

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.

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. Federal and California models use different crossovers to accommodate specific EGR systems. Starter fluid should NEVER be used or sprayed into crossover. If crossover is removed, air screens must be installed.

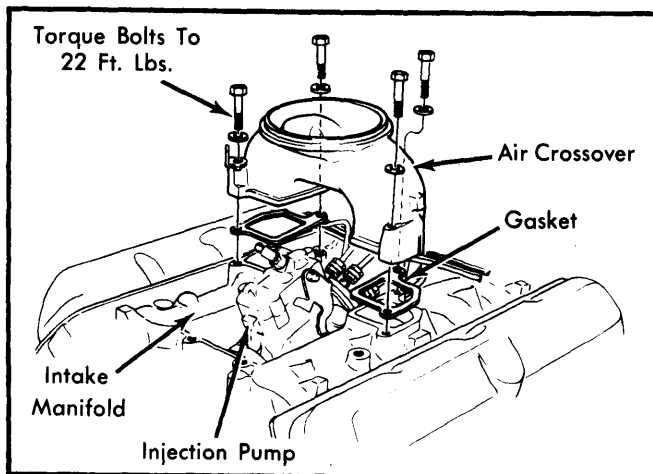


Fig. 1 Air Crossover Assembly (Federal Models)

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.

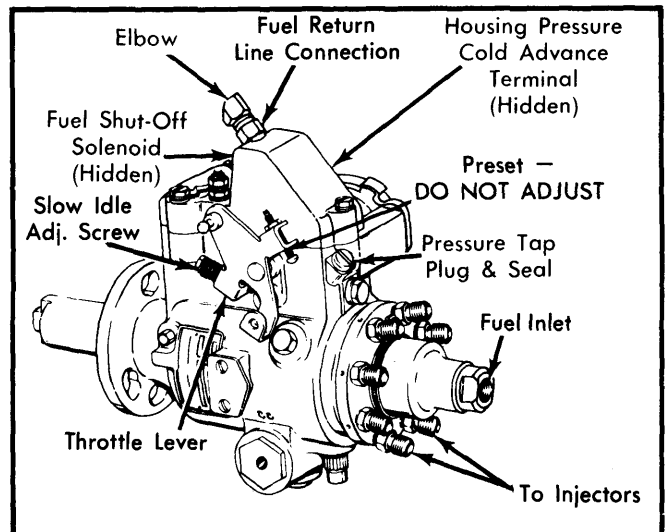


Fig. 2 Diesel Injection Pump

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.

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.

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

Glow plugs are small heaters provided to assist in cold starting. The glow plug controller and relay cycle 12 volts to these 6 volt heaters, which causes them to heat rapidly. After the engine starts, the glow plugs remain on for about a minute, then shut off. If the ignition is turned on and the engine is not started, the glow plugs will continue to cycle until the batteries are discharged.

CAUTION — Do not manually by-pass glow plug relay, or glow plugs will be ruined instantly.

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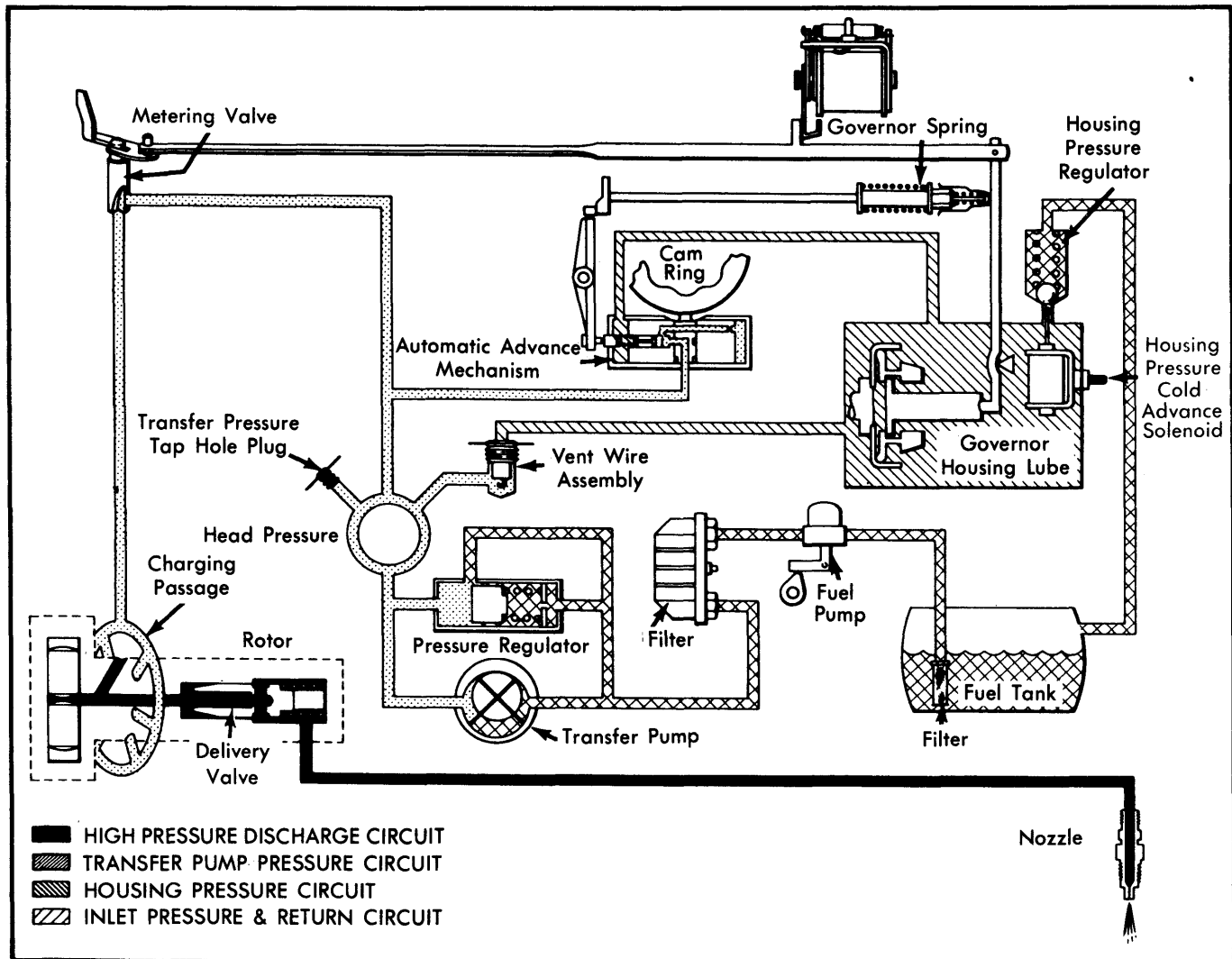


