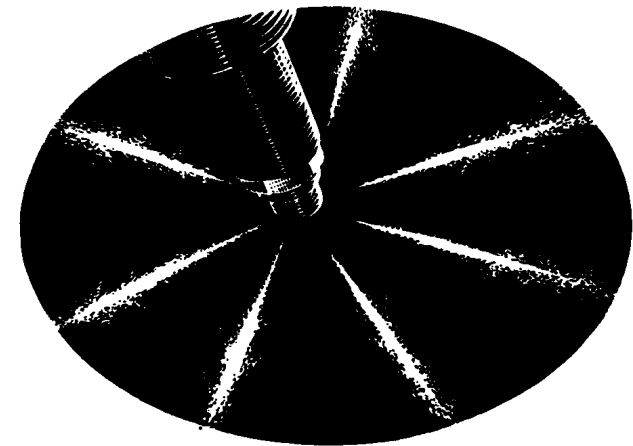




FUEL INJECTION EQUIPMENT

FOR

DIESEL ENGINES



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OPERATOR'S HANDBOOK

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FUEL INJECTION EQUIPMENT

for

DIESEL ENGINES

PETROL v. DIESEL

IT is well known that the performance of all internal combustion engines depends largely upon some device for converting the fuel, whether liquid or gas, into a condition suitable for consumption in the combustion chamber of the engine.

In the 4-stroke petrol engine, air is drawn into the cylinders (by the suction of the descending piston) via the carburettor, where it picks up petrol mist, with which it mixes to form an explosive gas. On reaching the cylinder, the mixing of air and petrol goes on during the piston's upstroke, or *compression* stroke, and the resulting explosive gas is ignited by a spark from the sparking plug, which is timed to occur at about top dead centre, i.e., when the piston is at the limit of its rise, as governed by the throw of the crank. The resulting burning of the mixture causes a rise in pressure within the cylinder, which forces the piston down on the *power* stroke. The exhaust valve is then opened, and the subsequent rise of the piston forces the burnt gases out into the exhaust pipe.

On the other hand, however, the compression ignition (or Diesel) engine, as its name implies, utilises the heat of compression of the air to fire the fuel charge. In this case, on the *suction* stroke air only is drawn into the cylinder; this is compressed by the rising piston to a high pressure (about 450-600 lb. per sq. in.) which also produces a large increase in temperature. At the required time, fuel is introduced into the cylinder, where the heat of the air causes it to ignite spontaneously. As in the petrol engine, this combustion causes a further rise in pressure, which forces the piston down on its *power* stroke: then follows the *exhaust* stroke.

For maximum efficiency in operation it is essential that the compression ignition engine not only be provided with fuel in quantities exactly proportional to the amount of work it is required to do, but also that each injection be timed with the utmost accuracy. This, briefly, is the function of the fuel injection pump, which, having metered and delivered the correct quantity of fuel, must then discharge it through a nozzle orifice at such a high pressure that the fluid is atomised and delivered into the combustion chamber in a form which will enable it to ignite and burn without smell or smoke.

As this process may have to be repeated many hundreds of times per minute, the unerring precision necessary in the production of the fuel injection equipment will be appreciated.

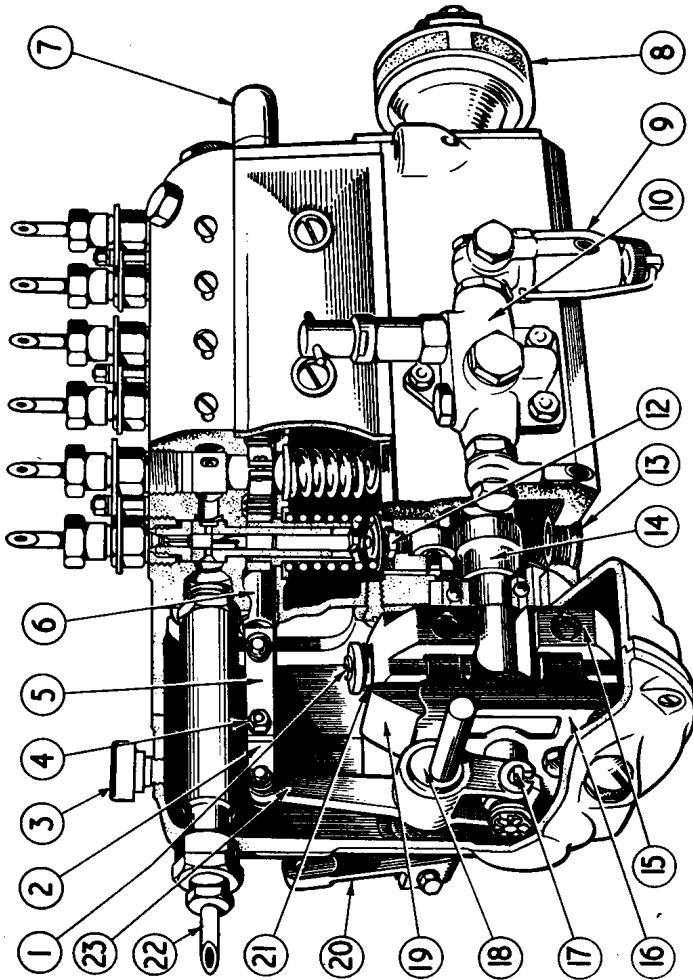


Fig. 1. Section through C.A.V. enclosed camshaft type BPE6B fuel injection pump, fitted with mechanical governor.

1. Adjusting nut.
2. Outer link fork.
3. Breather.
4. Screw for link forks.
5. Inner link fork.
6. Control rod.
7. Control rod stop.
8. Drive coupling.
9. Preliminary filter.
10. Plunger type feed pump.
12. Tappet screw.
13. Closing plug.
14. Camshaft.
15. Flyweights.
16. Bell crank pin retaining cage.
17. Coupling cross-head pin.
18. Eccentric.
19. Bell crank lever.
20. Control lever.
21. Governor spring.
22. Fuel inlet connection.
23. Floating lever.

FUEL INJECTION PUMPS

GENERAL DESIGN

The C.A.V. fuel injection pump is a cam-operated, spring return, plunger pump, with a separate pumping element for each engine cylinder. Two types are supplied: the "BPE" and "N" models (see figs. 1 and 3), which incorporate their own enclosed camshaft and tappet gear; and the "BPF" models (see fig. 2), which are operated from a camshaft on the engine and which are arranged for flange mounting. Multi-cylinder units are available in both forms. Each pump unit comprises the following essential components, which can be readily identified upon reference to fig. 4:—

- (a) Pump element (barrel 3 and plunger 4).
- (b) Delivery valve and seating 2.

Barrel and plunger, valve and seating are all of highly ground and hardened steel, finished to the finest limits and with the highest degree of precision to permit of accurate operation at high speeds and pressures. Thus each pair must therefore be regarded as inseparable and *not* interchangeable.

Fuel is supplied from a tank, either by gravity or by means of a feed pump, through a suitable filter to the inlet connection on the pump, and keeps the common suction chamber in the pump casing full of clean fuel oil, which can then be drawn readily into the pumping chambers of the various elements through the two small lateral ports provided in each barrel. In order to enable the pump to vary the quantity of fuel delivered per stroke, the plunger is provided with a vertical channel (fig. 5) extending from its upper edge to an annular groove, the top edge of which is cut in the form of a helix. External means (5 and 7, fig. 4) are provided whereby the plunger can be rotated in its barrel during operation.

OPERATION

Operation of the pump element, which comprises the plunger and barrel, is shown in fig. 5. When the plunger is at B.D.C. (bottom dead centre) as at (a), fuel can enter through the barrel ports either by gravity flow from an overhead tank, or force feed from a fuel feed pump. In a primed system, of course, the barrel and pipes leading from the pump to the injectors are full of fuel. As the pump plunger rises, a certain amount of fuel is pushed back through the barrel ports, until the plunger reaches the position (b) where the top land of the plunger has closed both ports. The fuel above the plunger is then trapped, and its only outlet is via the delivery valve 2 which is mounted on top of the pump barrel (fig. 4). The pressure exerted by the rising plunger causes the fuel to lift the valve and enter the pipe which connects the pump to the injector. As this is itself already full of fuel, the extra fuel which is being pumped in at the pump end causes a rise in pressure throughout the fuel line and lifts the nozzle needle (or injector valve). This permits fuel to be sprayed into the engine

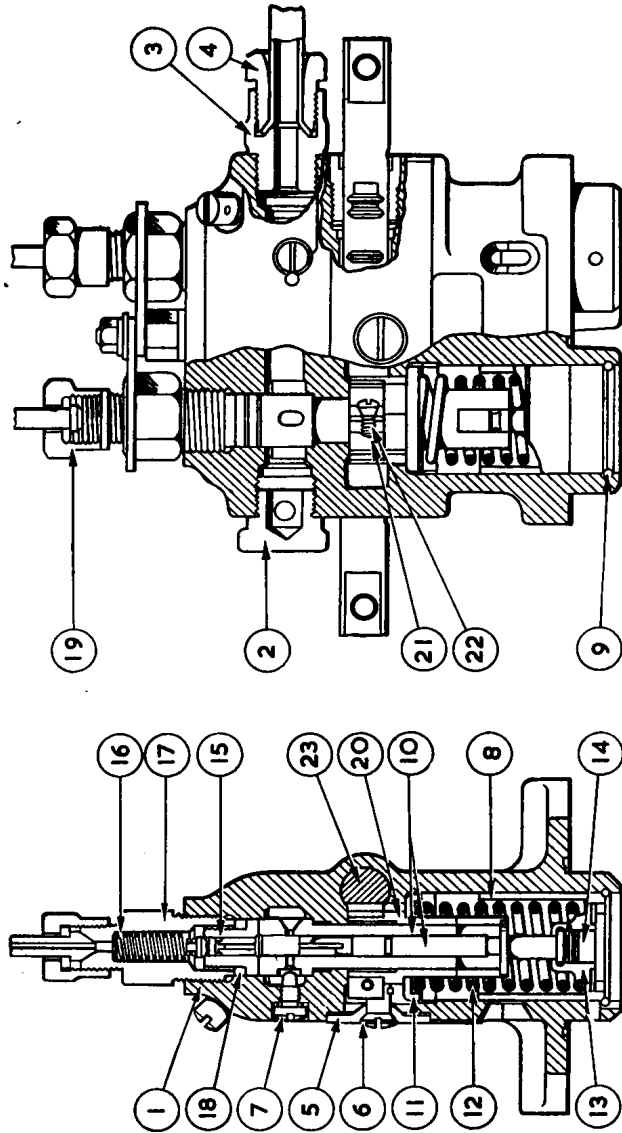


Fig. 2. C.A.V. flange mounted type BPF fuel injection pump, sectioned to show internal construction.

- 1. Pump housing.
- 2. Inlet closing plug.
- 3. Inlet connection stud.
- 4. Fuel inlet connection.
- 5. Inspection cover plate.
- 6. Screw with spring ring for (5).
- 7. Locking pin and joint.
- 8. Plunger guide.

- 9. Spring ring.
- 10. Pump plunger and barrel unit.
- 11. Upper spring plate.
- 12. Helical spring for plunger.
- 13. Lower spring plate.
- 14. Press bolt.
- 15. Delivery valve.
- 16. Delivery valve spring.

- 17. Delivery valve holder.
- 18. Joint for (17).
- 19. Delivery nipple nut.
- 20. Regulating sleeve.
- 21. Regulating toothed quadrant.
- 22. Clamp screw.
- 23. Control rod.

