SEMI-TRAILER, TANK, WATER, HEAVY, MC4, FRUEHAUF 37 000 LITRE

TECHNICAL DESCRIPTION

This instruction is authorised for use by command of the Chief of Army. It provides direction, mandatory controls and procedures for the operation, maintenance and support of equipment. Personnel are to carry out any action required by this instruction in accordance with EMEI General A 001.

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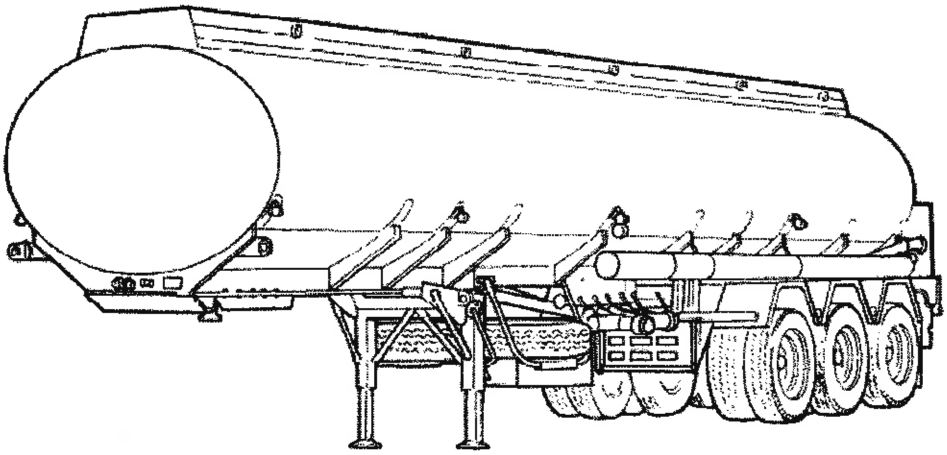


Figure 1 Semi-Trailer, Tank, Water, Heavy, MC4, Fruehauf 37 000 Litre

1. This EMEI contains the technical description of the Semi-Trailer, Tank, Water, Heavy, MC4, Fruehauf 37 000 litre (Figure1). All relevant weights, dimensions and performance figures are detailed in the Data Summary, EMEI Vehicle H 710.

Asscociated Publications

2. Reference may be necessary to the latest issue of the following documents:

a. Simplex Complete Equipment Schedules (CES) 12079;

b. Repair Parts Scale (RPS) 02200;

c. EMEI Vehicle H 710 - Truck, Tank, Water, Heavy, MC4 – Data Summary;

d. EMEI Vehicle H 713 - Truck, Tank, Water, Heavy, MC4 – Light Grade Repair;

e. EMEI Vehicle H 714-1 -Truck, Tank, Water, Heavy, MC4 – Medium Grade Repair; and

f. EMEI Vehicle H 719 -Truck, Tank, Water, Heavy, MC4 – Servicing Instruction.

Rotable Item Identification

3. Table 1 lists the location of identification numbers for the rotable items:

Table 1 Rotable Items Identification

Serial	Rotable Item	Location of Identification No.
1	Axle	Stamped on the axle
2	Engine	Stamped on the identification plate and the crankcase

GENERAL INFORMATION

4. The Semi-Trailer, Tank, Water, Heavy, MC4 is used to facilitate the movement of potable and non-potable water over all types of roads and short distances off road. The trailer is based on the standard Fruehauf TAG 37 000 litre commercial tanker. The trailer is fitted with a pin coupling at the rear to enable it to be used in conjunction with other trailers in a road train configuration.

Axles

5. The axles are Fruehauf Propar axles fitted with air-operated, S-cam actuated twin-shoe drum brakes. The axles are rated at 11.3 tonne for continuous operation. However, this is limited to 9 tonne per axle by the suspension.

Suspension

6. The trailer utilizes a Fruehauf F3 bolt-on undercarriage suspension to provide an extreme axle centre spacing of 2490 mm (Figure 2). Five stiffener plates are welded to the undercarriage mounting rails and are then bolted to the tank mounting rails. Six semi-elliptic leaf springs and four equaliser beams provide the suspension with a continuous operation rating of 27 tonne. Under emergency conditions a rating of 37 tonne can be applied.

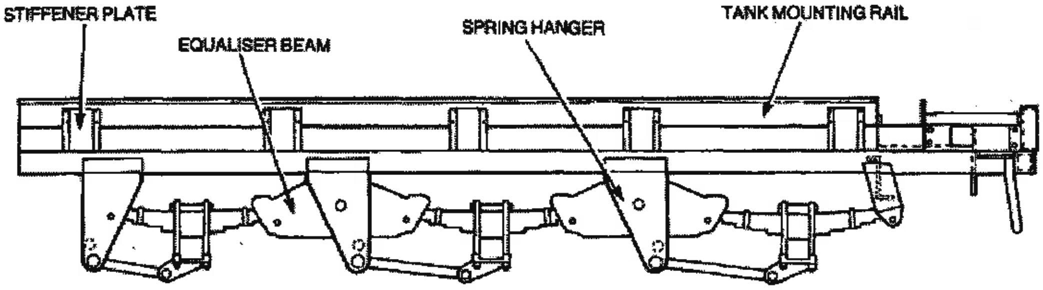


Figure 2 F3 Bolt-on Suspension

Service Brakes

7. Air operated brakes comprising a service brake and spring brake chamber are fitted to each axle on the trailer. The service and emergency lines are connected to the towing vehicle via Glad Hand couplings. This supplies air to the three air reservoirs (Figure 3) which supply the service and emergency parking brakes and the braking system of a towed dolly converter.

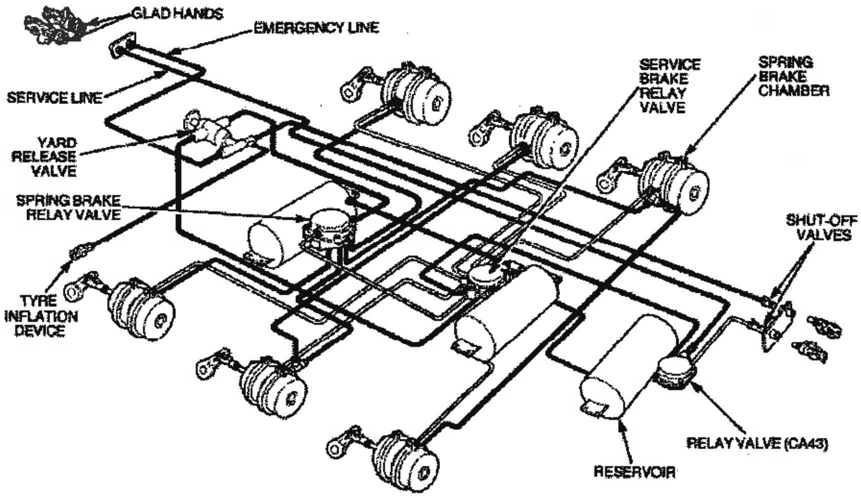


Figure 3 Air Brake System

8. The service brakes are S-cam actuated drum brakes, and operate when air pressure acting on a plunger diaphragm force a lever to turn the S-cam between rollers attached to the brake shoes, causing the brake linings to bear against the drum surface.

9. The service and emergency air lines for connection to the towing vehicle are connected to the front of the trailer. Air connections for a towed dolly converter are located at the rear of the trailer on a fixed plate attached to the tow coupling mounting. The towed dolly converter air connections are fitted with hand operated shutoff valves.

Emergency and Park Brakes

10. Spring brakes are used as emergency and parking brakes and are fitted to all axles. The spring brakes are integral with the service brakes in the brake chambers, but unlike the service brakes which are air operated, the emergency/parking brakes are spring operated. The strong springs are normally held in a compressed state by air pressure acting against the diaphragm on which the spring sits. Only when air pressure is removed, either by driver control when applying the parking brakes or by loss of air from the brake system, will the springs expand and apply the brakes on each axle.

11. A hand operated yard release valve is fitted to enable the semi-trailer to be moved without connection to a towing vehicle's air supply. Residual air in the trailer reservoirs is utilized to release the spring brakes, via the yard release valve. This method can only be used twice before exhausting the air supply.

