GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION

DESCRIPTION

Diesel mechanical fuel injection systems differ greatly from electronic fuel injection systems. In this diesel system, a mechanical high pressure rotary pump, gear driven by the camshaft at camshaft speed, injects a precisely metered amount of fuel to each cylinder at the proper time. The pump is mounted on top of the engine and provides necessary timing advance under all operating conditions.

Eight high pressure fuel pipes carry fuel from pump to an injection nozzle in each cylinder. All eight pipes are exactly the same length to ensure that there is no variance in timing. Engine RPM is controlled by a rotary fuel metering valve. As the accelerator pedal is pushed down, a throttle cable opens the metering valve and allows increased fuel delivery. A built-in low pressure transfer pump delivers fuel to the main injection pump.

A fuel filter is located between the mechanical fuel pump (mounted on the side of the engine block) and the injection pump. Any excess fuel is returned to the tank by a fuel return system.

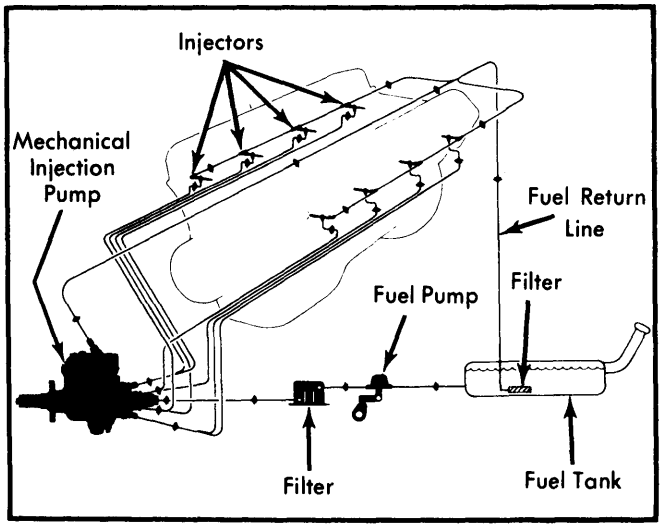

Fig. 1 Diesel Injection System Fuel Circuit

OPERATION

AIR INDUCTION SYSTEM

An air crossover housing is located on top of the engine over the injection pump. It is bolted to the intake manifold with 4 bolts and serves as the only air inlet in the system. No fuel passes through the crossover. It is an open-chambered housing with a single inlet drawing air through an air filter assembly mounted above. The crossover unit has two branches, one leading to each side of the intake manifold. Gaskets are installed between crossover and manifold to prevent vacuum leaks. Manufacturer states that starter fluid NEVER BE USED to aid in starting this type diesel engine. *See Fig. 2.*

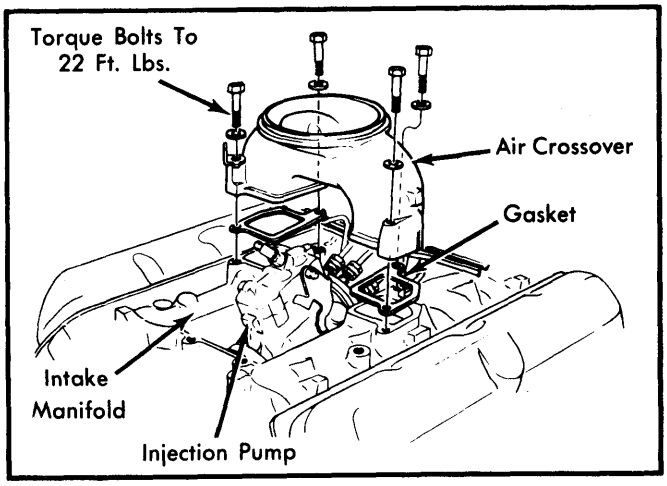

Fig. 2 Disassembled View Of Air Crossover Assembly on GM Diesel Engine

FUEL TANK-TO-PUMP SYSTEM

Diesel fuel, NOT gasoline, is drawn from the fuel tank by an engine mounted mechanical fuel pump. This pump is driven by an eccentric cam mounted on the crankshaft and puts out about 5½-6½ psi to the main injection pump. A small screen type filter is located in the fuel tank at the pickup. A larger sealed 11-12 micron fuel filter is located on the rear of the engine between fuel pump and main injection pump. Diesel fuel arrives at the center inlet fitting on the injection pump after leaving the filter. A fuel return line is provided to return any excess fuel to the tank. *See Fig. 3.*

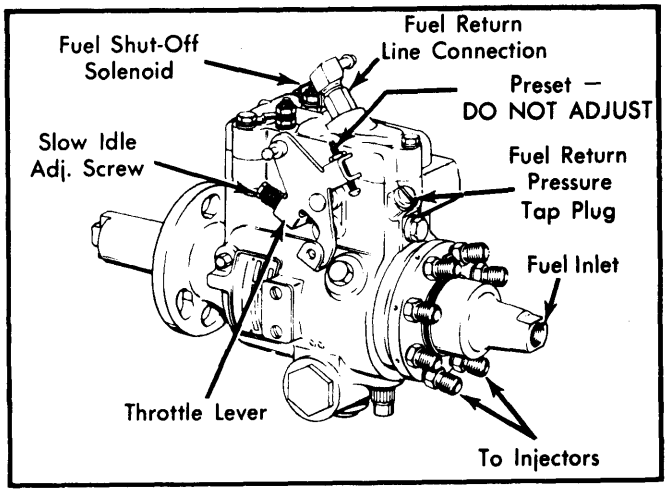

Fig. 3 Main Diesel Injection Pump

DIESEL INJECTION PUMP

The high pressure diesel injection pump is mounted to the top of the engine below the air crossover. The pump is cam driven at speed equal to the camshaft. Because of this, the pump can precisely govern time and amount of fuel injection. Eight equal length pipes, running from pump to each cylinders' injector nozzle, ensure that injection timing does not vary from cylinder to cylinder.

