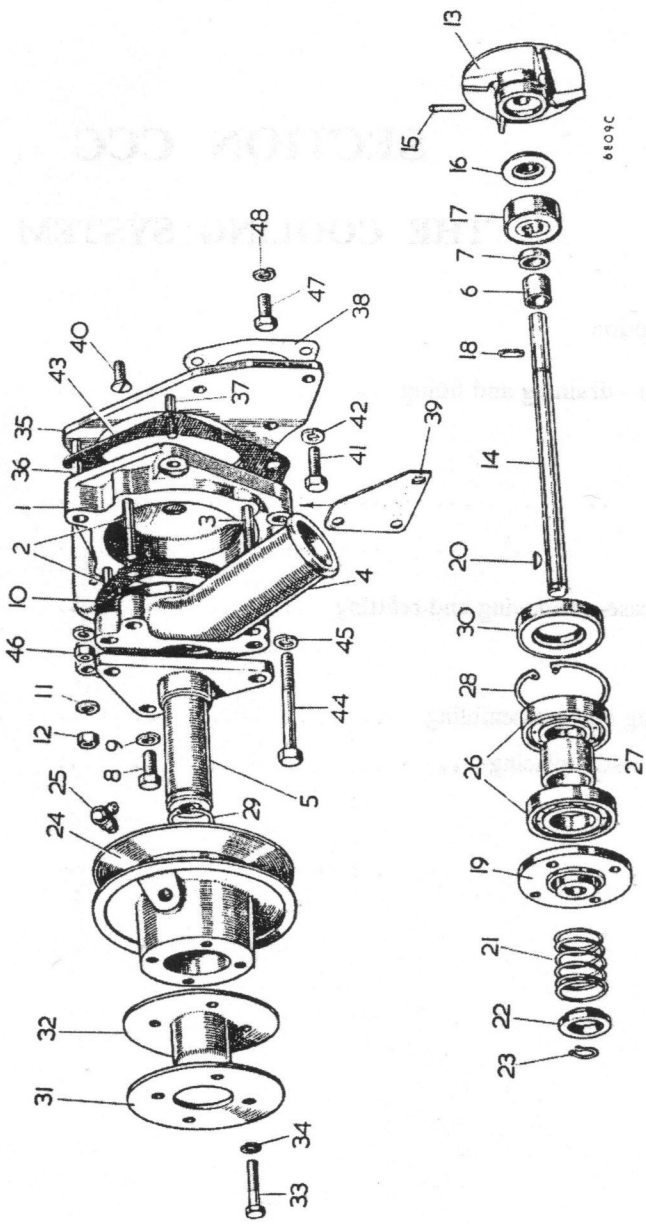
SECTION CCC

THE COOLING SYSTEM

	Section
General description	
Cooling system—draining and filling	CCC.1
Fan belt	
Adjusting	CCC.2
Changing	CCC.3
Radiator and case—removing and refitting	CCC.4
Water pump	
Dismantling and reassembling	CCC.6
Removing and replacing	CCC.5

THE COMPONENTS OF THE WATER PUMP



KEY TO THE COMPONENTS OF THE WATER PUMP

No.	*Description*
1.	Body (rear half).
2.	Stud (long).
3.	Stud (short).
4.	Body (front).
5.	Bearing support.
6.	Bush.
7.	Sealing ring.
8.	Screw.
9.	Spring washer.
10.	Joint.
11.	Spring washer.
12.	Nut.
13.	Impeller.
14.	Spindle.
15.	Pin—impeller to spindle
16.	Seal.
17.	Carbon gland.
18.	Peg—gland to spindle.
19.	Hub and end cover.
20.	Key—hub to spindle.
21.	Spring for spindle.
22.	Collar.
23.	Circlip.
24.	Pulley.
25.	Greaser.
26.	Bearing.
27.	Distance piece.
28.	Circlip (large).
29.	Circlip (small).
30.	Oil seal.
31.	Nave-plate.
32.	Cap—nave-plate.
33.	Screw.
34.	Spring washer.
35.	Plate assembly—adaptor.
36.	Stud (long).
37.	Stud (short).
38.	Gasket.
39.	Gasket.
40.	Screw.
41.	Bolt.
42.	Spring washer.
43.	Gasket.
44.	Bolt.
45.	Spring washer.
46.	Nut.
47.	Bolt.
48.	Spring washer.

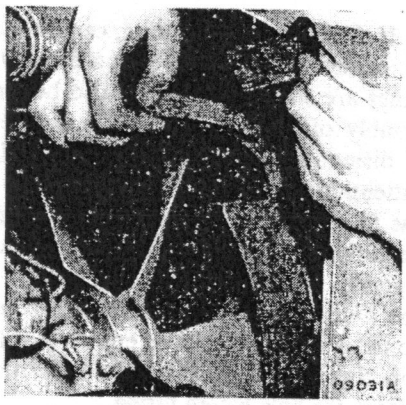


Fig. CCC.2

The sealing plate removed, showing the method of holding the belt to clear the blades

Feed the new belt through the slot in the cowling and then over the fan blades and pulleys.

Tension the belt as detailed in Section CCC.2 until there is 1 in. (25·4 mm.) of side-movement in the centre of the longest run and replace the cowl sealing plate.

Check the tension of a new belt after the first day's running.

Section CCC.4

REMOVING AND REPLACING THE RADIATOR AND CASE

Extract the screws from the bonnet hinge, remove the temperature gauge adaptor (if fitted) and air pre-cleaner, and lift off the bonnet.

Withdraw the four bolts to release the headlamp and radiator case from the support brackets, carefully supporting the headlamp and bracket on the main frame. Lift off the radiator case.

Before removing the radiator case from 'V' twin-front-wheeled vehicles the draglink must be disconnected from the steering lever.

Drain the cooling system.

Slacken the clips securing the top and bottom water pipe hoses and free the hoses.

Disconnect the shutter control rod from the radiator shutters (if fitted) and release the radiator top stay from the water outlet pipe.

Take out the bolts and nuts securing the radiator to the support brackets and lift it clear after noting the correct position of the rubber mounting blocks and chaff excluder. Store in an upright position to prevent the possibility of accumulated sediment in the bottom tank passing into the cooling ducts.

Refitting is a reversal of the dismantling procedure. See Section CCC.1 on refilling the system.

Section CCC.5

REMOVING AND REPLACING THE WATER PUMP

Lift the pre-cleaner and extension from the air cleaner and unscrew the temperature gauge adaptor (if fitted), complete with adaptor, from the water outlet pipe.

Remove the two bonnet hinge screws and lift off the bonnet. Drain the radiator and remove the radiator block (see Section CCC.4).

Slacken the dynamo pivot bolts, release the bolt securing the dynamo to the slotted link, and remove the fan belt.

Remove the three stud nuts and take out the two bolts securing the rear half of the pump body to the adaptor plate on the engine. A compound is used to seal the joint between the pump and the plate. The adaptor plate is secured to the engine by countersunk screws concealed by the pump.

Refitting is a reversal of the removal instructions. Adjust the fan belt after replacing the dynamo as instructed in Section CCC.2.

Section CCC.6

DISMANTLING AND REASSEMBLING THE WATER PUMP

Remove the four set screws securing the fan blades to the pulley and lift off the nave plate, cap, and fan blades.

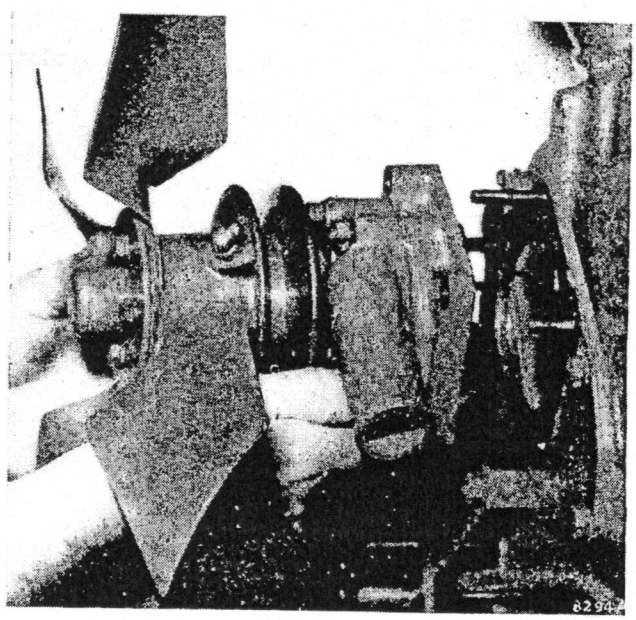


Fig. CCC.3

Removing the water pump from the adaptor plate

Next undo the four nuts holding the front half of the pump body to the rear half, break the joint, and remove the front half of the casing from the studs.

Detach the circlip from the front of the drive spindle and lift off the collar, spring, driving end cover, and key.

Withdraw the spindle complete with vane and rubber seal, and take care not to damage the carbon seal or lose the driving pin.

Remove the carbon seal and lift out its driving pin. Withdraw the Gaco rubber oil seal.

The vane is held to the shaft by a taper pin.

The front half of the pump body is in two parts secured together by three bolts which have UNF threads. Withdraw the bolts and separate the two halves to reach the oil seal and spindle bush.

Detach the fan pulley complete with bearings by removing the small circlip from the front of the bearing support. Drive the bearing support out of the bearings, using a piece of wood slightly smaller in diameter than the front end of the support.

Withdraw the oil seal from the pulley and remove the large circlip retaining the bearing assembly. The bearings and distance piece can then be pressed from the pulley body.

When reassembling the pulley unit a new oil seal must be fitted. If the rubber sealing ring, carbon gland, Gaco-type seal, or the spindle oilite bush are badly worn or if the bearings are slack they should also be renewed.

Reassembly of the water pump is a reversal of the order of dismantling, but the following points require special attention:

(1) The face of the water pump body, against which the carbon gland bears, must be flat and at right angles to the bore of the shaft.

(2) The hole in the sealing ring is smaller than the diameter of the spindle to ensure that the seal will grip the shaft tightly when in position. **Do not enlarge the hole before fitting.**

(3) See that the parts which come into contact with the seal when it is being fitted in position are smooth and free from sharp edges. This will prevent the seal from being damaged. A smear of soap will help it to slide down the shaft. Do not use oil on the Gaco-type seal as this will reduce the efficiency.

(4) Always use a new pump body jointing washer on reassembly.

(5) When reassembling, partially fill the space between the ball bearings with grease. For the correct grade see the lubrication instructions (Section PPP.2).

SECTION D

THE FUEL SYSTEM

	Section
General description	
Air cleaner	D.2
Bleeding the system	D.6
Fuel filters	D.1
Simms Type FF filter	D.19
Injection pump	
Calibration	D.10
Description	D.7
Dismantling, overhauling, and reassembling	D.9
Lubrication (first stage modification)	D.17
Lubrication (final stage modification)	D.18
Removing and replacing	D.8
Injectors	
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Nozzles and holders—dismantling and reassembling	D.15
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Lift pump	
Dismantling and reassembling	D.5
Removing and replacing	D.4
Pneumatic governor	
Altitude settings	D.16
Description	D.11
Removing, overhauling, and replacing	D.12
Service tools	End of Section
Tank—removing and replacing	D.3

GENERAL DESCRIPTION

The fuel is drawn from the 14-gallon (63·6-litre) supply tank by an A.C. diaphragm-type lift pump which is operated from the camshaft. It is imperative that the fuel is absolutely free from foreign matter and two filters are therefore employed, one on each side of the lift pump. Additional filter gauzes are fitted in the supply tank and in the lift pump.

The main fuel filter on the supply side of the lift pump is a Simms paper element type. From this filter fuel passes into the injection pump where it is metered and forced under high pressure in the form of a fine spray into the combustion chambers by the four-hole-type injectors.

The control lever is connected to a butterfly valve in the throttle unit (venturi), which is mounted on the air inlet manifold. This throttle unit (venturi) is connected to the pneumatic governor by two suction pipes, one from the engine side and one from the atmospheric side of the butterfly valve. The engine side suction pipe is connected to an air bottle which is in turn connected to the governor. The governor, mounted on the rear of the injection pump, uses variation of suction created in the throttle unit (venturi) to control the amount of fuel injected by the pump.

The operation and efficiency of the compression-ignition engine depends largely on the fuel injection system. The main components comprising this system, the injection pump and injectors, are manufactured to extremely fine limits, therefore cleanliness and accuracy in setting are absolutely essential. It is recommended that where facilities for servicing are not available at the premises of the tractor Dealer the parts be taken to a Simms Agent.

Complete detailed maintenance instructions are given under this section for all components of the injection system to guide operators who have the required special tools and test rigs.

Section D.1

FUEL FILTERS

Fuel tank filter

Fitted in the fuel tank outlet union is a gauze pencil-type filter. To reach it the tank must be drained (Section D.3), and the panels below the tank must be removed to allow the fuel pipe to be disconnected. The object of the pencil filter is to prevent any large particles of dirt which may have entered the main fuel tank from reaching and choking the fuel tap. The surging of the fuel keeps the pencil filter clean and it will not normally require attention.

Glass sediment bowl and filter

The main fuel tank is connected to a fuel filter and sediment bowl provided with an integral fuel tap and is situated on the left-hand side of the tractor beneath the air cleaner.

The glass filter container enables a visual check to be made on the amount of sediment present and is easily released for cleaning by unscrewing the wing nut beneath the glass bowl. Water or sediment which has collected in the container should be removed, the gauze filter screen washed in petrol (gasoline), and the container swilled clean.

On reassembly make sure before tightening up that the gauze filter screen is correctly positioned to ensure a good seal. To prevent an air lock turn on the fuel and allow it to flow over the side of the glass bowl before finally tightening the wing nut.

Lift pump filter

The fuel lift pump situated on the left-hand side of the engine is provided with a gauze filter screen fitted beneath the domed cover on the pump body.

The filter gauze should be examined and cleaned at the recommended intervals given in 'MAINTENANCE SCHEDULE' under **'GENERAL INFORMATION'.** Under extremely dusty or dirty conditions this interval should be reduced as the conditions dictate. Access is obtained to the filter gauze by releasing the set bolt in the domed cover and removing the cover from the pump

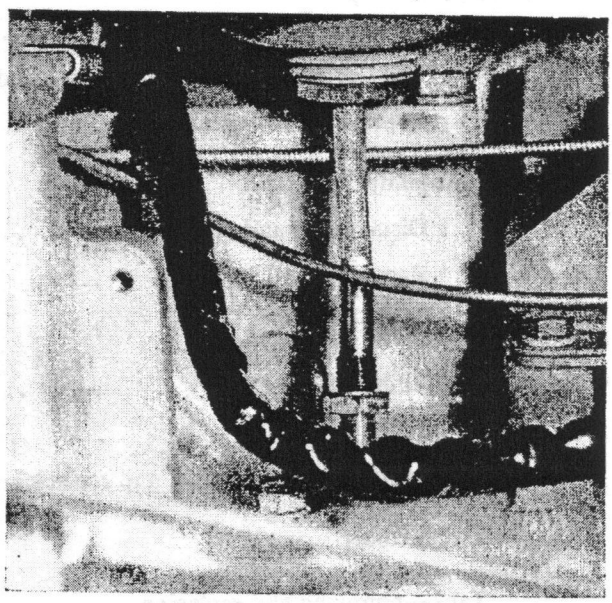


Fig. D.1

The pencil-type filter in the main fuel tank outlet union is here shown partly withdrawn

body. Remove the filter gauze and clean it in an air jet or petrol (gasoline). All deposits should also be cleaned from the sediment chamber.

Replace the filter gauze and dome cover; use a new cork gasket between the dome cover and body if the old one is broken or hardened. Tighten the retaining set bolt just sufficiently to make a fuel-tight joint. Overtightening is liable to damage the cork joint gasket.

Finally, bleed the system as described in Section D.6.

Main fuel filter

The main fuel filter is situated on the right-hand side of the engine close to the injection pump and contains an element of the paper type. Provided that clean filtered fuel has been used and the necessary precautions taken when handling any component of the fuel system, the element will only require renewing at the recommended intervals, for which see **'MAINTENANCE ATTENTION'.**

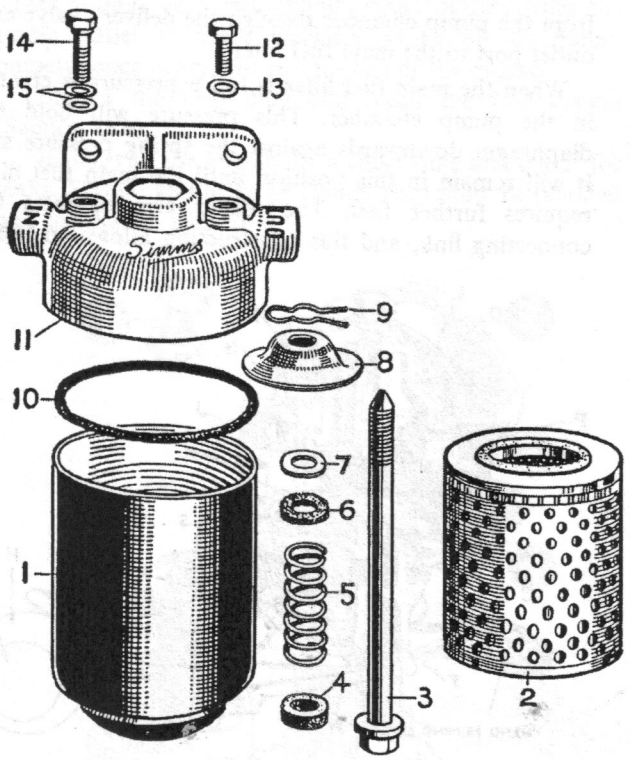


Fig. D.2

The main fuel filter

1. Filter body.
2. Element.
3. Centre-fixing bolt.
4. Bottom seal.
5. Spring.
6. Upper seal.
7. Washer.
8. Seal plate.
9. Clip.
10. Rubber seal.
11. Filter head.
12. Bleeder plug.
13. Washer.
14. Banjo pin.
15. Washers.

Should the engine misfire or run in an erratic manner through being starved of fuel due to a clogged element, a new element must be fitted irrespective of the number of hours run. A used element cannot be cleaned in any way.

To remove the element unscrew the large nut at the base of the filter bowl and lower the bowl.

Wash out the filter bowl in petrol (gasoline) and dry thoroughly. Renew the rubber sealing ring should it appear damaged. Failure to do this will reduce the efficiency of the filter.

After replacing the element casing and securing it in position expel the air trapped in the system as detailed in Section D.6.

To remove the complete filter unit from the engine first disconnect the two fuel pipe connections and the leak-off banjo connection from the filter head.

Remove the two set bolts securing the filter assembly to the support bracket and withdraw the unit from the engine.

Remove the element as described above. Wash the filter body thoroughly in petrol (gasoline). An air jet should be used to blow out any possible obstructions in the ports and bleed plug and leak-off apertures.

Renew the spring if it is weak or broken and fit new seals and joint washers all round. Fit the felt washer between the plain steel washer and the bottom seal plate.

Ensure that both seals are securely jointed to both ends of the new element.

Replacement is a reversal of the removal instructions.

Section D.2

AIR CLEANER

The time for cleaning the air cleaner depends on the operating conditions. Under normal conditions the oil in the air cleaner bowl should be changed every 50 running hours. Under extreme dusty conditions the oil bath should be changed and re-oiled twice daily.

To release, support the bowl with one hand and unscrew the retaining clip with the other until the bowl can be withdrawn downwards. Take care not to spill the oil it contains. Drain off the old oil, swill out any sediment with paraffin (kerosene), wipe clean and dry, and refill with engine oil to Ref. A to the level of the ridge inside the bowl.

Every 200 hours, or more often under extreme conditions, wash the air cleaner gauze. Unscrew the hose clip and withdraw the hose. Unscrew the air cleaner securing strap and remove the cleaner from the tractor. Clean the filter gauze in petrol (gasoline) to remove any deposit and then dry thoroughly. Should the gauze be entirely blocked by chaff, etc., the complete air cleaner must be renewed.

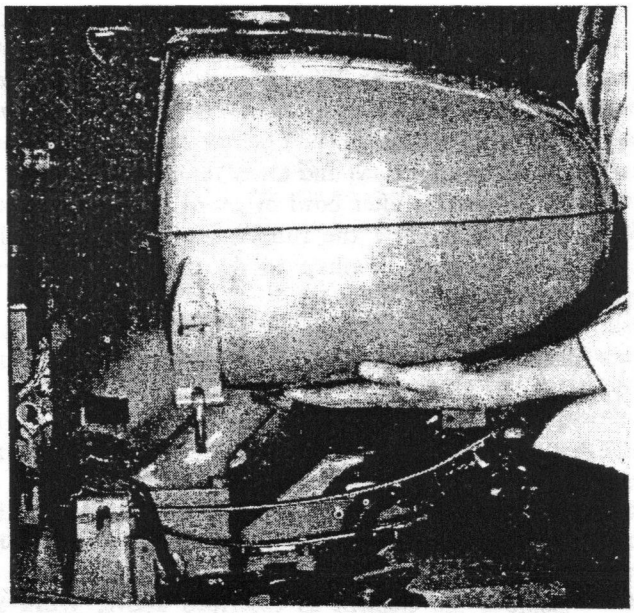


Fig. D.3

Withdrawing the main fuel tank from the steering column after removing the steering wheel

Section D.3

REMOVING AND REPLACING THE FUEL TANK

Disconnect the battery terminals.

Release the fuel pipe at the tap and filter unit and drain the tank—capacity 14 gallons (63 litres).

Remove the steering wheel as described in Section J.

Withdraw the pre-cleaner from above the bonnet. Release the clamp and withdraw the exhaust silencer. Extract the two securing screws and remove the bonnet.