Fig. 3 Diesel Injection Pump Fuel Circuit Diagram

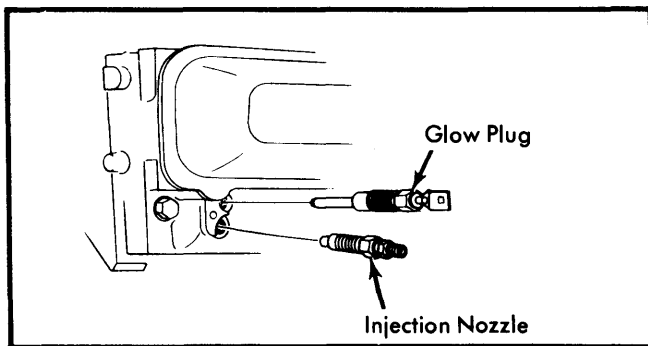


Fig. 4 Diesel Glow Plug & Injection Nozzle Location

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.

Two types of injection nozzles are used. The inlet fitting in the body of the injector must be tightened to the correct torque when installed or checked. See Fig. 5.

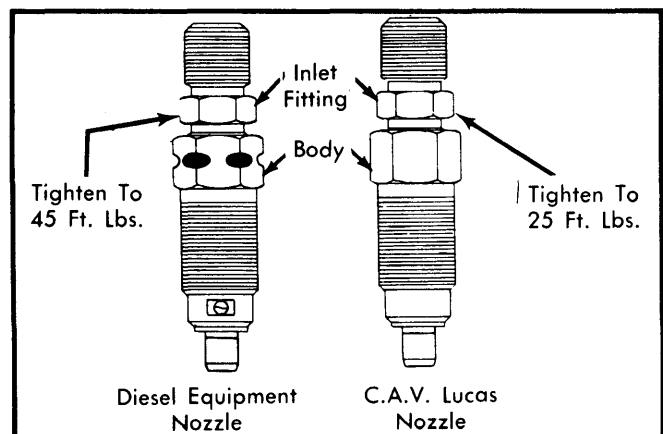


Fig. 5 Diesel Injection Nozzle Identification

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VACUUM PUMP

Vacuum to operate accessory systems on diesel vehicles is provided by a vacuum pump. On most models, the pump is located at the rear of the block and driven by the cam; others use a belt driven vacuum pump. Engines with block-mounted pump should never be operated without the pump in place as it is also the oil pump drive.

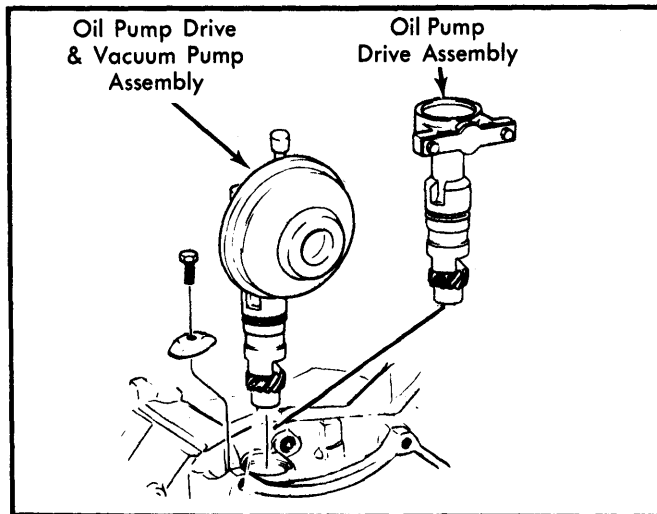


Fig. 6 Vacuum and Oil Pump Drive Units

HOUSING PRESSURE COLD ADVANCE (HPCA)

The HPCA is used to improve cold starting and emission control. The solenoid is controlled by the engine temperature switch and advances injection timing by 3° when the engine is cold. It does this by decreasing the housing pressure from 10 psi to zero. At the same time, the fast idle solenoid is activated. When the temperature switch opens (125° F), the HPCA solenoid is de-energized and housing pressure rises, retarding pump timing.

