T4BD1-TRBG TECHNICAL DESCRIPTION

TABLE OF CONTENTS

Page No

LIST OF FIGURES

Page No

GENERAL INFORMATION

Engine

4. An Isuzu 4BD1 TRB-G overhead valve, water-cooled, four-cycle, four-cylinder in-line, turbocharged diesel engine powers the vehicle. The engine utilises an open combustion chamber design with direct fuel injection. The cylinders are numbered from the front to the rear of the engine. The crankshaft rotates in a clockwise direction when viewed from the front of the vehicle.

DETAILED DESCRIPTION

Engine

19. Construction. The cylinder block and crankcase are cast in one piece. The engine block carries the camshaft bearings, the crankshaft main bearings and removable dry type cylinder liners. A water jacket incorporated within the engine block allows coolant to circulate around each cylinder to assist in keeping the engine at a constant operating temperature.

20. The cylinder head, which is detachable from the engine block, provides both the air inlet and exhaust gas ports and a means of sealing each cylinder. A gasket provides a gas/water tight seal when the cylinder head is bolted to the engine block. The alloy valve seats are pressed into place in the cylinder head and are, along with the valves, cooled when coolant flows up from the engine block and circulates through the passages in the head. The coolant also maintains the cylinder head at a constant temperature.

21. The crankshaft is drop-forged heat-treated steel, counter-weighted, machine ground to close limits and balanced. The shaft is mounted in five replaceable, precision shell-type bearings. Crankshaft end thrust is taken up on the number three bearing.

22. The camshaft, machined from a solid drop forging, is mounted in three replaceable bearings located in the engine block. A gear, integral with the camshaft, provides drive to the oil pump.

23. The cam ground pistons are made of aluminium alloy and fitted with two compression rings and one oil control ring. The crown of the piston is recessed for the combustion chamber and machined to allow the inlet and exhaust valves to open as they protrude below the surface of the cylinder head.

24. The flywheel is machined from a solid drop forging and bolted to the rear flange on the crankshaft. The ring-gear is heat shrunk onto the flywheel.

25. The camshaft drives a gear type oil pump. Oil drawn from the oil pan (sump) is pumped under pressure to the engine lubricating system via an oil pressure relief valve and a filter. The pressure relief valve prevents the oil pressure from exceeding the required pressure. A removable oil cooler is installed in the engine block and utilises the engine coolant to maintain the engine oil at a constant operating temperature.

26. Figures 3 and 4 illustrate the right- and left-hand views of the engine and show the location of the various components.

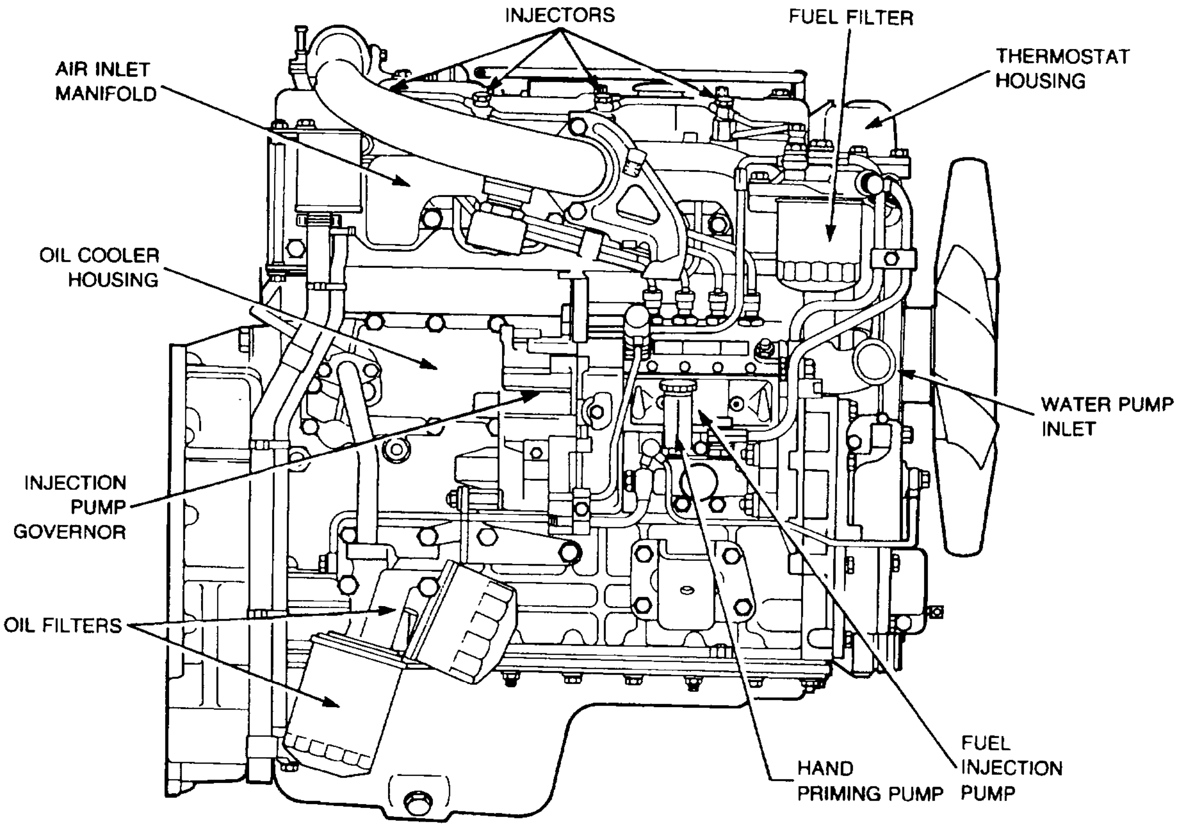


Figure 3 Isuzu Engine 4BD1T, Right-hand Side

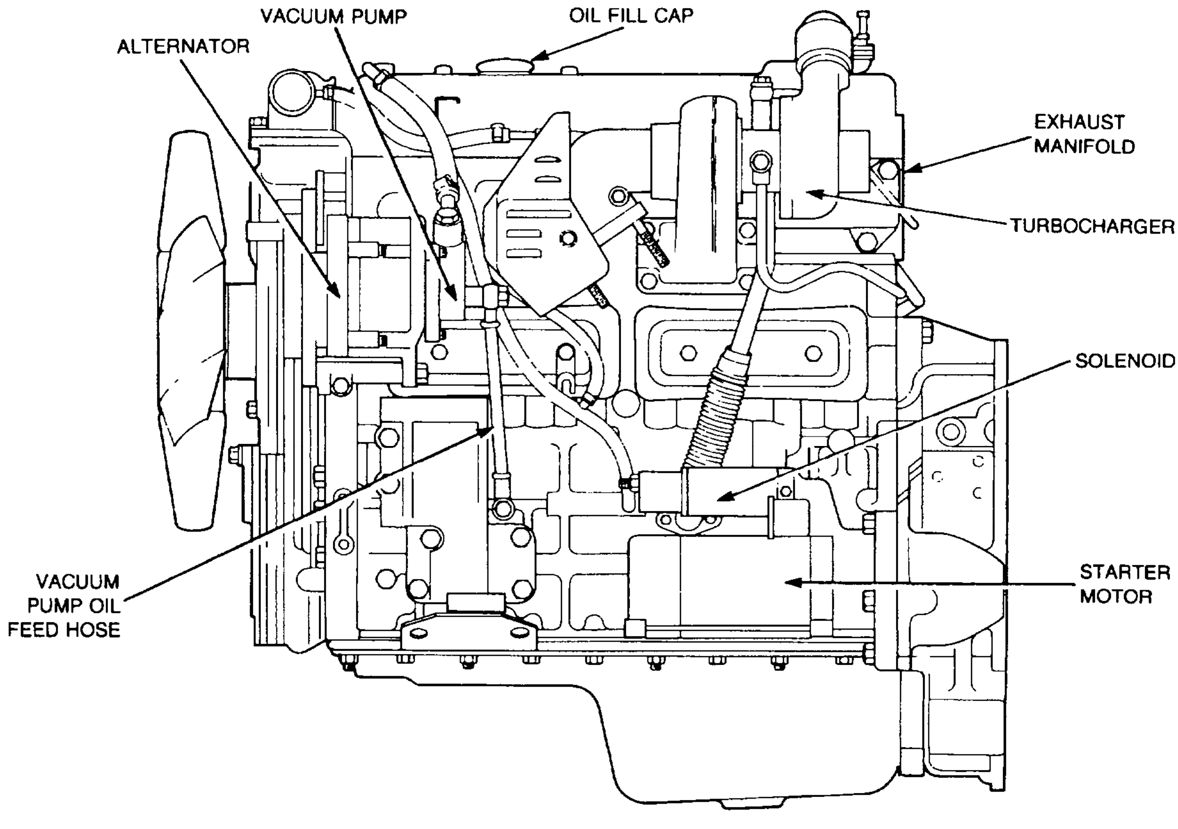


Figure 4 Isuzu Engine 4BD1T, Left-hand Side

Lubrication System

27. The purpose of the lubrication system is to deliver oil under pressure to the various engine components that require lubrication.

28. The oil pan is constructed from pressed steel and is bolted to the bottom of the engine block. It not only protects the lower internal components of the engine, e.g. oil pump, crankshaft, con rods, etc, but is also the storage reservoir for approximately 7.5 litres of engine oil. A dipstick, located on the left-hand side of the engine, enables the engine oil to be monitored for both quality and quantity.

29. The oil pump, located inside the oil pan, is a gear type, i.e. a pair of meshing gears inside a closed housing, and is mounted on the engine block. One gear is attached to the pump drive shaft, which is driven by a gear on the camshaft, while the second gear is driven by the first (refer to Figure 5). The oil pump is a self-priming type, i.e. when the pump gears are rotating, a low-pressure area is created in the pump housing causing atmospheric pressure to force oil through the oil strainer and inlet tube into the pump housing. The meshing of the pump gears displaces the oil and forces the oil from the pump. A pressure-relief valve in the pump housing limits the maximum pump outlet pressure to 686 kPa (100 psi). Surplus pump output is bypassed to the oil pan.

30. The pressure regulating (relief) valve in the lubrication system operates in the same manner as the oil pump relief valve. The regulating valve maintains a constant pressure in the lubrication system by means of a ball and a spring. When oil pressure in the lubricating system exceeds the desired pressure, the pressurised oil acts on the ball forcing it to compress the spring and open a gallery, which allows oil to drain back to the oil pan and relieve the pressure within the system. The regulating valve limits the oil pressure within the oil galleries to 441 kPa (64 psi).

31. The oil filter, mounted vertically on the right-hand side of the engine towards the rear, receives the oil from the oil pump and filters out the finer contaminants, which have passed through the oil pump inlet tube strainer. The oil flows through the oil adaptor into the filter housing and passes through the filter element, outside-to-inside, trapping the contaminants on the outside of the element. The clean oil then flows upward through the oil adaptor into the oil galleries. If the filter becomes blocked, a bypass relief valve, located in the oil adaptor, allows oil to bypass the filter restricting the oil flow.

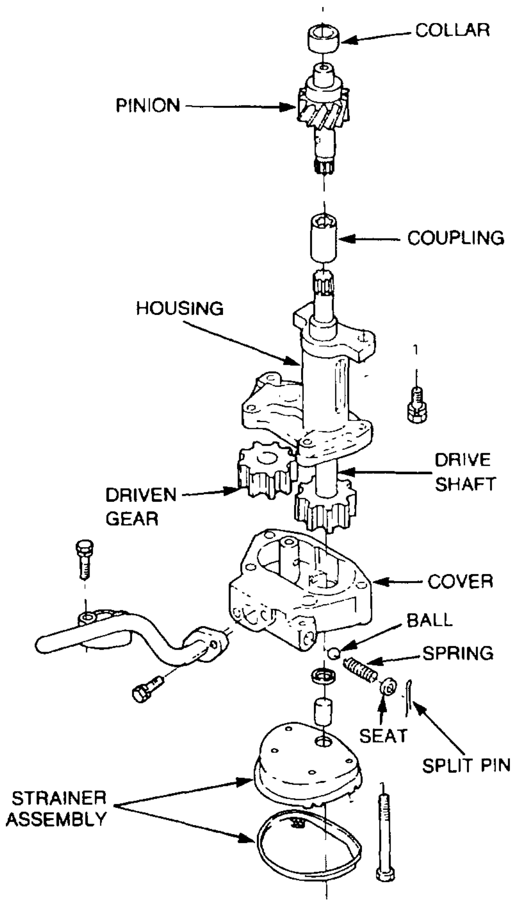


Figure 5 Oil Pump – Exploded View

32. An oil cooler is installed in the lubrication system to prevent the oil from overheating, which causes chemical degradation of the oil and the loss of lubricating qualities. A relief valve, located in the oil cooler housing, allows oil to bypass the cooler should it become blocked. The oil cooler is installed in the water jacket, behind a cover on the right-hand side of the engine, where engine coolant can flow over the oil cooler, dissipating the heat and cooling the oil.