Water Tank

12. The fabricated aluminium water tank comprises five separate compartments of which only the centre three are utilized under normal operating conditions. This allows for the carriage of 24 690 litres of water. Individual compartment water capacities are as follows:

- **a.** first compartment 8140 litres (not utilised);
- **b.** second compartment 8230 litres;
- **c.** third compartment 8230 litres;
- **d.** fourth compartment 8230 litres; and
- **e.** fifth compartment 4170 litres (not utilised).

13. In addition, the following items are fitted to the water tank:

- **a.** the king pin apron plate,
- **b.** the 90 mm king pin,
- **c.** the support legs,
- **d.** the 50 mm tow coupling,
- **e.** the spare wheel carrier,
- **f.** the water manifold and interconnecting compartment tubes,
- **g.** two stowage bins,
- **h.** the ladder,
- **i.** the power unit and pump,
- **j.** the hose stowage tubes,
- **k.** slinging and tie-down points, and
- **l.** the priming pump.

Power Unit

14. The power unit (Figures 4 and 5) is a Lombardini 3LD510 single cylinder, four-cycle diesel, direct injection, air-cooled engine. The engine has a compression ratio of 17.5:1, and bore and stroke dimensions of 85 mm x 90 mm respectively. The power developed by the engine is 8.1 kW (11 bhp) at 3000 rpm, with a maximum torque of 29.42 N.m (21.7 lbf.ft) at 2000 rpm. The power unit and water pump assembly is located in an enclosure at the left-hand rear of the trailer.

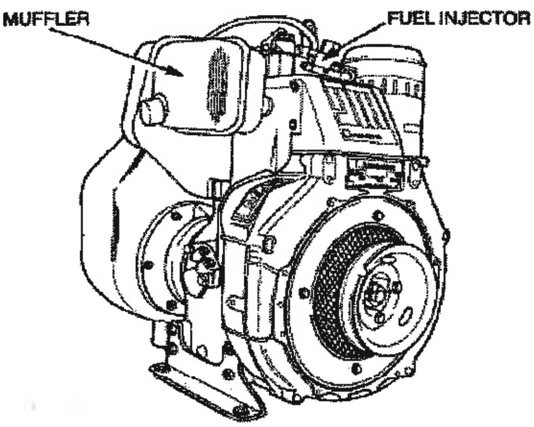


Figure 4 Power Unit – Right-hand View

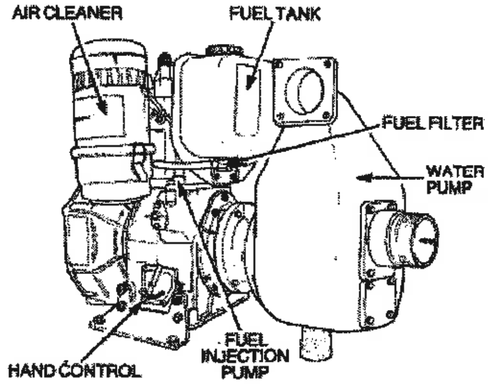


Figure 5 Power Unit – Left-hand View

Water Pump

15. The water pump is a Regent 80 SP-LD vane type pump which is flange mounted to the power unit and is directly driven by the power unit via the crankshaft.

Priming Pump

16. The priming pump is a hand operated Simac double acting semi-rotary pump, with a pumping capacity of 27 litres (6 gallons) per minute.

Lighting

17. The semi-trailer is fitted with standard 12 Vdc rear vehicle lighting, side clearance lights and an indicator light mounted mid-way down each side of the tank. Two combination blackout, stop and marker lights are fitted in close proximity to the rear lighting (Figure 6).

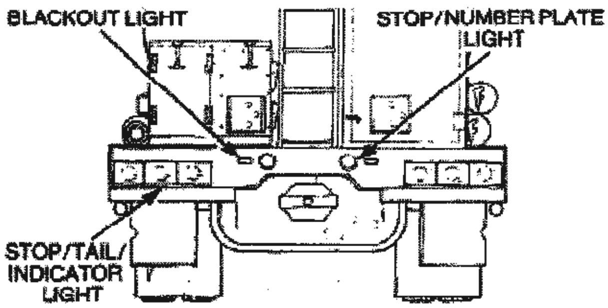


Figure 6 Semi-Trailer Lighting

Electrical Trailer Connector

18. A 12-pin NATO socket is attached to the front coaming rail of the trailer for connection to the towing vehicle. A 12-pin NATO socket is attached to a panel at the rear of the trailer for connection of a towed dolly converter.

Hubodometer

19. A Stemco-Engler hubodometer is located on the left-hand side of the trailer's centre axle and records the total distance travelled in kilometres for servicing purposes.

Wheels

20. The wheels on the trailer consist of 8.25 DC x 22.5 in one piece rims on cast spoke hubs. Each rim is fitted with an 11R22.5 16 ply tubeless radial tyre. A 4.25 in. spacer is utilized between the dual wheels. A tyre inflation facility is located on the left-hand side of the trailer.

DETAILED TECHNICAL DESCRIPTION

Axles

21. The axle tube is formed from a square section steel billet approximately 127 mm (5 in.) across the flats and an overall length of 2086 mm (82.125 in.). Brackets are welded to the axle tube to allow the S-cam shafts and brake chambers to be mounted in a cams-front configuration (Figure 7). A backing plate is welded to the tube to act as a mounting bracket for the brake shoes.

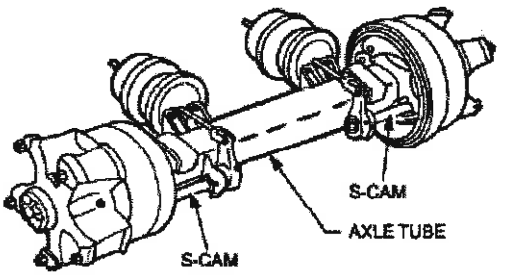


Figure 7 Axle Assembly

22. The hubs are supported on two tapered roller bearings on the axle tube and are retained by a hexagonal nut and tab washer. The hub is a cast five-spoke one-piece type and is secured to the brake drum by five bolts, washers and nuts. A transparent hub cap is fitted to allow oil level to be checked at a glance on five out of the six hubs (Figure 8). The remaining hub is fitted with a hubodometer in place of the hub cap.,

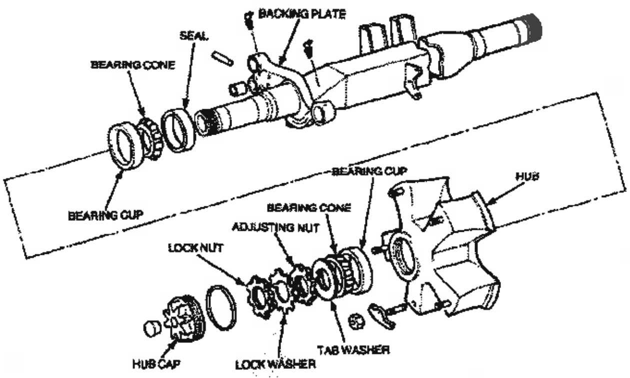


Figure 8 Axle And Hub - Exploded View

23. Two semi-elliptic 13-leaf springs are secured to each axle, along with a saddle plate, by four U-bolts. Each spring is located in a spring hanger and equaliser beam, but not secured. Wear plates are provided in the hanger and beams (Figure 9). Three adjustable radius rods are installed on the right-hand side of the trailer, to enable the axle alignment to be adjusted.