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

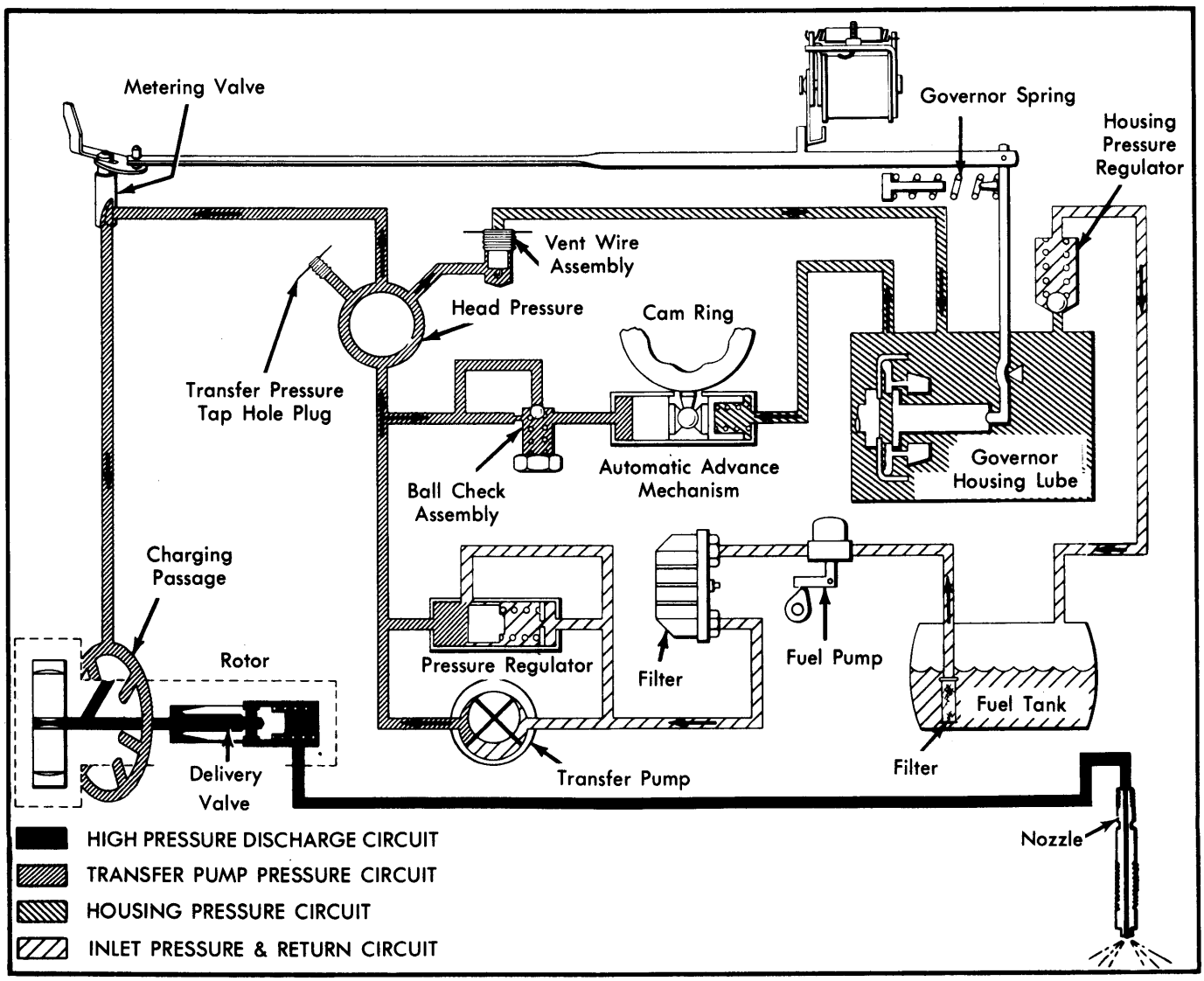

Fig. 4 Diesel Injection Pump Fuel Circuit Diagram

A built-in fuel pressure regulator and transfer pump picks up fuel at the pump inlet, and pushes it through a passage to the pump head. The pump head distributes fuel, still at transfer pump pressure (8-12 psi), to metering valve, governor and automatic advance mechanisms. Fuel then passes to the rotary fuel metering valve and into a charging passage. As the pump shaft rotates, fuel is fired, under high pressure, through each delivery pipe to an injector. The pump is not serviceable and must be exchanged in case of a malfunction. See *Fig. 4*.