33. Oil galleries direct the flow of oil to the various components requiring lubrication, e.g. crankshaft bearings mains and big ends, camshaft bearings, rocker arm shaft and the fuel injection pump. Four outlet nozzles connected to the main oil gallery direct jets of oil to the underside of the piston crowns to aid piston cooling. The jets of oil also provide additional lubrication to the gudgeon (piston) pins and piston rings by means of splash lubrication. Other components are splash lubricated by the oil run-off from the pressure-lubricated parts.

Cooling System

34. The cooling system consists of the following:

- **a.** coolant, which contains Nalcool corrosion inhibitor in water at a ratio of 1:12;
- **b.** water jackets and passages in the engine block and cylinder head;
- **c.** a belt-driven centrifugal water pump;
- **d.** a thermostat;
- **e.** a chassis mounted radiator, which is connected to the water pump inlet and the thermostat housing outlet by flexible rubber hoses; and
- **f.** an expansion tank, which is equipped with a removable pressure cap and connected to the radiator by means of a rubber hose.

35. Although the primary function of the cooling system is to maintain the engine at a constant operating temperature, it also assists the engine to quickly warm up to the normal operating temperature. When the engine/coolant is cold, the thermostat is closed, restricting coolant flow. The water pump circulates the coolant only through the engine block and cylinder head, via the bypass hose. When a coolant temperature of 82°C is reached, the thermostat opens, allowing the coolant to flow from the thermostat housing and circulate through the radiator, where it is cooled before being drawn back into the engine.

36. The thermostat is a wax pellet, disposable type, designed to open when a coolant temperature of 82°C is reached. At lower temperatures, spring pressure keeps the thermostat closed and the bypass valve at the bottom of the thermostat opens. This allows coolant to circulate from the water pump through the engine and back to the water pump via the bypass hose. As the desired temperature is reached, the wax pellet within the thermostat melts and expands. This exerts pressure on the plunger, which overcomes the spring pressure, opening the thermostat and closing the bypass valve (refer to Figure 6). Heated coolant now flows from the engine to the radiator.

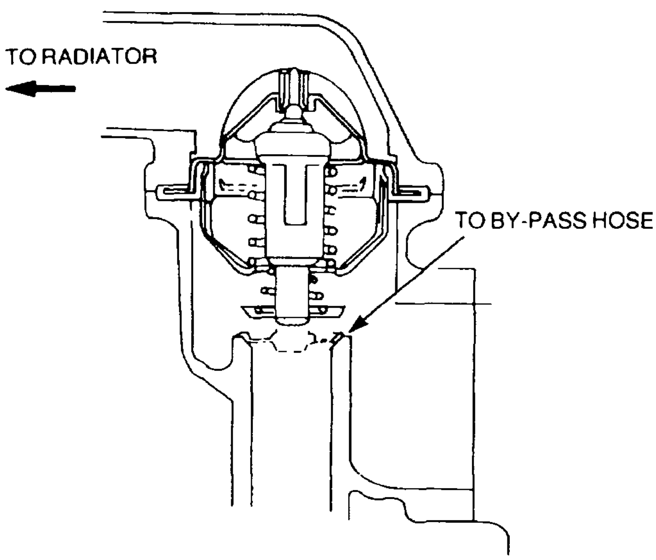


Figure 6 Thermostat Operation

37. The radiator is a cross flow type, i.e. the tanks are located on the sides of the radiator and the flutes run horizontally across the core. Each flute contains metal fins over its entire length, which by convection are heated to the temperature of the coolant. Airflow, induced by the forward motion of the vehicle and by the cooling system fan, passes through the radiator core dissipating heat from the fins, thereby reducing the temperature of the flutes and the coolant flowing through the flutes.

38. The expansion tank allows the heated coolant, which has expanded, to flow from the radiator into the tank via a rubber hose. The removable pressure cap, fitted to the expansion tank, maintains the cooling system under pressure, which effectively raises the boiling point of the coolant, enabling the engine to operate at high temperatures. The pressure cap is equipped with a pressure relief valve, rated at 103 kPa (15 psi), and a vacuum valve. Should the pressure exceed the specified limit, the pressure relief valve opens, allowing internal pressures to be vented to the atmosphere. After the engine is shut down, the coolant and the air within the cooling system contract, creating a partial vacuum. In this case, the vacuum valve opens, allowing outside air to enter. Damage to the radiator and/or hoses may result should either the pressure relief valve or the vacuum valve fail to function properly.

39. The water pump shown in Figure 7 is a belt-driven, mechanical, centrifugal type pump bolted to the front of the engine block. Drive for the water pump comes from the crankshaft pulley, via a V-belt, to the pulley attached to the water pump shaft. The coolant is drawn in through the inlet port, forced out through the port in the cover plate and into the engine block water jacket. An eight-blade fan, attached to the water pump impeller shaft, assists with engine cooling by drawing air through the radiator core, cooling the contents of the radiator, and circulating air over the engine extremities.

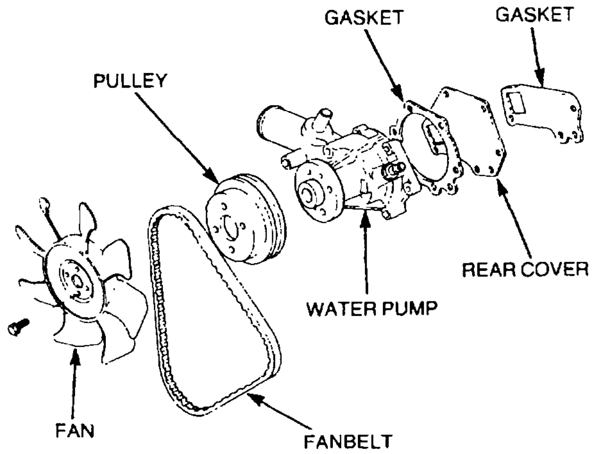


Figure 7 Water Pump Assembly

40. When the coolant in the cooling system reaches 82°C, the thermostat begins to open, permitting coolant to flow through the thermostat housing to the radiator, via the radiator hose. The coolant flows from the left-hand radiator tank through the flutes in the radiator core (where it is cooled) to the right-hand tank. The coolant then is drawn from the right-hand tank through the lower radiator hose to the water pump, where it is pumped into the engine block water jacket. The coolant circulates around the cylinders dissipating the heat from the cylinder walls. It then flows into the cylinder head where it circulates around the inlet and exhaust ports, cooling the valve seats and valves before flowing through the thermostat housing to the radiator to repeat the cooling cycle. An outlet incorporated on the water pump provides coolant to the turbocharger (refer to Figure 8) for cooling the bearing housing. The coolant then flows via piping to the thermostat housing.

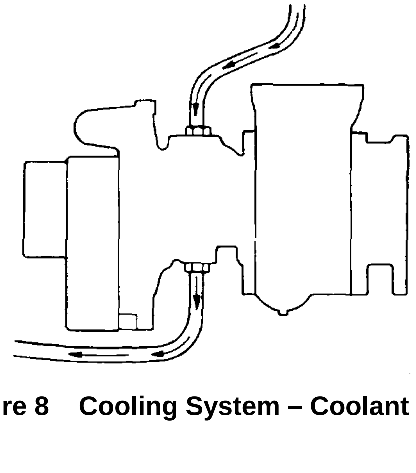


Figure 8 Cooling System – Coolant Flow

Air Cleaner

41. The air cleaner is utilised for the filtering of the air used in the engine's combustion process (refer to Figure 9). The air cleaner assembly is mounted on the rear of the engine and held in position by two metal bands. Incorporated within the air cleaner assembly's housing are the primary element and the safety element. The primary or main element is a dry-type paper element with a perforated metal surround and a plastic fin assembly fitted to one end. When the element is installed, the fin assembly is positioned towards the air inlet port in the housing. As air is drawn into the housing, via the air inlet hose, it passes between the fins, which induce a cyclonic twist to the air as it flows through. This action tends to cause the larger or heavier dust particles to be thrown outward, eventually falling to the bottom of the housing. The air then passes through the primary filter, which extracts finer dust particles from the air and retains the particles in the element. Clean air then flows to the engine's air inlet manifold, via the safety element, which is installed as a precautionary measure should the primary filter become damaged.

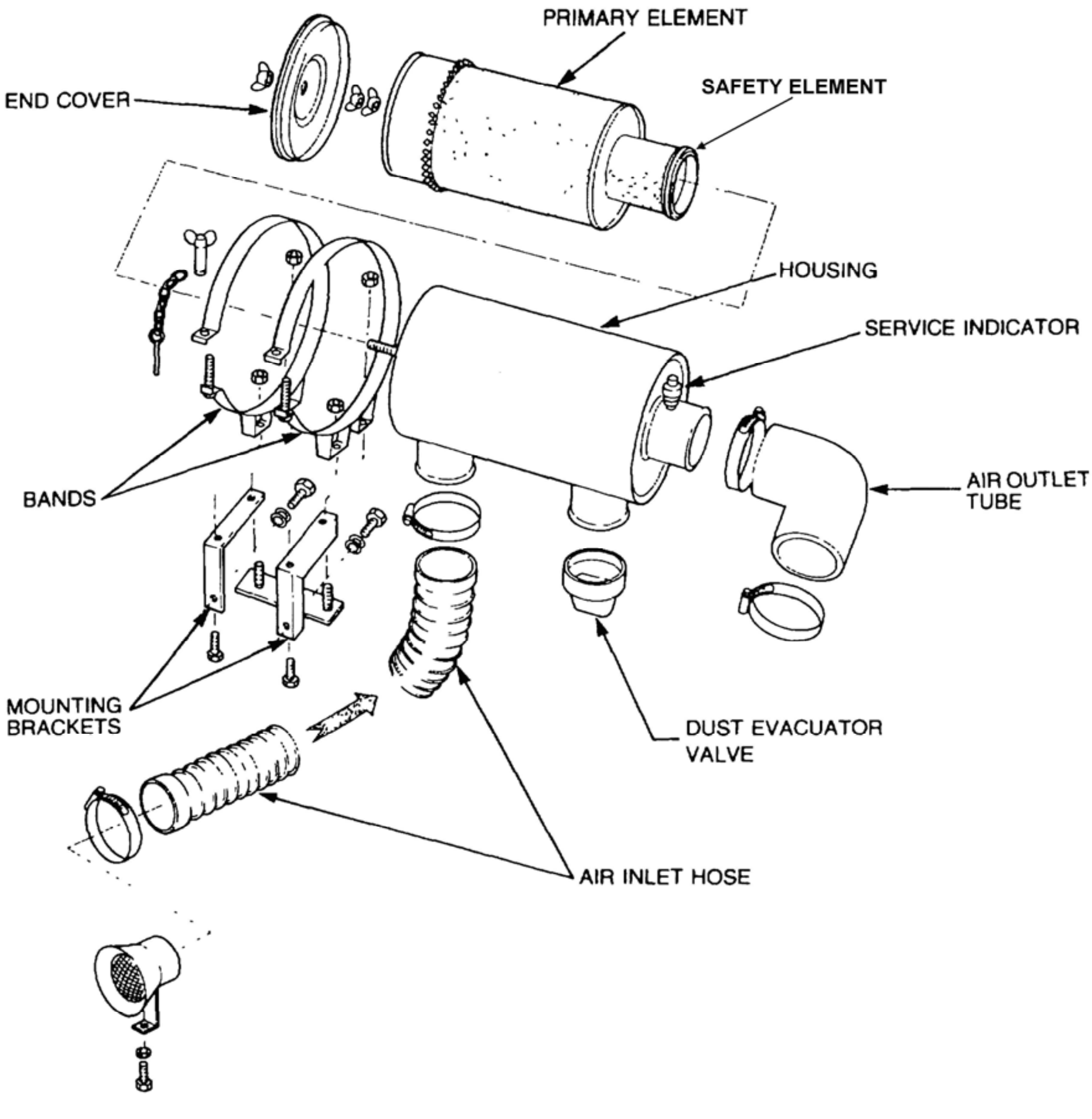


Figure 9 Air Cleaner Assembly – Exploded View

42. A service indicator (refer to Figure 10) is incorporated on the air cleaner housing to give a visual indication of air cleaner restriction. When the red float is clearly visible through the window of the indicator, the air cleaner requires servicing. When the air cleaner has been serviced, the service indicator can be reset by pressing the button on the top of the indicator.