STARTING INDICATOR

Lights are used to indicate when the vehicle is ready to be started. A wait lamp is lit when glow plugs are heating. As the combustion chambers reach starting temperature, the wait lamp goes off, indicating that the engine can be cranked to start. Early diesel models also used a start lamp.

DIESEL FUEL HEATER (OPTIONAL)

This option is used to heat the fuel during low temperature (below 20° F) operation. This prevents wax crystals from building up and blocking the fuel filters. The filter is located along the right side of the intake manifold and uses a resistance wire spiralled around the fuel line.

TESTING

INJECTION PUMP HOUSING FUEL PRESSURE

1) Engine must be at normal operating temperature. Remove air crossover assembly and install screen covers over openings in intake manifold.

2) Remove pressure tap plug from injector pump.

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. Start engine and run with transmission selector in "P". Pressure should be 8-12 psi, with no more than 2 psi fluctuation.

5) If pressure is zero, remove connector from housing pressure cold advance terminal. If pressure is still zero, remove injection pump cover and inspect solenoid operation. Free up solenoid if binding.

6) If pressure rose when solenoid lead was disconnected, check operation of temperature switch on rear head bolt. Switch should open above 125° F, then close when temperature drops to 95° F.

7) If pressure is still incorrect, replace or clean fuel return line connector assembly and return line.

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.

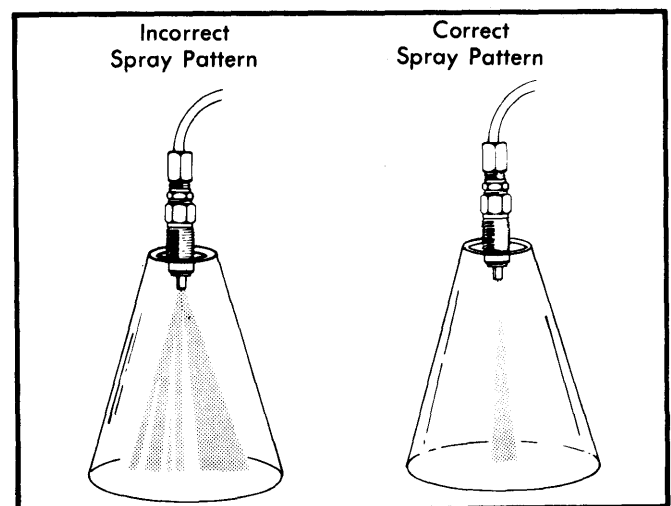


Fig. 7 Nozzle Spray Patterns

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.

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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 examples shown. If incorrect, or if a liquid stream, replace nozzle. See Fig. 7.

4) To test nozzle seat for leakage, decrease pressure to at least 290 psi BELOW actual opening pressure. Dry nozzle tip with compressed air, then increase pressure slowly to 218 psi BELOW actual opening pressure. Maintain pressure for 5 seconds and compare fuel leakage to examples. See Fig. 8.

5) Replace defective nozzles, then reinstall all nozzles. Install carefully and tighten to recommended torque.

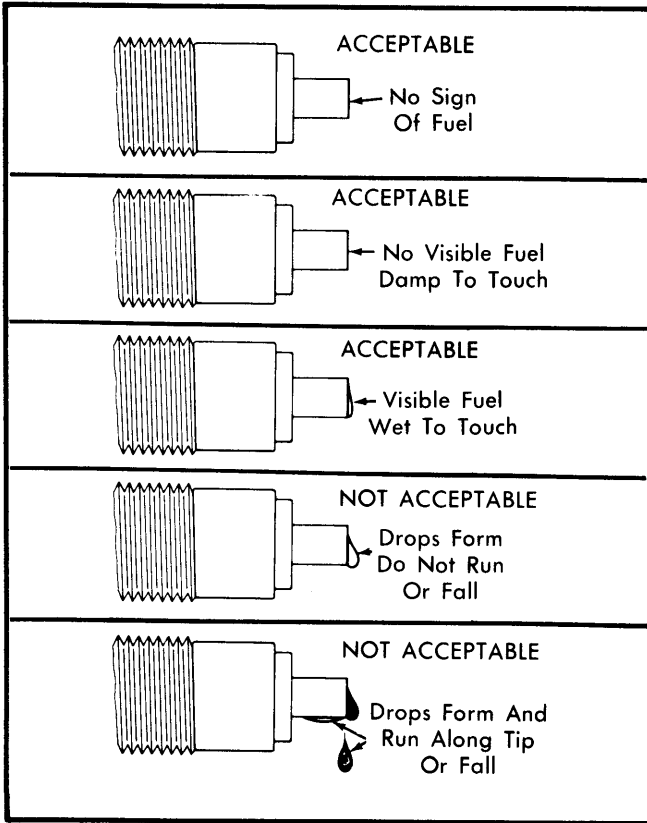


Fig. 8 Injection Nozzle Seat Tightness Check

REMOVAL & INSTALLATION

NOTE — Manufacturer does not recommend disassembly of pump. However, pump cover, guide stud, and throttle shaft seals may be replaced to eliminate leaks. For all other problems, pump must be removed and taken to an authorized repair station.

