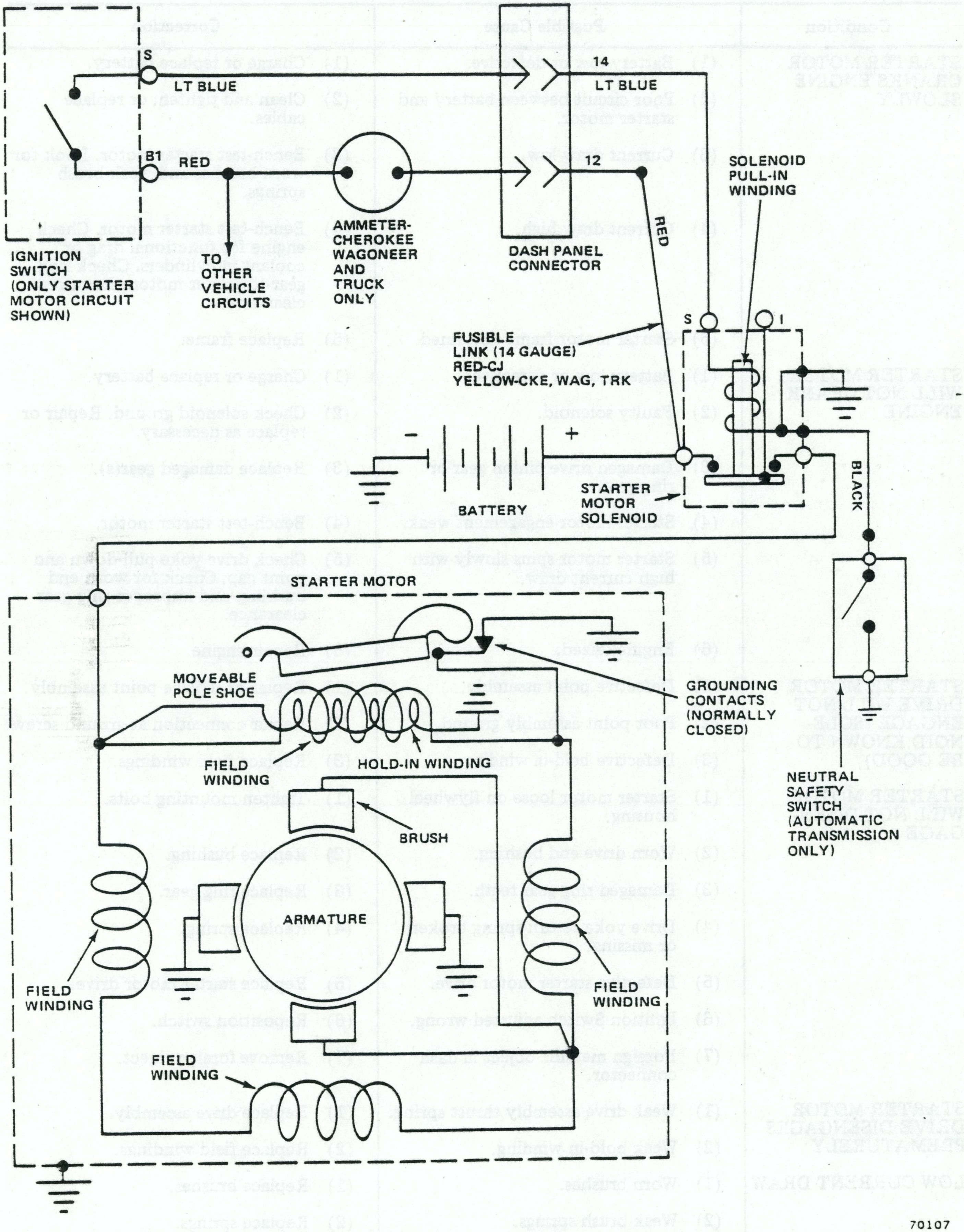

Fig. 1F-12 Six- and Eight-Cylinder Engine Starting System Schematic

Service Diagnosis

Condition	Possible Cause	Correction
STARTER MOTOR CRANKS ENGINE SLOWLY	(1) Battery low or defective.	(1) Charge or replace battery.
	(2) Poor circuit between battery and starter motor.	(2) Clean and tighten, or replace cables.
	(3) Current draw low.	(3) Bench-test starter motor. Look for worn brushes and weak brush springs.
	(4) Current draw high.	(4) Bench-test starter motor. Check engine for functional drag or coolant in cylinders. Check ring gear-to-starter motor pinion gear clearance.
	(5) Starter motor frame deformed.	(5) Replace frame.
STARTER MOTOR WILL NOT CRANK ENGINE	(1) Battery low or defective.	(1) Charge or replace battery.
	(2) Faulty solenoid.	(2) Check solenoid ground. Repair or replace as necessary.
	(3) Damaged drive pinion gear or ring gear.	(3) Replace damaged gear(s).
	(4) Starter motor engagement weak.	(4) Bench-test starter motor.
	(5) Starter motor spins slowly with high current draw.	(5) Check drive yoke pull-down and point gap. Check for worn end bushings and improper ring gear clearance.
	(6) Engine seized.	(6) Repair engine.
STARTER MOTOR DRIVE WILL NOT ENGAGE (SOLENOID KNOWN TO BE GOOD)	(1) Defective point assembly.	(1) Repair or replace point assembly.
	(2) Poor point assembly ground.	(2) Repair connection at ground screw.
	(3) Defective hold-in winding.	(3) Replace field windings.
STARTER MOTOR WILL NOT DISENGAGE	(1) Starter motor loose on flywheel housing.	(1) Tighten mounting bolts.
	(2) Worn drive end bushing.	(2) Replace bushing.
	(3) Damaged ring gear teeth.	(3) Replace ring gear.
	(4) Drive yoke return spring broken or missing.	(4) Replace spring.
	(5) Defective starter motor drive.	(5) Replace starter motor drive.
	(6) Ignition Switch adjusted wrong.	(6) Reposition switch.
	(7) Foreign metallic object in dash connector.	(7) Remove foreign object.
STARTER MOTOR DRIVE DISENGAGES PREMATURELY	(1) Weak drive assembly thrust spring.	(1) Replace drive assembly.
	(2) Weak hold-in winding.	(2) Replace field windings.
LOW CURRENT DRAW	(1) Worn brushes.	(1) Replace brushes.
	(2) Weak brush springs.	(2) Replace springs.

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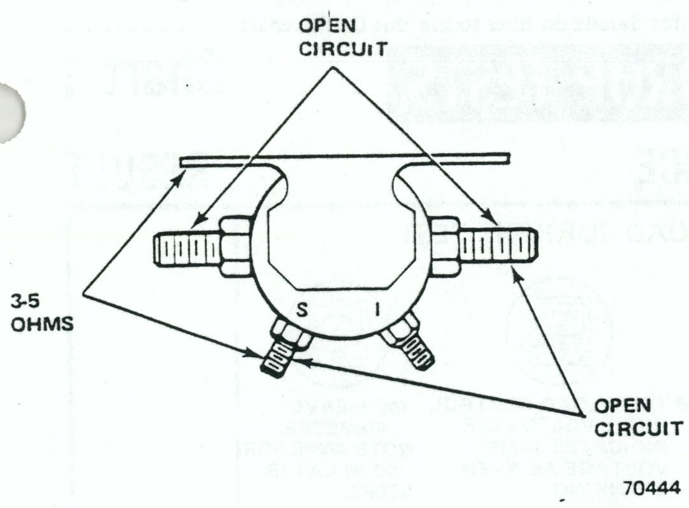


Fig. 1F-13 Ohmmeter Test of Starter Motor Solenoid

Starter Motor Cable and Ground Cable Tests (Voltage Drop)

The results of voltage drop tests will determine if there is excessive resistance in the high current circuit. When performing these tests, it is important that the voltmeter test lead probes be in contact with the terminals that the cables are connected to instead of with the cables themselves. For example, when testing between the battery and solenoid, the voltmeter probes must touch the battery post and the solenoid threaded stud.