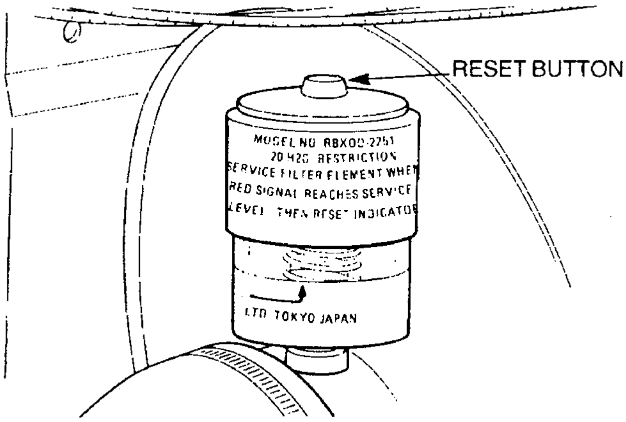


Figure 10 Air Cleaner Service Indicator

Fuel System

43. An outlet pipe, fitted to the top of each fuel tank, allows the transfer pump to draw fuel from the tank selected by the changeover switch on the dashboard. When the transfer pump is operating, it draws fuel from the selected tank via the fuel lines. The fuel passes through a sedimenter (refer to Figure 11) where water and large particles of contaminants are separated from the fuel. It then flows from the sedimenter to the transfer pump, passing through a fine mesh filter (strainer) before entering the pump. The transfer pump provides fuel at a pressure of 176–245 kPa (25.5–35.5 psi) to the fuel filter. The filtered fuel is then supplied to the injection pump, where it is pumped under high pressure, approx 18 000 kPa (2610 psi), to the injectors via the high-pressure fuel lines.

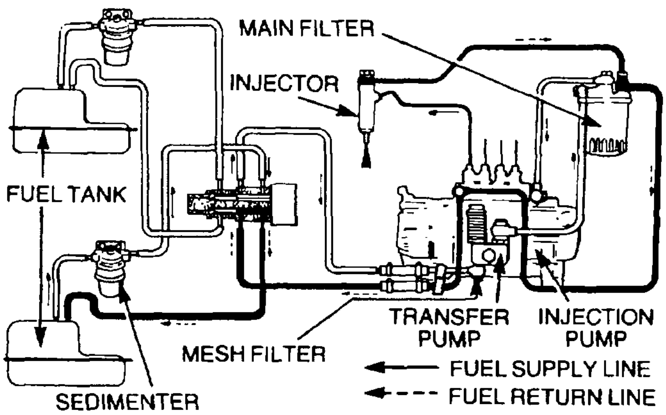


Figure 11 Fuel System

44. Each fuel tank is made from pressed steel and constructed in two sections, then spot-welded together. Prior to the joining of the two sections, a baffle plate is welded to the inside of the tank to prevent fuel surge during vehicle operation.

45. The fuel tanks are positioned below the seat base assembly on both the right- and left-hand sides of the vehicle. At the front of each tank is a single-point rubber mount, which bolts to a detachable mounting bracket on the chassis rail. A rigid mounting bracket (welded to the fuel tank seam) at the rear of each tank is secured by bolts, nuts and spacers to the body-mounting bracket. Installed in the top of the each fuel tank is a fuel gauge sender unit, comprising a float mounted on an arm connected to a rheostat (variable resistor). Electrical wiring to the fuel gauge connects the rheostat. An electric current flows through the fuel gauge to the rheostat, then to earth. The amount of current flow determines the position of the gauge pointer. The current flow is controlled by the amount of resistance created by the position of the float arm on the rheostat. The higher the float, the less the amount of resistance created by the rheostat. More current will flow through the gauge, causing the gauge pointer to react accordingly.

46. When either fuel tank is selected by operating the two-position switch, current is supplied to the fuel tank changeover valve. The motor in the changeover valve is caused to move and open ports to allow fuel from the selected tank to flow to the engine, while the ports for the other tank are closed off. The fuel return from the injectors and injector pump also flows through ports in the changeover valve, en-route to the fuel tank in use. When the fuel tank changeover switch is moved to select the fuel tank, a current also flows to the fuel gauge sender unit on the tank selected, while the current on the fuel gauge unit on the other fuel tank is cut. This method enables both fuel tanks to utilise the one fuel gauge. The low fuel warning device operates on the tank selected and utilises the one warning light.

47. In addition to the components described in Paragraph 45, the fuel gauge sender unit comprises a fuel return pipe and a low fuel level sensor. The fuel return pipe allows overflow fuel from the injection pump and injectors to be returned to the fuel tank. The fuel low-level sensor, attached to the fuel return pipe, causes a warning light to illuminate when the fuel level in the tank is below approximately nine litres.

48. Two sedimenters (refer to Figure 12) are incorporated in the fuel lines between the fuel tanks and the transfer pump to trap any water or heavy contaminants that may be in the fuel. A drain plug in the bottom of each sedimenter housing allows any water or contaminants to be drained off. The sedimenter is mounted on the chassis rail behind the fuel tank.

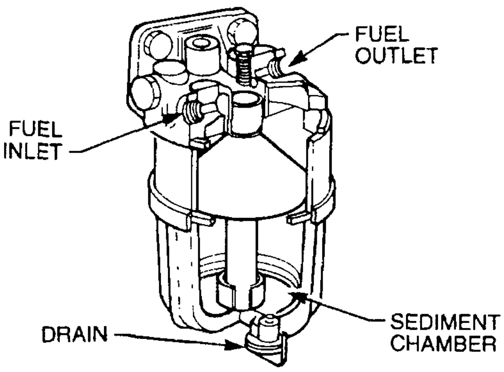


Figure 12 Fuel Sedimenter

49. The transfer (supply) pump is a self-regulating, mechanical type, attached to the side of the fuel injection pump and driven by the injection pump camshaft. The transfer pump supplies fuel at a pressure of 176–245 kPa (25.5–35.5 psi) to the fuel filter and the injection pump. A strainer, incorporated in the transfer pump fuel inlet bolt, filters out coarse particles in the fuel, preventing premature wear and damage to the internal components of the transfer pump.

50. Transfer Pump Sequence. When the injection pump camshaft is rotating, the transfer pump tappet, forced against the camshaft by the piston return spring via the piston and plunger, tracks the contours of the camshaft lobe causing the following:

a. Intake Stroke. When the tappet is on the back of the camshaft lobe, the piston is on its intake stroke. The inlet check valve opens, allowing fuel to flow into the piston spring chamber (refer to Figure 13).

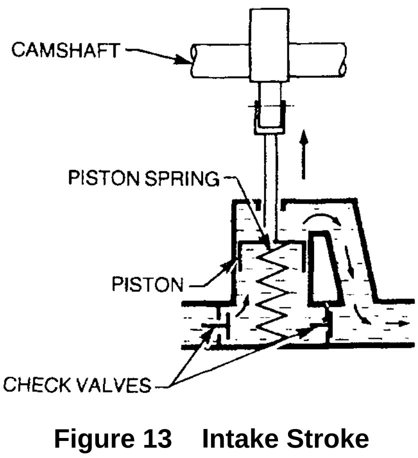


Figure 13 Intake Stroke

b. **Discharge Stroke.** As the camshaft rotates and forces the piston back into the spring chamber, the inlet check valve closes, causing the fuel pressure to increase and open the outlet valve (refer to Figure 14). The fuel flows through the outlet valve and around to the chamber on the plunger side of the piston. As the camshaft continues to rotate, the spring pressure acting on the piston causes the piston to force the fuel out of the chamber on the plunger side of the piston. The fuel pressure closes the outlet valve, causing the fuel to flow through the pump outlet port to the fuel filter.

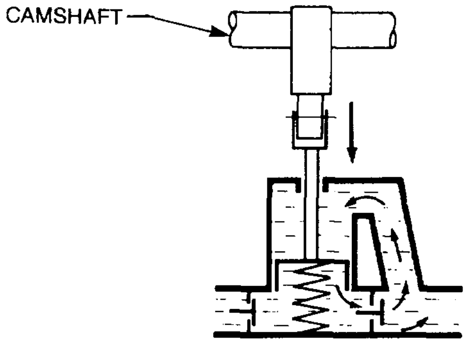


Figure 14 Discharge Stroke

c. **Pump Pressure Regulation.** When fuel supply exceeds the demand, the fuel pressure acting on the plunger side of the piston becomes equal to the force exerted by the piston spring, causing the piston to remain stationary (refer to Figure 15). At this stage, no further pumping action takes place until the fuel pressure in the injection pump fuel gallery drops, causing the fuel pressure in the transfer pump to drop.

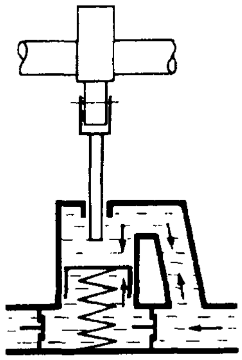


Figure 15 Pump Pressure Regulating

51. The main fuel filter, located at the front right-hand side of the engine, is comprised of a mounting adaptor, a removable housing, a disposable cartridge and a drain plug (refer to Figure 16). Due to the fine tolerances required for the injection pump components and the injectors, the fuel filter is designed to remove contaminants from the fuel in sizes of 100 microns or larger.

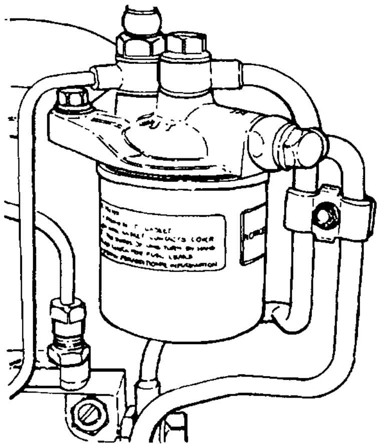


Figure 16 Main Fuel Filter

52. The injection pump is an in-line, A-type, located on the right-hand side of the engine and driven by the engine camshaft driving gear. Located within the injection pump housing are four plunger and barrel assemblies (one assembly for each of the engine cylinders) and a camshaft. The plunger and barrel of each assembly are finely ground and assembled together with extremely fine tolerances, forming a matched pair, and should never be intermixed with other plungers or barrels.

Fuel Metering

53. The plungers used in the injection pump are 9.5 mm in diameter and have a centre bore drilling, instead of the more common external groove. A lower helix, which rises diagonally to the left giving a left lead, is machined into the side of the plunger (refer to Figure 17).

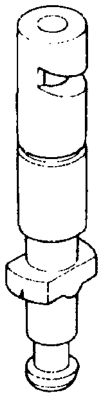


Figure 17 Plunger

54. The barrels in which the plungers operate have an inlet/spill port, machined through the side into the bore (refer to Figure 18). When the barrel is installed in the injection pump, the port aligns with the fuel gallery in the injection pump. Fuel supply for the plunger flows from the fuel gallery, through the inlet/spill port and into the high-pressure chamber above the plunger.

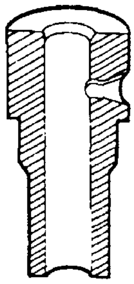


Figure 18 Barrel – Sectional View

55. As the stroke of the plunger is 8 mm, regardless of engine load or speed, the amount of fuel delivered to the injectors is regulated by the position of the helix in regard to the inlet/spill port. With the lowest point of the helix aligned with the inlet/spill port, maximum fuel delivery is achieved. As the plunger is rotated clockwise (when viewed from the bottom of the plunger), the quantity of fuel delivered is reduced with each stroke of the plunger. As the engine operates over varying loads and speeds, the fuel requirements of the engine also vary. To adjust the fuel delivery to suit the engine requirements, a control sleeve with a toothed segment clamped to its upper section and a toothed control rack are utilised. The barrel is installed into the sleeve from the top, while the plunger is installed from the bottom, with the control arms on the plunger stem positioned in the two longitudinal slots machined into the bottom of the control sleeve. When installed in the injection pump, the toothed segment of the sleeve meshes with the toothed control rack, which is mounted longitudinally in a bore within the body of the injection pump and free to move in that bore.

56. Both the accelerator and the injection pump governor regulate movement of the control rack. The accelerator is used for the initial or main movement of the rack, to enable the engine to reach the required pulling power, while the governor makes finer adjustments to the rack, to enable the engine to maintain that power over varying road conditions. As the accelerator pedal is depressed, the rack moves accordingly causing the control sleeve to rotate. The plunger, which is connected to the control sleeve via the control arms, also rotates moving the helix towards the lower point in relation to the barrel inlet/spill port, which is secured in a fixed position within the pump body. Figure 19 illustrates the plunger rotating mechanism, showing the plunger helix to barrel inlet/spill port relationship in non-delivery, partial delivery and maximum delivery positions.