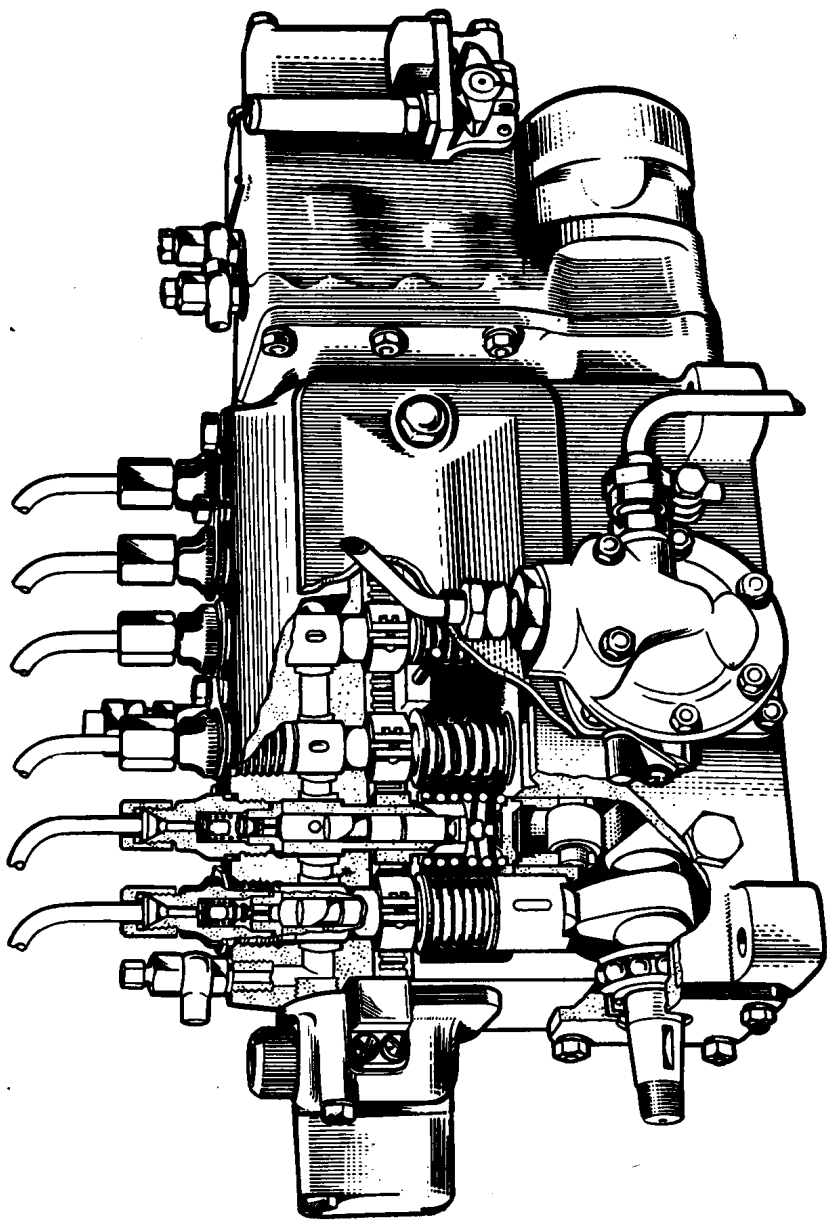
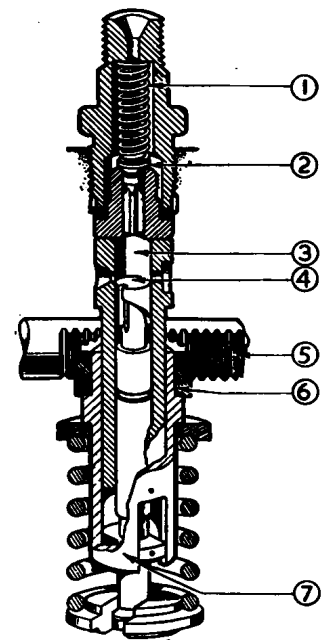


Fig. 3. Cut-away view of "N" type fuel injection pump, showing arrangement of pumping lines, tappets, etc., fitted with hydraulic governor.

combustion chamber. Thus, at this point we have fuel being pumped into the line at the pump end, and an equal quantity being pushed out at the nozzle end. This continues until the plunger reaches the position shown at (c). Here the lower edge of the control helix has uncovered the barrel port, allowing fuel to be by-passed back to the suction chamber (which is under a very much lower pressure than the fuel oil above the plunger) by way of the vertical slot. This causes the delivery valve to shut under the action of its spring, and with the consequent collapse of pressure in the pipe line, the nozzle valve also shuts. The plunger stroke is always constant, but that part of it which is actually pumping is variable. By means of the helical edge which runs around the plunger, which itself can be rotated within the barrel (fig. 5), it is possible to make this point of cut-off occur earlier, or later, in the stroke—compare positions shown at (c), (d) and (e), which show, full load, half load and idling respectively. To stop the engine, the plunger is turned so that the vertical slot coincides with the barrel port (f) during the whole of the plunger stroke; thus no fuel is delivered. The position of the plunger stroke at which the helical edge will uncover the port is adjustable by rotating the plunger axially by means of a toothed quadrant 6 (fig. 4), which is clamped to a sleeve 7, having slots engaging the lugs of the plunger at its lower end.



The toothed quadrant 6 meshes with a rack provided on the control rod 5, which similarly actuates all the pump elements in the unit, and is externally connected either to the governor or other controls by suitable linkage.

1. Valve spring.
2. Delivery valve and seat.
3. Pump barrel.
4. Pump plunger.
5. Control rod.
6. Toothed quadrant.
7. Control sleeve.

Fig. 4. Pump element in section, showing method of control.

ANTI-DRIBBLE DEVICE

When the helical edge of the pump plunger uncovers the port in the pump barrel near the end of the delivery stroke, the pressure of fuel is immediately reduced so that the delivery valve at once drops on its seating, thus cutting off communication between the pump and the nozzle until the next delivery stroke takes place. In coming to its seat to act as a non-return valve, the delivery valve is, however, made

to perform the other highly important function of pressure pipe release. This double function is obtained by the novel but entirely simple construction of the delivery valve unit, and reference to fig. 6 will show that it is an ordinary mitre-faced valve with a guide which has a circular groove cut in it, dividing the guide into two parts. The lower part has four longitudinal grooves communicating with the circular groove.

The upper part of the guide forms a small piston, which is a finely ground plunger fit for the valve seating, which is also internally ground. When the pump is on its delivery stroke, as the pressure of the fuel rises, the delivery valve is pushed up until the pressure fuel can escape through the longitudinal grooves over the valve face to the nozzle.

Immediately the pump plunger releases the pressure in its barrel, the delivery valve (under influence of its spring and the great difference in pressure between the pump barrel and the delivery pipe) resumes its seat, causing the small piston part of the guide to sweep down the

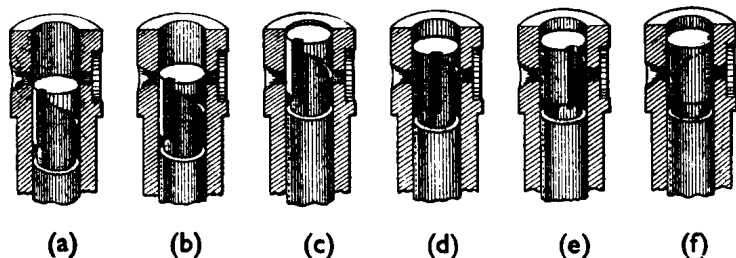


Fig. 5. Pump barrel, showing various plunger positions.

valve seating with a plunger action, thus increasing the space in the delivery pipe (by an amount equal to the volume of the small piston part of the valve guide) before the valve actually seats itself. The effect of this increase of volume in the delivery pipe system is, of course, that of suddenly reducing the pressure of the fuel therein so that the nozzle valve in the nozzle can "snap" to its seat, thus instantaneously terminating the spray of fuel in the cylinder entirely without dribble.

CONTROL OF OUTPUT

The word "Stop" and an arrow engraved on the top of one end of the control rod 5 (fig. 4) indicate which way the control rod should be moved to stop the engine. A pump element at no output or "Engine stopped" position is shown at (f) (fig. 5), when the control rod 5 will be in "Stop" position and the vertical channel of the pump plunger will be opposite the right-hand port in its pump barrel, so that even if the engine is moved no fuel will be pumped.

When the engine is to be started, the control rod 5 is moved over from the stopped position to the starting position. The elements are

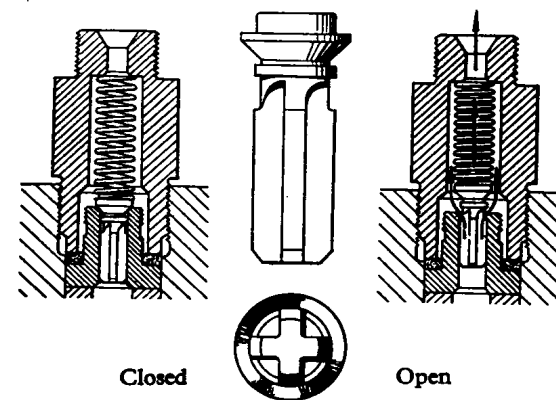


Fig. 6. Delivery valve (BPE type).

then at maximum output or engine starting, when they are capable of pumping more fuel than normally required with the engine at full load. This condition is generally required at starting to facilitate priming of the fuel pressure piping, etc., so that the engine will start readily.

AIR VENTING

If the fuel system has been opened at any time, say for an overhaul, it is necessary to ensure that all air has been removed before attempting to start the engine. This should be done as follows:—

BPE Pumps (enclosed camshaft type)

1. Partly unscrew closing plug immediately above control rod stop 7 (fig. 1) and turn the engine until fuel flows freely without any air bubbles.
2. Move control rod 6 (fig. 1) to maximum load position and turn the engine by hand again until fuel issues freely from the partly uncoupled union nuts of the pressure pipes at the nozzle holders.

BPF Pumps (flange mounted type)

1. If no special vent cock is provided for venting the suction system, set the control rod in the "Stop" position and unscrew the inlet pipe connection 4 (fig. 2) a little until fuel flows freely without air bubbles.
2. Set the control rod at "Maximum Output" position, and give a few strokes with the hand priming lever (or turn the engine by hand) until the pressure pipes are full, when the engine should be ready for starting.

LUBRICATION

BPE Pumps (enclosed camshaft type)

The lower part of the pump housing is filled up to the correct dipstick level on assembly with best quality engine oil. Subsequent topping up is not necessary as additional oil is supplied by back leakage of fuel oil past the pump plungers. On early type pumps without an open drain plug, periodic inspection is necessary to ensure that the oil does not rise above the correct level as marked on the dipstick. If level is too high, surplus oil should be drained off via the drain plug.

Later models are provided with an open oil level drain plug on the side of the fuel pump housing, from which surplus oil is drained. This arrangement ensures the correct oil level being maintained automatically.

Where pumps are dust-proofed, the dipstick is omitted, and the level of the oil is governed by the position of the drain plug.

BPF Pumps (flange mounted type)

The only lubrication required is that of putting a little engine oil on to the plunger guide 8 (fig. 2) from time to time, through the inspection window. The pump plunger needs no lubrication, as sufficient is derived from the fuel.

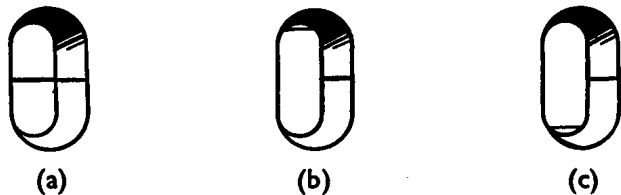


Fig. 7. Inspection window marks.