Extract the six screws from the right-hand-side panel below the fuel tank, but do not disturb the radiator shutter control if fitted.

Remove the left-hand-side panel but remember to mark the position of the throttle control lever bracket to ensure that it is returned to the original position.

Disconnect the fuel pipe from the union below the tank and the overflow return pipe from the union at the top of the tank at the front.

Remove the bolt securing the rubber-mounted strip to the fuel tank rear support bracket. Release the tank straps from the front support bracket and lift off the tank.

Reassembly is a reversal of the dismantling procedure. Ensure that there is no leak from the union below the tank before finally refitting the side panels. Align the throttle control lever bracket with the marks made on removal.

Section D.4

REMOVING AND REPLACING THE FUEL LIFT PUMP

The fuel lift pump is mounted on the left-hand side of the crankcase and is operated mechanically from an eccentric on the engine camshaft. A hand priming lever permits pumping a supply of fuel through the main fuel filter to the injection pump for bleeding the fuel system whenever any component has been dismantled or disconnected.

As the engine camshaft revolves, the eccentric lifts the pump rocker arm, which pulls the pull-rod together with the diaphragm downwards against the spring pressure, thus creating a vacuum in the pump chamber.

Fuel is drawn from the tank and enters the sediment chamber through the filter gauze and suction valve into the pump chamber. On the return stroke the spring pressure pushes the diaphragm upwards, forcing the fuel from the pump chamber through the delivery valve and outlet port to the main fuel filter.

When the main fuel filter is full a pressure is created in the pump chamber. This pressure will hold the diaphragm downwards against the spring pressure and it will remain in this position until the main fuel filter requires further fuel. The rocker arm operates the connecting link, and this construction allows an idling

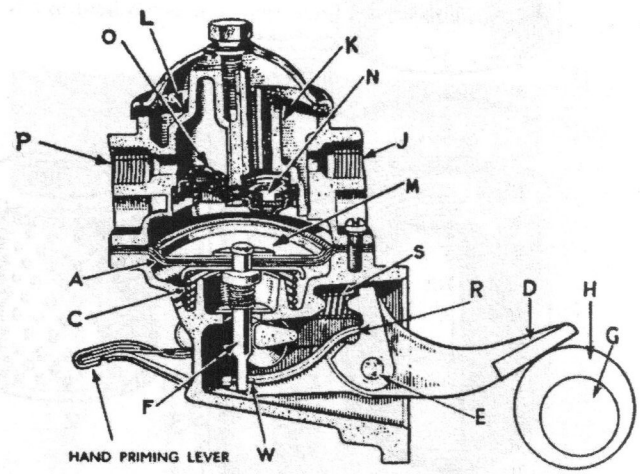


Fig. D.4

Sectional view of the fuel lift pump

A. Diaphragm.
C. Diaphragm spring.
D. Rocker arm.
E. Pivot pin.
F. Pull-rod.
G. Engine camshaft.
H. Camshaft eccentric.
J. Inlet (shown 45° out of position).
K. Sediment chamber.
L. Filter gauze.
M. Pump chamber.
N. Suction valve.
O. Delivery valve.
P. Outlet.
R. Contact point.
S. Rocker arm spring.
W. Link.

movement of the rocker arm when there is no movement of the fuel pump diaphragm.

The spring keeps the rocker arm in constant contact with the camshaft eccentric, thus eliminating noise.

Remove the pump from the engine by first disconnecting the two pipes. Unscrew the two bolts securing the pump to the engine crankcase and withdraw the pump and joint gasket.

To dismantle the pump see Section D.5.

To refit the pump carry out in reverse the removal instructions, having first lubricated the pump rocker arm and rocker arm pin. Crank the engine if necessary so that the shallow portion of the cam on the camshaft faces outwards, i.e. makes contact with the pump rocker arm.

Fit a new gasket between the pump flange and the cylinder block.

Before connecting the outlet fuel pipe to the pump test the operation of the pump by cranking the engine. There should be a well-defined spurt of fuel from the pump outlet at every working stroke of the pump, namely, once every two revolutions of the engine.

Connect the feed pipe and bleed the fuel system (Section D.6).

Finally, run the engine for a short time and check for leaks. Should any leaks be found, they must be rectified and the system re-bled.

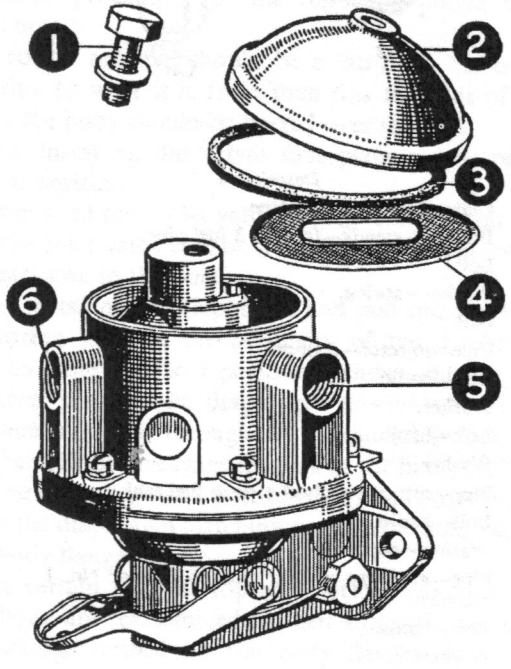


Fig. D.5

External view of the fuel lift pump

1. Cap bolt.
2. Cap.
3. Cork gasket.
4. Filter gauze.
5. Inlet.
6. Outlet.

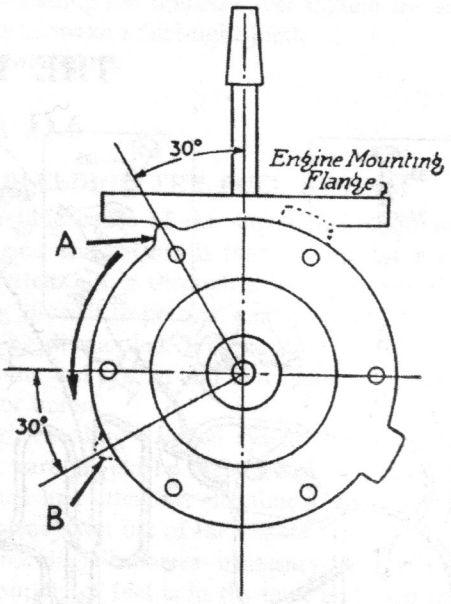


Fig. D.6

When first fitting the pump diaphragm the locating tab must be in the position shown at (A). *Turn the assembly a quarter of a turn to the left to engage the pull-rod and link, when the diaphragm tab should be in position* (B)

Section D.5

DISMANTLING AND REASSEMBLING THE FUEL LIFT PUMP

Remove the fuel pump from the engine as detailed in Section D.4.

Release the set bolt securing the domed cover and remove the cover with the cork gasket from the top half of the pump body. Lift off the filter gauze.

Make a file mark across the flanges of the two halves of the body for guidance on reassembly.

Unscrew the six set screws and separate the two halves of the pump body.

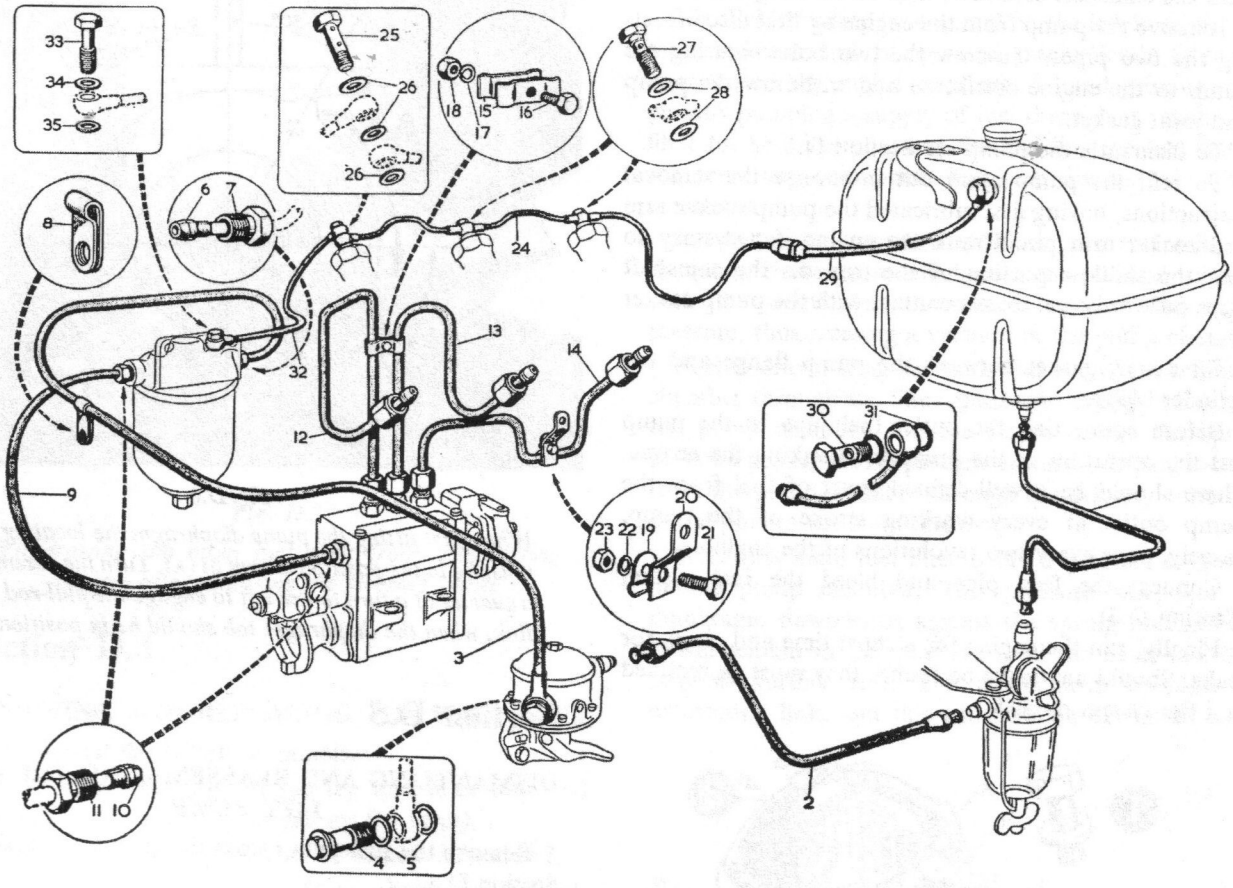
Unscrew the two set screws and remove the valve plate, the suction and delivery valves, and the gasket from the lower half of the pump body.

To remove the diaphragm and pull-rod assembly from the lower half of the pump body turn the diaphragm to the right through 90° and lift it out together with the return spring.

Remove the two rocker pin clips, push out the rocker pin, which in turn will release the rocker pin washers, the rocker arm, the link, and the rocker arm spring.

Remove the spring from the priming lever and body assembly. Further dismantling of the body assembly is not advisable as the priming lever is riveted over at the outer ends of the spindle.

THE FUEL SYSTEM PIPES



No.	*Description*
1.	Pipe—fuel tank to bowl filter.
2.	Pipe—bowl filter to fuel lift pump.
3.	Pipe—fuel lift pump to fuel filter.
4.	Bolt—banjo.
5.	Washer.
6.	Olive.
7.	Nut—union.
8.	Clip for pipe.
9.	Pipe—fuel filter to injection pump.
10.	Olive.
11.	Nut.
12.	Pipe—fuel injection—No. 1 cylinder.
13.	Pipe—fuel injection—No. 2 cylinder.
14.	Pipe—fuel injection—No. 3 cylinder.
15.	Clamp for Nos. 1 and 2 fuel pipes.
16.	Bolt.
17.	Washer—spring.
18.	Nut.

No.	*Description*
19.	Clamp for No. 3 fuel pipe.
20.	Bracket—steady—for No. 3 fuel pipe.
21.	Bolt.
22.	Washer—spring.
23.	Nut.
24.	Pipe—injector—spill-off.
25.	Bolt—banjo.
26.	Washer.
27.	Bolt—banjo.
28.	Washer.
29.	Pipe—return—spill-off pipe to fuel tank.
30.	Bolt—banjo.
31.	Washer—copper.
32.	Pipe—auxiliary spill-off filter to injector No. 1 cylinder.
33.	Bolt—banjo.
34.	Washer.
35.	Washer.

Wash all the components in petrol and blow them dry with compressed air. Blow through the fuel passages in the top half of the pump body.

Examine the valves for proper seating. No attempt should be made to dismantle the valve and seat assemblies. The complete assemblies should be renewed if they are not in absolutely perfect condition.

Inspect the rocker arm, linkage, and pin for wear. Parts should be renewed where evidence of wear or looseness is found. On the working surface of the rocker arm which engages the operating eccentric on the cam slight wear is permissible but not exceeding ·010 in. (·25 mm.) in depth.

Check for wear or broken rocker arm and diaphragm springs and renew if necessary. When renewing a diaphragm spring ensure that the replacement spring has the same identification colour and consequently the same strength as the original.

All the gaskets should be renewed as a matter of routine.

The diaphragm and pull-rod assembly should normally be renewed unless in an entirely sound condition without any signs of cracks or hardening.

Examine the mounting flange on the lower half of the pump body for signs of distortion; if it is not flat the flange should be lapped to restore it to its original condition.

Reassembly of the fuel pump is a reversal of the dismantling procedure but the following points must first be noted:

The rocker arm pin should be a tap fit in the body, but if due to wear it is freer than this the ends of the holes in the body should be burred over slightly.

Before installing the valves first place a new paper gasket in position.

Be sure to fit the outlet valve, spring foremost, into its port. The inlet valve cannot be incorrectly fitted owing to a restriction in the port.

When installing the diaphragm and pull-rod assembly the locating 'tab' on the periphery of the diaphragm should be at the 11 o'clock position as shown at (A) in Fig. D.6. After pressing the diaphragm downwards, at the same time turning it through 90° to the left (which will allow the pull-rod to engage the fork in the link), the 'tab' should be at the 8 o'clock position (B) (Fig. D.6), with the holes in the diaphragm matching up with the holes on the pump body flange.

Make certain that the top and bottom halves of the pump body are reassembled in their original positions; the markings scribed on the body flanges when dismantled must coincide. The securing screws should be tightened diagonally and securely while the diaphragm is held at the top of its stroke by pushing the rocker arm away from the pump.

When installing the domed cover tighten the set bolt sufficiently to make a fuel-tight joint.

Do not overtighten.

Section D.6

BLEEDING THE FUEL SYSTEM

One possible cause of the engine failing to start or erratic engine acceleration is that air may have entered the fuel system either through a leaking joint, the fuel tank being allowed to become empty, or any part of the system being dismantled. It is imperative that no air is present in the fuel system and that there is no leakage at any joint or union.

Although bleeding the fuel system is quite a simple operation, care should be exercised. In all cases of fuel filter or fuel line attention cleanliness is most essential to the efficiency and life of the engine.

When bleeding becomes necessary ensure that an adequate supply of fuel is in the tank and then proceed as follows:

First, bleed the fuel filter. Slacken the bleeder banjo connection positioned directly over the inlet port (see Fig. D.2), then operate the hand priming lever on the fuel lift pump until fuel completely free from air bubbles flows out from the plug; the connection must then be closed. Repeat this operation with the plug on the outlet side of the filter.

NOTE.—If the fuel system has been allowed to run dry the filter can be primed through the plug directly over the inlet port: this will save excessive manual operation of the lift pump. Replace the plug and washer, or banjo pin and washers, and carry out the bleeding operation as above.

Secondly, bleed the fuel injection pump. Slacken in turn the bleeder plugs on the pump and again operate the hand priming lever on the fuel lift pump until fuel flows freely without air bubbles, then securely tighten the plugs.

Finally, bleed each fuel delivery pipe in turn. Start the engine, slacken the union nut at the injector nozzle end of the pipe, and as soon as fuel flows free of air bubbles retighten the union nut.

Section D.7

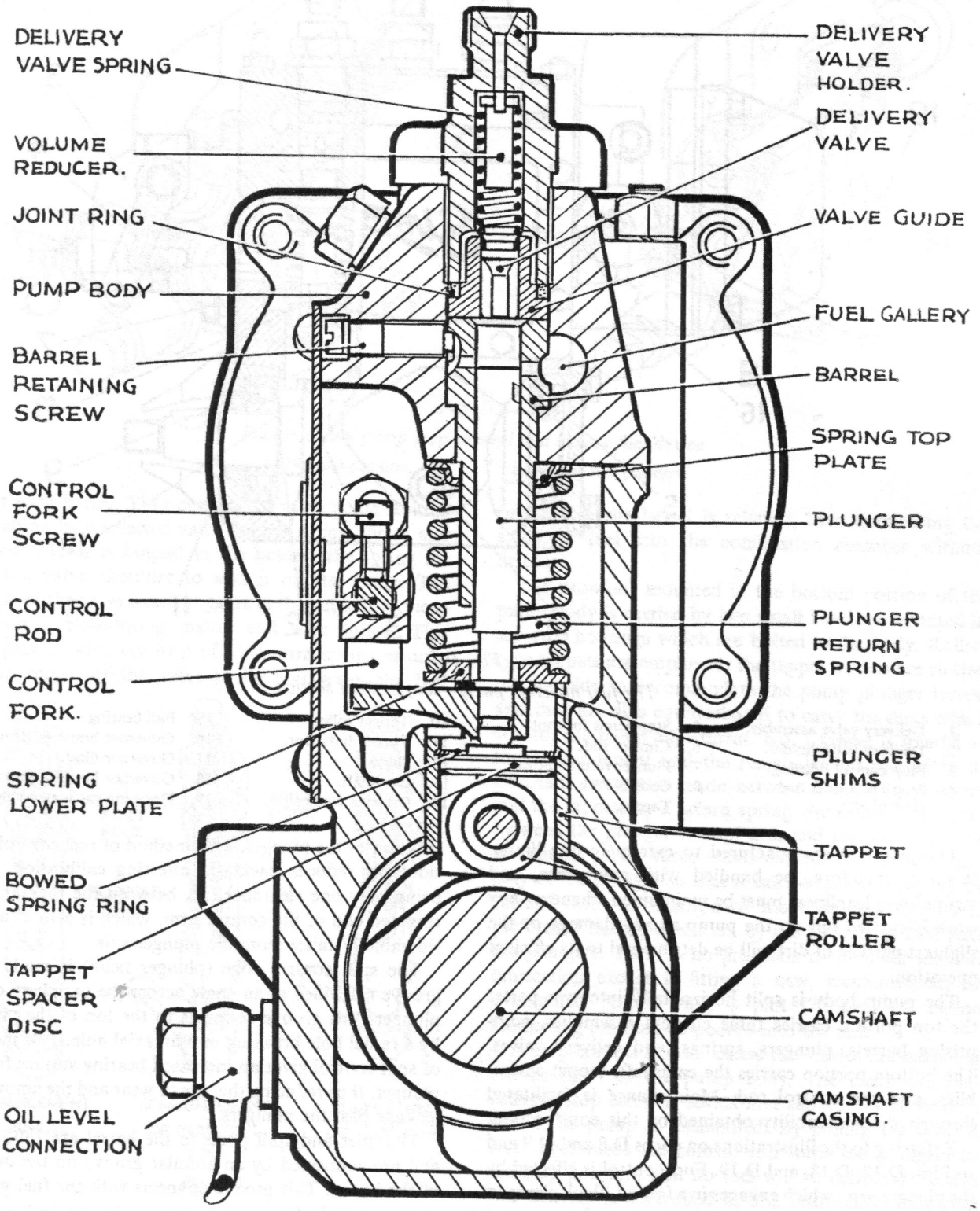
DESCRIPTION—FUEL INJECTION PUMP

The fuel injection pump is a Simms type SPE.3A.75. S473; this number is marked on the pump body and indicates the special features of the pump. The explanation of the type number is as follows:

SPE—Simms pump, self-contained type.
3—Number of elements.
A—Size of pump (38 mm. shaft centre height).
75—Plunger diameter in $\frac{1}{10}$ mm. (75 = 7·5 mm. dia.).
S473—Specification number, to suit engine application.