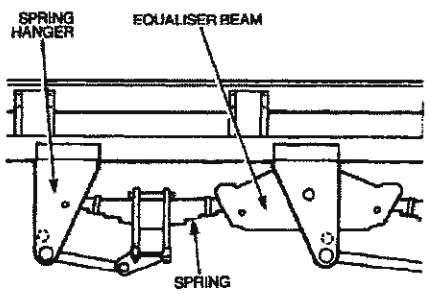
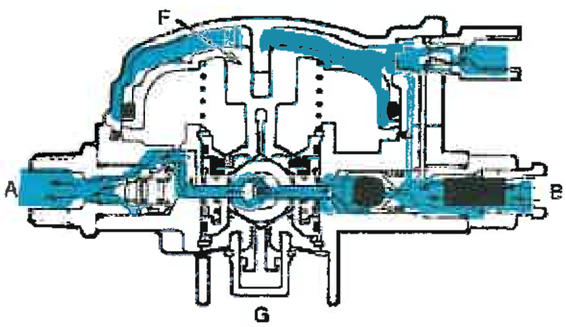


Figure 9 Spring Hanger and Equaliser Beam

Emergency and Parking Brakes

24. A spring brake relay valve is installed on the front reservoir to provide a means of admitting and releasing air to and from the spring brake chambers. Air supplied from the towing vehicle, via the emergency line, enters the spring brake relay valve (CA41 PARC) through the check valve and filter assembly located in port B. The air then passes through the valve body and exits through port A, which is directly mounted to the reservoir, to supply the reservoir. Emergency air also passes through a body drilling to allow air to enter the chamber above piston F (Figure 10). At this stage, air is prevented from entering the spring brake chambers by the holdback piston assembly, valve E (Figure 11).



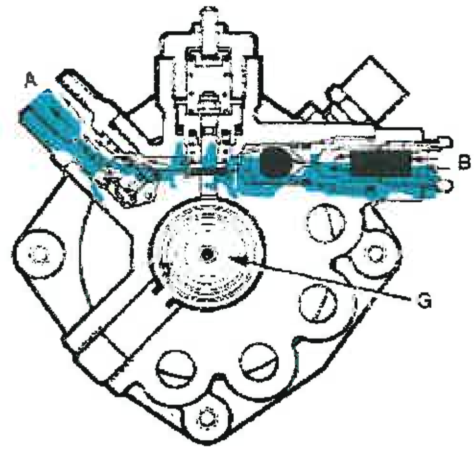
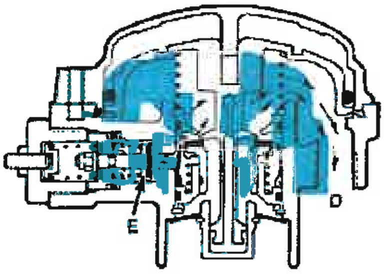


Figure 10 Spring Brake Relay Valve – Charging



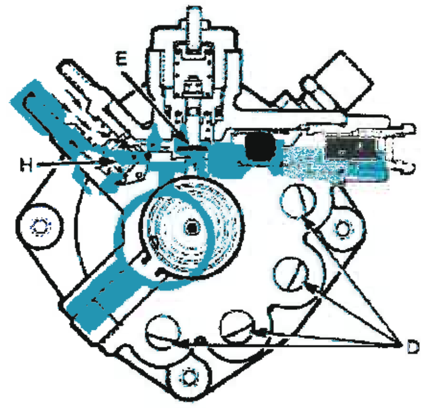


Figure 11 Spring Brake Relay Valve – Release

25. When air in the service reservoir reaches approximately 435 kPa (63 psi), the valve E opens and allows air through the four D ports releasing the springs brakes (Figure 11). A pressure balance now occurs at valve H. In the event of the air emergency line failing, all air is exhausted from port B, piston F is raised to open ports D (4 x) and G. Air in the spring brake chambers is now vented through port G, allowing the spring brakes to apply (Figure 12).

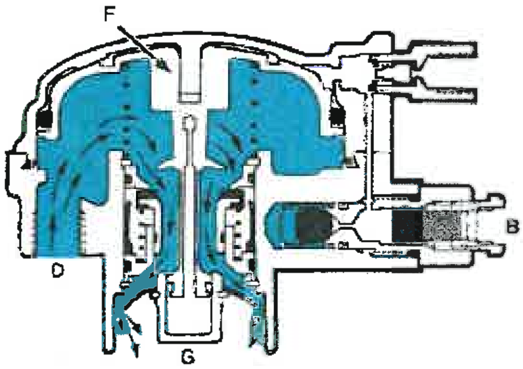


Figure 12 Spring Brake Relay Valve – Emergency Line Failure

26. Should the spring brake relay valve become detached from the air reservoir or a service brake chamber diaphragm fail, the brakes will not apply on any axle due to valve H sealing the reservoir port A and containing full line pressure in the spring brake system (Figure 13).

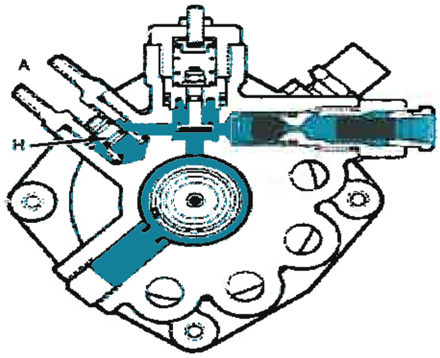


Figure 13 Spring Brake Relay Valve – Service Line Failure

27. As the emergency line pressure decreases, piston F rises to open ports D to exhaust port G and applies the spring brakes (Figure 14). Valve H now returns to the open position under spring pressure. The spring brakes cannot be released until the fault has been rectified.

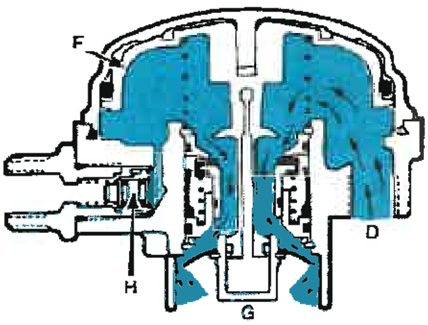


Figure 14 Spring Brake Relay Valve – Application

28. The spring brake relay valve is designed to prevent both service and spring brakes applying together. Air pressure through port B holds the check valve in port C, which is connected to a delivery line running from the relay valve, in the closed position. Should the towing vehicle brakes be applied and the emergency line be exhausted simultaneously, e.g. tractor protection valve being applied, delivery air pressure from the relay valve would pass through the check valve in port C (Figure 15) and depress piston F. This in turn, would hold the spring brakes in the released position until the brake valve in the towing vehicle is released.

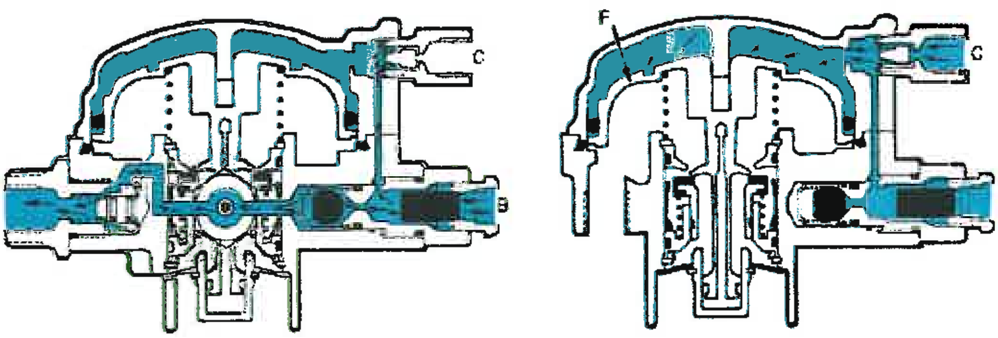


Figure 15 Spring Brake Relay Valve - Anti-Compound Function

Service Brakes

29. The relay valve (CA43) is fitted to speed up the application and release time of the trailer brakes in conjunction with the towing vehicle's foot brake valve. The valve is fitted in the rear air reservoir. When the relay valve is in the **OFF** position, the exhaust port is open which allows the service brake chambers to remain at atmospheric pressure.

30. When the foot brake is applied, air is passed down the service line from the towing vehicle and enters port A in the top cover (Figure 16). The piston moves downwards closing the exhaust port. Further increase in service line pressure allows air to pass from the air reservoir to the service brake relay valve via the delivery port. When the service line pressure decreases, the upper piston moves up closing the inlet port and opening the exhaust port. Rapid decrease in service line pressure causes the valve to react like a quick release valve.