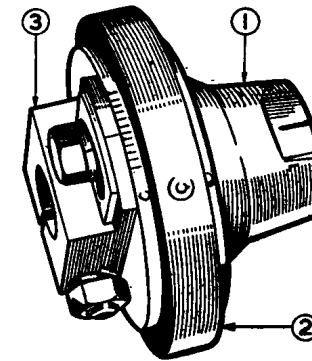
FITTING—TYPE BPF PUMPS

When fitting a pump to an engine (for instance, after an overhaul) it is important to see that the correct clearance is provided at the top of the stroke between the plunger and the delivery valve. In the case of BPF1A and BPF1B pumps this clearance is approximately half a millimetre minimum; in the case of BPF1Z and BPF1C pumps, 1 millimetre; BPF1X pumps, 1.2 millimetres; and BPF1D pumps, 1.5 millimetres. To facilitate accurate mounting and setting, a small inspection window is provided in the pump casing corresponding with a horizontal mark on the plunger guide 8 (fig. 2). This mark and a similar line mark on the inspection window are engraved before the pumps leave the factory. The three principal positions of the guide relative to the housing are shown in fig. 7.

The point in the plunger stroke at which delivery of fuel commences is shown at (a), where the mark on the guide 8 (fig. 2) is in line with the mark on the window. Diagrams (b) and (c) show, respectively, the mark on the guide just visible in the window at the top and at the bottom of the plunger stroke. These are the limits beyond which the guide must not move after final adjustment of the tappet. On X series pumps the line mark indicates the theoretical spill point.

FITTING—TYPE BPE PUMPS

When preparing to couple the engine and pump drive together, care should be taken to see that the lines marked R and L (right- and left-hand rotation) on the half coupling boss (fig. 8) are in line with the mark on the pump body, relative to the direction in which the pump is to be driven.



1. Pump side half coupling. 2. Centre disc.
3. Engine side half coupling.

Fig. 8. C.A.V. close slot coupling.

The engine should then be turned until No. 1 cylinder is in the position (usually about 10° before top dead centre) at which fuel injection should commence. The engine drive and pump can then be coupled, after which final adjustments may be made by means of the adjusting slots and set screws provided on the coupling flanges. Component parts of the coupling should be assembled in the first place as shown in fig. 8, i.e., with "zero points" exactly corresponding. The amount of adjustment can be measured by means of the graduation on the coupling flange, each division representing 3° measured on the pump camshaft (6° engine crankshaft).

Finally, the pipes connecting the nozzles of the various cylinders to the injection pump should be fitted, according to the particular firing order of the engine concerned.

NOZZLES AND NOZZLE HOLDERS

From the pump, the fuel is directed via the pressure pipe to the nozzle holder, which holds the injection nozzle in place in the combustion chamber of the engine (fig. 11). The fuel flows via the passage to the fuel gallery at the base of the nozzle body, where pressure is built up until it is sufficient to raise the nozzle needle 8, which is held on its seat by means of the spring 5 bearing on the pressure spindle 6. When the valve lifts, the fuel charge is forced at high pressure through the small discharge area of the spray holes or pintle clearance, and so broken up into a very fine "spray," in which form it enters the engine combustion chamber. The type of nozzle to be used depends on the requirements of the combustion chamber (see figs. 9 and 10).

SINGLE HOLE NOZZLES

A single hole nozzle is shown (fig. 9) and it will be seen that the outlet of this type consists of one hole bored centrally through the nozzle body and closed by the nozzle valve. The hole can be of any diameter from 0.2 mm (0.008") upwards. A variation of the single hole type is also shown (fig. 10), and is known as the conical end type. One hole only is used, but it is set at an angle to the vertical centre line of the valve as required.

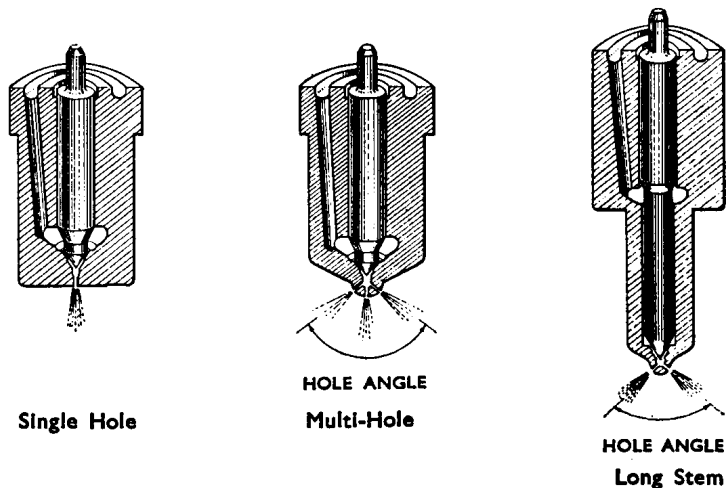


Fig. 9. C.A.V. fuel injection nozzles (see also fig. 10).

MULTI-HOLE NOZZLES

Multi-hole nozzles can have varying numbers of holes bored in a bulbous end under the nozzle mouth. These holes are usually arranged radially in a circle with even pitch, about the axis of the nozzle—their number, size and "hole angle" depending upon the requirements of the engine.

LONG STEM NOZZLES

For direct injection engines, where owing to limited space between valves in the cylinder head it is not possible to provide cooling of the nozzle in the usual way, an alternative form of multi-hole nozzle has been developed. This type is known as the "long stem" nozzle (fig. 9) and has an extended body, in the tip of which is provided the usual valve seating and dome for the injection holes. The valve stem is also elongated, but is a clearance fit in the body, the lapped portion of the barrel being confined to the section located above the fuel gallery.

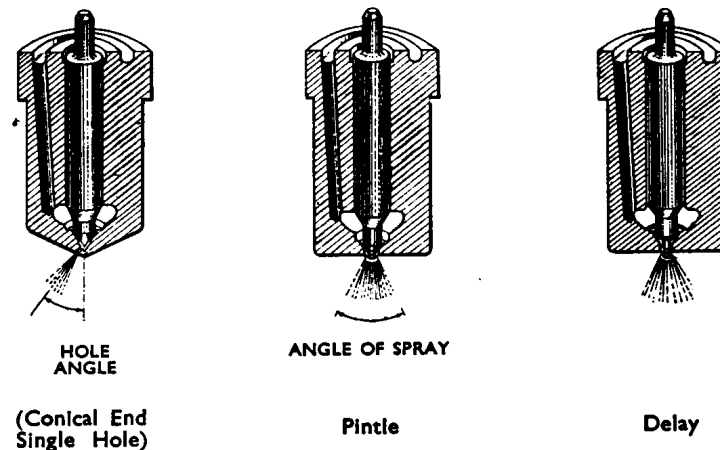


Fig. 10. C.A.V. fuel injection nozzles (see also fig. 9).

PINTLE NOZZLES

If the nozzle is of the pintle type, such as used in "air-cell," swirl chamber or pre-combustion chamber engines, for example, the stem of the nozzle valve, already described, is extended to form a pin or pintle which protrudes through the mouth of the nozzle body. By varying the size and shape of the pintle, sprays varying from a hollow parallel-sided pencil form up to a hollow cone with an angle of 60° or more can be provided.

DELAY NOZZLES

Certain pre-combustion chamber type engines require nozzles with peculiar spray characteristics in order to obtain quieter running at idling speeds. These results are produced by a modification of the pintle by means of which the rate of injection is reduced at the beginning of the delivery, the effect of this being, briefly, to reduce the amount of fuel in the combustion chamber when combustion commences, thus diminishing "diesel knock." The nozzle referred to is called the "delay" nozzle (fig. 10).

NOZZLE HOLDERS

C.A.V. nozzles are held in the correct position in the engine cylinder head by means of a specially designed C.A.V. nozzle holder (fig. 11) which carries the valve spring 5 against which the nozzle valve opens as a result of the fuel delivery pressure. At the lower end of the holder is a finely ground face which forms a joint with the flange of the nozzle body when tightened by means of the nozzle cap nut 7. Fuel is fed through the piping connected to the fuel inlet connection 10 through a hole in the nozzle holder which terminates in an annular semi-circular groove at the ground face of the flange of the nozzle body.

The nozzle valve is held down on its seat by means of the spring 5 acting through the spindle 6, the amount of compression placed upon the spring being adjusted by the compression screw 3.

The slight leakage of fuel which accumulates within the nozzle holder serves to lubricate the nozzle, and is led away by a pipe connected to the leak-off connection 11.

TROUBLES IN SERVICE

The first symptoms of nozzle trouble usually manifest themselves under one or more of the following headings:—

1. Cylinder knock.
2. Engine overheating.
3. Loss of power.
4. Smoky exhaust (black).
5. Increased fuel consumption.

Do not immediately assume, however, that the nozzles are the cause of the trouble, for such features as faulty engine valve timing, badly leaking engine valves, incorrect pump timing, dirty or damaged fuel filters, unsuitable fuel filtration, wrong fuel, water in fuel, defective engine lubrication or "hot" bearings may cause similar signs of distress.

Assuming, therefore, that everything else is in order and the nozzles are still suspect, the particular nozzle causing trouble can often be determined by releasing the pipe union nut on each nozzle holder in turn, with the engine running, and listening to the idling performance of each of the other cylinders.

In order to test the doubtful nozzle, first remove the nuts from its flange, and then withdraw the complete unit (i.e., nozzle holder and nozzle) from the cylinder head, turning it round the oil feed pipe so that the nozzle is pointing outwards, away from the engine. Next slacken the unions of the other nozzle holder oil feed pipes (to prevent fuel being sprayed into their cylinders) and turn the engine until the suspected nozzle sprays into the air, when it will be seen at once if the spray is in order.

If the spray is unduly "wet" or "streaky" or obviously to one side, or if the nozzle "dribbles," disconnect the unit and replace it with

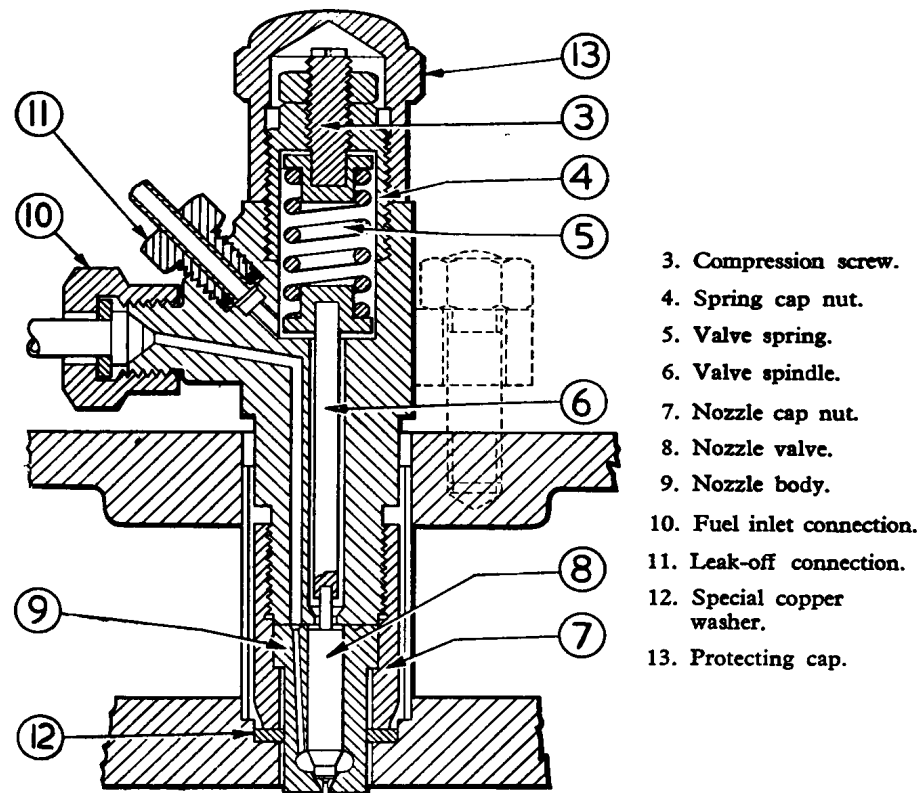


Fig. 11. Section through typical C.A.V. nozzle holder.

the complete spare unit (nozzle holder and nozzle) from the tool kit. **Great care should be taken to prevent the hands from getting into contact with the spray, as the high pressure will cause oil to penetrate the skin with ease.**

FITTING

When preparing to fit the spare nozzle holder and nozzle unit into the cylinder head, care should be taken to see that the special copper washer 12 (fig. 11)—obtainable from all C.A.V. depôts—is provided to make the joint between the nozzle cap nut and the cylinder head. Where engines have an integral copper face in the injector pocket, no washer is required.

