

Section Ca.6

DESCRIPTION OF THE FUEL INJECTION PUMP

The injection pump is a single-cylinder, opposed-plunger, inlet-metering, distributor-type pump fitted with a mechanical flyweight-type governor and a hydraulically operated automatic advance mechanism. The pump is flange-mounted on the rear of the engine front mounting plate and is driven by the timing chain. A splined quill shaft, having a master spline at each end

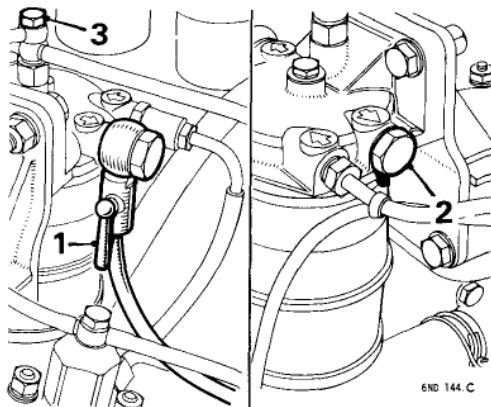


Fig. Ca.1

Main fuel filter air bleed points

1. Fuel cut-off tap. 2. Blanking plug. 3. Union screw.

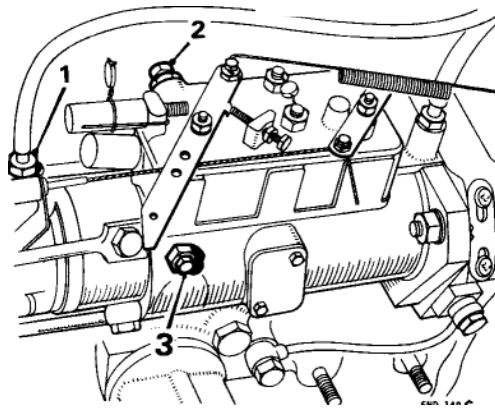


Fig. Ca.2

Fuel injection pump air bleed points

1. Union nut. 2. Air bleed screw. 3. Air bleed screw.

to ensure correct location, transmits the drive from the chain wheel to the injection pump drive hub.

A central rotating member forms the pumping and distributing rotor, and this is driven by the drive hub through a splined drive shaft on which is mounted the governor flyweight assembly.

Mounted on the outer end of the pumping and distributing rotor is a sliding-vane-type transfer pump. This pump raises the fuel pressure to an intermediate level, and as its capacity is many times the maximum requirements of the injection pump a regulating valve, housed in the pump end plate, allows excess fuel to be by-passed back to the suction side of the transfer pump.

The pressure regulating valve, in addition to regulating the pressure of the fuel from the transfer pump, also provides a means of by-passing the transfer pump when priming the injection pump. Referring to Fig. Ca.3, it will be seen that the valve is cylindrical and contains a small 'free' piston, the travel of which is limited by two light springs. When priming the injection pump, fuel at lift pump pressure enters the central port in the regulating valve sleeve and moves the 'free' piston against the pressure of the piston retaining spring to uncover the priming port in the lower end of the valve sleeve. The priming port is connected by a passage in the end plate to the delivery side of the transfer pump, thus enabling the fuel to by-pass the stationary transfer pump and prime the injection pump.

When the injection pump is in operation fuel at transfer pressure enters the lower end of the valve sleeve, forcing the 'free' piston upwards against the regulating spring. As the engine speed increases, the transfer pressure rises, moving the piston against the pressure of the regulating spring to progressively uncover the regulating port in the valve sleeve and allow a metered flow of fuel to by-pass back to the inlet side of the transfer pump.

The transfer pressure, therefore, is controlled by a balance between the regulating spring pressure and the requirements of the injection pump at any moment.

The pumping and distributing rotor revolves, and is a

close fit, in the stationary hydraulic head. The pumping section of the rotor has a transverse bore containing twin opposed pumping plungers. These plungers are operated by means of a cam ring, carried in the pump housing, through rollers and shoes which slide in the rotor. The cam ring has four internal lobes operating in diagonally opposite pairs. The opposed plungers have no return springs but are moved outwards by fuel under pressure from the transfer pump, the flow of fuel and outward displacement of the plungers being determined by the setting of the metering valve and the speed at which the pump is rotating. As a result the rollers, which operate the plungers, do not follow the contour of the internal cam ring entirely, but will contact the cam lobes at points which will vary according to the amount of plunger displacement.

The automatic light load advance mechanism operates by rotating the cam ring within the pump body. A ball-ended lever, screwed into the cam ring, is operated by a piston, one side of which is spring-loaded, sliding in a cylinder. The other side of the piston is subjected to fuel at transfer or drain pressure, according to engine load, which is admitted to the cylinder through the hollow locating bolt and a port in the cylinder wall. The pressure of fuel is controlled by the rotary and endwise movement of the metering valve.

Machined in the surface of the metering valve is a helical groove. A vertical flat extends upwards from the helical groove and protrudes beyond the hydraulic head.

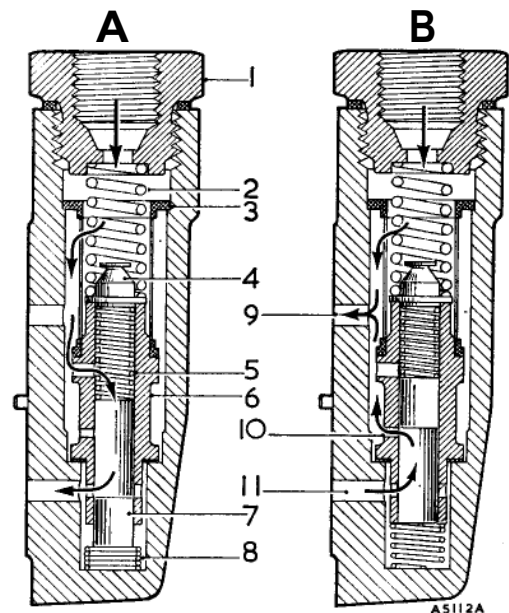


Fig. Ca.3

Section through the end plate and regulating valve

- | | |
|-----------------------------|---|
| A. Priming. | 7. Regulating piston. |
| B. Regulating. | 8. Piston retaining spring. |
| 1. Inlet connection. | 9. Fuel passage to transfer pump inlet. |
| 2. Sleeve retaining spring. | 10. Regulating port. |
| 3. Nylon filter. | 11. Fuel passage to transfer pump outlet. |
| 4. Sleeve guide plug. | |
| 5. Regulating spring. | |
| 6. Regulating sleeve. | |

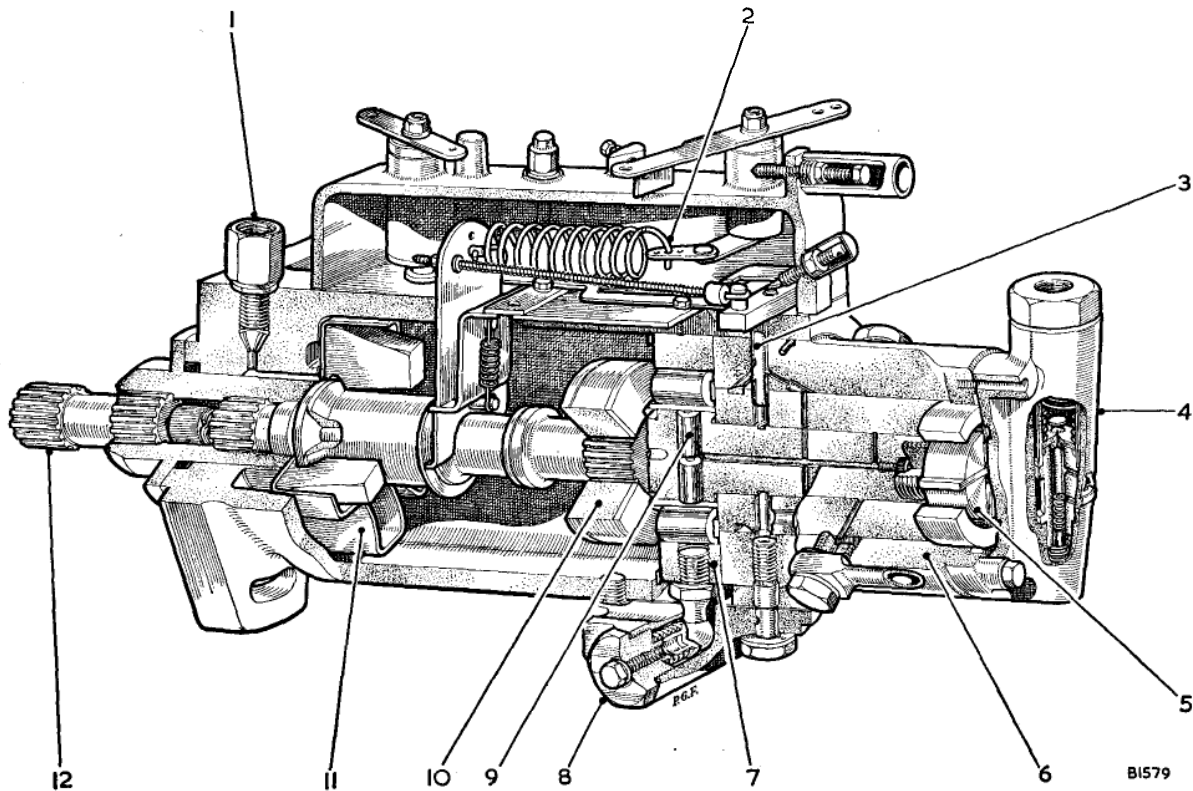


Fig. Ca.4

Section through the fuel injection pump

- | | | |
|------------------------------------|------------------------------|-------------------------------|
| 1. Back-leakage connection. | 5. Transfer pump. | 9. Pumping plunger. |
| 2. Governor spring. | 6. Hydraulic head. | 10. Drive plate. |
| 3. Metering valve. | 7. Cam ring. | 11. Governor weight assembly. |
| 4. End plate and regulating valve. | 8. Automatic advance device. | 12. Quill shaft. |

This flat is open to fuel at drain pressure in the governor housing.

In the surface at the lower end of the metering valve is machined a flat, the upper edge of which is of the same pitch as the helical groove. This flat is open to fuel at transfer pressure.

The width of the land between the helical groove and the flat at the lower end of the metering valve is slightly less than the diameter of the timing port in the metering valve chamber in the hydraulic head. The timing port, which is situated opposite the metering port, is connected by a passage in the hydraulic head and the hollow locating bolt to the port in the advance cylinder.

When the metering valve is in the full-load position the helical groove in the valve is aligned with the timing port in the hydraulic head and fuel at drain pressure is applied to the advance piston. As the drain pressure is insufficient to overcome the piston spring pressure the cam ring is held in the fully retarded position.

Under light-load conditions the metering valve is moved to the low fuelling position, aligning the flat at the lower end of the metering valve with the timing port. The advance piston is now subject to fuel at transfer pressure, and the piston and cam ring move to the fully advanced position.

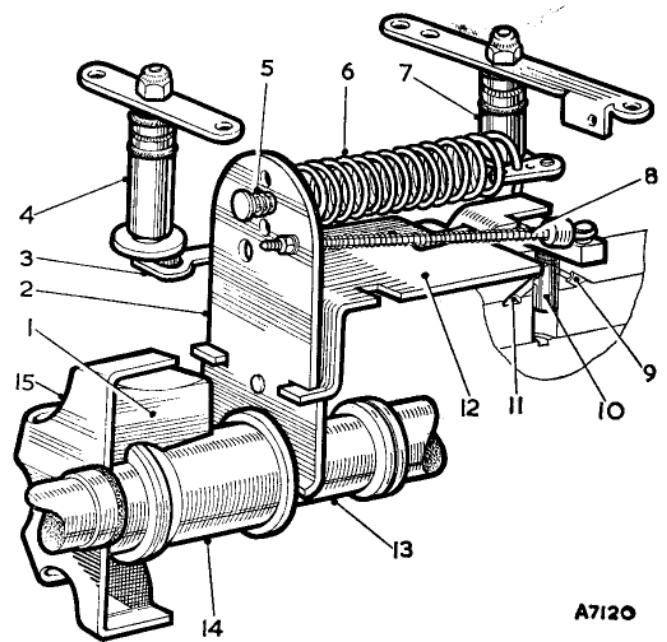
The under side of the metering valve is subject to fuel at transfer pressure which tends to force the valve upwards. This upward movement of the valve is controlled by an adjustable stop screw, which sets the relative positions of the helical groove, the flat on the lower end of the valve, and the timing port so that light-load advance is obtained at the required engine speed.