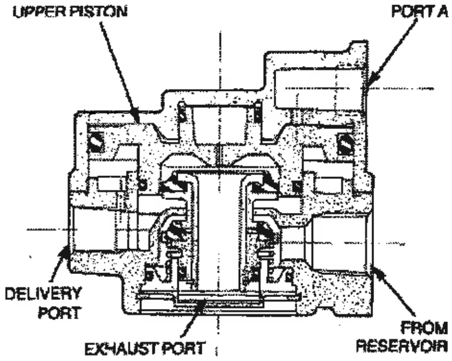


Figure 16 Relay Valve – Released Position

31. The service brake relay valve (CA38) is fitted to control the air pressure to the service brake chambers in conjunction with the towing vehicle's foot brake valve and the CA43 relay valve. The relay valve is installed on the centre air reservoir. When the relay valve is in the **OFF** position, the exhaust port is open, which allows the service brake chambers to remain at atmospheric pressure.

32. When the foot brake is applied, air is passed down the service line from the towing vehicle via the relay valve (CA43) and enters port A in the top cover (Figure 17). The piston moves downwards closing the exhaust seat against the inlet/exhaust valve. When the pressure acting on the piston is sufficient to overcome the valve spring, the inlet/exhaust valve is moved away from the inlet seat and air pressure is delivered to the service brake chambers directly from the reservoir.

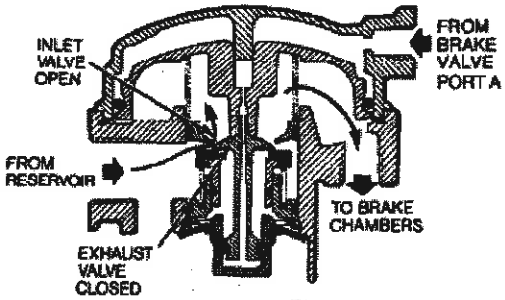


Figure 17 Service Brake Relay Valve – Applying Position

33. As compressed air builds up in the brake chambers, the pressure builds up on the underside of the piston, moving the piston upwards allowing the inlet/exhaust valve to contact the inlet seat in the body. The valve is in a balanced state with the inlet and exhaust seats closed. In this condition, the valve has delivered compressed air corresponding to the driver's application of the brake pedal (Figure 18).

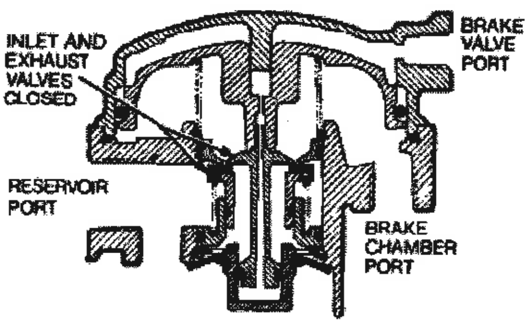


Figure 18 Service Brake Relay Valve – Balanced Position

34. As the driver exerts more pressure on the brake pedal, the pressure on the top of the piston is increased. This moves the inlet/exhaust valve away from the inlet seat and allows more compressed air to flow to the service brake chamber. If the driver permits the pedal to return slightly, some air is exhausted from the foot brake valve and from the top of the piston, allowing the piston to move upwards and opening the exhaust passage, releasing some air from the service brake chambers to atmosphere.

35. When the driver releases the foot brake completely, all the air is released from the top of the piston through the brake valve, allowing the piston to rise and opening the exhaust passage (Figure 19). This allows all the air from the service brake chambers to pass through the exhaust diaphragm to atmosphere and release the brakes fully.

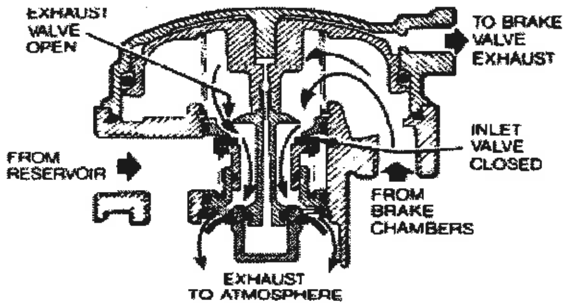


Figure 19 Service Brake Relay Valve – Release Position

Slack Adjuster

36. The slack adjusters act as a lever during normal braking for brake application, provide a means of adjusting the brakes, and prevent the over extension of the diaphragm. Brake adjustment can be made after depressing the worm shaft lock and then turning the adjusting screw of the adjuster with a spanner so that is rotates the worm shaft (Figure 20).

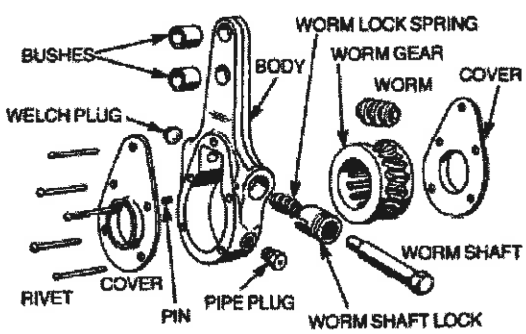


Figure 20 Slack Adjuster – Exploded View

37. The worm shaft meshes with the worm gear which is connected to the brake cam, so by turning the worm gear the brake cam spreads the shoes and compensates for lining wear. The slack adjuster screws must be locked after adjustment and the adjuster must be just over 90 degrees to the brake chamber push rod when the brakes are applied (Figure 21).

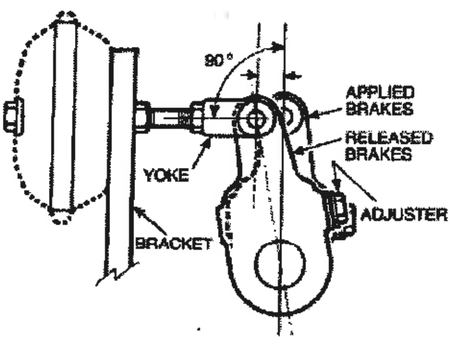


Figure 21 Slack Adjuster – Adjustment

Spring Brake Chambers

38. The spring brake chamber can be used as a parking brake, an emergency brake in the event of loss of air from the service brakes and an emergency brake operated from a cab mounted valve. During normal driving, air pressure overcomes the pressures exerted by the spring in the spring brake chamber (Figure 22).

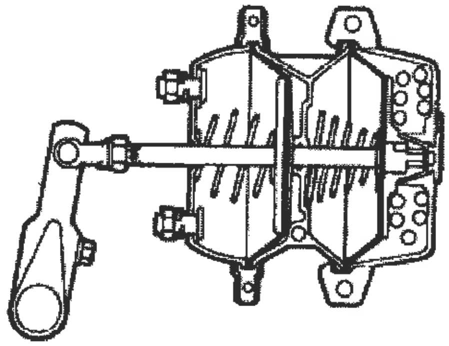


Figure 22 Spring Brake Chamber – Normal Driving

39. As the footbrake is applied, the spring remains compressed and the service brake chamber is allowed to operate independently (Figure 23).

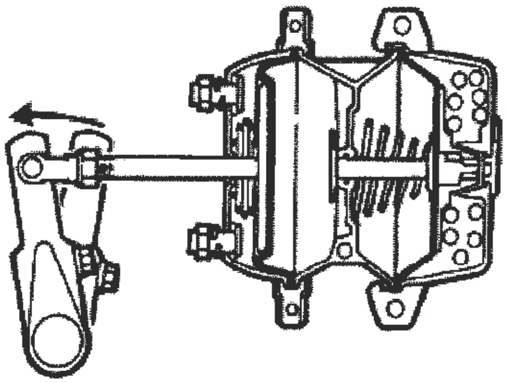


Figure 23 Spring Brake Chamber – Service Brake Application

40. When the park brake valve is operated in the towing vehicle, air is exhausted from the spring brake chamber (Figure 24) permitting the spring to apply the service brake. In the event of an air loss in the spring brake circuit the brakes would apply automatically.