FUEL DELIVERY PIPES

Eight high pressure pipes are routed from injection pump to an injector in each cylinder. The pipes are of equal length but are bent differently to achieve this equal length. Pipes are not interchangeable and are pre-bent by the manufacturer.

GLOW PLUGS

A diesel engine has no ignition system and therefore, no spark plugs. It does have glow plugs; one in each combustion chamber. These electrically operated glow plugs are used to heat the pre-chamber to aid in starting the engine. They are actually miniature heaters that turn on when ignition key is turned to "RUN" position prior to starting the engine. There are two types of glow plugs. The first type uses a continous 12 volts to heat the plug. The second type uses a controlled pulsing current with 6 volts. These plugs can be identified by the width of the electrical connection. The first type uses a $\frac{1}{4}$" wide blade connector while the second type uses a $\frac{5}{16}$" wide blade connector. Both types of plug remain on for a short time after the engine starts to run.

CAUTION — *Do not interchange the two types of glow plugs.*

Depending on coolant temperature, glow plugs will activate for a period of time (longer for cold engine, shorter for warm engine) and a yellow "WAIT" or "DON'T START" light on the dash panel will come on. When "WAIT" light goes out and green indicator lights up, pre-chamber is sufficiently warm to cause combustion and start engine. At temperatures below −10° F, a block heater must be used to aid in starting. Glow plugs are replaceable, but usually require no servicing. See *Fig. 5*.

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

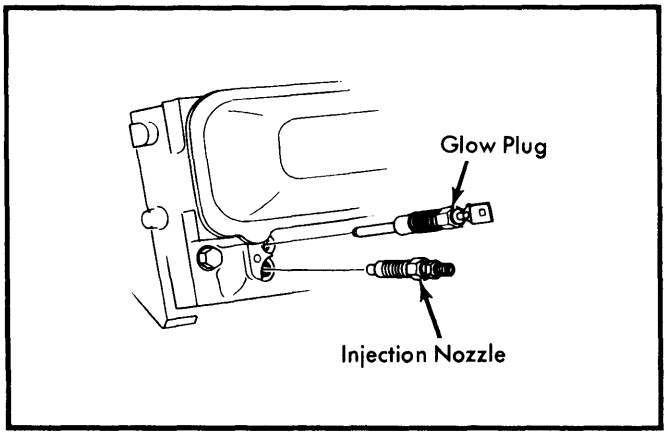

Fig. 5 Glow Plug & Injection Nozzle Location In Diesel Engine Cylinder Head

INJECTION NOZZLES

One injection nozzle is located in each combustion chamber. It has a single fuel inlet fitting and is threaded into the cylinder head as are the glow plugs. Injection nozzles are spring loaded and calibrated to open at specified fuel line pressure. The combustion chamber end of the nozzle has a replaceable copper compression seal.

NOTE – *Never try to interchange pickup and passenger car injectors.*

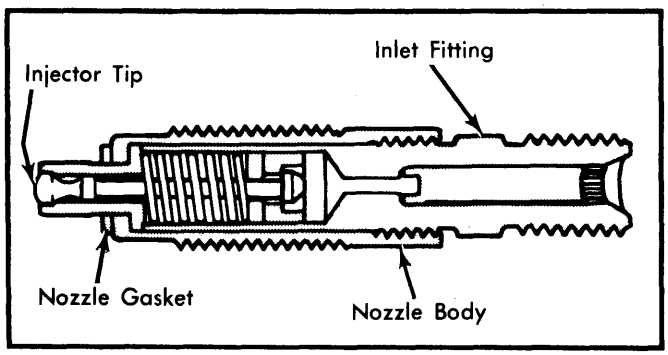

Fig. 6 Cutaway View Of Injection Nozzle

VACUUM SYSTEMS

There are no vacuum pickups incorporated within the diesel injection system. Only vehicles with a requirement for vacuum, such as air-conditioned units, or vehicles equipped with Cruise Control or a transmission modulator, are equipped with a cam driven mechanical vacuum pump. This pump is combined with the oil pump drive and is located in the same place. Maximum vacuum available at the vacuum pump is 18 in. Hg. A reducer valve in some systems cuts vacuum to 5-7 in. Hg.

It is extremely important to note that the engine MUST NOT be operated without vacuum pump or oil pump drive assembly installed. Without this unit in place, no lubrication will be available within the engine. *See Fig. 8*

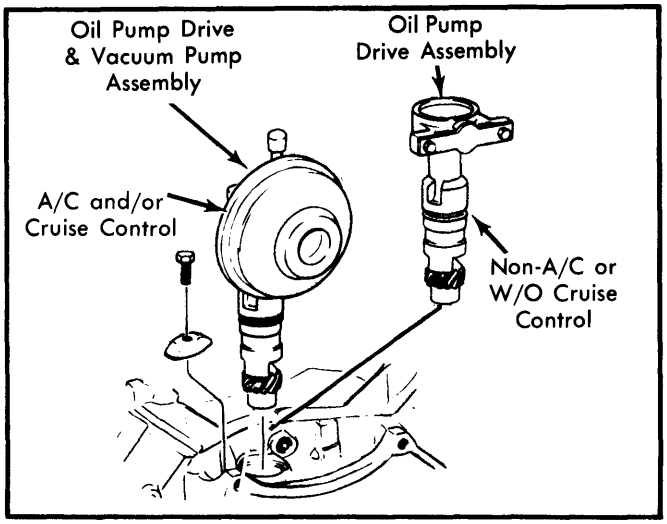

Fig. 7 Vacuum Pump/Oil Pump & Oil Pump Drive Units

STARTING PROCEDURES

Diesel engines require a slightly different starting procedure for normal operation and "jump" starting conditions. DO NOT use starting aids such as ether or starting fluid and DO NOT pour fuel down the air crossover to aid in starting.

