



SERVICE MANUAL

TRUCKS

L 385

Export Service Department

AKTIEBOLAGET

VOLVO

GÖTEBORG, SWEDEN

PART 1

ENGINE

DESCRIPTION

GENERAL

The L 385 truck is fitted with a direct-injection Diesel engine with type designation D 67 A. It is a six-cylinder overhead-valve in-line engine with wet cylinder liners.

The greater part of the combustion chambers are in the crowns of the pistons as shown in Fig. 1-6.

The engine block and the upper part of the crankcase are cast in one unit in which the replaceable cylinder liners are fitted. The engine has two cylinder heads with two separate rocker arm covers.

The induction manifold together with the throttle housing and the air cleaner are fitted on the right side of the engine. The exhaust manifold is fitted on the left side of the engine.

The auxiliary drive gears are fitted on the front of the engine and are protected by a casing. The fuel injection pump is driven from the auxiliary drive gears by means of a shaft.

The vacuum pump which is fitted on the right side of the engine is driven from the auxiliary drive gears by means of a separate gear on early production engines. On late production engines the vacuum pump or compressor is driven by means of a belt from the crankshaft pulley.

The cylinder bore is 104.77 mm (4.125") stroke 130 mm, (5.118") total displacement 6.73 liters (410 cu. in.). The compression ratio is 17:1. Maximum output is 115 b.h.p. at 2400 r.p.m. Output and torque curves are shown in Fig. 1-1.

The series and production numbers of the engine are stamped on a plate attached to the right side of the engine above the generator.

The engine is mounted in the chassis on six rubber blocks in order to reduce vibration to a minimum.

CYLINDER BLOCK

The cylinder block (37, Illustration 1-A is made of cast-iron and is cast in one unit with

the upper part of the crankcase. The cylinder block is fitted with replaceable, wet-type cylinder liners which are directly flushed by the coolant to ensure the most effective cooling of the cylinder walls and pistons. There are drilled channels supplying oil to the main bearings and the connecting rod bearings, the camshaft bearings and the auxiliary drive gears. Both the camshaft bearing recesses and the recesses for the upper main bearing shells are cast directly in the cylinder block. There are three inspection covers for the push rods, the middle one of which is fitted with a breather for crankcase ventilation.

CYLINDER LINERS

The cylinder liners (125, Illustration 1-B) are made of special-alloy centrifugally-cast material and are flanged. The flanges rest against shoulders in the cylinder block. The cylinder liners are retained in position against the shoulders by the cylinder head. This simple system makes the cylinder liners very easy to replace. Sealing between the cylinder block and the liners consists of two rubber rings at the bottom (O-rings) which are fitted in grooves in the cylinder block. At the top the liner is sealed by the cylinder head gasket since the upper part of the liner has been designed in a special way and by the fact that the liner flange is at a certain level above the cylinder block surface.

PISTONS

The pistons (5) are made of light-alloy and are fitted with three compression rings and two oil control rings, the lower of which is below the piston pin hole. The piston pin projections are robustly reinforced as is also the crown of the piston in the top of which the greater part of the combustion chamber is located.

There are a number of holes drilled in the bottom of the oil control ring grooves round the complete circumference of the piston.

PISTON RINGS

A set of piston rings consists of three compression rings (131, 132) and two oil control rings (127, 130). The upper compression ring on each piston is chromed. Both the lower rings or oil control rings scrape off most of the oil which is thrown up onto the cylinder walls while the engine is running. Only a very thin film of oil is left to lubricate the cylinder walls. The oil control rings are designed for this purpose with a groove round the complete circumference and a number of holes passing through to the inside of the rings. Since the piston itself has corresponding holes, excess oil runs through these holes back to the crankcase.

PISTON PINS

The piston pins (84) are made of case-hardened steel. Due to case-hardening, the piston pins have a hard wearing surface but the core retains its toughness, the result being great durability.

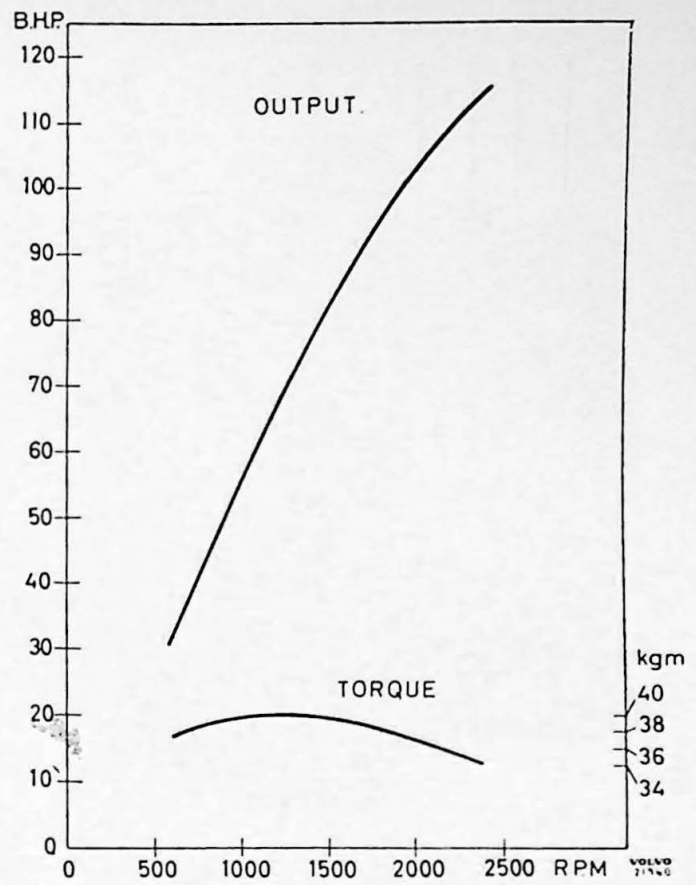
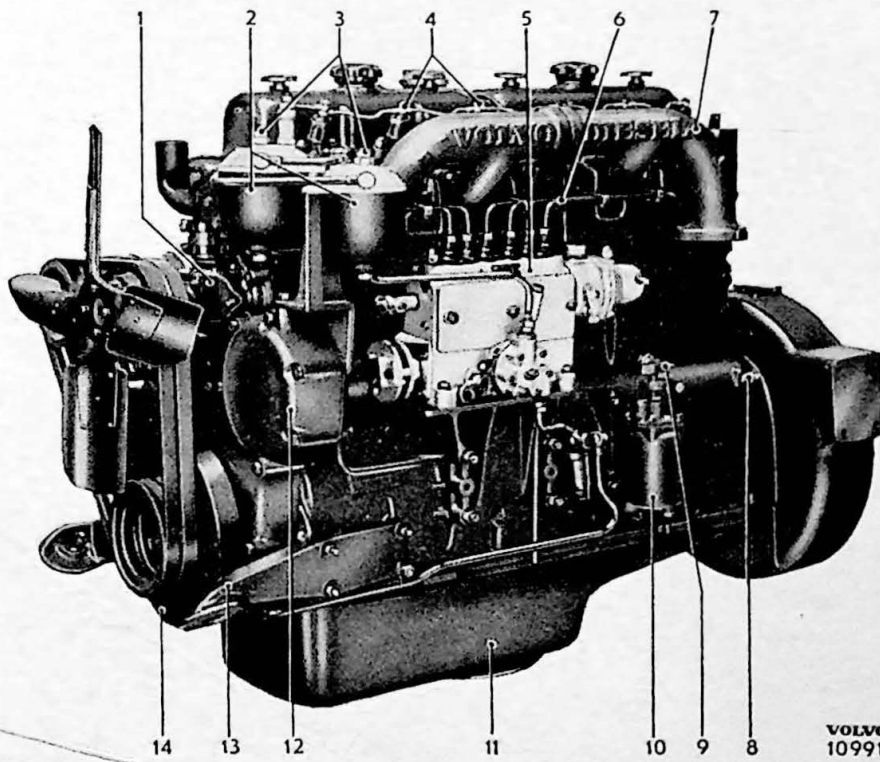


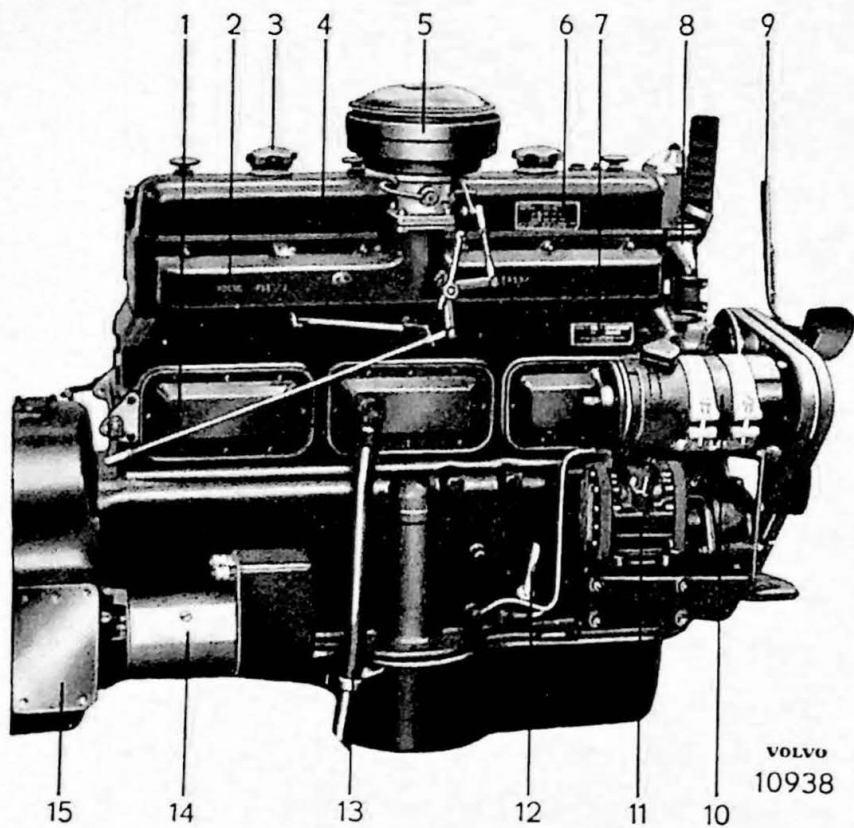
Fig. 1—1. Output and torque diagram.