Preliminary Preparation for Tests

(1) Remove ignition coil secondary wire from distributor and ground to engine.

(2) Place transmission in Neutral (manual transmission) or Park (automatic transmission) and set parking brake.

(3) Ensure battery is fully charged.

Test Procedure

Follow the steps as outlined in the Starter Motor Voltage Drop Tests DARS charts.

Full Load Current Test

(1) Prior to performing full load current test, battery must be fully charged as described in Chapter 1D—Batteries.

NOTE: *The lower the available voltage, the higher the current flow.*

(2) Disconnect and ground ignition coil secondary wire.

(3) Connect remote control starting switch between battery positive terminal and S-terminal on starter solenoid.

NOTE: *Do not consider the initial voltage at the beginning of engine cranking. A very hot or very cold engine may cause a current of 400 to 600 amperes for the first few revolutions. Note the voltage after the starter motor has obtained its maximum rpm.*

CAUTION: *Do not operate for more than 15 seconds.*

(4) Connect battery-alternator-starter motor tester leads as depicted in figure 1F-14. Operate remote control starting switch and note voltage indicated on voltmeter while starter motor is rotating engine.

(5) Release remote control starting switch.

(6) Turn load control knob toward INCREASE (clockwise) until voltmeter indication matches that obtained when starter motor was rotating engine.

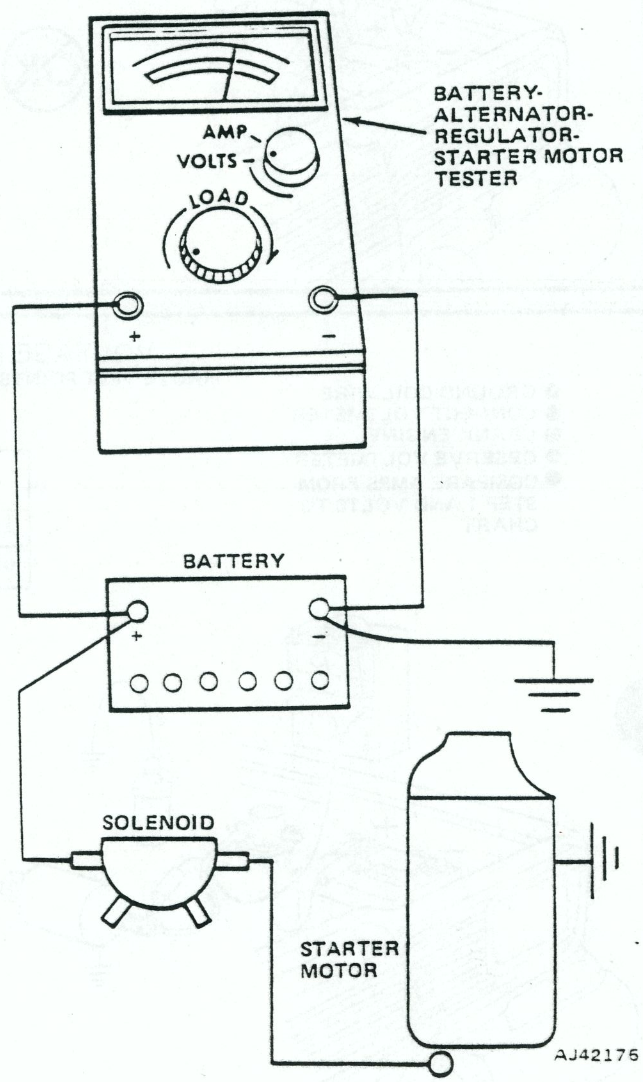


Fig. 1F-14 Starter Motor Full-Load Current Test

STARTER MOTOR VOLTAGE DROP TEST DIAGNOSIS AND REPAIR SIMPLIFICATION (DARS) CHARTS

Note: Refer to Chapter A — General Information for details on how to use this DARS chart.

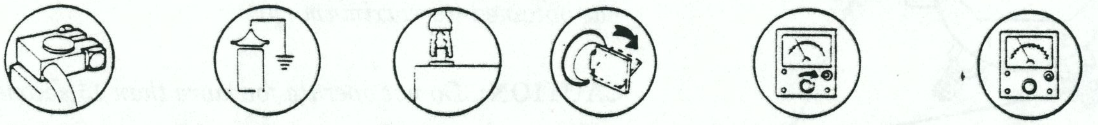
STARTER MOTOR VOLTAGE DROP TESTS

Chart 1

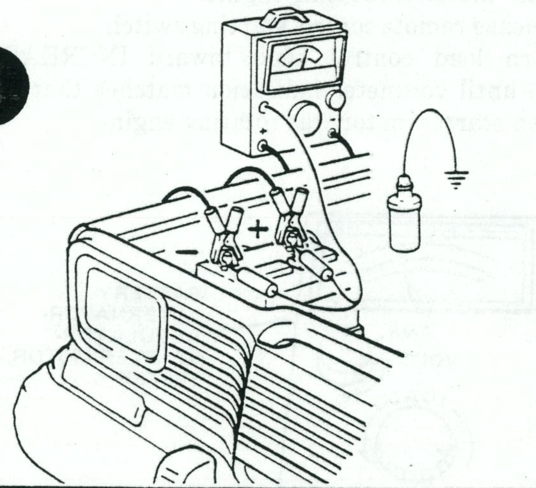
STEP — SEQUENCE — RESULT

Step 1

STARTER MOTOR FULL LOAD CURRENT TEST



- CLEAN AND CONNECT BATTERY CABLES
- REMOVE COIL WIRE FROM DISTRIBUTOR AND CONNECT TO GROUND
- CONNECT HEAVY LOAD TESTER
- CRANK ENGINE FOR THREE SECONDS AND OBSERVE VOLTMETER
- TURN LOAD CONTROL UNTIL VOLTMETER INDICATES SAME VOLTAGE AS WHEN CRANKING
- OBSERVE AMMETER. NOTE AMPS FOR USE IN LATER STEPS.