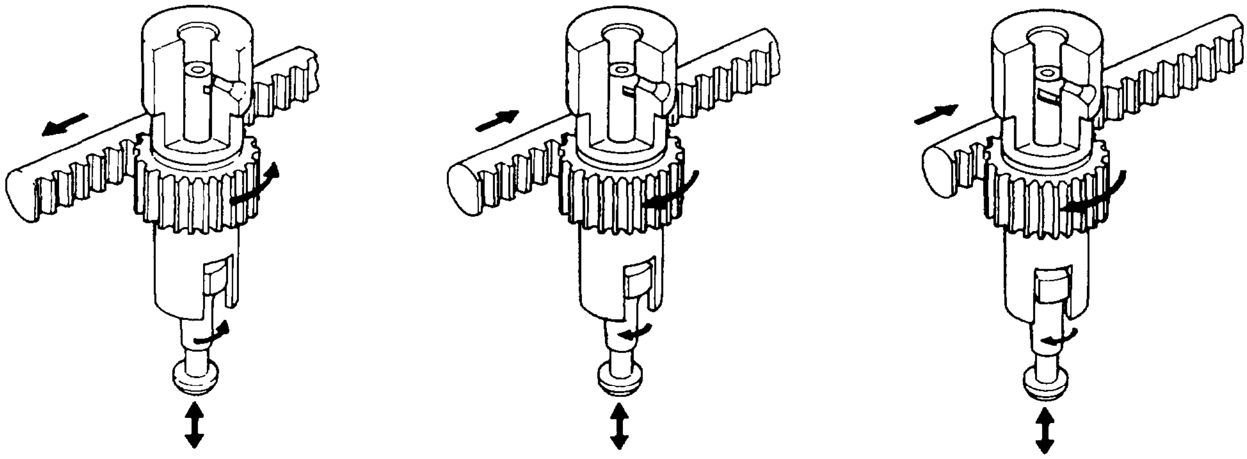


Figure 19 Plunger Rotating Mechanism

57. The injection pump camshaft has four tangential-shaped lobes. When installed in the injection pump body, each camshaft lobe is positioned directly below a plunger and barrel assembly. The camshaft rotates in accordance with the engine's timing gear. The camshaft lobes act on the roller tappets, shims, spring seats and return springs causing the plungers to move up and down within the bore of the barrel (refer to Figure 20). The camshaft drives the pump plunger and influences the duration of injection, the pump delivery, and the rate of delivery by the amount of lift and the profile of the camshaft lobe.

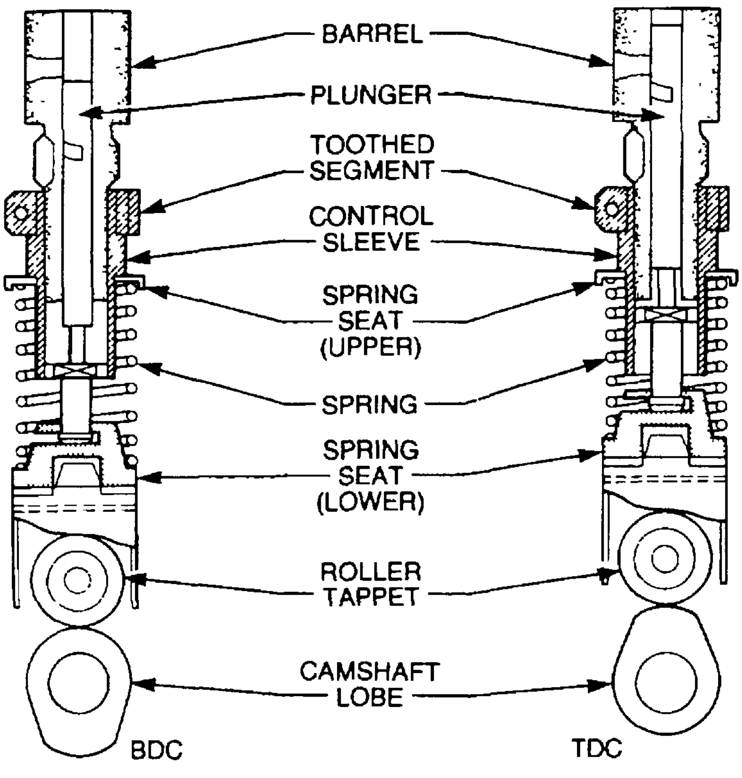


Figure 20 Plunger Drive Assembly

58. A housing is placed over the plunger and barrel assembly to enable the fuel to be pumped under high pressure to the injectors. A delivery valve and return spring are incorporated within the housing. When the housing is installed over the plunger and barrel assembly in the injection pump body, it effectively seals the area above the plunger, creating a high-pressure chamber (refer to Figure 21).

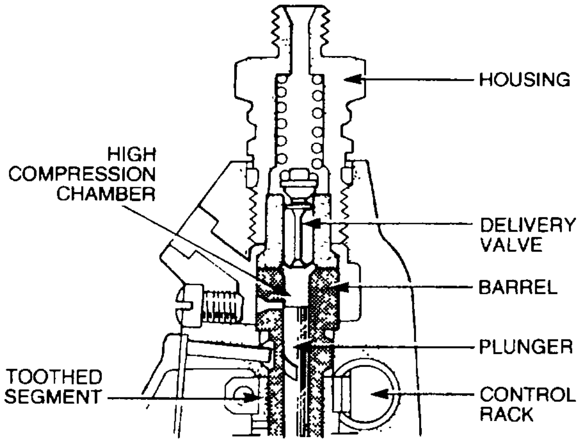


Figure 21 Housing and Delivery Valve Location

59. With the plunger at the bottom of its stroke (BDC), the inlet/spill port is open, allowing fuel under low pressure to flow from the injection pump fuel gallery into the high-pressure chamber. As the camshaft rotates, causing the plunger to move towards the top of its stroke (TDC), a series of phases called strokes take place (refer to Figure 22) as follows:

- **a.** Pre-stroke is the closing-off of the inlet spill port by the plunger.
- **b.** Effective stroke occurs when the pressure of the fuel above the plunger has attained the point where the delivery valve is lifted off its seat, against the return spring pressure, allowing the high-pressure fuel to flow to the injectors.
- **c.** Residual stroke occurs after the plunger helix has uncovered the inlet spill port, allowing the high-pressure fuel above the plunger to spill out into the injection pump fuel gallery, via the plunger centre bore and helix.

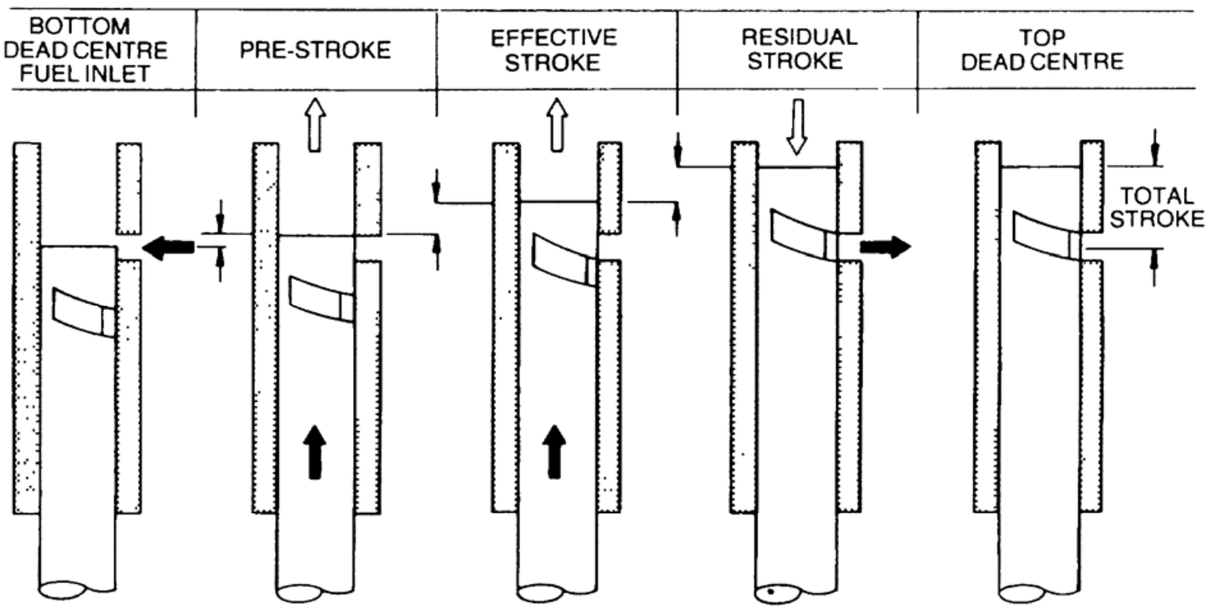


Figure 22 Phases (Strokes) of the Plunger

Fuel Injectors

60. The pressurised fuel from the injection pump passes along high-pressure fuel lines to the four fuel injector nozzle assemblies mounted in the cylinder head, with the nozzle of each assembly protruding into the combustion chamber. After the pressurised fuel enters the nozzle holder body, it passes through a high-pressure fuel duct into a pressure chamber and down alongside the nozzle needle in the nozzle body (refer to Figure 23). The high-pressure fuel in the pressure chamber acts against the exposed annular area on the nozzle needle, pushing the nozzle needle and spindle up against spring pressure; opening the needle seat and allowing the fuel to flow out through the orifices, where it is sprayed into the combustion chamber.

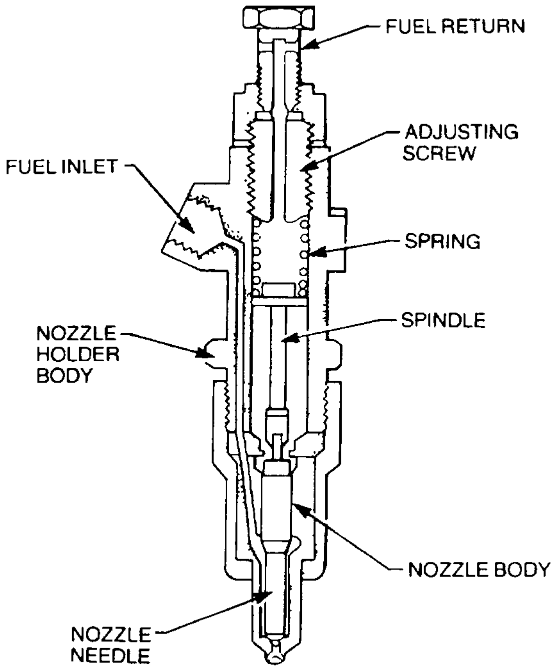


Figure 23 Fuel Injector Assembly

61. A small amount of fuel leakage takes place during fuel injection. The fuel seeps between the nozzle needle and the nozzle body, cooling and lubricating the needle and body as it does so. This fuel is then returned to the fuel tank via the injection pump overflow valve.

Injection Pump Governor

62. The governor is attached to the back of the injection pump. It is a variable speed control type, which not only controls the idle and maximum speed of the engine, but also maintains maximum torque output under varying loads and conditions, at selected speeds between idle and the maximum no-load speed. Using flyweights, springs, rods and levers, the governor ensures that the engine does not stall when in the idle-speed range and that the maximum engine speed is not exceeded. When the engine is operating between idle and maximum speed, a torque cam and a sensor lever regulate the position of the control rack which, in turn, regulates the amount of fuel injected to maintain the engine at the required torque output.