1. Water pump
2. Fuel filters
3. Air-venting screws
4. Injectors
5. Fuel injection pump
6. Delivery pipes
7. Exhaust manifold
8. Oil pressure gauge connection
9. Drain cock for cooling system
10. Oil filter
11. Oil pan
12. Injection pump drive gear
13. Front engine mounting
14. Vibration damper

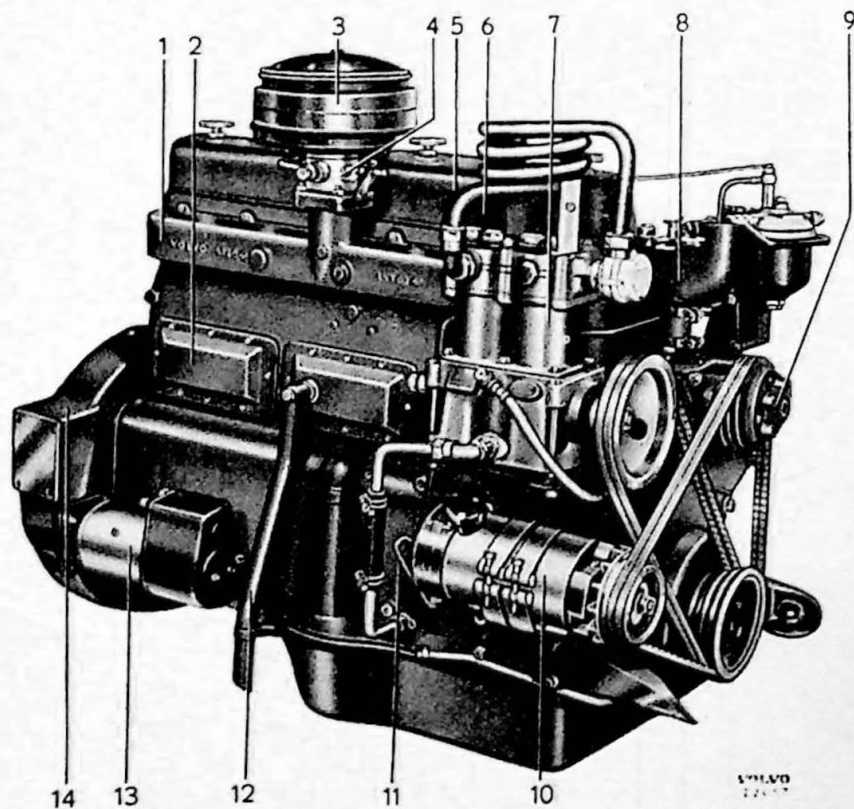
Fig. 1—2. Engine, left side (D 67 A, early production).

VOLVO
10991



1. Inspection cover
2. Induction manifold
3. Oil filler cap
4. Rocker arm cover
5. Air cleaner
6. Plate showing valve clearance
7. Plate showing engine number
8. Thermostat housing
9. Fan
10. Generator
11. Vacuum pump
12. Oil dipstick
13. Evacuating pipe
14. Starter motor
15. Flywheel housing

Fig. 1—3. Engine, right side (D 67 A, early production).



1. Induction manifold
2. Inspection cover
3. Air cleaner
4. Throttle housing
5. Rocker arm cover
6. Plate showing valve clearance
7. Compressor
8. Thermostat housing
9. Fan hub
10. Generator
11. Oil dipstick
12. Evacuating pipe
13. Starter motor
14. Flywheel housing

Fig. 1—4. Engine, right side (D 67 A, late production with compressor).

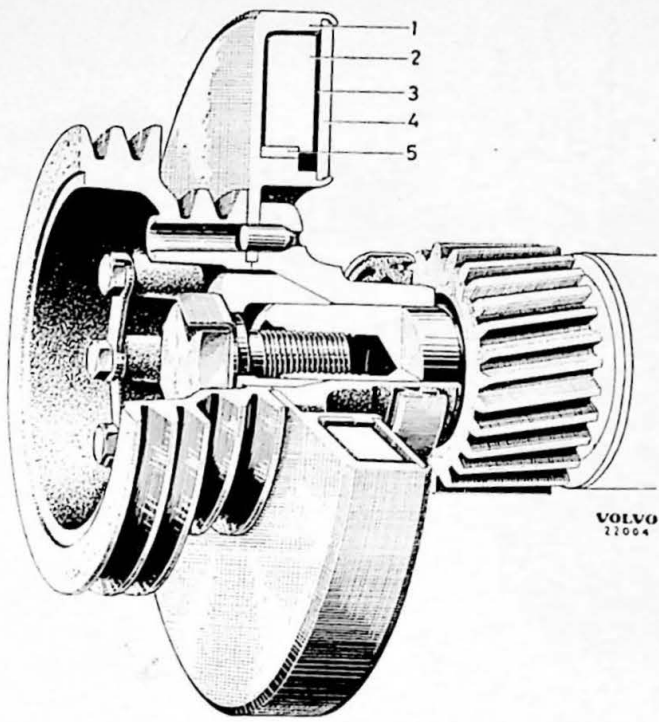


Fig. 1—7. Vibration damper.

- 1. Housing
- 2. Mass
- 3. Silicon gel
- 4. Cover
- 5. Bushing

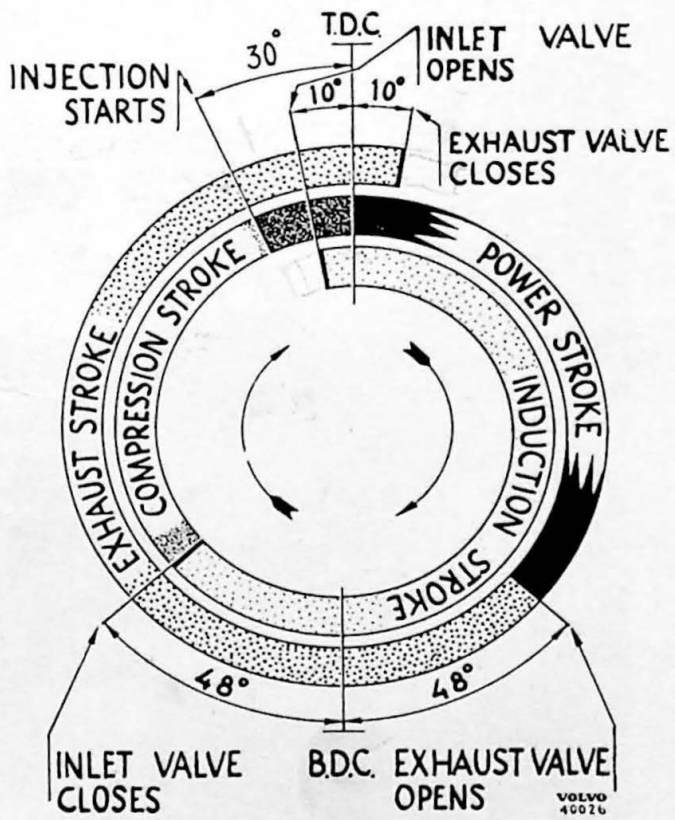


Fig. 1—8. Valve diagram.

