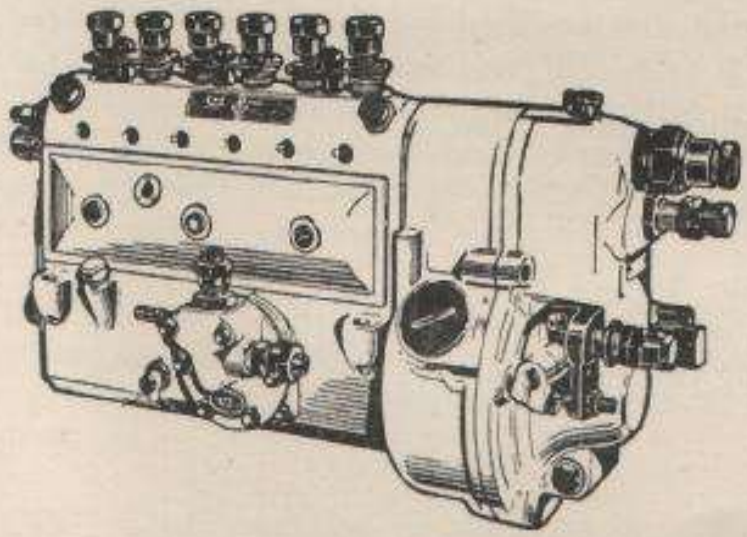
C.A.V. LIMITED

FUEL INJECTION PUMP

ENCLOSED CAMSHAFT TYPE MODEL B.P.E.



INSTRUCTION BOOK

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FUEL INJECTION PUMP MODEL BPE

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 this respect the modern high speed oil engine is no exception since the injection system is an integral part of the engine design. For maximum efficiency in operation it is essential that the engine not only be provided with fuel in quantities proportional in the most minute degree 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 fuel injection equipment will be appreciated.

The successful operation of such equipment, however, depends first and foremost on one item of supreme importance—complete cleanliness of the fuel oil. It is our experience that many complaints regarding fuel injection equipment are due to lack of knowledge on the part of operators in the care and maintenance of fuel filters, and in the handling and storage of fuel oil. Full details regarding all aspects of filtration and storage of fuel oil will gladly be supplied on request.

BRIEF CONSTRUCTIONAL DETAILS

C.A.V. Fuel Injection Pumps, models BPE-A and BPE-B have a constant plunger stroke and a range of plunger diameters as shown in the following table.

BPE-A PLUNGER STROKE=7 mm.		**BPE-B** PLUNGER STROKE=10 mm.	
Plunger dia.	*Maximum output per stroke*	*Plunger dia.*	*Maximum output per stroke*
4·0 mm.	·0015 ins.³= 25 mm.³	5·0 mm.	·0041 ins.³= 65 mm.³
5·0 „	·0024 „ = 40 „	6·0 „	·0061 „ =100 „
6·0 „	·0038 „ = 60 „	6·5 „	·0076 „ =125 „
6·5 „	·0053 „ = 87 „	7·0 „	·0082 „ =135 „
7·0 „	·0062 „ =102 „	7·5 „	·0098 „ =160 „
		8·0 „	·0109 „ =180 „
		9·0 „	·0143 „ =230 „
		10·0 „	·0171 „ =280 „

Note.—Pumps of larger output than Series B are also available; particulars will be supplied on request.

The selection of suitable plunger diameters should be considered in relation to the duration of injection to suit the particular engine for which it is required; the larger the plunger diameter the shorter will be the injection duration, other factors remaining constant.

WEIGHTS OF STANDARD PUMPS

Type	*Engine*	*Housing*	*Approximate Weight*	
			lb.	*kg.*
BPE4A	4-cyl.	Aluminium	18	8·2
BPE6A	6-cyl.	Aluminium	21	9·5
BPE2B	2-cyl.	Aluminium	15	6·8
BPE3B	3-cyl.	Aluminium	19	8·6
BPE4B	4-cyl.	Aluminium	21	9·5
BPE5B	5-cyl.	Aluminium	25	11·3
BPE6B	6-cyl.	Aluminium	30	13·6

DIMENSION DRAWINGS ON REQUEST

FUEL STORAGE

Whenever possible, fuel oil should be purchased and stored in bulk, large tanks being used for the latter purpose, so arranged that they can be periodically emptied and cleaned out. It is preferable to use twin tanks connected in such a way that one can serve as a settling tank in which the heaviest of sludge can gravitate from the fuel during storage. The fuel oil should then be drawn through suitable large capacity filters into the engine fuel tank, care being taken to avoid any possibility of dirt entering the system during the process.

GENERAL DESIGN

The C.A.V. Type BPE Fuel Injection Pump is of the cam-operated, spring-return, plunger type, employing one pumping unit for each engine cylinder, and incorporates its own camshaft and tappet gear. It is available in single and multi-cylinder form as desired.

Each pumping unit comprises the following essential components, which can be readily identified upon reference to Fig. 2 :—

(1) Pump Element (barrel and plunger) .. 3 and 4
(2) Delivery Valve and Seating 2

Barrel and plunger, valve and seating are of highly-ground steel, being finished to the finest limits and with the highest degree of precision to permit of accurate operation at high speeds and pressures ; each pair must therefore be regarded as inseparable and not interchangeable—a point which is covered more fully under the heading, " Dismantling."

Fuel should be supplied from a tank preferably placed higher than the pump so that it flows easily through a suitable filter to the inlet connection 22 (Fig. 5) 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 two small lateral ports provided. As already mentioned, the plunger 4 moves vertically in the barrel with a constant stroke. To enable the pump to vary the quantity of fuel delivered per stroke, the plunger is provided with a vertical channel (see Fig. 2) extending from its top edge to an annular groove, the upper edge of which is cut in the form of a helix. External means 5, 6 and 7 (Fig. 2) are provided whereby the plunger can be rotated in its barrel during operation.