OK: 6 CYL. – 150-180 AMPS; 8 CYL. – 160-210 AMPS → STOP

NOT OK: 6 CYL. – ABOVE 180 AMPS; 8 CYL. – ABOVE 210 AMPS

- BATTERY CABLES AND SOLENOID NOT TESTED → 2

OR

- BATTERY CABLE AND SOLENOID REPAIRS COMPLETED → REPAIR STARTER → STOP

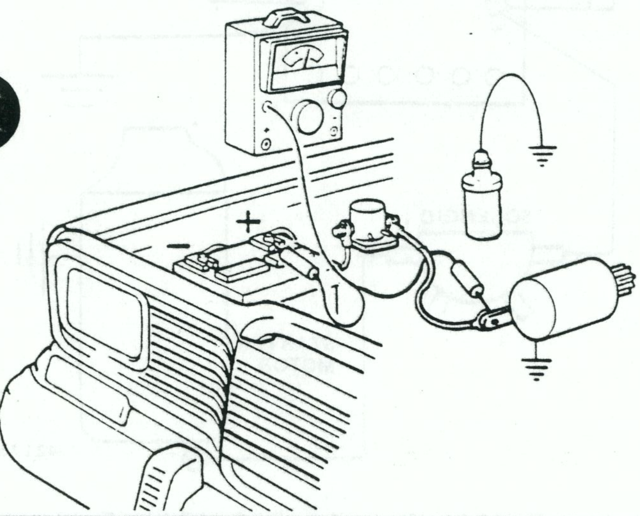
Step 2

VOLTAGE DROP TEST
(NOTE TEST POINTS IN ILLUSTRATION)

- GROUND COIL WIRE
- CONNECT VOLTMETER
- CRANK ENGINE
- OBSERVE VOLTMETER
- COMPARE AMPS FROM STEP 1 AND VOLTS TO CHART

MAXIMUM VOLTAGE DROP BY FULL LOAD AMPERAGE

AMPS	150-210	215-295	300-420	425-600
VOLTS	0.5 V	0.7 V	1.0 V	1.5 V



OK: VOLTAGE AT OR BELOW MAXIMUM → 5

NOT OK: VOLTAGE ABOVE MAXIMUM → 3

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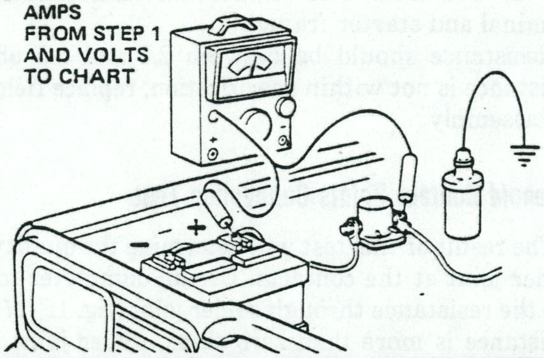
STEP	SEQUENCE	RESULT

3

VOLTAGE DROP TEST
(NOTE TEST POINTS IN ILLUSTRATION)

- GROUND COIL WIRE
- CONNECT VOLTMETER
- CRANK ENGINE
- OBSERVE VOLTMETER
- COMPARE AMPS FROM STEP 1 AND VOLTS TO CHART



MAXIMUM VOLTAGE DROP BY FULL LOAD AMPERAGE

AMPS	150-210	215-295	300-420	425-500
VOLTS	0.3 V	0.5 V	0.6 V	0.9 V

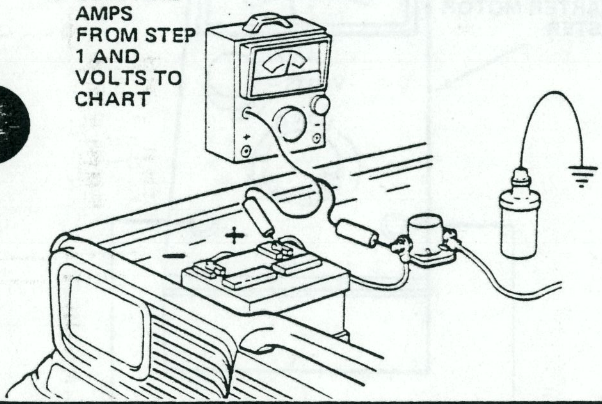
OK — VOLTAGE AT OR BELOW MAXIMUM → REPAIR SOLENOID-TO-STARTER MOTOR CABLE → 5

NOT OK — VOLTAGE ABOVE MAXIMUM → 4

4

VOLTAGE DROP TEST
(NOTE TEST POINTS IN ILLUSTRATION)

- GROUND COIL WIRE
- CONNECT VOLTMETER
- CRANK ENGINE
- OBSERVE VOLTMETER
- COMPARE AMPS FROM STEP 1 AND VOLTS TO CHART



MAXIMUM VOLTAGE DROP BY FULL LOAD AMPERAGE

AMPS	150-210	215-295	300-420	425-600
VOLTS	0.2V	0.3V	0.4V	0.5V

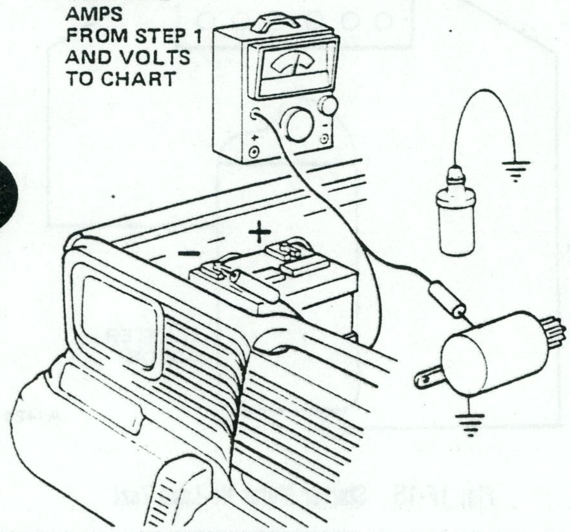
OK — VOLTAGE AT OR BELOW MAXIMUM → REPAIR SOLENOID → 5

NOT OK — VOLTAGE ABOVE MAXIMUM → REPAIR BATTERY-TO-SOLENOID CABLE → 5

5

VOLTAGE DROP TEST
(NOTE TEST POINTS IN ILLUSTRATION)

- GROUND COIL WIRE
- CONNECT VOLTMETER
- CRANK ENGINE
- OBSERVE VOLTMETER
- COMPARE AMPS FROM STEP 1 AND VOLTS TO CHART



MAXIMUM VOLTAGE DROP BY FULL LOAD AMPERAGE

AMPS	150-210	215-295	300-420	425-600
VOLTS	0.2V	0.3V	0.4V	0.5V

OK — VOLTAGE AT OR BELOW MAXIMUM
- REPAIRS TO SOLENOID OR CABLES PERFORMED IN A PREVIOUS STEP → 1
- REPAIRS TO SOLENOID OR CABLES NOT REQUIRED IN A PREVIOUS STEP → REPAIR STARTER MOTOR → STOP

NOT OK — VOLTAGE ABOVE MAXIMUM → REPAIR ENGINE-TO-BATTERY CABLE → 1

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(7) Switch to AMP position and note current indicated on ammeter scale. This is current being used by starter motor under full-load conditions. If current is not within 150 to 180 amperes for six-cylinder engines or 160 to 210 amperes for eight-cylinder engines at room temperature, remove starter motor from engine for bench testing.

Neutral Safety Switch Test

(1) Insert voltmeter test lead probes into switch with all switch wire terminals connected. Refer to wiring diagrams for correct terminal connections.

NOTE: *Probe-type tips are required on voltmeter test leads. If not available, push cotter pins into switch connector to provide contacts for aligator jaw type test lead terminals.*

(2) Turn ignition switch to Start position.
(3) Voltmeter should indicate less than 0.1 volt.