63. Figure 24 illustrates the governor assembly showing the location of the various components.

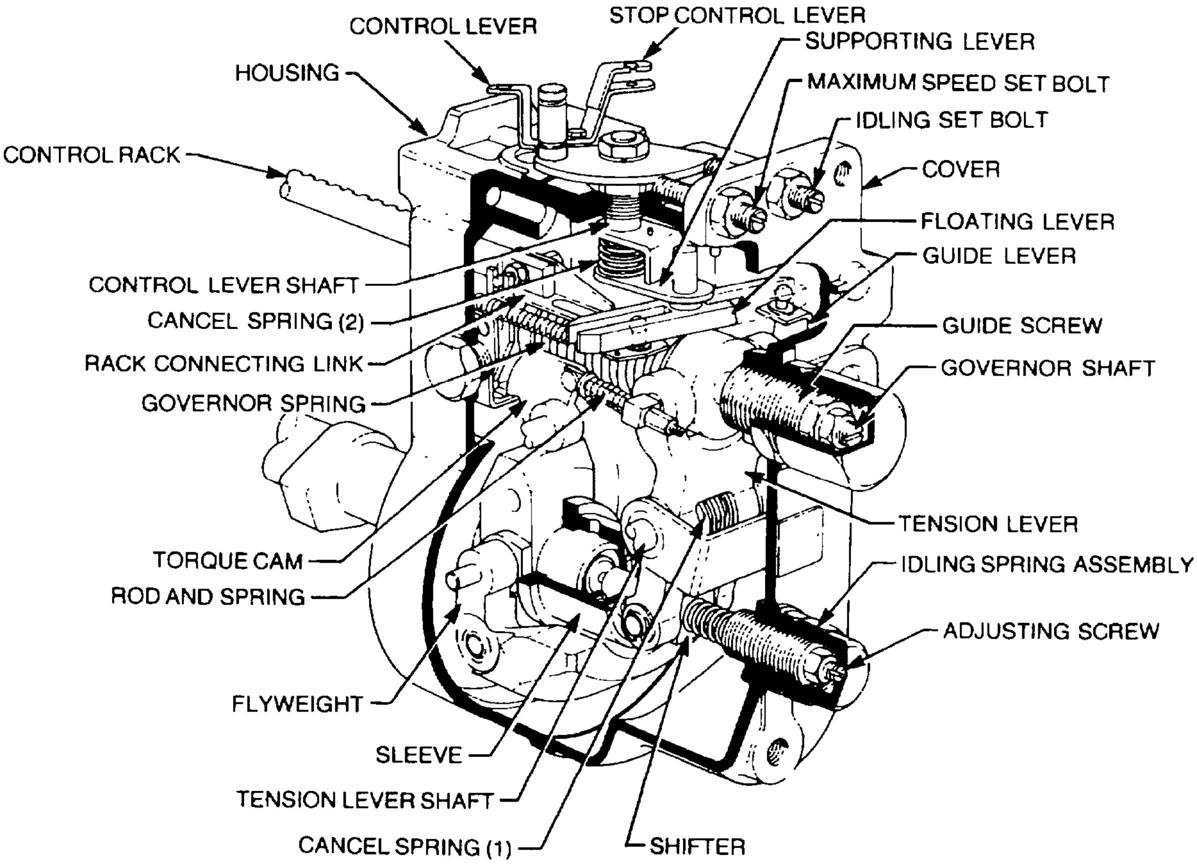


Figure 24 Governor Assembly

64. The flyweight holder (refer to Figure 25) is secured to the rear of the injection pump camshaft by means of a taper, woodruff key and a lock nut. The flyweights are secured to the holder by press-fit pins, around which the flyweights pivot. When the camshaft revolves, the flyweight holder and the flyweights revolve with it. As the camshaft speed increases, the flyweights move outward due to centrifugal force. This action causes the sliders, which are fixed to the arms on the flyweights, to push against a sleeve which causes the sleeve to move in an axial direction (refer to Figure 26).

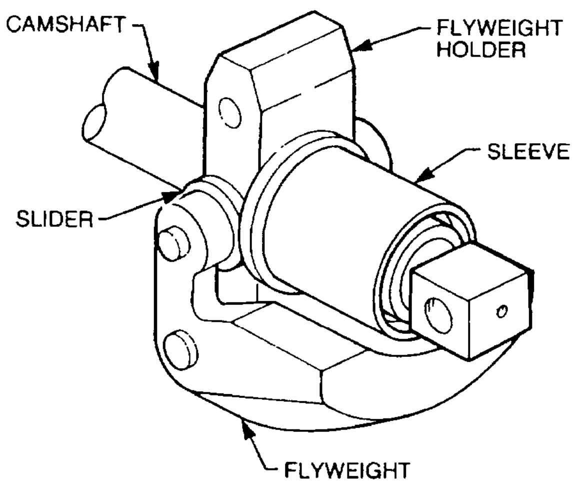


Figure 25 Flyweights Closed

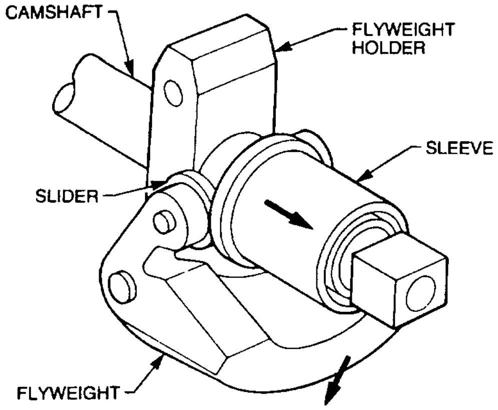


Figure 26 Flyweights Open

65. As the sleeve moves, it pushes against the shifter (which rides in the bearing in the end of the sleeve) causing the shifter to move in an axial direction. The shifter, which is connected to the tension lever by a pivot pin, causes the tension lever (which is shaft mounted to the governor cover) to pivot on the shaft. As the lower section of the tension lever moves away from the pump body, the upper section moves toward the pump body. A spring seat is attached by a pin to the upper section of the tension lever with the governor shaft running through the centre bore of the spring seat. The governor shaft is secured to the governor cover at one end by a guide-screw. The other end of the shaft is mounted in a bore in the governor housing (refer to Figure 27).

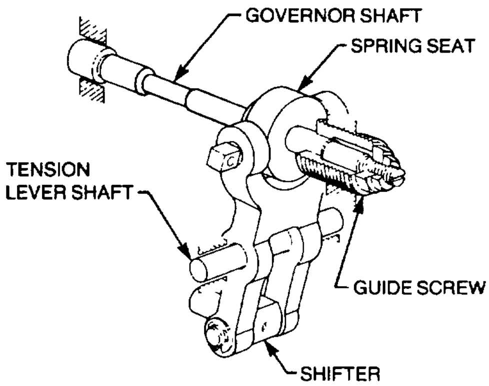


Figure 27 Tension Lever and Governor Shaft

66. A spring seat is positioned on the governor shaft at the housing end. The governor springs are installed on the governor shaft and held uncompressed between the two seats. An idling spring capsule is positioned toward the bottom of the governor cover. The adjustable capsule houses the idling spring, which butts against the back of the shifter (refer to Figure 28). The combination of the governor springs and the idling spring counter the centrifugal force of the flyweights over the entire engine speed range, ensuring that the setting of the tension lever, in the position appropriate to the amount of flyweight lift, is smooth and progressive.

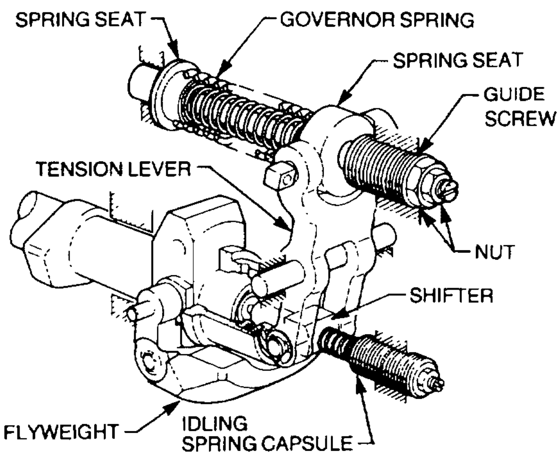


Figure 28 Governor Springs and Idling Spring Locations

67. The guide lever is also mounted on the tension lever shaft and is concentric with the tension lever. Both levers are held together by the force of the cancel spring (1) as shown in Figure 29. A ball joint is welded to the top of the guide lever.

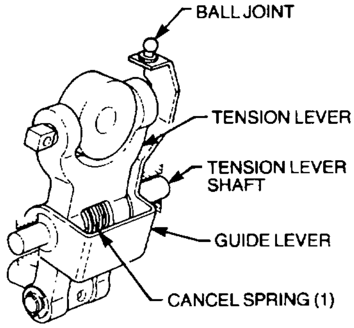


Figure 29 Guide Lever and Cancel Spring (1) Location

68. The connecting link, which has a ball joint welded to it, is secured to the end of the injection pump control rack by a bolt; nut and washer (refer to Figure 30). The start spring is connected to the connecting link and to the spring eye, which is bolted to the governor housing. The spring always works to pull the control rack into the fuel increase direction.

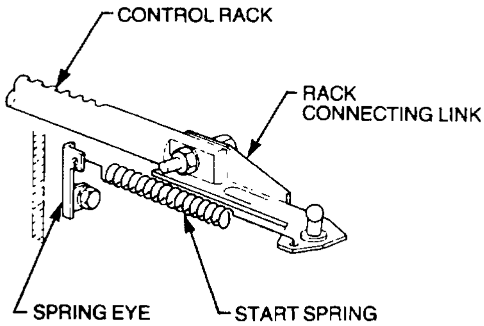


Figure 30 Connecting Link and Start Spring Location

69. The control lever assembly, which is installed in the governor cover, comprises a floating lever, supporting lever, cancel spring, control lever shaft and a control lever. The centre drilling of the floating lever is positioned on the lower pivot pin on the supporting lever and secured in place by a snap-ring. The supporting lever and the cancel spring (2), as shown in Figure 31, are positioned on the lower end of the control lever shaft and secured by a snap-ring. The force of the cancel spring (2) keeps the elbow on the control lever shaft in contact with the supporting lever. This assembly fits up through the governor cover and the control lever is positioned on the control lever shaft and secured by a nut. The forked ends of the floating lever engage with the tension lever ball joint at one end and the control rack connecting link ball joint at the other. The control lever assembly forms the mechanical linkage between the accelerator cable and the injection pump fuel control rack and also between the governor assembly and the injection pump fuel control rack.

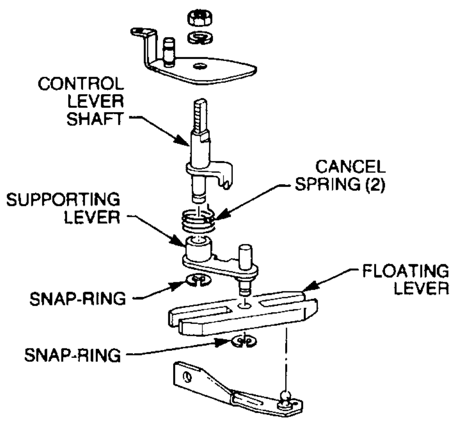


Figure 31 Control Assembly – Exploded View

70. A torque cam is mounted on a pivot pin, which is pressed into the inside of the governor cover on the control rack side. A rod, spring and adjusting nut connects the cam to the spring seat pin on the tension lever. The torque cam pivots on the pin in accordance with the movement of the tension lever, or by adjusting the length of the connecting rod (refer to Figure 32).

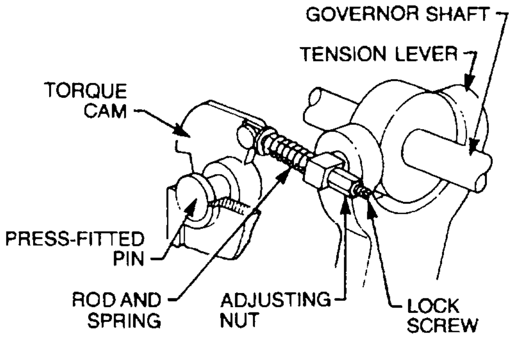


Figure 32 Torque Cam Location

71. The shaft for the full-load setting lever is installed in the governor housing. As shown in Figure 33, the cancel spring (3) is installed over the end of the shaft inside the housing. The U-shaped lever is positioned in the housing, with one end located by a guide screw (on the control rack side of the housing). The other end is mounted on the end of the shaft against the cancel spring. The sensor lever is mounted on a pivot pin on the U-shaped lever on the control rack side. The full-load setting lever, together with a return spring, is secured by a nut and washer to the full-load setting lever shaft on the outside of the governor housing. The full-load setting lever (refer to Figure 33) is always forced against the adjustable full-load setting bolt (also located outside the governor housing) by the return spring (3).