OPERATION

The system of operation of the pump element, which is comprised of the barrel and plunger, is shown in Fig. 1. When the plunger is at b.d.c. 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, the latter being the most usual arrangement. In a primed system, of course, the barrel and the 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. (See Fig. 2). The pressure exerted by the rising plunger upon the

fuel causes this to lift the valve and to 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 line and lifts the nozzle needle (or injector valve). This permits fuel to be sprayed into the engine combustion chamber. Thus, at this moment 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, thus

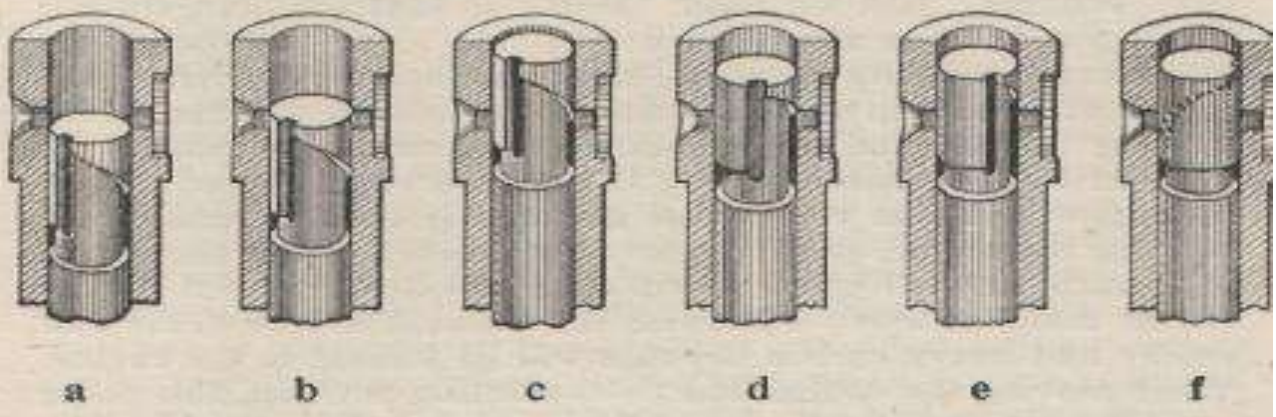


Fig. 1. Barrel with various Plunger Positions

allowing fuel to be by-passed to the suction chamber (which is under a very much lower pressure than the fuel 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.

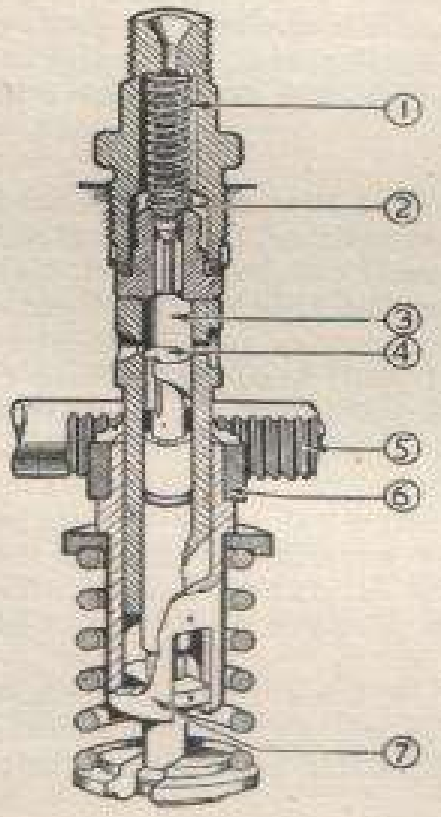
The plunger stroke is always constant, but that part of it which is actually pumping, is variable. By means of the helical edge which runs around the plunger, which itself can be rotated within the barrel (see Fig. 2) it is possible to make this point of cut-off occur earlier, or later, in the stroke—compare positions shown at (c), (d) and (e) which shows 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 (see 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 (see Fig. 2) 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.

CONTROL OF OUTPUT

The word " Stop " and an arrow are engraved on one end of the pump control rod 5 to indicate in which direction it must be moved to cease pumping and so stop the engine. A pump element at no output or " Engine Stopped " position is shown at f (Fig. 1) when the vertical channel of the pump plunger will be opposite the right-hand port in its pump barrel, so that no fuel is delivered, even when the engine is turned.

To start the engine the control rod 5 should be moved over to the " starting " position from " stop " so that the plungers will be in the position shown in c (Fig. 1). At this point the plungers are actually delivering more fuel than is required by the engine at full load, which condition is necessary to obtain easy starting. When the engine starts, the control rod should be released to the position giving the desired engine speed. It is important that the excess fuel delivery is only obtainable for starting the engine, and to ensure that this is so when the engine is operating at full speed, a trip collar is often provided by the engine manufacturer; otherwise the exhaust will be dense and smoky and heavy carbon deposits will be formed in the engine. When moving the control rod to its starting position, this collar must be temporarily " tripped " out of use, but should automatically come into operation again immediately the engine starts. At d (Fig. 1) the pump element is shown at normal output, in which position the engine will be operating at normal load. The actual position of the control rod in these conditions can be found only by experiment on the particular engine



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

Fig. 2—
Pump Element in Section

concerned. The control rod 5 (Fig. 2) can be connected to the governor at one end and to the hand control or accelerator at the other. In linking these, however, care should be taken that no transverse or rotational forces are transmitted to the control rod which may result in the latter either jamming or becoming stiff in action, with consequent faulty control of the engine.

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 means of the novel but entirely simple construction of the delivery valve unit, and reference to Fig. 3 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.