OFF-VEHICLE TESTING

No-Load Test

The starter motor no-load test results will indicate faults such as open or shorted windings, worn bushings (rubbing armature) or bent armature shaft.

NOTE: *The tester load control knob must be in the DECREASE (extreme counterclockwise) position.*

(1) Operate starter motor with test equipment connected as diagramed in figure 1F-15. Note voltage indication.

(2) Determine exact starter motor rpm using mechanical tachometer (not shown).

NOTE: *To use a mechanical tachometer, remove the seal from the end of the drive end housing and clean the grease from the end of the armature shaft.*

(3) Disconnect starter motor from battery.

(4) Turn load control knob toward INCREASE (clockwise) until voltage indication matches that obtained with starter motor connected to battery.

(5) Switch to AMP position and note current. If less than specification, starter motor has high electrical resistance and should be repaired or replaced. If current is more than specification and starter motor rpm is less than specification, disassemble, clean, inspect and test starter motor as outlined in following paragraphs.

Hold-In Coil Winding Resistance Test

The result of this test will determine the resistance of the hold-in winding.

(1) Insert piece of paper between contact points to serve as insulator (fig. 1F-16).

(2) Use ohmmeter to measure resistance between terminal and starter frame.

Resistance should be between 2.0 and 3.5 ohms. If resistance is not within specification, replace field winding assembly.

Solenoid Contact Points Connection Test

The result of this test will determine the quality of the solder joint at the contacts. Use an ohmmeter to measure the resistance through solder joint (fig. 1F-17). If the resistance is more than zero ohms, solder joint has excessive resistance. Repair by heating joint with 600 watt soldering iron.

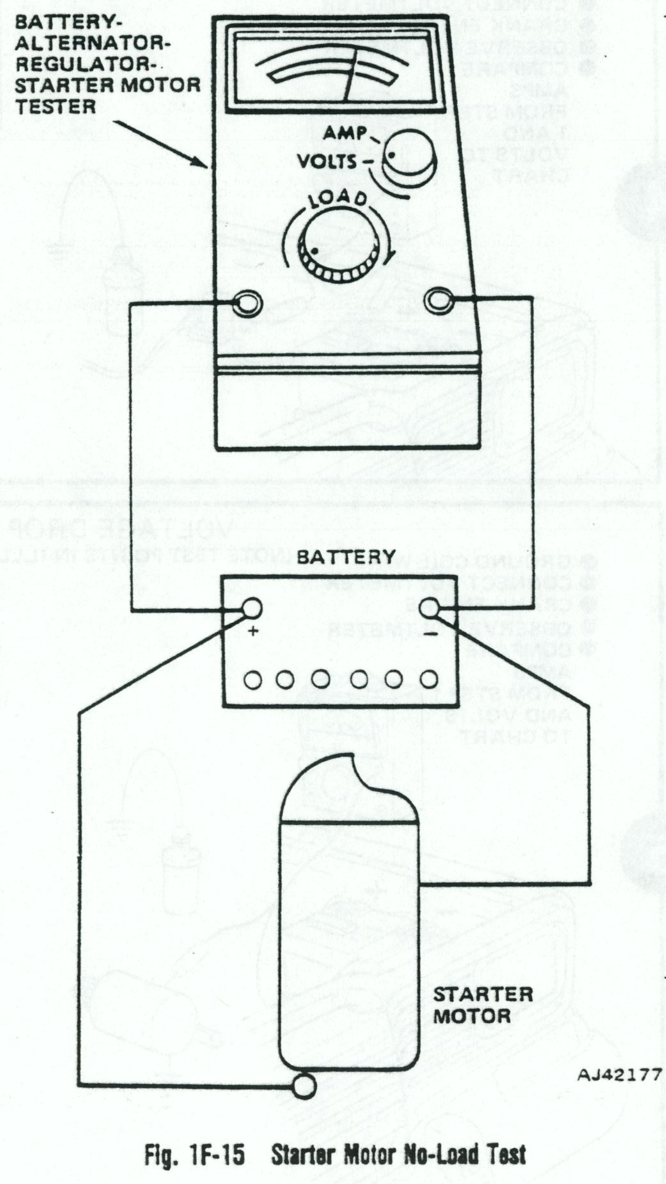


Fig. 1F-15 Starter Motor No-Load Test

Insulated Brush Connection Test

The result of this test will determine the quality of the solder joint between the insulated brush braided wire and the field windings. Use an ohmmeter to test the resistance through solder joint by touching probes to brush and to copper bus bar (fig. 1F-18). If resistance is more than zero ohms, solder joint has excessive resistance. Repair by heating joint with 600 watt soldering iron.

Terminal-to-Brush Continuity Test

The result of this test will determine the condition of all field winding solder joints.

(1) Insert piece of paper between contact points to serve as insulator (fig. 1F-19).

(2) Touch ohmmeter probes to terminal and to insulated brush.

If resistance is more than zero ohms, test all solder joints to determine which one(s) has/have excessive resistance. Repair faulty solder joint(s) by heating with a 600 watt soldering iron.

Terminal Bracket Insulation Test

The result of this test will determine if the terminal bracket is properly insulated from the end cap. Use an ohmmeter to test continuity between the bracket and cap (Fig. 1F-20). If the resistance is not infinite, the insulator is faulty. Repair by replacing the end cap.

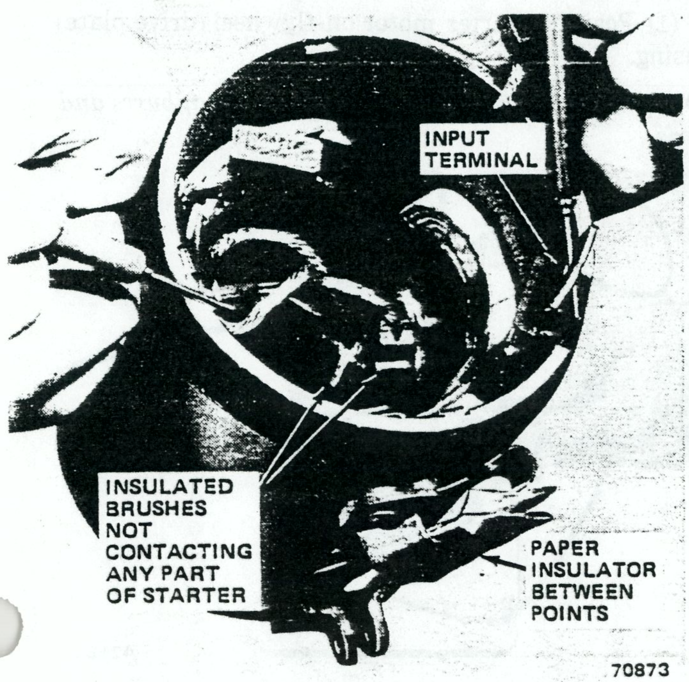


Fig. 1F-16 Hold-In Coil Winding Resistance Test

Armature Tests

Test the armature winding for a short circuit to ground (armature core), short circuit between windings and balance whenever the starter motor is overhauled. Follow the test equipment manufacturer's instructions or the following procedure.

Grounded Armature Winding Test

(1) Place armature in growler jaws and turn power switch to TEST position (fig. 1F-21).

(2) Touch one test lead probe to armature core, touch other lead probe to each commutator bar one at a time and observe test lamp. Test lamp should not light. If test lamp lights on any bar, armature winding is shorted to armature core and armature must be replaced.