INJECTION PUMP SEAL REPLACEMENT

1) Disconnect ground cables from both batteries, then remove air cleaner and crossover. Install screens over air intakes. Disconnect fuel return line and wiring from injection pump.

2) Clean injection pump cover and area around throttle rod and guide stud. Place rags in engine valley to catch fuel. Remove vacuum regulator valve, throttle rod, and return springs. Remove throttle cable bracket.

3) Install tool (J-29601) over throttle shaft with slots of tool engaging pin. Put spring clip of tool over throttle shaft advance cam and tighten wing nut. Without loosening wing nut, pull tool off shaft. This provides a reference for proper alignment during reassembly.

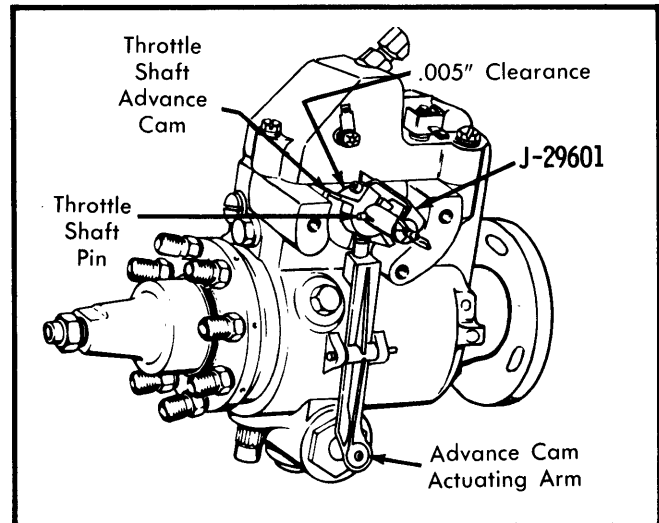


Fig. 9 Injection Pump With Advance Cam Tool Installed

4) Drive pin from throttle shaft and remove advance cam and fiber washer. Remove any burrs that may have been caused by pin removal. Remove injection pump cover and remove screws from cover.

CAUTION — Do not allow any dirt or foreign objects to drop into injection pump. Engine damage will result.

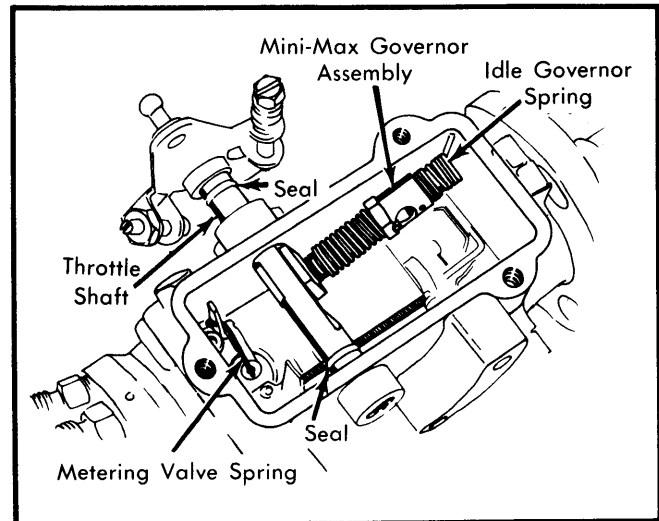


Fig. 10 Injection Pump With Cover Removed

5) Note position of metering valve spring over top of guide stud. This position must be exactly duplicated during reassembly. Remove guide stud and washer, then rotate mini-max governor assembly up and remove from throttle shaft.

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6) Remove throttle shaft and inspect. If damaged or worn, replace. It may be necessary to loosen and rotate pump slightly to remove throttle shaft. Inspect shaft bushings. If replacement is necessary, pump must be sent to authorized repair dealer.

7) Remove throttle shaft seals. Do not cut off, as a nick on shaft will cause leakage. Coat new seals lightly with grease and install on shaft.

8) Slide shaft into pump until mini-max governor will slip onto throttle shaft. Rotate governor downward, hold in position, and slide shaft and governor cam into place.

9) Install new fiber washer, throttle shaft advance cam (do not tighten screw) and throttle shaft drive pin. Realign advance cam in original position with tool (J-29601), place a .005" feeler gauge between fiber washer and cam, and tighten cam screw.

10) Reinstall guide stud with new washer. Ensure that metering valve spring extension rides on top of guide stud. Tighten guide stud to 85 INCH Lbs.

11) Hold throttle in idle position and install new pump cover seal. Do not insert screws in cover; position cover slightly forward and above pump. Carefully move cover rearward and downward into position, taking care not to damage seal.

12) Insert screws, using flat and lock washers with flat washers against pump cover. Tighten to 33 INCH Lbs., then install vacuum regulator valve.