STARTING INDICATOR LIGHTS

A special system of indicator lights is installed in the instrument panel on diesel equipped vehicles. These lights are to advise the vehicle operator when the engine is ready to be started. Each cylinder has a glow plug intended to pre-heat the combustion chamber to aid in starting. The length of time that glow plugs remains on is determined by coolant temperature. Lights indicate when the glow plugs are activated, when the pre-chambers are warm enough and when to start the vehicle. An explanation of each light follows:

"WAIT" – Amber light will come on when ignition key is turned to RUN position. "WAIT" means the engine pre-chambers are not warm enough. Do not attempt to start the engine while these lights are on. These indicator lights may stay on a short time or go out immediately, depending on coolant temperature.

NOTE – *When engine is warm already, "WAIT" or "DON'T START" lights may not come on at all. This is normal and means the engine is ready to be started.*

"START" - Green "START" light will come on when "WAIT" light goes out. This indicates that engine is ready to be started.

STARTING THE ENGINE

1) Place transmission in PARK or NEUTRAL. PARK is preferred.

2) Turn ignition key to RUN position. Amber "WAIT" or "DON'T START" light will come on. "GLOW PLUGS" light will come on (trucks). DO NOT try to start engine yet.

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

3) When "WAIT" or "DON'T START" light goes out and green "START" light comes on, engine is ready to start.

4) Push accelerator pedal HALFWAY to floor and hold. Turn ignition key to START position and crank engine. Engine should start within 10 to 15 seconds.

NOTE – *Pumping the pedal will not aid in starting. There is no carburetor and therefore, no accelerator pump.*

5) If engine does not start, repeat procedure.

6) If engine still does not start, refer to the Diesel Injection Trouble Shooting table in this section.

"JUMP" STARTING

NOTE – *Do not tow or push vehicle to start engine. Do not use charging equipment or power packs that exceed 16 volts to start engine.*

Procedure for starting a diesel engine is the same as for a conventional gas burning engine. Jumper cables may be connected to either battery, but battery on driver's side is preferred.

1) Set parking brake and place automatic transmission in PARK. Place manual transmissions in NEUTRAL.

2) Turn off lights, heater, radio or any other electrical load.

3) Ensure that batteries are in safe condition and that vent-cap type batteries are filled to the split rings.

4) Attach one end of jumper cable to positive (+) terminal of booster battery. Attach other end of SAME CABLE to positive (+) terminal of discharged battery.

5) Do not allow vehicles to touch each other. This may cause a grounding condition.

6) Attach one end of remaining jumper cable to negative (−) terminal of booster battery. Connect other end of that cable to a good ground on the car being started.

CAUTION – *Ground connection should be made at least 12" away from battery of car being started. DO NOT connect directly to negative (−) post of discharged battery.*

7) Start engine of car providing the jump start. Turn all accessories OFF.

8) Now start diesel engine following proper starting procedure.

9) Reverse directions step by step to remove jumper cables.

NOTE – *Disconnect negative (−) jumper cable from diesel engine that was jump started FIRST.*

TESTING

INJECTION PUMP HOUSING FUEL PRESSURE

1) Remove air crossover assembly. Install screened covers over openings in intake manifold.

2) Remove pressure tap plug from injector pump. *See Fig. 3.*

3) Place seal from pressure tap plug onto pressure tap adapter J-28382 and screw adapter into pump housing in place of plug. Screw pressure tap adapter J-28526 into pressure tap adapter J-28382.

4) Connect a low pressure gauge to adapter. Install magnetic pickup tachometer.

5) Start engine. Run engine at 1000 RPM with transmission in PARK. Observe gauge.

6) Pressure should be 8-12 psi with no more than 2 psi fluctuation.

7) If pressure is incorrect, replace fuel return line connector assembly.

8) Recheck pressure. If pressure is still not correct, remove injection pump for repair. Pump is not serviceable and must be exchanged for another unit. *See Injection Pump Removal.*

9) Remove tachometer, pressure gauge and adapter. Install a NEW pressure tap plug seal on plug. Install tap plug into pump.

10) Remove screened covers from manifold. Install air crossover assembly.

INJECTION NOZZLE

1) Remove injection nozzles. *Refer to removal procedure under REMOVAL & INSTALLATION.* Clean carbon from tip of nozzle with a soft brass brush. Check torque of inlet fitting to nozzle body and correct as necessary.

