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Systems Operation (Section 2)

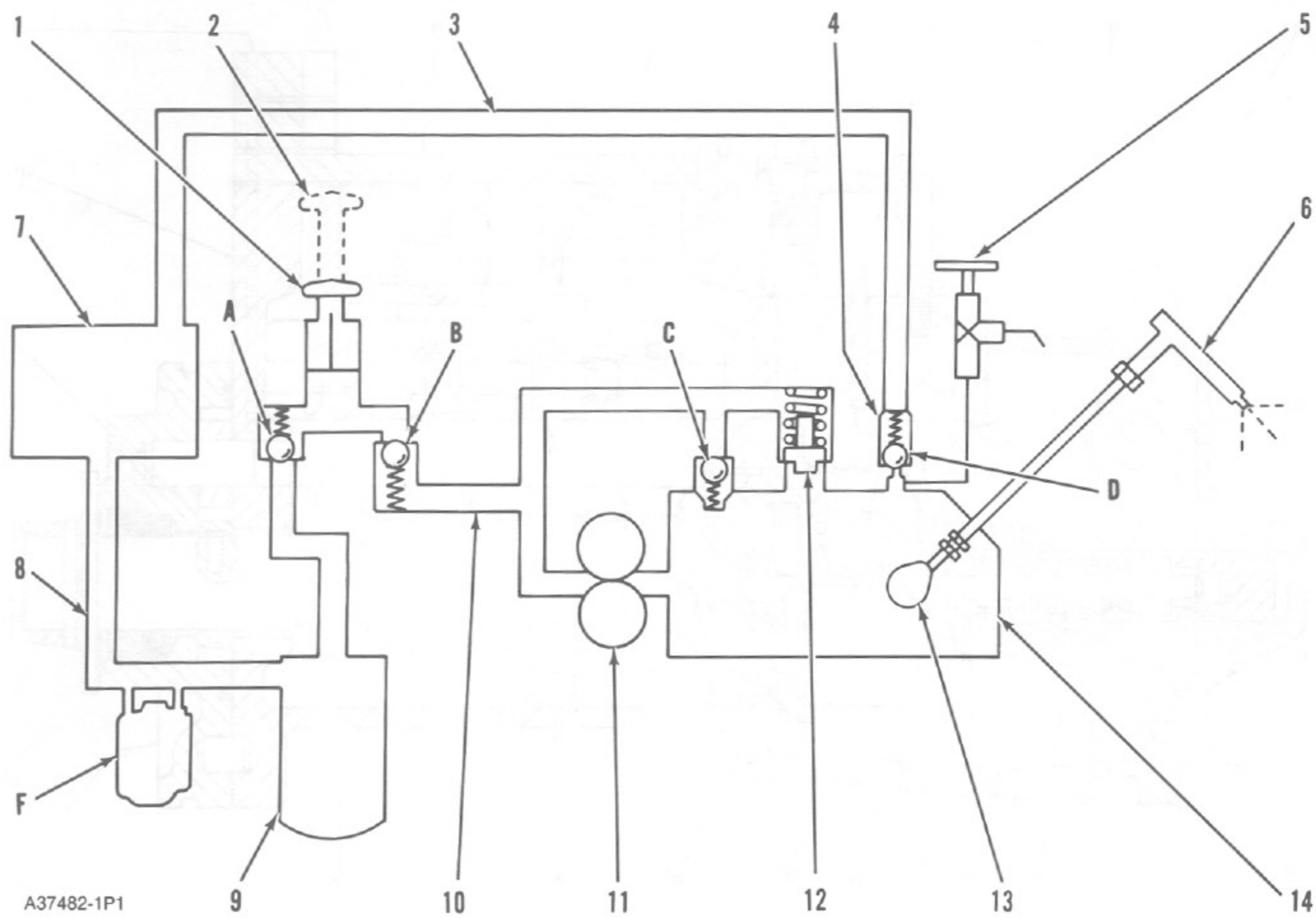
Systems Operation

Fuel System

The sleeve metering fuel system is a pressure type fuel system. The name for the fuel system is from the method used to control the amount of fuel sent to the cylinders. This fuel system has an injection pump for each cylinder of the engine. It also has a fuel transfer pump on the front of the injection pump housing. The governor is on the rear of the injection pump housing.

The drive gear for the fuel transfer pump is on the front of the camshaft for the injection pumps. The carrier for the governor weights is bolted to the rear of the camshaft for the injection pumps. The injection pump housing has a bearing at each end to support the camshaft. The camshaft for the sleeve metering fuel system is driven by the timing gears at the front of the engine.

The injection pumps, lifters and rollers, and the camshaft are all inside of the pump housing. The pump housing and the governor housing are full of fuel at transfer pump pressure (fuel system pressure).



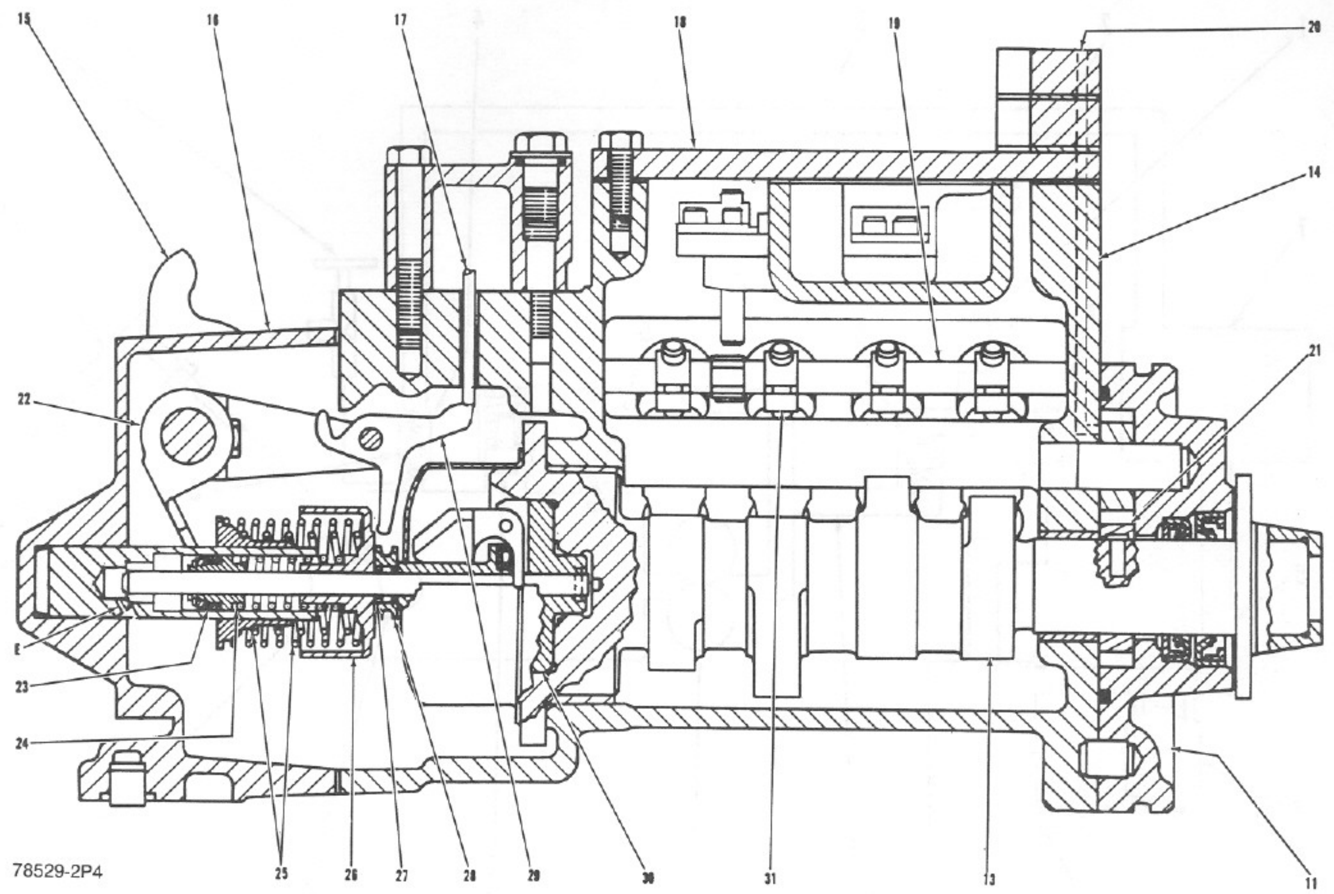
Schematic Of Fuel System
(1) Fuel priming pump (closed position). (2) Fuel priming pump (open position). (3) Return line for constant bleed valve. (4) Constant bleed valve. (5) Manual bleed valve. (6) Fuel injection nozzle. (7) Fuel tank. (8) Fuel inlet line. (9) Fuel filter. (10) Fuel line to injection pump. (11) Fuel transfer pump. (12) Fuel bypass valve. (13) Camshaft. (14) Housing for fuel injection pumps. (A) Check valve. (B) Check valve. (C) Check valve. (D) Check valve. (F) Water Separator.

NOTICE

Diesel fuel is the only lubrication for the moving parts in the transfer pump, injection pump housing and the governor. The injection pump housing must be full of fuel before turning the camshaft.

This fuel system has governor weights, a thrust collar and two governor springs. One governor spring is for high idle and the other governor spring is for low idle. Rotation of the shaft for governor control, compression of the governor springs, movement of connecting linkage in the governor and injection pump housing controls the amount of fuel sent to the engine cylinders.

Fuel from fuel tank (7) is pulled by fuel transfer pump (11) through water separator (F) (if so equipped) and fuel filter (9). From fuel filter (9) the fuel goes to housing for fuel injection pumps (14). The fuel goes in housing (14) at the top and goes through inside passage (20) to fuel transfer pump (11).



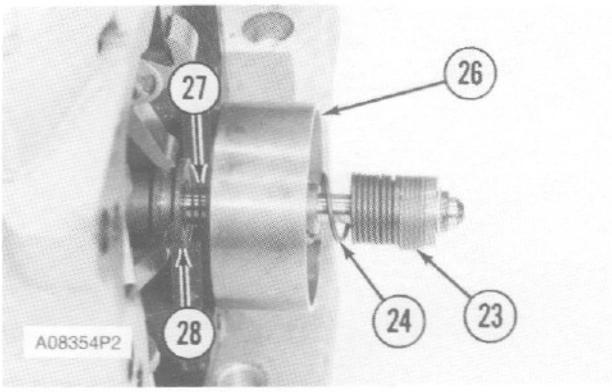
Cross Section Of Fuel System With Dashpot Governor
(11) Fuel transfer pump. (13) Camshaft. (14) Housing for fuel injection pumps. (15) Lever. (16) Governor housing. (17) Load stop pin. (18) Cover. (19) Sleeve control shafts (two). (20) Inside fuel passage. (21) Drive gear for fuel transfer pump. (22) Lever on governor shaft. (23) Piston for dashpot governor. (24) Spring for dashpot governor. (25) Governor springs (inner spring is for low idle: outer spring is for high idle). (26) Spring seat. (27) Over fueling spring. (28) Thrust collar. (29) Load stop lever. (30) Carrier and governor weights. (31) Sleeve levers. (E) Orifice for dashpot.

From fuel transfer pump (11), fuel under pressure, fills the housing for the fuel injection pumps (14). Pressure of the fuel in housing (14) is controlled by bypass valve (12). Pressure of the fuel at FULL LOAD is 205 ± 35 kPa (30 ± 5 psi). If the pressure of fuel in housing (14) gets too high, bypass valve (12) will move (open) to let some of the fuel return to the inlet of fuel transfer pump (11).

Lever (15) for the governor is connected by linkage and governor springs (25) to the sleeve control shafts (19). Any movement of lever (22) will cause a change in the position of sleeve control shafts (19).

When lever (15) is moved to give more fuel to the engine, lever (22) will put governor springs (25) in compression and move thrust collar (28) forward. As thrust collar (28) moves forward, the connecting linkage will cause sleeve control shafts (19) to turn. With this movement of the sleeve control shafts, levers (31) will lift sleeves (32) to make an increase in the amount of fuel sent to the engine cylinders.

When starting the engine, the force of over fueling spring (27) is enough to push thrust collar (28) to the full fuel position. This lets the engine have the maximum amount of fuel for injection when starting. At approximately 400 rpm, governor weights (30) make enough force to push spring (27) together. Thrust collar (28) and spring seat (26) come into contact. From this time on, the governor works to control the speed of the engine.



Governor Parts
(23) Piston for dashpot governor. (24) Spring for dashpot governor. (26) Spring seat. (27) Over fueling spring. (28) Thrust collar.

When governor springs (25) are put in compression, the spring seat at the front of the governor springs will make contact with load stop lever (29). Rotation of the load stop lever moves load stop pin (17) up until the load stop pin comes in contact with the stop bar or stop screw. This stops the movement of thrust collar (28), the connecting levers, and sleeve control shafts (19). At this position, the maximum amount of fuel per stroke is being injected by each injection pump.

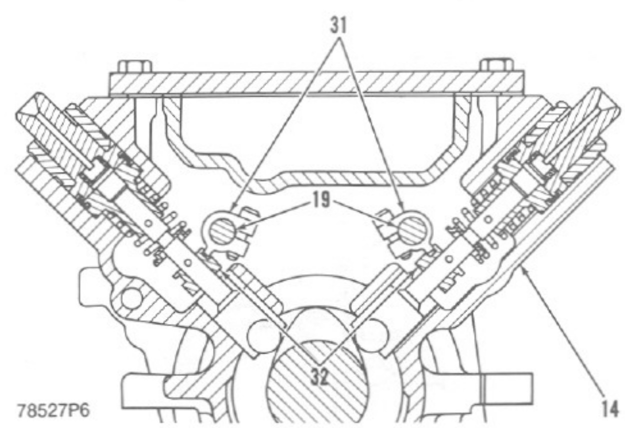
The carrier for governor weights (30) is held on the rear of camshaft (13) by bolts. When engine rpm goes up, injection pump camshaft (13) turns faster. Any change of camshaft rpm will change the rpm and position of governor weights (30). Any change of governor weight position will cause thrust collar (28) to move. As governor weights (30) turn faster, thrust collar (28) is pushed toward governor springs (25). When the force of governor springs (25) is balanced by the centrifugal force of the governor weights, sleeves (32) of the injection pumps are held at a specific position to send a specific amount of fuel to the engine cylinders.