Machined on each lobe of the cam ring, immediately after the peak of the cam, is a retraction curve. Under running conditions, when the injection cycle is completed the distributing port in the rotor and the outlet port on the hydraulic head are still in partial alignment with each other. As the plunger rollers move off the peaks of the cams the retraction curves allow the plungers to move slightly outwards. This movement of the plungers effects a sudden reduction of pressure in the injection line, so preventing secondary injection and allowing the injector nozzle needle valve to snap onto its seating to terminate the spray of fuel into the combustion chamber without 'dribble'. When starting the engine the metering valve is in the full-load position and the advance piston is subject to fuel at drain pressure. As drain pressure is not sufficient to overcome the pressure of the advance piston return spring, the piston and the cam ring remain in the fully retarded position.

The distributor part of the rotor has a central axial passage which connects the pumping space between the plungers with the four inlet ports and single distributing port drilled radially in the rotor. The radial hole at the outer end of the rotor is the distributing port, and, as the rotor turns, this port is aligned successively with the outlet ports in the hydraulic head, from which the injectors are fed via external high-pressure pipes. The inlet or charging ports are equally spaced around the rotor at an intermediate position, and, as the rotor turns, these are aligned successively with the inlet or metering port in the hydraulic head. This port admits fuel to the rotor under control of the metering valve, which is mechanically governed.

The mechanical governor is of the flyweight type, the weights being held in a retainer, which is clamped between the injection pump drive hub and the drive shaft and rotates with these components as a single unit. The weights are a sliding fit in the retainer pockets and are so shaped that, when under the influence of centrifugal force, they pivot about one edge. A thrust sleeve, which is a sliding fit on the injection pump drive shaft, is moved axially by the flyweights. Movement of the thrust sleeve is transmitted by means of the governor arm and the spring-loaded hook link to rotate the metering valve. The governor arm pivots about a fulcrum on the control bracket and is held in contact with the thrust sleeve by spring tension. Connection between the governor arm and the throttle arm and shaft assembly is made through the governor spring and the idling spring and its guide.

A shut-off bar, operated by an external lever, rotates the metering valve to close the metering port.



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Fig. Ca.6

Mechanical governor

- | | |
|---------------------|----------------------|
| 1. Governor weight. | 9. Metering port. |
| 2. Governor arm. | 10. Metering valve, |
| 3. Shut-off bar. | 11. Timing port. |
| 4. Shut-off shaft. | 12. Control bracket. |
| 5. Idling spring. | 13. Drive shaft. |
| 6. Governor spring. | 14. Thrust sleeve. |
| 7. Throttle shaft. | 15. Weight retainer. |
| 8. Linkage hook. | |

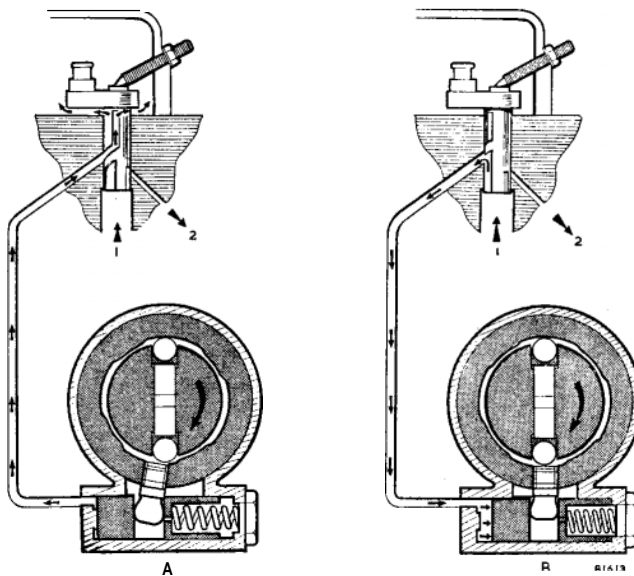


Fig. Ca.5

Light-load advance device

- | | |
|---------------|------------------------|
| A. Full load. | 1. Transfer pressure. |
| B. Low load. | 2. To pumping element. |

The metering valve is provided with a vertical slot along which fuel passes at transfer pressure into the metering port. The valve is situated in a chamber in the hydraulic head, into which the diagonally drilled metering port opens, and rotation of the valve varies the effective area of the metering port to regulate the flow of fuel to the pumping and distributing rotor.

When the throttle arm is moved to give increased speed, the light idling spring is compressed as the guide is drawn through the governor arm and the governor spring is tensioned. Tension of the governor spring acting upon the governor arm and thrust sleeve resists movement of the governor flyweights. As the engine speed increases, the increasing centrifugal force moves the flyweights outwards, overcoming the governor spring tension to move the governor arm and the metering valve towards the closed position. When the selected speed has been attained it will be maintained by governor action. Should the engine speed fall, the flyweights will move inwards, causing an increase of fuelling which restores the selected engine speed.

When the throttle arm is in the idling position the governor spring is untensioned and governing action is controlled by the light idling spring.

In operation fuel at lift pump pressure enters the pump through the connection on the pump end plate and passes

through a fine nylon gauze filter to the inlet side of the transfer pump.

From the transfer pump the fuel passes through a passage in the hydraulic head to an annular groove surrounding the rotor, and thence to the metering valve. The position of the metering valve depends upon the setting of the throttle arm which varies the governor spring pressure on the governor arm. Any variation in pump speed is accompanied by an increase or decrease in transfer pressure, which assists in regularizing the flow of fuel into the pumping section of the rotor. The volume of fuel passing into the pumping element is thus controlled by the transfer pressure, the position of the metering valve, and the time during which an inlet port in the rotor is aligned with the metering port in the hydraulic head.

When one of the rotor inlet ports is aligned with the metering port in the hydraulic head, fuel at metering pressure flows into the rotor and forces the pumping plungers apart, the amount of plunger displacement being governed by the quantity of fuel which can flow into the rotor while the ports are aligned. As the rotor turns, the inlet port is cut off and the pump plungers begin to be forced inwards by their rollers bearing on a pair of cam lobes. This causes an immediate rise in pressure, and as the single distributor port in the rotor comes into register with an outlet port in the hydraulic head the plungers force the fuel up the central bore of the rotor and out to the respective injector.

The maximum amount of fuel delivered at one charge is controlled by limiting the maximum outward movement of the plungers. In Fig. Ca.7 is shown an end-on view of the rotor, and it will be seen that the cam rollers are carried in shoes which bear against the ends of the plungers. The roller shoes, which slide in slots in the rotor, have specially shaped projecting 'ears' which

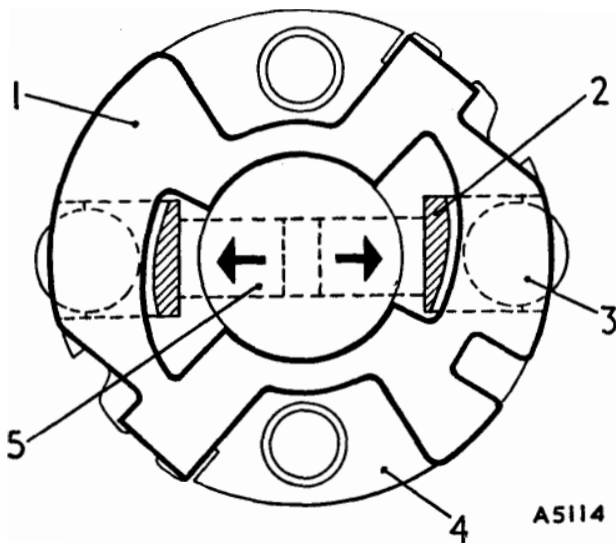


Fig. Ca.7

Maximum fuel adjustment

- 1. Top adjusting plate.
- 2. Roller shoe ear.
- 3. Roller.
- 4. Pumping end of rotor.
- 5. Pumping plunger.

Ca.8

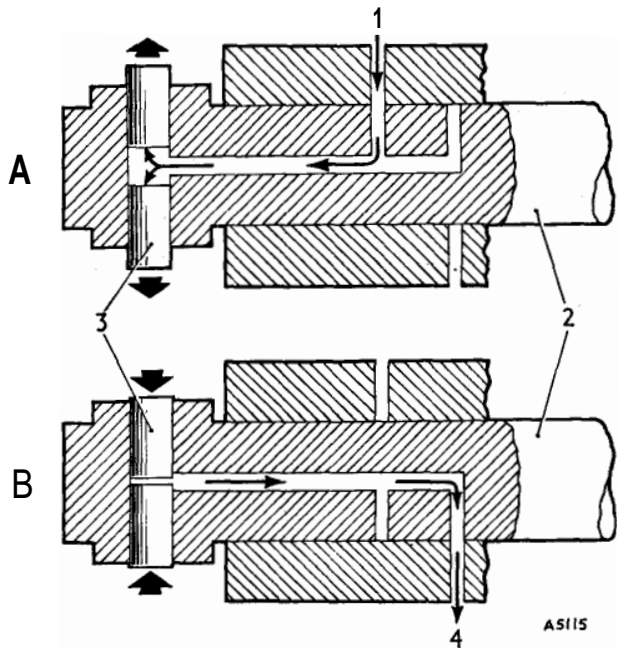


Fig. Ca.8

The injection cycle

- A. Inlet stroke.
- B. Injection stroke.
- 1. Fuel inlet.
- 2. Pumping and distributing rotor.
- 3. Pumping plungers.
- 4. Fuel to injector.

engage eccentric slots in the top and bottom adjusting plates. Two lugs on the top adjusting plate engage slots in the bottom adjusting plate to locate the plates one to the other.

The top adjusting plate is clamped to the rotor by the drive plate, the adjusting plate being cut away in the areas of the drive plate securing screws to permit adjustment of the plates by rotation. The maximum outward travel of the pump plungers is limited by the 'ears' of the roller shoes coming into contact with the curved slot sides in the adjusting plates. As the slots are eccentric, rotation of the adjusting plates relative to the rotor provides a means of adjusting the maximum plunger stroke.

Section Ca.7

REMOVING AND REPLACING THE FUEL INJECTION PUMP

Thoroughly clean the outside of the injector pump body, and then disconnect the throttle, stop and kick-down (if fitted) controls. Disconnect the fuel feed and return pipes from the pump.

Disconnect the high pressure pipes from the pump and the injectors, remove the clamp and damper bushes and detach the pipes individually from the engine. Seal the pump outlet unions with sealing caps 18G 216 to prevent the ingress of foreign matter.

Unscrew the three nuts with plain washers securing the injection pump flange to the rear of the engine front plate and draw the pump rearwards to disengage it from the engine. Withdraw the quill shaft from inside the injection pump chain wheel hub.

Before replacing the fuel injection pump it is necessary to set the static injection timing.

To ensure correct timing relationship between the injection pump and the engine the injection pump driving hub, the quill shaft, and the driving flange of the injection pump chain wheel are provided with master splines; also, a timing mark, is scribed on the fuel injection pump mounting flange and an adjustable timing pointer is secured to the flange of the chain wheel hub.

Before fitting the injection pump to the engine the position of the timing pointer on the flange of the chain wheel hub should be checked, using timing gauge 18G 698, and reset if necessary.

A degree plate, fitted to the crankshaft pulley, with a corresponding pointer on the timing case, is provided to facilitate ease of timing.

Initial adjustment of the injection timing is provided for in the injection pump driving flange, the holes for the bolts which secure it to the chain wheel being elongated.

Crank the engine until the appropriate timing mark coincides with the timing groove on the crankshaft pulley. Ensure that No. 1 piston is on its compression stroke.

Remove the injection pump chain wheel cover-plate from the front of the timing chain case and note the position of the master spline in the pump driving flange, which should now be in the seven o'clock position as seen-from the front of the engine.