The copper joint washer should be an easy but not loose fit on the nozzle body, and as this is quite an important feature, on no account should normal sparking plug type washers be used. The metal of the cylinder head, the faces of the copper joint washer and the face of the nozzle cap nut should be cleaned in order to facilitate the making of a leak-proof joint.

When fitting the nozzle holder in position, care should be taken to see that it is an easy fit in the cylinder head tunnel and on the holding-down studs, so that it can be placed down on the copper joint without force of any kind. If the nozzle end seems tight in the injector pocket, the pocket should be cleaned out with a piece of hardwood.

The securing nuts should be tightened down evenly in order to prevent the nozzle being canted and so "nipped" in the cylinder head. This is very important, since any unevenness in tightening down may cause distortion of the nozzle, and subsequent failure of the latter.

After fitting the spare nozzle holder and nozzle unit, the faulty unit should be placed in the tool kit, securely wrapped in clean grease-proof paper or rag, for attention by a C.A.V. Agent. The dismantling, cleaning and reassembling of these units is a highly skilled business and demands the use of special test equipment.

FUEL FEED PUMPS

PLUNGER AND DIAPHRAGM TYPES

To ensure the consistent working of a fuel injection pump it is essential that an uninterrupted supply of fuel is available. With many oil engines the only practical position for mounting the fuel tank is below the engine level, which necessitates the provision of some method of raising the fuel to the injection pump. With high-speed oil engines, as with other types, it is necessary that the output of fuel should vary in proportion to the amount demanded by the engine in order to cope with varying loads. This means it is necessary that the amount of fuel delivered by the feed pump should vary correspondingly in order to avoid starving or conversely overfeeding the fuel injection pump.

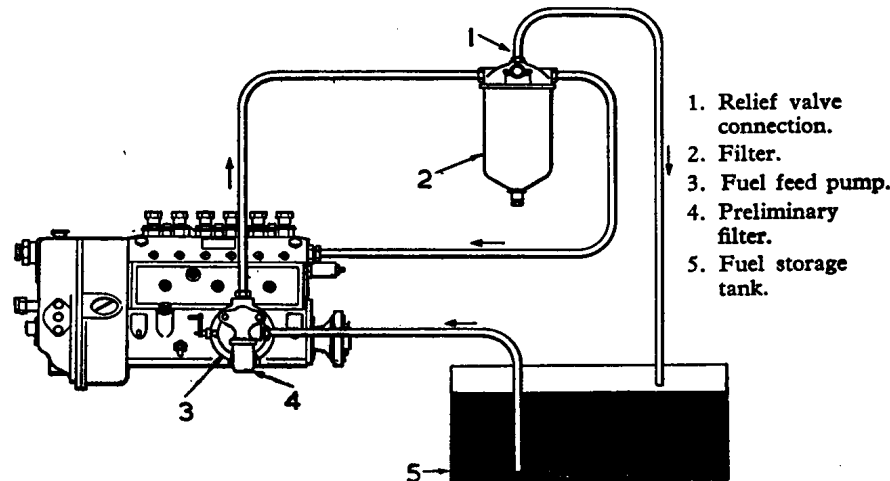


Fig. 12. Diagram of fuel system.

With any form of fuel feed the possibility always exists of the fuel tank becoming absolutely empty, due perhaps to the vehicle or machine undergoing repair or the operator failing to replenish the supply in good time. The inevitable result of this is an air-locked system which, in the absence of some form of priming device, necessitates motoring the engine by means of the electric starter, or turning by hand, until the system is free from air. As the former method means a prohibitive drain on the battery, a hand primer is incorporated in the fuel feed pump by which it can be operated with the engine at rest, in order to prime the piping and expel all air.

PLUNGER TYPE

CONSTRUCTION

Referring to fig. 13, it will be seen that the C.A.V. plunger type fuel feed pump consists of a main flanged body 20 into which are screwed the fuel inlet and outlet connections 9 and 5.

Under the two projecting hexagonal heads 17 are the spring-loaded valves 6 and 8.

A plunger 11, machined to a close fit in the body, is actuated via the guide 22 and spindle 12 by the injection pump camshaft, through the tappet roller 2.

The possible creepage of fuel along the spindle 12 and into the camshaft housing of the injection pump has been eliminated by providing an oil connecting groove and making the spindle a piston-fit in the housing. A hole is bored from the oil groove into the inlet plug chamber so that any oil collected in the groove is sucked into the inlet oil flow.

Should any difficulty be experienced in keeping fuel in the main tank free from coarse dirt, it is necessary to fit a preliminary filter to the feed pump, as shown in figs. 1 and 13.

The metal filter gauze 13 is of a sufficiently fine mesh to withhold any particles of dirt in the fuel large enough to cause damage to the fuel feed pump plunger, or to prevent the valves reseating. The filter is mounted within a metal container 21; this is clamped to an inlet plug connector of special shape and is detachable to permit the cleaning of the filter element.

This preliminary filter is fitted only upon request and takes the place of the small inlet plug filter gauze 24, fitted as standard. It must, however, be clearly understood that the fitting of any preliminary filter does *not* dispense with the necessity of providing a main filter between the feed and injection pumps.

OPERATION

When the cam 1 is in the position of minimum lift as shown in diagram (A), the spring 7 forces plunger 11 down so that the fuel is sucked up from the fuel tank through inlet 9 and into inner

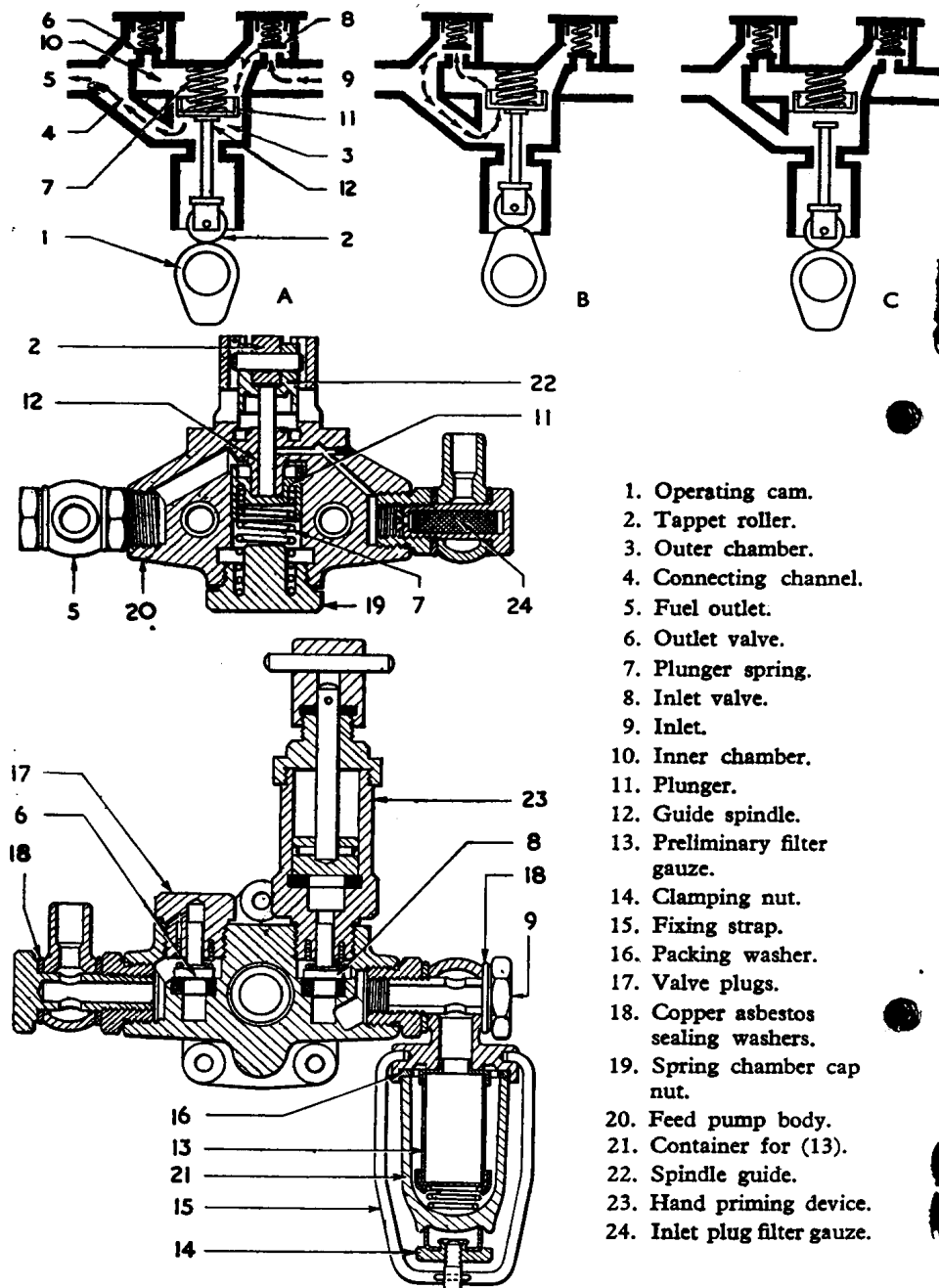


Fig. 13. Sectional and operational diagrams of C.A.V. plunger type fuel feed pump. The lower illustration shows the preliminary filter in position.

chamber 10. During the same movement the opposite side of the plunger forces the fuel from the outer chamber 3 through connecting channel 4 into fuel outlet 5.

As the cam turns and lifts the plunger, the inlet valve 8 is closed and the fuel forced past outlet valve 6 through connecting channel 4 into the outer chamber 3, as shown in fig. 13 (B).

It will be seen that the upward stroke of the plunger 11 effected by the cam 1 is not the pumping stroke. As the cam returns to bottom position fuel is delivered due to the spring-operated return stroke of the plunger which displaces fuel from chamber 3 into outlet 5, the valve 6 now being closed.

Excess fuel pressure on the delivery side of the feed pump must be relieved by means of a valve, preferably mounted on top of the main filter housing cap. In order to ensure the correct working of this valve it is important that the filter is placed between the feed pump and injection pump and on a higher level than the latter as shown in fig. 12. The fuel will then flow from the main filter housing by gravity and any air in the system will accumulate in the filter housing cover and pass out with any excess fuel through the relief valve back into the fuel tank via the overflow pipe.