The parts of the dashpot work together to make the rpm of the engine steady. The dashpot works as piston (23) moves in the cylinder which is filled with fuel. The movement of piston (23) in the cylinder either pulls fuel into the cylinder or pushes it out. In either direction the flow of fuel is through orifice (E). The restriction to the flow of fuel by orifice (E) gives the governor its function.

When the load on the engine decreases, the engine starts to run faster and governor weights (30) put force against springs (25). This added force puts more compression on springs (25) and starts to put spring (24) in compression. Spring (24) is in compression because the fuel in the cylinder behind piston (23) can only go out through orifice (E). The rate of flow through orifice (E) controls how fast piston (23) moves. As the fuel is pushed out of the cylinder by piston (23), the compression of spring (24) becomes gradually less.

When springs (25) and spring (24) are both in compression, their forces work together against the force of weights (30). This gives the effect of having a governor spring with a high spring rate. A governor spring with a high spring rate keeps the engine speed from having oscillations during load changes.

When the load on the engine increases, the engine starts to run slower. Governor weights (30) puts less force against spring (25). Spring (25) starts to push seat (26) to give more fuel to the engine. Seat (26) is connected to piston (23) by spring (24). When seat (26) starts to move, the action puts spring (24) in tension. As piston (23) starts to move, a vacuum is made inside the cylinder. The vacuum will pull fuel into the cylinder through orifice (E). The rate of fuel flow through orifice (E) again controls how fast piston (23) moves. During this condition, spring (24) is pulling against springs (25). This makes the movement of seat (26) and springs (25) more gradual. This again gives the effect of a governor spring with a high spring rate.



Fuel System Components
(14) Housing for fuel injection pumps. (19) Sleeve control shafts. (31) Sleeve levers. (32) Sleeves.

When the governor control lever is turned toward the FUEL-OFF position with the engine running, there is a reduction of force on governor springs (25). The movement of the linkage in the governor will cause fuel control shafts (19) to move sleeves (32) down, and less fuel will be injected in the engine cylinders.

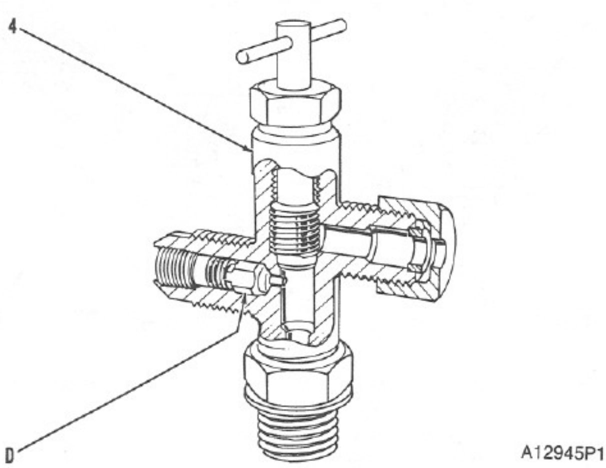
To stop the engine, turn the ignition switch to the "OFF" position. This will cause the shut-off solenoid to move linkage in the fuel pump housing. Movement of the linkage will cause sleeve levers (31) to move sleeves (32) down, and no fuel is sent to the engine cylinders. With no fuel going to the engine cylinders, the engine will stop.

Flow Of Fuel Using The Priming Pump

When the handle of priming pump (2) is pulled out, negative air pressure in priming pump (2) opens check valve (A) and pulls fuel from fuel tank (7). Pushing the handle in closes check valve (A) and opens check valve (B). This pushes air and/or fuel into housing (14) through the fuel passages and check valve (C). More operation of priming pump (2) will pull fuel from fuel tank (7) until the fuel lines, fuel filter (9) and housing (14) are full of fuel. Do this until the flow of fuel from manual bleed valve (5) is free of air bubbles.

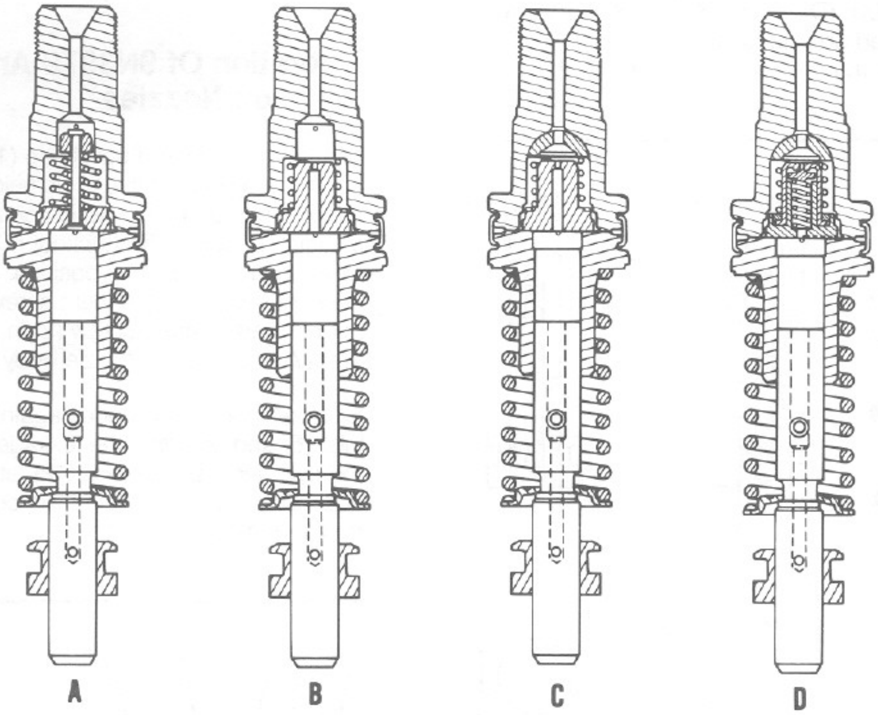
Constant Bleed Valve

Constant bleed valve (4) lets approximately 9 gallons of fuel per hour go back to fuel tank (7). This fuel goes back to fuel tank (7) through return line for constant bleed valve (3). This flow of fuel removes air from housing (14) and also helps to cool the fuel injection pump. Check valve (D) makes a restriction in this flow of fuel until the pressure in housing (14) is at 55 ± 20 kPa (8 ± 3 psi).



Constant Bleed Valve
(4) Constant bleed valve. (D) Check valve.

Fuel Injection Pumps



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A. 9N5857 Fuel Injection Pump uses a reverse flow check valve (RFC) and is used in engines with serial nos. 2Z1 to 2Z13749.

B. 4W5868 Fuel Injection Pump uses an orificed delivery valve (ODV) and is used in engines with serial nos. 2Z13750 to 2Z34220.

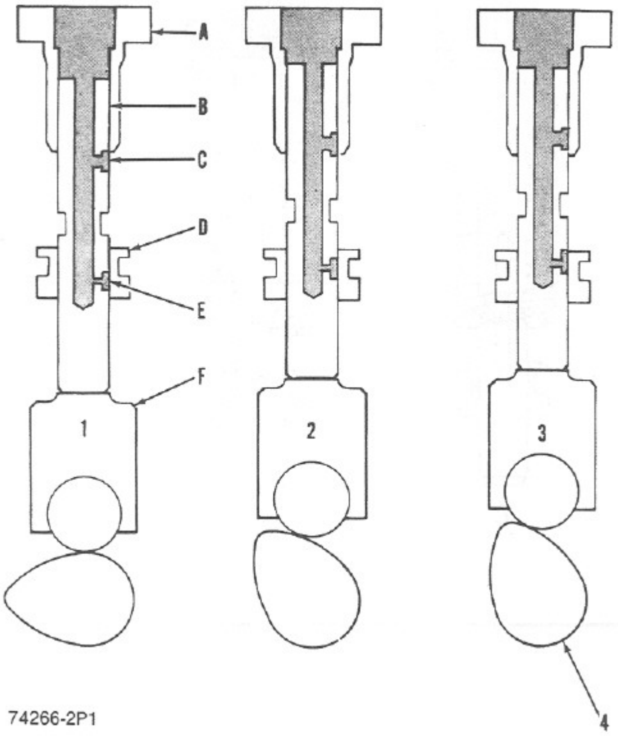
C. 7W8040 Fuel Injection Pump also has an orificed delivery valve (ODV). This fuel injection pump is used in engines with serial nos. 2Z24754 to 2Z34220*.

D. 7C8927 Fuel Injection Pump uses an orificed reverse flow check. Valve (ORFC) is used in engines with serial nos. 2Z34221-Up.

*The engines rated at 240 hp at 2200 rpm and the air to air aftercooled (ATAAC) engines above 250 hp that have 12.5° BTC timing use this fuel system.

Operation Of Fuel Injection Pumps

The main components of a fuel injection pump in the sleeve metering fuel system are barrel (A), plunger (B), and sleeve (D). Plunger (B) moves up and down inside barrel (A) and sleeve (D). Barrel (A) is stationary while sleeve (D) is moved up and down on plunger (B) to make a change in the amount of fuel for injection.



Fuel Injection Sequence
(1), (2), (3) Injection stroke (positions) of a fuel injection pump.
(4) Injection pump camshaft. (A) Barrel. (B) Plunger. (C) Fuel inlet.
(D) Sleeve. (E) Fuel outlet. (F) Lifter.

When the engine is running, fuel under pressure from the fuel transfer pump goes in the center of plunger (B) through fuel inlet (C) during the down stroke of plunger (B). Fuel cannot go through fuel outlet (E) at this time because it is stopped by sleeve (D), (see position 1).

Fuel injection starts (see position 2) when plunger (B) is lifted up in barrel (A) enough to close fuel inlet (C). There is an increase in fuel pressure above plunger (B), when the plunger is lifted by camshaft (4). The fuel above plunger (B) is injected into the engine cylinder.

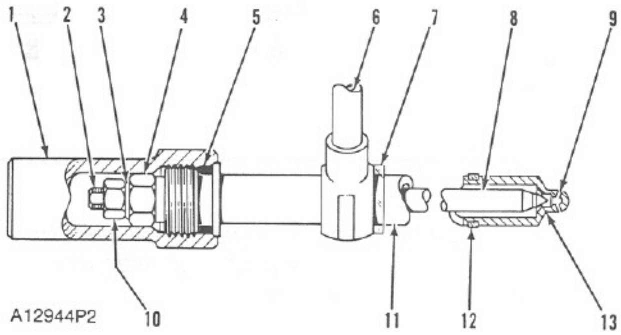
Injection will stop (see position 3) when fuel outlet (E) is lifted above the top edge of sleeve (D) by camshaft (4). This movement lets the fuel that is above, and in, plunger (B) go through fuel outlet (E) and return to the fuel injection pump housing.

When sleeve (D) is raised on plunger (B), fuel outlet (E) is covered for a longer time, causing more fuel to be injected in the engine cylinders. If sleeve (D) is low on plunger (B) fuel outlet (E) is covered for a shorter time, causing less fuel to be injected.

Operation Of 9N3979 And 1W5829 Fuel Injection Nozzles

The fuel inlet (6) and nozzle tip (13) are parts of the nozzle body (11). Valve (8) is held in position by spring force. Force of the spring is controlled by pressure adjustment screw (3). Locknut (4) holds pressure adjustment screw (3) in position. The lift of valve (4) is controlled by lift adjustment screw (2). Locknut (10) holds lift adjustment screw (2) in position. Compression seal (7) goes on the nozzle body (11).

Compression seal (7) goes against the fitting of fuel inlet (6) and prevents the leakage of compression from the cylinder. Carbon dam (12), at the lower end of the nozzle body (11), prevents the deposit of carbon in the bore in the cylinder head.



Fuel Injection Nozzle
(1) Cap. (2) Lift adjustment screw. (3) Pressure adjustment screw.
(4) Locknut for pressure adjustment screw. (5) O-ring seal.
(6) Fuel inlet. (7) Compression seal. (8) Valve. (9) Orifices (four).
(10) Locknut for lift adjustment screw. (11) Nozzle body.
(12) Carbon dam. (13) Nozzle tip.

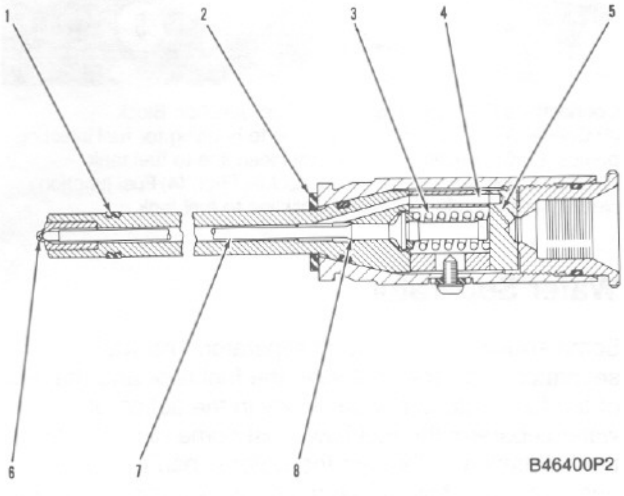
Fuel, under high pressure from the fuel injection pump goes through the hole in fuel inlet (6). The fuel then goes around valve (8), fills the inside of the nozzle body (11) and pushes against the valve guide. When the force made by the pressure of the fuel is more than the force of the spring, valve (8) will lift. When valve (8) lifts, fuel under high pressure will go through the four 0.325 mm (.0128 in) orifices (9) into the cylinder. When the fuel is sent to the cylinder, the force made by the pressure of the fuel in the nozzle body will become less. The force of the spring will then be more than the force of the pressure of the fuel in the nozzle body. Valve (8) will move to the closed position.

Valve (8) is a close fit with the inside of nozzle tip (13), this makes a positive seal for the valve.

When the fuel is sent to the cylinder, a very small quantity of fuel will leak by the valve guide. This fuel gives lubrication to the moving parts of the fuel injection nozzle.

Operation Of 7000 Series Fuel Injection Nozzle

The fuel injection nozzle goes through the cylinder head into the combustion chamber. The fuel injection pump sends fuel with high pressure to the fuel injection nozzle where the fuel is made into a fine spray for good combustion.



Fuel Injection Nozzle
(1) Carbon dam. (2) Seal. (3) Spring. (4) Passage. (5) Inlet passage. (6) Orifice. (7) Valve. (8) Diameter.