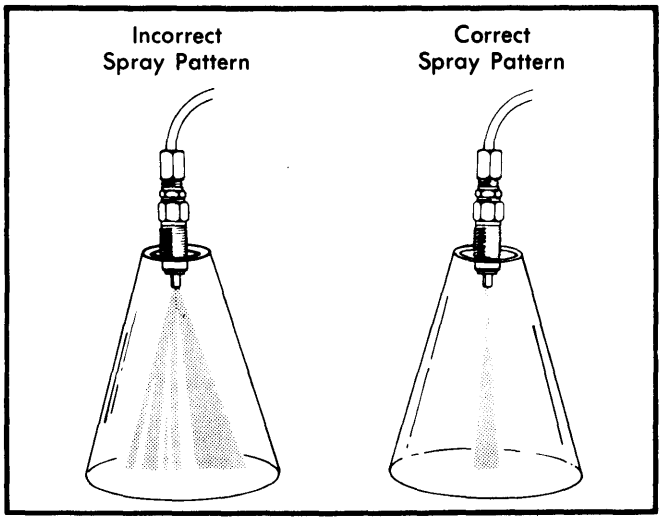

Fig. 8 Nozzle Spray Pattern

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

2) Assemble nozzle to a suitable diesel injection nozzle tester using a connecting line (high pressure) 12" long by 1/4" O.D by 1/16" I.D. between nozzle and tester. Refer to test equipment manufacturers' instructions for exact tester operating instructions.

CAUTION – *When testing nozzles, keep spray contained to avoid serious injury. DO NOT allow injector to release line pressure on hands, arms or any part of body. Pressure of atomized test spray has sufficient penetrating power to puncture flesh.*

3) Build nozzle pressure slow enough to determine exact minimum opening pressure of nozzle. Minimum opening pressure is 870 psi. When nozzle releases pressure, note spray pattern and compare with those shown in *Fig. 8* If liquid stream of fuel is emitted, replace nozzle.

4) To test nozzle seat for leakage, decrease line pressure to at least 180 psi. Dry tip of nozzle with compressed air. Increase line pressure to 218 psi for 5 seconds. Nozzle tip should remain dry, indicating no fuel has leaked past seat. If injection nozzle fails any of these tests, it should be replaced. Install injection nozzles. *Refer to installation procedure under REMOVAL & INSTALLATION.*

REMOVAL & INSTALLATION

AIR CROSSOVER

Removal – 1) Remove air cleaner assembly.

2) Remove filters and pipes from valve covers and air crossover. See *Fig. 2*.

3) Remove 4 bolts and washers and lift air crossover from manifold.

4) Place screened covers (Tool J-26996-2) over openings in intake manifold.

Installation – Reverse removal procedure. Torque air crossover bolts to 22 ft. lbs. Be sure to install new gaskets between crossover and intake manifold.

INJECTION PUMP FUEL LINES

Removal – 1) Remove air crossover assembly and install screened covers (Tool J-26996-2) over manifold openings.

2) Remove injection pump line clamps. It is not necessary to use a back-up wrench when removing lines from pump.

3) Remove injection pump lines and cap open lines.

4) Using a back-up wrench on upper injector nozzle hex, disconnect injection pump lines at nozzle inlet fittings.

5) It is not necessary to remove pump to replace a line(s).

Installation – 1) Install new injection pump line(s) loosely. Position line properly.

2) Torque all high pressure fuel lines to 25 ft. lbs.

NOTE – *Use a back-up wrench when tightening fuel lines to fuel inlet fittings on injector nozzles.*

3) Install line clamps. Start engine and check for fuel leaks.

NOTE – *If several lines are to be replaced, start by connecting lower lines first.*

4) Remove screened covers from intake manifold and install air crossover and air filter assembly.

INJECTION PUMP

Removal – 1) Remove air crossover assembly and place screened covers (Tool J-26996-2) over intake manifold openings.

2) Disconnect throttle rod and return spring.

3) Remove bellcrank. Remove throttle and T.V. cables from intake manifold brackets. Position cables away from engine.

4) Remove lines to fuel filter and remove filter.

5) Disconnect fuel line at fuel pump. On models equipped with A/C, remove rear compressor brace.

6) Remove fuel line to injection pump.

7) Disconnect fuel return line at injection pump. Remove fuel return line bracket and fuel return line from engine.

8) Remove nozzle, using wrench on largest hex of injector nozzle and turning counterclockwise.

9) Use special wrench (J-26987 or equivalent) to remove 3 nuts securing injection pump. Remove pump and cap all open lines and nozzles.

Installation – 1) Remove caps over fittings.

2) Line up offset tang on pump driveshaft with pump driven gear and install pump. See *Fig. 9*.

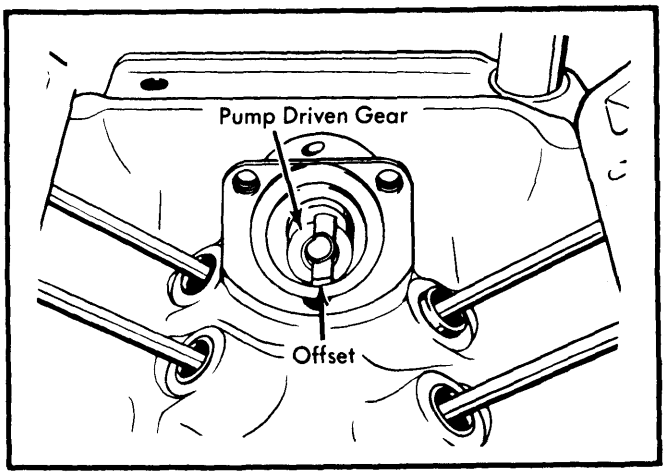

Fig. 9 View of Offset on Pump Driven Gear (Shown With Intake Manifold Removed)

3) Install 3 nuts and lockwashers securing pump but DO NOT tighten yet.