THE FUEL INJECTION PUMP—EXTERNAL VIEW

THE FUEL INJECTION PUMP—CROSS-SECTION



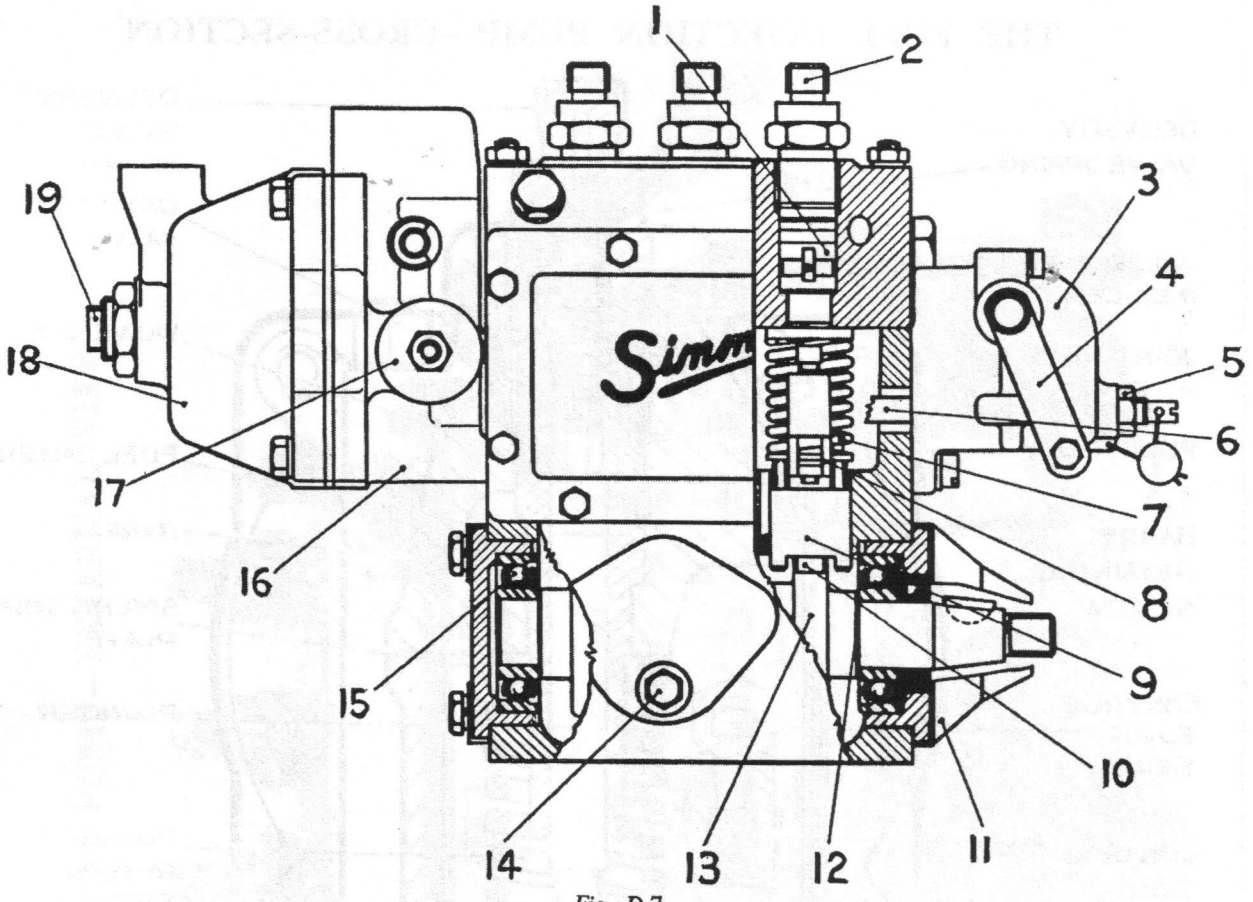


Fig. D.7

The fuel injection pump—longitudinal section

1. Delivery valve assembly.
2. Delivery valve holder.
3. Stop control housing.
4. Stop and excess fuel control arm.
5. Stop screw locknut.
6. Control rod.
7. Plunger return spring.
8. Control fork.
9. Tappet.
10. Tappet roller.
11. Timing indicator.
12. Shims.
13. Camshaft.
14. Oil level connection.
15. Ball bearing.
16. Governor housing—front.
17. Governor filter.
18. Governor housing—rear.
19. Damping valve assembly.

This pump is manufactured to extremely fine limits. It must, therefore, be handled with great care, and scrupulous cleanliness must be maintained whenever any work is carried out on the pump as any damage or the slightest particle of dirt will be detrimental to its efficient operation.

The pump body is split horizontally into two parts: the top portion carries three element assemblies, comprising barrels, plungers, springs, and delivery valves. The bottom portion carries the camshaft, tappet assemblies, and the control rod. Maintenance is facilitated through the accessibility obtained by this construction.

Referring to the illustrations on pages D.8 and D.9 and to Figs. D.17, D.18, and D.19. Fuel control is effected by the plunger arm, which engages in a forked block clamped to a square-section control rod. Movement of the control rod causes angular movement of the arm and partial rotation of the plunger. This method of fuel control considerably reduces backlash, affecting calibration, there being only one clearance, i.e. between the fork and the rounded end of the control arm, which is also at a considerable distance from the plunger axis.

The spill control edge (plunger helix) is made by a groove machined at an angle across the periphery of the plunger; this groove connects to the top of the plunger by a radial hole breaking into an axial hole. This method of spill control gives an increased bearing surface for the plunger, thus reducing the rate of wear and the amount of leakage past the plungers.

The inlet and spill ports in the barrel are 180° apart and are connected by an annular groove on the outside of the barrel. This groove connects with the fuel gallery in the pump body.

Conventional-type delivery valve assemblies are fitted

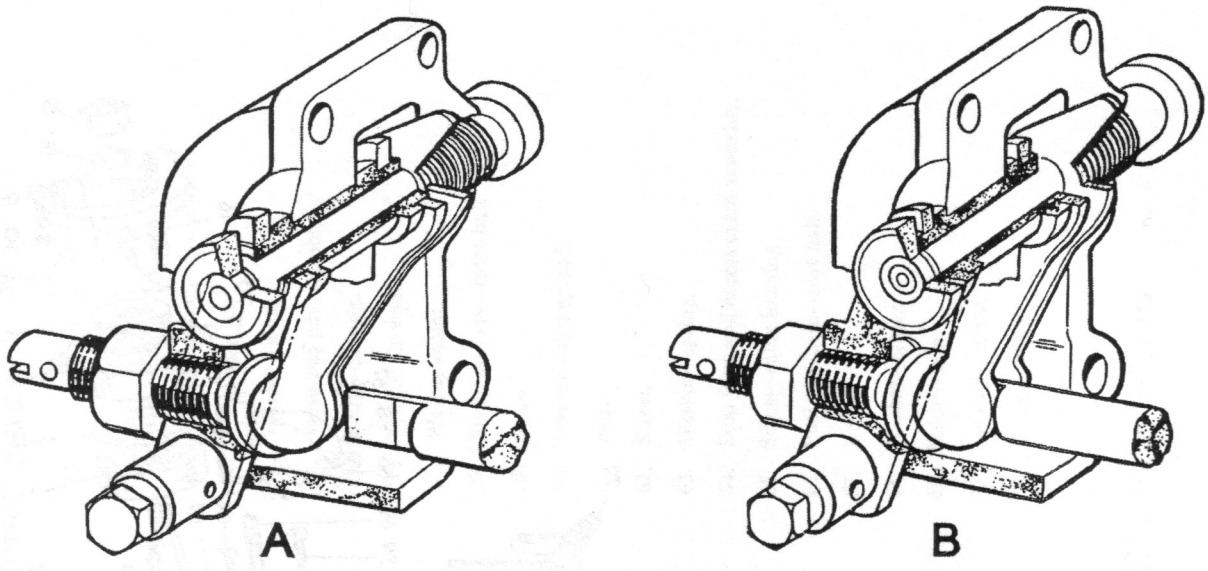


Fig. D.8

Fuel injection pump stop control and excess fuel device

A. Normal position. B. Excess fuel position.

above each barrel. They comprise a valve guide secured in position by a screwed valve holder. A coil spring and volume reducer is housed in the holder; the spring fits over the valve shoulder to seat it on the guide. The portion of the valve which engages in the guide is reduced to form a close-fitting piston and then fluted. This arrangement with the help of the return spring ensures a snap return of the valve to its seat when the fuel pressure in the barrel is relieved, thus terminating the spray of fuel into the combustion chamber without dribble.

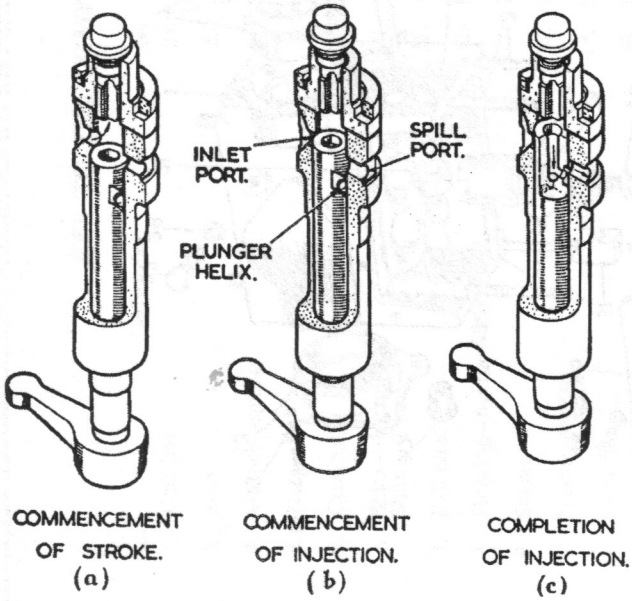


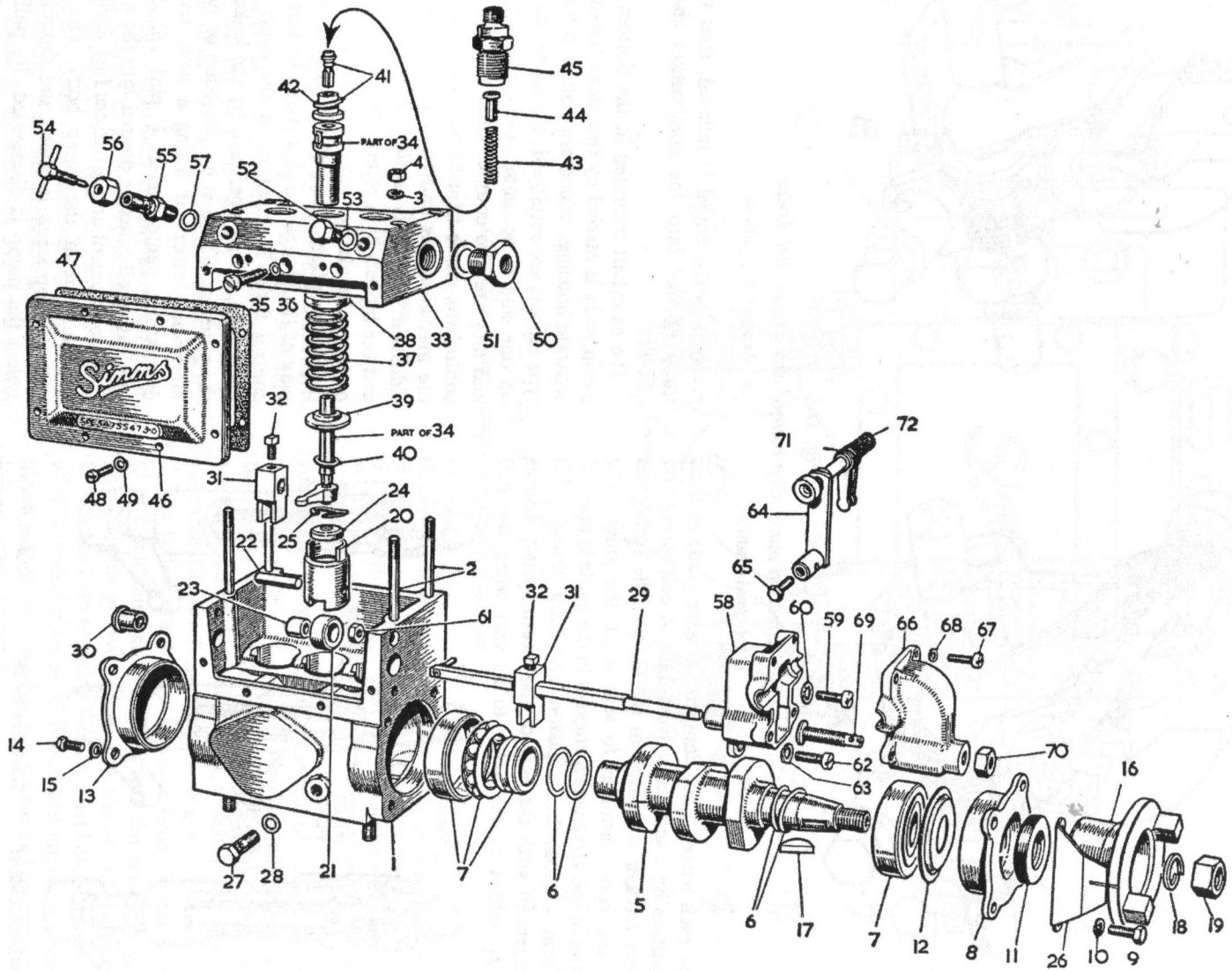
Fig. D.9

The fuel injection pump delivery stroke (normal running)

The camshaft mounted in the bottom portion of the pump body is carried by two small bearings mounted in separate housings which are bolted to the body. Roller-type tappets are employed; the tappet barrels are slotted on one side to accommodate the pump plunger levers, and they are also counterbored to carry the discs which control the phase adjustment. No. 1 tappet is treated as the master tappet and the remainder are phased to it. Constant contact is made between the pump plungers and the tappets by a return spring. Shims are interposed between the plunger control arm and the under side of the spring plate; these shims control the vertical end-play of the plunger so that it can be turned freely by its control fork. Lubrication of the cams and tappets is performed during operation by the leakage of fuel past the plungers. There is no provision or need for manual lubrication except if fitting a new, reconditioned, or overhauled pump, when $\frac{1}{8}$ pint (70 c.c.) of engine lubricating oil must be poured into the unit.

A stop control and an excess fuel device are mounted on the front of the pump body. The maximum fuel delivery stop screw is sealed and should not be broken unless the pump is dismantled. By pulling the control lever backwards the control rod turns the plungers to the stop position, and no fuel will be delivered. Excess fuel delivery is controlled by the push-button allowing the stepped portion of the control rod to pass between the stop lever and catch lever. No attempt should be

THE COMPONENTS OF THE FUEL INJECTION PUMP



KEY TO THE COMPONENTS OF THE FUEL INJECTION PUMP

No.	*Description*
1.	Cam box.
2.	Stud.
3.	Washer—spring.
4.	Nut.
5.	Camshaft.
6.	Shim—·1 mm. Shim—·2 mm.
7.	Ball race.
8.	Housing—bearing—drive end.
9.	Screw.
10.	Washer—spring.
11.	Oil seal.
12.	Washer—oil seal.
13.	Housing—bearing—governor end.
14.	Screw.
15.	Washer—spring.
16.	Coupling—fuel pump half.
17.	Key.
18.	Washer—spring.
19.	Nut.
20.	Tappet—body.
21.	Roller—tappet.
22.	Pin.
23.	Bush.
24.	Spacer—tappet—4·6 mm. Spacer—tappet—4·7 mm. Spacer—tappet—4·8 mm. Spacer—tappet—4·9 mm. Spacer—tappet—5·0 mm.
25.	Ring—spacer—retaining.
26.	Indicator—timing.
27.	Screw—banjo.
28.	Washer—joint.
29.	Rod—control.
30.	Bush.
31.	Fork—control.
32.	Screw—control fork—locking.
33.	Body—pump.
34.	Barrel and plunger assembly.
35.	Screw.
36.	Washer—joint.
37.	Spring—plunger.
38.	Disc—upper.
39.	Disc—lower.
40.	Shim for plunger.
41.	Delivery valve assembly.
42.	Joint ring for delivery valve.
43.	Spring valve.
44.	Volume reducer.
45.	Holder—delivery valve.
46.	Cover—inspection.
47.	Jointing.
48.	Screw.
49.	Washer.
50.	Inlet connection.
51.	Washer—sealing—for adaptor.
52.	Screw—air vent.
53.	Washer—joint.
54.	Valve and pin assembly.
55.	Body—air vent.
56.	Nut for air vent.
57.	Washer—joint.
58.	Fuel stop case—front half.
59.	Screw.
60.	Washer—shakeproof.
61.	Nut.
62.	Screw.
63.	Washer—spring.
64.	Stop lever and excess catch assembly.
65.	Screw—cable locating.
66.	Fuel stop case—rear half.
67.	Screw.
68.	Washer—spring.
69.	Screw—stop.
70.	Locknut—screw.
71.	Spring—return.
72.	Dust seal.

made to force the push-button out once it has been pushed in as possible damage to the lever inside the excess fuel device may result. As soon as the engine is running the governor comes into operation, and the control rod is pulled into its normal operating position when the excess fuel lever is also returned to its original position by its return spring.

Fig. D.9 shows the delivery operation of the pump plungers during normal running. The plunger stroke remains constant throughout the whole delivery range; the spill control edge governs the amount of fuel delivered.

When the plunger is at B.D.C. as in (*a*) the fuel can enter through the two ports into the bore of the barrel. As the plunger rises a certain amount of fuel is forced back into the fuel gallery until at the position (*b*) where the top edge of the plunger has just closed the inlet port. The fuel above the plunger is then trapped and its only outlet is through the delivery valve. The pressure on the fuel by the rising plunger causes the valve to lift and the fuel enters the pipe to the injector. As this pipe is already full of fuel the pressure of the fuel entering from the pump element causes the injector needle to lift and the fuel is then sprayed into the combustion chamber. Thus we have fuel being pumped into the pressure line at the injection pump end and an equal amount being sprayed into the combustion chamber at the injector end. This continues until the plunger reaches the position (*c*). At this point the top edge of the plunger helix has uncovered the spill port in the barrel, thus allowing the fuel to be by-passed to the fuel gallery (which is at a much lower pressure than the fuel above the plunger) by way of the communicating holes. This collapse of pressure causes the delivery valve to close smartly and to stop the injection of the fuel into the combustion chamber.

The cut-off is effected by the plunger helix, which is cut at an angle on the periphery of the plunger, which can be partially rotated in the barrel to vary the position of the cut-off. To stop the engine, with no fuel delivery from the elements, the plungers are turned to a position where the inlet port, which is the higher of the two, is on the point of being closed by the top of the plunger, while the lower one, the spill port, is just being uncovered by the uppermost tip of the plunger helix. Thus the fuel has an alternative outlet to the delivery valve throughout the plunger stroke and does not come under pressure, therefore no fuel is delivered into the combustion chamber.

Section D.8

REMOVING AND REPLACING THE FUEL INJECTION PUMP

Disconnect all the pipe connections from the injection pump.

Disconnect the flexible cable from the stop control at the front of the injection pump.

Remove the four set bolts from beneath the pump securing it to its mounting bracket. Disengage the coupling and carefully remove the pump from the engine.

Dismantling, overhauling, and reassembling the injection pump are dealt with in Section D.9.

Before refitting the injection pump to the engine it is necessary to set the engine for injection timing with No. 1 piston set on its compression stroke at 28° B.T.D.C.

Remove the valve rocker cover in order to observe the valve action (Section A).

Turn the crankshaft slowly in its normal direction of rotation until the exhaust valve (No. 5) of No. 3 cylinder commences to close. This indicates that No. 1 piston is approaching 28° B.T.D.C. on its compression stroke. Continue to crank the engine until the 28° injection timing mark on the rear face of the flywheel coincides with the pointer on the left-hand side of the engine.

Turn the pump coupling flange until the mark across the edge is in line with the mark on the timing indicator and place the pump on its mounting bracket.

Place the coupling centre disc between the pump flange and the drive flange and bring the two halves of the coupling together. The pump flange will probably be moved during the process, thus disturbing the timing; this will be rectified later during the timing procedure.

Set the injection pump timing as follows:

Slacken the two set bolts securing the drive flange adjustment to the claw plate.

Turn the injection pump coupling flange by hand until the line on the edge of the flange is in line with the mark on the timing indicator. During the above procedure it is essential that the driving flange is not moved.

Tighten the two set bolts to secure the driving flange adjustment. A final check should be made to ensure that the flywheel is still in the timing position of 28° B.T.D.C. It is essential that a clearance of ·005 to ·010 in. (·127 to ·254 mm.) exists between the coupling centre disc and the drive flange. Slacken the flange clamp bolt and adjust the position until the correct clearance exists.

Connect the fuel inlet pipe to the pump and the injector pressure pipes to their respective delivery valve unions, and the oil level and drain pipes to the pump.

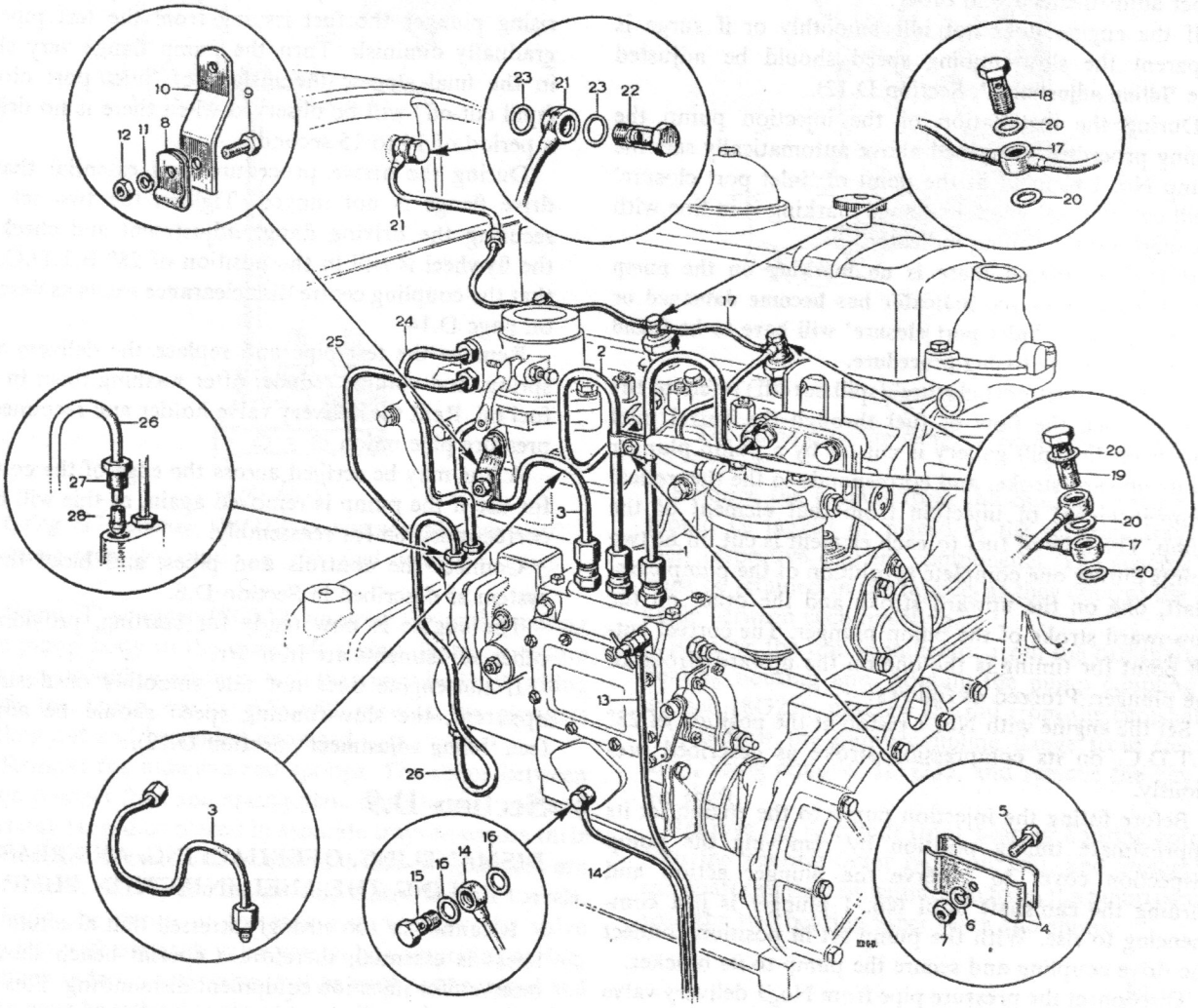
Bleed the fuel system (see Section D.6).