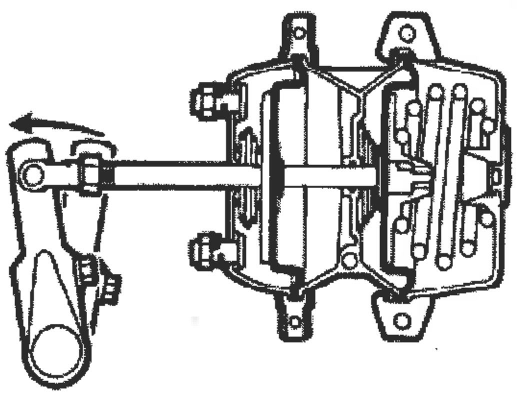


Figure 24 Service Brake Chamber – Parking or Emergency Application

41. A provision has been incorporated in the spring brake chamber to mechanically release the spring, by releasing the special tool from its holder and inserting it into the pressure plate (Figure 25). Turn the release tool one quarter of a turn to seat the cross pin, then turn the nut until the spring is fully compressed. This provision is for emergency use only.

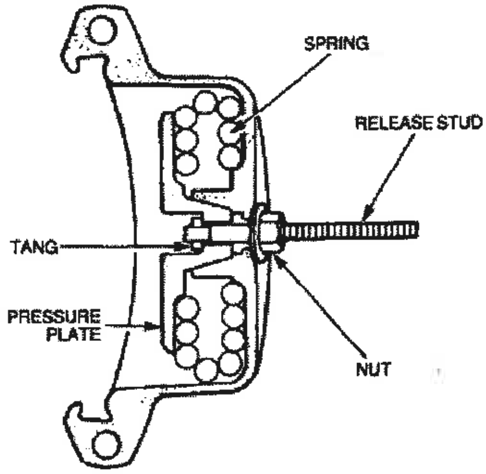


Figure 25 Spring Brake Release Stud

WATER TANK

Construction

42. The tank is constructed from 6 mm aluminium sheeting that is rolled and seam welded to form three individual sections. These sections are butt welded together to form the complete tank barrel length. Preformed baffles, bulkheads and end sections are also welded into the tank.

43. The J-rails (mounting rails) and the top rails are welded to the tank, with the outrigger and relevant belly pads and braces welded to the tank and the J-rails. An access manhole, dip tube and vent/overflow tube is installed in each compartment (Figure 26).

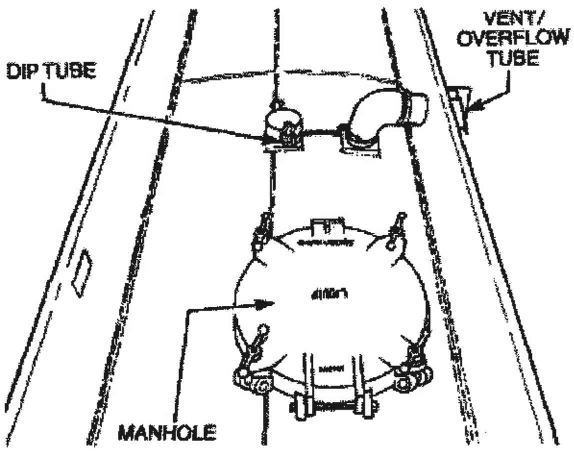


Figure 26 Manhole, Dip Tube and Vent Tube

King Pin Apron Plate

44. Bolted to the forward section of the mounting rails, beneath the trailer, is an 8 mm (5/16 in.) mild steel apron plate with provision for mounting a 90 mm (3-1/2 in.) Jost KZ 1708 removable king pin. The king pin is bolted to the apron plate by eight bolts, washers and nuts.

Support Legs

45. Two Jost E 200 G retractable support legs, fitted with sandshoes are mounted on a plate bolted to the J-rails to support the trailer and load when the trailer is uncoupled from the prime mover (Figure 27). The left-hand support leg has a two-speed gearbox operated by a crank handle, which transmits drive to the right-hand support leg via a connecting shaft to ensure concurrent operation of both support legs.

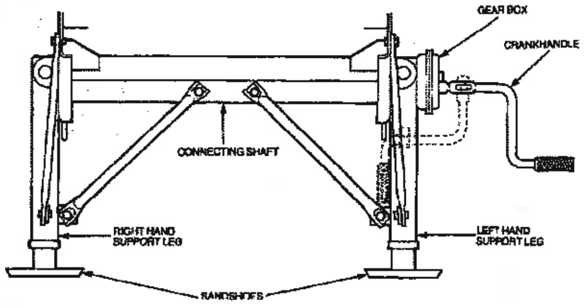


Figure 27 Retractable Support Legs

46. Mounted to the rear of the trailer is a VBG-8005 50 mm (2 in) automatic pin coupling (Figure 28) to allow for the coupling of a dolly converter and trailer for road train use. The coupling is capable of towing a laden 50 tonne trailer. With the coupling pin in the raised position, the drawbar eye, when it enters the jaw, releases the pin which automatically passes through the drawbar eye and locks in position. When coupling is achieved the pin is locked in position with the primary bolt lock which is integral with the lift lever.

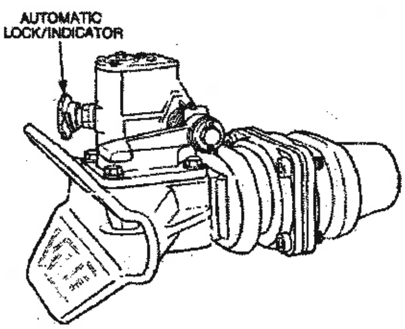


Figure 28 Tow Coupling

47. An automatic lock/indicator gives added security by indicating that the coupling pin is in the locked position and acts as a secondary safety lock. Normal rotational movement is 40 degrees, after which the coupling returns to the neutral position. In the event of a roll-over accident the coupling can rotate through 360 degrees in its mounting without damage to the towing vehicles chassis, drawbar or coupling.

Spare Wheel Carrier

48. The spare wheel carrier is manufactured from tubular steel pipe, mild steel channel and mild steel plate, and mounted to the rear of the support legs. Sufficient space is provided for the carriage of two spare wheels.

Water Manifold

49. The water manifold is mounted on the left-hand side of the trailer, and has five individual flow control valves which are connected via pipes to the five compartments. A common manifold tube fitted with two control valves is flange mounted to the flow control valves (Figure 29) to allow for loading and discharge of water. The water pump inlet/outlet is connected to the manifold via cam-locks and a rubber hose.

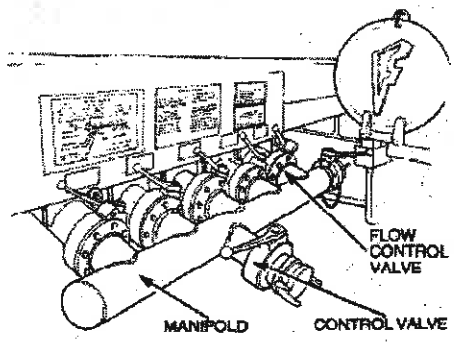


Figure 29 Water Manifold

Stowage Bins

50. Mounted on the trailer are two 1200 mm x 800 mm x 550 mm bins to allow for the stowage of camouflage nets and SCES items. One bin is located on the right rear of the trailer (Figure 30) with the other bin mounted on the right-hand side of the trailer forward of the axles.

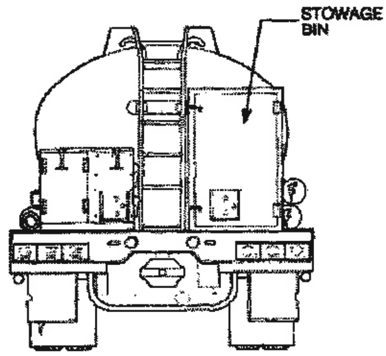


Figure 30 Stowage Bins

Power Unit

51. The engine crankcase (Figure 31) is a one piece casting made of aluminium alloy. The crankshaft (Figure 32) is made from high tensile steel forging, which is machine ground to close limits and fully counterweighted. The crankshaft revolves in two replaceable single-piece bearings.