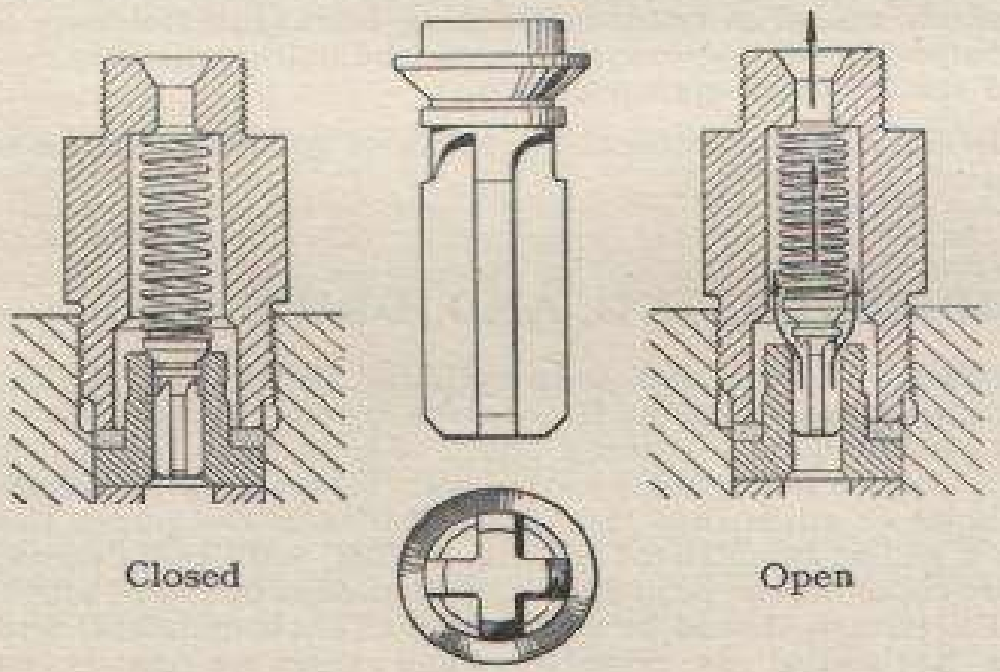


Fig. 3. Delivery Valve

The upper part of the guide forms a small piston which is a highly-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 parts to the guide to sweep down the 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."

GOVERNORS

C.A.V. governors are especially designed for use in connection with BPE type fuel injection pumps to control the engine speed, and may be of the Variable-Range Speed Mechanical, Idling and Maximum Speed Mechanical, Pneumatic, or Combined Pneumatic and Mechanical type as desired.

Each governor comprises a self-contained unit enclosing the mechanism and linkage, protecting it alike from the ingress of dirt of an abrasive nature and also from interference, and is constructed in such a way that it can be bolted directly on to the end of the injection pump housing.

Full details of each of the above types of governor will be sent on request.

PUMP MOUNTING AND DRIVE

Mounting : Single and twin-cylinder pumps are designed for mounting on a flat engine bracket by means of bolts through the flange provided on the pump base. Three, four and six-cylinder models may be mounted in two ways : (a) on a flat engine bracket with bolts or studs into the tapped holes in the pump base ; or (b) on a radial bracket (of 56 mm. radius) with bolts through the lugs provided on the pump sides or by means of straps and screws. All BPE pumps should be fitted so that their camshaft will be as nearly horizontal as possible when their engine is running normally, to ensure that the cam rollers will be effectively lubricated. When the pump is mounted with its axis 4—6° from the horizontal, special consideration must be given and in this event it is recommended that mention be made when ordering.

Drive : The pumps are provided with an extended camshaft with 20 mm. taper cones at both ends so that they may be coupled to the engine at either end, and allowing for the fitting of an injection advance device and governor where required.

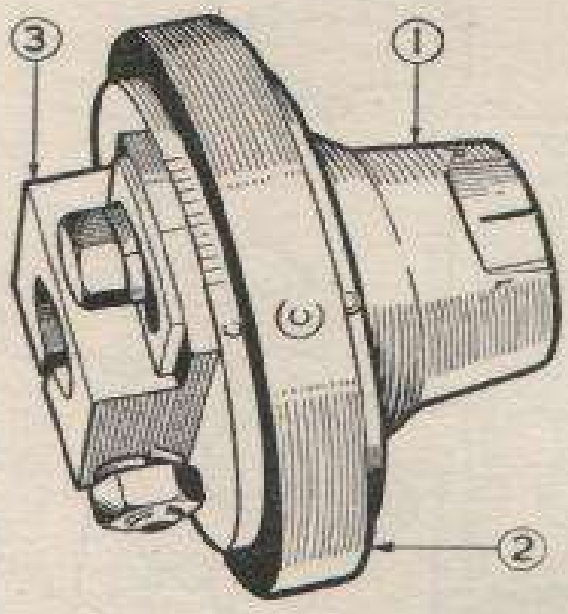


Fig. 4

C.A.V.
Close Slot Coupling

1—Pump side half coupling.

2—Special centre disc.

3—Engine side half coupling.

A positive engine drive, such as a well-designed helical gearing, is advised, and it is recommended that the rotation is transmitted to the pump through the medium of the C.A.V. closed slot cross coupling (Fig. 4). This has been specially developed for use in connection with the C.A.V. Fuel Injection Pump after a considerable amount of research, and is available in two models to suit two engine shaft diameters of 20 and 25 mm. Whilst allowing for any small misalignment between engine drive and injection pump, it also provides a ready method of finally adjusting the setting by means of the graduations marked on the coupling flanges.

The modern closed slot coupling is particularly robust in design, which gives durability and length of service very much superior to that of the old open slot type.

Note I.—So-called " elastic " couplings with rubber composition on spiral band cores, are unsuitable for driving these pumps and will only produce erratic running if fitted.

Note II.—On 4-stroke cycle engines the pumps are driven at half engine speed and on two cycle engines at full engine speed. The centre of the injection pump camshaft in this range is 45 mm. from its flat base, or 56 mm. from the radial surfaces of the base.