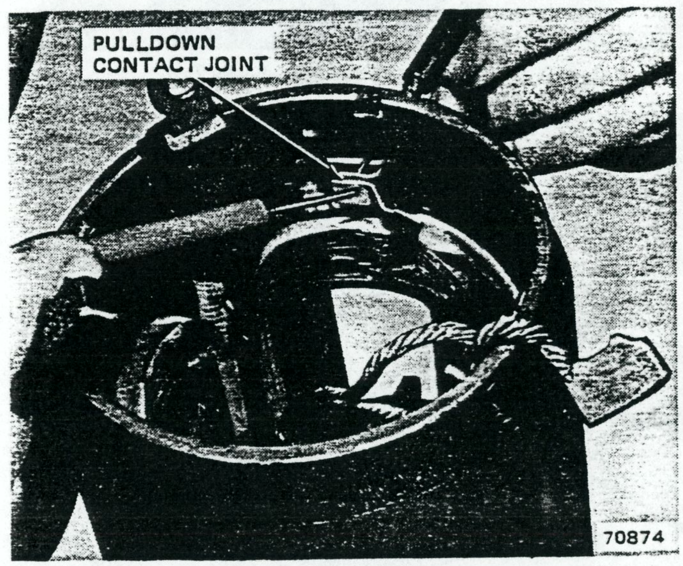


Fig. 1F-17 Solenoid Contact Points Connection Test

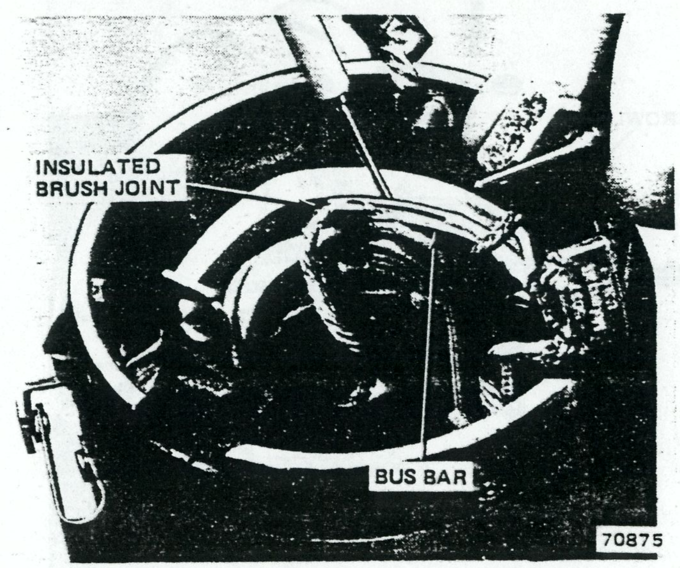


Fig. 1F-18 Insulated Brush Connection Test

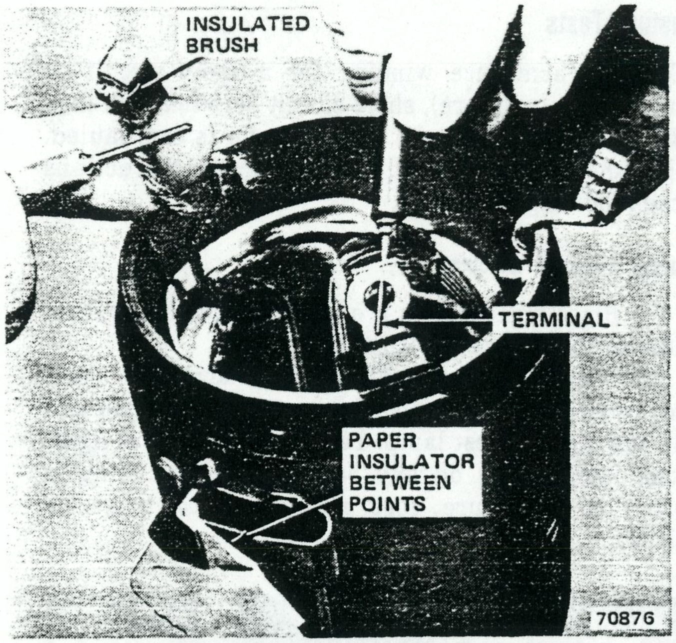


Fig. 1F-19 Terminal-To-Brush Continuity Test

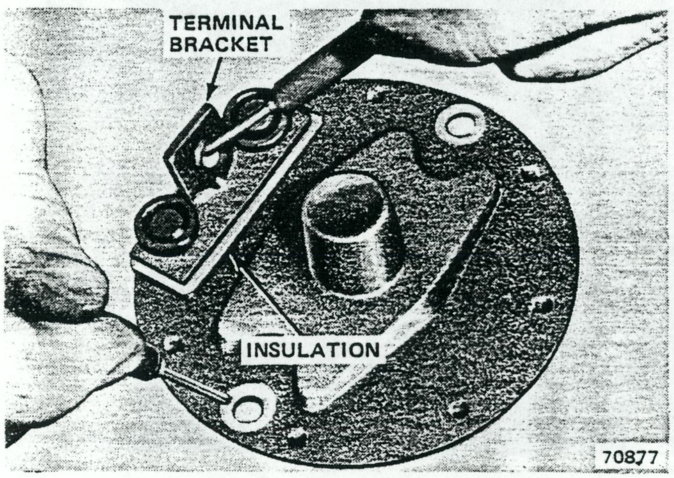


Fig. 1F-20 Terminal Bracket Insulation Test

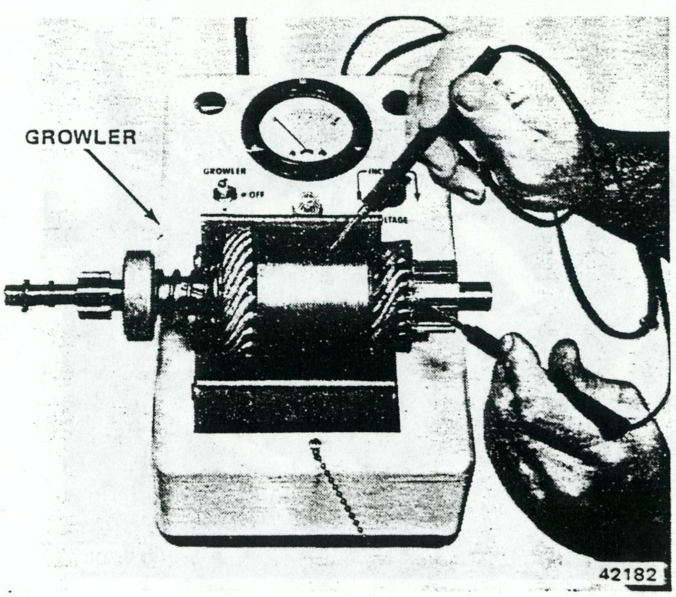


Fig. 1F-21 Grounded Armature Winding Test

Armature Winding Internal Short Test

CAUTION: *Never operate the growler in the growler test position without an armature in the jaws.*

(1) Place armature in growler jaws and turn power switch to GROWLER position (fig. 1F-22).

(2) Hold steel blade parallel to and touching armature core. Slowly rotate armature one or more revolutions in growler jaws. If steel blade vibrates at any area of core, winding is shorted at this area and armature must be replaced.