Insert injection timing gauge 18G 698 through the chain wheel hub, engaging the splined end of the gauge with the internal splines of the pump driving flange. The master spline will allow the gauge to engage the driving flange in one position only. Turn the gauge by hand (undue force is not necessary) in a clockwise direction, as seen from the rear of the engine, to take up any backlash in the injection pump drive mechanism. Hold the gauge in this position, slacken the two securing screws, and move the timing pointer to align it with the slot on the edge of the gauge. Should the movement required to line up the timing pointer be appreciable, then initial adjustment should be made by altering the position of the injection pump driving flange relative to the chain wheel. This adjustment is made by slackening the four bolts securing the driving flange to the chain wheel and carefully turning the driving flange the required amount by means of the timing gauge. Tighten the driving flange securing screws and carry out final adjustment of the timing pointer as described previously and then remove the timing gauge.

NOTE.—After every occasion of injection pump removal or attention to the crankshaft, camshaft, and timing gear the position of the timing pointer should be checked, and reset, if necessary, as described above.

Fit the injection pump quill shaft into the driving flange.

Rotate the injection pump drive hub and position the master spline in the drive hub at seven o'clock, when looking on the drive end of the pump. This will facilitate the engagement of the quill shaft splines with the drive hub.

Place a new joint washer in position on the engine front plate and offer up the injection pump to the engine. Engage the pump drive hub with the quill shaft and retain the pump in position by fitting the securing nuts and washers finger tight. Rotate the injection pump to align the timing mark on the pump mounting flange with the timing pointer. Tighten the three nuts to secure the injection pump in this position.

Refit the high-pressure pipes, and the fuel feed and drain pipes. Connect the throttle and shut-off controls and ensure that both controls have their full range of movement.

Bleed the fuel system as described in Section Ca.5.

Maximum and idling speed adjustments

After fitting either a new or overhauled injection pump the engine maximum light running speed and the idling speed must be checked, and adjusted if necessary. Before making either of these adjustments it is imperative that the engine air cleaner is correctly serviced and fitted.

Run the engine until it has attained its normal running temperature — this is **most important**. Ensure that the shut-off control is in the fully open position and remove the locking sleeve from the maximum speed adjusting screw.

Using a tachometer to check the engine speed, adjust the maximum speed stop screw to give a maximum light running speed of 3,700 r.p.m., thus giving a maximum road governed speed of 3,500 r.p.m. Tighten the locknut. Fit the locking sleeve and seal it with wire and a lead seal, using sealing pliers 18G 541.

Adjust the idling stop screw to give an idling speed of 600 r.p.m. and tighten the locknut.

Section Ca.8

DISMANTLING AND REASSEMBLING THE FUEL INJECTION PUMP

Dismantling and servicing of the fuel injection pump should only be carried out by specially trained personnel,

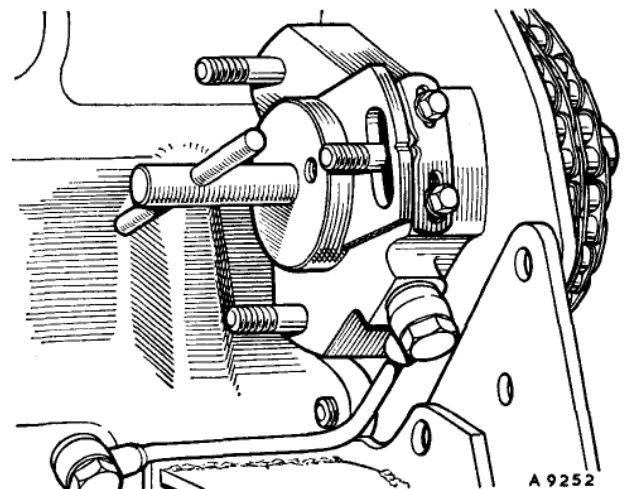


Fig. Ca.9

Checking the position of the injection pump timing pointer, using timing gauge 18G 698

and the Service tools and special test equipment referred to in the following instructions should be available. The workshop in which these operations are carried out should be absolutely clean and the atmosphere free from dust or dirt. It is also recommended that components are immersed in clean Shell Calibration Fluid 'C' immediately after they are dismantled from the main assembly to protect them from possible damage and corrosion and to prevent the ingress of foreign matter.

Abrasives should never be used for cleaning as the resulting damage would seriously impair both the efficiency and the working life of the pump. The components should be washed in clean Shell Calibration Fluid 'C', but they must not be wiped with cotton waste, rags, or cloth wipers of any kind.

Cut the sealing wire, remove the cover-plate and joint washer from the side of the pump housing, and drain the fuel oil from the pump.

Withdraw the quill shaft from the drive hub and mount the pump on assembly base 18G 633 A secured in a vice.

Remove the banjo pipes from the hydraulic head. Unscrew the self-locking nuts with plain washers and remove the shut-off lever and throttle arm from their shafts. Remove the dust cover from each shaft. Cut the locking wire, unscrew the two control cover securing nuts, and remove the two flat washers. Press the throttle shaft downwards and withdraw the control cover complete with shut-off shaft and adjusting screws. Remove and discard the control cover to pump housing gaskets.

Press back the locking tabs and unscrew the two control cover studs and the small set screw securing the control bracket to the pump housing. Remove the keep plate and tab washers, then lift the complete control bracket assembly together with the metering valve and shut-off bar from the pump housing. Remove the shut-off bar from the control bracket. Disconnect the metering valve from the linkage hook and protect its precision-ground surface by immersing it in a bath of Shell Calibration Fluid 'C'. Unscrew the self-locking nut and remove the nylon pivot washer to release the linkage hook from the governor arm. Disconnect the throttle shaft link from the governor spring and remove and discard the two 'O' seals from the throttle shaft. Disconnect the governor spring from the idling spring guide and withdraw the guide and spring from the governor arm. Remove the governor arm spring to release the governor arm from the control bracket.

Turn the pump upside-down and slacken both the spring cap and the end plug in the advance device housing until the pressure of the maximum advance stop spring inside the advance device housing is relieved. Unscrew the cap nut and the head locating bolt, both of which have aluminium and rubber sealing washers, and remove the advance device housing. Unscrew and remove the advance screw from the cam ring. Remove and discard the advance device housing gasket.

Unscrew the end plug and the spring cap, noting the adjusting shim inside the cap. Withdraw the spring, stop,

slide washer, and piston from inside the advance device housing. Remove and discard the 'O' seals from the spring cap and end plug.

Slacken the fuel inlet connection and then remove the screws and studs securing the end plate to the hydraulic head. Carefully remove the carbon vanes from their slots in the transfer pump rotor and withdraw the transfer pump liner.

Unscrew the fuel inlet connection and carefully withdraw the components of the regulating valve from the end plate in the following order: sleeve retaining spring, nylon filter, regulating plug, regulating spring, valve sleeve with piston and joint washer, and lastly the piston retaining spring.

Hold the drive hub with drive shaft screw assembly tool 18G 659 and, using box spanner 18G 634 in conjunction with a standard ratchet wrench, slacken the transfer pump rotor. The word 'OFF' and an arrow etched on the exposed face of the rotor indicate the direction in which the rotor is unscrewed.

Unscrew and remove the two hydraulic head locking screws, one of which carries an air vent valve, and carefully withdraw the hydraulic head and distributing rotor assembly from the pump housing. Remove the 'O' seal from the groove in the periphery of the hydraulic head.

Unscrew the transfer pump rotor, taking care not to allow the pumping and distributing rotor assembly to fall out from the hydraulic head.

Stand the hydraulic head assembly on the bench with the drive plate uppermost. Hold the drive plate with assembly spanner 18G641 and unscrew the two drive plate securing screws. Remove the drive plate, lift off the top adjusting plate, and withdraw the rollers and roller shoes from the pumping and distributing rotor.

Withdraw the rotor from the hydraulic head and remove the bottom adjusting plate. Refit the rotor to the hydraulic head, and to protect the working surfaces immerse the assembly in a bath of clean Shell Calibration Fluid 'C'.

Withdraw the cam ring from the pump housing, noting the arrow etched on the visible face of the cam ring. The arrow is to assist when reassembling, and its direction corresponds with the direction of pump rotation, as shown on the pump nameplate.

Compress the cam ring locating circlip, using circlip pliers 18G 1004, and withdraw the circlip from inside the pump housing.

Hold the drive hub with drive shaft screw assembly tool 18G 659 and, using torque adaptor 18G 664 and a standard socket wrench, unscrew the drive shaft screw from inside the drive hub, reversing the procedure shown in Fig. Ca.12. The splined drive shaft complete with governor weights assembly may now be withdrawn from inside the pump housing.

Remove and discard the 'O' seal from the drive shaft and remove the weight retainer, weights, thrust washer, and sleeve from the drive shaft.

Withdraw the drive hub from inside the pump housing

and remove the spring washer and support washer from their location inside the drive hub. The washers are removed by turning them end on inside the drive hub and withdrawing them along the master spline. Two flats are machined on the outside diameter of the support washer to facilitate this operation.

Remove the drive hub oil seal from the pump housing, using oil seal extractor tool **18G 658**.

Wash all components thoroughly in clean Shell Calibration Fluid 'C'. Cotton waste, rags, or cloth wipers must not be used to wipe the components. If necessary, unscrew the plug with sealing washer, using rotor plug spanner **18G 652**, and blow out the internal passages in the pumping and distributing rotor with compressed air. Coat the threads of the plug with Araldite and refit and tighten the plug to **28 lb. in. (.32 kg. m.)**.

Push out the pumping plungers, one at a time, for inspection, noting that the end of the plunger which has been in contact with the roller shoe is polished and should be replaced in this position. Examine the working surface of the plungers and the plunger bore in the pumping and distributing rotor for wear and abrasions. The bore of the hydraulic head and its mating surface in the rotor should also be examined for wear and scoring. Should any of these parts be worn, the pumping and distributing rotor and hydraulic head, which are mated assemblies, must be renewed as a unit.

Some injection pumps are fitted with hydraulic heads having an oversize metering valve bore and an oversize metering valve to suit. Oversize metering valves, which are identified by a machined groove, are available, but only hydraulic heads having a standard-size metering valve bore are supplied as replacements. Injection pumps fitted with oversize metering valves are identified by the number **6.375** etched upon the hydraulic head between the outlet connections adjacent to the metering valve bore.

Inspect the plunger rollers for flats and the cam ring lobes for signs of wear. Test the roller shoes in their

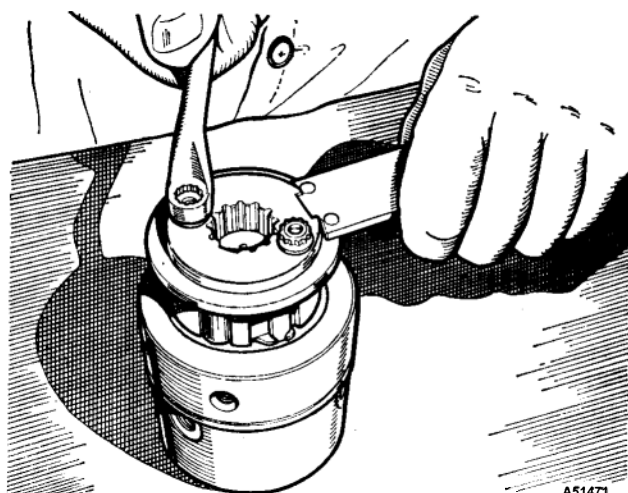


Fig. Ca.10

*Holding the drive plate with spanner **18G 641** when unscrewing the drive plate securing screws*

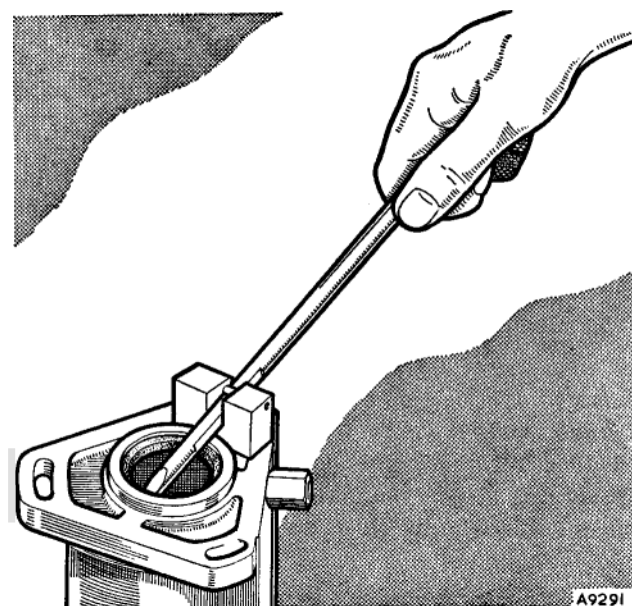


Fig. Ca.11

*Removing the drive hub oil seal, using oil seal extractor **18G 658***

guides in the pumping and distributing rotor for correct action and freedom of movement.