Connect the two suction pipes between the governor and throttle unit (venturi).

Connect the control lever to the throttle unit (venturi) and the stop control to the lever on the front of the pump.

NOTE.—When connecting the stop control to the lever on the injection pump it is essential that the lever is in its maximum forward position. This will mean that there is approximately $\frac{1}{2}$ in. (13 mm.) free travel on the stop lever which is necessary to allow the excess fuel device to operate.

THE FUEL INJECTION PIPES



No.	*Description*
1.	Pipe—fuel injection—No. 1 cylinder.
2.	Pipe—fuel injection—No. 2 cylinder.
3.	Pipe—fuel injection—No. 3 cylinder.
4.	Clamp for Nos. 1 and 2 fuel pipes.
5.	Bolt.
6.	Washer—spring.
7.	Nut.
8.	Clamp for No. 3 fuel pipe.
9.	Bolt.
10.	Steady bracket for clamp.
11.	Washer—spring.
12.	Nut.
13.	Overflow pipe—injection pump.
14.	Oil level pipe—injection pump.

No.	*Description*
15.	Banjo pin.
16.	Washer.
17.	Pipe—injector spill-off.
18.	Screw—banjo.
19.	Screw—banjo.
20.	Washer—joint.
21.	Pipe—spill-off to fuel tank.
22.	Bolt—banjo.
23.	Washer—copper.
24.	Pipe—vacuum—pump to venturi.
25.	Pipe—vacuum—venturi to air bottle.
26.	Pipe—vacuum—air bottle to pump.
27.	Nut.
28.	Pipe nipple.

The engine is now ready for starting providing all other adjustments are in order.

If the engine does not idle smoothly or if surge is apparent the slow-running speed should be adjusted (see **'Idling adjustment'**, Section D.12).

During the installation of the injection pump the timing procedure described above automatically sets the pump No. 1 element at the point of 'inlet port closure' (spill cut-off), i.e. when its flange marking is in line with the mark on the timing indicator.

If for any reason there is no marking on the pump coupling flange or the indicator has become damaged or lost the point of 'inlet port closure' will have to be found to accomplish the timing procedure.

The term 'inlet port closure' (spill cut-off) refers to the instant when the flow of fuel through the barrel inlet port from the spill gallery is cut off by a pump plunger on its upward stroke, and corresponds to the theoretical commencement of injection from that element of the pump. The flow of fuel to each element is cut off at two points during one complete revolution of the pump camshaft, one on the upward stroke and the other on the downward stroke of the pump plunger. The correct cut-off point for timing is the one on the upward stroke of the plunger. Proceed as follows:

Set the engine with No. 1 piston at the position of 28° B.T.D.C. on its compression stroke as described previously.

Before fitting the injection pump to the engine set its approximate timing position by removing the pump inspection cover to observe the plunger action and turning the camshaft until No. 1 plunger is just commencing to rise. With the pump set in position connect the drive coupling and secure the pump to its bracket.

Disconnect the pressure pipe from No. 1 delivery valve holder. Unscrew the valve holder and remove the valve, spring, and volume reducer. Connect the test pipe 18G233 in place of the valve holder and valve assembly.

If any of the engine controls are connected ensure that the engine stop control is right home and in the normal starting position so that the injection pump control rod is in the full power position. If the controls are not connected the governor spring will automatically position the control rod in the required position.

Slacken the two set bolts securing the drive flange adjustment to the claw plate.

Connect the fuel inlet pipe to the pump.

Prime the fuel system by using the priming lever on the lift pump; bleed the filter and the injection pump, when the fuel will flow out of the test pipe from No. 1 element.

Turn the injection pump coupling flange slowly by hand in its direction of rotation, when No. 1 element plunger will commence to rise from its B.D.C. position. Carefully observe the flow of fuel from the test pipe. As the element inlet port is progressively closed by the rising plunger the fuel issuing from the test pipe will gradually diminish. Turn the pump flange very slowly in the final stages; the instant of 'inlet port closure' (spill cut-off) will be observed when there is no drip for a period of 14 to 15 seconds.

During the above procedure it is essential that the drive flange is not moved. Tighten the two set bolts securing the driving flange adjustment and check that the flywheel is still in the position of 28° B.T.D.C., and that the coupling centre disc clearance exists as described on page D.14.

Remove the test pipe and replace the delivery valve, spring, and volume reducer after washing them in clean fuel oil. Refit the delivery valve holder and reconnect the pressure pipe union.

A line may be scribed across the edge of the coupling for use if the pump is removed again, as this will be the correct position for reassembly.

Connect the controls and pipes, and bleed the fuel system as described in Section D.6.

The engine is now ready for starting, providing all other adjustments are in order.

If the engine does not idle smoothly or if surge is apparent, the slow-running speed should be adjusted (see **'Idling adjustment'**, Section D.12).

Section D.9

DISMANTLING, OVERHAULING, AND REASSEMBLING THE FUEL INJECTION PUMP

It cannot be too strongly stressed that absolute cleanliness is essential, therefore a special bench should be reserved for injection equipment dismantling This bench should be covered with zinc or linoleum and kept absolutely free from dust, dirt, filings, grease, or acids. The bench should be provided with a suitable vice with a pair of copper or zinc jaw shields for protection.

Do not use cotton waste or fluffy cloth for cleaning purposes.

Remove the injection pump from the engine (Section D.8).

Remove and dismantle the governor (Section D.12). Remove the inspection cover.

Slacken the clamp screws in the control rod forks. Remove the front half of the control rod stop housing, withdraw the stop arm and spring, and then remove the rear half of the housing from the pump body. Slide the control rod out from the camshaft casing and remove the forks from the control rod as they become disengaged.

Remove the two set bolts and the countersunk set screw securing the governor front half housing and remove the housing from the pump body.

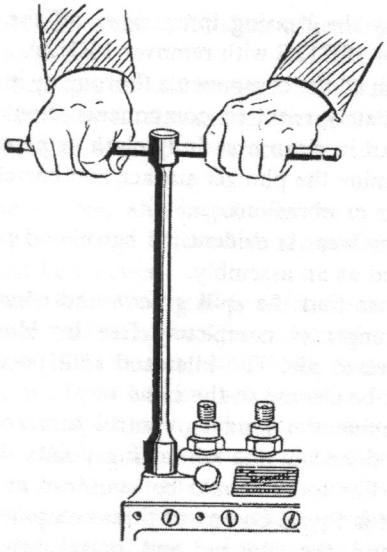


Fig. D.10

Using 'T' spanner 18G212 *to unscrew the camshaft casing securing nuts on the fuel injection pump*

Using 'T' spanner 18G212, unscrew the nuts securing the pump body to the camshaft casing. Place the pump on its side and carefully detach the pump body. Working with the pump on its side will prevent the plungers falling out and becoming damaged.

Remove the plungers and springs. The shims between each plunger foot and spring plate must be retained and suitably tagged or placed in separate trays to ensure their correct replacement. **It is essential that the plungers are not mixed, as they are individually mated to their barrels.**

Hold the pump in the vice and unscrew the valve holders. Lift out each valve assembly, comprising spring, volume reducer, and valve. **Valves must not be mixed and they must be refitted in the same positions from which they were removed.**

Remove the barrel locating screws and remove the barrel and valve guide by tapping them out, using a soft wooden drift. Alternatively, the valve guide only can be removed with remover 18G237, leaving the barrel in position.

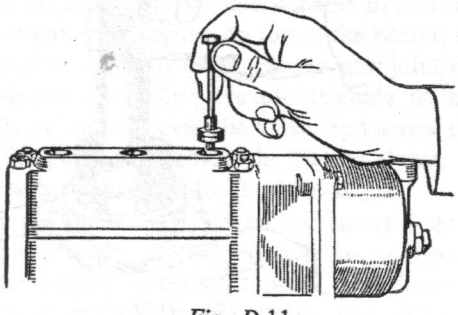


Fig. D.11

A valve guide may be removed, leaving the barrel in position, by using remover 18G237

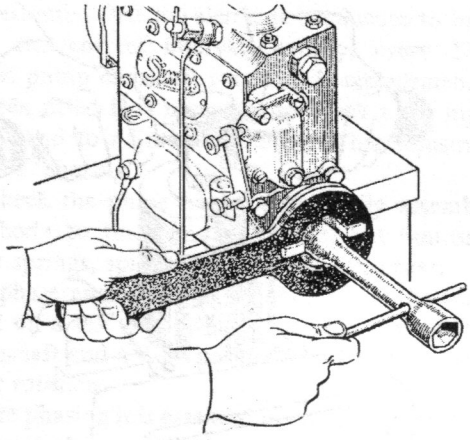


Fig. D.12

The pump coupling flange wrench 18G236 *in use*

Remove the tappets from the camshaft casing. They should be tagged or placed in the separate trays with their respective element components. The spacing discs must be retained in the tappets as they control the phase angle between each injection.

Remove the timing indicator from the camshaft front bearing housing and, holding the pump coupling with wrench 18G236, unscrew the nut from the camshaft.

Withdraw the pump coupling flange from the camshaft, using remover 18G235, and remove the key from the shaft.

Remove the camshaft front bearing housing complete with the bearing outer race, oil seal, and washer. The camshaft can then be withdrawn from the pump complete with the two bearing inner races and shims.

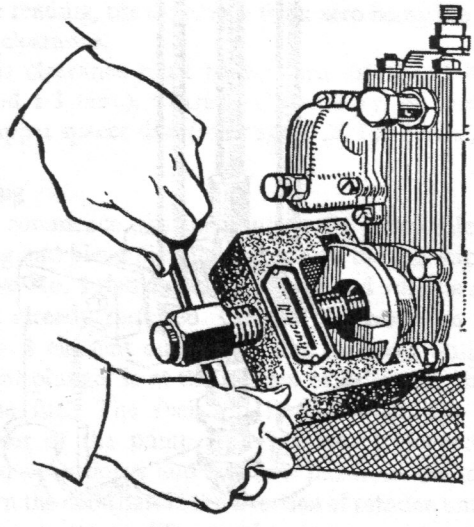


Fig. D.13

Withdrawing the pump coupling flange with remover 18G235

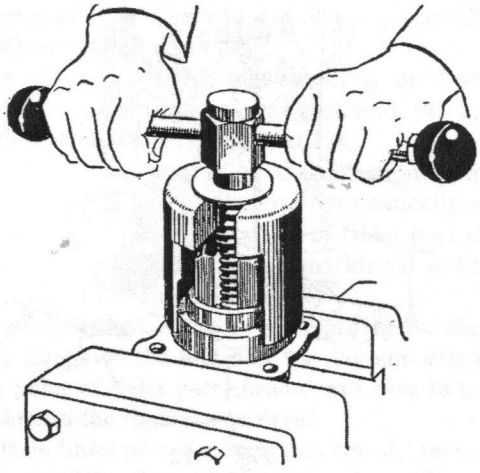


Fig. D.14

Removing the bearing outer races with remover 18G500 together with adaptors 18G500B and 18G500C

Remove the rear bearing housing and outer race.

Extract the bearing outer races from their housing with tools 18G500, 18G500B, and 18G500C.

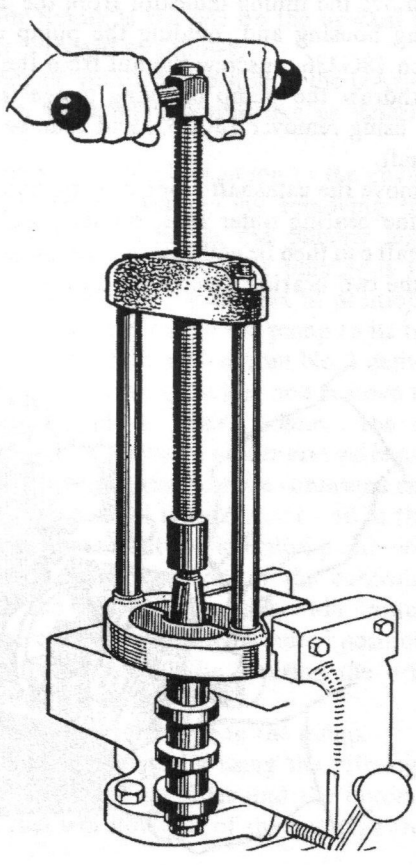


Fig. D.15

The inner races may be withdrawn from the camshaft, using remover 18G12A with adaptor 18G12E

Draw the bearing inner races off the camshaft with adaptor 18G12E with remover 18G12A.

Wash all the components thoroughly in paraffin. If not immediately required components should be oiled and wrapped in clean non-fluffy cloth or paper.

Examine the plunger surface and barrel bore for signs of wear or abrasions.

If any wear is evident the barrel and plunger must be renewed as an assembly.

Ensure that the spill groove and connecting bore of the plunger is completely free by blowing out with compressed air. The inlet and spill ports in the barrel should be cleared in the same way.

Examine the plunger control arm for wear on the rounded end at the contacting points with the control forks. The forks should be examined at the same time. If wear is found on any of these components the control fork and the plunger and barrel assembly must be renewed.

Test the plunger springs for fractures, and if they are below the length of new counterparts they should be renewed.

Inspect the seating of the delivery valve and guide. They should be perfectly smooth and flat. Inspect the valve return springs for fractures, and if they are below the length of new counterparts they should be renewed.

Examine the tappets for signs of wear; the rollers should be perfectly round, free to revolve, and with no signs of flats or pits. Examine the contact face of the spacing disc boss, which is positively held in the top of the tappet with a bowed spring ring, for signs of wear. If the slightest sign of wear is visible the disc must be renewed, but not until the correct size has been determined when re-phasing.

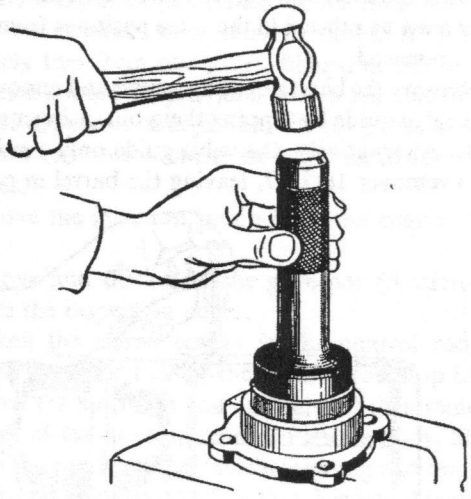


Fig. D.16

Press or drive the bearing outer races into their housings, thick edge foremost, using tool 18G240

Inspect the cam surfaces for signs of scoring and wear. Renew if necessary.

The ball bearings should be spun round in a bath of paraffin to clear any foreign matter. Inspect the balls and races for signs of wear, pits, or scoring; renew them if necessary.

Clean the oil seal and inspect for wear or damage. If the slightest damage is revealed, especially on the lip, the seal must be renewed.

Immediately before reassembly all components should be thoroughly washed in paraffin and dried.

Using tools 18G134 and 18G134AC, fit a serviceable oil seal into the front bearing housing with its lip facing towards the camshaft casing when in the fitted position. Press or drive the bearing outer races into their housings, thick edge foremost, using tool 18G240 to ensure correct alignment. The oil seal washer in the front housing must be fitted with its raised side facing outwards and located between the bearing and the oil seal. The bearing inner races can be fitted to the camshaft, using adaptor 18G12E with remover 18G12A.

Assemble the camshaft into its casing so that the end-play when the two bearing housings are bolted in position is from ·002 to ·006 in. (·051 to ·152 mm.).

The use of Service tool 18G538A will enable the end-float to be measured accurately. If any components have to be renewed adjust the end-play to the above by inserting or removing shims between the camshaft shoulders and the inner races of the bearings, otherwise the original shims should be replaced. The shims obtainable are ·004 in. (·1 mm.) and ·008 in. (·2 mm.) thick. Pack the ball bearings with grease before final assembly.

Insert the tappets in their original bores.

Wash the barrels in fuel oil and place them in the same bores of the body from which they were removed, and make sure that the slot in the barrel lines with the locating screw hole.

Fit the barrel locating screws, using a new joint washer under the head. When tightened the screws must engage in the barrel slots and they must not pinch the barrel.

Wash the delivery valve components in fuel oil. Place the valve guide in position on top of the barrel; the joint faces must be perfectly clean. Place a new joint ring over the guide and insert the valve into its guide, fit the spring and volume reducer over the valve, and screw the valve holder in position; tighten the holder down, using a torque wrench set to 30 lb. ft. (4 kg. m.).

Wash the plungers in fuel oil and insert them in their respective barrels. If the pump is to be reassembled using the original camshaft, tappets, and elements, then the plunger springs, spring plates, and shims can be placed in position over the plungers as it is not necessary to adjust the phase angle.

It is essential that the elements commence to inject at exactly the correct interval, namely, every 120° of injection pump camshaft rotation. If replacement parts have been fitted it is necessary to check these injection intervals and to adjust if necessary. This adjustment is known as 'phasing'.

To check the phase angles temporarily assemble the pump body to the camshaft casing, but omitting the plunger springs, spring plates, and control gear.

The phase angles should be checked by the fuel flow method on a test bench, having a degree plate fitted to the camshaft and a fixed pointer for measuring camshaft angular rotation.

Before phasing it is essential to set No. 1 tappet to give the correct clearance between the delivery valve guide and the top of the plunger when the plunger is at the top of its stroke.

This can be found by the use of the plunger head clearance gauge 18G538A in the following manner.

Remove from No. 1 element on the pump the delivery valve holder, valve, and spring, volume reducer, and joint washer.

Select the appropriate adaptor from the three supplied and assemble the dial gauge to it. When clamping the gauge make sure that the extension is central and does not foul the bore of the adaptor. Screw the adaptor and gauge into the position normally occupied by the delivery valve holder until the adaptor is tight against the top face of the valve guide.

Turn the camshaft until No. 1 element is at T.D.C. and zero the gauge.

Insert a suitable lever under the plunger control arm and gently lever the plunger upwards until it can be felt to touch the under side of the valve guide. Note the dial gauge reading, the difference from zero being the plunger head clearance.

This clearance must be between ·0315 and ·0512 in. (·8 and 1·3 mm.). Correct, if necessary, by exchanging the tappet spacer disc (see page D.20 for details).

Phasing

To commence phasing connect the pump inlet to the test rig and bleed the pump. Turn off the fuel supply and remove No. 1 delivery valve spring and volume reducer, if not already removed. Connect the test pipe 18G233 to No. 1 element outlet, turn the camshaft until No. 1 element plunger is at the bottom of its stroke, then turn on the fuel. The fuel will flow through the suction chamber of the pump, entering No. 1 element barrel by two open ports, and will flow out from the test pipe.

Turn the camshaft **in the direction of rotation** until No. 1 plunger starts to lift; as the ports are progressively closed by the plunger the fuel issuing from the test pipe will gradually diminish. Tap the camshaft round in the

final stages very gradually until fuel ceases to drip from the pipe. This is the point of inlet port closure—take note of the position on the degree plate.

Replace the delivery valve, spring, and volume reducer to No. 1 element and remove these components from the next element in order of injection, i.e. No. 3. Check the inlet port closing point of this element, which should be 120° after No. 1. Note any correction required.

Check the phase angle of No. 2 element and take note of the correction required. A maximum variation of ±½° of the phase angle is permitted. Variations exceeding this must be corrected by exchanging the tappet spacer.

The spacers are made in five graded thicknesses varying in steps of ·004 in. (·1 mm.) as follows:

Spacer thickness	*No. stamped on spacer*
·181 in. (4·6 mm.)	1 or 6A
·185 in. (4·7 mm.)	2 or 7A
·189 in. (4·8 mm.)	3 or 8A
·193 in. (4·9 mm.)	4 or 9A
·197 in. (5·0 mm.)	5 or 10A

The difference of ·004 in. (·1 mm.) of spacer thickness is equivalent to approximately ½° of camshaft rotation. Therefore, fitting a thicker spacer will advance the inlet closing point by ½°, while a thinner spacer will retard the inlet closing point by the same amount.