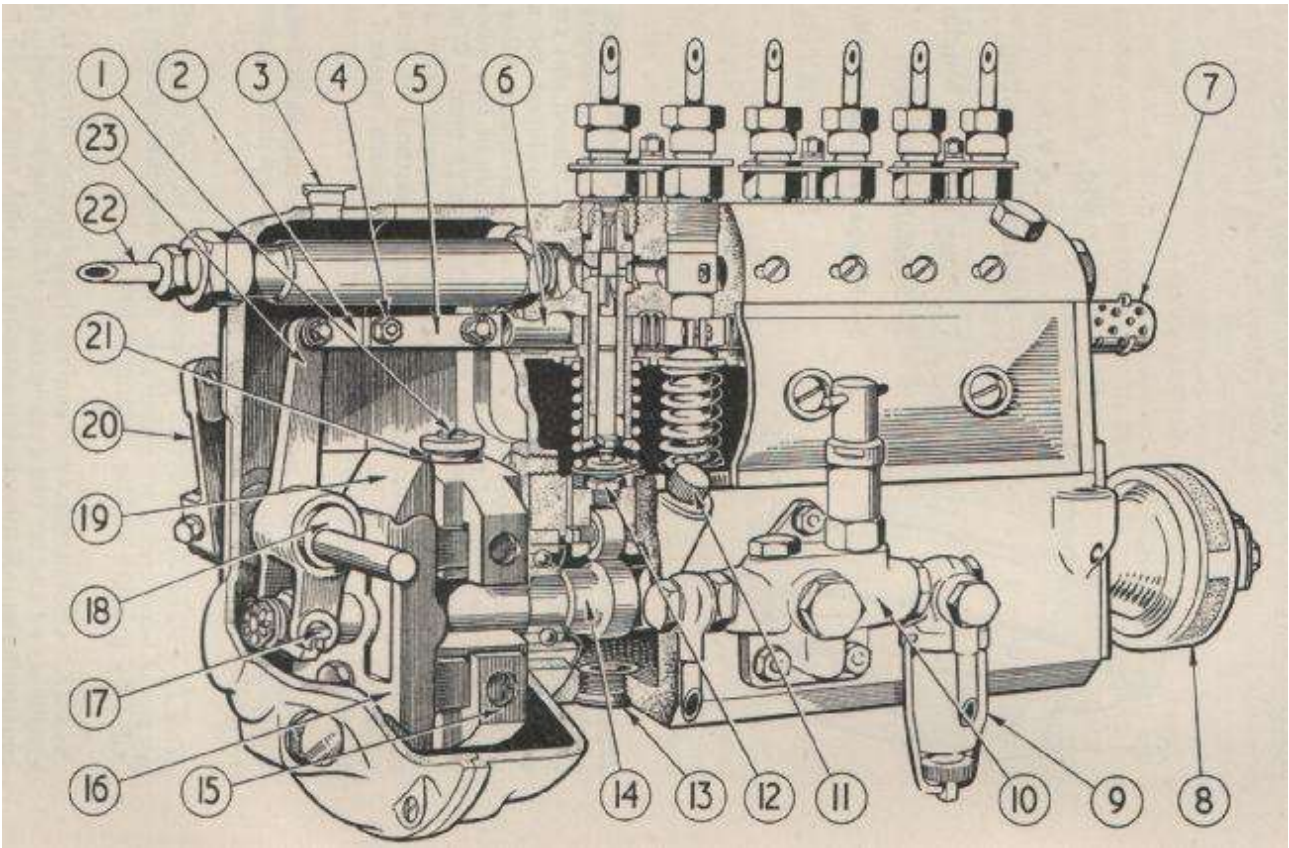


Fig. 5. C.A.V. Fuel Injection Pump BPE6B fitted with Idling and Maximum Speed Mechanical Governor (Variable-Range Speed Mechanical, Pneumatic, and Combined Pneumatic and Mechanical types of Governor are also available)

1. Adjusting nut
2. Outer link fork
3. Oil lubricator
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
11. Oil dipstick
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

The injection pumps are supplied with their cams set in the same firing order as the engine cylinders, and since the cams are symmetrical in form they can be driven in either direction without alteration other than resetting the couplings. It is, of course, in addition, possible to alter the firing order of a pump to suit a particular engine by crossing the delivery piping between the delivery connection of the injection pump and the nozzle.

Setting the Injection Pumps on the Engine: When preparing to couple the engine and pump drive together, care should be taken that the lines marked R and L (for right and left-hand rotation respectively) on the half coupling boss are in line with the mark on the pump body, relative to the direction in which the pumps are to be driven. 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 now be coupled, after which final adjustments may be made by means of the adjusting slots and set-screws provided on the coupling flanges. The amount of this adjustment can be measured by means of the graduations provided on the coupling flange, each division of which represents 3° measured on the pump camshaft. The pipes connecting the nozzle and the various cylinders to the injection pump should now be laid, always with particular reference to the firing order required. Component parts of the coupling should be assembled in the first place as shown in Fig. 4, i.e., with " zero points " (which can be clearly seen) exactly corresponding.

LUBRICATION

The level of oil in the camshaft chamber is normally maintained when running by the slight back leakage of fuel oil past the pump plungers. This serves to lubricate the plungers in the barrels, and supplements the original supply of lubricant. The level can be checked by the dipstick, which has a mark representing the highest level at which the oil should be maintained (see Fig. 6). Periodic inspection must be given to this point, which has an important bearing on the life of the driving gear, and the oil at each inspection made up to the prescribed level. The oil is filled into the camshaft chamber through the dipstick hole.

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 oil is governed by the position of the drain plug. In this case, the original lubricating oil is inserted on assembly before replacing the inspection cover.

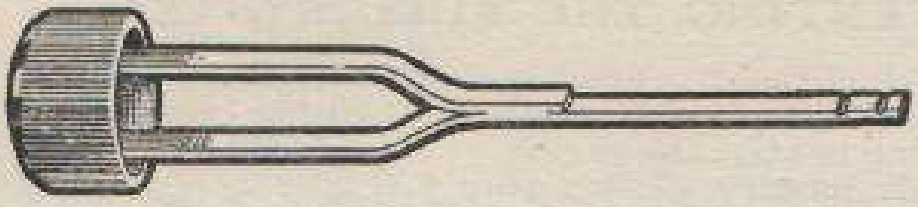


Fig. 6. Oil dipstick

FUEL SUPPLY, PIPING, CONNECTIONS, ETC.

Fuel should be fed from the storage tank through a suitable filter to the inlet connection of the fuel pump, the filter being of such design as to prevent even the smallest particles of dirt reaching the injection pump—this point is further referred to under the heading "Filtration." Where the head of fuel between the lowest level of the tank and the centre of the pump inlet connection is less than 8 in., an auxiliary feeding arrangement is required. Details of a feeding pump specially designed for mounting conveniently on the injection pump housing for this purpose will be sent upon application.

The inlet piping recommended is copper tubing, 8 mm. bore x 10 mm. outside diameter, and it should be led from the tank to the filter and from the filter to the inlet connection on the pump in a falling plane, care being taken to avoid sharp bends (the bending radius should never be less than 50 mm.). For the delivery piping between the pump and the nozzles steel tubing 2 mm. or 3 mm. bore x 6 mm. outside diameter is recommended, and here again sharp bends are to be avoided, the pipes being kept as short and as nearly equal in length as is practicable. The nipples for the delivery pipes can either be silver-soldered to the pipe or formed by "swelling" the material at the end by use of suitable dies in some form of press. A handy portable instrument for carrying out this work is the Nipple Forming Tool ET.078. This tool can be purchased from any C.A.V. Agent, and is, in addition, available at our Service Depots for repair work.

Note.—All finished fuel inlet and delivery pipes should, in addition to being thoroughly washed out with clean petrol, be blown through with high pressure air to ensure that they are absolutely clear and clean before being fitted into place. Any dirt, scale or filings remaining in the bore will ultimately be carried to the internal parts of the pump or nozzle, and may cause serious and costly damage.