Check the drive shaft splines for wear, assemble the drive shaft to the drive plate, and ensure that there is no excessive radial movement between the drive shaft and plate.

Test the fit of the vanes in their slots in the transfer pump rotor. The vanes should be a sliding fit when lubricated with fuel oil.

Inspect the bore of the regulating valve sleeve for wear and ensure that the valve piston can move freely along the whole length of the sleeve bore.

Inspect all springs for fractures and check them against new counterparts for length. Weak or fractured springs should be renewed. Check the governor weight retainer, thrust washer, and thrust sleeve against new counterparts for signs of wear.

When reassembling, thoroughly rinse all components in freshly filtered clean Shell Calibration Fluid 'C' and assemble all parts wet.

Fit a new drive hub oil seal to the pump housing, driving it onto its seat with oil seal guide **18G 663**. Insert oil seal inspection plug **18G 660** into the oil seal. A correctly fitted oil seal will show a continuous black line when viewed through the flange end of the oil seal inspection plug.

Fit the support washer and spring washer into the drive hub. Remove the oil seal inspection plug and pass the drive hub through the seal, seating the drive hub flange against the pump housing.

Place the governor weight retainer on plate **18G662** and pass locating pin **18G 661** through the weight retainer to locate in the plate so that the weight retainer

is trapped between the plate and the shoulder of the locating pin. Place the weights, equally spaced, in position on the weight retainer.

The slot in each weight should be uppermost and nearest the locating pin (Fig. Ca.13). Each weight should be aligned with a pocket in the weight retainer and with its inner end against the locating pin. Place the thrust washer and thrust sleeve on the locating pin and resting on the governor weights. The thrust sleeve must be fitted with the flange having the projection uppermost. Exert downward pressure on the thrust sleeve and the assembly will enter the weight retainer. Withdraw the locating pin and remove the assembly from the plate. Slide the assembly onto the drive shaft. Fit protection cap 18G 657 over the drive shaft splines and fit a new 'O' seal in the machined groove on the shaft. Insert the drive shaft and weight assembly into the pump housing and engage the drive shaft splines with the splines in the drive hub. Fit the drive shaft screw, and, holding the drive hub with drive shaft screw assembly tool 18G659, tighten the drive shaft screw to the figure given in 'GENERAL DATA', using torque adaptor 18G664 and torque wrench 18G 537 (Fig. Ca.12).

Compress the cam ring locating circlip, using circlip pliers, 18G 1004, and seat it against the shoulder in the bore of the pump housing. Place the cam ring in position against the circlip. The direction of the arrow on the visible face of the cam ring must conform with the direction of pump rotation as marked on the pump nameplate. Fit the cam advance screw finger tight to locate the cam ring and check the ring for freedom of movement in the pump housing.

If the hydraulic head and pumping and distributing rotor are renewed, ensure that the direction of the arrow

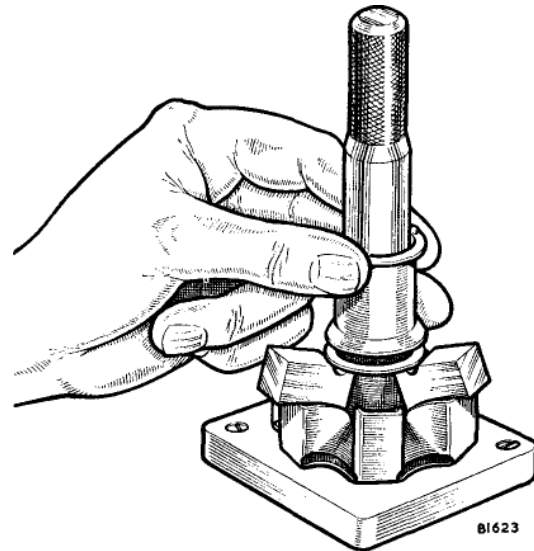


Fig. Ca.13

Assembling the governor weights, thrust washer, and thrust sleeve into the weight retainer, using Service tools 18G 661 and 18G 662

stamped on the periphery of the pumping end of the rotor corresponds with the pump rotation, as indicated on the pump nameplate.

Withdraw the pumping and distributing rotor complete with plungers from the hydraulic head. Place the top adjusting plate in its correct position on the rotor—that is, with the slot in the periphery of the adjusting plate aligned with the scribed mark on the periphery of the pumping end of the rotor (Fig. Ca.14).

Fit the drive plate to the rotor with its relieved face next to the top adjusting plate. The slot in the periphery of the drive plate must be in line with the scribe mark on the periphery of the rotor (Fig. Ca.14). Tighten the drive plate securing screws lightly to hold the top adjusting plate in position on the rotor. Invert this assembly so that the distributing end of the rotor is uppermost. Slide the rollers into their shoes and insert the roller and shoe assemblies into their guides in the rotor, ensuring that the contour of the roller shoe ears conforms with the contour of eccentric slots in the top adjusting plate. Assemble the bottom adjusting plate to the rotor with the contour of the eccentric slots in the adjusting plate conforming to the contour of the roller shoe ears and the slots in the periphery of the bottom adjusting plate engaging the lugs on the top adjusting plate. Fit the assembly of the pumping and distributing rotor to the hydraulic head and fit and lightly tighten the transfer pump rotor. Stand the assembly of the hydraulic head and the pumping and distributing rotor on the bench with the pumping end of the rotor uppermost.

Fit relief valve timing adaptor 18G 653 A, preset at 15 atmospheres, to high-pressure outlet 'V' on the hydraulic head and connect up the whole assembly to injector nozzle testing machine 18G 109 A (Fig. Ca.15).

Operate the handle of the test machine and turn the pumping and distributing rotor in the normal direction of

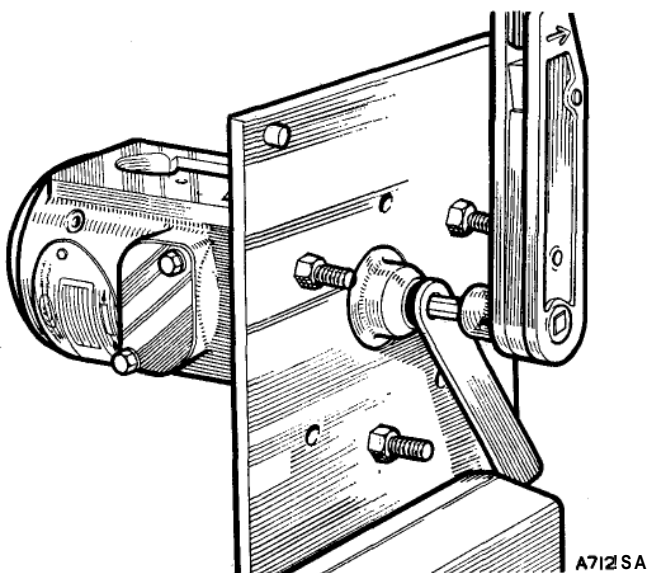


Fig. Ca.12

Holding the drive hub with drive shaft screw assembly tool 18G659 while tightening the drive shaft screw with torque adaptor 18G664 and torque wrench 18G 537

rotation until the pumping plungers are forced outwards to the maximum fuel position. Set the roller-to-roller dimension, using a micrometer, to the dimension given in 'GENERAL DATA'. Move the adjusting plates (clockwise to increase and anti-clockwise to decrease the dimension) with maximum fuel adjusting probe 18G 656. Tighten the drive plate securing screws to the figure given in 'GENERAL DATA', using torque wrench 18G 537. This setting is approximate, final adjustment being made with the pump mounted on a power-driven test machine (see Section Ca.9). The drive plate is held, when tightening the securing screws, with assembly drive plate spanner 18G 641. Disconnect the test machine and the hydraulic adaptor from the hydraulic head.

Fit a new oil seal into its groove in the machined periphery of the hydraulic head.

Turn the pump drive shaft in the pump housing and position the master spline at 12 o'clock. Align the master spline in the drive plate with the metering valve bore in the hydraulic head. Lubricate the periphery of the hydraulic head and the bore of the pump housing liberally with clean Shell Calibration Fluid 'C'. Hold the hydraulic head assembly square with the axis of the pump housing and, with the metering valve bore at 12 o'clock, push the hydraulic head into the pump housing. Rotate the drive shaft slightly to assist the engagement of the shaft with the drive plate.

Insert the two hydraulic head locking screws, leaving them finger tight and ensuring that the screw with the vent valve is fitted immediately above the pump name-plate.

Mount drive shaft screw assembly tool 18G 659 in the splined drive hub and, using torque wrench 18G 536 and assembly box spanner 18G 634, tighten the transfer pump rotor to the figure given in 'GENERAL DATA'.

Fit the transfer pump liner and insert the carbon vanes into the slots in the transfer pump rotor.

Ensure that the transfer pump liner locating peg is in position 'C' in the pump end plate.

Insert the piston retaining spring into the regulating valve bore in the end plate, ensuring that it is properly seated in the bottom of the bore. Fit a new seal washer

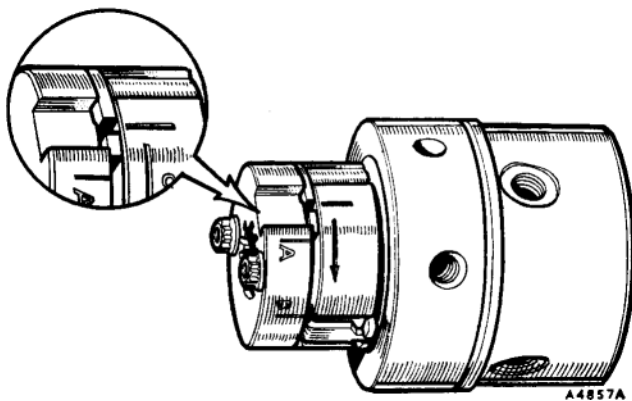


Fig. Ca.14

Assembly the top adjusting plate and the drive plate with the slots in their peripheries aligned with the scribed mark on the pumping end of the rotor

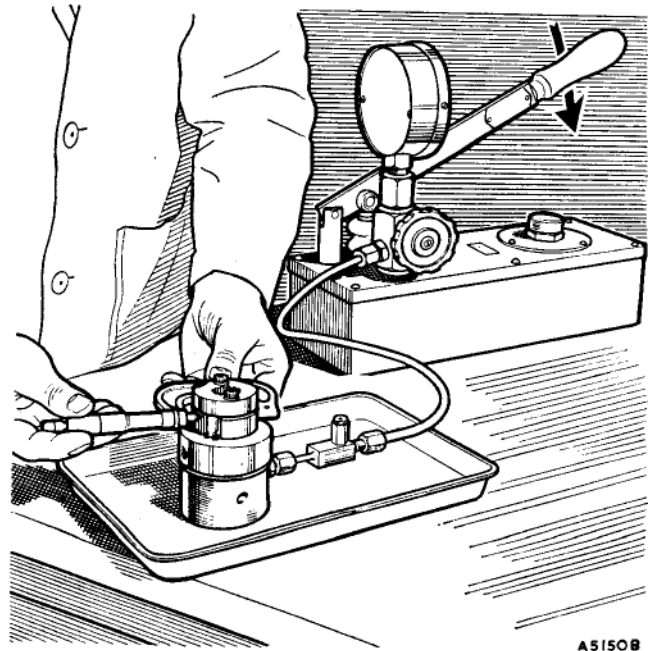


Fig. Ca.15

Setting the roller-to-roller dimension, using a micrometer and Service tools 18G 109A and 18G 653 A

to the small-diameter end of the regulating valve sleeve and insert the valve piston into the sleeve. Insert the regulating spring into the large-diameter end of the valve sleeve. Place the regulating plug on the top of the sleeve with its spigoted end engaging the sleeve bore. Fit the sleeve retaining spring onto the guide. Pass the nylon filter, small-diameter end leading, over the spring and regulating plug onto the shoulder of the valve sleeve. Insert this assembly, valve sleeve first, into the bore of the end plate and secure it in position with the fuel inlet connection and washer.