Remove the pump body from the camshaft casing and change the spacers as necessary. The spacer of No. 1 element should not be exchanged, but used as a datum for the adjustment of the other two elements.

After any adjustment to the phase angles check the clearance of the plungers, except No. 1, when at the top of their strokes, as detailed in the paragraph preceding **'Phasing'** on page D.19.

Assemble the pump body to the camshaft casing, but this time fit the plunger springs and spring plates with the shims between the control arm and lower spring plate.

Check that the plunger foot has a vertical clearance of ·002 to ·017 in. (·05 to ·425 mm.) when held in position on its tappet by the lower spring plate, so that the plunger can be turned freely by its control fork.

Adjust as necessary by means of plunger shims (see **'GENERAL DATA'**, page 4).

Refit the governor inner housing to the pump body.

Insert the control rod through the bores in the camshaft casing; at the same time thread on the control forks, which must be engaged with their respective plunger arms. Fit the control rod stop and the stop control housing. The maximum fuel delivery stop screw should be fully unscrewed for adjustment when testing.

Position the control forks on the control rod. The fork at the governor end should be secured by its clamp at the extreme end of the square portion. The gap between the adjacent forks is ·787 in. (20 mm.).

When refitting the inlet union to the pump care must be taken to centralize the copper washer which is fitted between this union and the pump body, as there will be a tendency for the washer to drop into the undercut at the end of the thread.

Refit the governor (see Section D.12).

Section D.10

FUEL INJECTION PUMP CALIBRATION

This adjustment is made to balance the output of all pumping elements throughout their delivery range. The method described below is for use on a fuel injection pump test bench, using a matched set of test injectors (nozzle type BDN.12.SD.12, holder type BKB.50.SD.19b set to open at 175 atmospheres).

Refit the pump coupling flange and timing indicator.

Check that the timing mark on the flange aligns with the mark on the indicator at the point of inlet port closure on No. 1 element. Re-mark if necessary.

Mount the pump less governor on the test bench. Link up the drive and connect the fuel supply.

Fit setting gauge 18G599 to the front half of the governor housing. Adjust the maximum fuel stop until the control rod is held against the setting gauge and secure the stop with the locknut. This will give a control rod setting of ·650 in. (16·5 mm.).

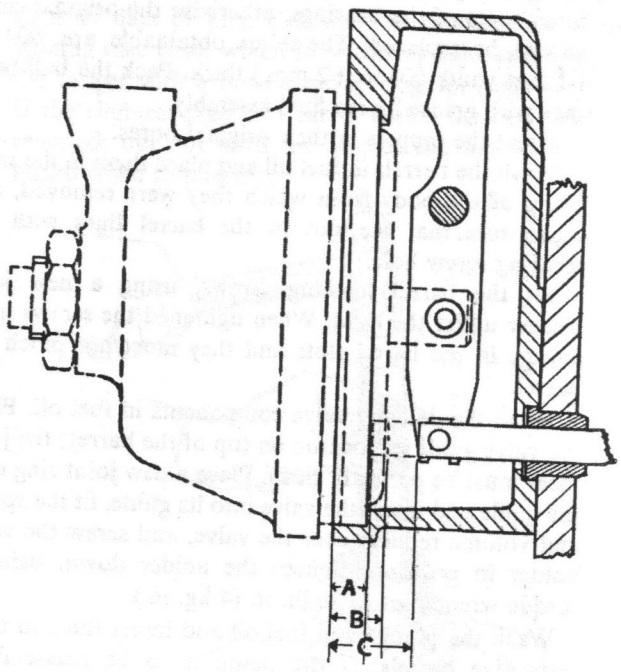


Fig. D.17

The injection pump control rod setting details

A. Stop position ·256 in. (6·5 mm.).
B. Commencement of injection ·373 in. (9·5 mm.)
C. Idling position ·650 in. (16·5 mm.).

NOTE.—The control rod setting position is the distance from the end face of the control rod to the end face of the governor front half, i.e. the distance (c) in Fig. D.17.

With the control rod in this position, check the pump output, which must be 3 c.c. ±·2 c.c. per element for 200 shots at 225 r.p.m. Adjustment is accomplished by slackening the control fork clamp screws and moving the control fork slightly on the control rod. Secure the control forks in position and re-check the pump output.

Remove the setting gauge and check that all elements cease to deliver at 600 r.p.m. when the control rod is set ·118 in. (3 mm.) from the zero position.

Maximum fuel setting

Refit the governor. Set the control rod to give an average delivery from all three elements of 10·6 ±·2 c.c. for 200 shots at 600 pump r.p.m.

The control rod setting is made by adjusting the position of the maximum fuel stop screw. The position of the control forks on the control rod must not be altered to obtain an acceptable maximum fuel setting.

In arriving at the above figure the output from each element must be between 10·2 and 11·0 c.c. Examples showing correct and incorrect settings are given below:

(*a*) Pump readings: 11·0, 11·0, 10·4 c.c.
Average delivery:

$$\frac{11{\cdot}0+11{\cdot}0+10{\cdot}4}{3} = 10{\cdot}8 \text{ c.c.}$$

This is **acceptable** as each element reading lies between 10·2 and 11·0 c.c. and the average is within 10·6±·2 c.c.

(*b*) Pump readings: 10·2, 10·3, 10·4 c.c.
Average delivery:

$$\frac{10{\cdot}2+10{\cdot}3+10{\cdot}4}{3} = 10{\cdot}3 \text{ c.c.}$$

Although the output from each element is within the limits of 10·2 and 11·0 c.c. the average delivery figure of 10·3 c.c. is **not acceptable** as it is outside the lowest average delivery limit of 10·4 c.c. by ·1 c.c.

To correct the setting adjust the maximum fuel stop (not the individual forks) so that each element output is increased. As the average output in example (*b*) is ·1 c.c. outside the lowest acceptable limit, the output of all elements must be increased by this amount plus a tolerance, in this case ·2 c.c. without which the average delivery would still only be the lowest limit acceptable.

The readings will then be 10·5, 10·6, and 10·7 c.c., giving an average delivery of 10·6 c.c., which is ideal. Similarly, if the average delivery happens to be in excess of 10·8 c.c., then each element output must be reduced by the excess amount plus a tolerance to give an average output as near as possible to the ideal of 10·6 c.c. The value of the tolerance is determined by the amount required to increase or decrease the average output to, as near as possible, the ideal, with the output from each element lying between 10·2 and 11·0 c.c.

If a satisfactory maximum fuel setting cannot be obtained by this method and the pump is correctly calibrated as outlined previously, the faulty pumping element or elements must be renewed.

When the maximum fuel setting is correct lock and seal the maximum fuel stop screw with wire and lead seal to discourage unauthorized adjustment, using sealing pliers 18G541.

Section D.11

DESCRIPTION—PNEUMATIC GOVERNOR

The governor is mounted to the rear of the injection pump and uses the suction created in the engine induction system to control the amount of fuel delivered to the engine. Connection between the throttle unit (venturi) (mounted on the air inlet manifold) and governor is made by two suction pipes. The main suction pipe connects the main port on the engine side of the throttle valve to an air bottle which is in turn connected to the port in the governor housing leading directly into the governor chamber. The auxiliary suction pipe connects the auxiliary port on the atmospheric side of the throttle valve to the governor chamber via the damping valve assembly. The inlet from the auxiliary suction pipe is

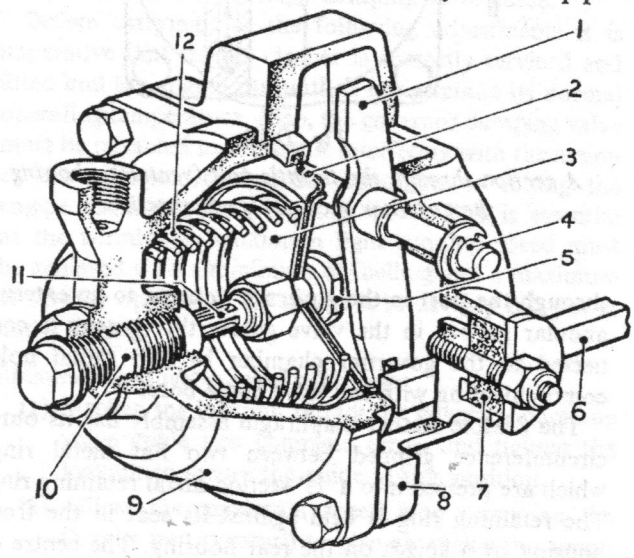


Fig. D.18

The fuel injection pump pneumatic governor

1. Rocker.
2. Diaphragm.
3. Diaphragm plate.
4. Rocker shaft.
5. Diaphragm guide.
6. Control rod.
7. Filter capsule.
8. Governor case—front half
9. Governor case—rear half.
10. Damping valve guide and bush.
11. Damping valve.
12. Governor spring.

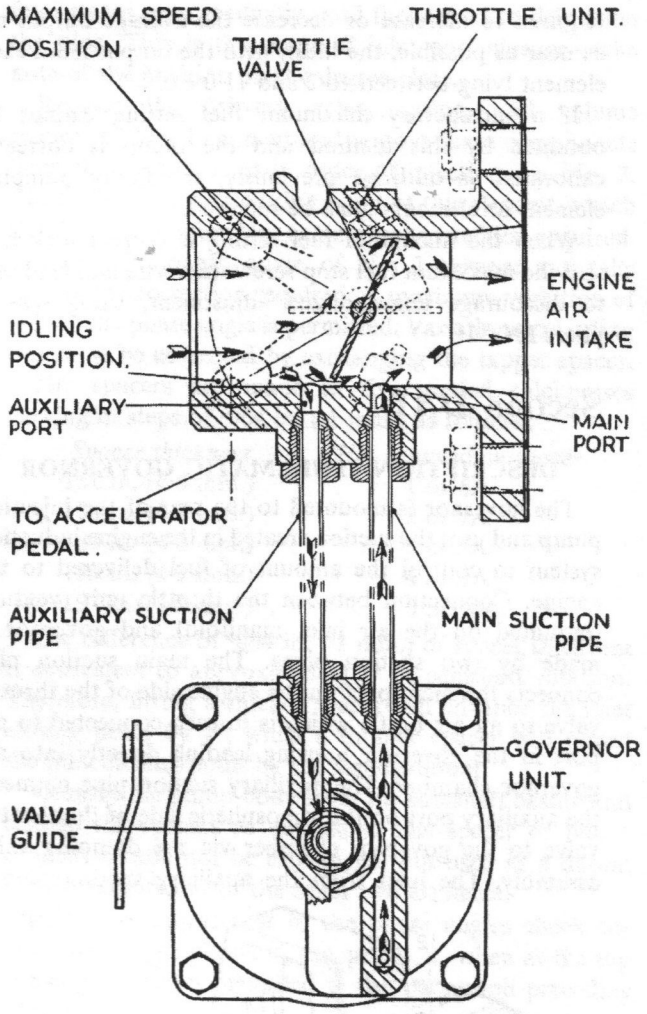


Fig. D.19

A section through the throttle unit (venturi), showing the governor suction pipe connections

through the port in the governor housing to an external annular groove in the valve guide; this groove is connected to the governor chamber by two radial holes communicating with the valve guide bore.

The flexible leather diaphragm assembly has its outer circumference gripped between two flat metal rings which are pressed into a 'U' section metal retaining ring. The retaining ring is held against its seat in the front housing by a spigot on the rear housing. The centre of the diaphragm is clamped between two dished plates. The inner dished plate carries the governor guide, which is drilled to accommodate a spindle located in the centre of the rocker, thus connecting the diaphragm assembly to the pump control rod. The location of this spindle gives the pump control rod and diaphragm assembly movement a ratio of 2 : 1.

The governor spring is positioned between the diaphragm dished plate and the wall of the governor housing; tabs on the dished plate and a machined seat in the housing wall keep the spring centralized. Thus the damping valve moves inside its guide in relation to the diaphragm movement. The damping valve guide assembly is screwed into the rear of the governor housing for anti-surge adjustment; an external locknut secures it in position.

The throttle valve in the throttle unit (venturi) is controlled by the accelerator, and when this valve is moved to the closed position an increased suction is created on the engine side of the valve. This is transmitted through the main suction pipe and air bottle to the governor chamber, thus reducing the pressure on that side of the diaphragm. As the chamber on the other side of the diaphragm is open to atmospheric pressure, the diaphragm is drawn back against the pressure of the spring, thus moving the pump control rod so as to reduce the amount of fuel delivered. Closing the throttle valve, therefore, reduces the engine speed, whilst opening the throttle valve reduces the suction on the diaphragm, so that the spring returns the pump control rod towards the increased fuel delivery position, thus increasing the engine speed. When the engine is at rest the pump control rod is held in the maximum fuel delivery position by the diaphragm spring.

The maximum speed of the engine is determined as a result of the throttle valve being fully opened, giving an increase in engine speed with consequent increasing air velocity in the throttle unit (venturi). The increase in air velocity in the throttle unit (venturi) causes a gradually increasing suction in the main port, which is transmitted to the diaphragm, and this draws back the pump control rod, limiting the speed of the engine.

The fluted damping valve prevents hunting or surging of the engine at idling speeds. Referring to Fig. D.19, it can be seen that when the engine is idling the pressure in the governor chamber will be low, the diaphragm spring becoming compressed, and the valve head will be in line with the radial holes in the guide. If the diaphragm moves too far towards the stop position the fluted portion of the valve head lines up with the radial holes in the guide and will admit air from the auxiliary port. As this port is connected to the auxiliary suction pipe the air is at approximately atmospheric pressure and will therefore relieve the suction on the diaphragm. The damping valve thus acts as a buffer, preventing excessive oscillations of the diaphragm at idling speeds.

An air bottle fitted on the rear right-hand side of the engine crankcase and connected in the main suction pipe between the venturi and the governor provides a reservoir of air which assists the governor damping valve to prevent hunting or surging.

Section D.12

REMOVING, OVERHAULING, AND REPLACING THE PNEUMATIC GOVERNOR

The diaphragm in the governor unit can be tested for leakage before removal as follows.

Remove the two suction pipes from the governor.

Pull the stop control lever to the stop position and place a finger over each pipe connection on the governor to act as seals.

Release the stop control lever. The control rod should move slowly back to the maximum fuel position after a quick initial movement. Should it return rapidly over the whole distance and no leak is evident between the faces of the cover and housing, then the diaphragm assembly should be regarded as faulty and must be renewed.

To remove and dismantle the governor first disconnect the two suction pipes from the governor housing.

Remove the four set bolts and withdraw the rear half housing and the governor spring.

Remove the rocker shaft exterior circlips.

Carefully lever the diaphragm assembly retaining ring from its seating. Draw the diaphragm assembly forward as far as possible to obtain access to the hollow pin in the rocker shaft locating collar and to the circlips on the rocker spindle and on the control rod.

Tap out the hollow pin, noting that the distance collar drilling is tapered, and remove both circlips. The rocker shaft can now be removed, leaving the rocker arm distance collar and the diaphragm assembly free to be withdrawn.

Remove the split pin to release the diaphragm assembly from the rocker.

Release the locknut on the air filter on the governor front half casting and withdraw the cover-plate and wire mesh.

Remove the two set bolts and the countersunk set screw securing the governor front half housing and remove the housing from the pump body.

Inspect the diaphragm for signs of perishing or cracks which are liable to affect efficient operation. If there is the slightest doubt as to its condition unscrew the valve from the valve guide and fit a new diaphragm assembly. Note the plain washer between the valve and the diaphragm outer dished plate. Inspect the diaphragm spring for signs of damage or weakness. It should be checked for length against a new one; renew the spring if there is any appreciable variation between lengths.

Ensure that the valve guide and its radial connecting holes are completely free; they should be blown out, using a compressed-air jet.

Inspect the valve on the end of the governor guide; it should be perfectly smooth and not bent in any way.

While the diaphragm assembly is removed from the pump refit the rocker shaft temporarily and check that the rocker and the pump control rod move perfectly freely as any tightness will cause defective governor operation.

Wash the air filter wire mesh in petrol (gasoline); when dry dip the mesh in clean engine oil and allow to drain before replacing.

The reassembly and installation of the governor is a reversal of the dismantling procedure but note the following points.

Coat the damping valve and bush with Oildag colloidal graphite grease.

Fit a new split pin in the rocker valve guide pin.

When pressing the diaphragm retaining ring onto its seating ensure that the diaphragm is not pulled from its natural position.

Test the governor for leakage as described previously.

Before putting the engine into service adjust the governor as described below.

NOTE.—Under no circumstances must the engine be run without the throttle unit (venturi) or the inlet manifold fitted, or with either of the two suction pipes disconnected.

To adjust

Two adjustable stop screws, which limit the opening and closing of the throttle unit (venturi) butterfly valve, are used to set the engine maximum and idling speeds. Engine 'surge' at idling speed is controlled by adjusting the position of the governor damping valve guide.

Before carrying out the following adjustments it is imperative that the air cleaner is correctly serviced and fitted and the engine run until it has attained its normal operating temperature. Also, the governor damping valve must be retracted to prevent it interfering with the action of the governor during the operation of setting the engine maximum light running speed. This is essential as the permissible maximum light running speed must be achieved with a minimum of fuelling and a maximum of throttle opening if the engine is to develop full power under load.

Maximum and idling speed adjustment

(1) Slacken the locknut, retract the governor damping valve guide two complete turns, and tighten the locknut to secure the guide in this position.

(2) Adjust the maximum speed stop screw on the throttle unit (venturi) to give an engine maximum light running speed of 2,100 r.p.m. as shown on a tachometer, thus giving a maximum governed speed under load of 2,000 r.p.m.

(3) Lock the maximum speed stop screw with the locknut, and to discourage unauthorized adjustment seal the screw with wire and a lead seal, using sealing pliers 18G541.

(4) Slacken the locknut, screw in the damping valve guide until the engine is running free of 'surge', and tighten the locknut to secure the damping valve guide in this position.

(5) Check the engine maximum light running speed to ensure that it has not been increased by the interference of the damping valve with the governor action. If necessary, adjust the damping valve guide to restore the engine maximum light running speed to the figure given in paragraph (2).

(6) Check the engine idling speed, using a tachometer, and, if necessary, adjust the idling stop screw on the throttle unit (venturi) to give an idling speed of between 520 and 550 r.p.m.

To obtain engine idling free from 'surge' it may be necessary to vary the position of both the idling stop screw and the governor damping valve guide. If the governor damping valve guide is adjusted the engine maximum running speed must be checked as described in paragraph (5).

Section D.13

DESCRIPTION—INJECTORS

The OEC three-cylinder diesel engine is of the direct-injection type, i.e. the fuel is sprayed directly into the combustion chambers. With this type of engine four-hole long-stem nozzle injectors are employed which are of Simms design. The injectors are located in copper sleeves which are completely water-jacketed in the cylinder head. The injector nozzle holes are positioned to give a spray cone angle of 150°, the centre-line of the cone being at an angle of 20° to the nozzle axis, which gives an approximately symmetrical spray about a vertical axis into the combustion chambers when the injectors are in position in the cylinder head.

The injector nozzle body locates against the dowelled face of the nozzle holder; the nozzle nut secures the two components together, making a pressure seal between the two faces. Located through the centre of the nozzle holder, the spindle is forced onto the valve by the spring. The spring plate centralizes the valve spring in the spring cap nut, which is screwed for the adjustment of the nozzle injection pressure. The spring cap nut is locked by the injector cap nut, which carries a leak-off connection for the return of fuel which leaks past the valve.

Fuel is fed to the annular reservoir in the nozzle body through the three holes which are connected to the inlet union via the channel in the nozzle body pressure face and the bore in the nozzle holder. The needle valve is raised off its seat against the spring resistance by the pressure of the fuel being fed from the injection pump acting on the valve. The accumulated fuel in the reservoir is then forced through the four nozzle holes into the combustion chamber in the form of a spray.

Section D.14

REMOVING, TESTING, AND REPLACING THE INJECTORS

It is difficult to give a hard and fast distance or time limit at which the injectors should be examined owing to the greatly differing conditions under which engines operate. For general operating conditions the injection nozzles should be tested every 450 hours. If injector trouble is experienced before this time has elapsed the period should be reduced accordingly.

It is often possible to locate an injector which is not working correctly by slackening off the injector feed pipe union nut a few turns, thus allowing the fuel to leak past the union whilst the engine is running slowly. If no change is noticed in the performance of the engine or sound of the exhaust it is reasonable to assume that the injector nozzle is faulty. The same applies if a faulty condition such as very thick blue smoke on engine acceleration disappears when one particular injection line is rendered inoperative.

To test an injector proceed as follows:

(1) Disconnect the injector feed pipe union nut and all the injector leak-off unions.

(2) Remove the two set bolts securing the injector to the cylinder head and withdraw the injector, using tool 18G491. Immediately plug the hole to prevent the ingress of foreign matter.

(3) If the injectors are to be stored for any length of time then the fuel feed and leak-off unions must be blanked off with protective sealing caps.

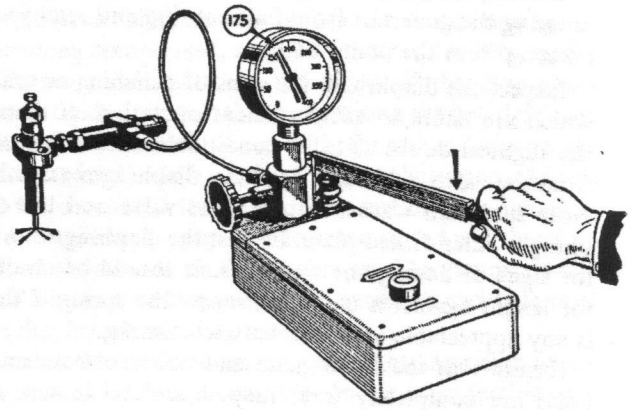


Fig. D.20

Using injector nozzle testing and setting outfit 18G109A

To completely test the nozzle or adjust the opening pressure the use of a nozzle-setting outfit as described in a later paragraph on this page is necessary.