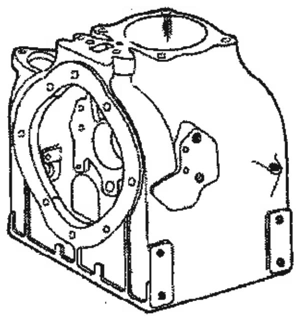


Figure 31 Engine Crankcase

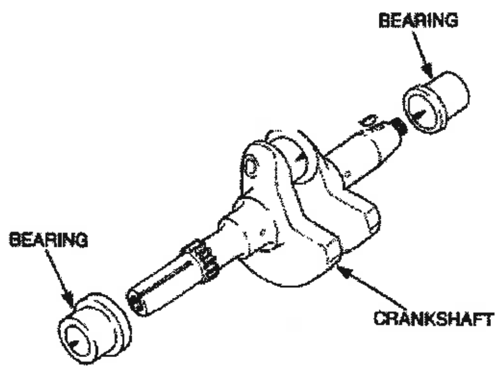


Figure 32 Crankshaft and Support Bearings

52. The piston connecting rod is made from cast steel and machined to fit a bearing at the crankshaft (large) end, and a bush at the piston (small) end (Figure 33). A removable bearing cap, which is bolted to the large end of the connecting rod, enables a precision shell type bearing to be installed and the connecting rod secured to the crankpin on the crankshaft. The piston is made of high strength aluminium silicium alloy with four machined grooves to permit the fitting of three compression rings and one oil ring (Figure 33), and is secured to the connecting rod by means of a gudgeon pin (piston pin) and two circlips.

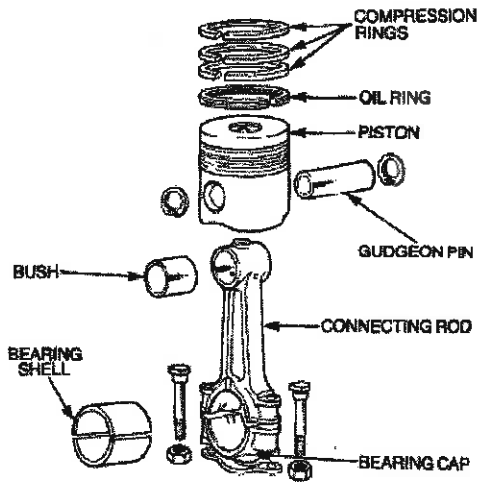


Figure 33 Piston and Connecting Rod

53. The cylinder, which can be re-bored, is made of cast-iron and has cooling fins cast in the outer section to dissipate heat (Figure 34). The cylinder head is made of aluminium alloy and provides the cylinder with one inlet and one exhaust port. The valve seats are inserts, secured in position by an interference fit. Coil springs are used to close each valve against the valve seats, while pushrods and rocker arms are used to open the valves. Provision is made in the cylinder head for the fitting of the fuel injector.

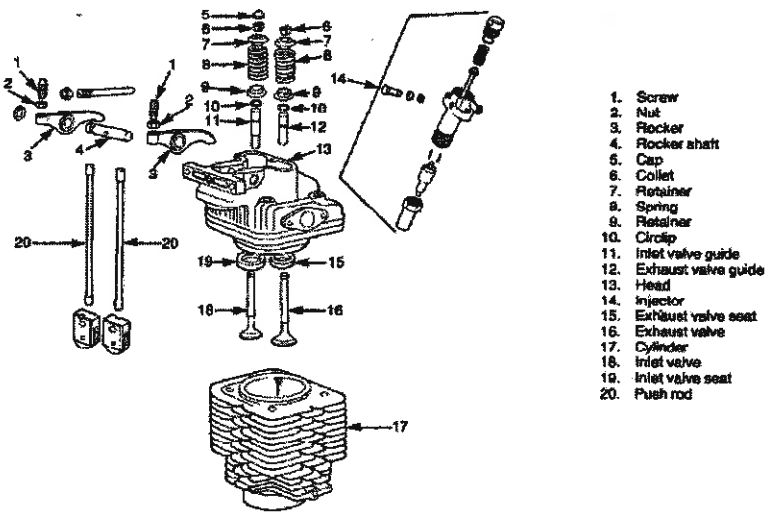


Figure 34 Cylinder and Cylinder Head – Exploded View

54. The camshaft is precision machine ground from a solid drop-forging and comprises three cam lobes, of which two control the opening and closing of the inlet and exhaust valves, while the third controls the operation of the fuel injection pump via a rocker lever. Drive for the camshaft comes directly from the crankshaft by means of timing gears fitted to both the crankshaft and the camshaft. The timing gears have a 2:1 ratio, i.e. the crankshaft revolves twice for every revolution of the camshaft.

Lubrication System

55. The function of the engine's lubrication system is to provide the working components of the engine with the lubricant required to function smoothly with minimal frictional losses (Figure 35). The lubrication system comprises:

a. an oil pan (sump);

b. an oil pump;

c. a pressure regulator;

d. a suction tube; and

e. oil galleries.

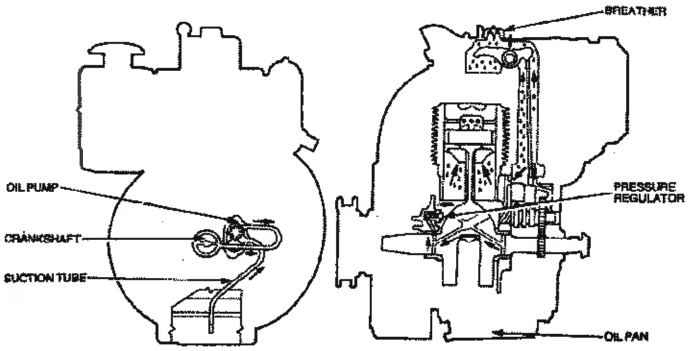


Figure 35 Engine Lubrication System

56. The oil pan is of a pressed steel construction, secured by bolts to the bottom of the engine crankcase to provide a storage reservoir for the engine's lubricating oil. The oil pan has a storage capacity of 1.75 litres, which can be monitored by means of a dipstick on the muffler side of the engine, for both quality and quantity.

57. The oil pump, illustrated in Figure 36, is a spur gear type pump located within the crankcase and driven by the crankshaft timing gear. The pump utilises a pair of meshing spur gears; one gear is driven by the pump drive shaft, while the second gear is caused to rotate by the first. When the pump gears are rotating, a low pressure area is created within the pump which in turn draws oil up the suction tube into the pump housing. The meshing of the spur gears displaces the oil from the pump into the oil galleries to the various components requiring lubrication. An oil pressure regulator is utilised to maintain the oil under pressure and is located in the crankshaft support at the flywheel end of the crankshaft.

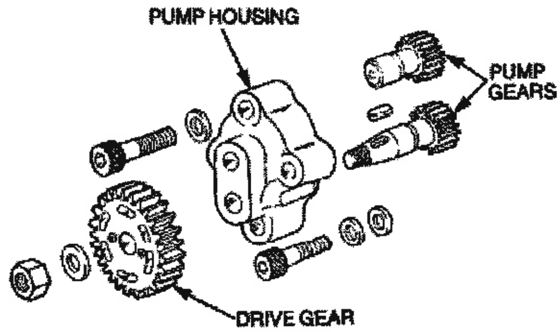


Figure 36 Oil Pump – Exploded View

Fuel System

58. The fuel system, illustrated in Figure 37, comprises:

- **a.** one fuel tank of 5.3 litre capacity,
- **b.** a fuel pump and filter, and
- **c.** a fuel injector.

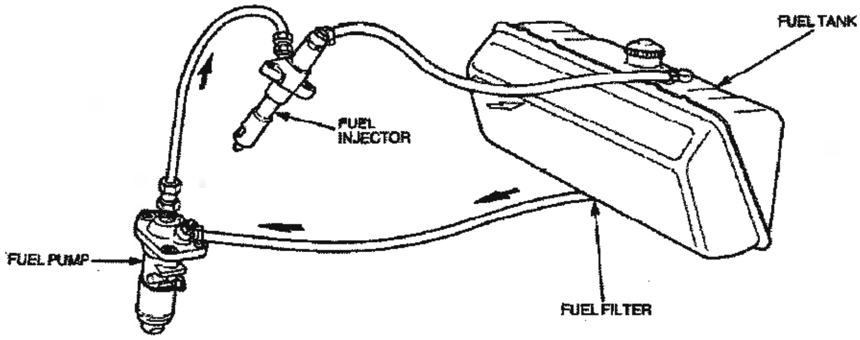


Figure 37 Fuel System

Fuel Flow

59. A tank secured to the top of the engine provides storage for the engine's fuel supply. A replaceable filter element is incorporated in the bottom of the tank to prevent contaminants entering and damaging the internal components of the fuel injection pump. Gravitational force is used to supply fuel from the tank, via the filter element and a low-pressure rubber hose, to the inlet port of the injection pump.