4) Connect pump lines at nozzles and tighten to 25 ft. lbs. with TWO wrenches.

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

5) Connect fuel return line to injection pump. Install fuel return line bracket onto block.

6) Align mark on injection pump with line on adapter. Tighten retaining nuts to 18 ft. lbs. See *Fig. 10*.

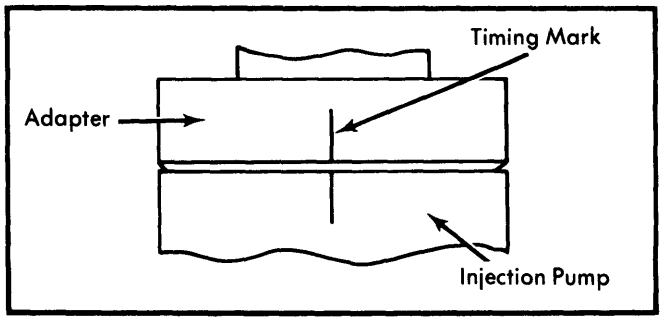

Fig. 10 Aligning Timing Marks on Pump & Adapter

NOTE – *Use a ¾" wrench on boss at front of injection pump to help in rotating pump while aligning marks.*

7) Adjust throttle rod. See *Linkage Adjustment in this article.*

8) Install fuel line from fuel pump to fuel filter. On A/C models, install rear compressor brace.

9) Install bellcrank and clip. Install throttle and T.V. cables to intake manifold. Attach cables to bellcrank.

10) Adjust T.V. cable. See *Linkage Adjustment.*

11) Connect throttle rod and return spring.

12) Start engine and check for fuel leaks.

13) Remove screened covers and install air crossover and filter assembly.

INJECTION PUMP ADAPTER, SEAL & NEW ADAPTER TIMING MARK

Removal – 1) Remove air cleaner, air crossover, injection pump and lines.

2) Remove injection pump adapter. Remove seal from pump adapter.

Installation – 1) File timing mark off of injection pump ADAPTER.

CAUTION – *DO NOT file timing mark off of injection pump.*

2) Rotate engine to place No. 1 piston at Top Dead Center (TDC). Align mark on balancer with ZERO mark on indicator. See *Fig. 9 for position of driven gear.*

NOTE – *Index is offset to the right with No. 1 at TDC.*

3) Apply chassis lube to seal area on adapter, taper edge and seal area in intake manifold. Install adapter and leave loose.

4) Thoroughly lube seal, inside and out, with chassis lube. Install seal on seal installation tool (J-28425).

5) Push seal onto pump adapter using the installation tool. See *Fig. 11.*

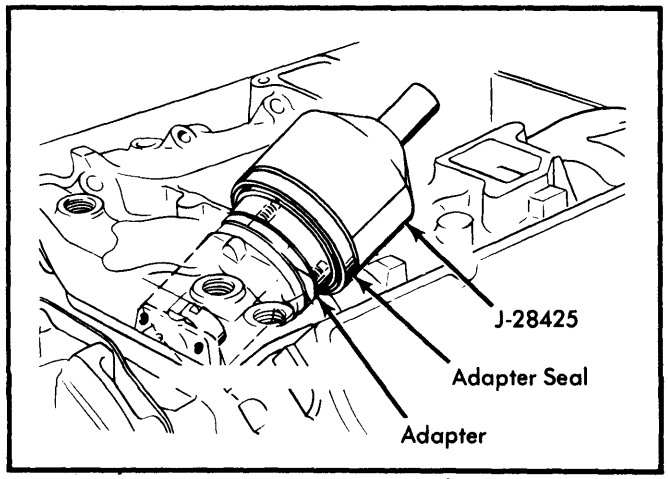

Fig. 11 Installation Of New Adapter Seal

6) Remove tool. Observe seal for proper positioning. Torque adapter bolts to 25 ft. lbs.

7) Install timing tool (J-26896) into injection pump adapter. Torque tool in direction of No. 1 cylinder to 50 ft. lbs.

8) While holding torque, mark injection pump adapter. See *Fig. 12.*

9) Remove tool. Install injection pump, lines and air crossover assembly.