Armature Balance Test

(1) Place armature in growler jaws and turn power switch to GROWLER position (fig. 1F-23).

(2) Place contact fingers of meter test cable across adjacent commutator bars at side of commutator.

(3) Adjust voltage control until pointer indicates highest voltage on scale.

(4) Test each commutator bar with adjacent bar until all bars have been tested. Zero voltage indicates short circuit between commutator bars.

STARTER MOTOR REPLACEMENT

Removal

(1) Disconnect cable from starter motor terminal.

(2) Remove attaching screws and remove starter motor from flywheel (drive plate) housing.

Installation

(1) Position starter motor on flywheel (drive plate) housing.

NOTE: *Ensure mounting surfaces are free of burrs and debris.*

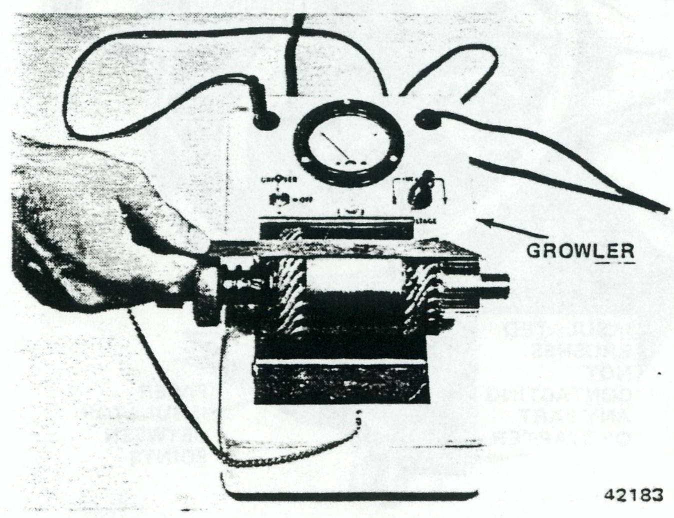


Fig. 1F-22 Armature Winding Internal Short Test

(2) Install mounting screws and tighten with 18 foot-pounds (24 N•m) torque.

(3) Clean terminal bracket on starter motor and terminal end of cable.

(4) Position cable on terminal bracket. Install screw and tighten with 55 inch-pounds (6 N•m) torque.

NOTE: *Initial torque may exceed this specification if the end plate is new. The terminal screw cuts threads in the terminal during installation.*

STARTER MOTOR OVERHAUL

Refer to figure 1F-24 for parts identification.

Disassembly

(1) Remove drive yoke cover and screw.

(2) Remove through-bolts and remove brush end plate.

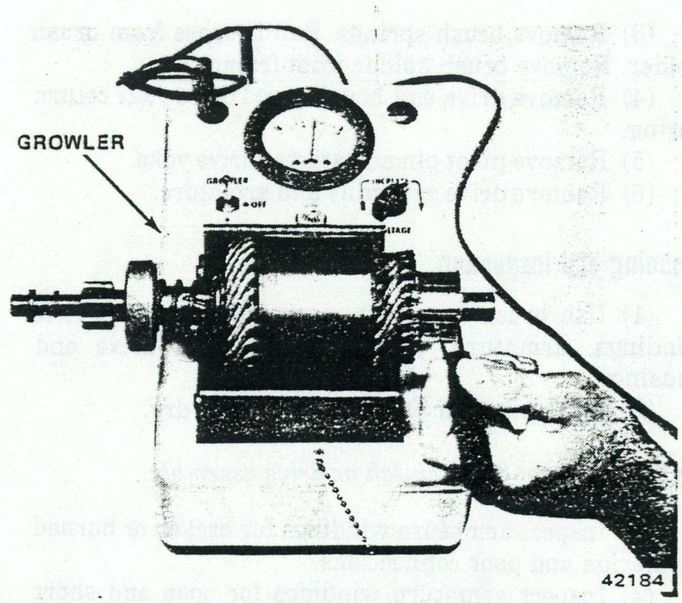


Fig. 1F-23 Armature Balance Test

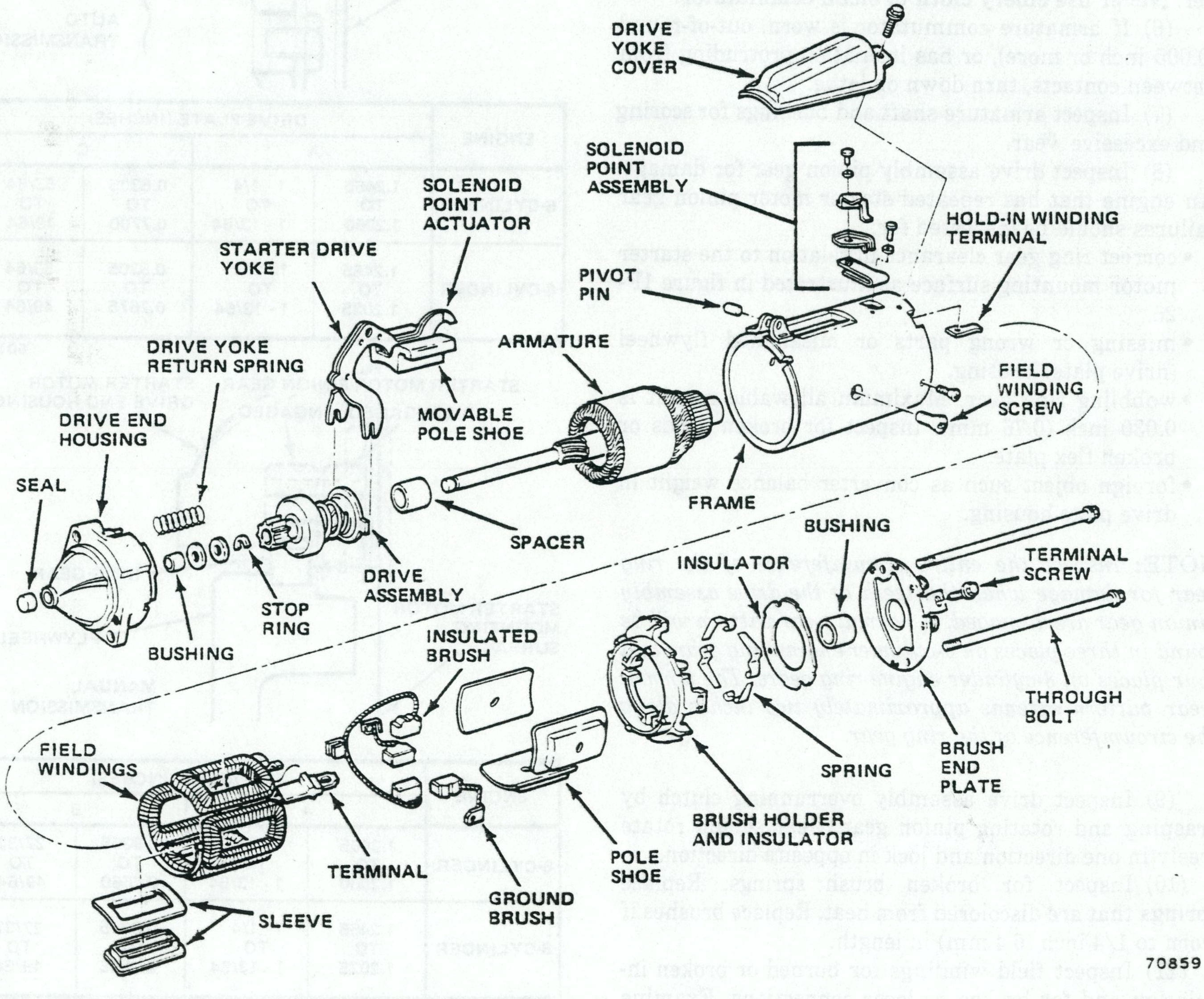


Fig. 1F-24 Parts Identification

(3) Remove brush springs. Pull brushes from brush holder. Remove brush holder from frame.