Position a new oil seal in its recess in the upper face of the hydraulic head and fit the assembled end plate to the head, engaging the locating peg on the inner face of the

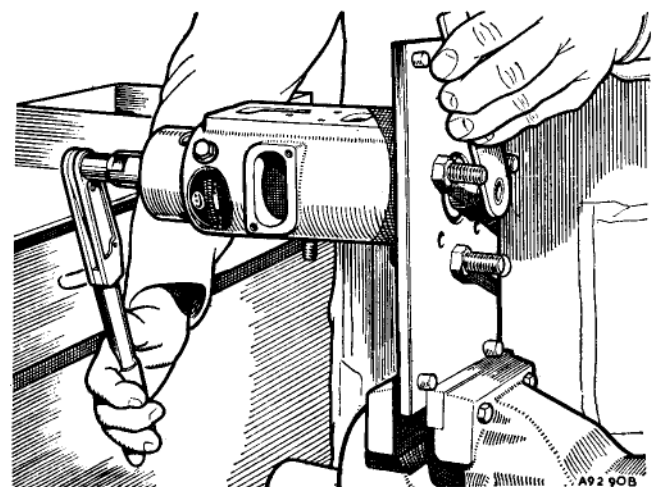


Fig. Ca.16

Tightening the transfer pump rotor, using torque wrench 18G 536 and Service tools 18G 659 and 18G 634

end plate with the slot in the periphery of the transfer pump liner. The end plate securing screw holes are unequally spaced to ensure correct assembly of the end plate to the hydraulic head. Tighten the set screws and studs to the torque figure given in 'GENERAL DATA', using torque wrench 18G 536. Tighten the fuel inlet connection to the torque figure in 'GENERAL DATA', using torque wrench 18G 537.

Tighten the cam ring advance screw to the figure given in 'GENERAL DATA', using torque wrench 18G 372. Check the cam ring for freedom of movement.

Place a new advance device housing gasket in position on the pump housing with the flat of the 'D'-shaped hole at the drive hub end of the pump. To ensure satisfactory sealing this gasket should be assembled dry. Assemble the advance device housing to the pump housing, using new rubber and aluminium sealing washers for the head locating bolt and cap nut. Using torque wrench 18G 537, tighten the head locating bolt, the cap nut, and the two head locking screws to the figures given in 'GENERAL DATA'. Check the cam ring for freedom of movement.

Fit new 'O'seals to the light-load advance piston plug and the spring cap, using protection cap 18G 640 to pass the seals over the threads.

Insert the slide washer and piston, in that order, into the advance device housing on the side where the fuel oil drilling enters the piston bore. Screw in the piston plug. Insert the maximum advance stop, and spring, in that order, into the remaining open end of the advance unit housing and screw in the cap. Tighten the piston plug and spring cap to the torque figures given in 'GENERAL DATA', using torque wrench 18G 537.

Insert the metering valve into the metering valve bore in the hydraulic head.

Engage the governor arm with the control bracket and connect the governor arm spring to both components.

Fit the assembly governor arm and control bracket to the pump housing. The lower end of the governor arm should engage the outside face of the thrust sleeve flange. Place the keep plate in position with its open end towards the shut-off bar. Fit new tab washers with their pointed tabs towards the governor arm. Secure the keep plate in position with the two governor control cover studs. Fit the small screw and tab washer at the metering valve end of the control bracket. Tighten the control cover studs to the torque figure given in 'GENERAL DATA', using torque wrench 18G 536. Lock the studs in position by bending up the pointed tabs. Tighten the small screw to the torque figure given in 'GENERAL DATA', and lock it with the tab washer.

Assemble the spring retainer, spring, and fibre washer onto the governor linkage hook, in that order. Pass the threaded end of the linkage hook through the governor arm. Fit the pivot ball washer onto the linkage hook and screw on the linkage nut about three turns. Press back the spring retainer and attach the linkage hook to the metering valve. The hook end should turn towards the metering valve.

Set the internal dimension between the metering valve

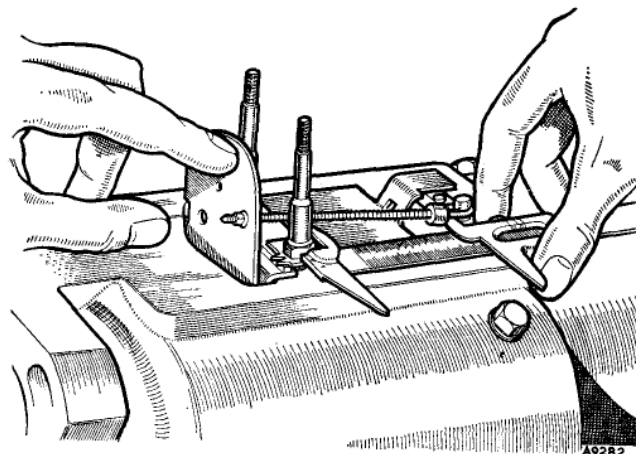


Fig. Ca.17

Setting the internal dimension between the metering valve lever pin and the control cover stud with the vernier held parallel to the axis of the pump

lever pin and its nearest control cover stud to the length given in 'GENERAL DATA', using a vernier gauge as shown in Fig. Ca.17. Adjustment is made by slackening or tightening the hook linkage nut. During this operation light pressure should be applied to the governor arm in the direction of the metering valve and the vernier gauge should be held parallel to the pump axis.

Locate the idling spring on the idling spring guide. Insert the guide into hole No. 2 in the governor arm (Fig. Ca.6) and connect the governor spring to the idling spring guide.

Insert the plain end of the shut-off bar into the slot in the control bracket and position the shut-off bar under the tab of the control cover stud locking washer.

Using protection cap 18G 564, fit the lower 'O'seal to the shut-off shaft. Fit the upper 'O'seal, using protection cap 18G 665. Pack the groove between the 'O'seals with Shell Alvania No. 2 grease. Press the shut-off shaft into its bore in the control cover. The peg which engages the shut-off bar should be close to the inside edge of the control cover, and should be left projecting slightly above the control cover face.

Place a new control cover gasket in position on the pump housing, ensuring that the locating tabs of the gasket engage the slots under the keep plate. To ensure satisfactory sealing this gasket should be soaked in Shell Calibration Fluid 'C' before assembly.

Fit new lower and upper 'O'seals to the throttle shaft, using protection caps 18G 654 and 18G 665. Pack the groove between the 'O'seals with Shell Alvania No. 2 grease. Connect the free end of the governor spring to hole No. 2 (2.2-litre engine) or hole No. 1 (2.52-litre engine) in the throttle shaft link (Fig. Ca.6).

Press the throttle shaft into its bore in the control cover. Place the control cover in position on the control cover studs. Ensure that the shut-off shaft peg engages the shut-off bar and pull the shut-off shaft fully home as the control cover is lowered onto the gasket. Fit new sealing washers on the control cover studs and fit and

tighten the stud nuts to the torque figures given in 'GENERAL DATA', using torque wrench **18G 536**. Place the dust caps on the throttle and shut-off shafts. Fit the throttle arm and the shut-off lever to their respective shafts and secure them in place with their nuts and washers.

Section Ca.9

TESTING AND ADJUSTING THE FUEL INJECTION PUMP

After overhaul the fuel injection pump must be checked functionally, and the maximum fuel output adjusted if necessary. These tests and adjustments are carried out on a power-driven test bench embodying the necessary vacuum and pressure gauges and equipment to test the fuel transfer pump and a graduated glass to measure the injection pump back-leakage. In addition, the tools mentioned in the following paragraphs are also required.

NOTE.—The following precautions must be observed when testing the pump:

- (1) **Ensure that the power-driven test bench is set to run in the direction of rotation of the injection pump, as indicated by the arrow on the pump nameplate. Serious damage may be caused to the pump if it is run in the reverse direction.**
- (2) **Ensure that the fuel flow at the pump inlet is not less than 1,000 c.c./min. If this flow cannot be obtained, a maximum feed pressure of 2 lb./sq. in. (15 kg./cm.2) is permissible.**
- (3) **Do not run the pump for long periods at high speed with low fuel output.**
- (4) **Do not run the pump for long periods with the shut-off control in the closed position.**

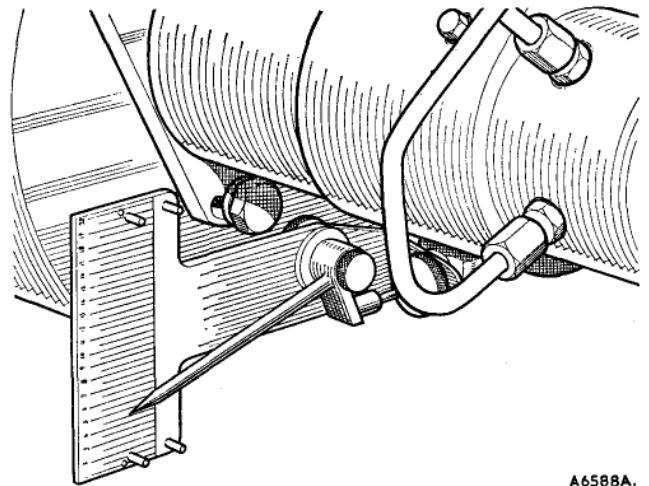
After checking the direction of rotation mount the pump on the test bench and connect up the drive. Fit radial connections to the hydraulic head in place of the banjo pipes. Using high-pressure pipes 6 mm. X 2 mm. X 865 mm. (34 in.) long, connect the radial connections to a matched set of test nozzles. The test nozzles should be Type BDN.12.SD.12 mounted in nozzle holders Type BKB.50.SD.533b (formerly BKB.50.SD.19b) and set to open at 175 atmospheres.

Ensure that the pump throttle arm has the full range of movement by unscrewing fully the idling and maximum speed stop screws.

Remove the hydraulic head locking screw, not the one incorporating the vent valve, and connect the pressure gauge by means of a flexible pipe to transfer pressure adaptor **18G 636**, which is screwed into the head locking screw hole.

Connect the feed pipe, preferably of the transparent type, to the fuel inlet connection on the injection pump end plate. The vacuum gauge should be fitted, by means of a 'T' coupling, to the feed pipe.

Connect the inlet connection on the measuring-glass to the drain connection on the pump housing and the drain cock on the measuring-glass to the return pipe on the test bench by means of flexible pipes.



A6588A.

Fig. Ca.18

Checking the automatic advance device, using advance gauge 18G 638 B

Remove the small set screw from the centre of the advance unit housing spring cap and assemble automatic advance gauge **18G 638 B** to the spring cap with the degree scale and pointer uppermost and the scale set to zero.

Throughout the following operations and tests the pump throttle and shut-off levers must be in the fully open position, except where stated otherwise.

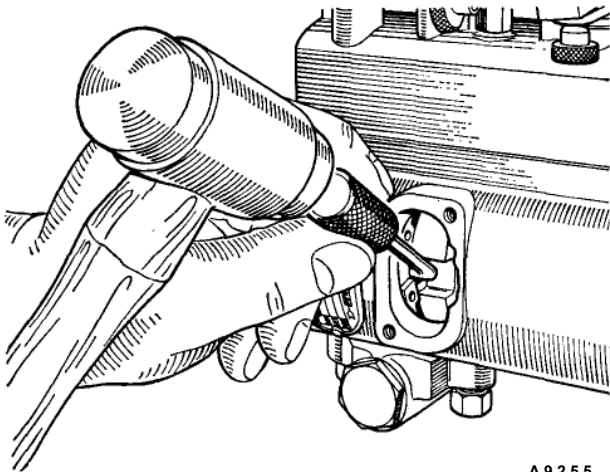
The pump and the feed pipe must now be filled and primed as follows:

- (1) Connect the fuel feed pipe to the drain connection on the pump housing.
- (2) Open both of the vent screws on the injection pump-
- (3) Turn on the gravity feed. When test oil free from air bubbles flows from the vent screw on the hydraulic head, close this vent screw. Wait till the test oil flowing from the vent screw in the governor control housing is free from air bubbles, then close this vent screw also.
- (4) Rotate the pump drive through 180° and repeat operations (2) and (3).
- (5) Fit the feed and return pipes to their respective connections.
- (6) Slacken the high-pressure pipe unions at the injector end.
- (7) Start the test machine and run at 100 r.p.m. until oil free from air bubbles issues from the injector pipe connections.
- (8) Tighten the injector pipe connection while the test machine is running.