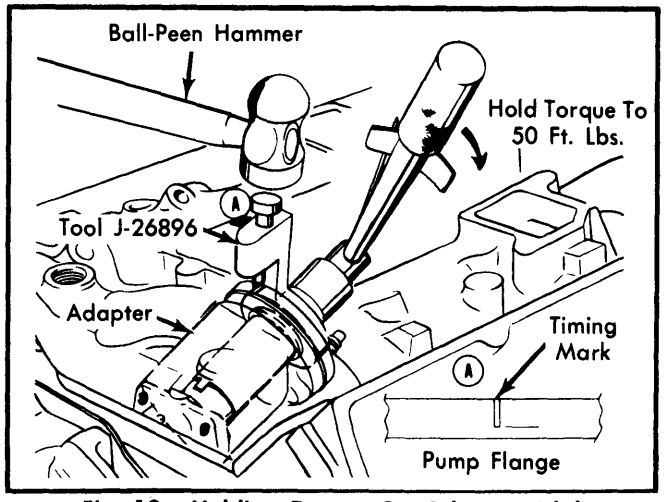

Fig. 12 Holding Torque On Adapter While Marking Timing Mark

INJECTION NOZZLES

Removal – 1) Remove fuel lines from injection pump-to-nozzle on bank of engine where nozzle is to be serviced. DO NOT bend lines out of way to remove nozzle.

2) Cap open fittings and nozzles. Remove nozzle, using wrench on largest hex of injector nozzle. Make sure copper compression seal is removed with nozzle.

NOTE – *Tip of nozzle must be protected from any damage or dirt.*

Installation – 1) Use new copper compression seal and install nozzle. Tighten to 25 ft. lbs. See *Fig. 5.*

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

2) Install fuel lines to fuel inlet fittings and using a back-up wrench on the upper hex of injector, tighten lines to 25 ft. lbs. Start engine and check for leaks.

GLOW PLUGS

Removal – 1) Glow plugs are mounted near each injector nozzle in the cylinder heads. They are threaded and have an electrical wire plugged into the top end.

2) Remove electrical wire from glow plug.

3) Using suitable deep-well socket, remove glow plug.

Installation – 1) Install glow plug and torque to 12 ft. lbs.

2) Connect wire to glow plug.

PRE-CHAMBER

NOTE – *Cylinder head must be removed to remove pre-chamber. There is one pre-chamber for each combustion chamber in cylinder head. Pre-chamber is opposite glow plug and can be tapped out with small blunt drift.*

CAUTION – *When removing pre-chamber, be sure to remove injection nozzle and glow plug from head first. If not, glow plug and/or nozzle could be bent and need replacement.*

ADJUSTMENT

INJECTION TIMING

Engine is properly timed when marks on top of injection pump adaptor and pump flange are aligned. *See Fig. 10.* If marks are not aligned, adjustment is necessary. Engine must be OFF for adjustment.

1) Loosen 3 pump retaining nuts with suitable wrench (J-26987).

2) Align mark on pump with mark on adapter and tighten nuts. Torque to 35 ft. lbs. *See Fig. 10.*

NOTE – *Use a ¾" wrench on boss at front of injection pump to help in rotating pump while aligning marks.*

3) Adjust throttle rod. *See Linkage Adjustment.*

LINKAGE ADJUSTMENT

Check timing and adjust if necessary (engine OFF).

Throttle Rod Adjustment – 1) Turn engine OFF.

2) On cruise control equipped models, remove clip from cruise control rod. Remove rod from bellcrank.

3) Remove T.V. cable from bellcrank.

4) Loosen lock nut on throttle rod. Shorten rod by several turns.

5) Rotate bellcrank to FULL THROTTLE STOP. Lengthen throttle rod until injection pump lever contacts injection pump full throttle stop. Release bellcrank.

6) Tighten throttle rod lock nut. Connect T.V. or detent cable and cruise control rod to bellcrank. Proceed to next adjustment.

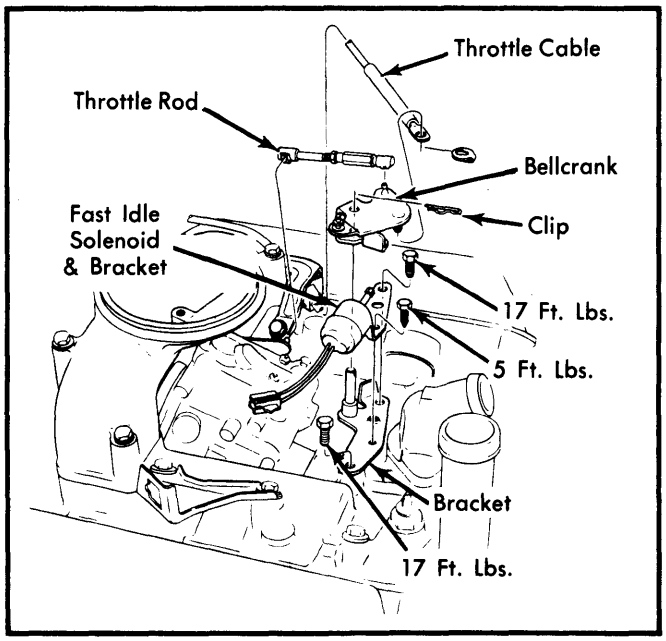

Fig. 13 Disassembled View of Throttle Linkage

Transmission T.V. Cable – 1) With engine OFF, remove throttle cable from bellcrank. Push snap-lock to disengaged position.

2) Rotate bellcrank to full throttle stop and hold there.

3) Push in snap-lock until it is even with cable end fitting. Release bellcrank. Reconnect throttle rod.