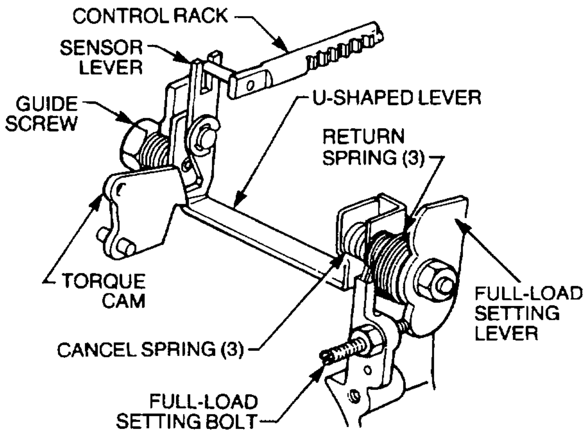


Figure 33 Full-load Setting Lever and Sensor Lever Locations

72. With the engine stationary (the injection pump not operating), depressing the accelerator pedal causes the control lever to move toward the maximum speed position. In so doing, the cancel spring (2) causes the supporting lever and the floating lever to move with the control lever (refer to Figure 34).

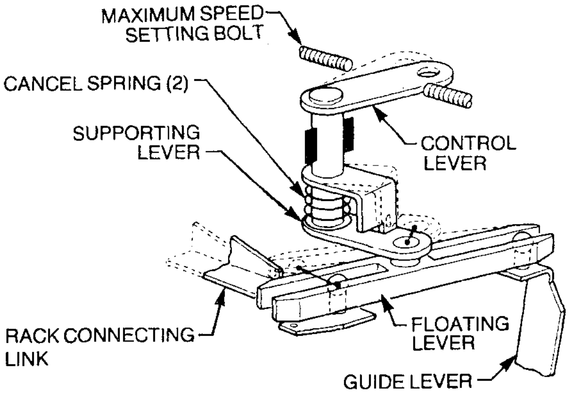


Figure 34 Control Lever Assembly Operation

73. As the guide lever ball joint is held stationary, the floating lever pivots on this ball joint, causing the control rack to move in the fuel increase direction (refer to Figure 35). By depressing the accelerator pedal fully, the control lever moves to the maximum speed position causing the elbow on the control lever shaft to move away from the supporting lever. The cancel spring (2) then forces the supporting lever to move toward the elbow causing the floating lever to pivot on the stationary guide lever ball joint and move the control rack to the starting position. In this position, the sensor lever engages with the notch of the torque cam, which controls the engine's starting fuel injection quantity. The governor and the injection pump are now in the engine start position.

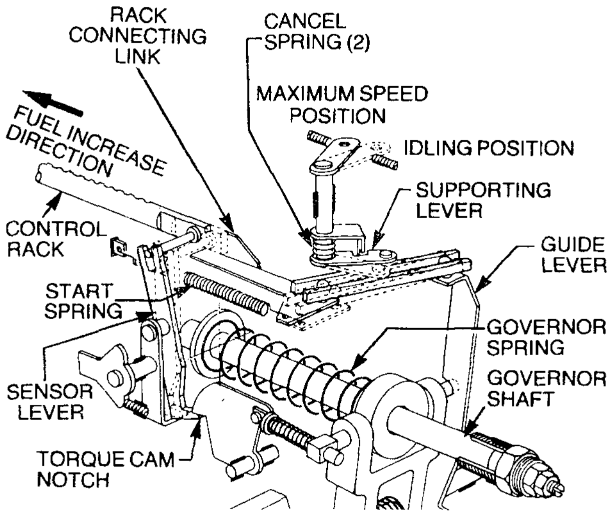


Figure 35 Engine Start Position

CAUTION

Do not allow the engine to rev up after it starts. This will prevent the sensor lever from disengaging from the notch on the torque cam and dangerously interfering with the governor control of the injection pump.

74. With the engine started and the accelerator pedal released, the control lever returns to contact the idle speed-setting bolt. The control rack moves to decrease the fuel injection quantity and the edge of the sensor lever is released from the torque cam notch (refer to Figure 36).

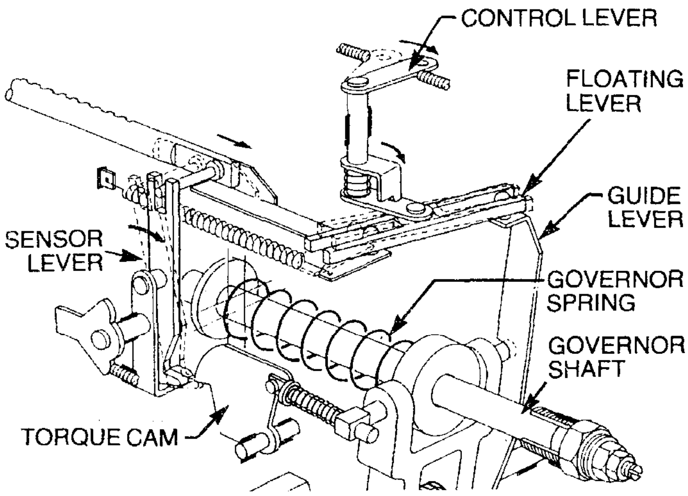


Figure 36 Returning to the Idle Position

75. When the control lever returns to the idle position, it causes the supporting lever to return to the idle position, creating a central fulcrum for the floating lever. As the engine speed decreases, the flyweight's centrifugal force also decreases to a point where the force of the idling spring causes the flyweight to close. As the flyweight closes, the tension lever moves inward causing the guide lever ball joint to move outward, pivoting the floating lever on the supporting arm pivot and moving the control rack in the increase fuel direction (refer to Figure 37). As the engine speed (and the pump speed) increases, the flyweight's centrifugal force overcomes the idling spring force. The bottom of the tension lever moves outward, causing the guide lever ball joint to move inward, pivoting the floating lever on the supporting arm pivot and moving the control rack in the decrease fuel direction. The governor continuously monitors the idle speed in this manner while the engine is at idle.

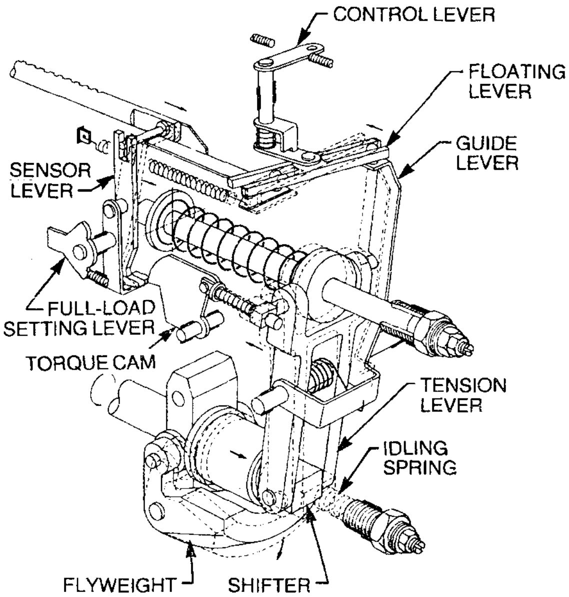


Figure 37 Governing Idle Speed

76. With the engine running under load, depressing the accelerator until the control lever reaches the maximum speed setting bolt will cause the floating lever to pivot on the guide lever ball joint. This moves the control rack to the full-load position, which in turn causes the sensor lever to contact the torque cam. Engine speed fluctuations will cause the flyweight to open and close causing the tension lever to pivot on its shaft, moving the torque cam around its pivot (refer to Figure 38). As the torque cam moves, the sensor lever edge follows the profile of the torque cam, moving the control rack position to control the amount of fuel injected in accordance with the cam profile.

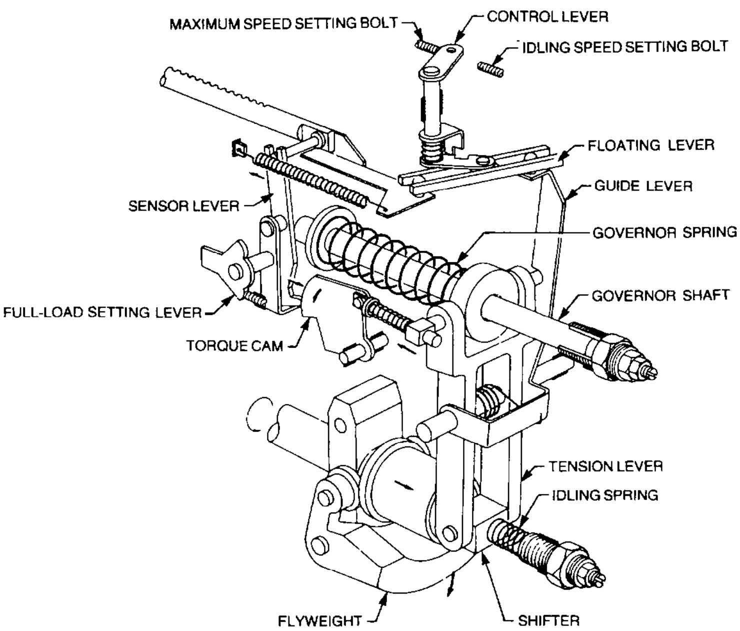


Figure 38 Full-load Operation

77. While the control lever is in contact with the maximum speed setting bolt, engine speed can increase while the fuel injection quantity is controlled by the torque cam and the sensor lever. With the supporting lever in contact with the elbow on the control lever shaft, an increase in engine speed causes the guide lever to move toward the fuel injection pump. This pivots the floating lever on the supporting lever pivot and moves the control rack toward the decrease fuel position, decreasing the fuel injection quantity for maximum speed governing. The sensor lever edge disengages from the torque cam for maximum speed governing (refer to Figure 39). The stop control lever moves the rack to the no-fuel position when the ignition is turned off.

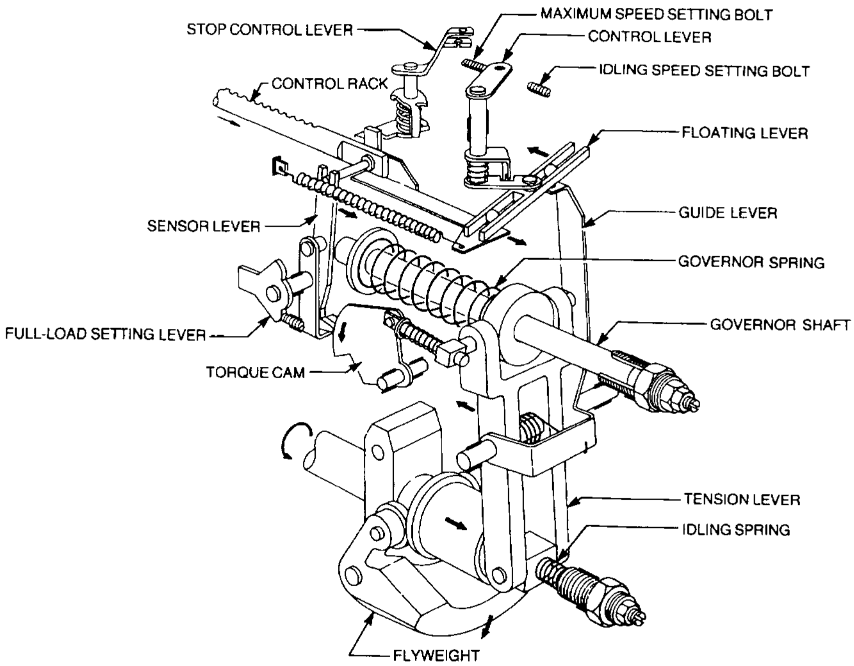


Figure 39 Maximum Speed Control

Automatic Timer

78. The injection pump is equipped with an automatic timer, which forms the drive connection between the engine's timing gears and the injection pump camshaft. The purpose of the automatic timer is to reduce ignition lag, which, if excessive, causes diesel knock. The automatic timer is designed to advance the injection timing as the engine speed increases, thus allowing additional time for fuel and air in the combustion chamber to form an ignitable mixture, which then ignites at the correct time.