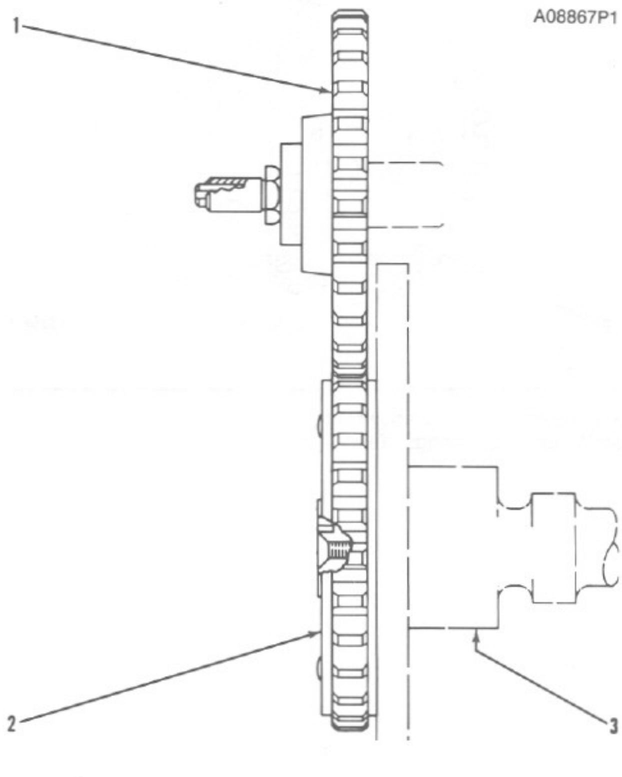
Seal (2) goes against the cylinder head and prevents leakage of compression from the cylinder. Carbon dam (1) keeps carbon out of the bore in the cylinder head for the nozzle.

Fuel with high pressure from the fuel injection pump goes into inlet passage (5). Fuel then goes into passage (4) to the area below diameter (8) of valve (7). When the pressure of the fuel that pushes against diameter (8) becomes greater than the force of spring (3), valve (7) lifts up. When valve (7) lifts, the tip of the valve comes off the nozzle seat and the fuel will go through the four 0.29 mm (.011 in) orifices (6) into the combustion chamber.

The injection of fuel continues until the pressure of fuel against diameter (8) becomes less than the force of spring (3). With less pressure against diameter (8), spring (3) pushes valve (7) against the nozzle seat and stops the flow of the fuel to the combustion chamber.

Automatic Timing Advance Unit

The automatic timing advance unit (2) is installed on the front of the camshaft (3) for the engine. The automatic timing advance unit (2) drives the gear (1) on the camshaft for the fuel injection pump. This gear is the drive for the camshaft for the fuel injection pump.

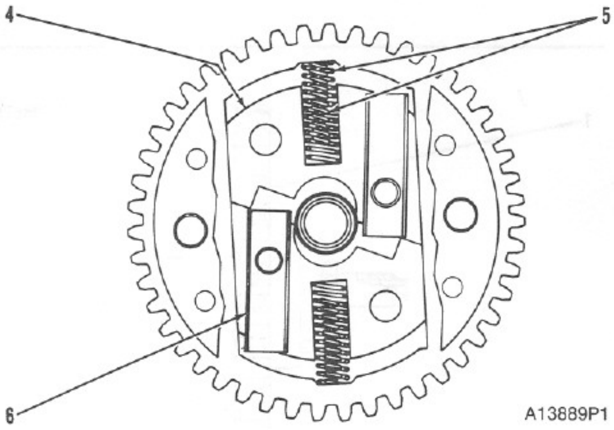


Automatic Timing Advance Unit
(1) Gear on camshaft for fuel injection pump. (2) Automatic timing advance unit. (3) Camshaft for the engine.

The weights (4) in the timing advance are driven by two slides (6) that fit into notches made on an angle in the weights. The slides (6) are driven by two dowels which are in the drive gear for the engine camshaft. As centrifugal force (rotation) moves weights (4) outward against the force of springs (5), the movement of the notches in weights (4) will cause the slides to make a change in the angle between the timing advance gear and the two drive dowels in the drive gear for the engine camshaft. Since the timing advance unit drives the gear (1) on the camshaft for the fuel injection pump, the fuel injection timing is also changed.

There are two different timing advance units used on the 3208 Truck Engine. One unit will give 5° of timing advance, and the other gives 3.5° of timing advance. The timing advance unit begins to advance the timing at low idle rpm and stops advance at rated engine rpm. No adjustment can be made to the automatic timing advance unit.

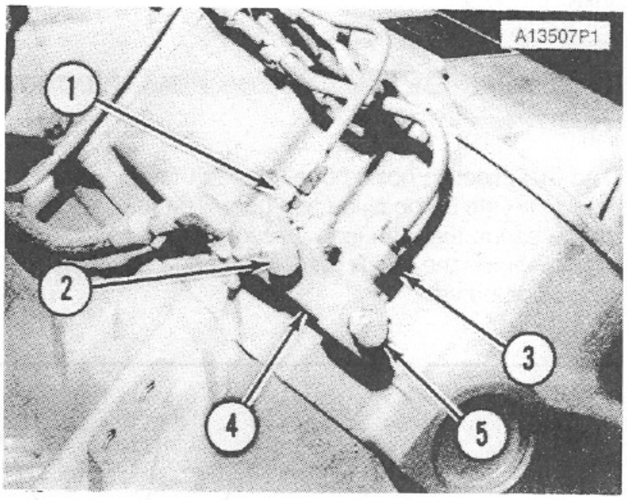
Lubrication oil for the timing advance unit comes from drilled holes that connect with the front bearing for the engine camshaft.



Automatic Timing Advance Unit
(4) Weights. (5) Springs. (6) Slides.

Fuel Junction Block

The location of the fuel junction block (4) is at the right rear of the engine. The fuel lines from the fuel tank and the engine connect at fuel junction block (4).



Connections For Fuel Lines At the Fuel Junction Block
(1) Connection for constant bleed line to housing for fuel injection pumps. (2) Connection for constant bleed line to fuel tank. (3) Connection for fuel supply line to fuel filter. (4) Fuel junction block. (5) Connection for fuel supply line to fuel tank.

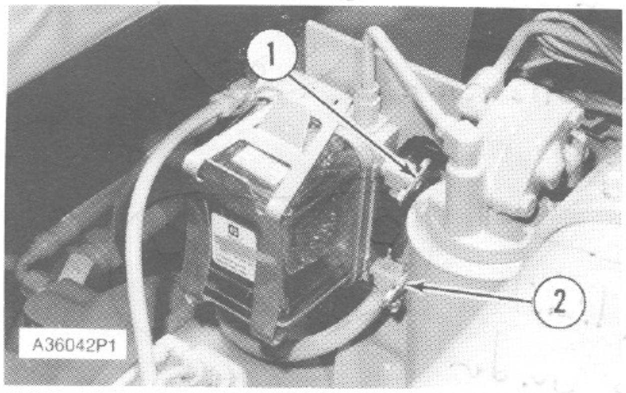
Water Separator

Some engines have a water separator. The water separator is installed between the fuel tank and the rest of the fuel system. For efficiency in the action of the water separator the fuel flow must come directly from the fuel tank and through the water separator. This is because the action of going through a pump or valves before the water separator lowers the efficiency of the water separator.

The water separator can remove 95% of the water in a fuel flow of up to 125 liter/hr (33 gph) if the concentration of the water in the fuel is 10% or less. It is important to check the water level in the water separator frequently. The maximum amount of water which the water separator can hold is 0.4 liter (.8 pt). At this point the water fills the glass to 3/4 full. Do not let the water separator have this much water before draining the water. After the water level is at 3/4 full, the water separator loses its efficiency and the water in the fuel can go through the separator and cause damage to the fuel injection pump.

Drain the water from the water separator every day or when the water level gets to ½ full. This gives the system protection from water in the fuel. If the fuel has a high concentration of water, or if the flow rate of fuel through the water separator is high, the water separator fills with water faster and must be drained more often.

To drain the water separator, open drain valve (2) in the drain line and vent valve (1) at the top of the water separator. Let the water drain until it is all out of the water separator. Close both valves.



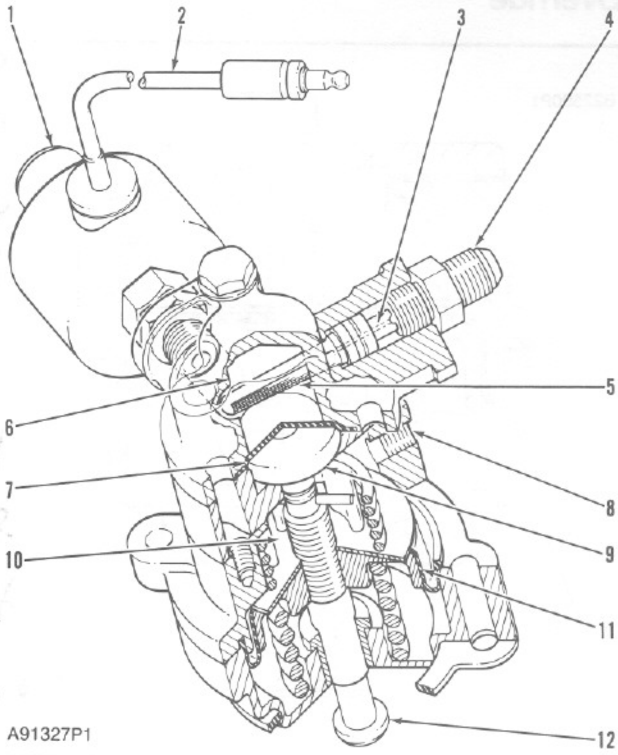
Water Separator
(1) Vent valve. (2) Drain valve.

Fuel Ratio Control With Hydraulic Override

NOTE: The hydraulic override was added to the fuel ratio control to permit easier cold weather starting.

The fuel ratio control limits the amount of fuel to the cylinders during an increase of engine speed (acceleration) to reduce exhaust smoke. The hydraulic override allows a maximum amount of fuel to the cylinders to start the engine.

Bolt (12) in the fuel ratio control limits travel of the fuel control shaft in the FUEL ON direction only. As the engine accelerates, the fuel control shaft makes contact with bolt (12) and will not go to the full fuel position. When the turbocharger gives enough air pressure to give good combustion in the cylinders, the inlet manifold pressure goes through a line to air inlet (8) into air chamber (10). The air pressure in air chamber (10) pushes on diaphragm (11) which moves bolt (12) down. When bolt (12) moves down, the fuel control shaft can move to the full fuel position.



Fuel Ratio Control
(1) Solenoid. (2) Wire. (3) Orifice. (4) Fitting (oil outlet). (5) Screen. (6) Oil chamber. (7) Diaphragm. (8) Air inlet. (9) Plunger. (10) Air chamber. (11) Diaphragm. (12) Bolt.

Wire (2) from solenoid (1) is connected to the start terminal of the starter switch. When the solenoid is activated by the starter switch, oil from the rear of the right cylinder head goes through solenoid (1) to oil chamber (6). Oil pressure in oil chamber (6) pushes on diaphragm (7) and plunger (9) which moves bolt (12) down. The fuel control shaft can now go to the full fuel position for easier starting.

When the engine starts and the starter switch is released, solenoid (1) closes and stops oil flow to oil chamber (6). Oil in oil chamber (6) goes through screen (5), orifice (3), and fitting (4). Oil now goes through a tube and drains into the left cylinder head. With no oil pressure in oil chamber (6), bolt (12) and plunger (9) move up. Bolt (12) will now limit the movement of the fuel control shaft until inlet manifold air pressure moves bolt (12) down.

C Fuel Ratio Control Without Hydraulic Override

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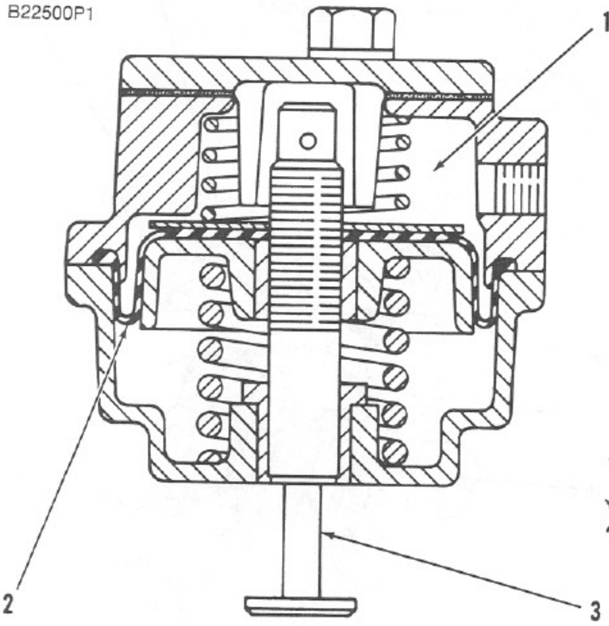
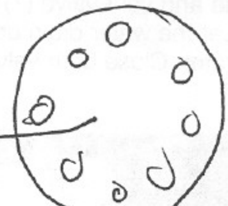


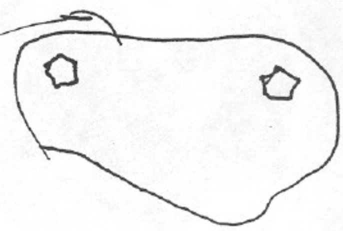
Fuel Ratio Control
(1) Air Chamber. (2) Diaphragm. (3) Bolt.