13) Connect battery ground cables, turn ignition on, and touch pink solenoid wire to solenoid terminal. A clicking sound should be heard as solenoid operates. If not, remove cover and check for solenoid operation.

CAUTION — *If clicking sound is not heard as solenoid wire is connected, DO NOT start engine. Throttle may be stuck in wide-open position.*

14) If solenoid clicks, connect all wires to pump housing. Reinstall throttle cable bracket and throttle rod. Reinstall throttle cable and return springs.

15) Adjust pump timing and throttle linkage. Install fuel return line and check that all fuel lines are tight. Start engine and check for leaks. Allow engine to idle for several minutes to purge air bubbles and smooth out idle. It may be necessary to stop engine for several minutes to allow air to rise and be purged.

16) Adjust vacuum regulator valve, then replace air crossover.

AIR CROSSOVER

Removal — Remove air cleaner, then remove filters and pipes from air crossover. Remove bolts and washers and lift crossover from manifold. Place screened covers over intake manifold openings.

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 cleaner and crossover, then install screened covers over openings in intake manifold.

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 cleaner and crossover, then install screened covers over openings in intake manifold.

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 injector fuel lines at pump, using 2 wrenches.

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) Position cylinder No. 1 at TDC by lining up crankshaft pulley mark with indicator. Remove caps placed over fittings.

2) Line up offset tang on pump driveshaft with pump driven gear and install pump.

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.

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.

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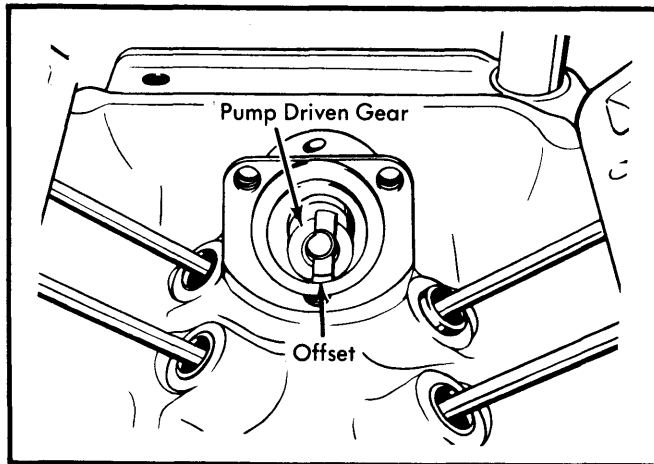


Fig. 11 Pump Driven Gear Offset at TDC (Shown with Intake Manifold Removed)

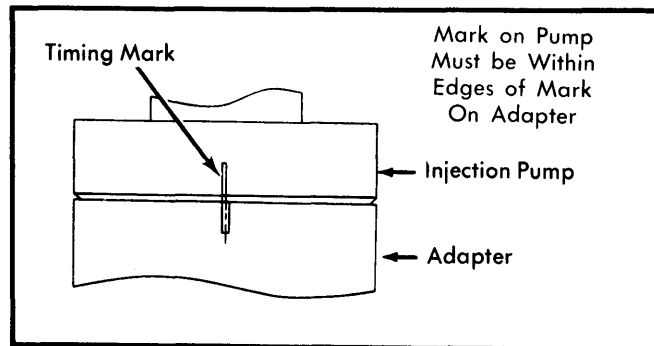


Fig. 12 Aligning Timing Marks on Pump & Adapter

NOTE — Use a $\frac{3}{4}$ " 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*.) Connect throttle rod and return spring, then start engine and check for leaks. Remove covers and install crossover.

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.

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.

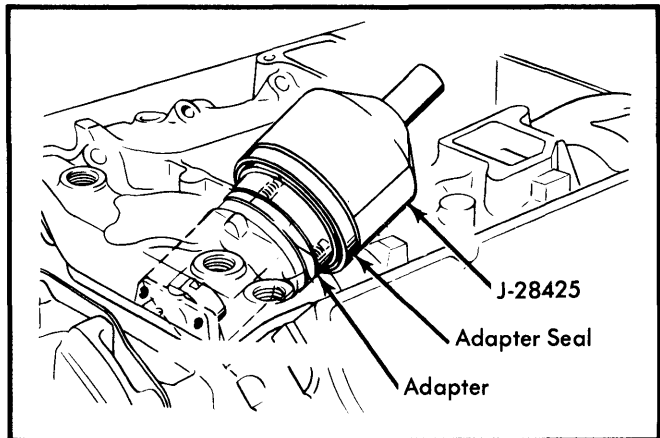


Fig. 13 Installation of New Adapter Seal

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.

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

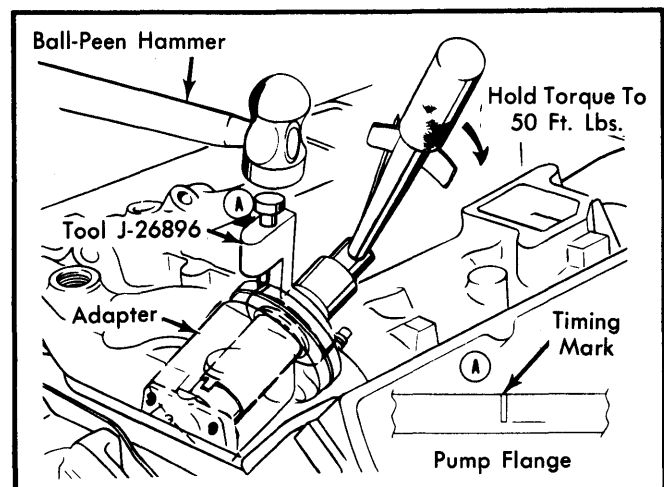


Fig. 14 Stamping Timing Mark On Adapter

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.