79. The automatic timer achieves this function by means of flyweights, springs and eccentric cams (refer to Figure 40).

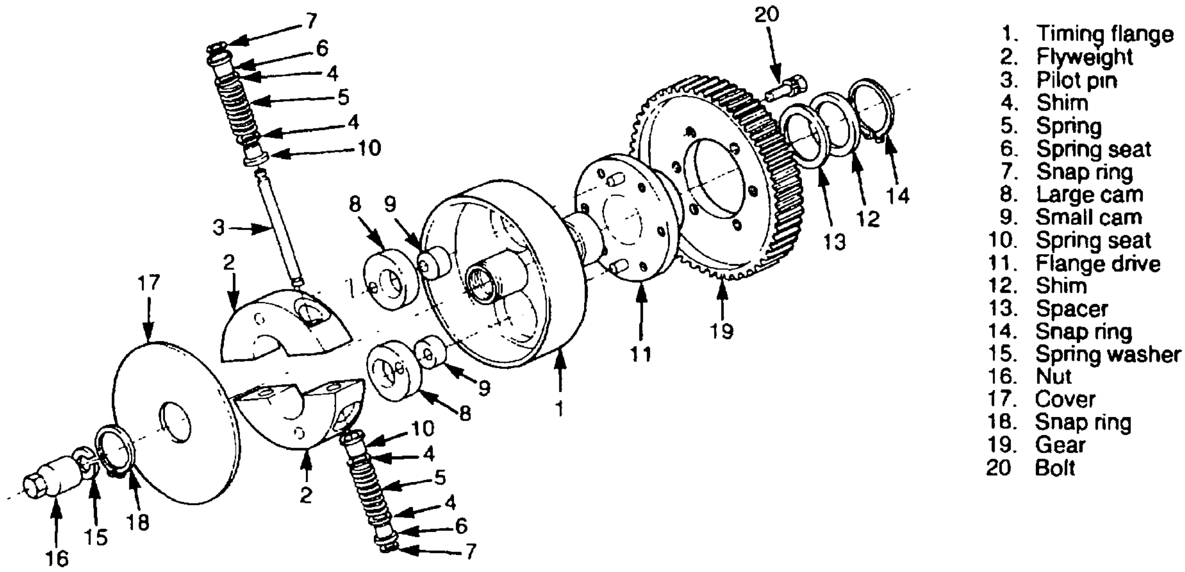


Figure 40 Automatic Timer – Exploded View

80. When the engine is operating at idle speed, the setting force of the four springs prevents the flyweights from expanding outward, but as the engine speed is gradually increased, the centrifugal force of the flyweights overcomes the setting force of the springs and the flyweights begin to expand outward. When the flyweights expand radially, the pivot pins connecting the flyweights to the large eccentric cams cause the large cams to rotate within the machined holes in the timing flange. The rotation of the large cams affects the small eccentric cams, which are located in the machined holes in the large cams and connected by pivot pins to the drive flange. As the large cams rotate in accordance with the movement of the flyweights, the small cams, which are held in position by the pivot pins on the drive flange, are caused to rotate around the pivot pins and within the large cams. The combined rotational movement of the large and small cams causes the timing flange to turn ahead of the drive flange and gear timing mark, and because the timing flange is connected directly to the injection pump camshaft. The injection timing also advances the same amount (refer to Figure 41). The timing flange limits the outward movement of the flyweight, which in turn limits the injection-timing advance, regardless of any engine speed increase.

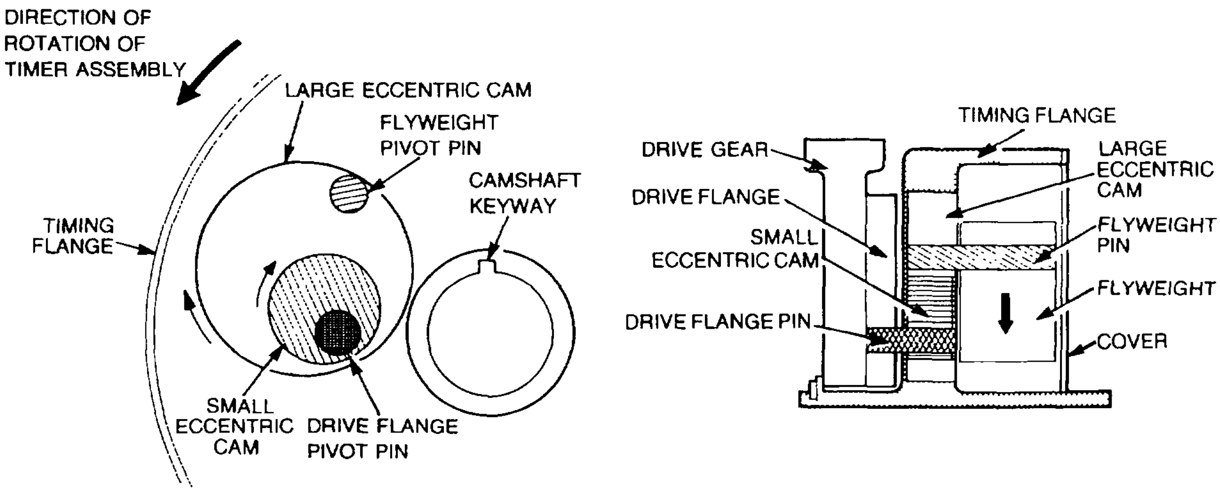


Figure 41 Automatic Timer – Static Position

81. When the engine speed is decreased to below that of maximum timing advance, the flyweight return springs overcome the centrifugal force of the flyweights and move the flyweights toward their static position. Both the large and small eccentric cams rotate in the reverse direction, moving the timing flange and fuel injection pump camshaft toward the normal timing mark (refer to Figure 42).

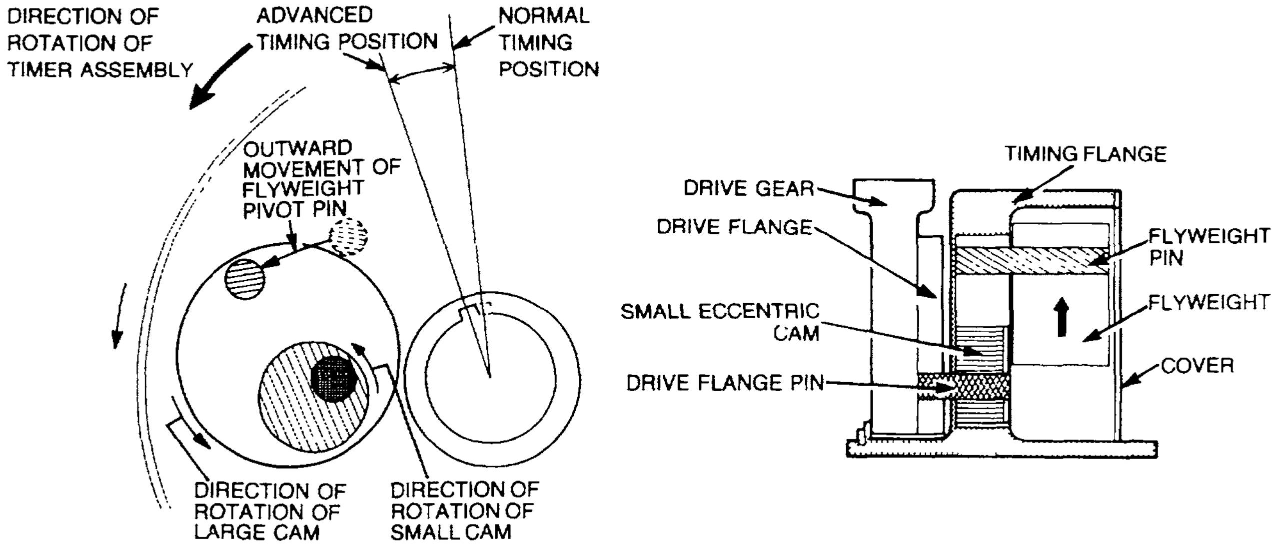


Figure 42 Flyweights in Timing Advance Position

Turbocharger

82. A turbocharger is fitted to the engine manifold and driven by exhaust gas energy. The turbocharger comprises three main components: the turbine, the bearing housing and the compressor.

83. The turbine consists of a housing and a wheel and shaft (which are manufactured in one piece), with the shaft mounted in sleeve type bearings located in the bearing housing. The bearings are pressure lubricated and cooled by oil from the engine lubricating system. Piston ring type seals are used at each end of the turbine shaft to effectively contain the oil to the bearing housing. Coolant from the engine cooling system flows through a water jacket surrounding the bearing housing, assisting with the cooling of the bearings.

84. The compressor impeller is secured to the end of the turbine shaft and rotates as one with the turbine. The turbine and compressor housings are positioned over their respective wheels and secured to the bearing housing. The turbocharger assembly is then secured to the exhaust manifold via the turbine-housing flange.

85. When the engine is running, the exhaust gas flowing from the exhaust manifold enters the turbine housing, where it flows radially inward increasing in velocity as the chamber decreases in size. The exhaust gas then flows through the specially designed vanes of the turbine, causing the turbine to spin as the gas passes through and enters the exhaust system.

86. As the turbine spins, the compressor impeller also spins, drawing air from the air cleaner through the central inlet of the compressor housing and then forcing the air into the chamber within the housing. The air then flows radially outward, through the diffuser, which enlarges in diameter as it winds outward to the crossover tube through which it flows to the inlet manifold.

87. As the compressor impeller draws in more air than the engine uses, the air accumulates in the crossover tube and inlet manifold where it increases in pressure. The pressure build-up of the air in the manifold causes additional air to flow into each cylinder as the inlet valves open, promoting a more complete combustion of the fuel, which in turn increases engine power and performance.

CAUTION

Always allow several seconds for oil pressure to build-up before accelerating the engine. Turbocharger bearing damage can occur when the turbocharger is operated at high speed without lubricant. This also applies when shutting down the engine. If the engine is shut down immediately after operating at a high rpm for an extensive period, the turbocharger will continue to rotate at a high rpm without lubricant. This in conjunction with the heat build-up during operation can easily cause turbocharger damage. Always allow the engine to idle for several minutes prior to shut down to allow the heat to dissipate and the rotational speeds of the turbochargers to slow down.

88. Good lubrication of the turbocharger bearings is essential because the turbocharger is precision machined and delicately balanced and operates at speeds in excess of 70 000 rpm. However, because the engine lubricating system lubricates the turbocharger, the delivery of oil to the turbocharger at engine start-up is not immediate.

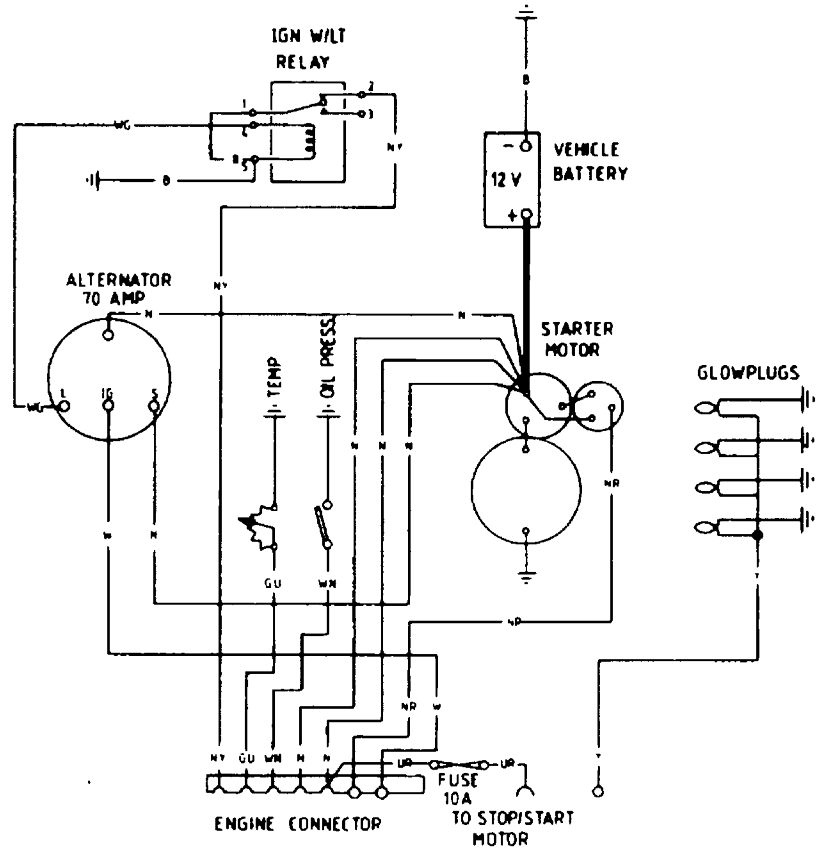


Figure 74 Engine Electrical Circuit

Starter Motor

159. The starter motor is a solenoid actuated drive type, i.e. the starter solenoid provides a means of engaging the drive pinion with the flywheel ring-gear for cranking the engine. The solenoid comprises a coil, a plunger and a lever. When the ignition switch is turned to OFF or IGNITION, current does not flow through the windings in the solenoid, thus the plunger and lever are held in the released position by spring pressure (refer to Figure 75).