Holds off Full Fuel until turbo kicks in - remove bolts and turn cover clockwise for more Fuel

counter clockwise for less



Rack limit screw under this plate

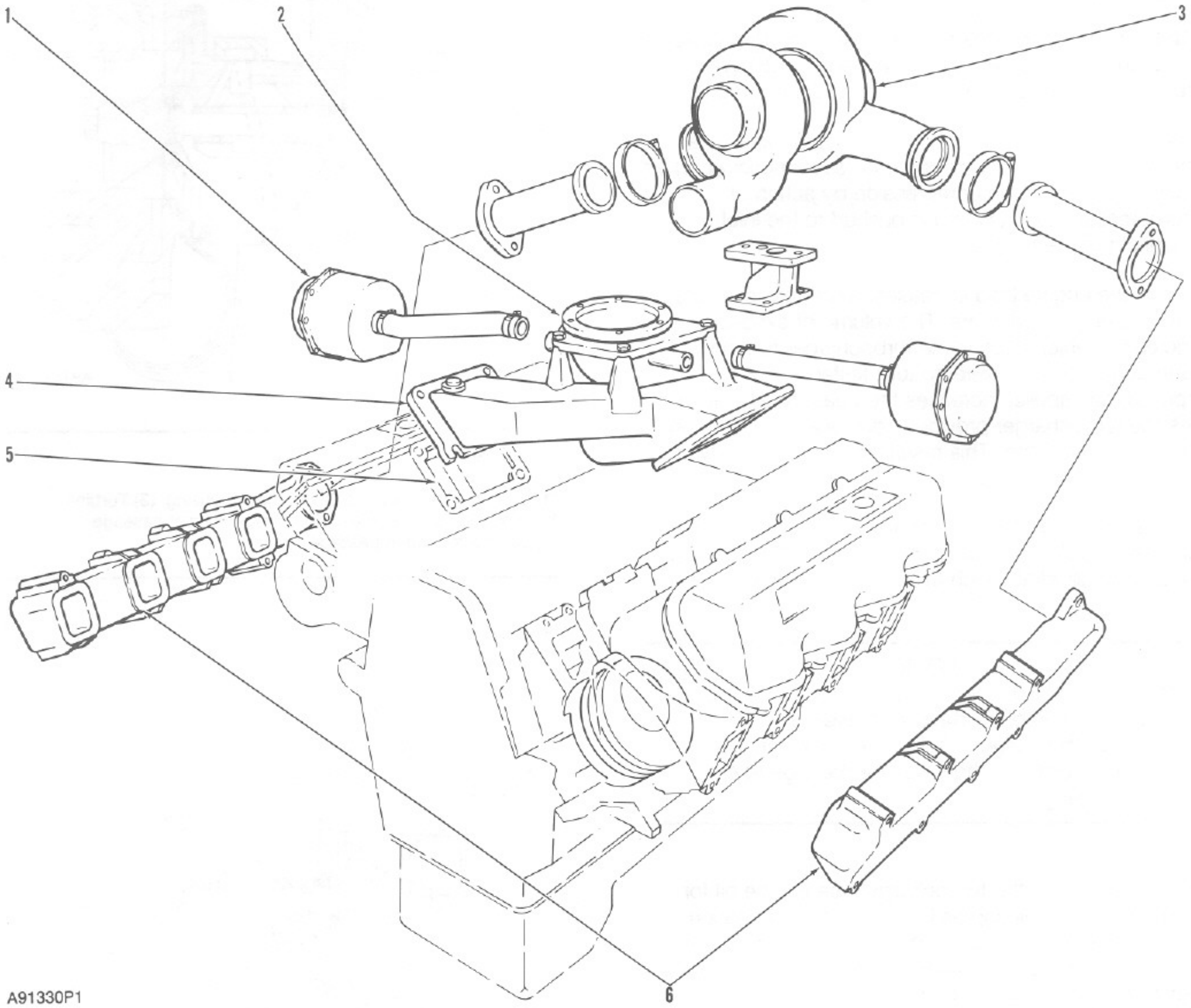


Screw it down to limit

Adj. Idle

The fuel ratio control limits the amount of fuel to the cylinders during an increase of engine speed (acceleration) to reduce exhaust smoke.

Bolt (3) in the fuel ratio control limits the travel of the fuel control shaft in the FUEL ON direction only. As the engine accelerates, bolt (3) will not let the fuel control shaft go to full fuel position. When the turbocharger gives enough air pressure to give good combustion in the cylinders, the inlet manifold pressure goes through a line into air chamber (1). The air pressure in air chamber (1) pushes on diaphragm (2) which moves bolt (3) down. When bolt (3) moves down, the fuel control shaft can move to the full fuel position.



Air Inlet And Exhaust System
(1) Positive crankcase ventilation valves. (2) Air cleaner adapter. (3) Turbocharger. (4) Air inlet pipe. (5) Inlet manifold. (6) Exhaust manifold.

The 3208 Turbocharged Engine has a turbocharger located at the rear of the engine. The exhaust gases from all of the cylinders are used to turn the turbocharger. Air is pulled through the air cleaner and adapter by the turbocharger compressor wheel. The air goes from the turbocharger through air inlet pipe (4) to the inlet manifold in each cylinder head. The air enters the cylinders when the intake valves open.

The exhaust gases go out of the cylinders and into the exhaust ports when the exhaust valves open. The exhaust then goes through the exhaust manifolds (6) to the turbocharger. The exhaust gases enter the turbocharger turbine housing and cause the turbine wheel to turn. The exhaust gases leave the turbocharger through the exhaust outlet.

There is a positive crankcase ventilation valve on each valve cover. The ventilation valves are connected to the air cleaner adapter on the air inlet side of the turbocharger.

Turbocharger

The turbocharger is supported by the mount at the rear of the engine. All the exhaust gases from the diesel engine go through the turbocharger.

The exhaust gases enter the turbine housing (3) and go through the blades of turbine wheel (4) causing the turbine wheel and compressor wheel (1) to turn.

When compressor wheel (1) turns, it pulls filtered air from the air cleaner through compressor housing (2) air inlet. The air is put in compression by action of compressor wheel (1) and is pushed to the inlet manifold of the engine.

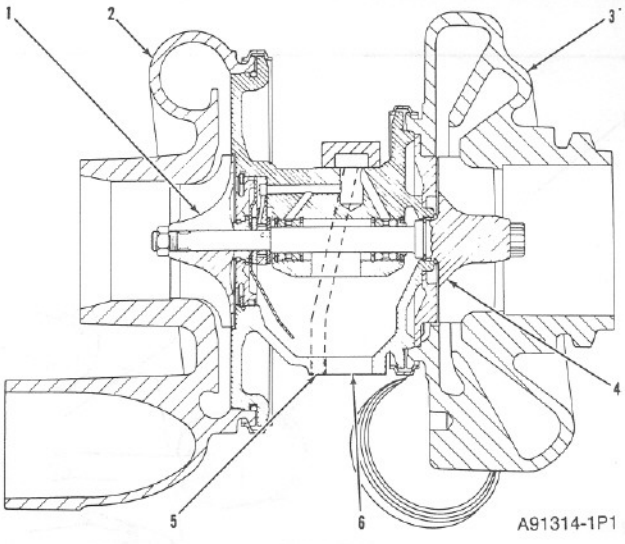
When the engine load increases, more fuel is injected into the engine cylinders. The volume of exhaust gas increases which causes the turbocharger turbine wheel and compressor impeller to turn faster. The increased rpm of the impeller increases the quantity of inlet air. As the turbocharger provides additional inlet air, more fuel can be burned. This results in more horsepower from the engine.

Maximum rpm of the turbocharger is controlled by the fuel setting, the high idle speed setting and the height above sea level at which the engine is operated.

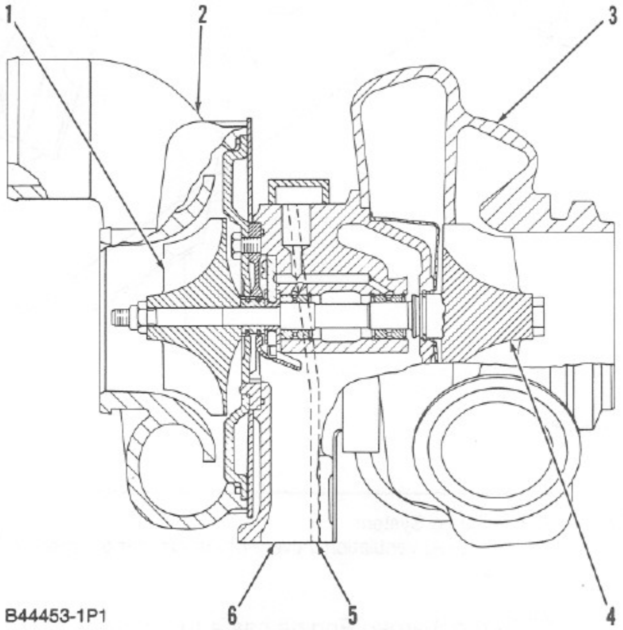
NOTICE

If the high idle rpm or the fuel setting is higher than given in the Fuel Setting And Related Information Fiche (for the height above sea level at which the engine is operated), there can be damage to engine or turbocharger parts.

The bearings for the turbocharger use engine oil for lubrication. The oil comes in through the lubrication inlet passage (5) and goes through passages in the center section for lubrication of the bearings. Oil from the turbocharger goes out through the lubrication outlet passage (6) in the bottom of the center section and goes back to the engine lubrication system.

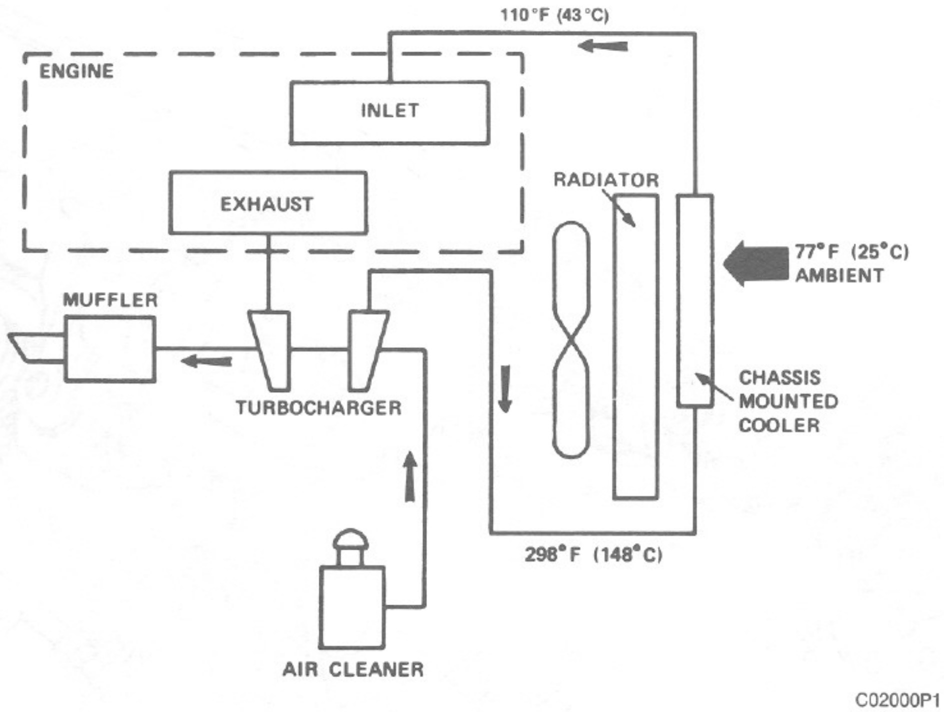


Turbocharger
(Schwitzer)
(1) Compressor wheel. (2) Compressor housing. (3) Turbine housing. (4) Turbine wheel. (5) Lubrication inlet passage. (6) Lubrication outlet passage.



Turbocharger
(AiResearch)
(1) Compressor wheel. (2) Compressor housing. (3) Turbine housing. (4) Turbine wheel. (5) Lubrication inlet passage. (6) Lubrication outlet passage.

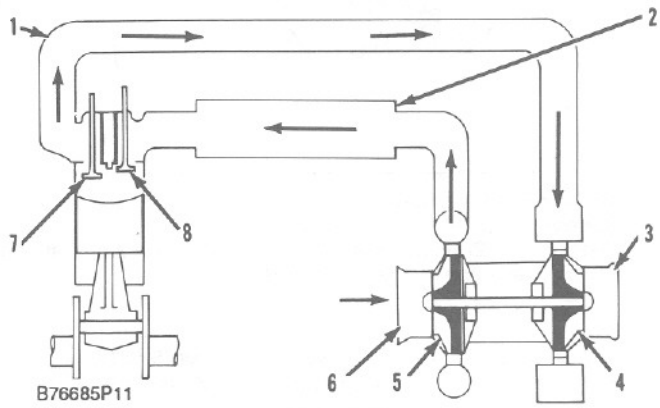
Air To Air Aftercooled System



Air To Air Aftercooled Schematic

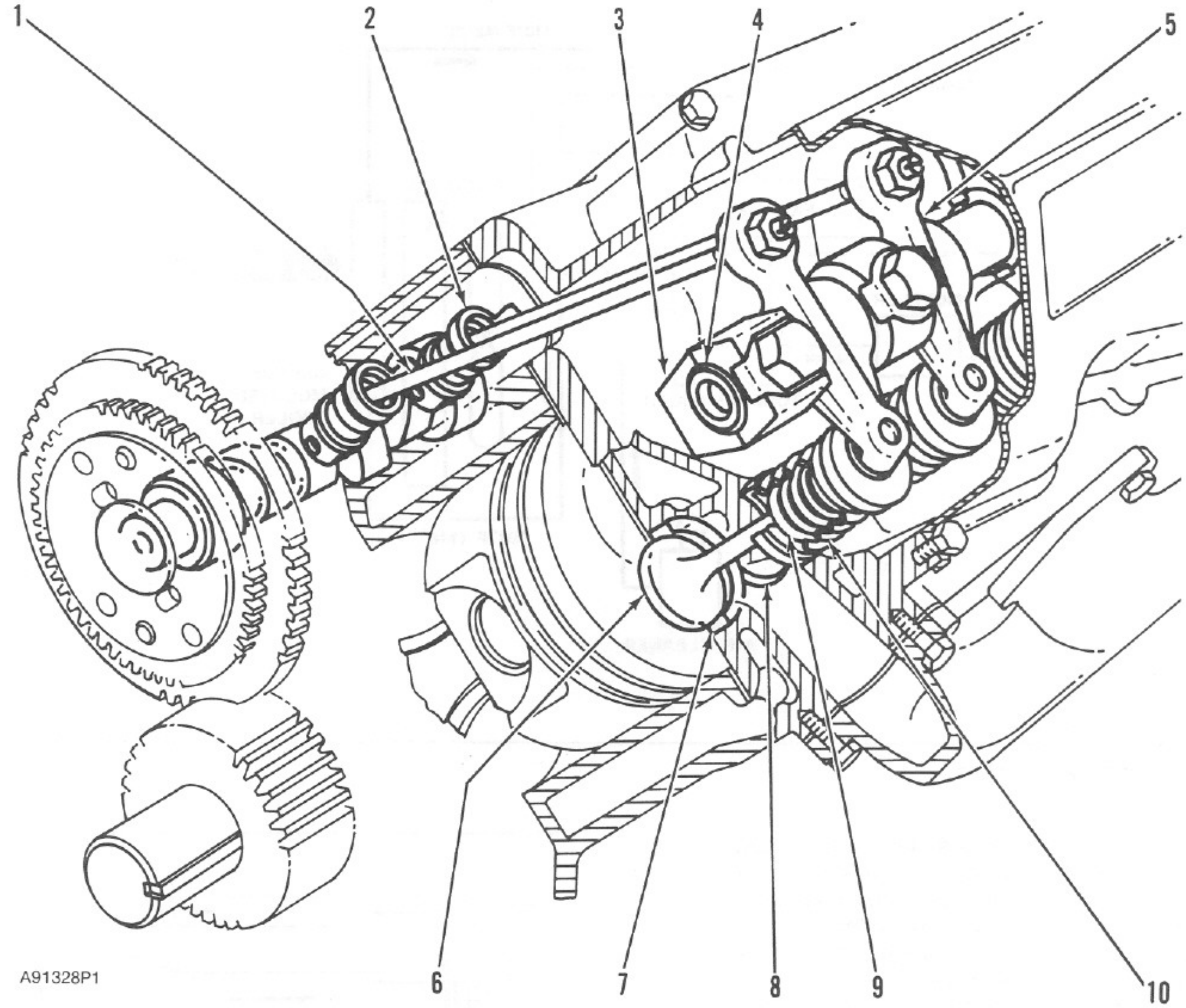
In the air to air aftercooler system, compressed turbocharger air is directed to a chassis mounted cooler in front of the radiator. Ambient temperature air is moved across the aftercooler to lower the inlet air temperature to approximately 45°C (110°F). The air then goes to inlet manifold (2) which is part of the cylinder head. Cooling of the inlet air increases combustion efficiency, which helps to lower fuel consumption and increase horsepower output.