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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. (C.A.V. Lucas nozzle) or 45 ft. lbs. (Diesel Equipment nozzle). See Fig. 5.

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 and remove plug with deep socket. Be sure to engage socket on largest diameter hex surfaces.

Installation — Install glow plug, torque to 12 ft. lbs., and connect electrical wire.

ADJUSTMENT

INJECTION TIMING

Engine is properly timed when mark on injection pump is aligned with mark on adapter. If marks are not aligned, adjustment is necessary. Engine must be off for adjustment.

1) Loosen 3 pump retaining nuts with wrench (J-26987). Align mark on pump with mark on adapter and tighten nuts. Torque to 35 ft. lbs.

2) Adjust throttle rod and linkage.

LINKAGE ADJUSTMENT

Throttle Rod Adjustment — 1) With engine off, check pump timing. If equipped with cruise control, remove clip from cruise control throttle rod and disconnect rod from throttle lever.

2) Disconnect transmission T.V. or detent cable from throttle assembly. Loosen lock nut on pump rod and shorten by several turns. Rotate lever to full throttle position and hold.

3) Lengthen rod until injection pump lever just contacts full throttle stop. Release lever and tighten lock nut. Remove pump rod from lever assembly.

4) Reconnect transmission T.V. or detent cable. Depress and hold metal lock tab on upper end of cable, then move slider away from lever assembly until it stops against metal fitting.

5) Release metal tab, rotate lever assembly to full throttle stop and release lever assembly. Reconnect pump rod and cruise control rod. Adjust idle speed. See *General Motors Diesel V8 Tune-Up* article in TUNE-UP Section.

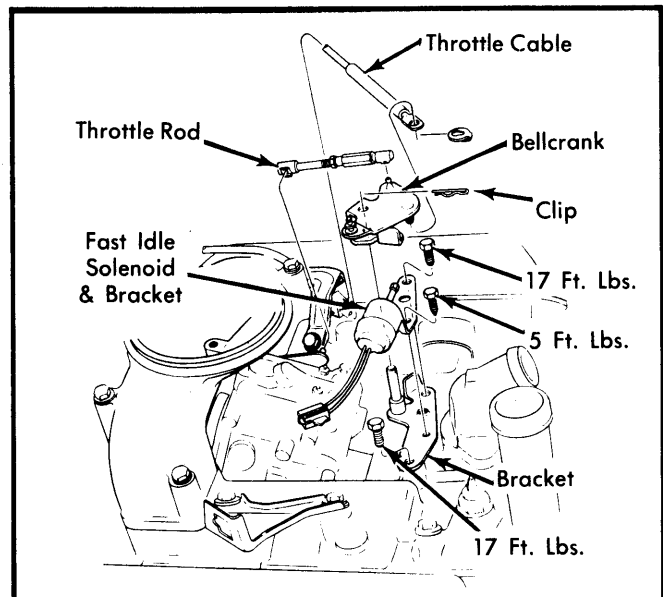


Fig. 15 Disassembled View of Throttle Linkage

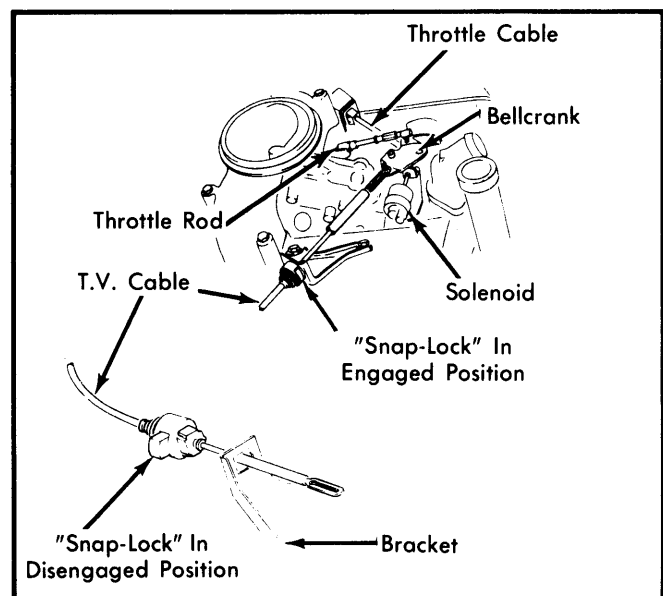


Fig. 16 Transmission T.V. or Detent Cable Adjustment

Vacuum Regulator Valve — 1) Remove air crossover and install screen covers over openings. Remove throttle rod from throttle lever. Loosen vacuum regulator valve-to-pump bolts.