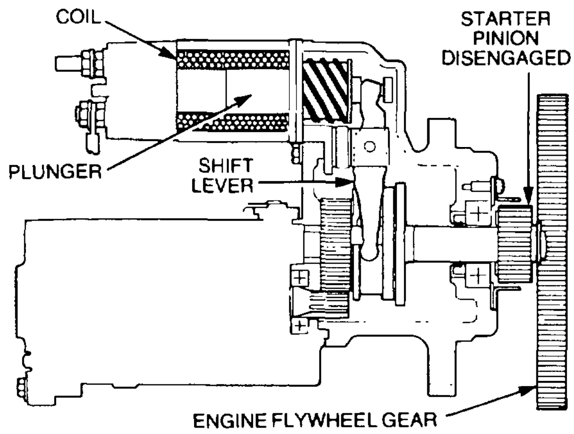


Figure 75 Ignition Switch OFF

160. When the ignition switch is turned to the starting position, current flows to the coil in the solenoid creating a magnetic field, which overcomes spring pressure and draws the plunger through the centre of the coil. As the plunger moves the lever, which is connected to the plunger also moves. The pivoting action of the lever moves the starter motor drive pinion into mesh with the flywheel ring-gear (refer to Figure 76). When the plunger reaches the end of its travel, it closes a set of contacts within the solenoid. These contacts permit full current flow direct from the battery to the starter motor. As the starter motor armature revolves, drive is transferred from the armature to the reduction gear, which is splined to the drive pinion shaft causing the drive pinion and thus the flywheel to revolve.

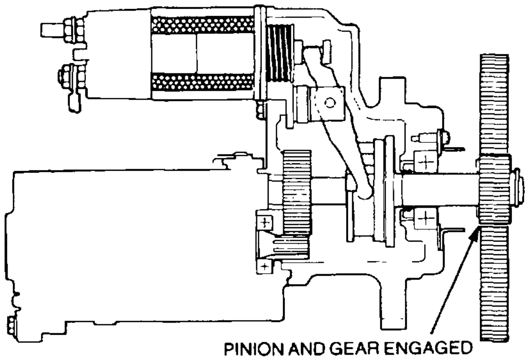
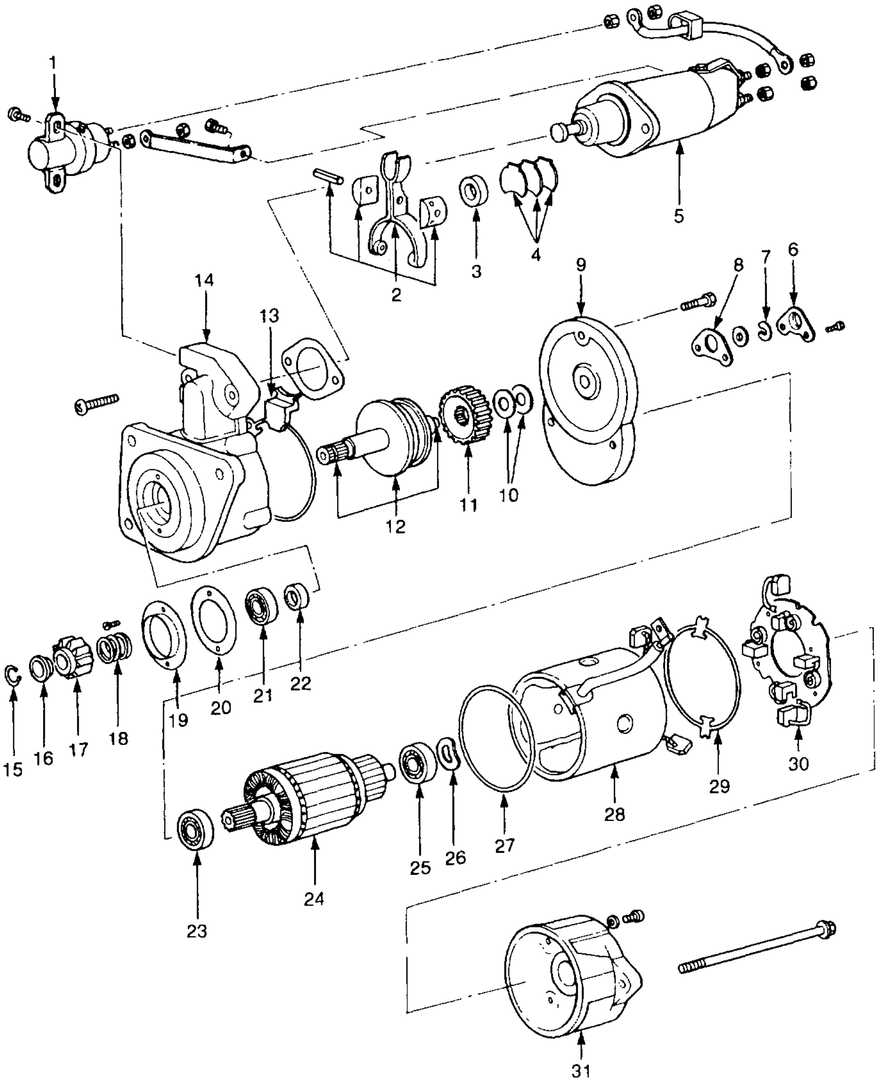


Figure 76 Ignition Switch in START

161. Figure 77 illustrates the various components of the starter motor.



1. Switch assembly
2. Lever assembly
3. Bush
4. Packing
5. Solenoid
6. Plate cover
7. Clip
8. Plate
9. Cover
10. Shims
11. Reduction gear
12. Clutch assembly
13. Seal
14. Clutch housing
15. Circlip
16. Collar
17. Pinion
18. Spring
19. Bearing cover
20. Bearing plate
21. Pinion bearing
22. Seal
23. Bearing
24. Armature
25. Bearing
26. Washer
27. Seal
28. Yoke
29. Seal
30. Brush holder assembly
31. End cover

Figure 77 Starter Motor – Exploded View

Alternator

162. The alternator utilises an integral regulator. The alternator is a 12 V type, with an output capability of 70 amperes. It is mounted on a bracket fitted to the left-hand side of the engine. Drive for the alternator comes from the crankshaft pulley via a V-belt. The alternator is comprised of a stator, a rotor, slip rings, brushes, and diode rectifiers. The stator is composed of three windings, which are wound on the inside of a laminated core. The field coil is wound on the rotor, which rotates within the stator (refer to Figure 78). The two brushes each ride on slip rings which are connected to their particular end of the field coil winding. The diode rectifiers connect the stator windings to the alternator output terminal.

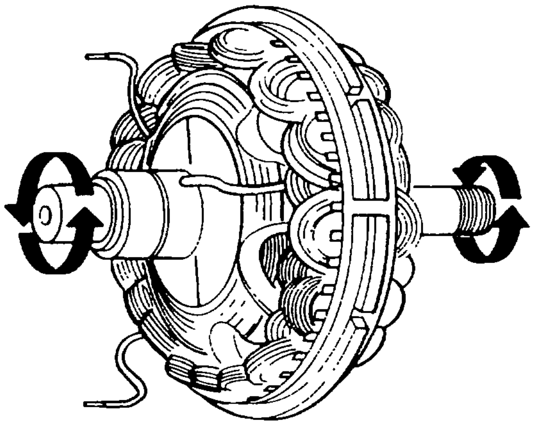


Figure 78 Rotor and Stator Assembly

163. When the ignition is turned ON, the Ignition warning light illuminates and battery voltage is applied via the ignition switch to the voltage regulator, to the field terminal (B) on the alternator and from the field terminal through the inner carbon brush to the inner slip ring. The current then flows from the inner slip ring through the field coil, where it creates a magnetic field to earth via the outer slip ring and carbon brush (refer to Figure 79). However, a current is not generated while the rotor is stationary. When the engine is started and both the rotor and magnetic field are rotated by the V-belt, the lines of force of the rotating magnetic field cut across the stationary stator windings, causing Alternating Current (AC) to flow in the stator windings and from there to the rectifiers. The current can only flow in one direction through the diodes. Thus the AC, which flows back and forth, is changed to Direct Current (DC), which flows in one direction only and is used to charge the battery, as well as to provide the current for the vehicle's electrical equipment.

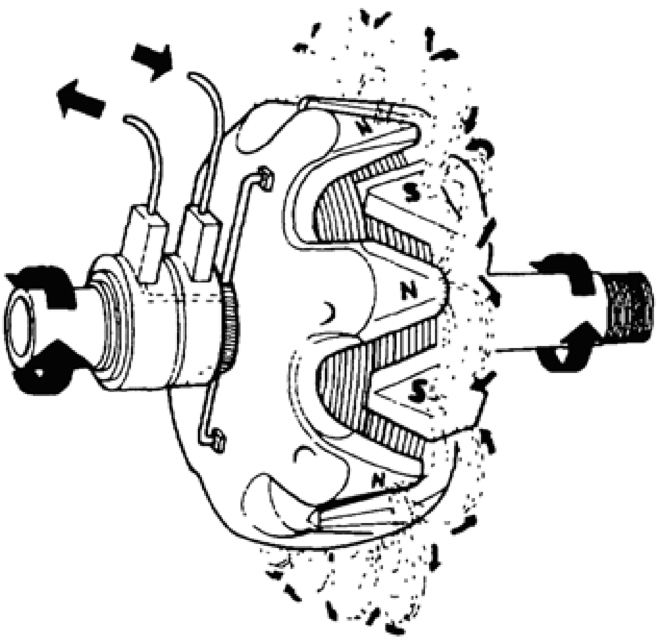


Figure 79 Rotor and Magnetic Field

164. A vacuum pump is fitted to the alternator rear cover and is driven by the alternator's rotor shaft, which is extended to protrude from the alternator rear cover and splined to drive the vacuum pump rotor. The vacuum pump consists of a housing, a rotor and four vanes, and is used to supply vacuum for the brake servo chamber as well as provide the means of actuating the transmission differential lock.

165. Figure 80 gives an exploded view of the alternator and vacuum pump assembly.

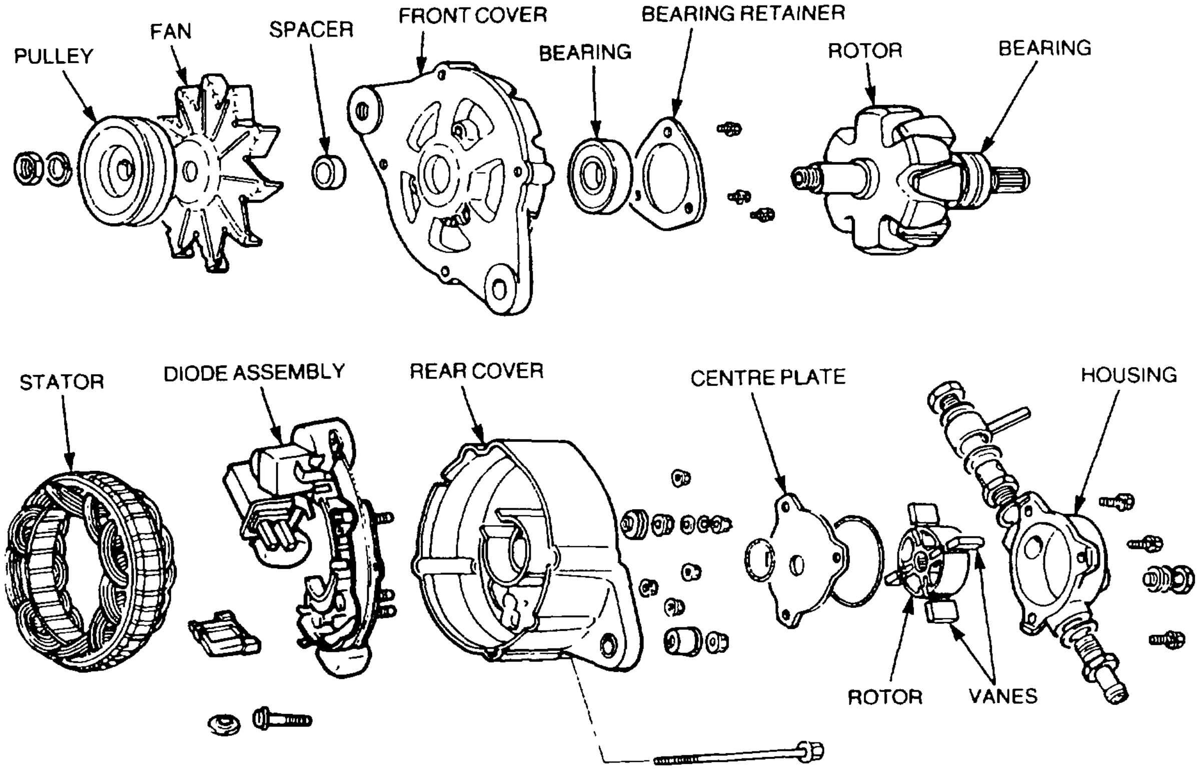


Figure 80 Alternator and Vacuum Pump – Exploded View