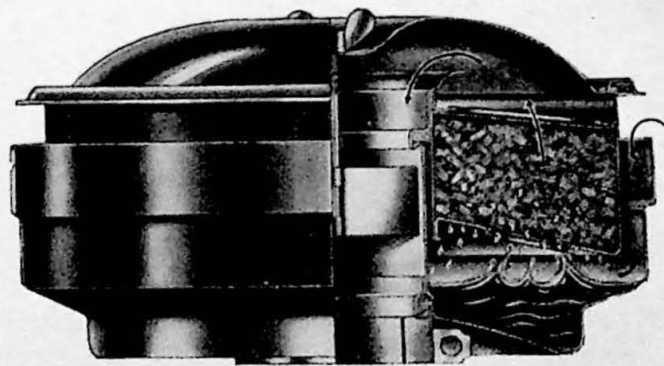
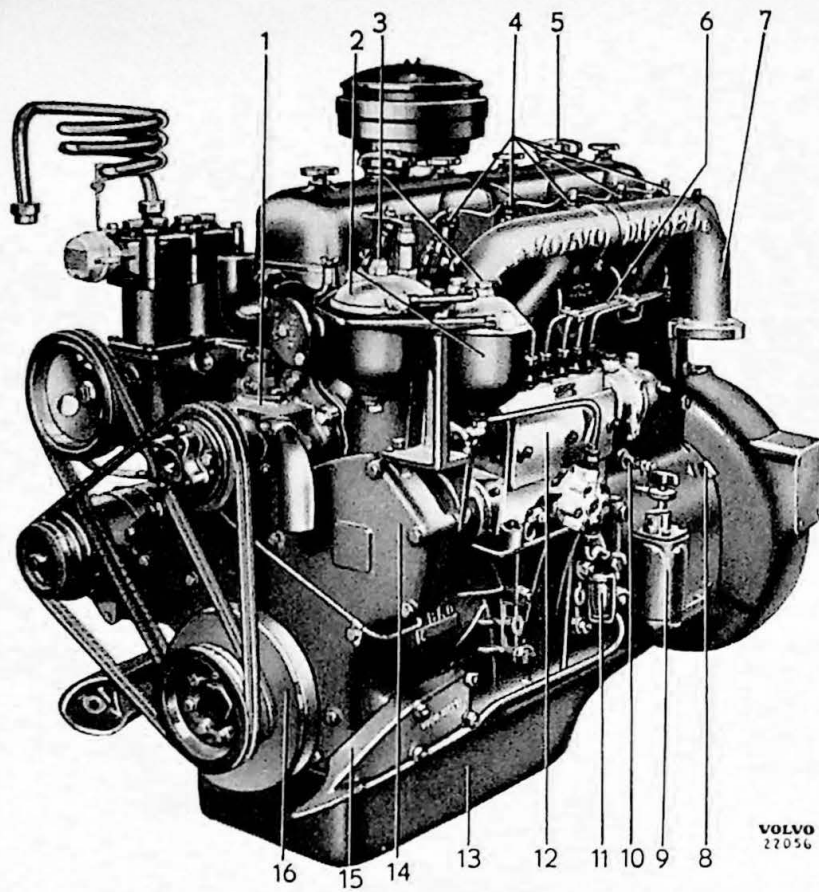


Fig. 1—9. Air cleaner.



- 1. Water pump
- 2. Fuel filters
- 3. Air-venting screw
- 4. Injectors
- 5. Oil filler cap
- 6. Delivery pipes
- 7. Exhaust manifold
- 8. Oil pressure gauge connection
- 9. Oil filter
- 10. Drain cock
- 11. Pre-filter
- 12. Fuel injection pump
- 13. Oil pan
- 14. Auxiliary drive gears
- 15. Front engine mounting
- 16. Vibration damper

VOLVO
27056

Fig. 1—5. Engine, left side (D 67 A, late production with compressor).

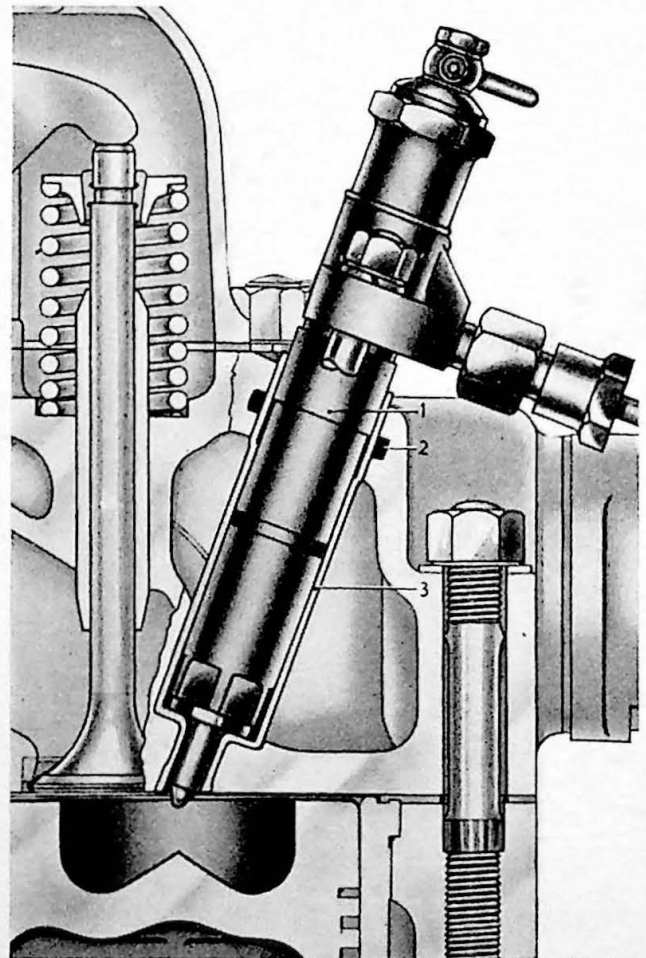
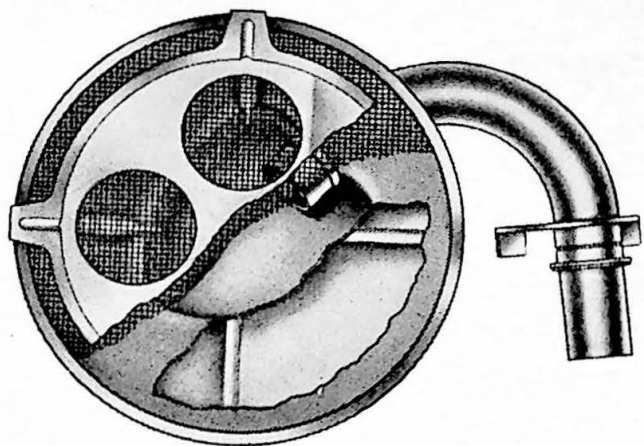


Fig. 1—6. Combustion chamber and injector.

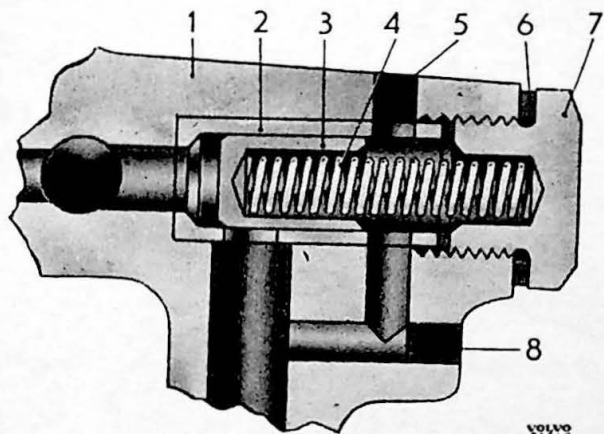
- 1. Injector
- 2. O-ring
- 3. Copper sleeve

VOLVO
21342



21113

Fig. 1—11. Oil strainer.



VOLVO
21348

Fig. 1—12. Oil relief valve.

1. Cylinder block
2. Bushing
3. Plunger
4. Spring
5. Plug
6. Washer
7. Plug
8. Plug

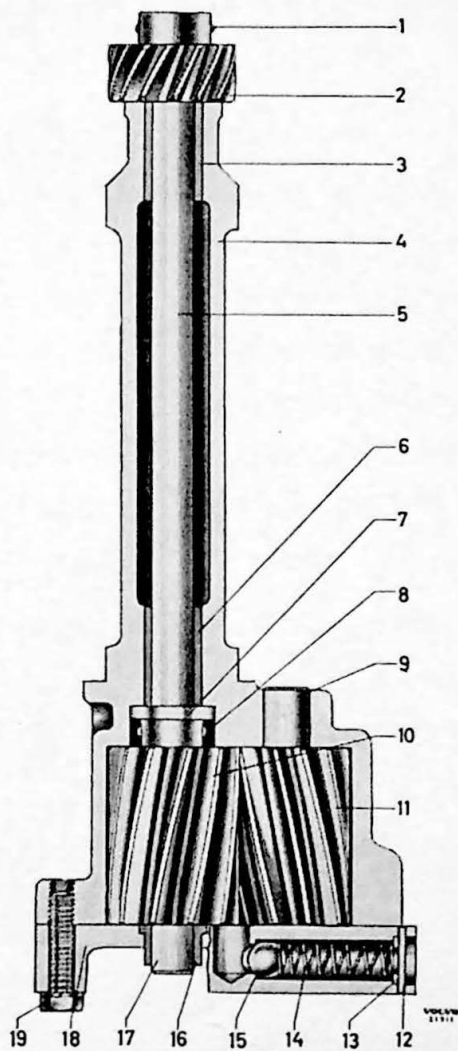


Fig. 1—13. Lubricating oil pump.