AIR VENTING THE FUEL SYSTEM

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 :

(1) Partly unscrew closing plug 4 (Fig. 9) and turn the engine until fuel flows freely without any air bubbles.

(2) Move control rod 30 to maximum load position and turn the engine by hand until fuel issues freely from the partly uncoupled union nut of the pressure pipe at the nozzle holder.

FILTRATION

It will be appreciated that the C.A.V. fuel injection pump is designed to operate against very high pressure at varying speeds and in order to meet these arduous conditions requires a very high standard of workmanship and the utmost precision in manufacture. Consequently the internal mechanism must be protected from the abrasive effects of dirt and other kinds of foreign matter present in all types of fuel oil. For this reason, special attention is directed to the fitting and frequent inspection of a suitable filter.

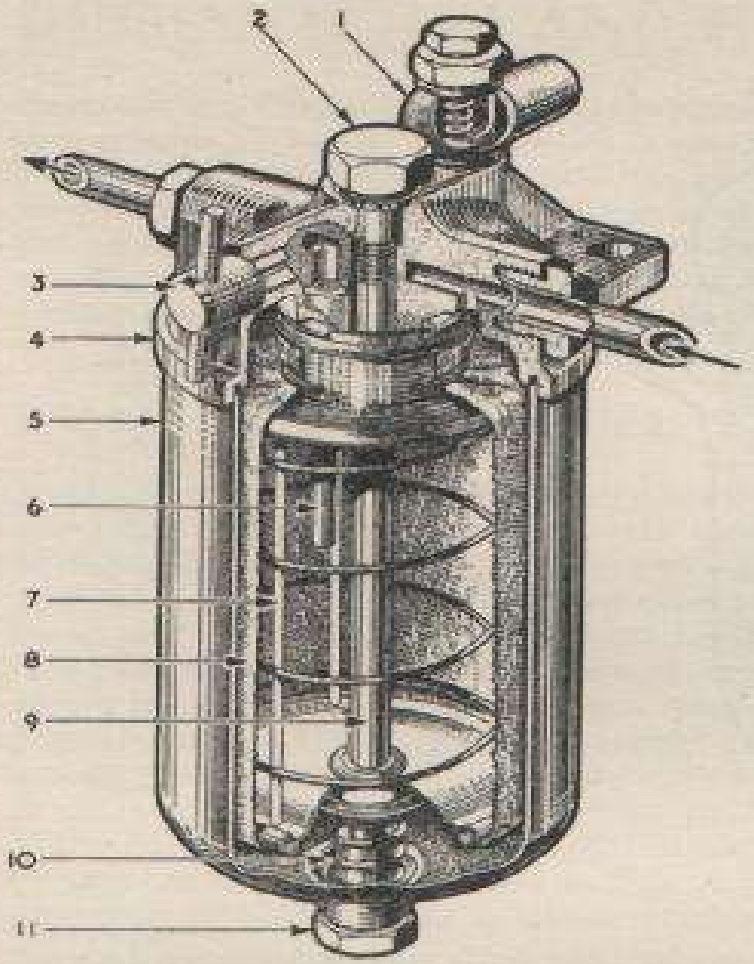
Several types of filter are available, to suit varying conditions of operation, including cloth element, felt element and combined cloth and felt element types.

Cloth Type Filter. The filter illustrated in Fig. 7 is of the cross-flow, cloth element type and consists of a metal housing 5, with cover 4, which carries the closing plug and air vent screw. It has a capacity of flow with a 3 ft. head of 3·5 to 4·5 pints/minute with a relative 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 in the cap, passes through the finely woven cloth 8, which is stretched over a spiral wire framework. The fuel then flows up through standpipe 6, and out into the main pipe line through the outlet connection fitted on the opposite side of the cap to the inlet 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 removing 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 withdrawn.

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 as described in our published instructions.



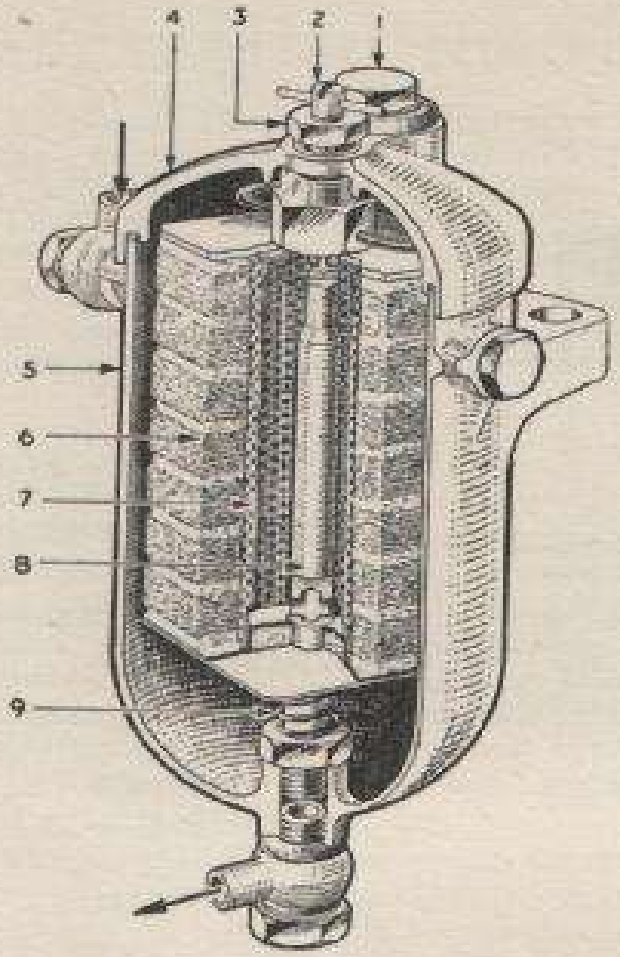
1—Closing plug.
2—Cap nut.
3—Air vent screw.
4—Cover.
5—Housing.
6—Standpipe.
7—Wire framework.
8—Fine filter cloth.
9—Centre tube.
10—Pressure spring.
11—Sludge Plug.