If a nozzle-setting outfit is not available the injector can be tested on the engine as detailed below:

(1) Fit the injector to be tested onto its feed pipe, facing away from the engine.

(2) If the engine is then motored at idling speed the spray can be observed. The spray from each of the holes in a good nozzle should persist for about 6 in. (15 cm.) before being diffused. Prolonged motoring of the engine is not necessary as the spray can be observed during the first few engine revolutions. If the spray does not atomize, but 'hosepipes', or is weak, or if any of the sprays are missing, or if the nozzle dribbles, then it must be replaced by a clean, tested nozzle The faulty nozzle should be wrapped in a clean cloth or greaseproof paper and taken for cleaning to a fully equipped workshop or the nearest Simms Service Station.

NOTE.—To carry out the above test it is essential that the throttle unit (venturi) with its suction pipes connecting it to the governor is in position. If they are not fitted the engine will not be governed and will race away if started.

The test may be carried out with these components removed if all the injectors are removed also; the engine can then be motored by the starter.

Great care must be taken to prevent the hands from getting into contact with the spray as the working pressure will cause the oil to penetrate the skin with ease.

Using nozzle-setting outfit 18G109A

Before using this testing outfit ensure that the fuel tank is full. There is no necessity for air-venting as the pump is self-priming.

A fuel which does not affect the skin of the person handling the injectors, such as Shell Fusus A oil, should be used; the oil has about the same viscosity as diesel oil and also prevents stickiness of the needle after long periods of injector storage.

Before removing an injector from the outfit close the check valve to prevent damage to the pressure gauge, which may result from a sudden drop in pressure.

WARNING.—It cannot be stressed too strongly that when a nozzle is spraying the nozzle holder must be turned away from the operator.

Checking the nozzle spray

Connect the injector to the nozzle setting outfit.

Close the check valve to cut off the pressure gauge and pump at the rate of 60 strokes per minute. There should be four equal sprays from the nozzle; each spray should be evenly distributed and should persist for about 6 in. (15 cm.), without any visible core or jets of unatomized fuel. If the spray is not correct, or if any leaks or dribble occur, the nozzle should be wiped dry and the test repeated to locate the cause.

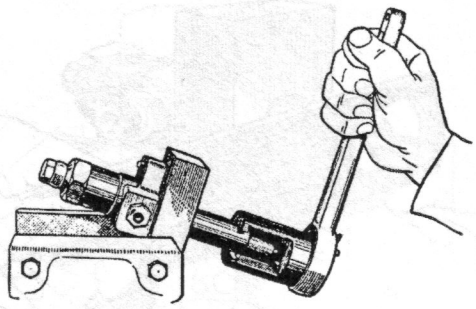


Fig. D.21

Injector dismantling fixture 18G388. *Socket* 18G210, *which is used with a standard wrench, is also illustrated*

(1) If the leak is from the nozzle holes, then it can be suspected that there is either carbon under the nozzle valve seat in the nozzle tip cavity or a sticking nozzle valve is causing the trouble.

(2) If the leak is from the body, then it can be suspected that the body is cracked or that there is dirt or carbon on the joint faces of the nozzle holder and body which is causing the trouble.

(3) If the spray is very wet and the injector does not 'buzz' when tested, then the causes may be due to the spring being out of adjustment or broken.

Checking and adjusting the nozzle opening pressure

Open the check valve and operate the pump lever. Note the pressure reading of the pressure gauge at the instant the nozzle sprays—this should be 175 atmospheres. If the opening pressure is incorrect the nozzle should be reset as follows:

(1) Remove the injector from the setting outfit.

(2) Remove the injector cap nut and copper joint washer.

(3) Screw in the valve spring cap nut to increase the injection pressure or out to reduce the pressure and lock in position with the injector cap nut.

(4) Re-check the opening pressure on the setting outfit.

(5) Repeat the operations (2) and (3) until the correct injection pressure of 175 atmospheres is obtained.

(6) Check the tightness of the injector cap nut and ensure that the copper joint washer is in position.

Checking the pressure tightness of seatings

Connect the injector to the nozzle setting outfit and open the check valve. Depress the pump lever slowly until a pressure of 160 atmospheres is obtained. The

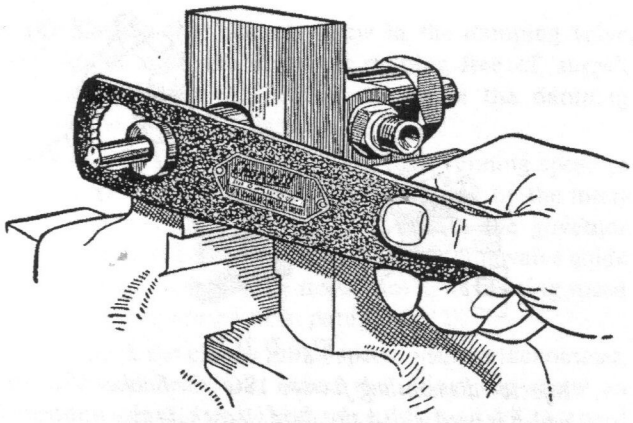


Fig. D.22

Injector nozzle nut wrench 18G208, *which may be used as an alternative to socket* 18G210

nozzle orifices should then be carefully examined for leakage, making sure beforehand that the nozzle is dry. The nozzle can be considered free from leakage if this pressure can be held for 10 seconds without any serious wetness being visible from the nozzle tip. If doubtful, a piece of blotting-paper held below the nozzle tip should not show a spot larger than $\frac{1}{2}$ in. (13 mm.) in diameter when the above pressure is maintained for a minute. If the seat leakage exceeds this the nozzle should be cleaned and lapped if necessary (see Section D.15). If a further test reveals no improvement the nozzle should be renewed.

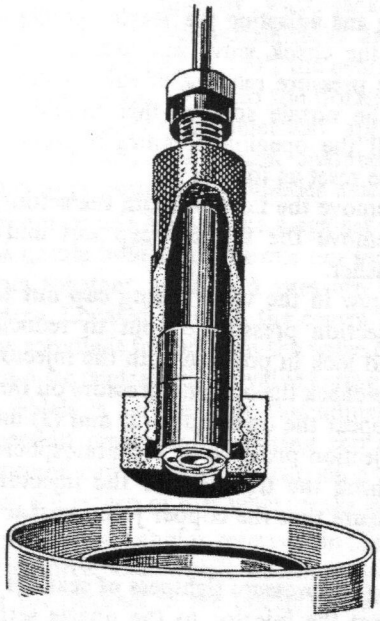


Fig. D.23

The injector reverse-flush nozzle adaptor 18G109E

If the seat dryness is satisfactory check the back-leak time of the nozzle, which indicates the fit of the needle in its guide. Depress the pump lever slowly until a pressure of 150 atmospheres is attained and check the time for the pressure to drop to 100 atmospheres. A time factor of 12 to 30 seconds should be recorded for a new nozzle, but after a period of service this time will obviously be reduced. This increase in leakage does not seriously affect the engine performance unless it becomes excessive, and nozzles can be considered serviceable until a time factor of less than 5 seconds is recorded. When the back-leak time is below 5 seconds the complete nozzle and valve must be renewed.

Before refitting the injectors to the engine thoroughly clean the injector sleeve in the cylinder head, making quite sure that all carbon is cleaned from the bottom copper face.

Place the injector in position in the sleeve; fit the set bolts and tighten evenly, half a turn at a time, to ensure even seating. The correct tightness is 12 lb. ft. (1·6 kg. m.).

Connect the fuel delivery pipe and leak-off unions.

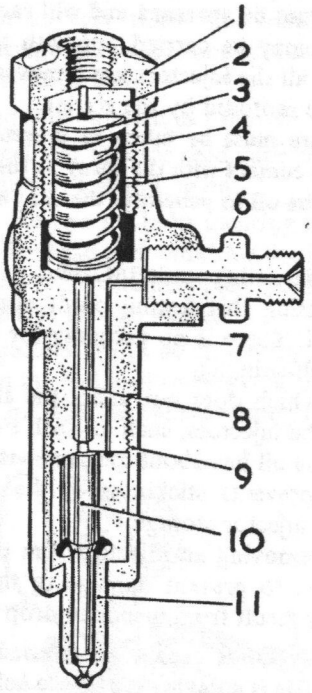


Fig. D.24

A fuel injector in section

1. Injector cap nut.
2. Spring cap nut.
3. Spring plate.
4. Spring.
5. Joint washer.
6. Inlet union.
7. Nozzle holder.
8. Spindle.
9. Nozzle nut.
10. Needle valve.
11. Nozzle body.

Section D.15

DISMANTLING AND REASSEMBLING INJECTOR NOZZLES AND HOLDERS

As in the case of injection pump dismantling, absolute cleanliness is essential, therefore the same facilities must be available and the same precautions taken for injector maintenance as those described at the beginning of the section on the injection pump. Dismantling should not be attempted unless nozzle cleaning kit 18G487 is available.

Nozzles

Fit the injector in the dismantling fixture 18G388 and secure in a vice.

Unscrew the injector cap nut and remove the copper joint washer.

Unscrew the spring cap nut, remove the valve spring plate, valve spring, and spindle.

If the complete dismantling of nozzle holder and nozzle is being carried out, remove the fuel inlet unions.

Unscrew the nozzle nut, using wrench 18G208, or alternatively socket 18G210, which is used with a standard ratchet wrench. Remove the nozzle body, taking care not to let the needle valve drop out. Nozzle maintenance can now be carried out as follows.

NOTE.—The nozzle components are mated and must always be kept together.

The needle valve should be free from all damage, and it is important that it is not blued due to overheating. Remove any carbon from the valve, using the brass wire brush, and polish with a piece of soft wood. No abrasive must be used. All polished surfaces should be relatively bright without scratches or dull patches. It is essential that the mating surfaces of the nozzle body and the nozzle holder are absolutely clean, free from scratches and burrs, as these must register together to form a high-pressure joint. The two dowels in the nozzle holder face must fit freely into their locating holes.

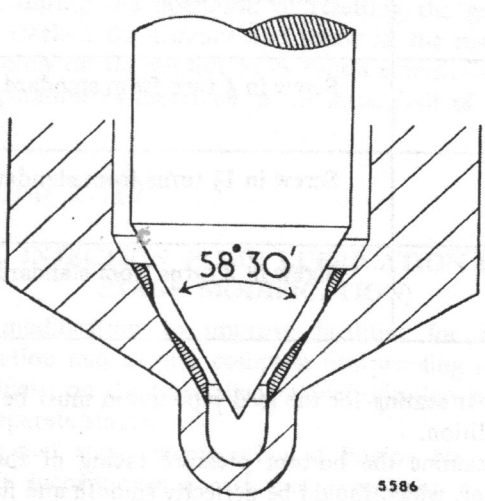


Fig. D.25

Lapping the nozzle contact seat

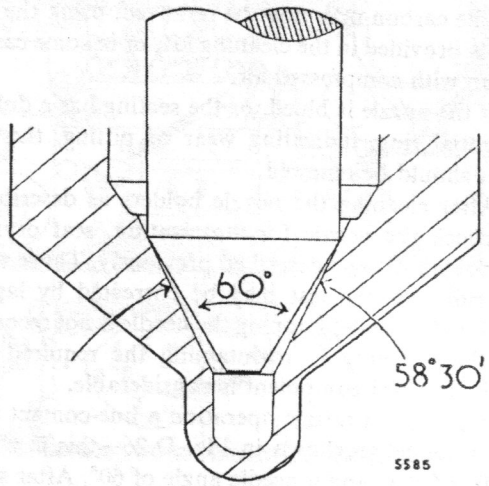


Fig. D.26

Correct needle and nozzle seat contact

Using the brass wire brush, all loose carbon must be brushed off the nozzle. Then scrape all carbon from the internal recesses, feed passages, and reservoir with the brass scrapers. The spray holes in the nozzle tip should be cleared out with the steel wire, provided in the cleaning kit, held in the probing tool. Reverse-flush the nozzle, using adaptor 18G109E. This allows oil to be forced through the spray holes in the reverse direction and flushes out the reservoir and internal passages to remove any loose carbon. It is most important that this operation be carried out.

In cases where the carbon build-up is particularly hard this may be softened in the following manner, thereby reducing the labour time.

Prepare a 10 per cent. solution of caustic soda with a detergent added by dissolving 2 oz. (56·7 gm.) of caustic soda in 1 pint (·57 litre) of water and add ½ oz. (14·2 gm.) of an ordinary washing detergent. Place the nozzle bodies in the liquid, bring it to the boil, and allow to boil for a minimum of 1 hour and not more than 1½ hours. Care must be taken not to allow the water to evaporate too much, because if the percentage of caustic soda rises above 15 per cent. the surface of the guide bore and seal may be roughened, making it impossible for the injectors to be serviced correctly.

Remove the nozzle bodies from the solution, wash them in running water, and then immerse them in a de-watering oil such as Shell Ensis 254. Remove the surplus by draining or compressed air.

The carbon may now be removed, using the standard tools provided in the cleaning kit, or in some cases blown clean with compressed air.

If the nozzle is blued, or the seating has a dull circumferential ring, indicating wear or pitting, the complete unit should be renewed.

After cleaning the nozzle holders as described below re-check the nozzle for atomization, seat dryness, and back-leak time as described previously. Those which still do not pass the test may be corrected by lapping the seat in the nozzle. Lapping the needle is not recommended as the difficulty in maintaining the required accuracy with standard equipment is considerable.

For efficient nozzle operation a line-contact seat must be obtained as shown in Fig. D.26—this is with a seat angle of 58½° and a needle angle of 60°. After some time in service the seating may become wider, or scratched and pitted, thus destroying efficient operation. By lapping the nozzle seat as shown in Fig. D.25 with one of the three laps 18G242, 18G243, or 18G244 the seating may be restored to give the correct line contact. It must be emphasized that excessive wear or pitting cannot be remedied by lapping. Proceed as follows.

Select one of the three laps which gives the best running fit in the nozzle bore—this is most important as the seating must be lapped in line with the nozzle bore.

Fit the lap into the collet of the lapping head, ensuring that it runs perfectly true.

Coat the guide diameter of the lap with tallow and place a small amount of lapping paste on the tip of the lap.

Slide the nozzle carefully over the rotating lap, ensuring that no paste touches the bore of the nozzle, otherwise the nozzle bore will be enlarged during the lapping operation.

Holding the nozzle, oscillate it quickly over the lap, using short strokes to engage the lap with the seat at the end of each stroke. After 30 seconds withdraw the nozzle, wipe the tip of the lap, and check that it is making contact over the majority of its conical tip and so giving a needle line contact at the top edge as shown in Fig. D.26.

Thoroughly wash out the paste and re-test at intervals until a dry seating is obtained.

NOTE.—Excessive lapping must not be attempted as this tends to produce an incorrect seat formation.

Nozzle holders

Fit the injector in the dismantling fixture 18G388 and secure in a vice.

Unscrew the injector cap nut and remove the copper joint washer.

Unscrew the spring cap nut, and remove the valve spring plate, valve spring, and spindle. If the complete dismantling of nozzle holder and nozzle is being carried out remove the fuel inlet unions.

Wash all the components in clean paraffin. Examine the spring for signs of weakness, rusting, or fracture. Ensure that the ends are perfectly square. The spindle should be perfectly smooth and straight. Examine the recessed end of the spindle which accommodates the top of the nozzle valve; the recess should be perfectly clear and the ball end round and free from flats. Clear out the fuel feed hole in the nozzle holder, using an air jet; the copper seating for the feed pipe union must be in good condition.

Examine the bottom pressure facing of the nozzle holder, which should be perfectly smooth and flat.

Before reassembling the injectors thoroughly wash the nozzle body and needle valve in fuel oil or Shell Fusus A.

Altitude	*Maximum fuel output for 200 strokes at 600 pump r.p.m.*	*Adjustment on maximum fuel stop screw*
	Tractor (OEC)	*Tractor (OEC)*
0 to 6,000 ft. (0 to 1830 m.)	10·4 to 10·8 c.c.	Standard setting
6,000 to 8,000 ft. (1830 to 2440 m.)	9·0 to 9·4 c.c.	Screw in ⅔ turn from standard
8,000 to 10,000 ft. (2440 to 3050 m.)	7·8 to 8·2 c.c.	Screw in 1⅓ turns from standard
10,000 to 12,000 ft. (3050 to 3660 m.)	6·5 to 6·9 c.c.	Screw in 2 turns from standard

Immerse both in a clean bowl of fuel oil or Shell Fusus A and assemble under the liquid. The valve should fit easily without tightness.

Thoroughly wash the nozzle holder and its parts.

Mount the nozzle holder in fixture 18G388 and secure in a vice. Make sure the pressure faces of the holder and nozzle body are perfectly clean. Place the nozzle assembly in position on the holder, ensuring that the dowels locate in the holes.

Fit the nozzle nut and tighten carefully, using spanner 18G210 with a torque wrench set to break at 70 lb. ft. (9·68 kg. m.). Do not overtighten this nut, since distortion and subsequent seizure of the nozzle may result.

Reassemble the spring and spindle, using a smear of grease to prevent rusting. Place the spring plate on top of the spring, flat face uppermost, and fit the spring cap nut and the injector cap nut with its copper joint washer.

Test the injector for spray and opening pressure (Section D.14).

If the nozzle is to be stored lightly smear it with grease before packing.

Section D.16

ALTITUDE SETTINGS

Before an engine leaves the Factory both the fuel pump calibrations and the governor settings are adjusted for sea-level conditions. If an engine is to be operated above zero altitude further adjustments are necessary. Reference to the schedule below will show the variations in maximum fuel output and in maximum fuel stop screw setting which are considered adequate for the altitudes indicated.

When an engine is operated at an altitude greater than that for which it is governed its maximum governed speed will increase. To obviate the possibility of excessive r.p.m. during the operation of resetting the governed speed slacken the locknut and screw in the maximum stop screw on the venturi to its fullest extent. Continue the operation as described in the latter half of Section D.12.

Section D.17

FUEL INJECTION PUMP LUBRICATION (FIRST STAGE MODIFICATION)

A modification to improve facilities for internal lubrication and to give complete dustproofing is to be introduced on the three-element fuel injection pump in two separate stages.

The first stage, commencing at Engine No. 25T/B/D4010, incorporates a cast side cover with a convex profile, housing a filler plug and a new leak-off assembly which is fitted higher in the cover and has a larger pipe

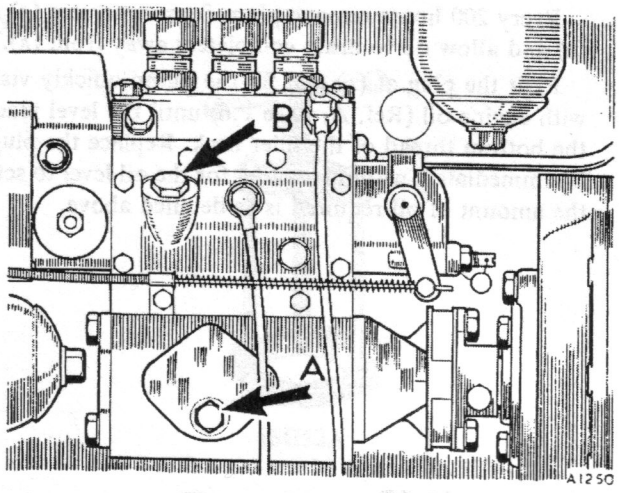


Fig. D.27

The three-element Simms fuel injection pump with first stage modification

A. Cam box drain plug.
B. Filler plug.

than the earlier assembly. The stop control cable clip is also repositioned.

A modified pump may be used to replace an early type, provided the larger leak-off pipe assembly is fitted. The existing stop control cable assembly can be used if $\frac{3}{4}$ in. (19·05 mm.) is removed from the outer casing and washer (Part No. ATJ9306) fitted between the end of the outer casing and the return spring. The stop control cable clip must be fitted to the rearmost cover set screw.

Before putting a new three-element fuel injection pump into service remove the plugs from apertures (A) and (B), illustrated in Fig. D.27, which shows the first stage modification injection pump. Pour engine oil (Ref. A, page P.6) via (B) until the oil emerges from (A). This procedure is to ensure that oil has reached the cam box, since the oil passage through the tappets is restricted and oil will flow through very slowly (if the plug is left in position at [A] oil may reach the level of [B] before sufficient oil has reached the cam box).

Refit plug (A) and continue to pour oil quickly via (B) until the level reaches the bottom thread of the filler neck. **Do not** wait for oil to drain down past the tappets; replace plug (B) **immediately.** If an accurate measure is available the quantity of oil required to raise the level from plug (A) to the bottom thread of the filler (B) is ·33 pint (190 c.c.).

This initial lubrication procedure must be carried out whenever a Simms three-element fuel injection pump is rebuilt or overhauled.

During service

Periodic maintenance is required on fuel injection pumps with the first stage modification.

Every 200 hours remove plugs from apertures (A) and (B) and allow oil to drain completely away from (A).

Refit the plug at (A) and fill the pump quickly via (B) with engine oil (Ref. A, page P.6) until the level reaches the bottom thread of the filler neck. Replace the plug at (B) immediately without waiting for the oil level to settle; the amount of oil required is as detailed above.