1. Slotted pin
2. Gear
3. Bushing
4. Pump housing
5. Pump shaft
6. Bushing
7. Flange
8. Slotted pin
9. Shaft
10. Driving gear
11. Driven gear
12. Slotted pin
13. Washer
14. Spring
15. Ball
16. Bushing
17. Pump shaft
18. Cover
19. Attaching bolt

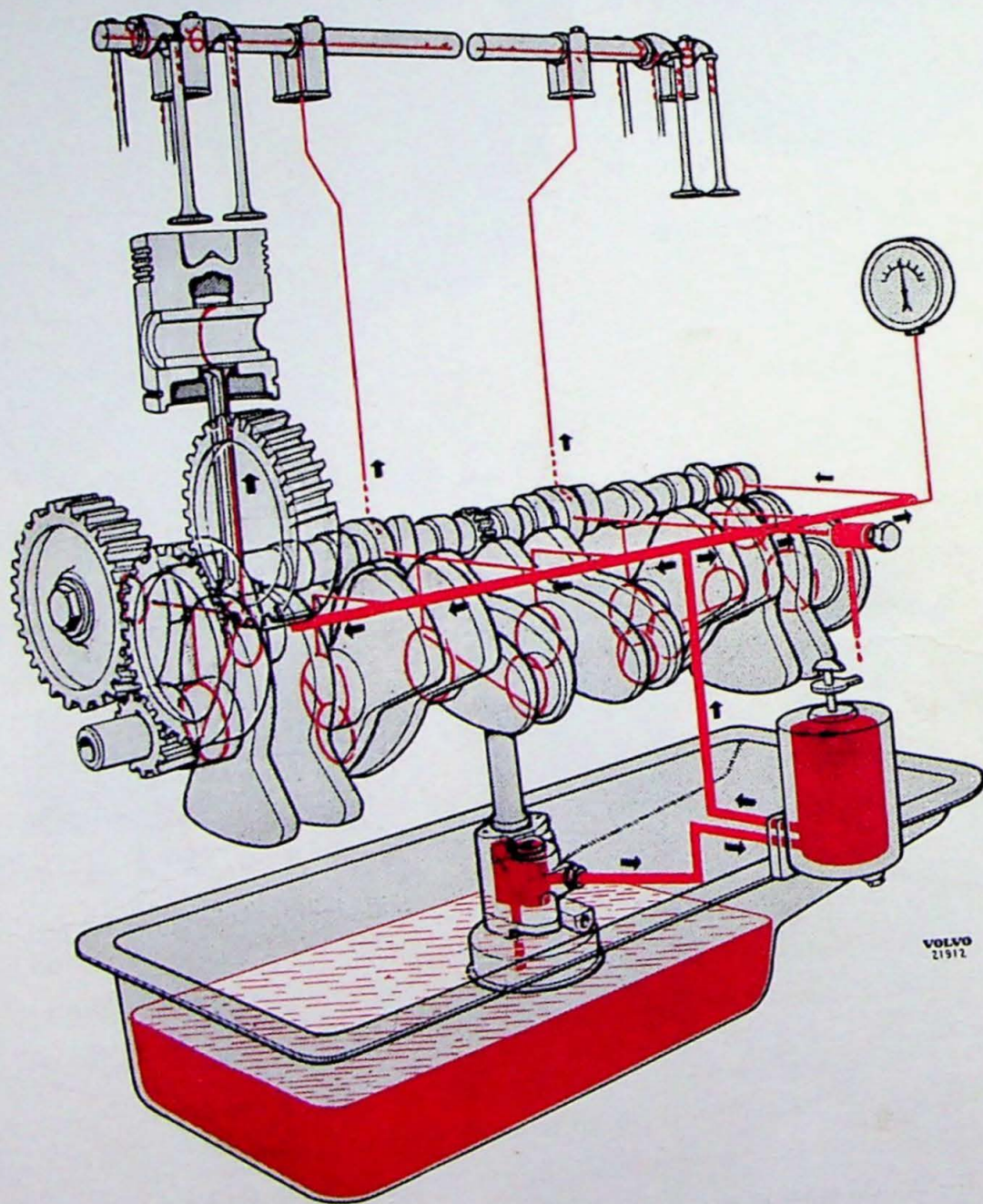


Fig. 1—10. Lubricating system.

At operating temperature, the piston pins have a floating fit in both the piston and the connecting rod. The fit in the piston, however, is so close that under normal conditions there is no significant movement.

The piston pins are retained axially by means of two circlips fitted in grooves at the end of the pin.

CYLINDER HEADS

The engine is designed with two cylinder heads (35), each of which covers three cylinders. The cylinder heads are made of special-alloy cast-iron with a high degree of heat resistance. The special steel valve seats which are shrunk into the cylinder heads are replaceable. In order to obtain efficient cooling of the exhaust valve seats there are jets pressed into the cylinder heads which direct a stream of water towards the exhaust valve seats. The fuel injectors are fitted in thin copper sleeves which are directly flushed by the cooling water ensuring very effective cooling of the injectors. The induction and exhaust channels pass out through each side of the cylinder heads.

The valves, rocker arms and rocker arm shaft are located in the cylinder heads. There is one rocker arm shaft for each cylinder head. These shafts are each carried in three bearing brackets. The valve guides, which are pressed into the cylinder heads, are replaceable.

CRANKSHAFT

The crankshaft (61) is made of drop-forged special steel which has been given a hard wearing surface by means of induction hardening.

The crankshaft has been very carefully balanced both statically and dynamically. It is carried in the crankcase in seven main bearings, the centre one of which serves as a guide bearing. Drilled oil galleries carry oil from the main bearings to the connecting rod bearings. The rear end of the crankshaft is in the form of a flange onto which the flywheel is attached by means of six bolts.

At the front end of the crankshaft there is a gear keyed on which drives the auxiliary drive gears. In front of this gear there is a hub onto which the vibration damper and crankshaft pulley are attached with bolts (early production engines had the vibration damper fitted with a fixed hub which was attached to the crankshaft by means of a key).

The vibration damper (69) on early production engines consisted of two halves with a rubber surface between into which the halves were attached by means of vulcanising. On late production engines a fluid type vibration damper is used.

The torque influencing the crankshaft varies periodically in both strength and direction.

If the torque comes into resonance with the natural period of vibration of the shaft,

very great stresses can occur with risk of breakage on the crankshaft. Torsional vibrations are particularly dangerous from this point of view. When these occur the crankshaft is twisted backwards and forwards about its axis.

In order to eliminate these vibrations, the above-mentioned vibration damper is used. This dampens the torsional vibrations and ensures that the engine runs smoothly and quietly.

Late production vibration dampers (see Fig. 1-7) consist of a housing in which a certain mass moves. This mass is carried in a bearing on a bushing in the center and on all other sides it is surrounded by a liquid (silicon). The vibration damper is attached to the crankshaft by means of a hub. When the crankshaft shows a tendency to suffer from torsional vibrations, the mass in the vibration damper moves backwards and forwards relative to the crankshaft, the result being that the crankshaft operates with hardly any vibration at all.

In the case of the early production vibration dampers consisting of a hub attached to the crankshaft and a mass vulcanised onto rubber, the mass operated in a similar manner.

MAIN BEARINGS AND CONNECTING ROD BEARINGS

The main bearings and the connecting rod bearings (51, 62) consist of bearing shells of steel with cast lead-bronze surfaces. The bearings are precision-manufactured and should be fitted without being filed or treated in any other way when the crankshaft has been ground to a suitable undersize.

When a standard crankshaft is fitted or the crankshaft has been ground down to a pre-determined undersize, the correct bearing clearance will automatically be obtained.

CONNECTING RODS

The connecting rods (83) are made of drop-forged, case-hardened special steel with a H-section in order to obtain the greatest possible rigidity and the lowest possible weight. The lower end of each crankshaft consists of a recess for the connecting rod bearing shells.

In order to make possible the removal of the connecting rods through the cylinder bores the bearing caps are divided diagonally. The axial forces occurring at the division are taken up by means of axial splines.

The upper end of the connecting rod is in the form of a head in which the piston pin is carried in a bushing.

A drilled channel from the connecting rod bearing recess to the head of the piston pin. This channel carries lubricating oil from the connecting rod bearing to the connecting rod bushing and lubricates the piston pin.

FLYWHEEL

The flywheel (48) is made of cast-iron and is attached by means of bolts to the crankshaft flange. In order to ensure greater durability, the flywheel is completely finished. It has also been accurately balanced both statically and dynamically. The ring gear is shrunk onto a shoulder on the front side of the flywheel.

The following gradations are marked on the flywheel: 40° , 30° , 20° , 10° before T.D.C., as well as 10° and 20° after T.D.C. for cylinders 1 and 6.

CAMSHAFT AND CAMSHAFT BEARINGS

The camshaft (52) is made of drop-forged steel, is case-hardened and has ground bearing surfaces and cams. The camshaft is carried in four, replaceable camshaft bearings. It is retained in its position by the forward bearing which is fitted with a flange. The flange is attached to the forward end of the block by means of two bolts.

The camshaft is driven from the crankshaft through an idler gear.

The camshaft bearings (53) are made of steel-backed soft bearing metal. After being pressed in they have been finished to close tolerances.

AUXILIARY DRIVE GEARS

The auxiliary drive gears (68, 77) are fitted on the forward end of the cylinder block. They are covered by a protective casing.

The gear fitted on the crankshaft drives the camshaft and the fuel injection pump through the medium of an idler gear.

The vacuum pump or compressor, depending on which brake system is used, was driven on early production engines from the camshaft, the pump gear meshing with the camshaft gear. On later production engines the compressor and the vacuum pump are driven through belts from the crankshaft pulley. In order to ensure as quiet operation as possible, the auxiliary drive gears are helically cut.

VALVE SYSTEM

The valves (11, 12) are fitted hanging in the cylinder head and are operated from the camshaft through the valve lifters (123), the push rods and the rocker arms. The valves run in replaceable valve guides. The rocker arms (92) are fitted with adjuster screws (90) permitting adjustment of the clearance between the valve and the end of the rocker arm. The rocker arms are carried on two shafts, one on each cylinder head, each being carried in three bearing brackets. Lubrication is carried out by means of oil which is forced from the camshaft bearings through channels in the cylinder block and cylinder head to the rocker arm shaft.