Fig. 7. C.A.V. Cloth Element Type Filter sectioned to show Internal Construction

Felt Type Filter. The felt element filter as shown in Fig. 8 is of the down-flow type and comprises a metal housing with oil-tight cover, provided with inlet and outlet connections. Pressure relief valves are incorporated where necessary, as when a fuel feed pump is fitted. The element consists of a series of felt pads built up on a perforated support tube, the fuel flow being from the outside to the inside of the element.

The filter element can be cleaned, using petrol, paraffin 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 would result in spreading the dirt across the pads and would increase the possibility of it getting through to the injection pump. When required, new felt pads (obtainable from C.A.V. depots) should be fitted to the filter frame. This operation, of course, demands a suitable dust-free workshop.



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. 8. C.A.V. Felt Element Type Filter sectioned to show Internal Construction

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.
In servicing this type of filter, the dirty filter cloth, as in the case of the cloth type filter, must not be cleaned and should be thrown away. The felt element should be cleaned as described above, replacing the felt pads if necessary. Finally a new filter cloth should be fitted and assembled on to the filter frame.

Choice of Filter Types. Before making a final decision as to the type of filter to be fitted, it is necessary to consider the method of fuel feed to the injection pump. If the fuel feed is pressure fed to the injection pump by means of a fuel pump or a similar arrangement, the filter employed should be 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.

DISMANTLING AND REASSEMBLING

To facilitate dismantling and reassembling fuel injection pumps it is advisable to use the special tools mentioned in the following paragraphs, these being in addition to the ordinary spanners and screwdrivers which are available in every workshop. A complete list of all tools available will be sent on request, and they can readily be supplied or obtained through any C.A.V. Service Depot or Agent.

DISMANTLING (See Figs. 9 and 10)

Note.—This should not be lightly undertaken as only mechanics specially trained can be expected to carry it out successfully. Strict cleanliness should be observed when preparing to dismantle fuel injection pumps, care being taken to see that all iron filings, dirt, grit, dust, etc., are removed from the bench on which the work is to be done. The bench should then be covered with a sheet of clean grease-proof paper and a number of small clean containers provided for the various parts removed. It is also advisable to have a thoroughly clean covered vessel available containing a supply of fresh clean petrol or fuel oil for washing these parts. If permanent facilities are installed for the servicing of injection equipment, the bench should be covered with zinc sheeting or linoleum or a similar easily cleaned material.

Special attention should be paid to the pump plunger and barrel unit, which should be carefully isolated, a specially important point being to ensure that the plungers are never laid down separately or fitted except into the barrels from which they were originally taken. Comment has already been made on the extremely fine limits to which these parts are finished, so that the pump plunger and its barrel should always work together as a pair. The surface of these parts should never at any time be touched with a file, scraper, or other hard tool or any abrasive compound. Should they be damaged, the entire injection pump should be sent to the nearest C.A.V. Depot for attention, rather than preliminary efforts be made with any form of grinding paste, powder, or stone.

The delivery valve and seating should be treated in the same way, as these are similarly matched, and if trouble is experienced after they have been cleaned and rubbed together, the pair should be replaced from spare parts stock.

In the case of multi-cylinder injection pumps, if it is considered necessary to dismantle the pump elements, control sleeves and control rod, it is important that this work should be referred to the nearest C.A.V. Service Depot, in whose shops will be found the necessary apparatus for ensuring that the controls are again assembled and adjusted to give the uniformity of delivery required. The importance of accuracy in this respect cannot be exaggerated, and a special power-driven machine has been devised to enable the calibration to be performed at high speed,

A. To change the Plunger Spring 21, examine Plunger 18 and Camshaft 13 (see Fig. 9).

(1) Remove inspection cover plate 10.

(2) Remove bearing end plate 15, after rotating camshaft 13 to bring the tappet 16 to its top dead centre position and inserting the tappet holder 32 (shown in Fig. 10) under the head of the tappet adjusting screw. (These tools can be obtained from any C.A.V. Depot). This should be repeated for each element, when the camshaft 13 can be easily withdrawn. The pump half coupling need only be removed from the camshaft if it is fitted at the opposite end to the bearing end plate. Should this be done, care should be taken that the shaft position is marked so that on reassembling the pump the firing sequence will be correct. The removal of the coupling from the cone of the camshaft should never at any time be done with the use of a hammer ; a properly fitting extractor, Part No. ET.008, should be used for this purpose.

(3) Unscrew the closing plugs 2 (with tool ET.105) at the base of the housing and push up the tappet 16 until it is possible to withdraw the tappet holder, after which the tappet assembly 16, the lower spring plate 22, the plunger spring 21 and plunger 18 may be withdrawn through the holes.

B. To change Delivery Valve and Seating.

Unscrew delivery valve holder 25, withdraw spring 24 and delivery valve. The valve seating and its joint can now be removed by means of the extracting tool 31 (shown in Fig. 10).

C. To remove the Pump Barrel.

Unscrew the locking screw 12 and push barrel from below by means of a fibre or soft brass drift. As this process involves complete readjustment to the delivery of the injection pump, it is recommended that it be placed in the hands of an accredited C.A.V. Service Depot for the reasons mentioned above.

REASSEMBLING (See Figs. 9 and 10)

In reassembling the pumps great care should be taken that all joints and other parts are entirely clean. They should be (a) rinsed in clean petrol or fuel oil, (b) allowed to drip, (c) smeared with a lubricating oil, and finally brought together entirely without the use of cotton waste, rags, or cloth wipers of any kind.

1 Refit the barrel of the element carefully, observing that the slot in it is opposite the hole for the locking screw 12. Tighten down locking screw after making sure that its joint is in place.

2 Refit valve seating and joint, carefully locating them in position in the pump housing. Replace delivery valve and its spring 24, and finally fit delivery valve holder 25 with its joint in position and screw down tightly.

3 Refit regulating quadrant 28, regulating sleeve 27 and upper spring plate 20.

4 Insert plunger with spring 21 and lower spring plate 22 into the barrel 19, taking care that the lug on the lower edge of the plunger fits into the slot in the control sleeve, for which it is marked.

5 Insert tappet assembly 16, and press against the spring until the tappet holder 32 (Fig 10) can be located between the tappet adjusting screw and the pump housing. Operations 1—5 should be repeated for each element.

6 Refit camshaft 13 in its bearing in the pump housing 1, taking care that the coupling (or advance device) is fitted so that the correct firing order will be maintained.

(*Note*.—The camshaft gives different firing orders according to the position in which it is placed in the pump. For instance, a 4-cylinder camshaft firing 1-3-4-2 when reversed in the housing gives a firing order of 1-2-4-3. This similarly affects a 6-cylinder pump).