The following tests are designed to check, in turn, each of the separate functions of the injection pump. Before, however, making these individual tests a general check should be carried out to ensure oil-tightness of all joint washers, oil seals, and pipe connections while the pump is running and when stationary.

(1) **Transfer pump vacuum test**

Start the test machine and run the pump at 100 r.p.m.



A9255

Fig. Ca.19

Adjusting the maximum fuel setting, using Service tool 18G656

Turn the test oil feed cock to the 'off' position and note the depression registered on the vacuum gauge. This should build up to 16 in. (406 mm.) Hg within 60 seconds maximum. Check the fuel feed pipe unions for air leaks, indicated by the presence of air bubbles in the pipe line. If necessary, tighten the feed pipe unions and carry out a further test.

NOTE.—Do not run the pump for periods exceeding 60 seconds with the test oil supply turned off.

After the vacuum test is completed turn on the test oil supply, and with the pump running at 100 r.p.m. air-vent the pump by means of the vent valve on the hydraulic head locking screw.

(2) Transfer pump pressure

With the pump running at 100 r.p.m. note the pressure registered on the pressure gauge which should read 12 lb./sq. in. (0.8 kg./cm.²).

(3) Transfer pump pressure

Increase the pump speed to 800 r.p.m., when a pressure of 32 to 44 lb./sq. in. (2.3 to 3.1 kg./cm.²) should be registered on the pressure gauge.

(4) Fuel delivery setting

Run the pump at 800 r.p.m., and after slackening the locknut alter the metering valve adjustment screw till a zero reading is obtained on the automatic advance gauge. Tighten the locknut and re-check the advance reading. Fit the shut-off lever adjustment tool 18G697 to the fuel pump and adjust the shut-off lever to obtain an average fuel delivery of 3.6 to 4.4 c.c. per 200 shots. Ensure that the advance gauge still shows a zero reading.

(5) Advance setting

Run the pump at 800 r.p.m. Slacken the metering valve adjustment screw locknut and alter the adjustment screw to obtain an advance reading of 134° to 214°. Tighten the locknut and re-check the advance reading.

(6) Fuel delivery check

Without altering any of the adjustments, check that the fuel delivery at 800 r.p.m. is 3.6 to 4.4 c.c. per 200 shots. Remove the shut-off lever adjustment tool.

(7) Advance check

Run the fuel pump at 800 r.p.m. Move the shut-off lever to the fully closed position and check that the advance reading is 31/2 to 41/2°. Fit and seal the metering valve adjustment screw sealing cap with wire and a lead seal, using sealing pliers 18G541.

NOTE—If for any reason it is found necessary to tighten or slacken the governor control cover cap nuts, the settings made at (4) and (5) will be disturbed, and operations (4), (5), (6), and (7) should be repeated.

(8) Back-leakage

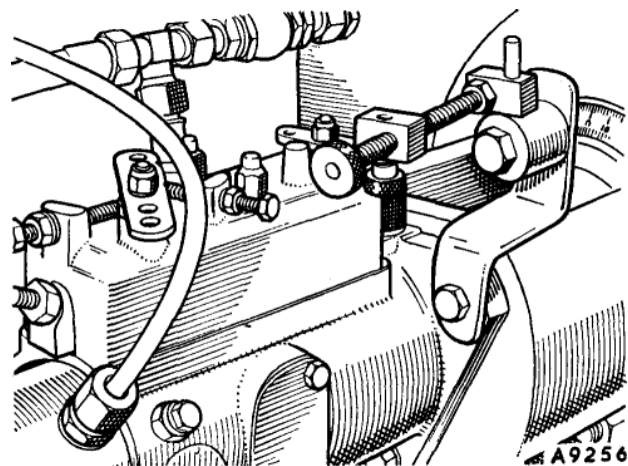
Set the shut-off lever fully open and the throttle arm fully closed. Run the pump at 1,000 r.p.m. and measure the back-leakage through the graduated measuring-glass. The back-leakage should be 5 to 50 c.c. per 100-shot cycle.

(9) Maximum fuel setting

NOTE:—Throughout this test the advance gauge must show a zero reading.

Run the pump at 1,000 r.p.m. with both controls in their fully open position, when the average delivery for 200 shots from all four test injectors should be 6.97-1 c.c. In arriving at this figure compare the delivery from all injectors to ensure that the difference in output from any two does not exceed .6 c.c. Before taking a reading the test oil in the measuring-glasses should be allowed to settle for 15 seconds and the measuring-glasses should be allowed to drain for 30 seconds before a fresh test is made.

To adjust the pump output stop the test bench and turn the test oil feed cock to the 'off' position. Remove the cover-plate from the side of the pump



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Fig. Ca.20

The shut-off lever adjuster 18G697 mounted on the fuel injection pump and test bench

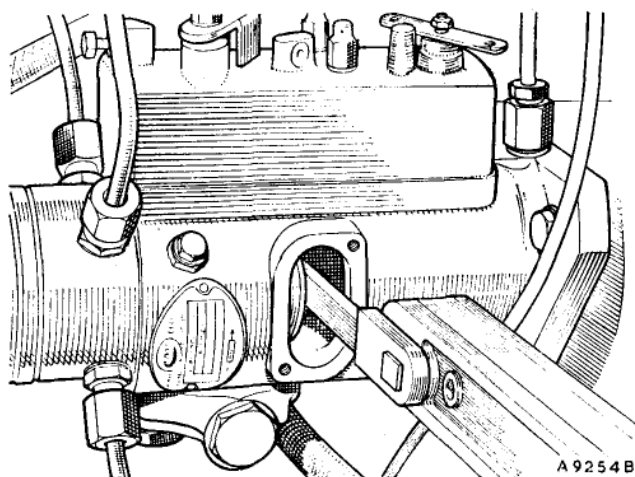


Fig. Ca.21

Tightening the drive plate screws, using torque wrench 18G 537 and torque adaptor 18G 655A

housing to provide access to the interior of the pump. Slacken the two drive plate securing screws sufficiently to permit movement of the adjusting plates. Turn the pump drive until the slots in the peripheries of the drive plate and the top adjusting plate are visible through the aperture in the pump housing. Engage the end of the maximum fuel adjusting probe 18G 656 in the slot in the top adjusting plate and tap the tool with a light hammer to move the plate in the required direction. The adjusting plate is turned in the same direction as the normal direction of the pump rotation to increase the maximum output. Movement of the adjusting plate in the opposite direction will decrease the maximum output. This operation must be carried out very carefully as the amount of movement required will be very small. Tighten the drive plate securing screws to the torque figure given in 'GENERAL DATA', using tools 18G 537, and 18G 655A. While tightening the screws the torque wrench must be in line with the spanner (Fig. Ca.21). After making this adjustment replace the cover-plate and carry out the complete filling and priming operation. Re-check the fuel delivery and, if necessary, re-adjust the pump output.

(10) Fuel delivery

Decrease the pump speed to 100 r.p.m. and check the output. The average delivery for 200 shots under these conditions should not be less than that obtained when setting the pump maximum fuel output minus 1.5 c.c. When carrying out this test use 30 seconds' measuring-glass draining time and allow the test oil to settle for 15 seconds before taking a reading.

(11) Cut-off test

With the shut-off lever held in the fully closed position run the pump at 200 r.p.m. The average delivery for 200 shots, with the throttle arm in the fully open position, should not exceed 1.0 c.c.

(12) Throttle operation

Run the fuel pump at 200 r.p.m. with the throttle arm in the fully closed position. The average delivery with the shut-off lever fully open should not exceed 1.0 c.c. per 200 shots.

(13) Fuel delivery check

With both controls fully open run the fuel pump at 1,650 r.p.m. and record the average delivery per 200 shots.

(14) Governor setting

Increase the pump speed to 1,850 r.p.m. and set the throttle arm by means of the maximum speed adjustment screw to give a maximum average delivery of 1.0 c.c. per 200 shots. No line should exceed 1.8 c.c. Tighten the adjustment screw locknut.

(15) Fuel delivery check

Reduce the pump speed to 1,650 r.p.m. and re-check the fuel delivery. The average delivery now should not be less than that recorded in operation (13) minus .4 c.c. per 200 shots.

(16) Timing setting

This setting is made, after **all** the foregoing tests have been completed, with the pump removed from the power-driven test bench.

It should be noted that, unlike the 'in-line' fuel injection pump, which has a static commencement of injection point, the point at which commencement of injection occurs in the distributor-type fuel injection pump varies according to the fuel requirements of the engine. The timing of the distributor-type pump is carried out with the pumping plungers set to delivery maximum fuel on No. 1 injection line and with the plunger rollers in contact with the cam lobes: therefore, after all occasions of pump overhaul or adjustment to the pump output it is imperative that the pump timing is checked, and the timing mark on the pump flange re-marked if necessary.

Remove the cover-plate from the side of the pump housing and the four radial connections from the hydraulic head. Connect injector nozzle testing machine 18G 109 A to outlet 'V' on the hydraulic head to means of relief valve timing adaptor 18G 653 A. The relief valve must be set to operate at 30 atmospheres.

Turn the pump drive hub in the normal direction of rotation until the timing mark 'E' on the drive plate becomes visible through the aperture in the side of the pump housing. Operate the handle of the test machine to apply a pressure of 30 atmospheres to the pump. This will force the pumping

plungers outwards to the limit of their travel as the drive hub is turned. Continue turning the drive hub in the normal direction of rotation until resistance is encountered. With the pump held in this position mount flange marking gauge 18G648A, preset to 86°, on the pump quill shaft. Check that the timing mark on the pump flange lies along the scribing guide on the flange marking gauge. If necessary, delete the old timing mark and scribe a new mark by drawing a scribing tool along the guide on the flange marking gauge.

Disconnect the pump from the test machine and fit the banjo pipes to the hydraulic head. Refit the cover-plate to the side of the fuel pump housing and seal the securing screws with wire and a lead seal, using sealing pliers 18G 541.

Maximum and idling speed adjustments

These adjustments are carried out after the pump has been installed on the engine, and are detailed in Section Ca.7.

Section Ca.10

ALTITUDE SETTINGS

Each vehicle leaves the Factory with its maximum fuel setting adjusted for sea-level conditions. If the vehicle is to be operated continuously above sea-level, adjustment of the injection pump is necessary to set the maximum fuel delivery to conform with the figures given in the following table.

Altitude	Maximum fuel output for 200 shots at 1,000 pump r.p.m.	
	2.2-litre diesel engine	2.52-litre diesel engine
0 to 2,000 ft. (0 to 600 m.)	6.8 to 7.0 c.c.	8.8 to 9.0 c.c.
2,000 to 4,000 ft. (600 to 1200 m.)	6.4 to 6.6 c.c.	8.3 to 8.5 c.c.
4,000 to 6,000 ft. (1200 to 1800 m.)	6.0 to 6.2 c.c.	7.7 to 7.9 c.c.
6,000 to 8,000 ft. (1800 to 2400 m.)	5.6 to 5.8 c.c.	7.2 to 7.4 c.c.
8,000 to 10,000 ft. (2400 to 3000 m.)	5.1 to 5.3 c.c.	6.6 to 6.8 c.c.
10,000 to 12,000 ft. (3000 to 3600 m.)	4.7 to 4.9 c.c.	6.1 to 6.3 c.c.

Section Ca.11

FUEL INJECTORS

Follow the instructions given in Section C.6, noting the following points.