A point worthy of note is that the outer pressure chamber 3, which surrounds the tappet plunger 11, is under continual pressure, thus eliminating the possibility of air locks due to air entering with the fuel from the tank.

HAND PRIMING DEVICE

This device is supplied as a self-contained unit. It is fitted to the feed pump on to the supply side by removing the valve plug 17 (see fig. 13) and screwing in the priming device in its place.

The hand priming device consists of a single acting plunger pump which draws oil from the supply tank on the suction stroke and delivers it via the piping and filter to the injection pump on the compression stroke.

When not in use the plunger is locked in position at the end of the delivery stroke by means of a few turns of the handle which engages with a coarse thread, this preventing movement of the plunger while the feed pump is being operated mechanically.

PERFORMANCE

The output of the feed pump is such that it can easily cope with the demands of a 6-cylinder fuel injection pump with the largest size of plunger (10 mm) up to 1000 r.p.m. (2000 engine r.p.m. on a

4-stroke engine). It is capable of lifting all normal light diesel fuels from a maximum distance of 6 feet below the level of the centre of the pump, an ample figure for most practical purposes.

MAINTENANCE

Periodically, the gauze of the preliminary filter should be withdrawn and washed in clean petrol or fuel oil, and at the same time inspected for breakages.

ADJUSTMENT

No adjustment whatever should be necessary, as all C.A.V. feed pumps are thoroughly tested and adjusted before leaving the works.

After a prolonged storage, the plunger surface is liable to become dry; it is, therefore, advisable to lubricate the plunger through the inlet plug before making the final pipe connections, in order to facilitate the pump suction.

DIAPHRAGM TYPE

CONSTRUCTION AND OPERATION

The diaphragm type fuel feed pump shown in fig. 14 incorporates a hand priming device and may be fitted with a preliminary filter if required.

An eccentric on the camshaft operates the diaphragm through a bell crank lever, which is proportioned to give a total diaphragm stroke of 3.5 mm. As the camshaft revolves; a thrust is imposed on the lever which, by the action of the fork at the opposite end of the lever, displaces the diaphragm. To minimise wear, the lever is provided with hardened and polished surfaces where it engages the eccentric at one end and the spring plate at the other end. The action of displacement on the diaphragm causes a depression above the inlet plate valve, which is then able to overcome its spring and, in consequence, to lift, allowing fuel to be drawn into a cavity through two passages. The return stroke is controlled by a special spring which replaces the diaphragm to its former position and allows fuel oil to be pumped from the cavity, through the passages and ball valve, to the fuel filter and on to the fuel gallery of the injection pump.

A constant pressure of $3\frac{1}{2}$ to $4\frac{1}{2}$ lb./sq. in. should be maintained in the fuel gallery. Once this pressure has been reached, the spring controlling the return stroke of the diaphragm ceases to function and the limited action decreases the flow of fuel oil until the pressure falls below the figures mentioned. In other words, the pumping stroke of the diaphragm will vary according to the amount of fuel required by the injection pump under varying engine loads. When the diaphragm is not making its full stroke the bell crank lever is kept in close contact with the eccentric by a spring and excessive wear due to hammering is minimised.

METHOD OF HAND PRIMING

The spindle 26 has one end formed as a special cam 30 which engages spring plate 4. At the other end is attached an operating lever 24 which, when depressed, displaces the diaphragm a full stroke as in normal running, and priming is a simple operation. When the feed

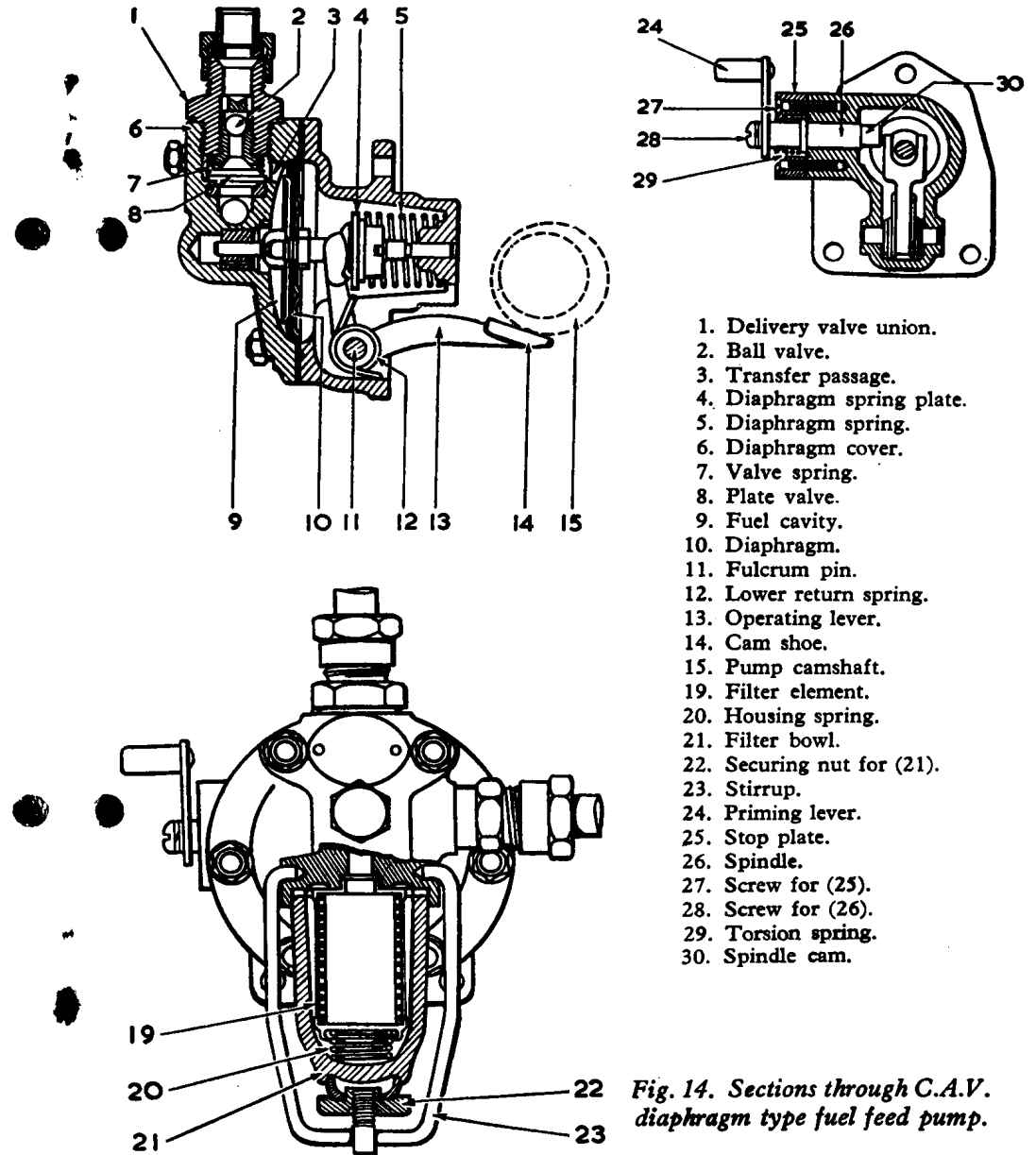


Fig. 14. Sections through C.A.V. diaphragm type fuel feed pump.

pump is operating by the camshaft eccentric the priming mechanism is held out of engagement by torsion spring 29.

MAINTENANCE

To clean the filter element, slacken the knurled nut 22, swing stirrup 23 clear and lower the bowl 21, housing spring 20 and element 19. The gauze should be cleaned only with a stiff brush dipped in petrol or fuel oil. On no account should a cloth be used for cleaning, as minute pieces of the fabric are liable to be left in the fuel system.

In some instances a pre-filter of the gauze type may be fitted externally on the suction side of the feed pump. A pre-filter is not a substitute for the main fuel filter which must be fitted between the feed pump and injection pump.

FILTRATION

It will be appreciated that the C.A.V. fuel injection pump and nozzle are designed to operate against very high pressures at varying speeds, and must retain their efficiency to a high degree throughout their working life. Accordingly, a very high standard of workmanship and the utmost precision in manufacture are required. The internal mechanism must be protected from the abrasive effects of dust and other foreign matter present in all types of fuel oil. For this reason, special attention is directed to the methods of fuel storage and to the fitting and frequent inspection of a suitable filter.

FUEL STORAGE

Fuel oil should always be stored in clean tanks or drums, *which must not be galvanised internally*. They may be galvanised externally or coated with two coats of bituminous paint as desired.

Tanks or drums must be cleaned thoroughly internally of all scale and rust before installation, and should be secured so that the bottom slopes down, away from the draw-off tap, to enable water and impurities to settle and not be drawn off with the fuel. A cock should be provided at the lowest point of the tank for draining off the accumulated sludge. More complete details regarding filtration and storage of fuel oil will be supplied on request.

SERVICING FILTERS

The importance of correctly servicing filters cannot be over-emphasised, as many complaints of fuel pump element wear can be traced to lack of care in the servicing of filters. If filters are found to choke with dirt in an unreasonably short time, this may point to unsatisfactory fuel supply storage or handling conditions, and steps should be taken to investigate in order to find out how, and at what point, an undue amount of impurities can enter the system.

TYPES OF FILTER

Several types of filter are available, to suit varying conditions of operation, including paper element, cloth element, felt element, and combined cloth and felt element types. If the fuel feed is pressure fed to the injection pump by means of a fuel feed pump or similar arrangement, the filter is fitted with a relief valve in order to provide a leak-off should the pressure become excessive. If a gravity method of fuel feed is employed, the relief valve is considered unnecessary.

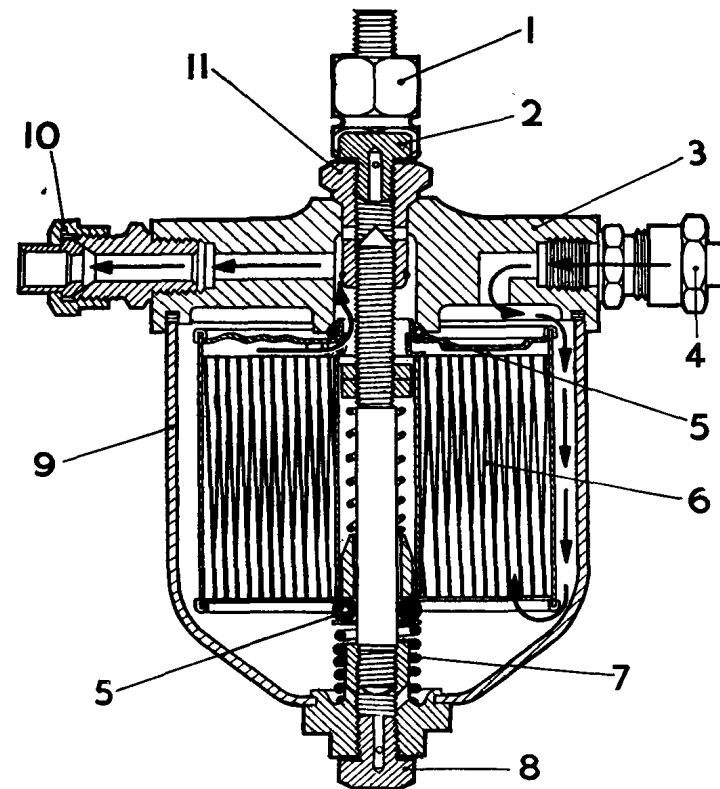


Fig. 15. Type "F" paper element filter in section.