7 Refit the bearing end plate 15 and tighten securing screws. Remove tappet holders from beneath adjusting screws.

8 Refit inlet connection union nut 8, inlet closing plugs 4 and oil dipstick 3.

9 Smear the mitre joint face of the closing plug 2 with white lead or other sealing compound and tighten up hard.

10 Fill the camshaft chamber with lubricating oil to the prescribed level with best quality engine oil.

11 Replace inspection cover plate 10.

12 When mounting and setting the pumps to the engine, refer particularly to the section of this booklet entitled " Pump Mounting and Drive."

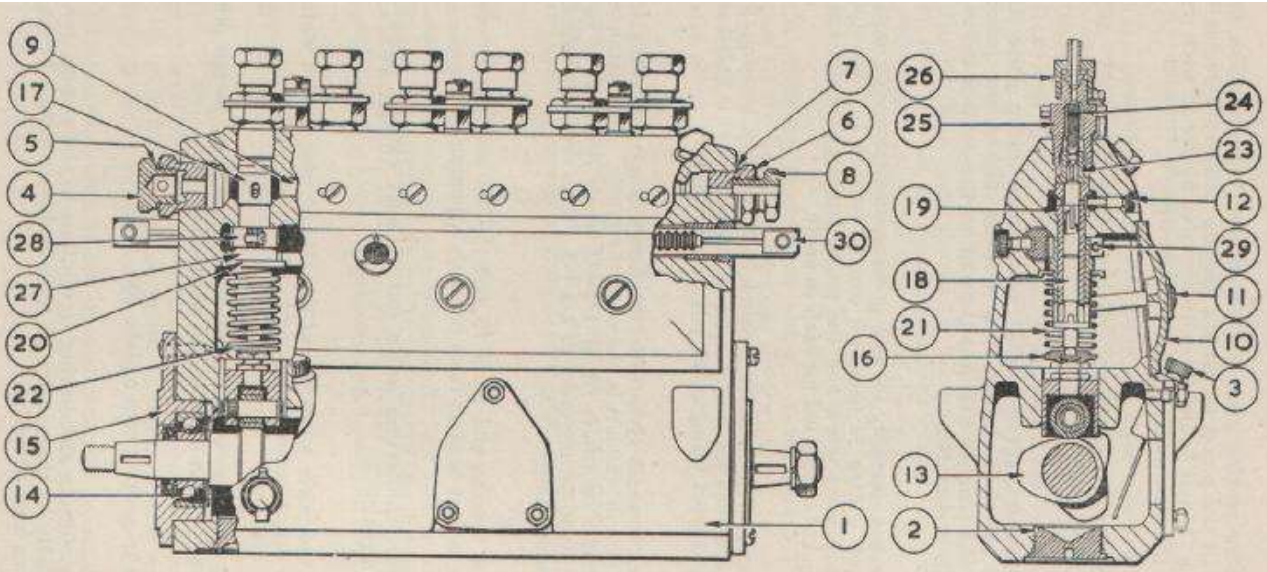


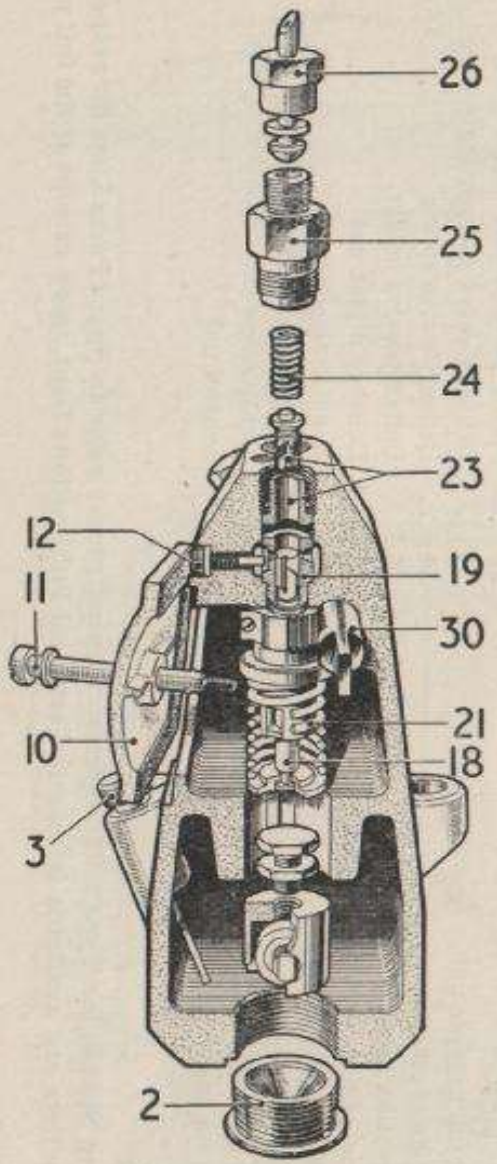
Fig. 9. C.A.V. Type BPE Fuel Injection Pump Sectioned to show Internal Construction

Illust. No.		Description
1	..	Housing
2	..	Closing plug
3	..	Oil dipstick
4	..	Inlet closing plug
5	..	Joint for (4)
6	..	Inlet connection stud
7	..	Joint for (6)
8	..	Fuel inlet nipple nut
9	..	Suction chamber
10	..	Inspection cover plate
11	..	Screw with spring ring for (10)
12	..	Locking screw and joint
13	..	Camshaft
14	..	Ball bearing
15	..	Bearing end plate

Illust. No.		Description
16	..	Tappet assembly
17	..	Pump element (barrel and plunger)
18	..	Pump element plunger
19	..	Pump element barrel
20	..	Spring plate (upper)
21	..	Helical spring for (18)
22	..	Spring plate (lower)
23	..	Delivery valve and seating
24	..	Delivery valve spring
25	..	Delivery valve holder
26	..	Delivery nipple nut
27	..	Regulating sleeve
28	..	Regulating toothed quadrant
29	..	Clamp screw
30	..	Control rod