Ca.18

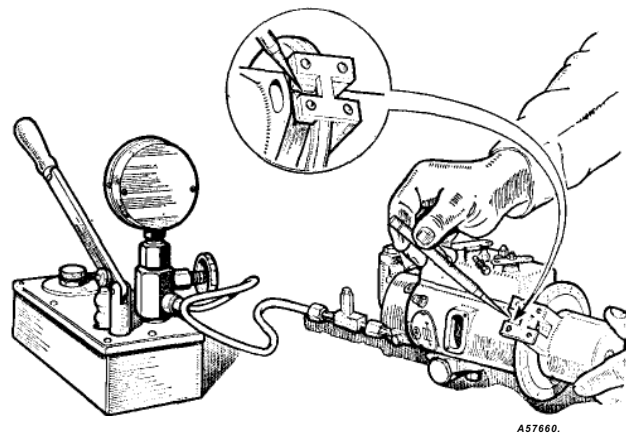


Fig. Ca.22

Scribing the timing mark on the fuel injection pump mounting flange, using Service tool 18G 648 A

- (1) When testing the injectors for spray and adjusting the injectors for service the nozzle opening pressure should be set to 130 atmospheres for 2.2-litre engines and 135 atmospheres for 2.52-litre engines.
- (2) The needle lift should be .029 to .035 in. (.75 to .90 mm.) for 2.2-litre engines and 4 to .75 mm. for 2.52-litre engines.

Section Ca.12

LIFT PUMP

Follow the instructions given in Section C.1, but after replacing the lift pump bleed the fuel system as described in Section Ca.5.

Section Ca.13

**MODIFIED INJECTION PUMP
(Type DPA. 3248050A)**

This pump is as described in Section Ca.6 but with various detail modifications to improve engine governing and the addition of an anti-stall device. The modifications include a governor spring, idling spring, and maximum advance stop spring of new load rates. Other modifications incorporated in this pump are to the metering valve, quill shaft, and banjo pipes.

The anti-stall device consists of an adjusting screw, which protrudes from the drive end of the control cover, and a locknut. In operation the inner end of the adjusting screw contacts the governor arm to act as a stop. The effect of this is to prevent the governor from reducing the metering area below the position permitted by the anti-stall screw. Therefore, adjustment of the anti-stall screw should only be carried out as described in Section Ca.13 under 'Maximum and idling speed adjustments'.

Removing and replacing

Follow the instructions in Section Ca.7 noting that the correct injection timing for this pump is 26° B.T.D.C.

Maximum and idling speed adjustments

After fitting either a new or overhauled injection pump, adjust the engine maximum light running speed as described in Section Ca.7. Then proceed as follows to adjust the idling speed and anti-stall device:

- (1) With the engine stopped unscrew the anti-stall screw until it is out of contact with the governor arm.
- (2) Start the engine, ensure that it is at its normal running temperature, and adjust the idling stop screw to set the engine speed at between **450** and **500** r.p.m.
- (3) Screw in the anti-stall screw carefully until a slight speed increase is noticed, then unscrew one third of a turn and lock in position with the locknut.
- (4) Readjust the idling stop screw to set the idling speed at 500 r.p.m. and tighten the idling stop screw locknut.
- (5) Test the anti-stall screw setting by running the engine at about 3,000 r.p.m. and then releasing the throttle:
 - (a) If the engine stalls the pump is underdamped and the anti-stall screw should be screwed in slightly, relocked, and the setting retested.
 - (b) If the engine deceleration is slow or sluggish the pump is overdamped and the anti-stall screw should be screwed out slightly, relocked, and the setting retested.
- (6) Check that the engine stops when the shut-off lever is operated.

NOTE.—After every adjustment of the anti-stall screw ensure that the engine idling speed is controlled by the idling stop screw and not by the anti-stall screw.

Dismantling and reassembling

Follow the instructions in Section Ca.8 noting that this pump is fitted with four governor weights.

Testing and adjusting

Mount the pump on a test bench and fill and prime the pump as described in Section Ca.9. Check the oil-tightness of all joint washers, oil seals, and pipe connections with the pump running and when stationary. Then proceed with the following tests, noting that the pump throttle arm and shut-off lever must be in the fully open position except where stated otherwise.

(1) *Transfer pump vacuum test*

Start the test machine and run the pump at 100 r.p.m.

Turn the test oil feed cock to the 'off' position and note the depression registered on the vacuum gauge. This should build up to 16 in. (406 mm.) Hg within 60 seconds maximum. Check the fuel feed pipe unions for air leaks, indicated by the presence

of air bubbles in the pipe line. If necessary, tighten the feed pipe unions and carry out a further test.

NOTE.—Do not run the pump for periods exceeding **60** seconds with the test oil supply turned off.

After the vacuum test is completed turn on the test oil supply, and with the pump running at 100 r.p.m., air vent the pump by means of the vent valve on the hydraulic head locking screw.

(2) *Transfer pump pressure*

With the pump running at 100 r.p.m. note the pressure registered on the pressure gauge, which should read 11 lb./sq. in. (.8 kg./cm.2).

(3) *Transfer pump pressure*

Increase the pump speed to 1,300 r.p.m. when a pressure of 43 to 54 lb./sq. in. (2.9 to 3.8 kg./cm.2) should be registered on the pressure gauge.

(4) *Fuel delivery setting*

Run the pump at 1,300 r.p.m. and after slackening the locknut alter the metering valve adjustment screw till a zero reading is obtained on the automatic advance gauge. Tighten the locknut and recheck the advance reading. Fit shut-off lever adjustment tool 18G 697 to the fuel pump and adjust the shut-off lever to obtain an average fuel delivery of 6.2 to 7.0 c.c. per 200 shots.

Ensure that the advance gauge still shows a zero reading.

(5) *Advance setting*

Run the pump at 1,300 r.p.m. Slacken the metering valve adjustment screw locknut and alter the adjustment screw to obtain an advance reading of 13/4 to 2 1/4°. Tighten the locknut and re-check the advance reading.

(6) *Fuel delivery check*

Without altering any of the adjustments check that the fuel delivery at 1,300 r.p.m. is 6.2 to 7.0 c.c. per 200 shots. Remove the shut-off lever adjustment tool.

(7) *Advance check*

Run the fuel pump at 1,300 r.p.m. Move the shut-off lever to the fully closed position and check that the advance reading is 33 to 43". Fit and seal the metering valve adjustment screw sealing cap with wire and a lead seal, using sealing pliers 18G 541.

NOTE.—If for any reason it is found necessary to tighten or slacken the governor control cover cap nut the settings made at (4) and (5) will be disturbed and operations (4), (5), (6), and (7) should be repeated.

(8) *Back-leakage*

Set the shut-off lever fully open and the throttle arm fully closed. Run the pump at 1,000 r.p.m.

and measure the back-leakage through the graduated measuring-glass. The back-leakage should be 5 to 50 cc. per 100 shot time cycle.

(9) Maximum fuel setting

NOTE.—Throughout this test the advance gauge must **show** a zero reading.

Run the pump at 1000 r.p.m. with both controls in their fully open position, when the average delivery for 200 shots from all four test injectors should be 6-9±.1 c.c. In arriving at this figure compare the delivery from all injectors to ensure that the difference in output from any two does not exceed .6 c.c. Before taking a reading the test oil in the measuring-glasses should be allowed to settle for 15 seconds and the measuring-glasses should be allowed to drain for 30 seconds before a fresh test is made.

To adjust the pump output, stop the test bench and turn the test oil feed cock to the 'off' position. Remove the cover-plate from the side of the pump housing to provide access to the interior of the pump. Slacken the two drive plate securing screws sufficiently to permit movement of the adjusting plates. Turn the pump drive until the slots in the peripheries of the drive plate and the top adjusting plate are visible through the aperture in the pump housing. Engage the end of the maximum fuel adjusting probe 18G656 in the slot in the top adjusting plate and tap the tool with a light hammer to move the plate in the required direction. The adjusting plate is turned in the same direction as normal pump rotation to increase the maximum output. Movement of the adjusting plate in the opposite direction will decrease the maximum output. This operation must be carried out very carefully as the amount of movement required will be very small. Tighten the drive plate securing screws to the torque figure given in 'GENERAL DATA', using tools 18G 537 and 18G 655A. While tightening the screws the torque wrench must be in line with the spanner (Fig. Ca.21). After making this adjustment replace the cover-plate and carry out the complete filling and priming operation. Re-check the fuel delivery and, if necessary, re-adjust the pump output.

(10) Fuel delivery

Decrease the pump speed to 100 r.p.m. and check the output. The average delivery for 200 shots should now be not less than that obtained when setting the pump maximum fuel output minus 1.5 cc. When carrying out this test use 30 seconds measuring-glass draining time and allow the test oil to settle for 15 seconds before taking a reading.

(11) Cut-off test

With the shut-off lever held in the fully closed position run the pump at 200 r.p.m. The average delivery for 200 shots, with the throttle arm in the fully open position should not exceed .8 cc.

(12) Throttle operation

With the throttle arm in the fully closed position unscrew the anti-stall screw until it is out of contact with the governor arm and tighten the locknut. Run the pump at 200 r.p.m. with the throttle arm still fully closed. The average delivery with the shut-off lever fully open should not exceed 1.0 cc. per 200 shots.

(13) Fuel delivery check

With both controls fully open run the fuel pump at 1,630 r.p.m. and record the average delivery per 200 shots.

(14) Governor setting

Increase the pump speed to 1,850 r.p.m. and set the throttle arm by means of the maximum speed adjustment screw to give a maximum average delivery of 1.0 c.c. per 200 shots. No line should exceed 1.8 c.c. Tighten the adjustment screw locknut.

(15) Fuel delivery check

Reduce the pump speed to 1,630 r.p.m. and re-check the fuel delivery. The average delivery now should not be less than that recorded in operation (13) minus -4 c.c. per 200 shots.

(16) Timing setting

This setting is made, after all the foregoing tests have been completed with the pump removed from the power-driven test bench.

It should be noted that, unlike the 'in-line' fuel injection pump, which has a static commencement of injection point, the point at which commencement of injection occurs in the distributor-type fuel injection pump varies according to the fuel requirements of the engine. The timing of the distributor type pump is carried out with the pumping plungers set to deliver maximum fuel on No. 1 injection line and with the plunger rollers in contact with the cam lobes: therefore, after all occasions of pump overhaul or adjustment to the pump output it is imperative that the pump timing is checked, and the timing mark on the pump flange remarked if necessary.

Remove the cover plate from the side of the pump housing and the four radial connections from the hydraulic head. Connect injector nozzle testing machine 18G 109 A to outlet 'V' on the hydraulic head by means of relief valve timing adaptor 18G 653 A. The relief valve should be set to operate at 30 atmospheres.

Turn the pump drive hub in the normal direction of rotation until the timing mark 'E' on the drive

plate becomes visible through the aperture in the side of the pump housing. Operate the handle of the test machine to apply a pressure of 30 atmospheres to the pump. This will force the pumping plungers outwards to the limit of their travel as the drive hub is turned. Continue turning the drive hub in the normal direction of rotation until resistance is encountered. With the pump held in this position mount flange marking gauge 18G648A, pre-set to 86°, on the pump quill shaft. Check that the timing mark on the pump flange lies along the scribing guide on the flange marking gauge. If necessary delete the old timing mark and scribe a new mark by drawing a scribing tool along the guide on the flange marking gauge.

Disconnect the pump from the test machine and fit the banjo pipes to the hydraulic head. Refit the cover-plate to the side of the fuel pump housing and seal the securing screws with wire and lead seal, using sealing pliers 18G 541.

Altitude settings

Follow the instructions in Section Ca.10.

Section Ca.14

AIR CLEANER (Oil Bath Type)

Removing

- (1) Release the clips and detach the air inlet tube and the breather hose from the air cleaner body.
- (2) Remove the screws retaining the air cleaner assembly to the left-hand valance.
- (3) Lift out the air cleaner assembly.

Refitting

- (4) Reverse the procedure in (1) to (3).