(4) Remove drive end housing and drive yoke return spring.

(5) Remove pivot pin and starter drive yoke.

(6) Remove drive assembly and armature.

Cleaning and Inspection

(1) Use brush or air to clean starter frame, field windings, armature, drive assembly and drive end housing.

(2) Wash all other parts in solvent and dry.

NOTE: *Do not wash clutch or drive assembly.*

(3) Inspect armature windings for broken or burned insulation and poor connections.

(4) Inspect armature windings for open and short circuits as outlined in Armature Tests.

(5) Clean dirty commutator with commutator paper. **Never use emery cloth to clean commutator.**

(6) If armature commutator is worn, out-of-round (0.005 inch or more), or has insulation protruding from between contacts, turn down on lathe.

(7) Inspect armature shaft and bushings for scoring and excessive wear.

(8) Inspect drive assembly pinion gear for damage. An engine that has repeated starter motor pinion gear failures should be inspected for:

- correct ring gear clearance in relation to the starter motor mounting surface as illustrated in figure 1F-25.
- missing or wrong parts or misaligned flywheel (drive plate) housing.
- wobbling ring gear. Maximum allowable runout is 0.030 inch (0.76 mm). Inspect for broken welds or broken flex plate.
- foreign object such as converter balance weight in drive plate housing.

NOTE: *Inspect the entire circumference of the ring gear for damage when the teeth of the drive assembly pinion gear are damaged. A normal wear pattern will be found in three places on 6-cylinder engine ring gears and four places on 8-cylinder engine ring gears. The normal wear pattern extends approximately two inches along the circumference of the ring gear.*

(9) Inspect drive assembly overrunning clutch by grasping and rotating pinion gear. Gear should rotate freely in one direction and lock in opposite direction.

(10) Inspect for broken brush springs. Replace springs that are discolored from heat. Replace brushes if worn to 1/4 inch (6.4 mm) in length.

(11) Inspect field windings for burned or broken insulation and for broken or loose connections. Examine field brush connections and wire insulation.

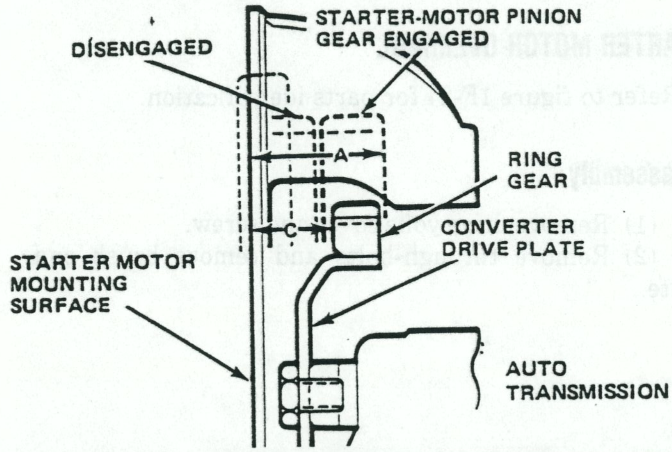
Field Winding Replacement

Remove armature and brush holder before proceeding with this procedure.

(1) Remove field winding screws using arbor press and Starter Pole Screw Wrench J-22516. Remove pole shoes.

(2) Cut field winding strap as close as possible to solenoid point contact-to-field winding joint.

CAUTION: *Do not cut solenoid point contact.*



ENGINE	DRIVE PLATE (INCHES)			
	A		C	
6-CYLINDER	1.2465 TO 1.2060	1 - 1/4 TO 1 - 13/64	0.8305 TO 0.7700	53/64 TO 49/64
8-CYLINDER	1.2465 TO 1.2035	1 - 1/4 TO 1 - 13/64	0.8305 TO 0.7675	53/64 TO 49/64

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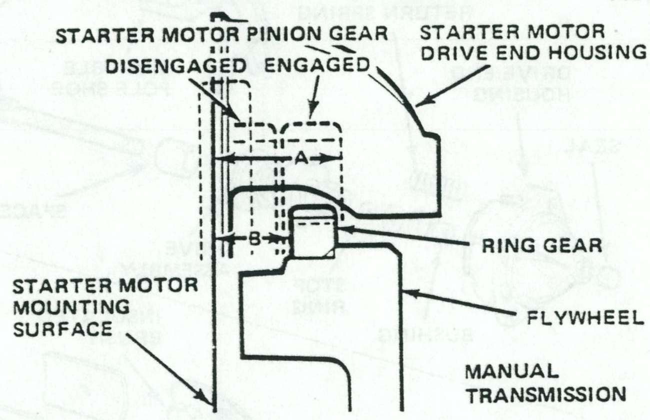

ENGINE	FLYWHEEL (INCHES)			
	A		B	
6-CYLINDER	1.2465 TO 1.2060	1 - 1/4 TO 1 - 13/64	0.8365 TO 0.7660	27/32 TO 49/64
8-CYLINDER	1.2465 TO 1.2035	1 - 1/4 TO 1 - 13/64	0.8365 TO 0.7635	27/32 TO 49/64

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Fig. 1F-25 Flywheel/Drive Plate-To-Ring Gear Clearance

(3) Cut hold-in winding wire at terminal strip.

(4) Straighten tabs of pull-down winding sleeve. Remove sleeve and flange.

(5) Remove field winding assembly from frame.

(6) Clean and tin surfaces of contact tab and field winding strap that are to be soldered.

(7) Install replacement field winding assembly in frame using original pole shoes and screws. Apply drop of Loctite or equivalent to screw threads. Tighten screws using arbor press and Starter Pole Screw Wrench J-22516.

(8) Install pull-down winding sleeve and flange. Have helper hold winding and sleeve assembly against frame while bending retaining tabs.

(9) Wrap hold-in winding wire around terminal strip and solder. Cut off excess wire.

(10) Solder field winding strap to contact strap. Use 600 watt soldering iron and rosin-core solder.

Solenoid Contact Point Assembly Replacement

Remove armature and brush holder before proceeding with this procedure.

(1) Cut upper contact as close as possible to contact point-to-field winding joint.

CAUTION: *Do not cut field winding strap.*

(2) Unsolder hold-in winding wire from terminal strip.

(3) Remove field winding screws using arbor press and Tool J-22516. Remove pole shoes.

(4) Cut rivets inside frame with chisel. Remove contact point assembly.

NOTE: *Ensure holes for second rivet are aligned before upsetting copper rivet.*

(5) Position replacement lower (movable) contact point on frame (fig. 1F-26). Position hold-in winding terminal strip inside frame. Insert *copper* rivet through contact, frame and terminal. Upset rivet.