2) Install carburetor angle gauge to injection pump throttle lever. Rotate throttle lever to wide-open throttle position and set angle gauge to zero degrees, then center bubble.

3) Set angle gauge to 58°, then rotate throttle lever until bubble is centered. Attach vacuum pump to port "A" of vacuum regulator valve and vacuum pump to port "B". See Fig. 20.

4) Apply 18-22 in. Hg vacuum to port "A", then rotate vacuum valve clockwise to obtain 8.5-9.0 in. Hg. Tighten bolts and connect throttle rod. Remove vacuum pump and angle gauge.

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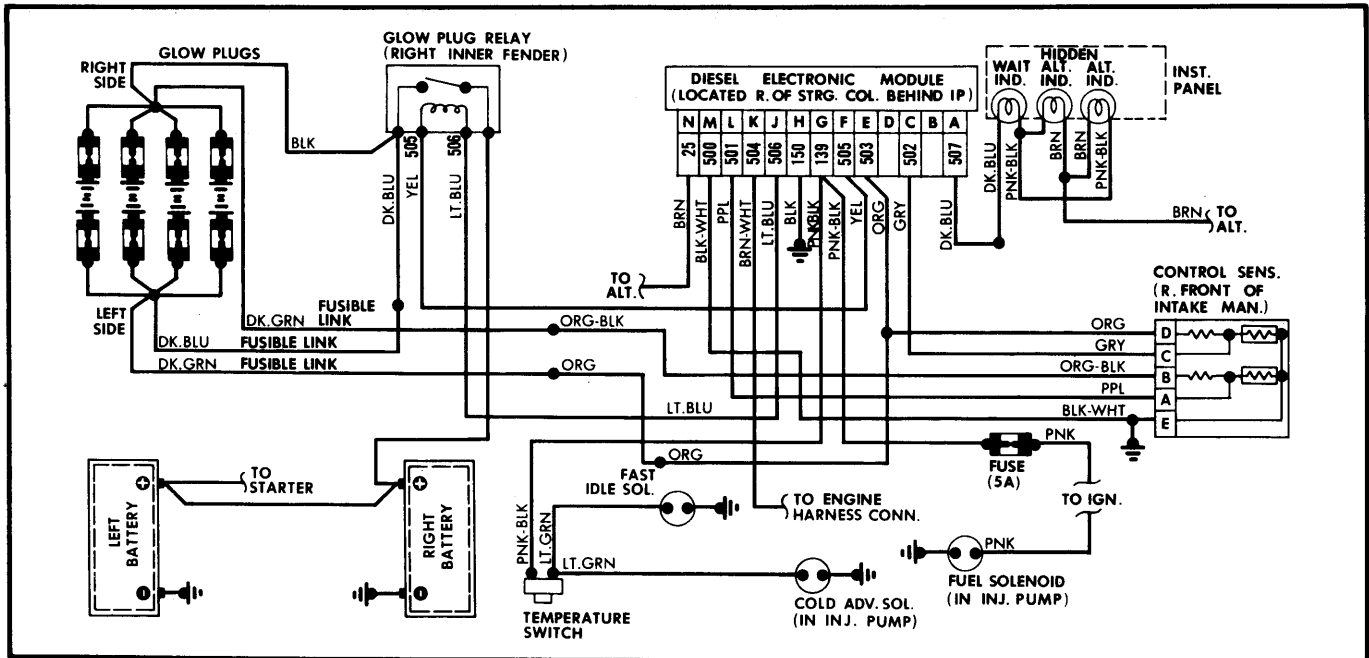


Fig. 17 Glow Plug System Wiring Diagram (Cutlass & Grand Prix)