Section Ca.15

AIR CLEANER (Dry Type)

Removing

- (1) Remove the drive screw retaining the air intake hose clip to the radiator frame.
- (2) Release the clip and detach the breather hose from the air cleaner intake.
- (3) Remove the central wing nut, detach the air cleaner top cover and remove the element.
- (4) Release the air cleaner body from its support bracket.

- (5) Lift off the air cleaner body and intake hose as an assembly. Note the rubber air seal between the cleaner body and the intake manifold on the engine.

Refitting

- (6) Reverse the procedure in (1) to (5).

Section Ca.16

INJECTION PUMP (2.52-litre diesel engine)

The pump is as described in Sections Ca.6 and Ca.13, but with a type number DPA 3249F520 and the setting code stamped on the pump nameplate.

Later engines are fitted with a modified pump. This pump is as described above, but with a type number DPA 3342F110 and having two springs fitted to the linkage hook instead of a single spring.

Removing and replacing

Follow the instructions in Section Ca.7, noting that the correct injection timing for this pump is 23° B.T.D.C.

Maximum and idling speed adjustments

Follow the instructions given in Section Ca.13.

Dismantling and reassembling

Refer to the instructions given in Section Ca.13 and Section Ca.8.

Testing and adjusting

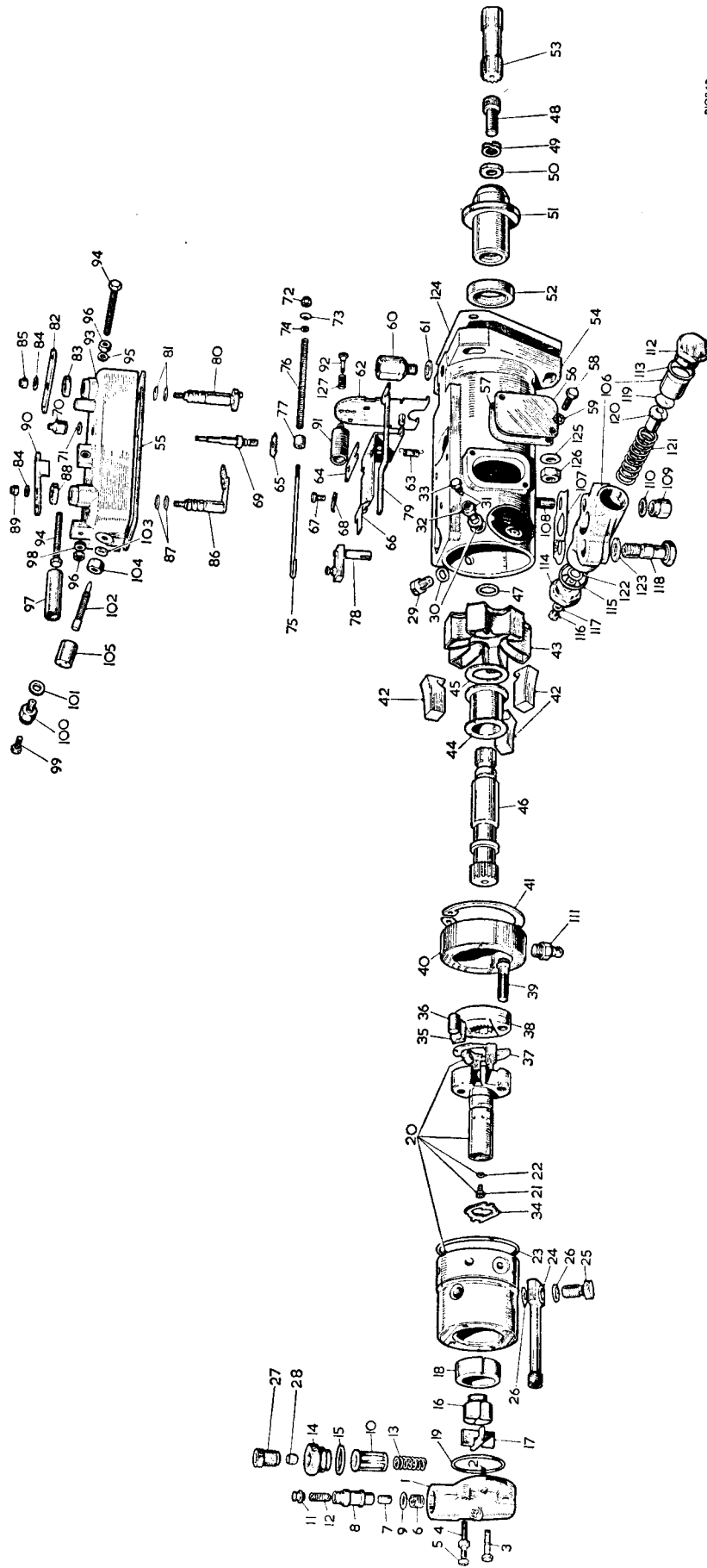
Conditions for test

1. The test equipment must be set to drive the pump in the direction of rotation indicated on the pump nameplate.
2. Fuel available at the injection pump inlet must be 1000 c.c./min. flow minimum, or 2 lb./sq. in. (-15 kg./cm.2) pressure maximum.
3. Test injectors must be a matched set with type BDN.12.SD.12 nozzles operating at 175 atmospheres.
4. Injector pipes should be 6 mm. x 2 mm. x 34 in. (865 mm.) long.
5. The injection pump throttle and shut-off levers must be in the fully open position except where otherwise stated.
6. All fuel delivery figures are for 200 shots.
7. Allow 30 seconds glass draining time and 15 seconds settling time when taking fuel delivery readings.
8. The maximum fuel delivery given in the test plan is for sea-level conditions. For continuous use above sea-level see Section Ca.10 for maximum fuel settings.

Test plan for pumps DPA 3249F520 and DPA 3342F110: Setting code A45/1200/4/3700

<i>Test No.</i>	<i>Description</i>	<i>R.P.M.</i>	<i>Requirements</i>	<i>Remarks</i>
1.	Transfer pump vacuum	100	16 in. (406 mm.) Hg within 60 seconds	Fuel supply turned off. After test, air-vent from hydraulic vent screw at 100 r.p.m.
2.	Transfer pressure	100	11 lb./sq. in. (.8 kg./cm.2) minimum	
3.	Transfer pressure	1,200	58 to 78 lb./sq. in. (4.1 to 5.5 kg./cm.2)	
4.	Advance position	1,200	1½° to 2°	Use metering valve adjustment screw to obtain this reading.
5.	Advance position	1,800	3¾° to 4¼°	Metering valve adjustment as in test 4. Shut-off lever fully closed. Lock valve adjustment screw and seal it using tool 18G 541.
6.	Backleakage	1,200	3 to 50 c.c. for 100 stroke time cycle	Throttle lever fully closed.
7.	Maximum fuel delivery	1,200	9.0 ± _{0.2} ⁰ c.c. average. Spread between lines not to exceed 1.0 c.c.	Adjust output by moving adjusting plate relative to drive plate with tool 18G 656. Tighten drive plate screws to correct torque with tool 18G 655 A.
8.	Fuel delivery check	100	Average as test 7 minus 3.2 c.c.	This is a minimum delivery figure.
9.	Cut-off operation	200	Average delivery 0.8 c.c. maximum	Shut-off lever fully closed.
10.	Throttle operation	200	Average delivery 1.0 C.C. maximum	Throttle lever fully closed and anti-stall screw unscrewed and locked.
11.	Fuel delivery check	1,650	Record delivery	
12.	Governor setting	1,850	Average delivery 1.8 c.c. maximum. No line to exceed 2.5 c.c.	Set throttle lever with maximum speed adjustment screw. Lock stop screw.
13.	Fuel delivery check	1,650	Average delivery as in test 11 minus 0.4 c.c.	This is a minimum figure. Throttle set as in test 12.
14.	Governor setting	1,850	Average delivery of 1-8c.c.	Set throttle with maximum speed adjustment screw. Lock stop screw.
15.	Timing			Adaptor 18G653 A (set at 30 atmospheres) connecting 18G 109 A to outlet 'V'. Apply fuel pressure, rotate drive hub with tool 18G648A (set at 86°) and mark pump flange with scribe.

THE DISTRIBUTOR-TYPE FUEL INJECTION PUMP COMPONENTS



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KEY TO THE DISTRIBUTOR-TYPE FUEL INJECTION PUMP COMPONENTS

<i>No.</i>	<i>Description</i>	<i>No.</i>	<i>Description</i>	<i>No.</i>	<i>Description</i>
1.	End plate.	44.	Thrust sleeve.	86.	Throttle shaft.
2.	Locating pin.	45.	Thrust washer.	87.	Seal for throttle shaft.
3.	Screw for end plate.	46.	Drive shaft.	88.	Dust cap for shaft.
4.	Stud for end plate.	47.	Drive shaft seal.	89.	Nut for shaft.
5.	Nut for stud.	48.	Drive shaft screw.	90.	Throttle arm.
6.	Piston retaining spring.	49.	Spring washer for screw.	91.	Governor spring.
7.	Regulating piston.	50.	Support washer.	92.	Guide for idling spring.
8.	Regulating sleeve.	51.	Drive hub.	93.	Control cover.
9.	Washer for sleeve.	52.	Drive hub seal.	94.	Adjusting screw.
10.	Filter.	53.	Quill shaft.	95.	Washer for adjusting screw.
11.	Regulating plug.	54.	Pump housing.	96.	Locknut for screw.
12.	Regulating spring.	55.	Gasket for control cover.	97.	Locking sleeve.
13.	Sleeve retaining spring.	56.	Cover-plate.	98.	Adaptor for sleeve.
14.	Inlet connection.	57.	Gasket for cover-plate.	99.	Vent screw.
15.	Washer for inlet connection.	58.	Screw for cover-plate.	100.	Vent screw body.
16.	Transfer pump rotor.	59.	Washer for screw (shakeproof).	101.	Washer for vent screw body.
17.	Transfer pump blade.	60.	Drain connection.	102.	Adjustment screw for metering valve.
18.	Transfer pump liner.	61.	Washer for connection.	103.	Washer for nut.
19.	Transfer pump seal.	62.	Governor arm.	104.	
20.	Hydraulic head and rotor assembly.	63.	Spring for governor arm.	105.	Sealing cap.
21.	Rotor plug.	64.	Keep plate.	106.	Automatic advance device housing and piston.
22.	Washer for plug.	65.	Tab washer.	107.	Gasket for housing.
23.	Hydraulic head seal.	66.	Control bracket.	108.	Stud for housing.
24.	Banjo pipe.	67.	Screw for bracket.	109.	Cap nut for stud.
25.	Bolt for banjo pipe.	68.	Tab washer for screw.	110.	Washer for cap nut.
26.	Washer for bolt.	69.	Stud for control cover.	111.	Cam advance screw.
27.	Fuel feed pipe connection.	70.	Nut for stud.	112.	Piston plug.
28.	Olive for fuel feed pipe.	71.	Washer for stud.	113.	Seal for plug.
29.	Hydraulic head locking screw.	72.	Linkage nut.	114.	Piston spring cap.
30.	Washer for screw.	73.	Pivot ball washer.	115.	Seal for cap.
31.	Hydraulic head vent screw assembly.	74.	Linkage washer.	116.	Screw for cap.
32.	Vented locking screw for hydraulic head.	75.	Linkage hook.	117.	Washer for screw.
33.	Vent screw.	76.	Linkage spring.	118.	Head locating bolt.
34.	Adjusting plate (bottom).	77.	Spring retainer.	119.	Slide washer.
35.	Roller shoe.	78.	Metering valve.	120.	Maximum advance stop.
36.	Roller	79.	Shut-off bar.	121.	Spring for stop.
37.	Adjusting plate (top).	80.	Shut-off Shaft.	122.	Shim washer for spring.
38.	Drive plate.	81.	Seal for shut-off shaft.	123.	Washer for head locating bolt.
39.	Drive plate screw.	82.	Shut-off lever.	124.	Joint washer for pump mounting flange.
40.	Cam ring.	83.	Dust cap for shaft.	125.	Washer for nut.
41.	Locating circlip for cam ring.	84.	Washer for shaft.	126.	Nut for injection pump mounting bolt.
42.	Governor weight.	85.	Nut for shaft.	127.	Idling spring.
43.	Retainer for governor weights.				