The valve mechanism is protected by means of two rocker arm covers (31) which are made of light-alloy. The rocker arm covers are fitted with breathers to prevent the condensation of water vapor which could cause rust on the valve mechanism.

The valves are made of chrome-nickel steel with hard-chromed stems for maximum durability. The exhaust valves have stellite seats for maximum resistance to the hot exhaust gases.

The push rods (128) are made of steel tubing in the end of which are pressed steel balls and steel shells respectively.

AIR CLEANER

The air cleaner (26) is of the oil-bath type and is fitted on the throttle housing.

The air cleaner consists of a bowl in which oil is filled to a certain level and over this an element consisting of copper wool. The air cleaner is protected at the top by means of a cover which is held in position with a butterfly nut.

Air is sucked in at the sides and passes through the oil-bath, through the copper wool filter and into the induction manifold.

LUBRICATING SYSTEM

The engine is fitted with a complete pressure lubricating system. Oil pressure is produced by a gear pump which is driven by means of a worm direct from the camshaft. This pump is fitted on the lower flange of the crankcase between cylinders 3 and 4.

Oil is sucked from the oil pan through a strainer to the pump. The oil is carried by the teeth on the gear from the suction side to the pressure side and then through a screen filter to the main feed pipe which has branches passing to the main bearings. Then the oil goes through drilled galleries in the crankshaft to the connecting rod bearings. Through channels in the connecting rods the oil is forced up to the head of the piston pins where the piston pins and bushings are lubricated. The oil then returns to the oil pan.

From the main feed pipe oil is lead through channels to the camshaft bearings. The rocker arms are lubricated with oil which is taken from the camshaft bearings through galleries in the cylinder block and cylinder head to a nipple in each cylinder head from which it passes through a pipe to the center bearing bracket. From here it is distributed through the hollow rocker arm shaft, which is drilled, to the rocker arms. The oil passes through holes and grooves in the rocker arms to the push rods and then returns to the oil pan. The auxiliary drive gears are lubricated by oil from the front camshaft bearing.

Oil Pan

A pressed metal oil pan (58) is bolted to the lower part of the cylinder block. The oil pan serves as a reservoir for the oil. In the bottom of the oil pan there is a round cover through

which the oil strainer can be removed for cleaning purposes. The oil drain plug, which is fitted with a magnet to collect metallic particles, is fitted in the center of the above-mentioned cover.

Oil Strainer

The oil strainer (56) in the oil pan on early production engines is of the float type, that is to say it is free to swivel and it is fitted with an air-filled container to ensure that it is always floating on the oil. This means that it always sucks up the oil just under the surface where the oil is cleanest. The oil strainer is fitted with a check stop limiting its vertical movement.

On late production engines, a fixed oil strainer is fitted. In order to eliminate the risk of sucking up dirty oil into the pump, the suction pipe has been shortened so that only oil from the upper layers is sucked in.

Oil Pump

The oil pump (57) is of the gear type with spiral gears. It is driven directly from the camshaft through a worm gear.

The oil pump sucks in oil through the strainer and the suction pipe leading to the suction side of the pump. Oil is transported through the spaces between the gear teeth over to the pressure side and then through the screen filter and out into the oil system main pipe. On late production pumps there is a relief valve built in to the cover in order to decrease the maximum oil pressure in the pump. This step has been taken in order to decrease stresses on the pump gear teeth.

Oil Relief Valve

A relief valve (109) is fitted on the left side of the crankcase in such a way that it is connected with the oil system main channel and the oil pan. The valve consists of a spring-loaded plunger made of bronze on early production engines and steel on late production engines. The steel plunger is cyanide-hardened for greater durability.

The relief valve limits the oil pressure so that it does not reach excessively high values. Oil pressure should be 3-4 kg/cm² (42-56 p.s.i.) at operating speed and temperature.

Oil Channels

Oil is forced to the oil filter from the oil pump. From here the oil is forced to the main oil channel in the cylinder block which branches out into channels to the relief valve, the oil pressure gauge and the various lubricating points on the engine.

See Fig. 1-10.

Lubricating Oil Filter

The lubricating oil filter (111) is of the self-cleaning type. It is fitted on the left side

of the engine and is directly connected with the oil channels. The incoming oil passes through a screen filter which traps any impurities. The screen filter is cleaned by means of a scraper mechanism actuated by the handbrake lever. If the screen filter should be blocked by impurities for some reason there is a by-pass valve which opens when a certain resistance is encountered and allows oil to pass directly to the outlet channel. The by-pass valve which consists of an inlet channel, an outlet channel and a spring-loaded bore, is fitted in the oil filter cap. There is a drain plug in the bottom of the oil filter to drain off impurities.

Crankcase ventilation

In order to prevent water vapor and the gaseous combustion products which may leak past the piston rings from having a damaging affect on the lubricating oil, the crankcase is fitted with a breather. This consists of an evacuating pipe on the right side of the engine as well as the earlier mentioned breathers on the rocker arm covers. Each of the breathers is fitted with a filter. Air passes through these filters into the rocker arm covers and then through the push rod channels down into the crankcase where it combines with the other gaseous products and passes out through the evacuating pipe.

FUEL SYSTEM

The fuel tank has a capacity of 120 liters (32 U.S. gallons). It is made of sheet metal and has been leaded after manufacture. It is divided up by means of splash plates in order to avoid excessive movement of the fuel during travel and to prevent the feed pump from sucking in air when the fuel level is low.

The suction line from the fuel tank is fitted with a strainer which traps larger impurities as well as ice crystals which can form at extremely low temperatures.

There is a drain plug in the bottom of the tank to dispose of any sludge that may form.

The passage of fuel through the system can be seen in Fig. 1-16.

Fuel feed pump

The fuel feed pump (105) is of the plunger-diaphragm type. The type designation is CAV DFP 3/7 and it is used together with early production injection pumps CAV type NL 6 E 75/91 and late production type NL 6 F 75/91.

The function of the fuel feed pump is to suck fuel from the fuel tank through the pipe (1, Fig. 1-16) and then pump this fuel through the fuel filters to the injection pump. Its capacity is so designed that the amount of fuel pumped considerably exceeds the requirements of the injection pump. The excess fuel is lead through an overflow valve and then through a return pipe (8, Fig. 1-16) back to the fuel tank. In this way a continual air-venting of the fuel system is carried out.

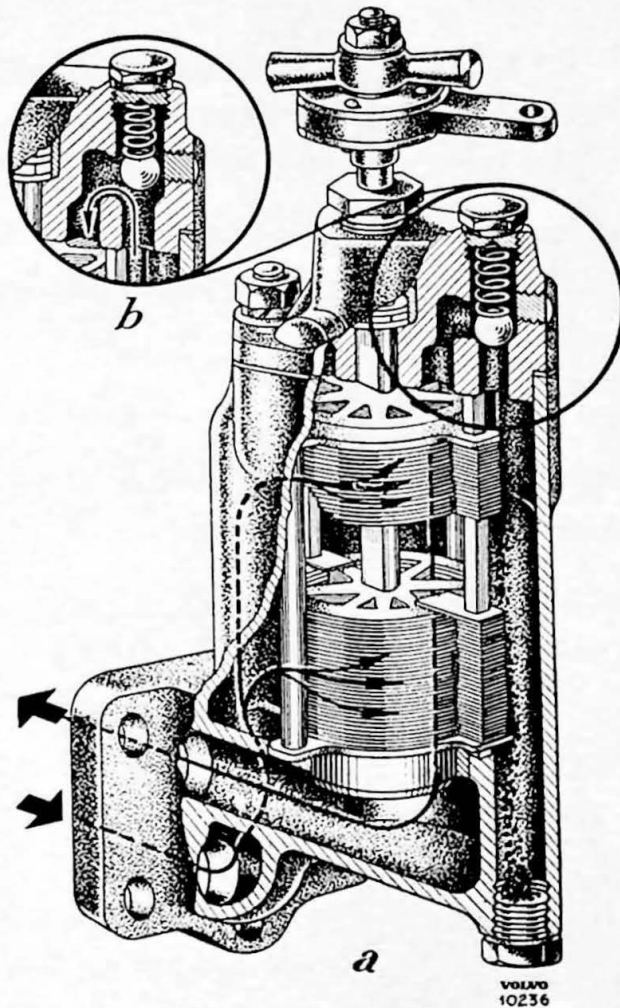


Fig. 1—14. Lubricating oil filter.

- a. Relief valve closed
- b. Relief valve open

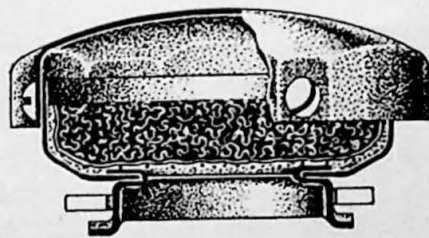


Fig. 1—15. Breather.