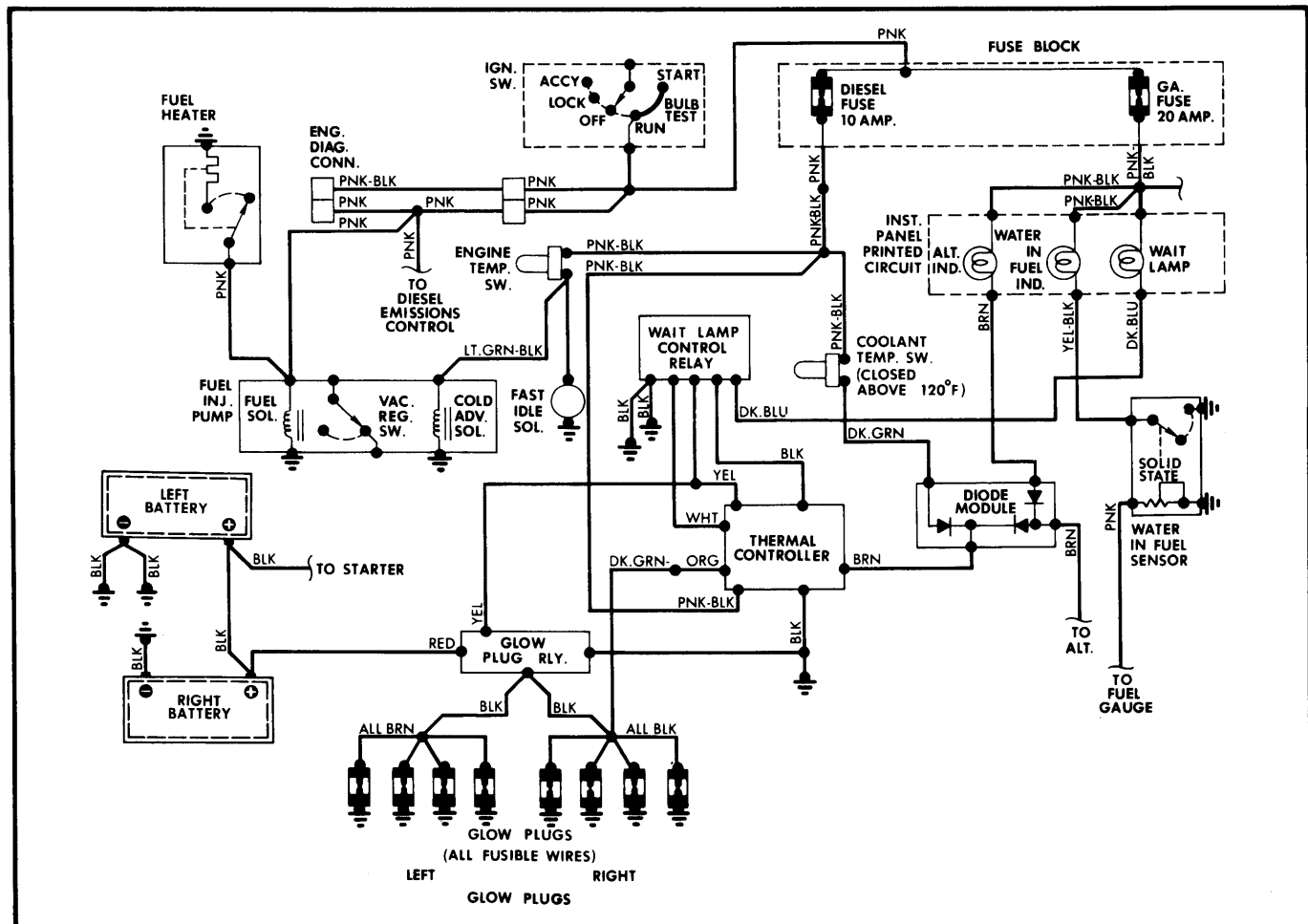


Fig. 18 Glow Plug System Wiring Diagram (All Except Cutlass & Grand Prix)

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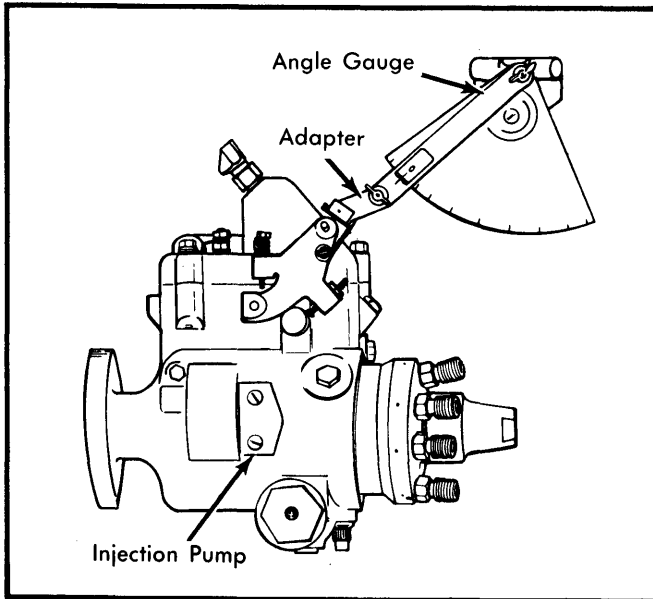


Fig. 19 Vacuum Regulator Valve Adjustment

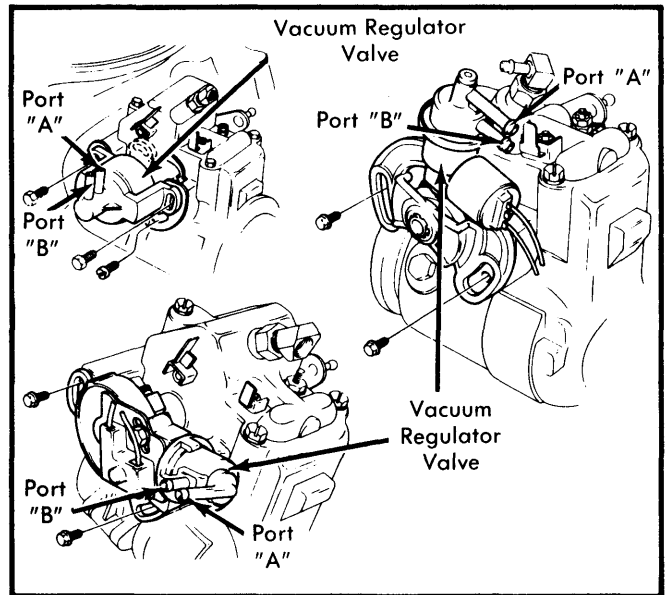


Fig. 20 Vacuum Regulator Valve Port Locations