- | | |
|------------------------|------------------------|
| 1. Gravity vent valve. | 7. Pressure spring. |
| 2. Air vent plug. | 8. Drain plug. |
| 3. Cover. | 9. Filter bowl. |
| 4. Inlet connection. | 10. Outlet connection. |
| 5. Oil seal. | 11. Cap nut. |
| 6. Paper element. | |

Paper Element (type "F") Filter.—The general arrangement of the type "F" filter will be seen by reference to fig. 15. The filter is of the cross-flow type, the inlet and outlet connections 4 and 10 being carried on the cover 3, which also incorporates a bracket for support. The pot or bowl 9 is of pressed steel, and forms an oil-tight

container for the paper element 6. An air vent plug 2 is also carried on the cover, and according to requirements a gravity vent valve or pressure relief valve may be carried in addition. A drain plug 8 is provided at the bottom of the filter bowl.

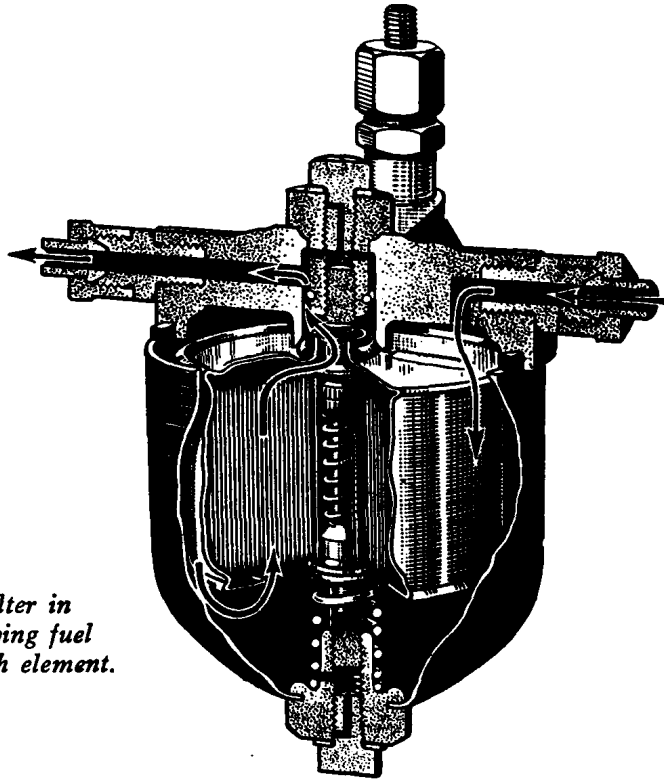


Fig. 16. Filter in section showing fuel flow through element.

Method of Operation. — Further reference to figs. 15 and 16 will show just how the paper element filter operates. Fuel enters the filter through connection 4, passes down outside the element container, then up through the element, and finally emerges via the central outlet at the top of the element and so out through the outlet connection 10.

Dirty fuel is excluded from the clean side of the element by means of oil seals 5 at top and bottom of the element core, oil tightness of the seals being maintained by the pressure of spring 7.

Paper elements are not intended to be cleaned and must be discarded when choked. The cost of replacement elements has been kept down to the lowest possible figure compatible with meticulous care in manufacture, and compares more than favourably with other less efficient filtering elements.

The number of filters employed for any engine installation will obviously depend upon the capacity of the particular engine and the

conditions of operation. In all cases the main object is to provide the highest possible degree of filtration consistent with long filter element life.

A single paper filter is normally recommended, but in cases where operating conditions are particularly severe, or when an extra long element service life between changes is required, two or more filters may be used in parallel. For this purpose, multiple bowl filters with common cover are available and particulars will be supplied upon request.

It is recommended that a spare element be carried in the tool kit until a suitable servicing interval can be determined. An instruction book containing servicing procedure can be obtained from C.A.V. Ltd.

Cloth Type Filter. — The filter illustrated in fig. 17 is of the cross-flow, cloth element type, and consists of a metal housing 5, with cover 4, which carries the closing plug 1 and air vent screw 3. It has a

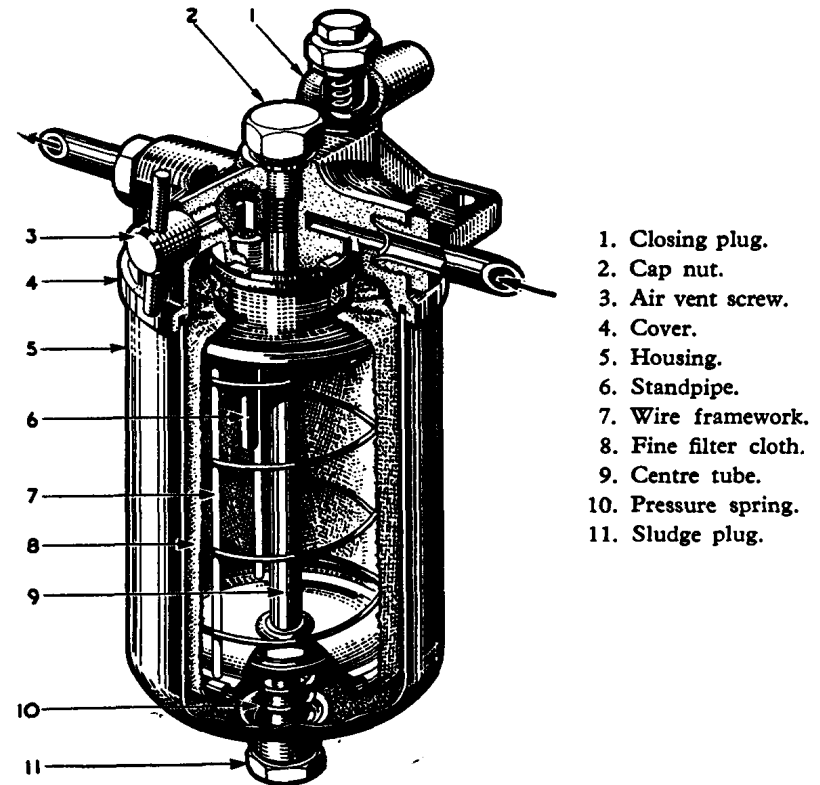


Fig. 17. Section through C.A.V. cloth type filter.

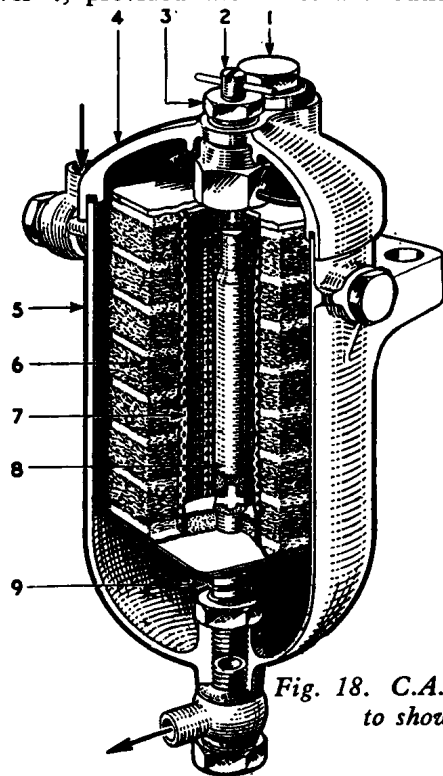
capacity of flow with a 3 ft. head of fuel of 3.5 to 4.5 pints/minute with a reasonably clean condition of cloth and fuel. A cloth element filter of similar design, but arranged for down-flow operation, is also available.

The fuel, on entering through the inlet connection, passes through the finely woven cloth 8, which is stretched over a spiral wire framework 7. The fuel then flows up through standpipe 6, and out into the main pipeline via the outlet connection.

When the filter is assembled, the element is held tightly pressed against the spring 10 in the base of the housing so that there is no possibility of fuel issuing without having passed through the filter cloth. The filter can be dismantled with ease for inspection by unscrewing the cap nut 2 and separating the housing 5 from the cover 4. The filter element can then be easily withdrawn from its housing. A sludge plug 11 is provided at the base of the housing through which any dirt deposit can be drained.

No attempt should be made to clean the filter cloth, as this invariably results in some of the impurities being transferred to the clean side of the filter. Used filter cloths should therefore be discarded, and new ones fitted

Felt Type Filter.—The felt element filter shown in fig. 18 is of the down-flow type and comprises a metal housing 5 with oil-tight cover 4, provided with inlet and outlet connections. The element



1. Closing plug.
2. Air vent screw.
3. Cap nut.
4. Filter cover.
5. Filter housing.
6. Felt pads.
7. Gauze tube.
8. Centre tube.
9. Pressure spring.

Fig. 18. C.A.V. felt type filter, sectioned to show internal construction.

consists of a series of felt pads 6, built up on a perforated support tube 8, the fuel flow being from the outside to the inside of the element.

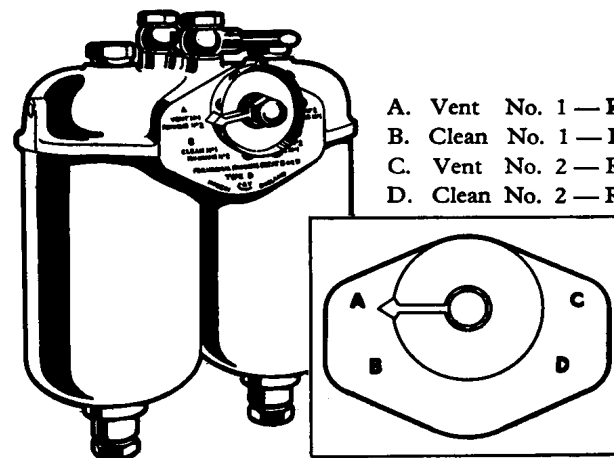
The filter element can be cleaned, using petrol or carbon tetrachloride, but it is not recommended that an element be cleaned more than three or four times before replacement. When servicing this element, particular care must be taken to seal the exposed orifices with clean corks and to use a soft brush to remove dirt during immersion in the cleaning fluid.

On no account should the felt pads be removed during the cleaning operation, as this will result in spreading the dirt across the pads and so increase the possibility of it getting through to the injection pump. When required, new felt pads (obtainable from C.A.V. depôts) should be fitted to the filter frame. This operation, of course, demands a suitable dust-free workshop.

Combined Cloth and Felt Type Filter.—These filters are basically similar in design to the felt type, but in this case the felt pads are surrounded by a cloth element through which the fuel has first to pass before reaching the felt element.

When servicing this type, the dirty cloth element must not be cleaned, but should be discarded in the same manner as when servicing a cloth type filter. The felt element should be cleaned as described above, replacing the felt pads if necessary. Finally, a new cloth element should be fitted and assembled on to the filter frame.

Duplex Filters.—These consist of two standard single units connected together by means of a common cover, and may be fitted with either cloth or felt type elements. A two-way valve is located between the filters, which operates on both inlet and outlet connections, its purpose being to direct the fuel to either one of the two filters. The valve is operated by a convenient handwheel with pointer, with clearly marked



- A. Vent No. 1 — Running No. 2.
- B. Clean No. 1 — Running No. 2.
- C. Vent No. 2 — Running No. 1.
- D. Clean No. 2 — Running No. 1.

Fig. 19. Instruction plate on twin type filter.

index positions, including venting points (see fig. 19). By this means the servicing of one unit may be carried out while the other is still in use.

Before replacing or cleaning the elements, turn the pointer to the position B or D, which will shut off the supply of fuel to the filter which it is desired to remove, and then proceed as described above for cloth or felt type filters. Similarly, before using a serviced duplex filter it is necessary to air vent the unit by turning the pointer to position A or C and opening the vent.