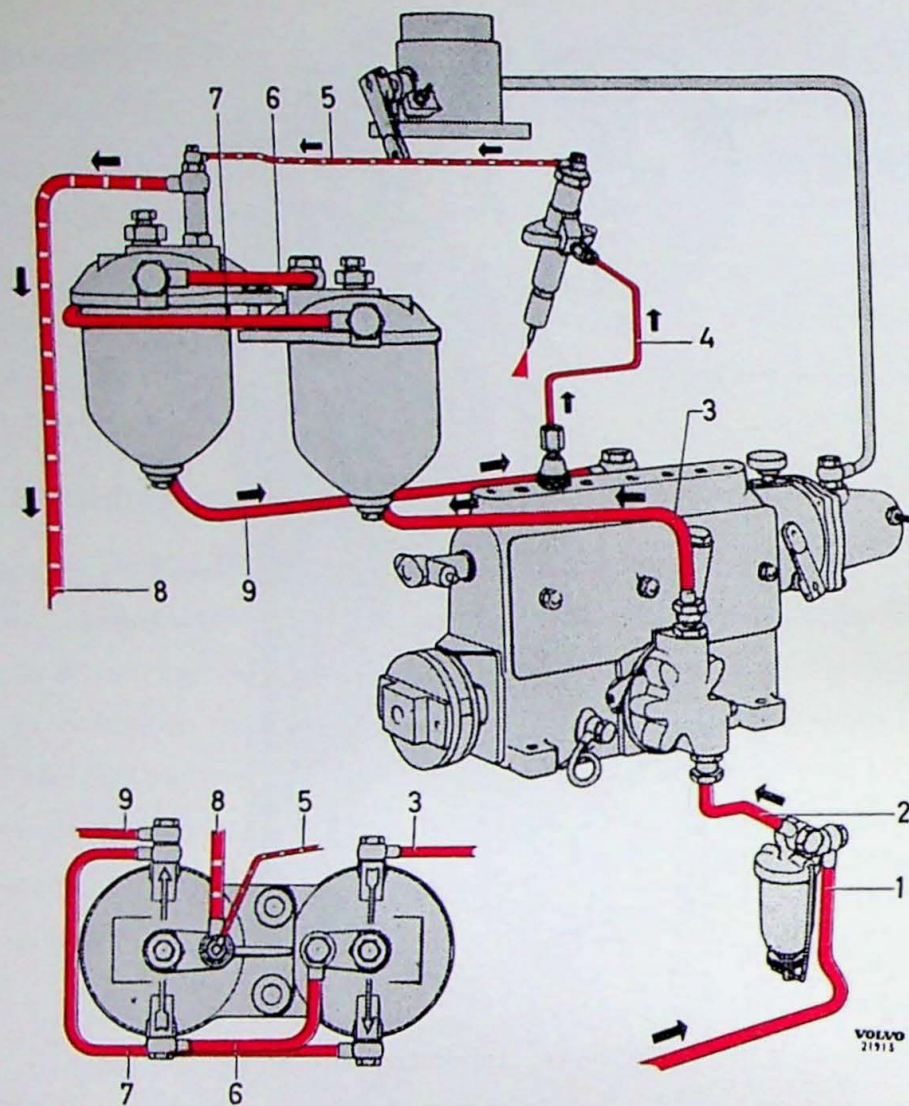


Fig. 1-16. Fuel system.

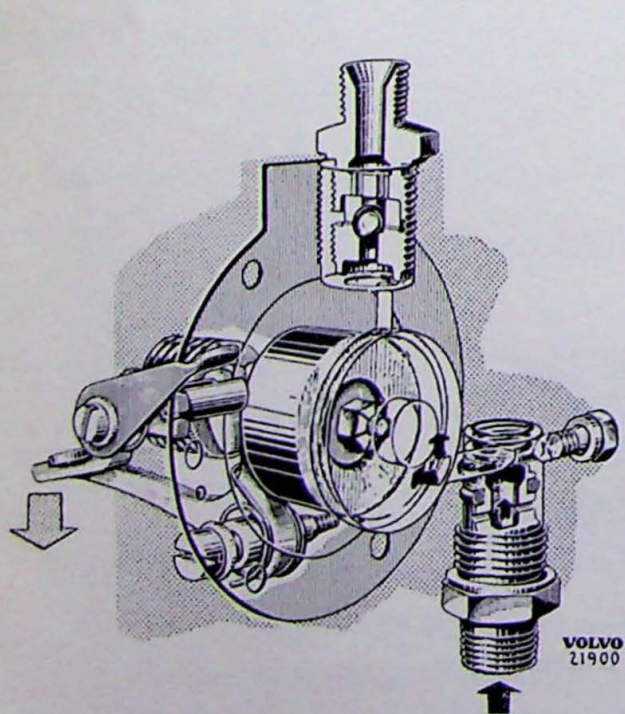


Fig. 1-17. Suction stroke.

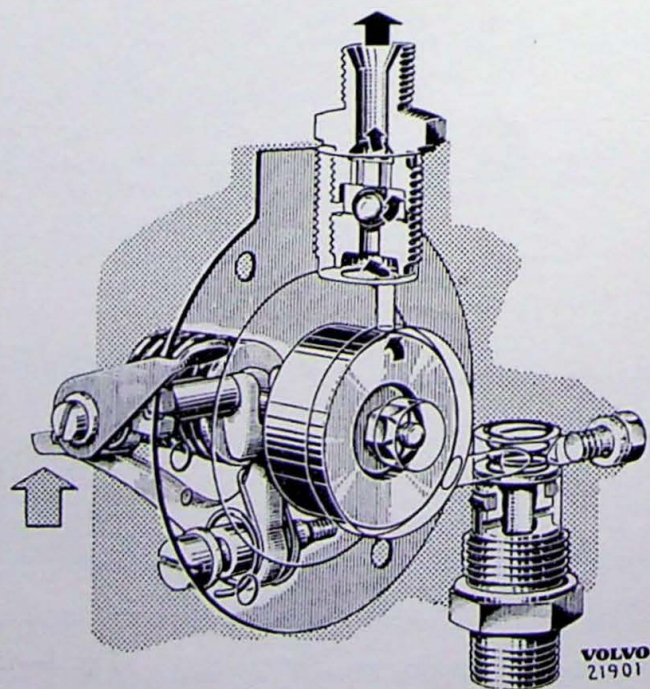


Fig. 1-18. Pressure stroke.

The maximum pressure of the fuel feed pump is about 1.5 kg/cm^2 (21 p.s.i.). If the back pressure in the fuel system should exceed this value for some reason the fuel feed pump ceases to operate with the result that excessive pressure increases are avoided.

The fuel feed pump is fitted with a hand primer pump. The purpose of this is to enable fuel to be pumped to the fuel filters and the injection pump when adjustment work is being carried out.

The function of the pump is as follows:

The fuel feed pump diaphragm and plunger are influenced by a lever driven from an eccentric cam on the injection pump camshaft as well as by a spring.

The fuel pump suction stroke (Fig. 1-17) commences when the plunger-diaphragm is in its outer position. When the eccentric cam pushes down the outer end of the arm, the plunger-diaphragm is pulled inwards, the inlet valve opens and fuel is sucked in to the space outside the plunger. Aided by a spring on the right-angle lever pin, the arm then follows the eccentric cam whereby it is raised and the inner arm leaves the plunger-diaphragm push rod. In this position the push rod spring operates and pushes the push rod together with the plunger and diaphragm outwards whereby the suction valve closes and fuel is forced out through the pressure valve.

The maximum feed pressure of the pump is thus determined by the degree of tension on the spring. If the full amount of fuel fed by the pump is not used, the plunger and the diaphragm stop in the fully out position until the engine requires more fuel.

While the engine is running the plunger-diaphragm operates with a certain stroke which corresponds to the amount of fuel consumed. The length of the stroke carried out by the plunger-diaphragm is a few tenths of a millimeter, in other words it is more or less a form of vibration.

For manual pumping there is an external lever which operates the push rod through an eccentric cam in the same way as the right-angle lever does during ordinary operation.

Fuel filters

Pre-filter

The pre-filter (110) is fitted on the pipe (1-2, Fig. 1-16) from the tank to the feed pump. This filter consists of a glass bowl containing a wire netting insert. The insert and the glass bowl are retained in position by means of a bail. A leak-proof seal between the cover and the bowl is attained by means of a cork gasket.

Fuel comes from the tank directly into the bowl, impurities and water remain in the bowl while the fuel passes on through the strainer to the feed pump.

Fuel filters

.....
In order to trap the impurities which may have passed through the pre-filter, there are two fuel filters connected in parallel and these clean the fuel very effectively before it passes to the injection pump.

The fuel filters are fitted on a bracket fitted to the left side of the engine. Each consists of a container with a tightly fitting cover and a filter element. The filter element consists of two layers of specially-treated paper which are folded and glued at alternate points so that the fuel is forced to pass through this paper on its way through the filter.

The filter container has an air-venting valve in the top and a drain plug in the bottom.

From the feed pump, the fuel is forced in through the pipe (3, Fig. 1-16) into the lower filter, through this and then through a pipe (7, Fig. 1-16) to the upper filter outlet and through another pipe (9, Fig. 1-16) to the fuel injection pump.

If the lower filter is not able to allow all the fuel to pass through it, there is a connection (6, Fig. 1-16) between the inlet on the lower filter and the inlet on the upper filter so that the fuel can pass either through one or other of the filters or through both of them. There is a relief valve on the upper filter through the return line (8, Fig. 1-16) of which also fuel oil from the injector leak-off line (5, Fig. 1-16) passes. The passage of fuel through the filter is shown with arrows in Fig. 1-16.