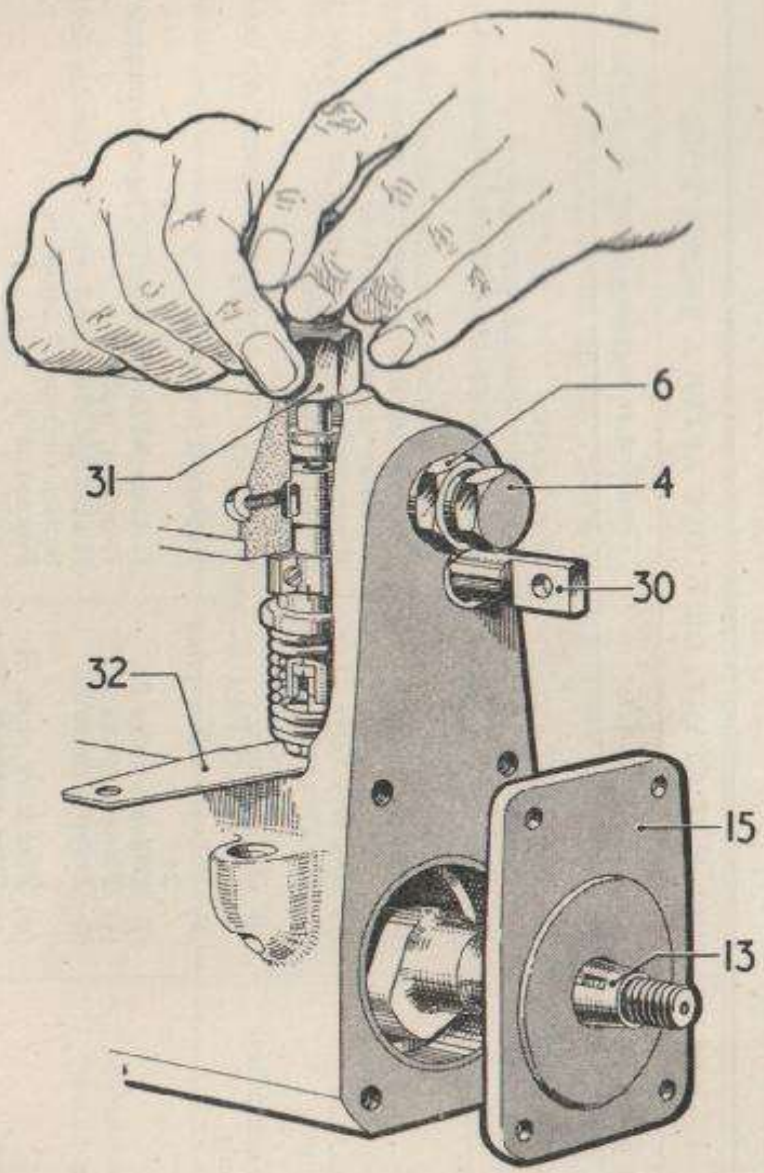
IMPORTANT

When ordering Spares for Type BPE Injection Pumps, please refer to Spare Parts Lists for respective types. These lists are available from our Technical Publications Dept. upon receipt of the full pump type symbol.



2. Closing plug
3. Oil dipstick
4. Inlet closing plug
6. Inlet connection stud
10. Inspection cover plate
11. Screw with spring ring for (10)
12. Locking pin and joint
13. Camshaft
15. Bearing end plate
18. Pump element plunger
19. Pump element barrel
21. Helical spring for (18)
23. Delivery valve and seating
24. Delivery valve spring
25. Delivery valve holder
26. Delivery nipple nut
30. Control rod
31. Delivery valve extracting tool
32. Tappet holding tool

Fig. 10. Dismantling and Reassembling



C.A.V. Type BPE Fuel Injection Pumps

ENGINE TROUBLES AND THEIR REMEDIES

Fuel injection difficulties can arise on the engine from several causes, some of which may be traced to the injection pumps. Such difficulties, with the likely cause and suggested cure, are set out in the following table. The first move when a pump is suspected should be to uncouple the piping between the pump and the nozzles. If the engine is then rotated with the pump control rod set at full load position it will be seen whether or not fuel is being delivered. Observe each discharge outlet on the pump to see if all discharge outlets are in order. In the following table the word " pump " applies to the pump unit block as a whole or to individual elements and the numbers referred to are shown in Fig. 9.

Possible Cause	*Location*	*Condition or suggested remedy for correct working*
1.—ENGINE WILL NOT START, OR STOPS AFTER A SHORT TIME		
Pump does not deliver fuel	(*a*) Fuel cock	Must be open.
	(*b*) Fuel tank	Must contain an adequate supply.
	(*c*) Fuel inlet pipe or filter elements.	Clean—examine, and if choked replace cloth or clean filter pads.
	(*d*) Air in pump.	Air vent filter and pump (see section "Air Venting ")
	(*e*) Pump plunger 18	If worn, replace element 17. Inspect filter and if necessary insert new cloth or felt element.
	(*f*) Delivery valve 23.	Clean and inspect. If worn or damaged replace both valve and seating.
Pump does not deliver fuel uniformly.	(*g*) Air in pump.	Air vent filter and pump (see section "Air Venting ")
	(*h*) Delivery valve spring 24.	Replace if broken.
	(*j*) Delivery valve 23.	If damaged on face or guide, replace complete.
	(*k*) Plunger spring 21.	If broken, replace.
	(*l*) Pump plunger 18.	If sticking, clean and refit. If trouble continues, replace element 17 complete.
	(*m*) Fuel inlet pipes of filter elements.	Proceed as (*c*).
	(*n*) Head between tank and pump.	Increase if too small.
The moment of injection commencement has altered.	(*o*) Tappet adjusting screw	If loose, readjust and well tighten nut.
	(*p*) Cam profiles.	If badly worn, replace camshaft.
2.—ENGINE DOES NOT PULL		
Quantity of fuel delivered per stroke is insufficient.	(*a*) Delivery valve 23.	If leaking, scored or damaged, replace both valve and seating.
	(*b*) Pressure system joints.	If leaking, clean joint faces and tighten.
3.—ENGINE "CARBONISED" BADLY		
Quantity of fuel delivered per stroke excessive.	(*a*) Regulating quadrant 28.	If moved, due to screw 29 being loose, adjust to mark and tighten screws thoroughly.
4.—MAXIMUM SPEED OF ENGINE TOO HIGH		
Control rod 30 has jammed.	(*a*) Pump plunger 17	If seized, dismantle and clean. Replace if damaged.
	(*b*) Control rod 30	Clean toothed rack if coated with dirt or other foreign matter.