When intake valves (8) open, the air goes into the engine cylinder and is mixed with the fuel for combustion. When exhaust valves (7) open, the exhaust gases go out of the engine cylinder and into exhaust manifold (1). From the exhaust manifold, the exhaust gases go through the blades of the turbine wheel. This causes the turbine wheel and compressor wheel to turn. The exhaust gases then go out exhaust outlet (3) of the turbocharger.



Air Inlet And Exhaust System Schematic
(1) Exhaust manifold. (2) Aftercooler/inlet manifold. (3) Exhaust outlet. (4) Turbine side of turbocharger. (5) Compressor side of turbocharger. (6) Air inlet. (7) Exhaust valve. (8) Intake valve.

c **Cylinder Head And Valves**



Cylinder Head And Valves
(Camshaft With Roller Lifter Shown)
(1) Push rod. (2) Lifter. (3) Guide support. (4) Rocker arm shaft. (5) Rocker arm. (6) Exhaust valve. (7) Valve seat insert. (8) Intake valve. (9) Inner valve spring. (10) Outer valve spring.

The valves and valve system components control the flow of inlet air and exhaust gases into and out of the cylinder during engine operation.

The intake and exhaust valves are opened and closed by movement of these components; crankshaft, camshaft, lifters, push rods, rocker arms, and valve springs. Rotation of the crankshaft causes rotation of the camshaft. The camshaft gear is driven by, and timed to, a gear on the front of the crankshaft. When the camshaft turns, the cams on the camshaft also turn and cause the lifters to go up and down. This movement makes the push rods move the rocker arms.

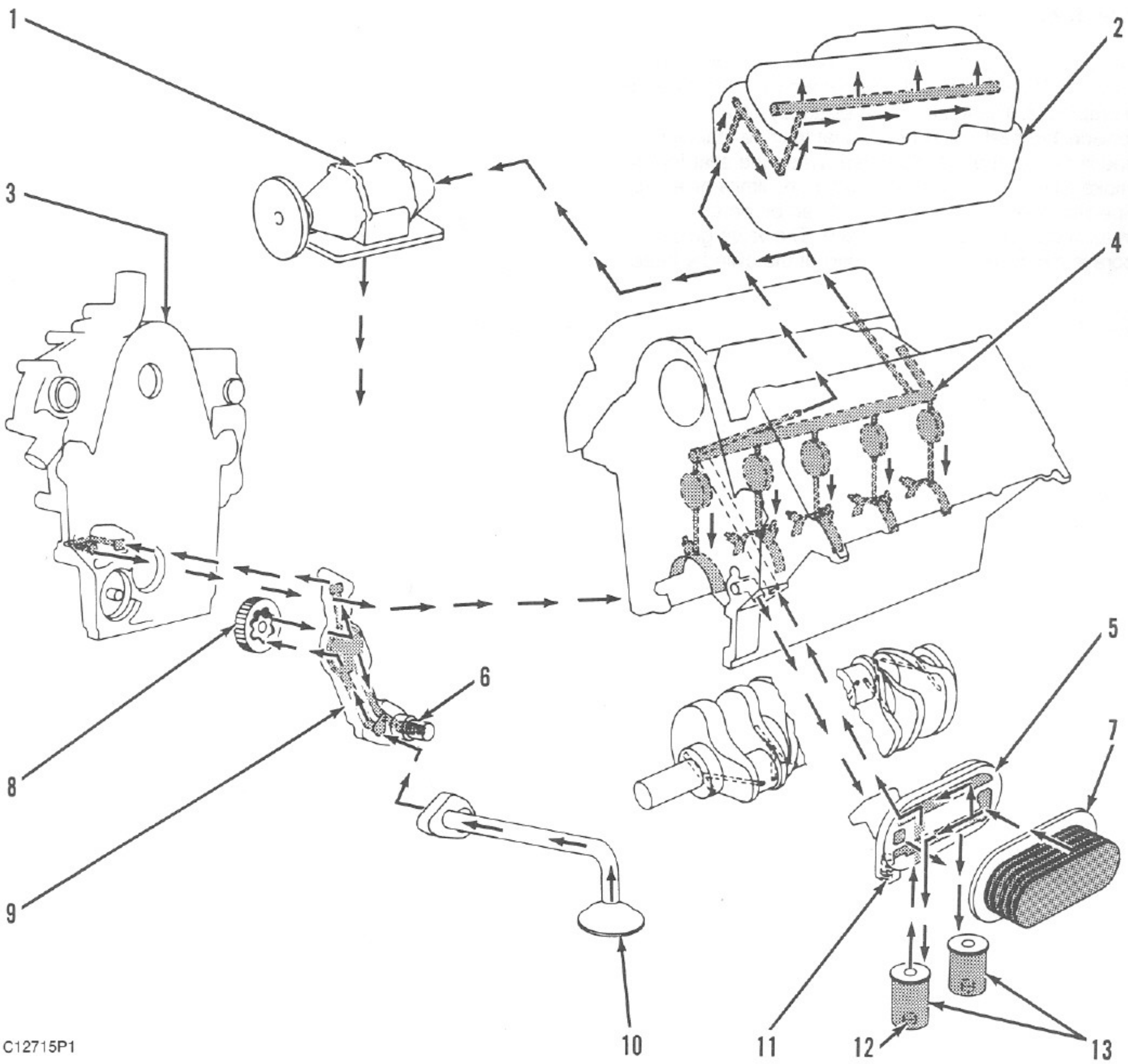
The movement of the rocker arms will make the intake and exhaust valves in the cylinder head open and close according to the firing order (injection sequence) of the engine. Two valve springs for each valve help to hold the valves in the closed position.

NOTE: Some 3208 engines have camshafts that use roller lifters and others have camshafts that use flat face lifters.

There is one intake and one exhaust valve for each cylinder. The valve seat insert for the exhaust valve can be replaced. The intake valve seat may be a replaceable seat insert or the seat may be machined and is part of the cylinder head. When the seat for the intake valve has been machined to the limits given in Specifications, the cylinder head can be bored (machined) for a valve seat insert. The valve guide bore is machined in and is a part of the cylinder head.

Lubrication System

(Engines With Oil Filter Bypass Valve In Oil Filter)



Schematic Of Lubrication System
(1) Vacuum pump or air compressor. (2) Cylinder head. (3) Front cover for the engine. (4) Oil manifold. (5) Base for the oil cooler. (6) Oil pump bypass valve. (7) Oil cooler. (8) Oil pump. (9) Cover for oil pump. (10) Suction bell for oil pump. (11) Oil cooler bypass valve. (12) Oil filter bypass valve. (13) Oil filters.

The lubrication system uses a six lobe, rotor type oil pump (8). Bolts hold the cover for the oil pump (9) on the front cover for the engine (3). The gear on the crankshaft drives the outer rotor. The outer rotor has rotation in a bearing in the front cover for the engine. The inner rotor goes on a short shaft in the front cover for the engine. The inner rotor is driven by the outer rotor.

Oil pump bypass valve (6), in the cover for the oil pump (9) controls the pressure of the oil coming from oil pump (8). The pump can put more oil into the system than needed. When the pressure of the oil going into the engine is more than 380 to 550 kPa (55 to 80 psi) the bypass valve (6) will open. This permits the oil that is not needed to bypass the system.

Oil from the oil pan is pulled through the suction bell for the oil pump (10) by oil pump (8). The oil is sent by the pump to an oil passage in the front cover for the engine (3). Oil from this passage goes to the cylinder block and on to the base for the oil cooler (5). The base for the oil cooler is on the left side of the engine, near the front of the engine. Oil cooler bypass valve (11) in the base for the oil cooler, will let the oil go around the oil cooler (7) when the oil is cold or if the restriction in the oil cooler is more than the other parts of the system. A difference in pressure of 85 to 105 kPa (12 to 15 psi) between the oil inlet and the oil outlet will open the bypass valve.

Oil from the oil cooler goes to the oil filters. Oil filter bypass valve (12) in the oil filters will let the oil go around the filters if there is a restriction in the filters.

There are two pressure outlets in the base for the oil cooler. The pressure outlets are on the outlet side of the oil cooler and oil filters. The pressure outlets are for the sending unit and switch for the oil pressure.

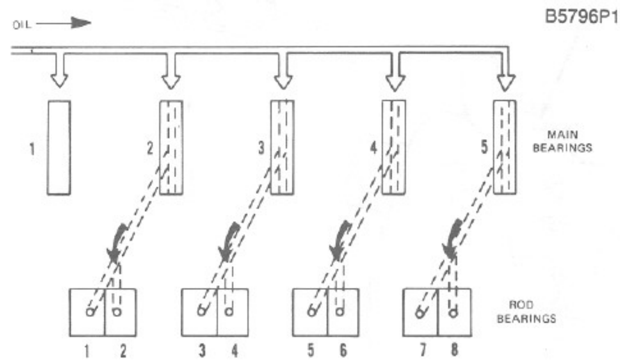
Oil from the oil filters (13) goes through a passage in the cylinder block to oil manifold (4). The oil manifold is in the center of the cylinder block, above the camshaft, and goes the full length of the cylinder block. Oil goes from the oil manifold to the bearings for the camshaft. There are grooves in the bores in the cylinder block around the bearings for the camshaft. The bearing surfaces (journals) on the camshaft get lubrication from these grooves through a hole in the bearings for the camshaft. Some of the oil goes aròund the grooves and down through a passage to a hole and groove in the top half of the main bearing. Oil from the hole and groove gives lubrication to the bearing surfaces (journals) of the crankshaft for the main bearings.

Oil gets into the crankshaft through holes in the bearing surfaces (journals) for the main bearings. Passages connect the bearing surface (journal) for the main bearing with the bearing surface (journal) for the connecting rod. The piston pins get lubrication from oil thrown by other parts.

Oil for the rocker arms comes from the oil manifold (4) through passages in the cylinder block. The passages in the cylinder block are in alignment with a passage in each cylinder head. The passage to the cylinder head on the left side is near the front of the cylinder block. The passage to the cylinder head on the right side is near the rear of the cylinder block.

The passage in each cylinder head sends the oil into an oil hole in the bottom of the mounting surface of the bracket that holds the shaft for the rocker arms. The oil hole is in the front bracket on the left side and in the rear bracket on the right side. The oil then goes up through the bracket and into the center of the shaft for the rocker arms. Oil goes along the center of the shaft to the bearings for the rocker arms. From the rocker arms, the oil is pushed through small holes to give lubrication to the valves, push rods, lifters, and camshaft lobes.

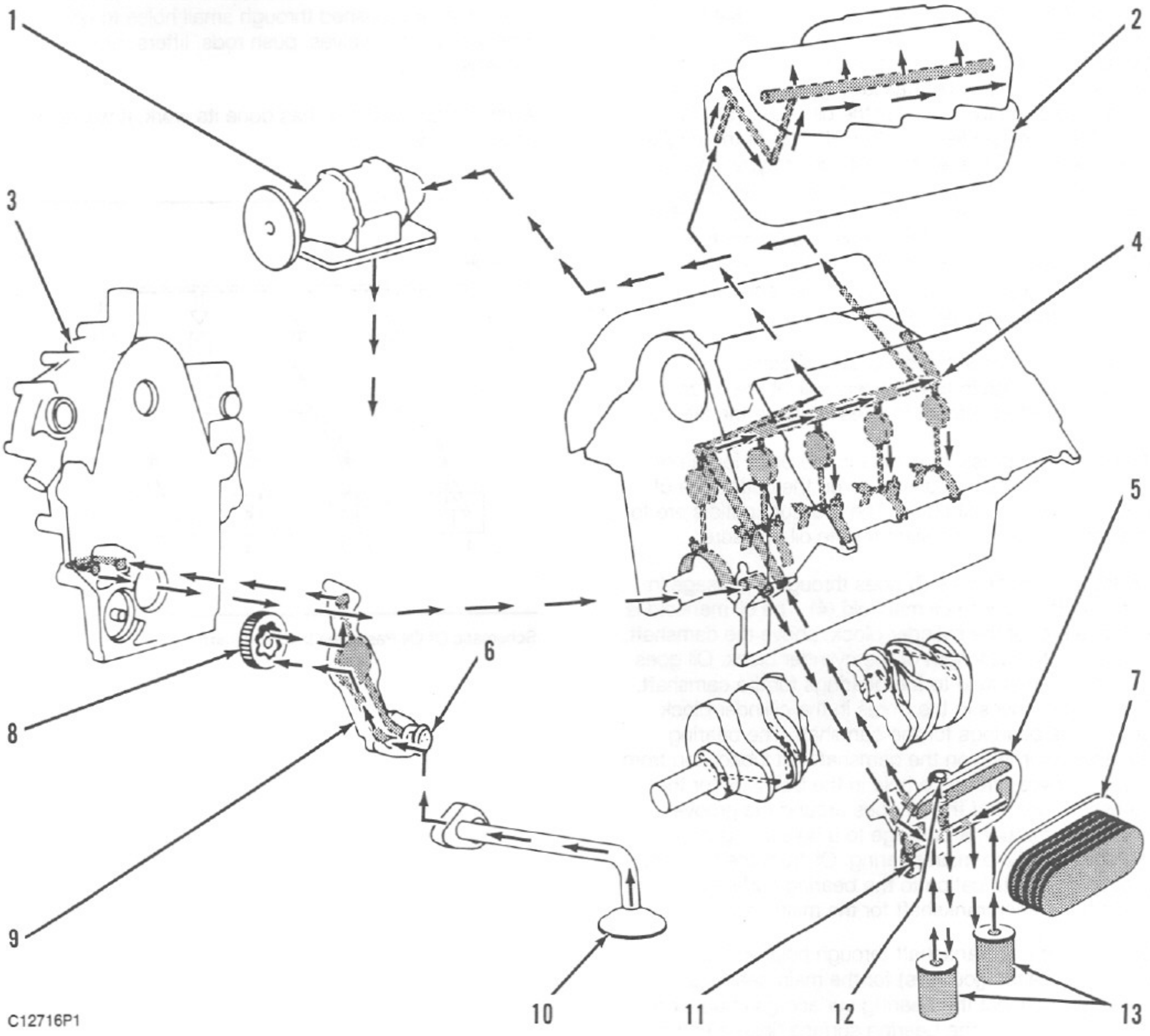
After the lubrication oil has done its work, it will return to the engine oil pan.