When the filters have become blocked, both filter elements are replaced simultaneously. The point at which this replacement should be carried out is determined by the feed pressure which may not sink lower than 0.5 kg/cm^2 (7 p.s.i.).

Relief valve

The relief valve has two functions. One of these is to limit the pressure in the fuel system and the other is to ensure that the fuel system is being continually air-vented.

The relief valve consists of a sleeve in which a spring-loaded valve ball operates, being retained against its seat by the spring. As soon as the pressure exceeds 0.6 kg/cm^2 ($8\frac{1}{2}$ p.s.i.) the ball lifts and fuel passes out and back to the fuel tank. Any air bubbles that may be present in the fuel are also returned to the tank.

Fuel injection pump

The fuel injection pump (Illustration 1-C) is fitted on a bracket on the left side of the engine. The injection pump drive shaft gear is driven from the crankshaft gear through the medium of an idler gear. The fuel injection pump runs at half the crankshaft speed.

The fuel injection pump is of the plunger type and operates with constant stroke. The pumping action comes from a camshaft, the cams of which lift the plungers and the

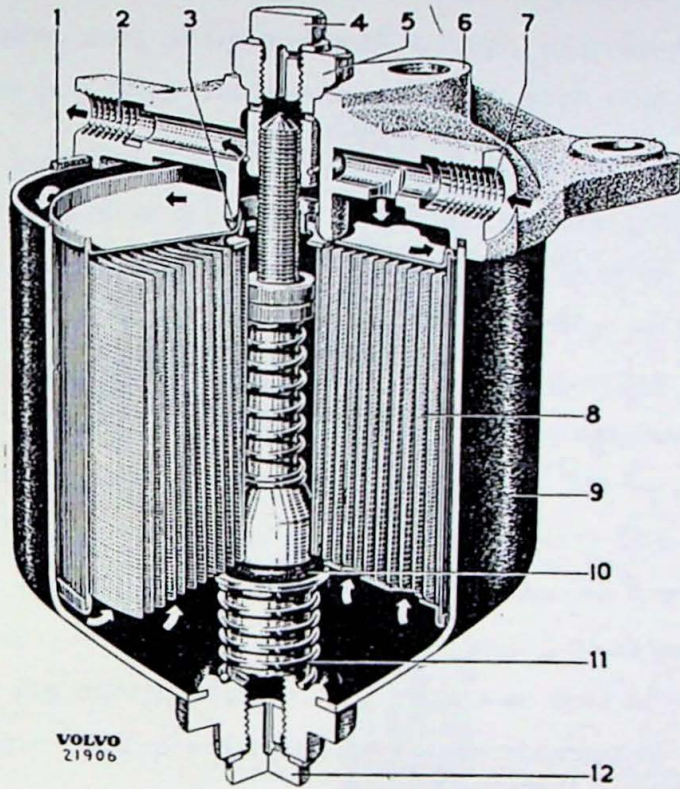


Fig. 1—19. Fuel filter.

1. Gasket
2. Outlet connection
3. O-ring
4. Air-venting screw
5. Nut
6. Filter cover
7. Inlet connection
8. Filter element
9. Filter housing
10. O-ring
11. Spring
12. Plug

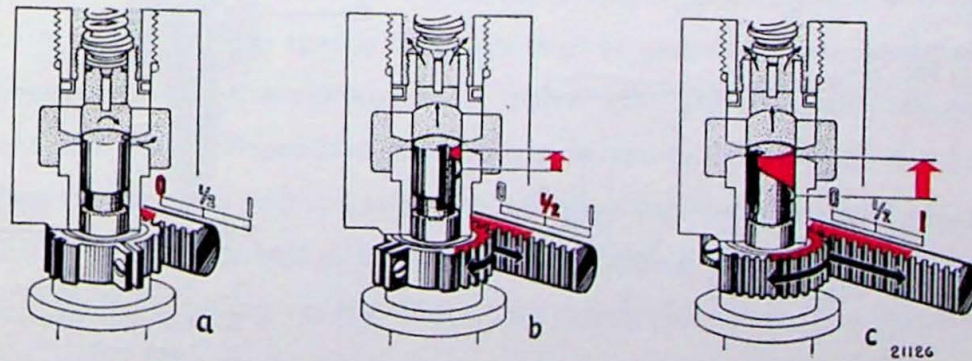


Fig. 1—20. Various feed positions on injector pump.

- a. Zero feed b. Partial feed c. Full feed

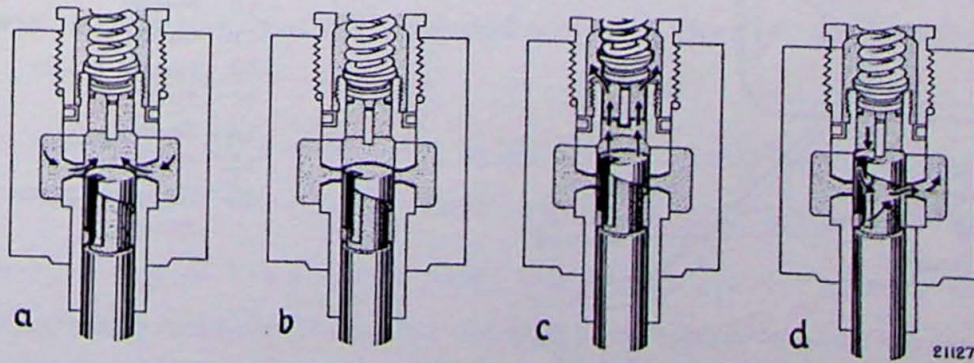


Fig. 1—21. Commencement and termination of feed.

- a. Filling b. Pressure stroke commences c. Pressure stroke d. Unloading

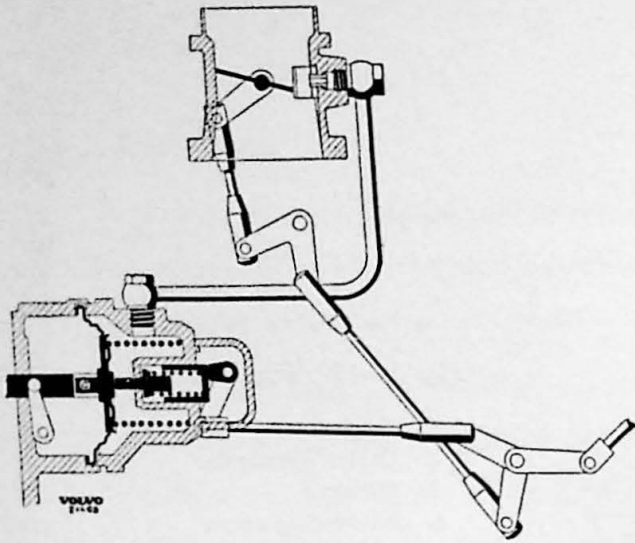


Fig. 1—22. Idling.

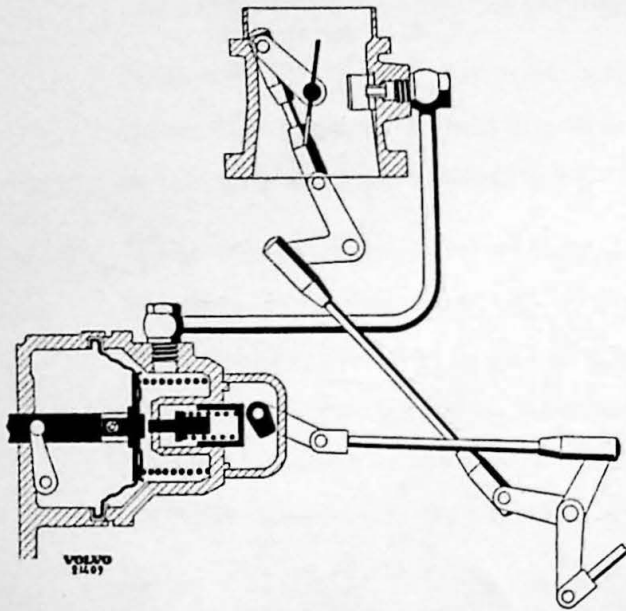


Fig. 1—23. Max. speed.

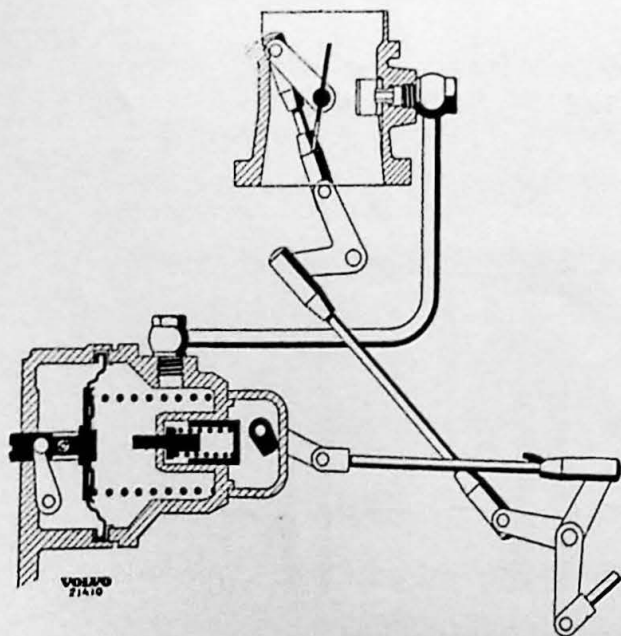


Fig. 1—24. Full loading.