AIR VENTING

All C.A.V. filters are fitted with an air vent valve for this purpose. In order to air vent a filter, open the vent valve and turn the engine until fuel oil pours out free from air bubbles. Then tighten vent valve.

GOVERNORS

Among the problems created by the development of the diesel engine was the characteristic tendency of this type of engine to "stall" or "race" when idling. It was, therefore, found desirable to provide a governor for idling conditions which would automatically control the fuel delivery in accordance with a predetermined engine idling speed. The idea naturally followed to combine in this device an arrangement which would enable it to limit also the maximum speed of the engine.

C.A.V. governors are designed for either mechanical, pneumatic or hydraulic means of control, fully detailed descriptions and methods of adjustment and maintenance of same being dealt with in separate publications, copies of which may be obtained on request.

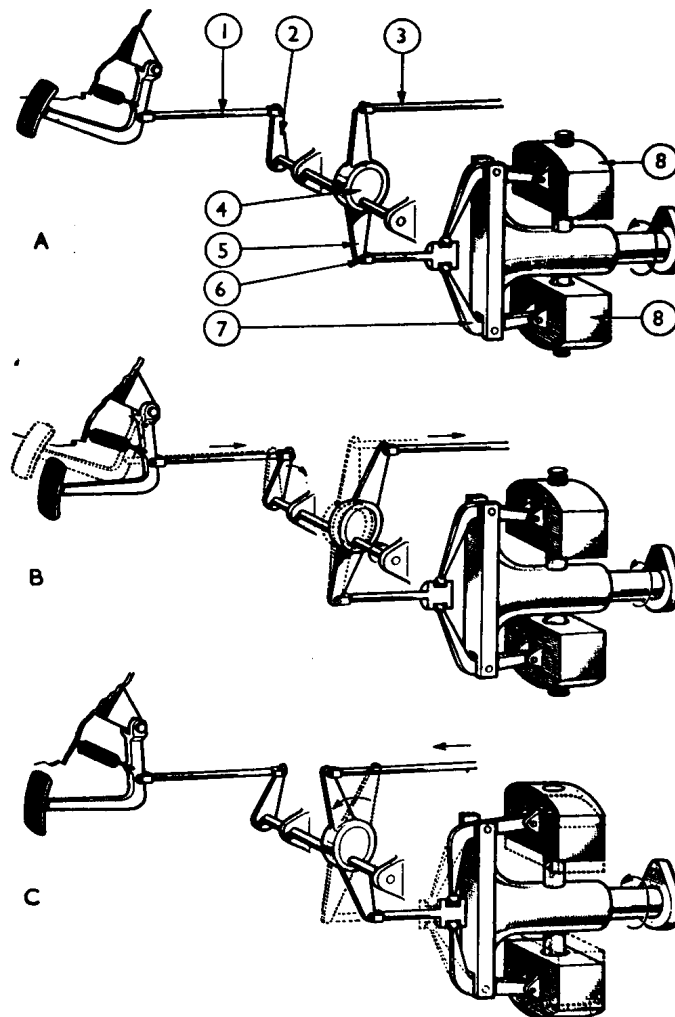
MECHANICAL GOVERNOR

IDLING AND MAXIMUM SPEED TYPE

In principle, this governor comprises centrifugally actuated, spring-loaded weights complete with suitable linkage which transmits the motion of the weights to the fuel pump control rod as shown in fig. 1.

The operation of the governor is shown diagrammatically by fig. 20, from which it will be seen that the two weights 8 are mounted on an extension of the fuel pump camshaft, and to these weights are attached bell crank levers 7 which, in turn, are connected to the floating lever 5 by coupling pin 6.

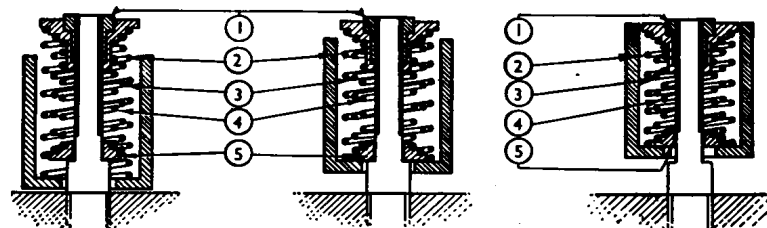
When the engine is accelerated, the governor weights tend to fly outwards under centrifugal force and thus pull the control rod of the pump towards the "Stop" position (sketch C), as a result of which the engine is slowed down. These weights are, however, retained by springs so that if the engine speed falls the springs move the weights inwards, when the delivery of fuel (and consequently the speed of the engine) is increased (sketch B).



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|---------------------|----------------------|
| 1. Operating lever. | 5. Floating lever. |
| 2. Control lever. | 6. Coupling pin. |
| 3. Control rod. | 7. Bell crank lever. |
| 4. Eccentric. | 8. Weights. |

Fig. 20. Principle of the mechanical governor.

Combined Automatic and Foot Control.—It is a generally accepted principle that for the best oil engine control it is desirable that the accelerator pedal should operate the pump control rod independently of the governor. Thus, in the C.A.V. type governor, when the pedal is depressed the lever 2 and eccentric 4 are turned to the right; the floating lever 5 is thus moved by a corresponding amount and the pump control rod 3 drawn from the "Stop" position so that the engine is accelerated irrespective of the position of the governor weights. In other words, it has been found possible by this arrangement to combine automatic governing with foot control by means of the floating lever 5 having for its pivot firstly the eccentric 4, and secondly the coupling pin 6.



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|--------------------------|-------------------------|
| 1. Spring retaining nut. | 3. Strong inner spring. |
| 2. Light outer spring. | 4. Strong inner spring. |
| | 5. Spring plate. |

Fig. 21. Operation of mechanical governor weight springs.

The light outer springs 2 (fig. 21) control the idling speed and bear directly on the bottom of the governor weight recess. Actuation of the accelerator pedal gives sufficient fuel to enable the engine speed to rise to such an extent as will cause the governor weights to overcome the tension of these outer springs. The weights will then be restricted in any further upward movement by spring plate 5 which is loaded by one or (in the case of higher speeds) two stronger springs 3 and 4. When, however, the engine speed reaches its maximum, the weights will have attained sufficient centrifugal force to overcome even these stronger springs, so that once again the pump control rod will be pulled back via the governor linkage; the fuel output to the pump will be reduced and so the engine speed will fall. In between the idling and maximum speeds, the governor is inoperative and the accelerator pedal has full control over the engine speed.

Spring Link and Manual Stop.—With this governor a spring link is sometimes used to connect the fuel injection pump control rod with the governor mechanism. This not only forms a ready means in emergency of bringing the control rod to its zero position by hand,

regardless of any damage that may have happened to the governor or accelerator pedal linkage, but also helps to improve the governor cut-off characteristics.

VARIABLE RANGE SPEED GOVERNOR

In this type of governor, any speed between idling and maximum can be pre-set by means of an operating lever and automatically maintained by the flyweight mechanism. For full details see separate publication.

PNEUMATIC GOVERNOR

The C.A.V. pneumatic governor has been designed to control the output of the fuel injection pump and therefore the engine at any given speed throughout the entire range between the maximum and idling limits which are predetermined by stop-screw adjustments.

PRINCIPLE AND CONSTRUCTION

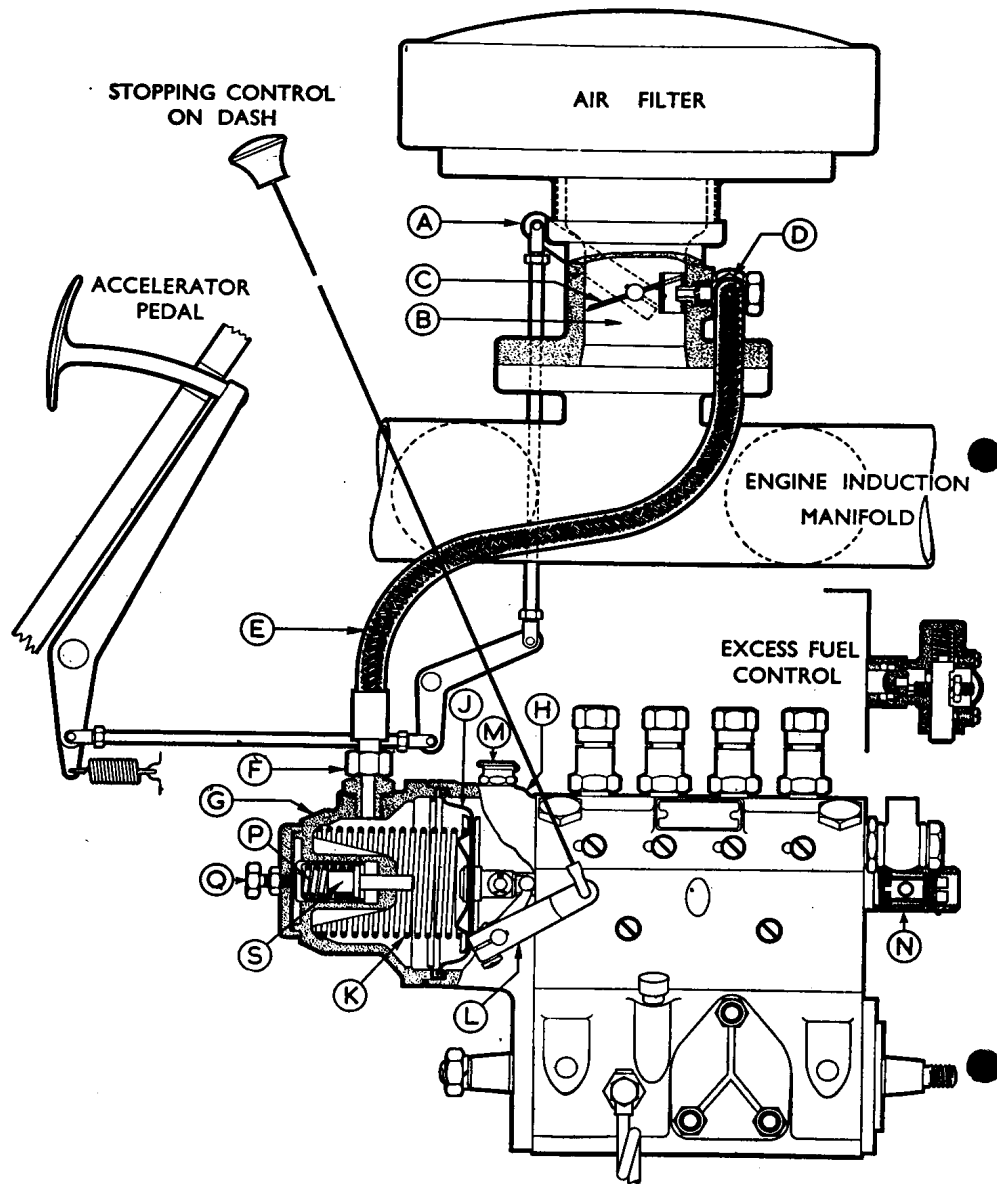
It is a well-known fact that air passing through a pipe tends to create a pressure drop in any smaller pipe joining into it at an angle. This is the principle used in the pneumatic governor, the engine suction in this case being utilised to provide the necessary air flow. The differences in pressure are communicated by means of a flexible tube, and operate a diaphragm control connected directly to the control rod of the fuel injection pump.

The two main units are:—

1. The venturi air flow control unit mounted between the induction pipe of the engine and the air filter.
2. The diaphragm unit mounted directly on the fuel pump.