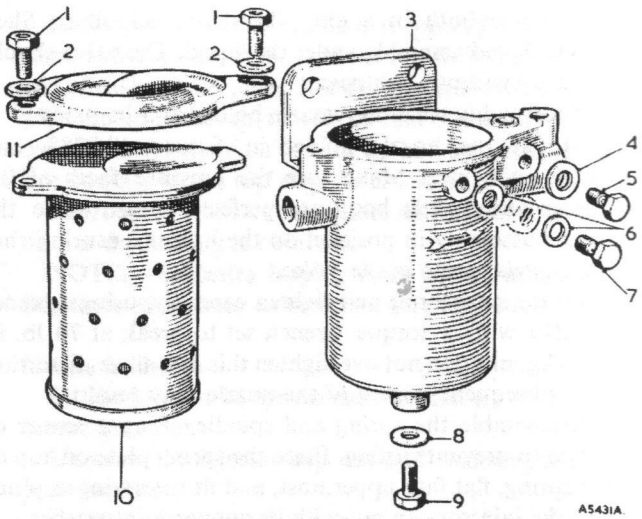


Fig. D.28

Simms Type FF fuel filter

1. Set screw.
2. Steel washer.
3. Filter body.
4. Nylon washer.
5. Air bleed plug.
6. Copper washer.
7. Banjo union bolt.
8. Nylon washer.
9. Drain plug.
10. Filter element.
11. Cover.

Section D.18

FUEL INJECTION PUMP LUBRICATION (FINAL STAGE MODIFICATION)

The final stage of the fuel injection pump lubrication modification referred to in Section D.17 is incorporated on three-element fuel injection pumps fitted to engines numbered 25T/B/D5946 onwards.

The lower plug in the cast cover has been omitted and the leak-off pipe assembly has been moved to a position high in the cam box. Internal modifications have also been made to facilitate lubrication.

No periodic maintenance is required on pumps with the final stage modification, but before putting into service or after dismantling or overhauling such pumps the following lubrication procedure must be carried out.

Remove the filler plug and pour in engine oil (Ref. A, page P.6) until oil flows from the leak-off pipe assembly in the cam box. Provision should be made to catch the surplus oil. Replace the filler plug securely.

Care must be taken to prevent the ingress of foreign matter during the lubrication operation.

Section D.19

SIMMS TYPE FF FUEL FILTER

A Simms Type FF fuel filter with a renewable paper element is fitted to tractors commencing at Engine No. OEC14897.

A full description of the filter, together with element renewal instructions, is given in Section DDDD.6.

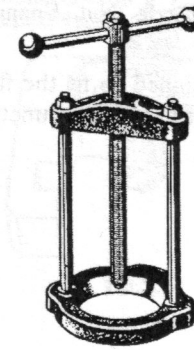
The filter is secured on the right-hand side of the engine in a similar manner to the previous type. On later engines an additional steady plate is fitted between the filter body and the engine cylinder block.

(For 'SERVICE TOOLS' see page D.31 onwards)

SERVICE TOOLS

18G12A. Bevel Pinion Bearing Remover (basic tool)

Application: Fuel injection pump inner race removing.



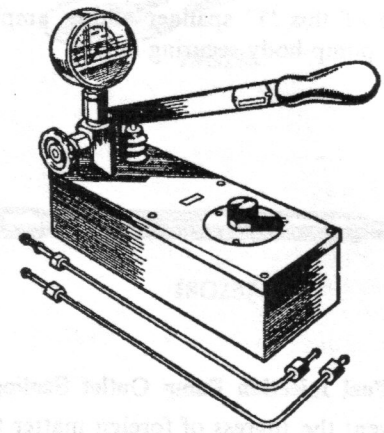
18G12A

18G12E. Fuel Injection Pump Ball Bearing Inner Race. Remover Adaptor

The use of these tools together is to remove or replace the camshaft inner races without danger of damage to the camshaft or races.

18G109A. Injector Nozzle Testing Machine

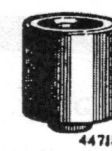
This pump is essential if injector nozzles are to be tested correctly or if it is desired to adjust the opening pressure. The use of the pump is fully described in Section D.14.



18G109A

18G134. Bearing and Oil Seal Remover and Replacer (basic tool)

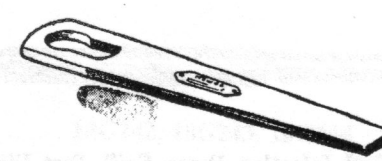
18G134AC. Fuel Injection Pump Camshaft Oil Seal Replacer Adaptor



18G134 and 18G134AC

18G208. Nozzle Nut Wrench (alternative to 18G210)

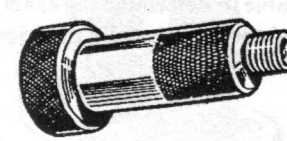
This wrench is designed to fit the flats on the injector-nozzle nut.



18G208

18G109E. Injector Nozzle Reverse-flush Adaptor (formerly 18G209)

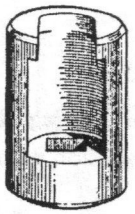
When the nozzle has been scraped internally to remove carbon deposits, then it can be flushed clean with the aid of this adaptor, which fits onto the nozzle setting pump 18G109A. When the pump is operated fuel oil is forced through the nozzle in a reverse direction through the spray holes, thus removing all loose carbon.



18G109E (formerly 18G209)

18G210. Injector Nozzle Nut Spanner (alternative to 18G208)

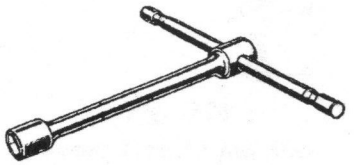
This socket is designed to fit the flats on the injector nozzle nut and can be used in conjunction with a standard ratchet wrench.



18G210

18G212. Fuel Injection Pump 'T' Spanner

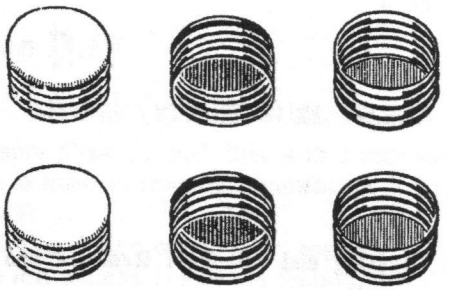
The use of this 'T' spanner allows ample clearance round the pump body securing nuts.



18G212

18G216. Fuel Injection Pump Outlet Sealing Caps

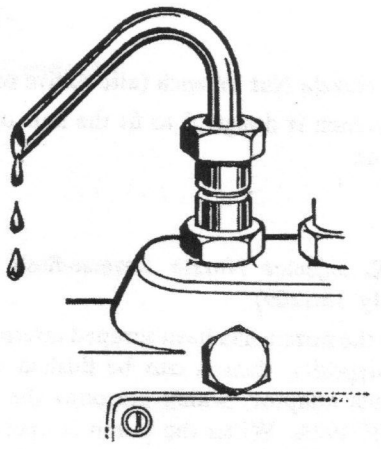
To prevent the ingress of foreign matter to the pump when not in use.



18G216

18G233. Fuel Injection Pump Spill Test Pipe

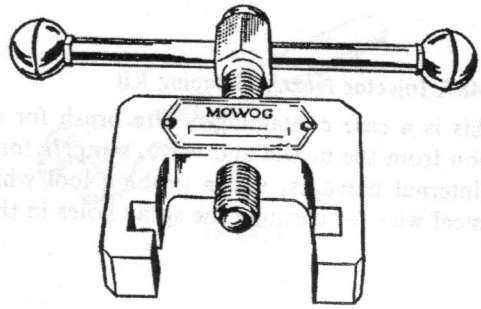
The use of this pipe enables the 'phasing' of the injection pump to be carried out with great accuracy, since it is possible to determine the exact point of spill cut-off. The use of the pipe is fully described in Section D.8



18G233

18G235. Injection Pump Coupling Flange Remover

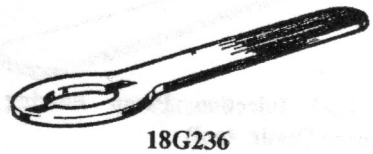
The extractor is placed over the coupling flange with the ball end of the screw against the pump camshaft. The use of the extractor will obviate any possibility of damage to the flange, which is usually a tight fit and cannot safely be tapped free. Holding wrench 18G236 may be used in conjunction with the extractor if necessary.



18G235

18G236. Fuel Injection Pump Coupling Flange Wrench

This wrench holds the flange firmly whilst the pump camshaft nut is released or tightened. The wrench may also be used in conjunction with extractor 18G235 if necessary.



18G236

18G237. Fuel Injection Pump Delivery Valve Guide Remover

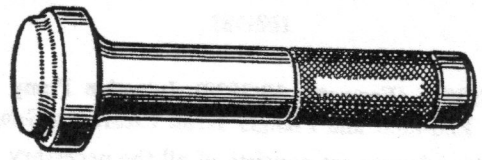
Due to the slight expansion of the fibre sealing washer round the delivery valve guide, these guides can be difficult to remove without the aid of this extractor, which is of the expanding type. The plunger of the element must be at the bottom of its stroke to allow the use of the extractor.



18G237

18G240. Fuel Injection Pump Bearing Outer Race Replacer

The use of this drift enables the race to be fitted squarely in the camshaft bearing housing bore. The shape of the drift is such that it fits exactly the shape of the bearing face, thus ensuring even distribution of the driving force.



18G240

18G242. Injector Nozzle Lap (6·00 mm.)

18G243. Injector Nozzle Lap (6·01 mm.)

18G244. Injector Nozzle Lap (6·02 mm.)

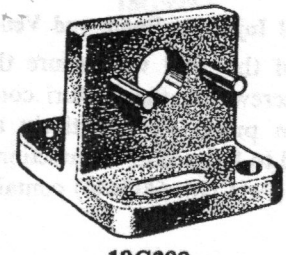
These tools are for restoring the correct nozzle seat angle. The graded diameters are to cater for slight variations in the bore for the nozzle valve stem.



18G242, 18G243, 18G244

18G388. Injector Nozzle Dismantling Fixture

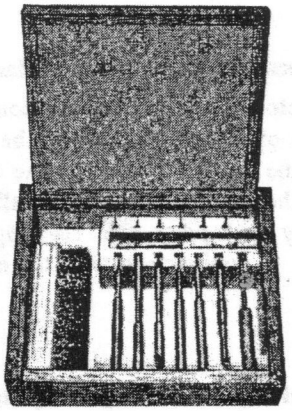
The fixture with the injector is held in a vice for dismantling, cleaning, and reassembling purposes.



18G388

18G487. Injector Nozzle Cleaning Kit

This is a case containing a wire brush for removing carbon from the nozzle and valve, scrapers for cleaning the internal passages, and a probing tool which holds the steel wire for cleaning the spray holes in the nozzle.



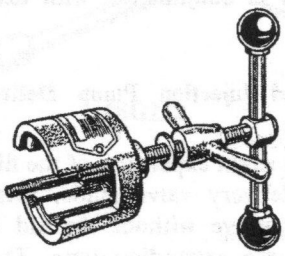
18G487

18G500. Fuel Injection Pump Bearing Outer Race Remover (basic tool)

This is an expanding tool which grips the race from the under side and pulls it out of the camshaft bearing housing without coming into contact with the bearing face, thus eliminating any possibility of damage.

18G500B. Fuel Injection Pump Bearing Outer Race Remover Adaptor

18G500C. Adaptor for Front End Bearing

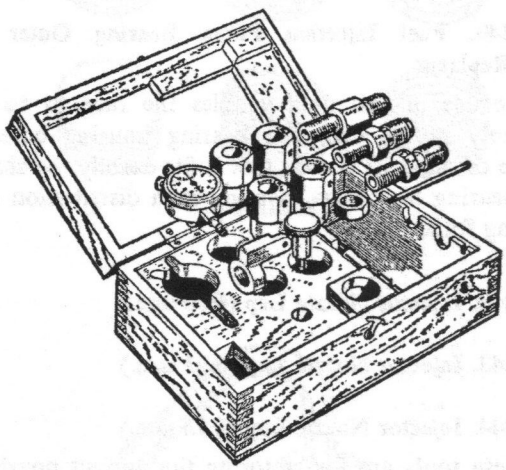


18G500

18G538A. (Formerly 18G538). Injection Pump Camshaft End-float and Plunger Head Clearance Gauge Set.

The adaptor set consists of all the necessary adaptors, dial indicator, and fixing brackets for checking camshaft end-float and plunger head clearance on all three-, four-, and six-cylinder fuel injection pumps as fitted to B.M.C. diesel engines.

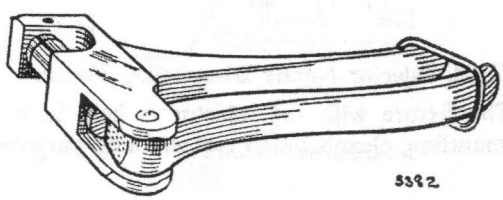
This neatly boxed set is a necessity when overhauling and reconditioning injection pumps.



18G538A

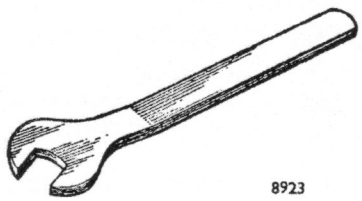
18G541. Fuel Injection Pump and Venturi Sealing Pliers

The use of this tool will ensure that the maximum speed stop screws on the venturi control unit and the fuel injection pump are effectively and easily sealed. It is intended to be used in conjunction with the contents of the pack (Part No. 58G444) containing 36 lead seals and wire.



18G541

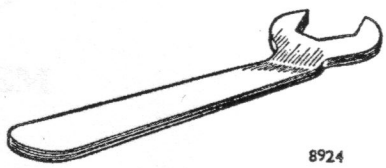
18G472. Governor Damper Valve Spanner



18G472

18G473. Governor Damper Valve Locknut Spanner

Two specially cranked thin spanners designed to facilitate the setting of the pneumatic governor damper valve whilst the air cleaner is left in position.

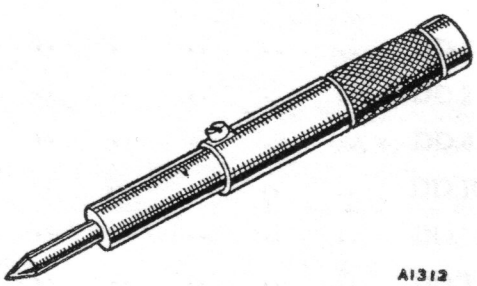


18G473

18G561. Injector Nozzle Sleeve Replacer

The replacer has a retractable pilot which centralizes the injector sleeve and guides it squarely into position, ensuring a gas- and water-tight seal between the sleeve and cylinder.

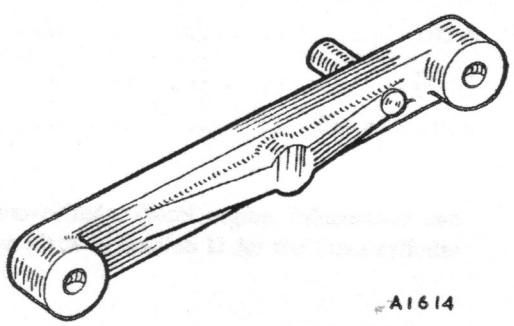
The new sleeve is first fitted on the replacer, the retractable pilot then extended to its limit, located in the nozzle hole, and the sleeve driven into position. The piston in the cylinder being worked upon must be at the bottom of its stroke to avoid any possibility of damage.



18G561

18G599. Fuel Injection Pump Setting Gauge

With the gauge bolted to the end face of the governor front half the maximum fuel delivery stop is adjusted while the control rod is held against the gauge stop.



18G599

SECTION DD

THE FUEL SYSTEM

	Section
General description	
Air cleaner	DD.1
Injection pump	
Calibration	DD.5
Description	DD.2
Dismantling, overhauling, and reassembling	DD.4
Lubrication (first stage modification)	DD.10
Lubrication (final stage modification)	DD.11
Removing and replacing	DD.3
Pneumatic governor	
Altitude settings	DD.8
Auxiliary vacuum pipe restrictor fitting	DD.9
Description	DD.6
Removing, overhauling, and replacing	DD.7
Service tools	End of Section

Section DD applies only to the fuel injection pump on the four-cylinder diesel engine. Information and instructions not included in this Section are the same as those given in Section D for the three-cylinder engine

GENERAL DESCRIPTION

The general description given in Section D also covers the four-cylinder engine, the only exception being that no air bottle is fitted between the engine suction pipe and the governor.

Section DD.1

AIR CLEANER

The time for cleaning the air cleaner depends on the operating conditions. Under normal conditions the oil in the air cleaner bowl should be changed every 50 running hours. Under extreme dusty conditions the oil bath should be changed and re-oiled twice daily.

Support the bowl with one hand, release the retaining clips, and withdraw the bowl from the body. Take care not to spill the oil it contains. Drain off the old oil, swill out any sediment with paraffin (kerosene), wipe clean and dry, and refill with engine oil to Ref. A, page P.6, to the level of the ridge inside the bowl.

Every 200 hours, or more often under extreme conditions, wash the air cleaner gauze. Unscrew the hose clip and withdraw the hose. Unscrew the air cleaner securing strap and remove the cleaner from the tractor. Clean the filter gauze in petrol (gasoline) to remove any deposit and then dry thoroughly. Should the gauze be entirely blocked by chaff, etc., the complete air cleaner must be renewed.

Section DD.2

DESCRIPTION—FUEL INJECTION PUMP

The fuel injection pump is a Simms type SPE.4A.75 364A; this number is marked on the pump body and indicates the special features of the pump. The explanation of the type number is as follows:

SPE—Simms pump, self-contained type.
4—Number of elements.
A—Size of pump (38 mm. shaft centre height).
75—Plunger diameter in $\frac{1}{10}$ mm. (75=7·5 mm. dia.).
S364A—Specification number, to suit engine application.

The description given in Section D.7 also covers the injection pump fitted to the four-cylinder engine, the only difference being that four element assemblies are fitted.

Section DD.3

REMOVING AND REPLACING THE FUEL INJECTION PUMP

Disconnect all the pipe connections from the injection pump: one inlet from the fuel filter, four pressure pipes to the injectors, the oil level plug and pipe, fuel bleeder plug and pipe, and finally the two suction pipes from the governor.

Disconnect the flexible cable from the stop control and excess fuel lever at the front of the pump.

Remove the four set bolts from beneath the pump securing it to its mounting bracket. Disengage the coupling and carefully remove the pump from the engine.

Dismantling, overhauling, and reassembling the injection pump are dealt with in Section DD.4.

Before refitting the injection pump to the engine it is necessary to set the engine for injection timing with No. 1 piston set on its compression stroke at 28° B.T.D.C.

Slacken the decompressor screws in the cylinder head to permit the engine to be cranked more easily.

Remove the valve rocker cover to enable the valve action to be observed.

Remove the clutch inspection cover on the left-hand side of the clutch housing to expose the timing pointer (see Fig. DD.1).

Turn the crankshaft slowly in its normal direction of rotation until the exhaust valve (No. 1) of No. 1 cylinder is just closing and the inlet valve (No. 2) of the same cylinder is just opening. This indicates that No. 1 piston is commencing to move downwards on its induction stroke. Continue to crank the engine until the 28° injection timing mark on the rear face of the flywheel (this is the mark without any identification letters) coincides with the timing pointer.

The injection pump can now be fitted to the engine in the following manner.

Turn the pump coupling flange until the mark across the edge is in line with the mark on the timing indicator and place the pump on its mounting bracket.

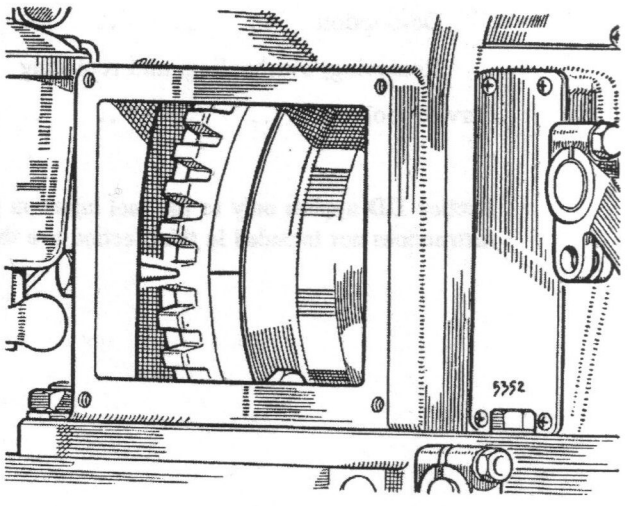


Fig. DD.1

The 28° injection timing mark is here shown opposite the pointer

Place the coupling centre disc between the pump flange and the drive flange and bring the two halves of the coupling together. The pump flange will probably be moved during the process, thus disturbing the timing; this will be rectified later during the timing procedure.

Set the injection pump timing as follows:

Slacken the two set bolts securing the drive flange adjustment to the claw plate.

Turn the injection pump coupling flange by hand until the line on the edge of the flange is in line with the mark on the timing indicator. During the above procedure it is essential that the driving flange is not moved.

Tighten the two set bolts to secure the driving flange adjustment. A final check should be made to ensure that the flywheel is still in the timing position of 28° B.T.D.C.

Connect the fuel inlet pipe to the pump and the injector pressure pipes to their respective delivery valve unions, and the oil level and drain pipes to the pump.

Bleed the fuel system (see Section D.6).

Connect the two suction pipes between the governor and throttle unit (venturi).

Connect the control lever to the throttle unit (venturi) and the stop control to the lever on the front of the pump.

NOTE.—When connecting the stop control to the lever on the injection pump it is essential that the lever is in its maximum forward position. This will mean that there is approximately ½ in. (13 mm.) free travel on the stop lever which is necessary to allow the excess fuel device to operate.