Schematic Of Oil Passages In Crankshaft

Lubrication System

(Engines With Oil Filter Bypass Valve In Oil Cooler Base)



Schematic Of Lubrication System
(1) Vacuum pump or air compressor. (2) Cylinder head. (3) Front cover for the engine. (4) Oil manifold. (5) Base for the oil cooler. (6) Oil pump bypass valve. (7) Oil cooler. (8) Oil pump. (9) Cover for oil pump. (10) Suction bell for oil pump. (11) Oil cooler bypass valve. (12) Oil filter bypass valve. (13) Oil filters.

The lubrication system uses a six lobe, rotor type oil pump (8). Bolts hold the cover for the oil pump (9) on the front cover for the engine (3). The gear on the crankshaft drives the outer rotor. The outer rotor has rotation in a bearing in the front cover for the engine. The inner rotor goes on a short shaft in front cover for the engine. The inner rotor is driven by the outer rotor.

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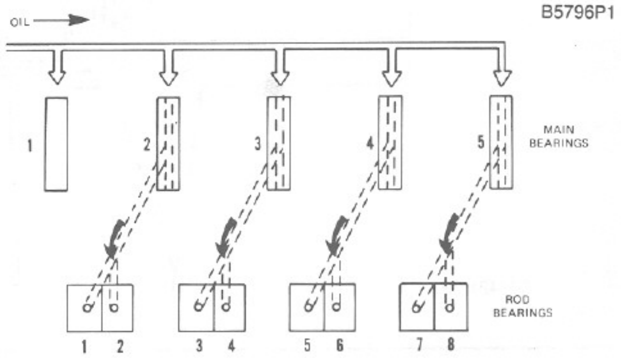
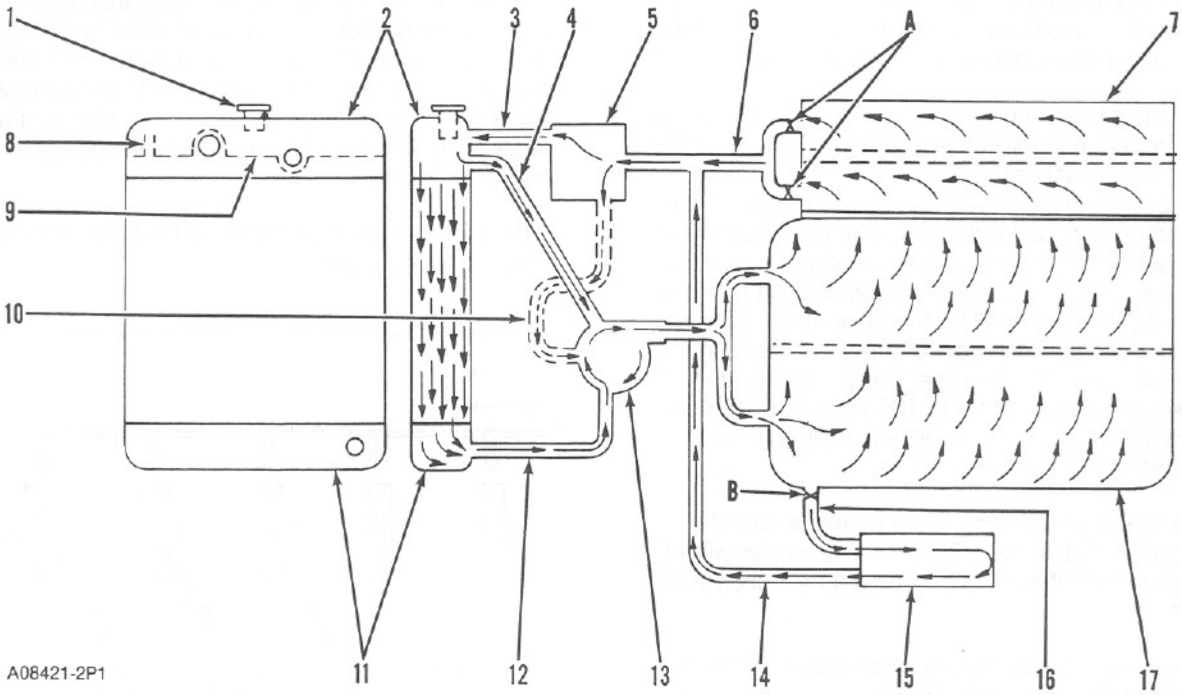
The passage in each cylinder head sends the oil into an oil hole in the bottom of the mounting surface of the bracket that holds the shaft for the rocker arms. The oil hole is in the front bracket on the left side and in the rear bracket on the right side. The oil then goes up through the bracket and into the center of the shaft for the rocker arms. Oil goes along the center of the shaft to the bearings for the rocker arms. From the rocker arms, the oil is pushed through small holes to give lubrication to the valves, push rods, lifters, and camshaft lobes.

After the lubrication oil has done its work, it will return to the engine oil pan.

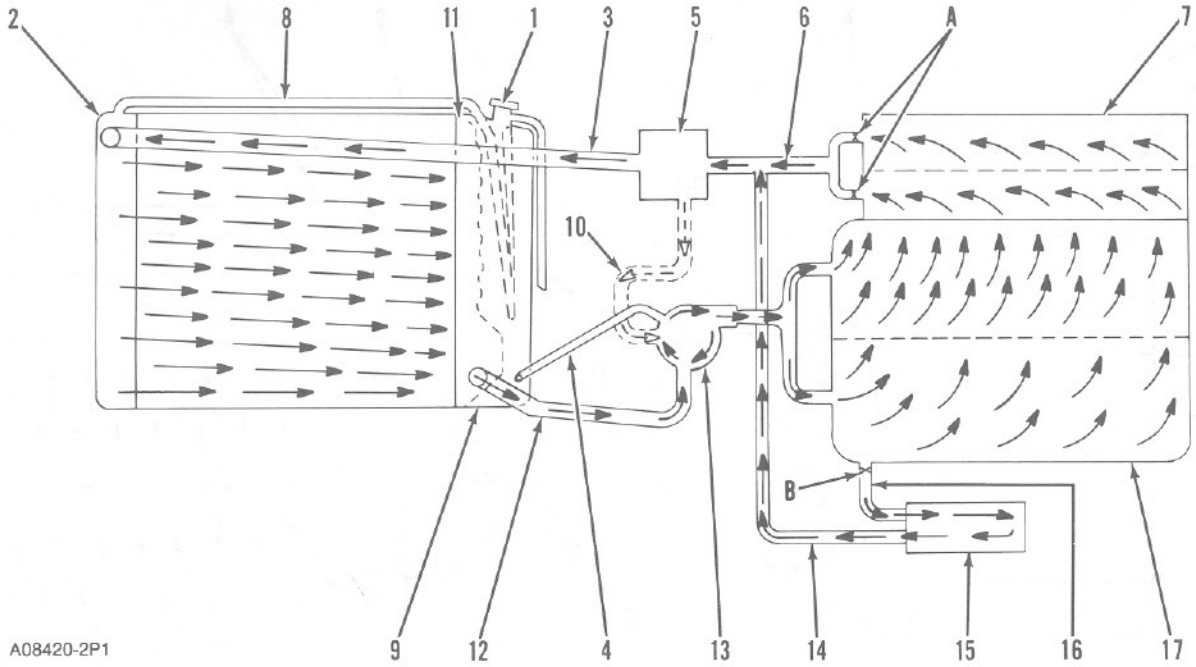


Schematic Of Oil Passages In Crankshaft

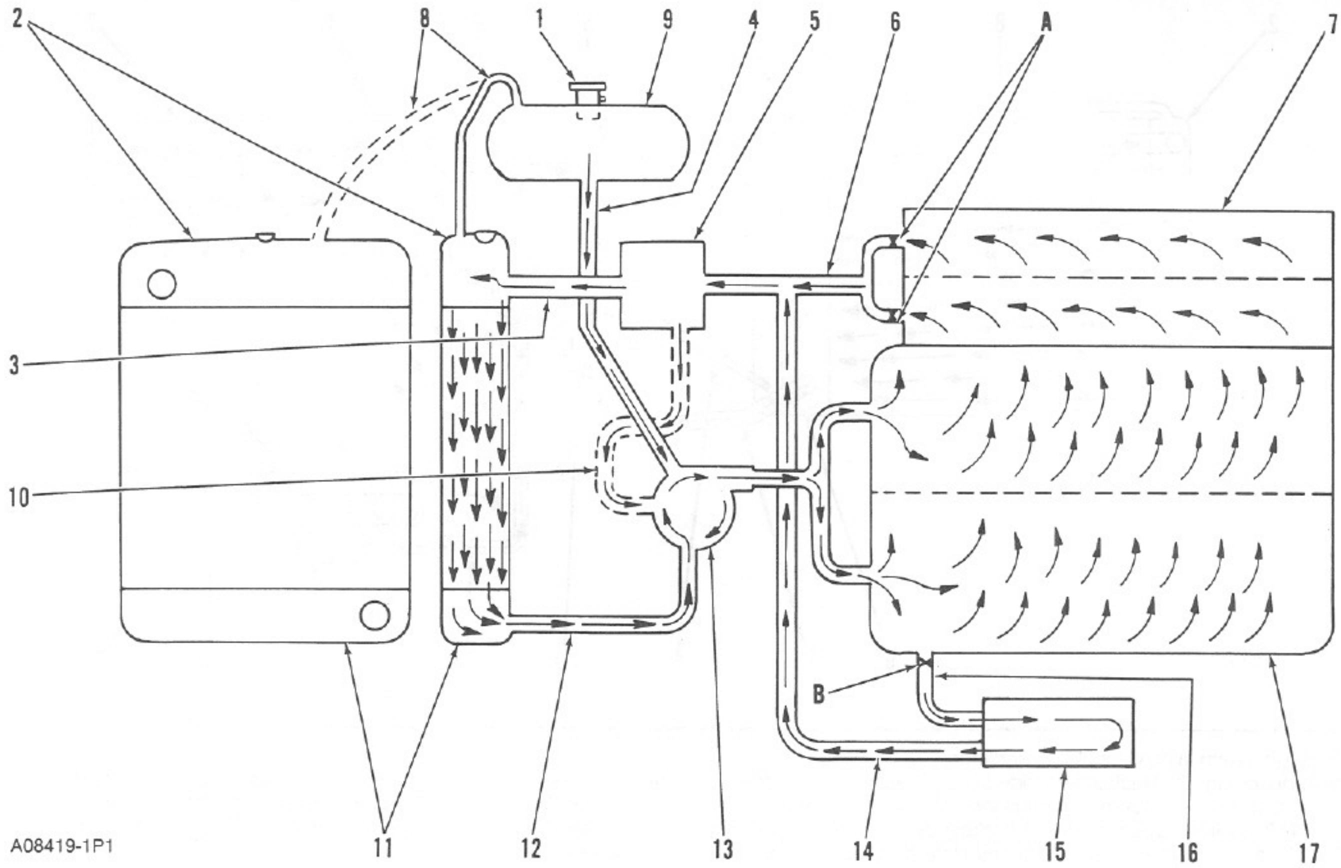
Cooling System



Cooling System With Standard Vertical Radiator
(1) Radiator cap. (2) Radiator top tank. (3) Radiator top hose. (4) Shunt line. (5) Housing for water temperature regulators. (6) Return to housing for water temperature regulators. (7) Cylinder heads (two). (8) Vent tube. (9) Surge tank. (10) Inside bypass. (11) Radiator bottom tank. (12) Radiator bottom hose. (13) Water pump. (14) Outlet line for oil cooler. (15) Oil cooler. (16) Inlet line for oil cooler. (17) Cylinder block. (A) Orifices between cylinder heads and front cover. (B) Orifice in oil cooler inlet.



Cooling System With Cross Flow Radiator
(1) Radiator cap. (2) Radiator left side tank. (3) Radiator top hose. (4) Shunt line. (5) Housing for water temperature regulators. (6) Return to housing for water temperature regulators. (7) Cylinder heads (two). (8) Vent tube. (9) Surge tank. (10) Inside bypass. (11) Radiator right side tank. (12) Radiator bottom hose. (13) Water pump. (14) Outlet line for oil cooler. (15) Oil cooler. (16) Inlet line for oil cooler. (17) Cylinder block. (A) Orifices between cylinder heads and front cover for the engine. (B) Orifice in oil cooler inlet.



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Cooling System With Vertical Radiator And Separate Surge Tank
(1) Radiator cap. (2) Radiator top tank. (3) Radiator top hose. (4) Shunt line. (5) Housing for water temperature regulators. (6) Return to housing for water temperature regulators. (7) Cylinder heads (two). (8) Vent tube. (9) Surge tank. (10) Inside bypass. (11) Radiator bottom tank. (12) Radiator bottom hose. (13) Water pump. (14) Outlet line for oil cooler. (15) Oil cooler. (16) Inlet line for oil cooler. (17) Cylinder block. (A) Orifices between cylinder heads and front cover. (B) Orifice in oil cooler inlet.