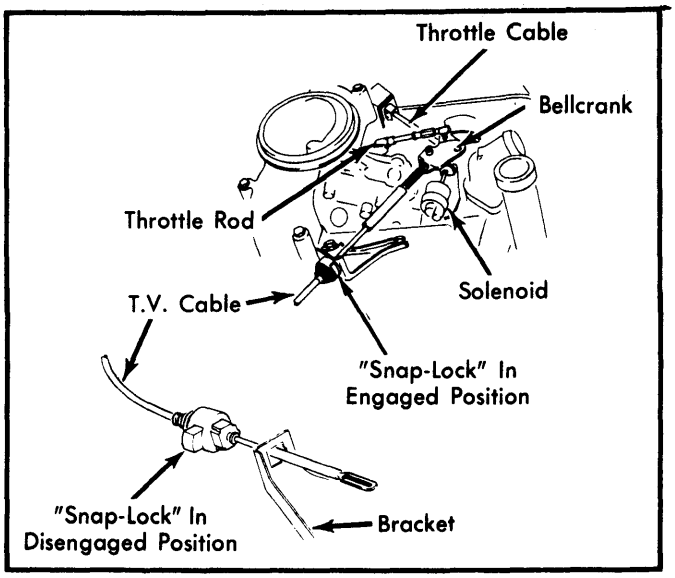

Fig. 14 Transmission T.V. Cable Adjustment

Transmission Vacuum Valve – 1) Remove air crossover and install screened covers. Remove throttle rod from throttle lever.

GENERAL MOTORS DIESEL MECHANICAL FUEL INJECTION (Cont.)

2) Loosen transmission vacuum valve bolts.

3) Install a carburetor choke plate angle gauge adaptor (BT-7944 or J-26701-15) to the injection pump throttle lever.

4) Install carburetor choke plate angle gauge (BT-7704 or J-26701) on the adaptor.

5) Rotate throttle lever to wide open throttle position and set angle gauge to zero degrees. Center bubble in gauge.

6) Reset angle gauge to 49°. Rotate throttle lever until bubble in level is centered. Hold throttle lever in this position while completing this adjustment.

7) Attach an outside vacuum source to center port of vacuum valve. Attach vacuum gauge to outside port of vacuum valve. Apply 18-22 INCH Hg outside with vacuum source.

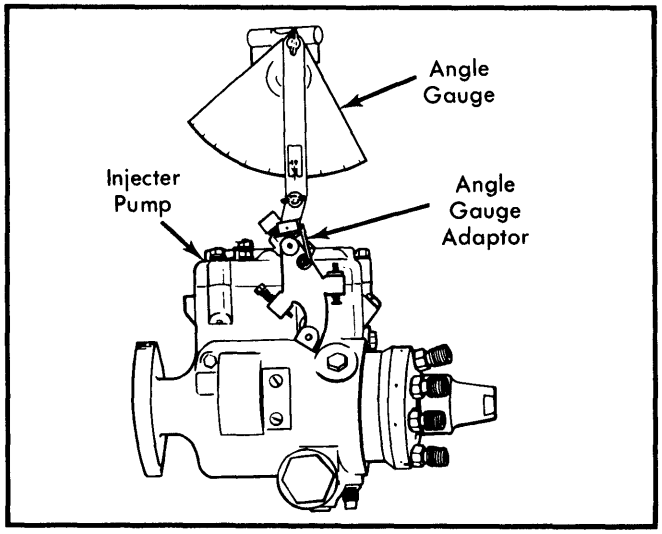

Fig. 15 Transmission Vacuum Valve Adjustment Showing Carburetor Choke Angle Gauge Installed

8) Rotate vacuum valve until 8½ INCH Hg is indicated on vacuum gauge. Tighten vacuum valve bolts.

9) Remove all adjustment tools. Install throttle rod to throttle lever. Remove screened covers and install air crossover.

Slow Idle Speed Adjustment – **1)** Ensure engine is warmed up to operating temperature and running.

NOTE – *To check idle speeds, it is necessary to insert probe of magnetic pickup tachometer (J-26925) in timing indicator hole.*

2) Block driving wheels. Engage parking brake. Place transmission in DRIVE.

3) Adjust slow idle screw on injection pump to 575 RPM. A/C must be OFF. *See Fig. 3.*

Fast Idle Solenoid Adjustment – **1)** Block driving wheels and engage parking brake. Start engine.

2) Adjust fast idle solenoid plunger to 650 RPM with transmission in DRIVE, A/C switch ON and compressor wires disconnected.

NOTE – *On vehicles without A/C, unplug solenoid connector. Attach jumper wires to solenoid terminals and ground one jumper wire. Connect other jumper wire to a 12 volt source to energize solenoid while performing adjustment.*

Cruise Control Servo Relay Rod – **1)** Turn engine OFF.

2) Adjust rod to minimum slack. Put clip in first free hole closest to bellcrank, but within servo bail.

TIGHTENING SPECIFICATIONS

Application	Ft. Lbs.
Fuel Pump-to-Block Bolt/Nut	25
Injection Pump Attaching Nuts	18
Injection Line Nut-to-Pump	25
Injection Pump Adapter Bolts	25
Injection Line Nut-to-Nozzle	25
Injection Nozzle	25
Inj. Pump Fuel Filter Inlet	20
Inj. Pump Fuel Filter Outlet	18
Injection Pump Fuel Inlet Line	20
Glow Plug	12