The engine is now ready for starting providing all other adjustments are in order.

If the engine does not idle smoothly or if surge is apparent the slow-running speed should be adjusted (see **'Idling adjustment'**, Section D.12).

During the installation of the injection pump the timing procedure described above automatically sets the pump No. 1 element at the point of 'inlet port closure' (spill cut-off), i.e. when its flange marking is in line with the mark on the timing indicator.

If for any reason there is no marking on the pump coupling flange or the indicator has become damaged or lost the point of 'inlet port closure' will have to be found to accomplish the timing procedure.

The term 'inlet port closure' (spill cut-off) refers to the instant when the flow of fuel through the barrel inlet port from the spill gallery is cut off by a pump plunger on its upward stroke, and corresponds to the theoretical commencement of injection from that element of the pump. The flow of fuel to each element is cut off at two points during one complete revolution of the pump camshaft, one on the upward stroke and the other on the downward stroke of the pump plunger. The correct cut-off point for timing is the one on the upward stroke of the plunger. Proceed as follows:

Set the engine with No. 1 piston at the position of 28° B.T.D.C. on its compression stroke as described previously.

Before fitting the injection pump to the engine set its approximate timing position by removing the pump inspection cover to observe the plunger action and turning the camshaft until No. 1 plunger is just commencing to rise. With the pump set in position connect the drive coupling and secure the pump to its bracket.

Disconnect the pressure pipe from No. 1 delivery valve holder. Unscrew the valve holder and remove the valve, spring, and volume reducer. Connect the test pipe 18G233 in place of the valve holder and valve assembly.

If any of the engine controls are connected ensure that the engine stop control is right home and in the normal starting position so that the injection pump control rod is in the full power position. If the controls are not connected the governor spring will automatically position the control rod in the required position.

Slacken the two set bolts securing the drive flange adjustment to the claw plate.

Connect the fuel inlet pipe to the pump.

Prime the fuel system by using the priming lever on the lift pump; bleed the filter and the injection pump, when the fuel will flow out of the test pipe from No. 1 element.

Turn the injection pump coupling flange slowly by hand in its direction of rotation, when No. 1 element plunger will commence to rise from its B.D.C. position. Carefully observe the flow of fuel from the test pipe. As the element inlet port is progressively closed by the rising plunger the fuel issuing from the test pipe will gradually diminish. Turn the pump flange very slowly in the final stages; the instant of 'inlet port closure' (spill cut-off) will be observed when there is no drip for a period of 14 to 15 seconds.

During the above procedure it is essential that the drive flange is not moved. Tighten the two set bolts securing the driving flange adjustment; a final check should be made to ensure that the flywheel is still in the position of 28° B.T.D.C.

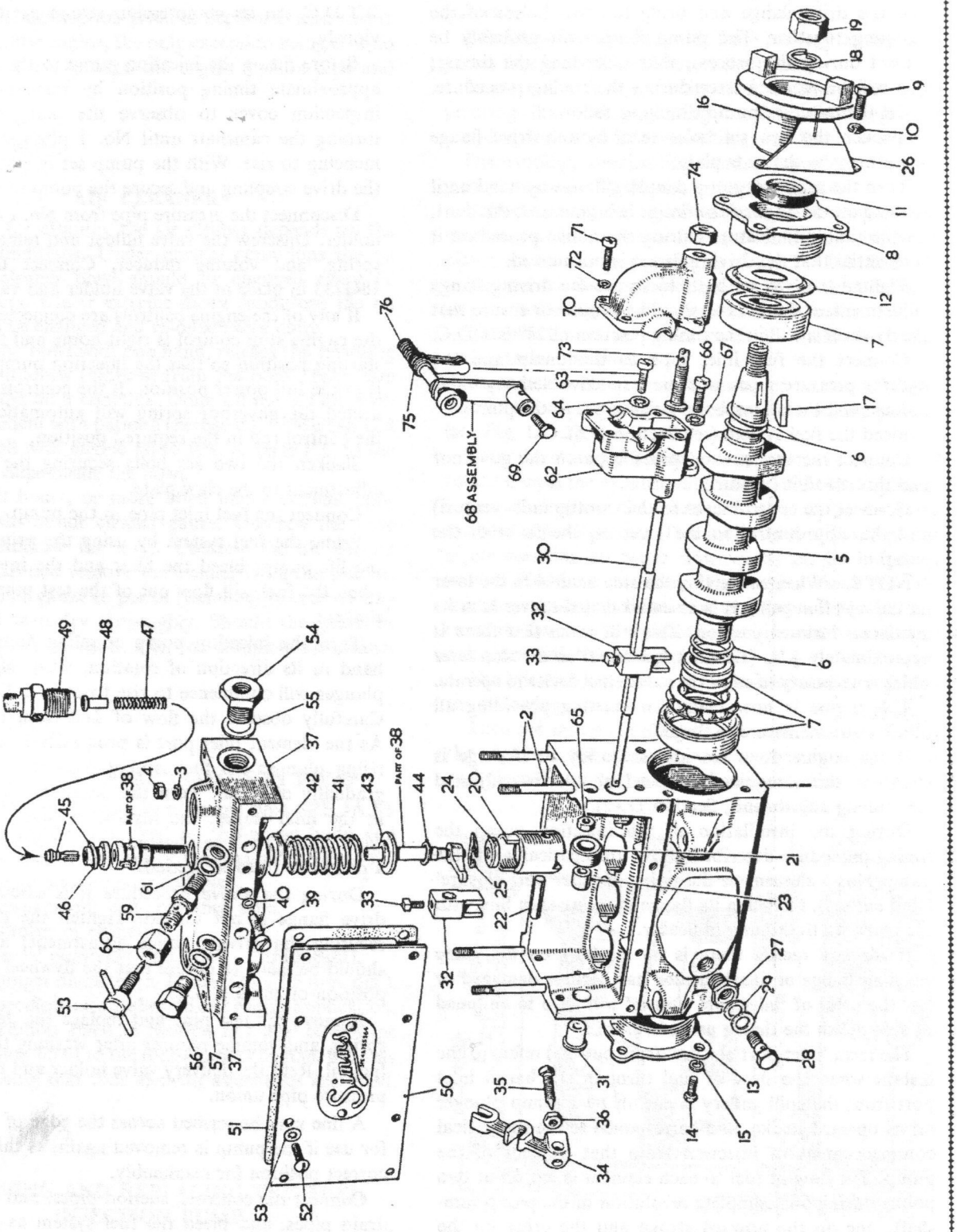
Remove the test pipe and replace the delivery valve, spring, and volume reducer after washing them in clean fuel oil. Refit the delivery valve holder and reconnect the pressure pipe union.

A line may be scribed across the edge of the coupling for use if the pump is removed again, as this will be the correct position for reassembly.

Connect the controls, suction pipes, and oil level and drain pipes, and bleed the fuel system as described in Section D.6.

The engine is now ready for starting, providing all other adjustments are in order.

THE COMPONENTS OF THE FUEL INJECTION PUMP



KEY TO THE COMPONENTS OF THE FUEL INJECTION PUMP

No.	Description
1.	Cam box.
2.	Stud.
3.	Spring washer.
4.	Nut.
5.	Camshaft.
6.	Shim.
7.	Ball race.
8.	Bearing housing (drive end).
9.	Screw.
10.	Spring washer.
11.	Oil seal.
12.	Washer for oil seal.
13.	Bearing housing (governor end).
14.	Screw.
15.	Spring washer.
16.	Coupling—fuel pump half.
17.	Key.
18.	Spring washer.
19.	Nut.
20.	Tappet body.
21.	Roller tappet.
22.	Pin.
23.	Bush.
24.	Tappet spacer.
25.	Spacer retaining ring.
26.	Timing indicator.
27.	Banjo adaptor.
28.	Banjo screw.
29.	Joint washer.
30.	Control rod.
31.	Bush.
32.	Control fork.
33.	Control fork locking screw.
34.	Link.
35.	Locking screw.
36.	Locknut.
37.	Pump body.
38.	Barrel and plunger assembly.
39.	Screw.
40.	Joint washer.
41.	Plunger spring.
42.	Upper disc.
43.	Lower disc.
44.	Shim for plunger.
45.	Delivery valve assembly.
46.	Joint ring for delivery valve.
47.	Valve spring.
48.	Volume reducer.
49.	Delivery valve holder.
50.	Inspection cover.
51.	Jointing.
52.	Screw.
53.	Shakeproof washer.
54.	Inlet connection.
55.	Connection sealing washer.
56.	Air-vent screw.
57.	Screw joint washer.
58.	Valve and pin assembly.
59.	Air-vent body.
60.	Nut for air vent.
61.	Joint washer.
62.	Fuel stop case (front half).
63.	Screw.
64.	Shakeproof washer.
65.	Nut.
66.	Screw.
67.	Spring washer.
68.	Stop lever and excess catch assembly—R/H.
69.	Cable locating screw.
70.	Fuel stop case (rear half).
71.	Screw.
72.	Spring washer.
73.	Stop screw.
74.	Stop screw locknut.
75.	Return spring.
76.	Dust seal.

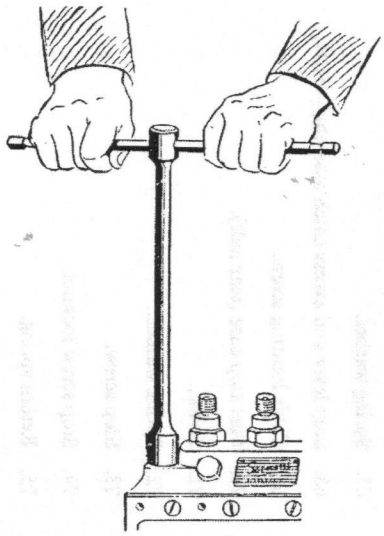


Fig. DD.2

Using spanner 18G212 *to unscrew the camshaft casing securing nuts on the fuel injection pump*

If the engine does not idle smoothly or if surge is apparent, the slow-running speed should be adjusted (see **'Idling adjustment'**, Section DD.7).

Section DD.4

DISMANTLING, OVERHAULING, AND REASSEMBLING THE FUEL INJECTION PUMP

It cannot be too strongly stressed that absolute cleanliness is essential, therefore a special bench should be reserved for injection equipment dismantling. This bench should be covered with zinc or linoleum and kept absolutely free from dust, dirt, filings, grease, or acids. The bench should be provided with a suitable vice with a pair of copper or zinc jaw shields for protection.

Do not use cotton waste or fluffy cloth for cleaning purposes.

Remove the injection pump from the engine (Section DD.3).

Remove and dismantle the governor (Section DD.7). Remove the inspection cover.

Slacken the clamp screws in the control rod forks. Remove the front half of the control rod stop housing, withdraw the stop arm and spring, and then remove the rear half of the housing from the pump body. Release the transverse link from the control rod at the governor end by removing the nut and locking screw. Slide the control rod out from the camshaft casing and remove the forks from the control rod as they become disengaged.

Remove the two set bolts and the countersunk set screw securing the governor front half housing and remove the housing from the pump body.

Using 'T' spanner 18G212, unscrew the nuts securing the pump body to the camshaft casing. Place the pump on its side and carefully detach the pump body. Working with the pump on its side will prevent the plungers falling out and becoming damaged.

Remove the plungers and springs. The shims between each plunger foot and spring plate must be retained and suitably tagged or placed in separate trays to ensure their correct replacement. **It is essential that the plungers are not mixed, as they are individually mated to their barrels.**

Hold the pump in the vice and unscrew the valve holders. Lift out each valve assembly, comprising spring, volume reducer, and valve. **Valves must not be mixed and they must be refitted in the same positions from which they were removed.**

Remove the barrel locating screws and remove the barrel and valve guide by tapping them out, using a soft wooden drift. The valve guide can be removed with remover 18G237, leaving the barrel in position.

Remove the tappets from the camshaft casing. They should be tagged or placed in the separate trays with their respective element components. The spacing discs must be retained in the tappets as they control the phase angle between each injection.

Remove the timing indicator from the camshaft front bearing housing and, holding the pump coupling with wrench 18G236, unscrew the nut from the camshaft.

Withdraw the pump coupling flange from the camshaft, using remover 18G235, and remove the key from the shaft.

Remove the camshaft front bearing housing complete with the bearing outer race, oil seal, and washer. The camshaft can then be withdrawn from the pump complete with the two bearing inner races and shims.

Remove the rear bearing housing and outer race.

Extract the bearing outer races from their housing with tools 18G500, 18G500B, and 18G500C.

Draw the bearing inner races off the camshaft with adaptor 18G12E with remover 18G12A.

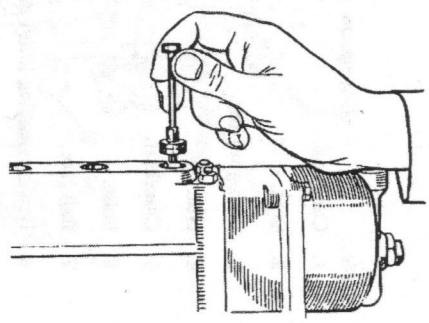


Fig. DD.3

A valve guide may be removed, leaving the barrel in position, by using remover 18G237

Wash all the components thoroughly in paraffin. If not immediately required components should be oiled and wrapped in clean non-fluffy cloth or paper.

Examine the plunger surface and barrel bore for signs of wear or abrasions.

If any wear is evident the barrel and plunger must be renewed as an assembly.

Ensure that the spill groove and connecting bore of the plunger is completely free by blowing out with compressed air. The inlet and spill ports in the barrel should be cleared in the same way.

Examine the plunger control arm for wear on the rounded end at the contacting points with the control forks. The forks should be examined at the same time. If wear is found on any of these components the control fork and the plunger and barrel assembly must be renewed.

Test the plunger springs for fractures, and if they are below the length of new counterparts they should be renewed.

Inspect the seating of the delivery valve and guide. They should be perfectly smooth and flat. Inspect the valve return springs for fractures, and if they are below the length of new counterparts they should be renewed.

Examine the tappets for signs of wear; the rollers should be perfectly round, free to revolve, and with no signs of flats or pits. Examine the contact face of the spacing disc boss, which is positively held in the top of the tappet with a bowed spring ring, for signs of wear. If the slightest sign of wear is visible the disc must be renewed, but not until the correct size has been determined when rephasing.

Inspect the cam surfaces for signs of scoring and wear. Renew if necessary.

The ball bearings should be spun round in a bath of paraffin to clear any foreign matter. Inspect the balls and

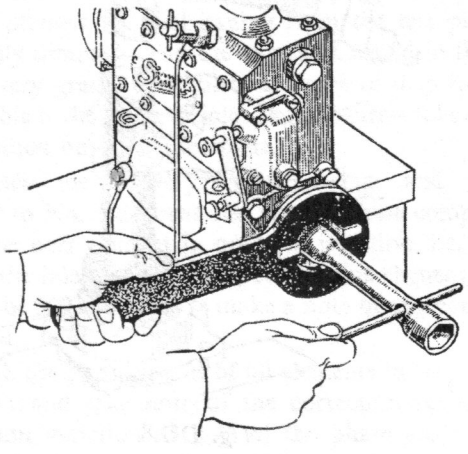


Fig. DD.4

The pump coupling flange wrench 18G236 *in use*

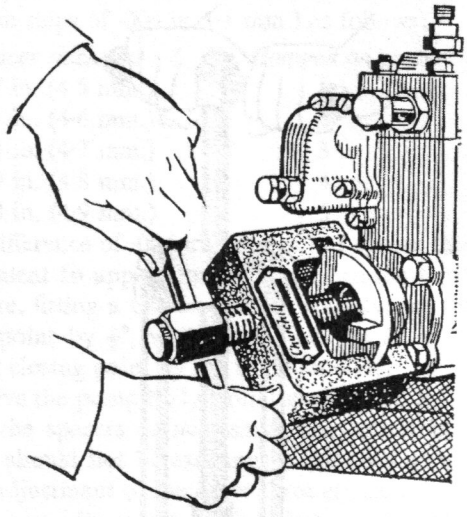


Fig. DD.5

Withdrawing the pump coupling flange with remover 18G235

races for signs of wear, pits, or scoring; renew them if necessary.

Clean the oil seal and inspect for wear or damage. If the slightest damage is revealed, especially on the lip, it must be renewed.

Immediately before reassembly all components should be thoroughly washed in paraffin and dried.

Using tools 18G134 and 18G134AC, fit a serviceable oil seal into the front bearing housing with its lip facing towards the camshaft casing when in the fitted position. Press or drive the bearing outer races into their housings, thick edge foremost, using tool 18G240 to ensure correct

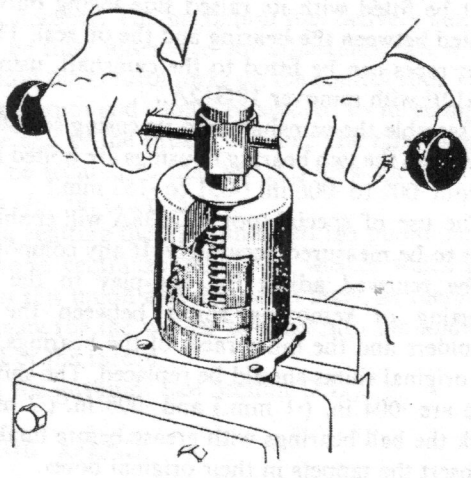


Fig. DD.6

Removing the bearing outer races with remover 18G500 *together with adaptors* 18G500B *and* 18G500C

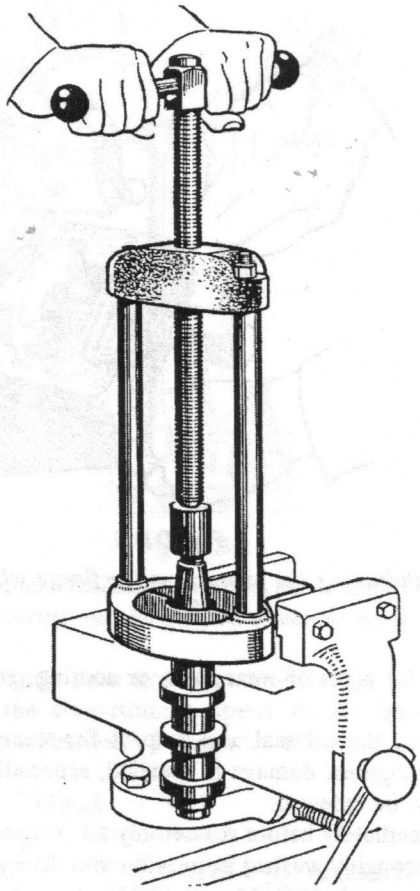


Fig. DD.7

The inner races may be withdrawn from the camshaft, using remover 18G12A *with adaptor* 18G12E

alignment. The oil seal washer in the front housing must be fitted with its raised side facing outwards and located between the bearing and the oil seal. The bearing inner races can be fitted to the camshaft, using adaptor 18G12E with remover 18G12A.

Assemble the camshaft into its casing so that the end-play when the two bearing housings are bolted in position is from ·002 to ·006 in. (·051 to ·152 mm.).

The use of special tool 18G538A will enable the end-float to be measured accurately. If any components have to be renewed adjust the end-play to the above by inserting or removing shims between the camshaft shoulders and the inner races of the bearings, otherwise the original shims should be replaced. The shims obtainable are ·004 in. (·1 mm.) and ·008 in. (·2 mm.) thick. Pack the ball bearings with grease before final assembly.

Insert the tappets in their original bores.

Wash the barrels in fuel oil and place them in the same bores of the body from which they were removed, and make sure to line the slot in the barrel with the locating screw hole.

Fit the barrel locating screws, using a new joint washer under the head. When tightened the screws must engage in the barrel slots and they must not pinch the barrel.

Wash the delivery valve components in fuel oil. Place the valve guide in position on top of the barrel; the joint faces must be perfectly clean. Place a new joint ring over the guide and insert the valve into its guide, fit the spring and volume reducer over the valve, and screw the valve holder in position; tighten the holder down, using a torque wrench set to 30 lb. ft. (4 kg. m.).

Wash the plungers in fuel oil and insert them in their respective barrels. If the pump is to be reassembled using the original camshaft, tappets, and elements, then the plunger springs, spring plates, and shims can be placed in position over the plungers as it is not necessary to adjust the phase angle.

It is essential that the elements commence to inject at exactly the correct interval, namely, every 90° of injection pump camshaft rotation. If replacement parts have been fitted it is necessary to check these injection intervals and to adjust if necessary. This adjustment is known as 'phasing'.

To check the phase angles temporarily assemble the pump body to the camshaft casing, but omitting the plunger springs, spring plates, and control gear.

The phase angles should be checked by the fuel flow method on a test bench, having a degree plate fitted to the camshaft and a fixed pointer for measuring camshaft angular rotation.

Before phasing it is essential to set No. 1 tappet to give the correct clearance between the delivery valve guide

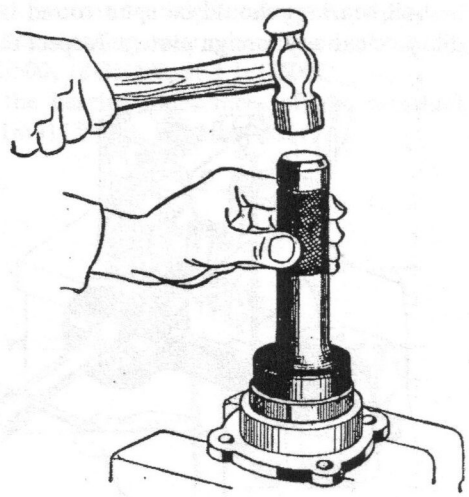


Fig. DD.8

Press or drive the bearing outer races into their housings, thick edge foremost, using tool 18G240