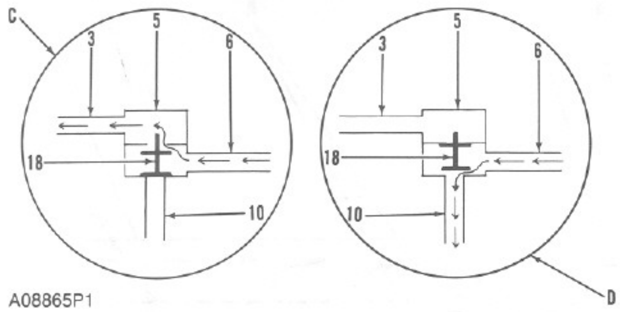
Water pump (13) is installed on the front face of the front cover for the engine and is driven by V-belts from the crankshaft pulley. The inlet opening of water pump (13) is connected to radiator bottom hose (12). The outlet flow of coolant from water pump (13) goes through inside passages in the front cover for the engine.

As the coolant goes from the water pump, it divides and goes through the inside passages in the front cover for the engine to cylinder block (17). Most of the coolant goes through cylinder block (17) and up to cylinder heads (7). From cylinder heads (7) the coolant goes forward through orifices (A) to the front cover for the engine.

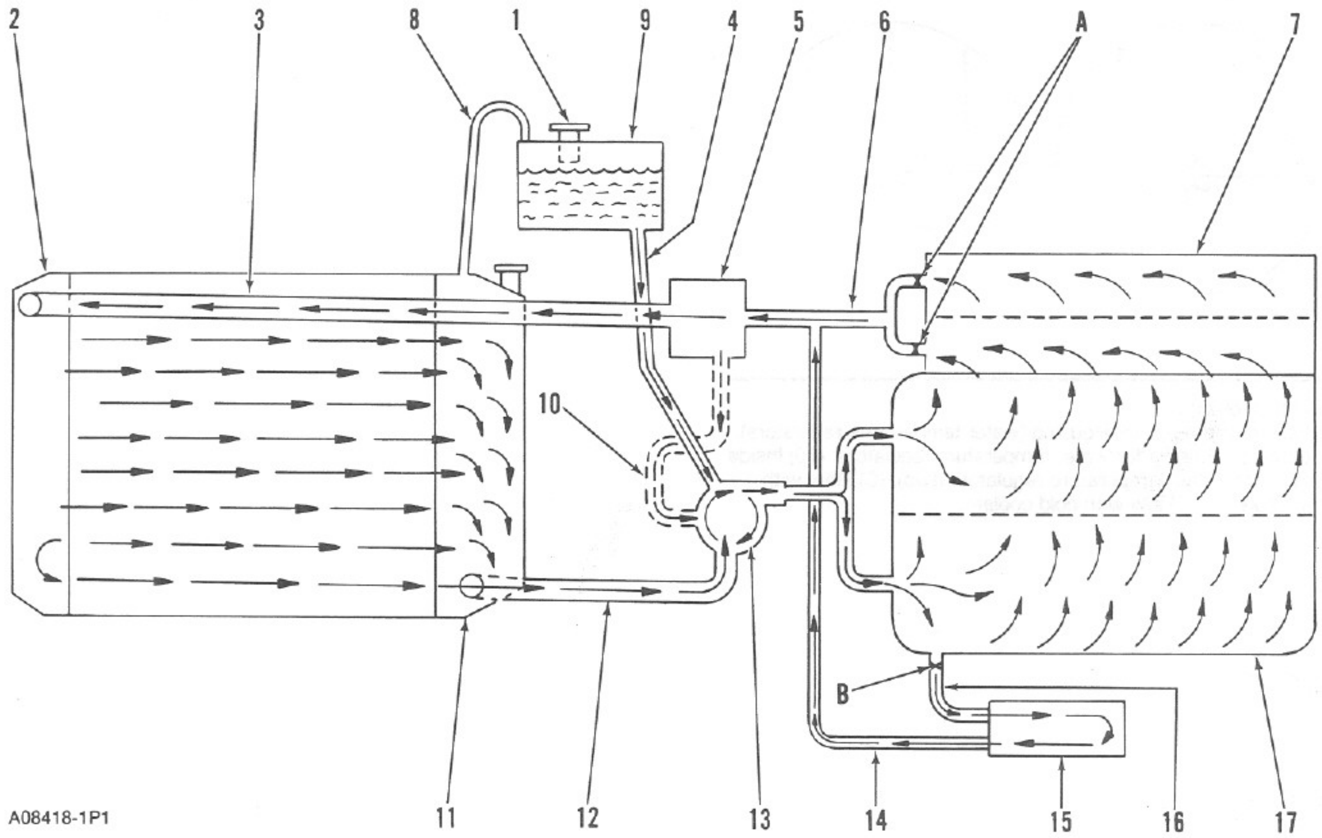
Part of the coolant going to the left side (as seen from the flywheel) of cylinder block (17) goes through orifice (B) to inlet line (16) and on to oil cooler (15), to cool the oil for lubrication of the engine, and back to the front cover for the engine through outlet line (14).

From the front cover for the engine, the coolant either goes to the inlet for water pump (13) or to the radiator.

If the coolant is cold (cool), the water temperature regulators (18) will be closed. The coolant will go through inside bypass (10) to water pump (13). If the coolant is warm, the water temperature regulators (18) will be open. When the water temperature regulators (18) are open, they make a restriction in the inside bypass (10) and the coolant goes through radiator top hose (3) and into radiator top tank (2) or left side tank (2). Coolant then goes through the core of the radiator to the radiator bottom tank (11) or radiator right side tank (11), where it is again sent through the cooling system. A small amount of coolant goes through inside bypass (10) when temperature regulators (18) are open.

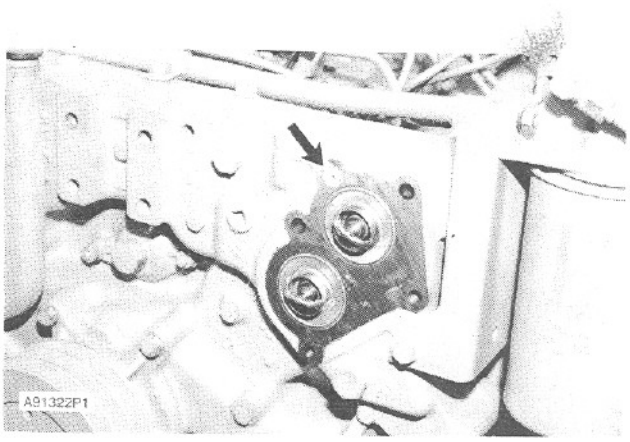


Flow Of Coolant
(3) Radiator top hose. (5) Housing (water temperature regulators). (6) Return to housing for water temperature regulators. (10) Inside bypass. (18) Water temperature regulators (two). (C) Flow with warm coolant. (D) Flow with cold coolant.



Cooling System With Cross Flow Radiator And Separate Surge Tank
(1) Radiator cap. (2) Radiator left side tank. (3) Radiator top hose. (4) Shunt line. (5) Housing for water temperature regulators. (6) Return to housing for water temperature regulators. (7) Cylinder heads (two). (8) Vent tube. (9) Surge tank. (10) Inside bypass. (11) Radiator right side tank. (12) Radiator bottom hose. (13) Water pump. (14) Outlet line for oil cooler. (15) Oil cooler. (16) Inlet line for oil cooler. (17) Cylinder block. (A) Orifices between heads and front cover. (B) Orifice in oil cooler inlet.

NOTE: The water temperature regulators (18) are an important part of the cooling system. They divide coolant flow between radiator (2) and inside bypass (10) as necessary to maintain the correct temperature. If the water temperature regulators are not installed in the system, there is no mechanical control, and most of the coolant will take the path of least resistance through the bypass. This will cause the engine to overheat in hot weather. In cold weather, even the small amount of coolant that goes through the radiator is too much, and the engine will not get to normal operating temperatures.

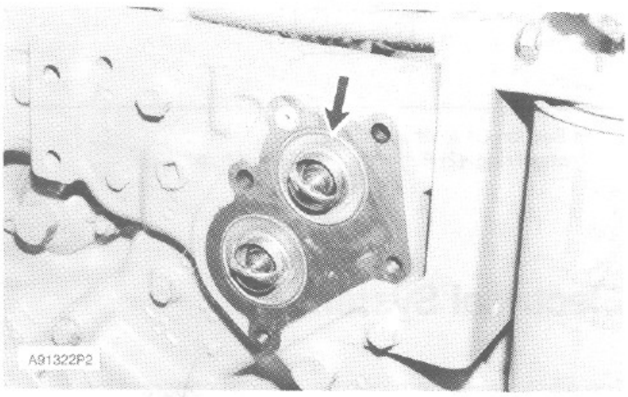


Location Of Water Temperature Regulators

The vertical radiator is made with a top tank (2) above the core and a surge tank (9) either above or separate from the top tank. Vent tube (8) connects radiator top tank (2) and surge tank (9). The cross flow radiator is made with a left side tank (2) and a right side tank (11), separated by an inside baffle, or a tank separate from the radiator. Vent tube (8) connects the surge tank (9) to the radiator.

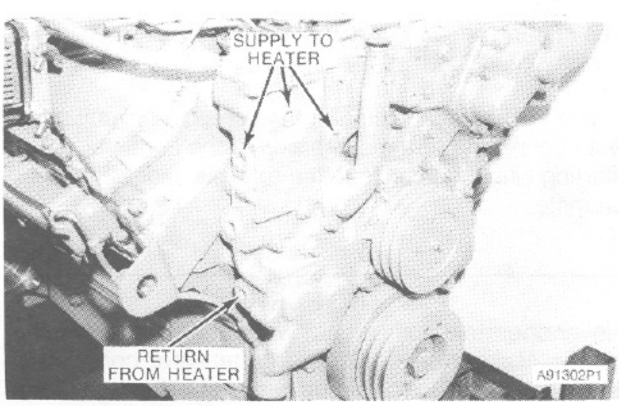
Surge tank (9) has a shunt line (4) that connects to the inlet of water pump (13). Shunt line (4) must always go down hill. This shunt type system keeps a positive pressure on the inlet of water pump (13) at all times. When putting coolant in the cooling system, coolant from surge tank (9) goes through shunt line (4) to the inlet of water pump (13) and fills cylinder block (17) from the bottom. By filling the system from the bottom, any air in the system is pushed out through radiator top tank (2), through vent tube (8) into surge tank (9).

Radiator cap (1) is used to keep the correct pressure in the cooling system. This pressure keeps a constant supply of coolant to water pump (13). If this pressure goes too high, a valve in radiator cap (1) moves (opens) to get a reduction of pressure. When the correct pressure is in the cooling system, the valve in radiator cap (1) moves down (to the closed position).



Location Of Vent Valve

The vent valve is located in the front housing next to the temperature regulators. The vent valve is used to let the air out of the cooling system when the cooling system is filled. When the engine is in operation, the vent valve will close and not let coolant go through. This will help increase the temperature of the coolant at low engine loads.



Locations Of Heater Connections

The front housing has several plugs that give access to water passages inside the housing. For the correct access points to install heater hoses, see the Locations Of Heater Connections picture.

Basic Block

Cylinder Block

The cylinders are a part of the cylinder block. There are no replaceable cylinder liners. The cylinders can be machined (bored) up to 1.02 mm (.040 in) oversize for reconditioning. The cylinders in the block are at a 90° angle to each other. There are five main bearings in the block to support the crankshaft.

Cylinder Head

There is one cylinder head for each side (bank) of the engine. One intake and one exhaust valve is used for each cylinder. The valve guides are a part of the cylinder head and can not be replaced. Valve seat inserts are used for the intake and exhaust valve and can be replaced.

Pistons, Rings And Connecting Rods

The 3208 Truck engine uses both a two and a three ring piston. The two ring pistons have two rings which are located above the piston pin bore. There is one compression ring and one oil control ring. The oil ring is made in one piece and has an expansion spring behind it. The compression ring is also one piece and goes into an iron band that is cast into the piston. Both the compression and the oil control rings are of the conventional type (not Keystone).

The three ring piston is an aluminum casting with an iron band for the two compression rings. All rings are located above the piston pin bore. The two compression rings are of the Keystone type and seat in an iron band that is cast into the piston. Keystone rings have a tapered shape and the movement of the rings in the piston groove (also of tapered shape) results in a constantly changing clearance (scrubbing action) between the ring and the groove. This action results in a reduction of carbon deposit and possible sticking of rings. The oil ring is a standard (conventional) type and is spring loaded.

The piston pin is held in the piston by two snap rings which go into the piston pin bore.

Pistons with different compression ratios are used for 3208 Truck Engines. The pistons must not be interchanged with pistons of a different compression ratio.

The piston pin end of the connecting rod is tapered to give more bearing surface at the area of highest load. The rod is installed on the piston with the boss on the connecting rod on the same side as the crater in the piston. The connecting rod bearings are held in location with a tab that goes into a groove in the connecting rod.

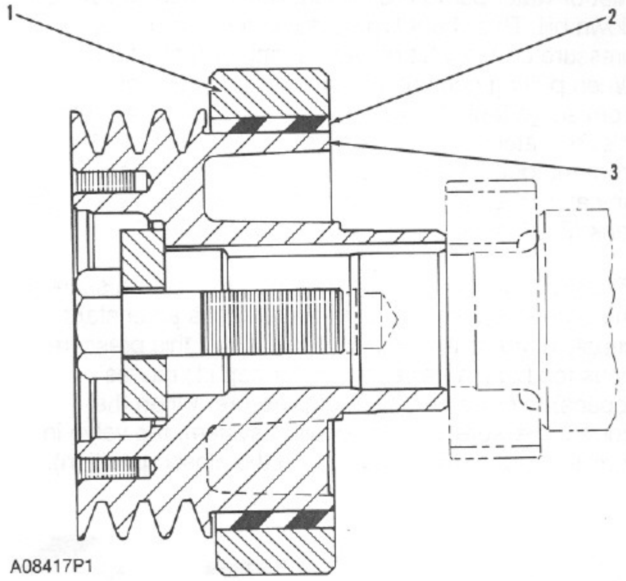
Crankshaft

The force of combustion in the cylinders is changed to usable rotating power by the crankshaft. The crankshaft can have either six or eight counterweights. A gear on the front of the crankshaft turns the engine camshaft gear and the engine oil pump. The end play of the crankshaft is controlled by the thrust bearing on No. 4 main bearing.

Vibration Damper

The twisting of the crankshaft, due to the regular power impacts along its length, is called twisting (torsional) vibration. The vibration damper is installed on the front end of the crankshaft. It is used for reduction of torsional vibrations and stops the vibration from building up to amounts that cause damage.