Fuel Injection Pump

60. A Bosch PFR1K single barrel injection pump is utilised to provide fuel to the injector. The fuel pressure varies in accordance with the thickness of the shims used to obtain correct injection timing. The pump is flange mounted to the engine crankcase and is driven by the engine's camshaft via a roller-rocker lever. Located in the pump body are a plunger and barrel which are finely ground and assembled with extremely fine tolerances, forming a matched pair.

Fuel Metering

61. The plunger used in the injection pump is 9 mm in diameter and has a lower helix which rises diagonally to the right giving a right lead (Figure 38). An external groove is machined vertically from the helix to the top of the plunger. The barrel, in which the plunger operates, has an inlet/spill port machined through the side into the bore (Figure 39). 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.

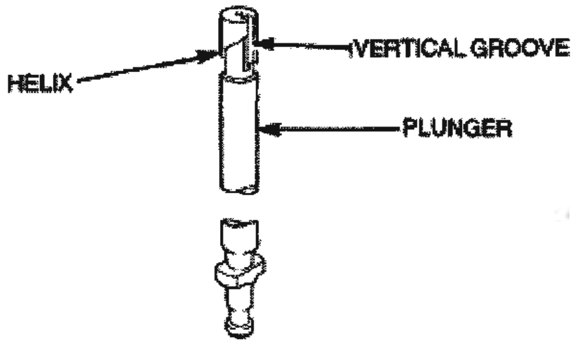


Figure 38 Plunger

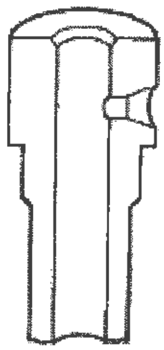


Figure 39 Barrel

62. As the stroke of the plunger is 7 mm regardless of engine speed or load, 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 various loads and speeds the fuel requirements of the engine also vary. To adjust fuel delivery to suit engine requirements, a control sleeve with a toothed segment and a toothed control rack is 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 two longitudinal slots machined in to the bottom of the control sleeve. When installed in the injection pump, the toothed segment of the sleeve meshes with the toothed control rack. The control rack is mounted longitudinally on the body of the injection pump and free to move back and forth.

63. Movement of the control rack is regulated by setting of the hand throttle lever, the excess fuel device (used during starting) and the injection pump governor. The excess fuel device is used for the initial movement of the control rack during engine start-up. The hand throttle controls the intermediate and maximum speed of the engine while the governor makes the finer adjustments to the rack to maintain power during pumping operations. As engine speed increases the governor moves the rack accordingly, causing the control sleeve to rotate. Because the plunger is connected to the control sleeve via the control arms, the plunger also rotates, moving the helix towards the lower point in relation to the barrel inlet/spill port which is fixed in position within the pump body. Figure 40 illustrates the plunger rotating mechanism showing the plunger helix-to-barrel inlet/spill port relationship in non-delivery, partial delivery and maximum delivery positions.

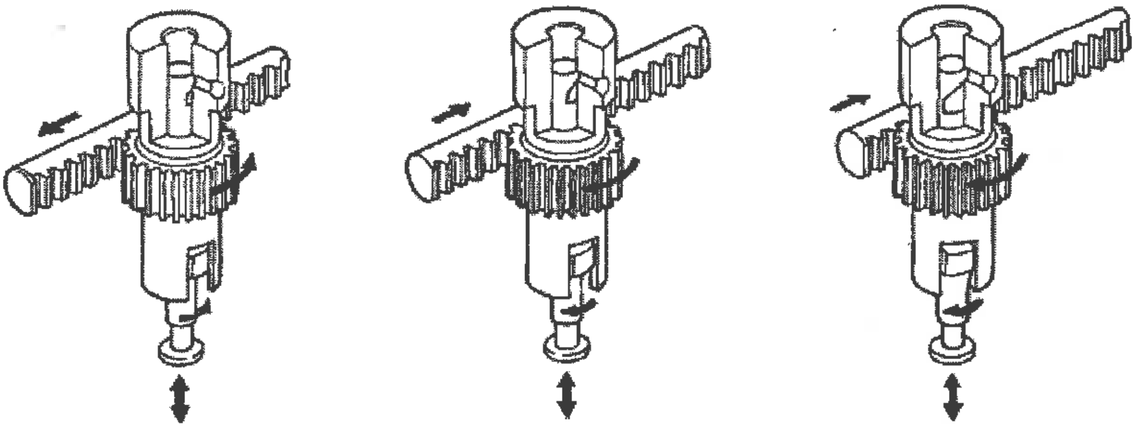


Figure 40 Plunger Rotating Mechanism

64. The engine's camshaft has an eccentric shaped lobe for operation of the fuel pump. As the camshaft rotates in accordance with the engines' timing gear, rotation of the camshaft lobe moves with the rocker lever to act on the roller tappet, shim, spring seat and return spring causing the plunger to move up and down within the barrel bore (Figure 41). The camshaft not only drives the pump plunger, but also influences duration of injection, pump delivery and rate of delivery by the amount of lift and the profile of the camshaft lobe.

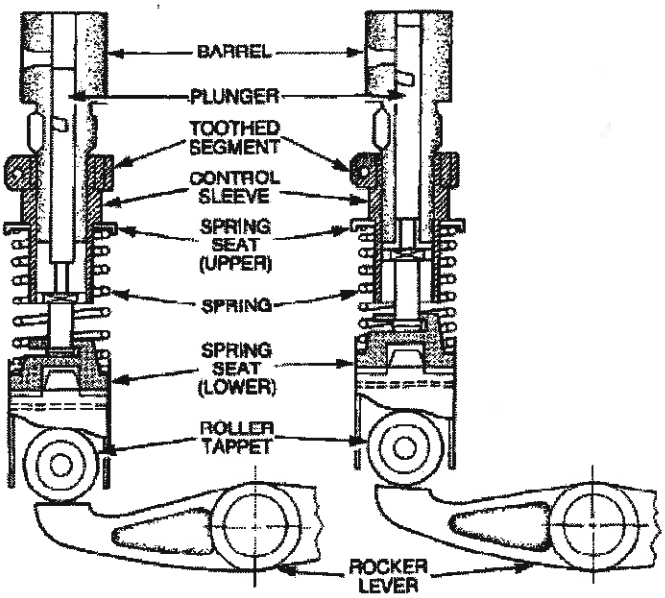


Figure 41 Plunger Drive Assembly

65. To enable fuel to be pumped under high pressure to the injector, a housing is placed over the plunger and barrel assembly. 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 (Figure 42).

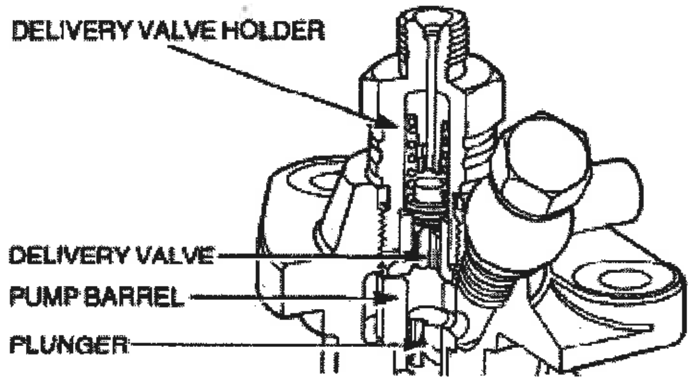


Figure 42 Delivery Valve

66. With the plunger at BDC of its stroke, the inlet/spill port is open, allowing fuel under low pressure from the injection pump fuel gallery into the high pressure chamber. As the camshaft rotates, causing the plunger to move towards TDC of its stroke, a series of phases takes place (Figure 43). These phases are called strokes and are as follows:

- **a.** Pre-stroke is the closing-off of the inlet/spill port by the plunger.
- **b.** Retraction stroke is the slight compression of the fuel. This occurs because of the elasticity characteristics of the fuel.
- **c.** 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.
- **d.** 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's vertical groove and helix.