Referring to fig. 22, it will be seen that the venturi unit consists of a body provided with a flange for mounting generally direct on the engine induction pipe and a spigot at the opposite end for accommodating the air filter. The throat of the body is machined to form a venturi, the dimensions varying according to the type of engine to which it is fitted. At the smallest throat diameter of the venturi is fitted the butterfly valve C for controlling the air flow and actuated from the accelerator pedal through the lever A; the amount of movement for maximum and idling speed is governed by two adjustable stops T and U (fig. 23). On the same centre line as the butterfly valve is a screwed connection D through which the air is exhausted from the diaphragm unit actuating the pump control rod.

The diaphragm unit consists of a housing G mounted on a separate casting H with the special leather diaphragm clamped between the two, and providing an air-tight compartment within the housing G. A light spring K, acting on the diaphragm, is provided in order to damp out any undue variations in pressure that may occur, and tends to keep the control rod in full open position. An additional lever L is provided for stopping the engine and is operated from the dashboard by a steel wire or similar control.



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|----|------------------------------|----|-----------------------------|
| A. | Venturi valve control lever. | J. | Diaphragm. |
| B. | Venturi throat. | K. | Main diaphragm spring. |
| C. | Venturi butterfly valve. | L. | Stop lever. |
| D. | Vacuum pipe union. | M. | Oil cap. |
| E. | Vacuum pipe. | N. | Control rod stop. |
| F. | Diaphragm housing union. | P. | Auxiliary idling spring. |
| G. | Diaphragm housing. | Q. | Auxiliary idling set-screw. |
| H. | Main housing. | S. | Auxiliary idling plunger. |

Fig. 22. Diagrammatic and sectional view of the C.A.V. pneumatic governor.

When the pneumatic governor is required for use with engines on which the air intake is subject to wide pressure fluctuations, difficulty might be experienced in controlling idling speeds. As a result, an alternative form of diaphragm control incorporating an additional adjustable spring has been developed.

The auxiliary spring P can be adjusted and permanently set to suit the particular requirements of any engine by means of the adjustable set-screw Q.

OPERATION

The operation of the C.A.V. pneumatic governor may be easily understood from the following paragraph, read in conjunction with figs. 22 and 23:—

With the engine stationary and the lever L released, the spring K forces the control rod to the full extent of its travel, so that it is in the starting position when the starter button is pressed. When the engine has started it may be idled by releasing the accelerator pedal and thus closing partially the butterfly valve C, when high vacuum is created in the connecting tube E and air-tight compartment G. As the air in the compartment H is at atmospheric pressure and therefore now in excess of that in compartment G, the diaphragm together with the control rod is moved towards the "Stop" position until the engine is running at the predetermined idling speed required.

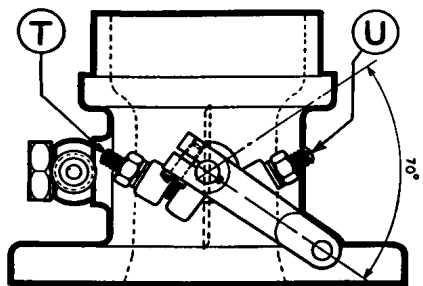
To increase engine speed, the accelerator pedal is depressed, opening the valve C and so decreasing the air velocity past the mouth of the connecting tube. This results in an increased pressure in G, and the movement of the control rod towards the maximum speed position. A maximum speed stop T is therefore provided in order to prevent the valve moving beyond this position as further movement will tend partially to close the opening, thereby reducing rather than increasing the speed.

The restriction caused by fitting the venturi unit does not affect the running of the engine, as it is always less than the restriction at the air inlet valves. There is, therefore, no loss of volumetric efficiency of the engine through the use of the pneumatic governor.

The venturi control unit is located between the air filter and the engine induction pipe, and a flange is provided on the venturi unit body to permit mounting directly on the induction pipe itself. Care must be taken, in any case, to avoid all leaks in the induction system, particularly between the venturi unit and the governor housing, as these may render the governor inoperative and cause the engine to race, with consequent serious damage.

Lever A of the venturi is connected to the accelerator pedal in such a way as to provide the pedal with a large path of travel in order that the control rod stops T and U may be adjusted to provide engine regulation to fine limits. To prevent the full force which is applied

to the accelerator pedal being brought directly to bear on the adjustable stops, it is necessary to provide suitable pedal stops. Care should be taken, when linking up the venturi, to set these pedal stops so that the force is just taken off the venturi stops. When adjustments are made to the venturi stops, corresponding adjustments should also be made to the pedal stops.



T. Adjustable screw for maximum speed.
U. Adjustable screw for idling.

Fig. 23. Control stops on venturi.

MAINTENANCE

The diaphragm, being made from a specially prepared leather, should give lasting service, but in the event of a leak being suspected, the following procedure should be adopted:—

- (a) Remove vacuum pipe E.
- (b) Move the stop lever L into "Stop" position.
- (c) Place a finger over the diaphragm housing union F in order to seal it.
- (d) Release the stop lever.
- (e) The control rod should then remain stationary, any movement towards the maximum speed position indicating leakage either at the diaphragm or at the housing union, or between the housing and main cover. If the union, housing and cover joints are tight, then the leakage is occurring at the diaphragm, which should be replaced.

If it returns quickly for the whole movement and the housings G and H are clamped firmly together, then the diaphragm is leaking and should be replaced, preferably by a C.A.V. Agent.

The diaphragm should be kept pliant by the addition of one tablespoonful of lubricating oil through the oil cap M every week.

Note: When injection pumps are dust-proofed, oil cap M is replaced by a covered breather, and in this case it is unnecessary to insert oil, the diaphragm being lubricated by oil mist from within.

Vacuum pipe E can be tested for leaks in exactly the same way as the diaphragm, except that the diaphragm housing end is connected to union F and a finger applied to the venturi end of the pipe.

See that slackness does not occur between the accelerator pedal and all the levers and pins connected with the venturi or diaphragm unit. Clean the air filter fitted to the venturi unit at regular intervals, according to the conditions under which the engine is operating. If the supply is restricted through a partially choked filter the maximum speed will be diminished.

Never run the engine without the air filter in position.

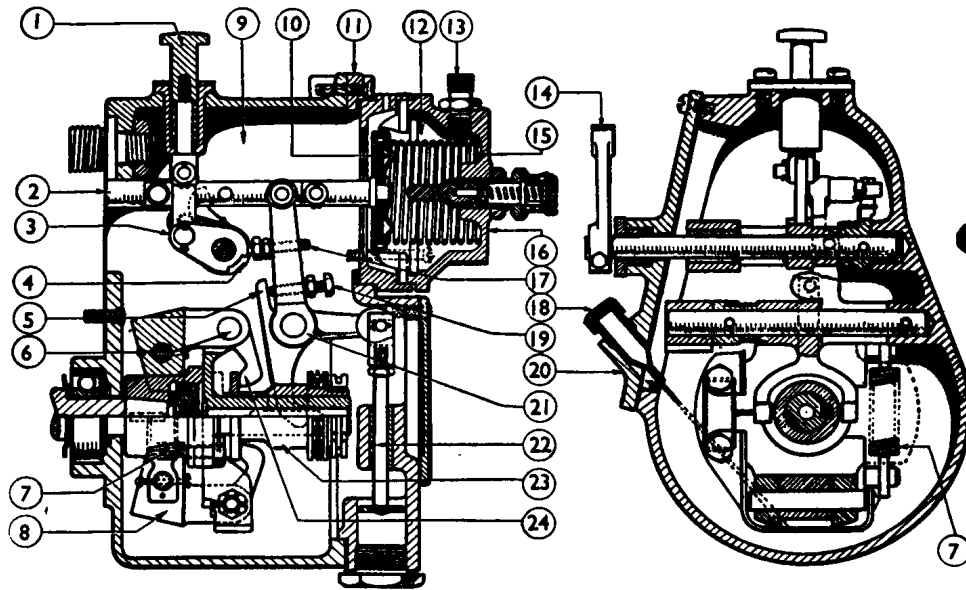
Stop lever L should be perfectly free throughout the whole of its permitted movements.

CAUTION

The C.A.V. Pneumatic Governor depends for its action upon pressure variations set up in the air intake pipe of the engine by the venturi control valve. If this should be removed either by itself or with the inlet manifold during overhaul, or if all pressure pipe unions are not always kept perfectly tight, then the governor may fail to operate, causing damage to the engine. **IN NO CIRCUMSTANCES SHOULD THE ENGINE BE RUN WITHOUT VENTURI CONTROL UNIT, PRESSURE PIPE OR INLET MANIFOLD.**

COMBINED GOVERNOR

As its name implies, this governor consists of a combination of the pneumatic and mechanical governors, both of which are located in a common housing (see fig. 24) which is attached to the fuel pump.



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|----------------------------|---|
| 1. Plunger knob. | 13. Vacuum pipe connection. |
| 2. Control rod. | 14. Operating lever. |
| 3. Spring-loaded pawl. | 15. Diaphragm spring. |
| 4. Slot in (3). | 16. Diaphragm housing. |
| 5. Pick-up lever. | 17. Adjusting screw (excess fuel stop). |
| 6. Pivots for (24). | 18. Oil dipstick. |
| 7. Springs. | 19. Adjusting screw (maximum speed). |
| 8. Weights. | 20. Side cover. |
| 9. Air-tight compartment. | 21. Linkage. |
| 10. Diaphragm. | 22. Oil damper plunger. |
| 11. Diaphragm cover. | 23. Sleeve assembly. |
| 12. Air-tight compartment. | 24. Bell crank lever. |

Fig. 24. Sectional views of combined governor.

In this case the control rod 2 is connected to a spring-loaded leather diaphragm 10, which seals the spring chamber 12 from the remainder of the space inside the main governor housing. A pipe coupled to connection 13 is connected to a "venturi" or throttle unit fitted with a butterfly valve in the air inlet manifold (see fig. 22). According to the position of the butterfly valve, the amount of vacuum in the

connection air pipe will vary. Thus with the engine stationary and the butterfly valve open, the spring 15 forces the control rod to the full extent of its travel, so that it is in the starting position when the starter button is depressed.

When the engine has started it may be idled by releasing the accelerator pedal, thus partially closing the butterfly valve, when high vacuum is created in the connection pipe and air-tight compartment 12. As the air in compartment 9 is at atmospheric pressure and, therefore, now in excess of that in chamber 12, the diaphragm 10 together with control rod 2 is moved towards the "Stop" position, until the engine is running at the predetermined idling speed.

To increase engine speed the accelerator pedal is depressed, opening the butterfly valve, and so decreasing the air velocity past the mouth of the connection pipe. This results in an increased pressure in chamber 12 and movement of the control rod towards the maximum speed position follows. When the maximum speed is reached the weights 8, which are keyed to the pump camshaft, attain sufficient centrifugal force to overcome tension of their springs 7, and so move outwards on pivots 6. In doing so, their cranks 24 move the sleeve assembly 23 inwards, and by means of the linkage 21, the control rod is moved towards the "Stop" position, thus cutting down the fuel delivered to the engine.

Excess fuel for starting is provided by means of a pawl mechanism 3. Depression of the knob 1 enables the screw 17 carried on the linkage 21 to engage in the slot 4, thus permitting the control rod to move further open. Once the engine has started and the control rod been moved back by means of diaphragm 10, the screw 17 abuts against the raised surface of the pawl 3, which is spring-loaded, thus restricting the maximum control rod opening under normal running conditions.

HYDRAULIC GOVERNOR

This governor is specially designed for use with "N" type fuel injection pumps and is fully described in separate publications, copies of which may be obtained on request.