The damper is made of a flywheel ring (1) connected to an inner hub (3) by a rubber ring (2). The rubber makes a flexible coupling between the flywheel ring and the inner hub.



Cross Section Of A Vibration Damper
(1) Flywheel ring. (2) Rubber ring. (3) Inner hub.

Electrical System

The electrical system can have three separate circuits: the charging circuit, the starting circuit and the low amperage circuit. Some of the electrical system components are used in more than one circuit. The battery (batteries), circuit breaker, ammeter, cables and wires from the battery are all common in each of the circuits.

The charging circuit is in operation when the engine is running. An alternator makes electricity for the charging circuit. A voltage regulator in the circuit controls the electrical output to keep the battery at full charge.

The starting circuit is in operation only when the start switch is activated.

The low amperage circuit and the charging circuit are both connected to the same side of the ammeter. The starting circuit connects to the opposite side of the ammeter.

NOTICE

Never operate the alternator without the battery in the circuit. Making or breaking an alternator connection with heavy load on the circuit can cause damage to the regulator.

Charging System Components

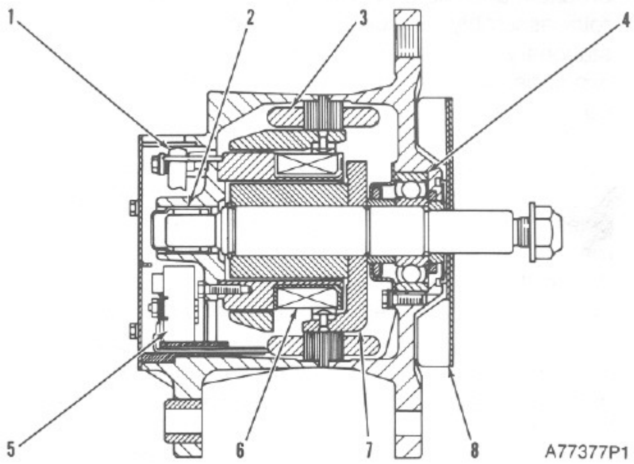
Alternator (Delco-Remy)

The alternator is driven by V-belts from the crankshaft pulley. This alternator is a three phase, self-rectifying charging unit, and the regulator is part of the alternator.

This alternator design has no need for slip rings or brushes, and the only part that has movement is the rotor assembly. All conductors that carry current are stationary. The conductors are the field winding, stator windings, six rectifying diodes and the regulator circuit components.

The rotor assembly has many magnetic poles like fingers with air space between each opposite pole. The poles have residual magnetism (like permanent magnets) that produce a small amount of magnet-like lines of force (magnetic field) between the poles. As the rotor assembly begins to turn between the field winding and the stator windings, a small amount of alternating current (AC) is produced in the stator windings from the small magnetic lines of force made by the residual magnetism of the poles. This AC current is changed to direct current (DC) when it passes through the diodes of the rectifier bridge. Most of this current goes to charge the battery and to supply the low amperage circuit, and the remainder is sent on to the field windings. The DC current flow through the field windings (wires around an iron core) now increases the strength of the magnetic lines of force. These stronger lines of force now increase the amount of AC current produced in the stator windings. The increased speed of the rotor assembly also increases the current and voltage output of the alternator.

The voltage regulator is a solid state (transistor, stationary parts) electronic switch. It feels the voltage in the system and switches on and off many times a second to control the field current (DC current to the field windings) for the alternator to make the needed voltage output.

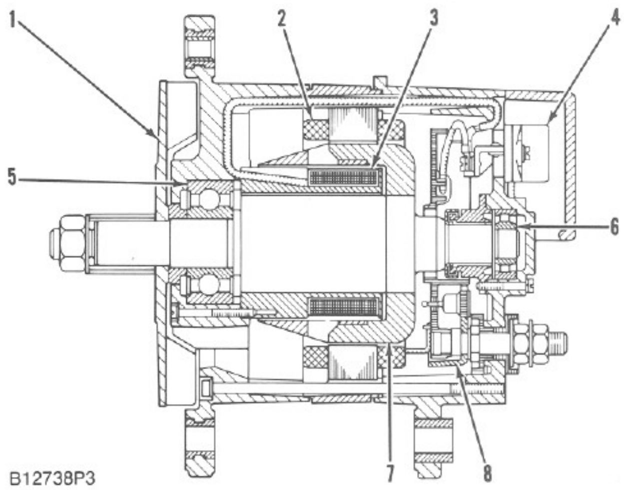


Delco-Remy Alternator
(1) Regulator. (2) Roller bearing. (3) Stator winding. (4) Ball bearing. (5) Rectifier bridge. (6) Field winding. (7) Rotor assembly. (8) Fan.

Alternator (Bosch)

The alternator is driven by V-belts from the crankshaft pulley. This alternator is a three phrase, self-rectifying charging unit, and the regulator is part of the alternator.

The 7N9720 Alternator has an output of 37A. The 9W3043 Alternator has an output of 40A.



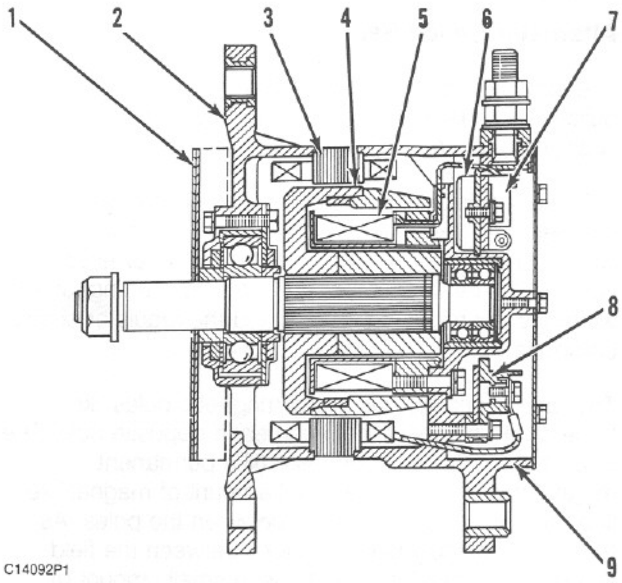
Bosch Alternator
(1) Fan. (2) Stator winding. (3) Field winding. (4) Regulator. (5) Ball bearing. (6) Roller bearing. (7) Rotor. (8) Rectifier assembly.

This alternator design has no need for slip rings or brushes, and the only part that has movement is the rotor assembly. All conductors that carry current are stationary. The conductors are: the field winding, stator windings, six rectifying diodes, and the regulator circuit components.

The rotor assembly has many magnetic poles like fingers with air space between each opposite pole. The poles have residual magnetism (like permanent magnets) that produce a small amount of magnet-like lines of force (magnetic field) between the poles. As the rotor assembly begins to turn between the field winding and the stator windings, a small amount of alternating current (AC) is produced in the stator windings from the small magnetic lines of force made by the residual magnetism of the poles. This AC current is changed to direct current (DC) when it passes through the diodes of the rectifier bridge. Most of this current goes to charge the battery and to supply the low amperage circuit, and the remainder is sent to the field windings. The DC current flow through the field windings (wires around an iron core) now increases the strength of the magnetic lines of force. These stronger lines of force now increase the amount of AC current produced in the stator windings. The increased speed of the rotor assembly also increases the current and voltage output of the alternator.

Alternator (Nippondenso)

The Nippondenso alternator has three-phase, full-wave rectified output. It is brushless. The rotor and bearings are the only moving parts. There is a 24 volt, 9G4574 Alternator with 35 amp output and a 12 volt, 8T9900 Alternator with a 55 amp output.



9G4574 Nippondenso Alternator
(1) Fan. (2) Front frame assembly. (3) Stator assembly. (4) Rotor assembly. (5) Field winding (coil assembly). (6) Regulator assembly. (7) Condenser (suppression capacitor). (8) Rectifier assembly. (9) Rear frame assembly.

When the engine is started and the rotor turns inside the stator windings, three-phase alternating current (AC) and rapidly rising voltage is generated.

A small amount of alternating current (AC) is changed (rectified) to pulsating direct current (DC) by the exciter diodes on the rectifier assembly. Output current from these diodes adds to the initial current which flows through the rotor field windings from residual magnetism. This will make the rotor a stronger magnet and cause the alternator to become activated automatically. As rotor speed, current and voltages increase, the rotor field current increases enough until the alternator becomes fully activated.

The main battery charging current is charged (rectified) from AC to DC by the other positive and negative diodes in the rectifier and pack (main output diodes) which operate in a full wave linkage rectifier circuit.

Alternator output is controlled by a regulator, which is inside the alternator rear frame.

Alternator Regulator (Bosch)

The voltage regulator is an electronic switch. It feels the voltage in the system and gives the necessary field current (current to the field windings of the alternator) for the alternator to make the needed voltage. The voltage regulator controls the field current to the alternator by switching on and off many times a second.

Alternator Regulator (Nippondenso)

The regulator is fastened to the alternator by two different methods. One method fastens the regulator to the top, rear of alternator. With the other method the regulator is fastened separately by use of a wire and a connector that goes into the alternator.

The voltage regulator is a solid state electronic switch. It feels the voltage in the system and gives the necessary field current (current to the field windings of the alternator) for the alternator to make the needed voltage. The voltage regulator controls the field current to the alternator by switching on and off many times a second. There is no voltage adjustment for this regulator.

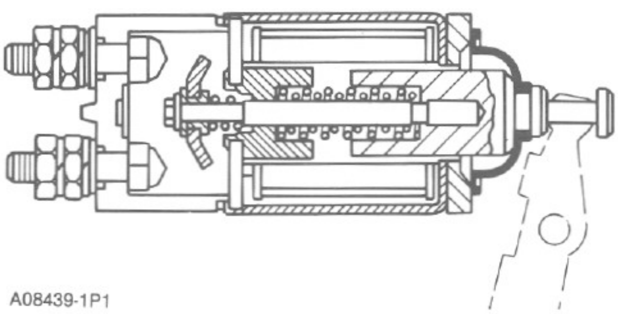
Starting System Components

Solenoid

A solenoid is a magnetic switch that does two basic operations:

a. Closes the high current starter motor circuit with a low current start switch circuit.

b. Engages the starter motor pinion with the ring gear.



Typical Solenoid Schematic

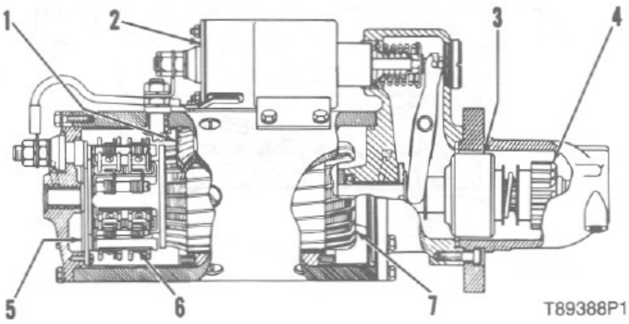
The solenoid switch is made of an electromagnetic (one or two sets of windings) around a hollow cylinder. There is a plunger (core) with a spring load inside the cylinder that can move forward and backward. When the start switch is closed and electricity is sent through the windings, a magnetic field is made that pulls the plunger forward in the cylinder. This moves the shift lever (connected to the rear of the plunger) to engage the pinion drive gear with the ring gear. The front end of the plunger then makes contact across the battery and motor terminals of the solenoid, and the starter motor begins to turn the flywheel of the engine.

When the start switch is opened, current no longer flows through the windings. The spring now pushes the plunger back to the original position, and, at the same time, moves the pinion gear away from the flywheel.

When two sets of windings in the solenoid are used, they are called the hold-in winding and the pull-in winding. Both have the same number of turns around the cylinder, but the pull-in winding uses a larger diameter wire to produce a greater magnetic field. When the start switch is closed, part of the current flows from the battery through the hold-in windings, and the rest flows through the pull-in windings to motor terminal, then through the motor to ground. When the solenoid is fully activated (connection across battery and motor terminal is complete), current is shut off through the pull-in windings. Now only the smaller hold-in windings are in operation for the extended period of time it takes to start the engine. The solenoid will now take less current from the battery, and heat made by the solenoid will be kept at an acceptable level.

Starter Motor

The starter motor is used to turn the engine flywheel fast enough to get the engine running.



Starter Motor
(1) Field. (2) Solenoid. (3) Clutch. (4) Pinion. (5) Commutator. (6) Brush assembly. (7) Armature.

The starter motor has a solenoid. When the start switch is turned to the START position, the solenoid will be activated electrically. The solenoid core will now move to push the starter pinion, by a mechanical linkage, to engage with the ring gear on the flywheel of the engine. The starter pinion will engage with the ring gear before the electric contacts in the solenoid close the circuit between the battery and the starter motor. When the circuit between the battery and the starter motor is complete, the pinion will turn the engine flywheel. A clutch gives protection for the starter motor so that the engine, when it starts to run, cannot turn the starter motor too fast. When the start switch is released, the starter pinion will move away from the flywheel ring gear.

Magnetic Switch

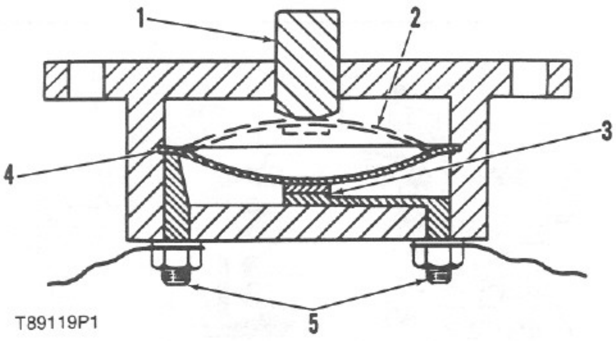
A magnetic switch (relay) is used sometimes for the starter solenoid circuit. Its operation electrically is the same as the solenoid. Its function is to reduce the current load on the start switch and control current to the starter solenoid.

Other Components

Circuit Breaker

The circuit breaker is a switch that opens the battery circuit if the current in the electrical system goes higher than the rating of the circuit breaker.

A heat activated metal disc with a contact point completes the electric circuit through the circuit breaker. If the current in the electrical system gets too high, it causes the metal disc to get hot. This heat causes a distortion of the metal disc which opens the contacts and breaks the circuit. A circuit breaker that is open can be reset after it cools. Push the reset button to close the contacts and reset the circuit breaker.



Circuit Breaker Schematic
(1) Reset button. (2) Disc in open position. (3) Contacts. (4) Disc. (5) Battery circuit terminals.