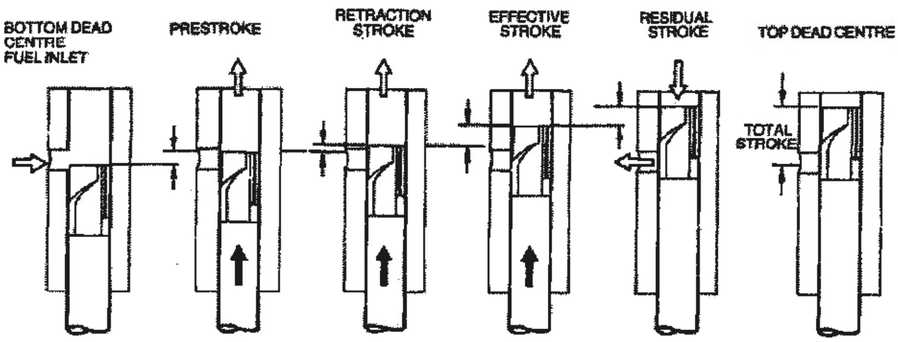


Figure 43 Phases (Strokes) of The Plunger

Fuel Injector

67. The pressurized fuel from the injection pump passes along a high pressure fuel line to the fuel injector nozzle assembly mounted in the cylinder head, with the nozzle of the assembly protruding into the combustion chamber. After the pressurized 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 (Figure 44). The high pressure fuel in the pressure chamber acts against the exposed annular 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.

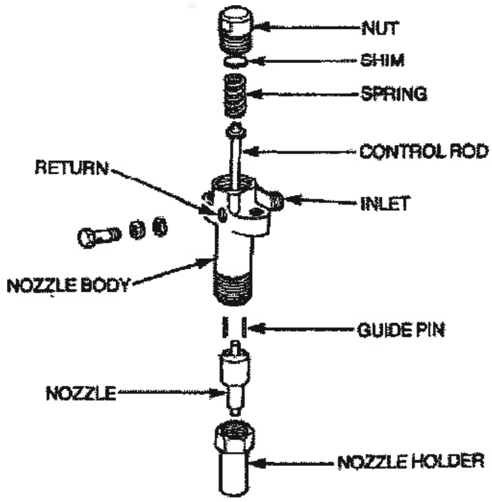
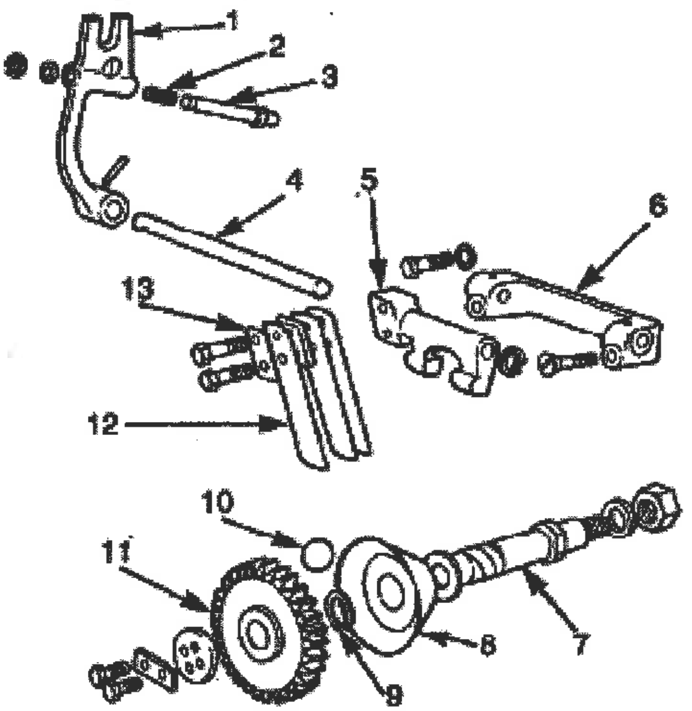


Figure 44 Fuel Injector – Exploded View

68. 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 injector return line.

Governor

69. The governor is directly driven by the engine crankshaft and is a variable speed type which controls the engine's speed in conjunction with the hand throttle control. Using steel balls, springs, rods and levers, the governor ensures that the engine speed set by the hand throttle is not exceeded. Figure 45 illustrates the various components of the governor.



1. Lever
2. Spring
3. Pin
4. Pin
5. Yoke
6. Support
7. Governor shaft
8. Governor speed bell
9. Circlip
10. Steel ball
11. Gear
12. Spring
13. Safety plate

Figure 45 Governor Assembly – Exploded View

70. As the speed of the engine reaches the required rpm set by the hand throttle control, the steel balls that are located in the rear of the governor drive gear move outward due to centrifugal force and bear against the governor speed bell. The speed bell in turn acts on the yoke which moves the governor lever in an axial direction causing the fuel rack to move to a lesser fuel position, maintaining the engine at the set rpm.

Water Pump

71. The water pump is a centrifugal type that requires priming prior to operation, and is mounted to the engine by means of an adapter coupling. Drive for the pump is provided by the engine's crankshaft which has the impeller keyed and bolted directly on the end of the shaft. When drive is applied to the water pump, the rotating impeller draws water into the pump via the suction flange and the suction valve rubber, and forces it out through the water outlet. Priming of the pump is achieved by opening the shutoff valve on the inlet side of the priming pump and operating the pump to prime the pick-up tube and the water pump. Figure 46 illustrates the various components of the water pump.

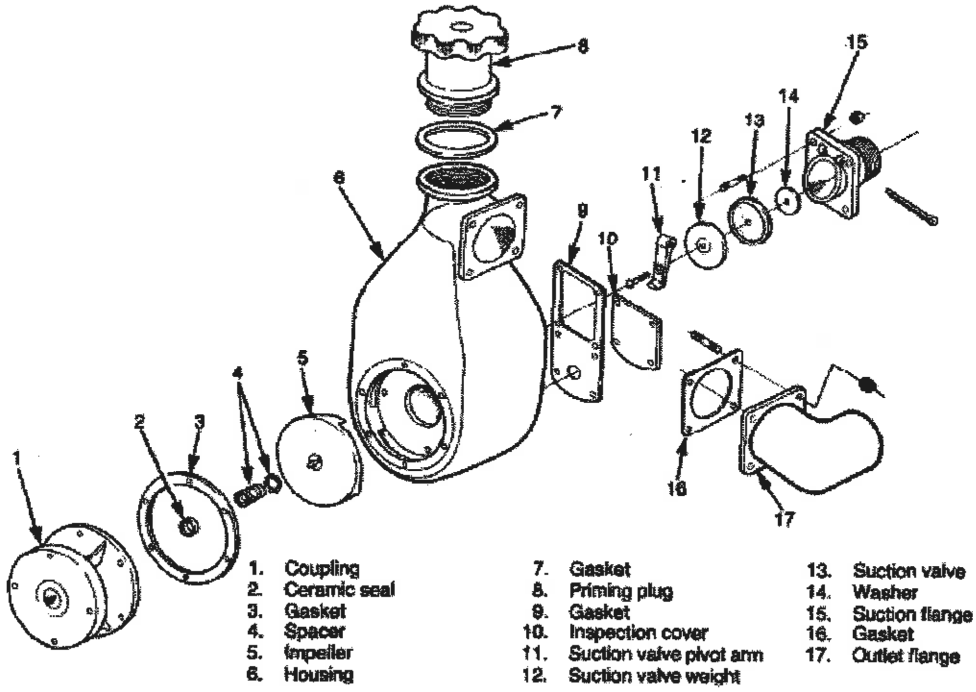


Figure 46 Water Pump – Exploded View

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