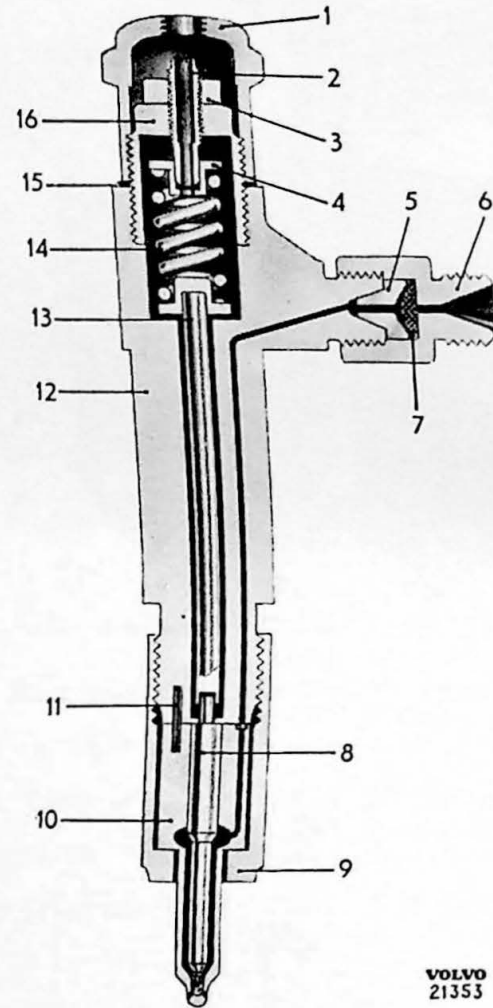


Fig. 1—25. Injector.

1. Protector cover
2. Adjuster screw
3. Lock nut
4. Spring plate
5. Cone
6. Screw union
7. Filler
8. Nozzle needle
9. Nozzle nut
10. Nozzle
11. Guide pin
12. Nozzle holder
13. Push rod
14. Spring
15. Washer
16. Nut over pressure spring

plungers force the fuel out of their respective barrels. The return action of the plungers is taken care of by means of springs. In order to prevent uneven loading of the plungers, there is a lifter mechanism between each cam and each plunger.

The injection pump consists of six pump units built into a light-alloy housing. Each pump unit consists of a plunger and a barrel. The pump units obtain their fuel from a common fuel chamber through a channel in the wall of the barrel which is uncovered when the plunger is in its lowest position. Each plunger has a helix leading up to the space above the plunger. When the plunger moves upwards the channel in the barrel is uncovered by the helix and fuel above the plunger passes back to the fuel chamber. The amount of fuel injected is controlled by virtue of the fact that the plunger is rotated thus exposing the channel at an earlier or a later point. This rotation of the plungers is taken care of by a control rod which receives its impulse from the vacuum governor so that movements of the control rod are transferred to the plungers through a toothed segment which is bolted onto the control sleeve. On the lower part of the control sleeve there is a recess for the plunger cross-piece so that every movement of the control rod is transferred to the plungers.

The vacuum governor consists of a divided diaphragm housing, in the inner chamber of which the control rod terminates. There is a leather diaphragm clamped between both sections of the housing. This diaphragm is so large that it can move several centimeters in the direction of movement of the control rod. The diaphragm is connected to the control rod by means of a link. There is a coil spring in the outer half of the diaphragm housing which pushes the control rod towards the position for the maximum amount of fuel. The inner chamber is connected with the outer air while the outer chamber is connected with the throttle housing on the induction manifold inside the throttle flap.

There is a venturi in the smallest cross-section of the throttle housing and the pipe from the governor terminates here. The throttle flap is also fitted in the same position and this flap has a recess which leaves the venturi open when the throttle flap is fully closed. The two outer limiting positions of the throttle flap are determined by means of two set screws. One of these is used to adjust idling speed and the other is used to adjust maximum engine speed.

The venturi has two functions. One of these is to obtain a powerful ejector effect and the other is to limit the speed if the engine starts running in a reverse direction.

When air passes the open end of the vacuum pipe, there is an ejector effect, that is to say the air in the diaphragm housing is sucked out and this occurs to such an extent that it is 2-3 times stronger than the effect produced by the air in the large inlet manifold. The partial vacuum is therefore sufficiently great to exceed the spring pressure on the diaphragm which then moves and takes with it the control rod towards the position for lower fuel injection. When the engine is running there is a partial vacuum inside the throttle flap. The extent of this vacuum depends on the position of the throttle flap and

the engine speed. Since the pipe to the pump diaphragm housing terminates on the inside of the throttle flap, this partial vacuum is also communicated to the enclosed section of the diaphragm housing where the spring is located. Due to the effect of the pressure of the outer air, the diaphragm is pushed into the enclosed section and the spring tends to counteract this movement.

The extent to which the pressure of the outer air presses in the diaphragm depends on the difference in pressure between the inside and the outside of the diaphragm. When the engine is idling, the throttle flap is almost completely closed with the result that the pressure in the induction manifold and on the inside of the diaphragm is low (high degree of vacuum). The result of this is that the diaphragm tends to move away from the enclosed space and moves the control rod to a position where less fuel is injected.

When the throttle flap is opened, the degree of vacuum in the intake manifold as well as in the diaphragm housing decreases so that the spring is then able to move the diaphragm towards the pump and increase the amount of fuel injected. The diaphragm follows the various positions of the throttle flap and since the control rod is connected to the diaphragm, this is also moved. Any alteration in the position of the accelerator pedal is registered immediately by the diaphragm and consequently by the pump which then gives the required effect. In order to stabilize the idling speed of the engine there is another spring in the diaphragm housing which is known as the idling spring. The diaphragm rests against this spring by means of a pin (idling control pin). This pin supports the diaphragm so that a comparatively large difference in pressure is required to move the diaphragm. In this way any surging effect on the part of the diaphragm is prevented thus ensuring that the engine idles evenly. The idling spring is adjusted by means of an adjuster screw in the diaphragm housing cover.

There is a pressure valve fitted above each pump unit. Each pressure valve consists of a sleeve with a valve which is retained in its seat by a powerful spring. Both the sleeve and the valve have been precision ground and lapped together. In order to ensure that the injectors close rapidly when injection is terminated, the valves are fitted with a cylindrical section which fits extremely accurately in the sleeve. When the fuel pressure ceases during unloading, the valve is forced back onto its seat by the spring. The cylindrical part then pumps back a certain amount of fuel so that the pressure in the delivery pipe rapidly sinks and the fuel jet in the injector ceases immediately.

The sleeve and the valve seat are retained in the housing by the delivery pipe nipple which is screwed into the housing from the top.

The injection pump has a built-in fuel filter which serves as a supplementary safety filter but is not intended to replace the other filters. This built-in filter requires no servicing except when the complete injection pump is reconditioned.

Lubrication of the injection pump is carried out by means of oil in the camshaft housing. The cams rotate into this oil and lubricate the lifter mechanism units and their rollers.

There is a cold starting device on the fuel injection pump in order to facilitate starting in very cold weather. This device consists of a cast housing bolted on to the pump housing.

In this housing there is a spring-loaded thrust bolt which moves at right angles to the control rod. The control rod extends outside the cold starting device housing. There is a threaded stop screw at right angles in the thrust bolt which reaches the control rod and determines how far the rod moves at maximum fuel feed. When the thrust bolt is pushed in, the stop screw engages in a hole in the end face of the control rod making possible greater fuel feed. As soon as the engine starts the control rod is pulled back under the influence of the vacuum regulator whereby the thrust bolt is pushed back into the normal position by its spring.

The engine is stopped by means of the stop control on the instrument panel which is connected to a lever on the pump by a steel cable. This moves the control rod over to the zero feed position and the engine stops.

Injectors

The function of the injectors (Fig. 1-25) is to atomize the fuel and to supply the exact amount of fuel required corresponding to the loading on the engine. In order to ensure that the fuel is atomized as finely as possible, injection is carried out at an extremely high pressure. Each injector consists of a nozzle and a nozzle holder. The nozzle is retained in its correct position in the cylinder head by the nozzle holder to which it is attached with a nut called the nozzle nut.

The fuel which is forced up from the injection pump passes through a channel in the screw union and reaches the ring-shaped grooves in the union and the nozzle holder body. From here it is forced through the channel in the nozzle holder to the actual injector nozzle.

The movements of the nozzle needle are controlled by the fuel pressure as well as a spring. When the fuel fed from the fuel injection pump to the pressure chamber reaches a certain pressure, the needle lifts and the fuel is sprayed in a finely atomized form into the combustion chambers in the engine through four precision-calibrated holes in the nozzle. Nozzle opening pressure should be 135 kg/cm^2 (1921 p.s.i.).

This pressure is determined by the strength of the push rod spring which can be altered by means of a set screw.

New injectors seal so tightly that fuel cannot leak past the needle and up into the holder but after the injector has been in use for some considerable time due to a small amount of dirt which can never be completely eliminated by filtering, a certain amount of leakage occurs. Both the needle and the needle guide become more and more worn after