NOTE: *Ensure upper contact point is positioned on shoulder of plastic insulator before upsetting rivet.*

(6) Install plastic insulator, upper contact point and fiber washer to remaining hole in frame. Insert *aluminum* rivet and upset.

(7) Install field winding assembly, pole shoes and screws. Apply a drop of Loctite or equivalent to each screw.

(8) Solder hold-in winding wire to terminal strip.

(9) Solder field winding strap to upper contact. Use 600 watt soldering iron and rosin-core solder.

Bushing Replacement

Drive End Bushing

(1) Support drive end housing and remove original bushing and seal.

(2) Install replacement bushing using armature and pinion as bushing driver. **Do not** install drive end housing seal at this time.

Commutator End Bushing

(1) Carefully remove original bushing with chisel.

(2) Drive replacement bushing into end plate until seated, using suitable socket or bushing driver.

Drive Assembly Replacement

(1) Pry stop ring off and remove starter motor drive assembly from armature shaft.

(2) Apply grease to armature shaft and end bushings. Service replacement drive assembly is prelubricated.

(3) Apply thin coating of Lubriplate or equivalent on armature shaft splines.

(4) When installing drive assembly, examine snap ring for tight fit on shaft. Slide drive assembly over shaft and install stop ring and original retainer.

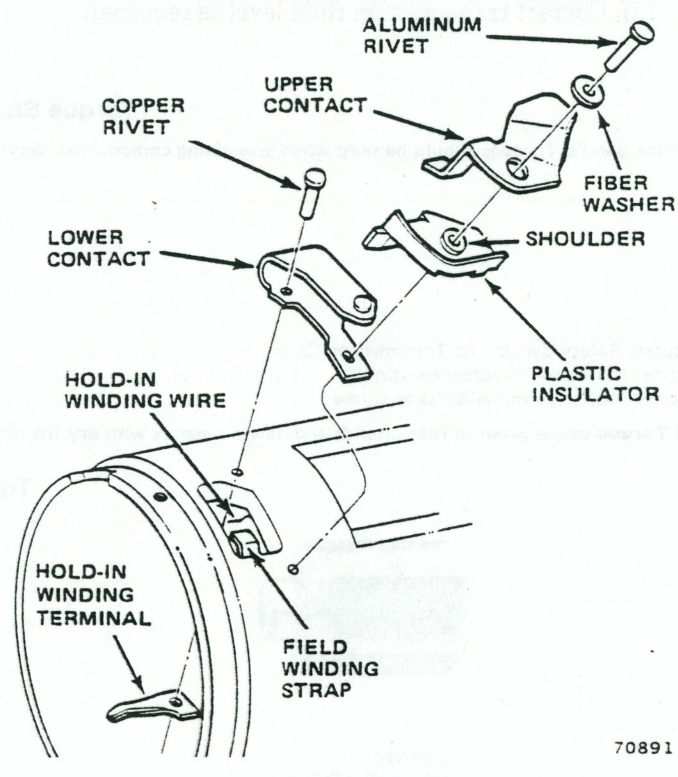

Fig. 1F-26 Solenoid Contact Points Replacement

Assembly

(1) Insert armature into frame. Install drive yoke and pivot pin. Drive yoke must engage lugs on drive assembly.

(2) Insert drive yoke return spring into recess in drive housing. Join housing to frame.

(3) Install brush holder. Ensure depression in holder aligns with rubber boot on terminal.

(4) Insert brushes into brush holder. Refer to figure 1F-27 for proper wire routing. Install brush springs.

(5) Install end plate. Align hole in terminal with hole in terminal bracket.

(6) Install through-bolts.

(7) Depress movable pole shoe and adjust contact point clearance by bending upper contact as required. Refer to Specifications.

(8) Install drive yoke cover and screw.

NEUTRAL SAFETY SWITCH REPLACEMENT

(1) Disconnect wiring connector and remove switch from transmission. Allow fluid to drain into container.

(2) Move selector lever to Park and Neutral positions. Inspect switch operating lever fingers to ensure they are properly centered in switch opening.

(3) Install switch and seal on transmission case. Tighten switch with 24 foot-pounds (6 N•m) torque.

(4) Test switch continuity.

(5) Correct transmission fluid level as required.

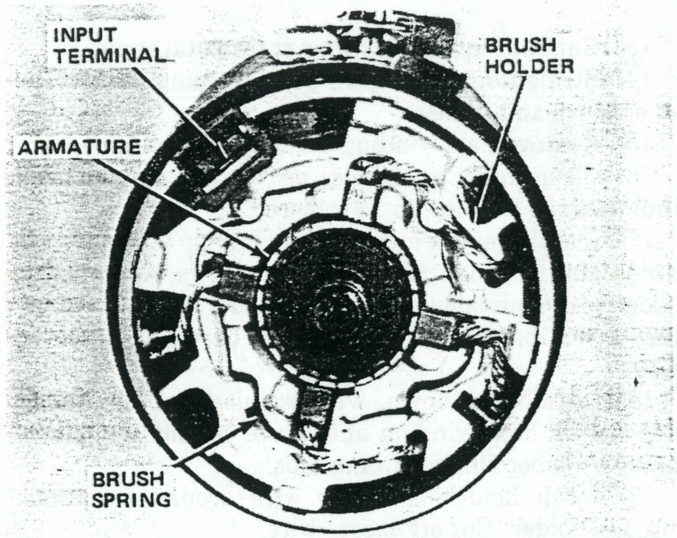

Fig. 1F-27 Brush Wire Routing

SPECIFICATIONS

Six- and Eight-Cylinder Engine Starter Motor Specifications

Usage	ALL
Brush Length	0.5 in. (12.7 mm)
Wear Limit	0.25 in. (6.35 mm)
No-Load Test (Free Speed)	
Volts	12
Amps	77
Min. RPM	8900
Max. RPM	9600
Contact Point Clearance	0.100-0.020 in. (2.5-0.5 mm) 0.060 (1.5 mm) preferred

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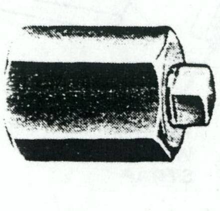
Torque Specifications

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item.

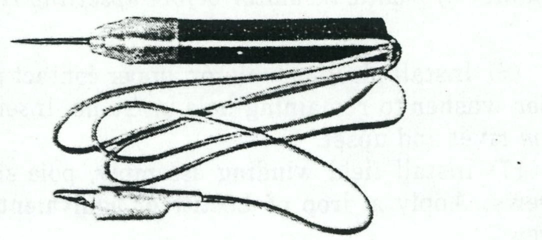
	USA (ft-lbs) Service Set-To Torque	USA (ft-lbs) Service In-Use Recheck Torque	Metric (N·m) Service Set-To Torque	Metric (N·m) Service In-Use Recheck Torque
Neutral Safety Switch-To-Transmission Case	17	14-21	23	19-28
Starter Motor-to-Flywheel Housing	18	13-25	24	18-34
Starter Motor Terminal Bracket Screw	55 in-lbs	40-70 in-lbs	6	4.5-8

All Torque values given in foot-pounds and newton-meters with dry fits unless otherwise specified.

Tools



J-22516
STARTER POLE
SCREW WRENCH



J-21008
CONTINUITY
TEST LAMP

70112