

FUEL SYSTEM

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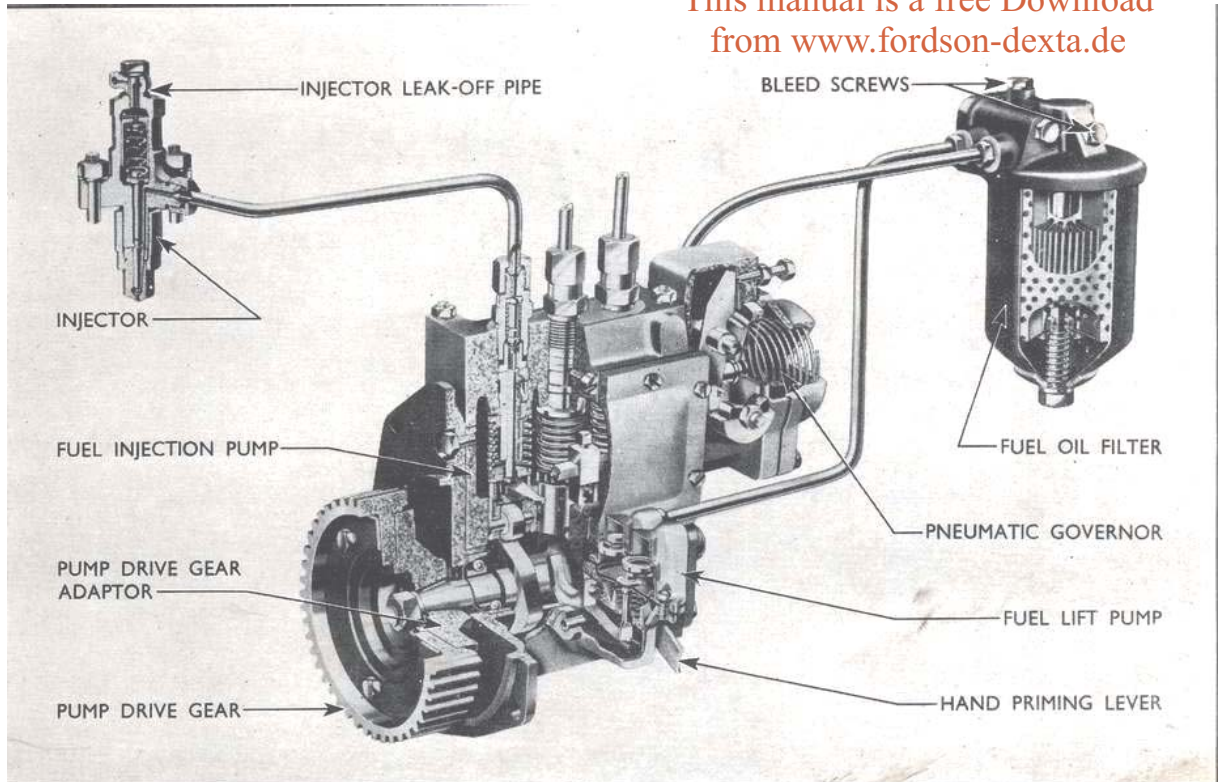


Fig. 1
Fuel Injection System

The diesel fuel system comprises a fuel tank, diaphragm type lift pump, renewable element filter, injection pump and injectors (see Fig. 1).

The lift pump, operated by an eccentric on the injection pump camshaft, supplies fuel under slight pressure, through the filter to the injection pump.

The injection pump, consisting of three pumping elements, accurately meters the fuel before passing it under high pressure to the two-hole injectors. The spring-loaded nozzle valve in each injector ensures that the high pressure fuel from the injection pump enters the cylinders in a highly atomised state. Fuel, which leaks past the injector nozzle valve, lubricates the valve stem before returning to the fuel tank via a common leak-off pipe.

Incorporated in the injection pump is a pneumatic governor which adjusts the fuel delivery according to engine speed and load requirements.

Located in the main fuel gallery of the injection pump adjacent to the inlet adaptor is a gallery damper. This consists of a rubber diaphragm fitted in a sealed metal casing; its function being to dampen any fluctuations in fuel pressure within the gallery.

ROUTINE SERVICING OF THE FUEL SYSTEM

The purpose of the following servicing operations is to ensure that the high performance of the fuel injection system is maintained, so obtaining maximum efficiency from the engine. All the operations listed can be accomplished with the fuel injection pump installed on the tractor.

Some of the operations are regular service items and should be dealt with at the recommended intervals during normal servicing.

FUEL FILTER

The element of the fuel oil filter should be renewed at intervals not exceeding 600 working hours.

To Renew the Fuel Filter Element

1. Unscrew the centre bolt from the filter, remove the filter body and discard the element (see Fig. 2). Using a brush and clean fuel oil, thoroughly clean the interior of the filter body. **On no account use rag for this operation.**

2. Fit a new element to the filter body and a new sealing ring in the groove in the filter head. Tighten the centre bolt to a torque of 10 lbs. ft. (1.38 Kg.m.).
3. It will now be necessary to bleed the fuel system as detailed below.

BLEEDING THE FUEL SYSTEM

1. Ensure that there is sufficient fuel in the tank and that all the fuel pipe connections are tight.
2. Remove the two bleed screws from the top of the fuel filter (see Fig. 3), and operate the priming lever on the fuel lift pump until a stream of fuel free from air bubbles issues from the filter. Replace and tighten first the inlet and then the outlet bleed screws as the priming lever returns to its uppermost position.

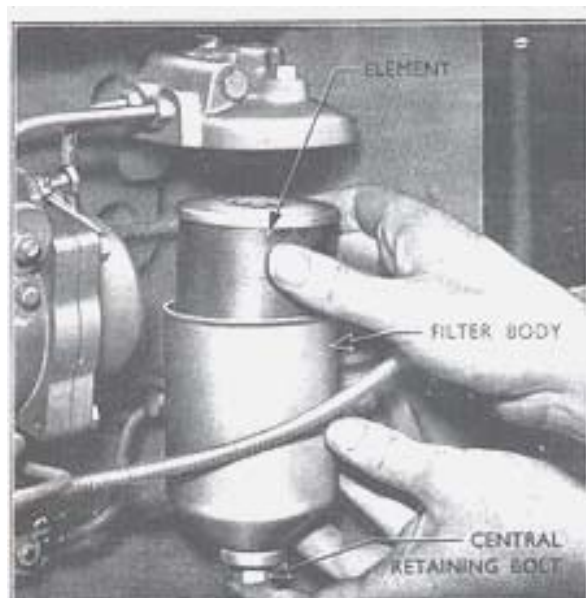


Fig. 2

Changing the Fuel Filter Element

3. Loosen the bleed screw on the fuel injection pump approximately three turns and operate the lift pump as before, tightening the bleed screw when the air bubbles cease and a solid stream of fuel flows from the pump.
4. Wipe all surplus fuel from the exterior of the filter and the fuel injection pump.

NOTE.—Never lever the injection pump plungers up and down to bleed the injection pipes or test the injectors.

FUEL INJECTORS

The injectors should normally be removed for testing and servicing, at intervals not exceeding 600 working hours. For details of removing, testing, cleaning and replacing, refer to page 16 of this section.



Fig. 3

Bleeding the Fuel System

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AIR CLEANER

The air cleaner consists of a primary cleaner mounted on top of the main air cleaner, the whole assembly being bolted to the battery heat baffle and connected by a rubber hose to the inlet manifold.

The air cleaner should be removed and cleaned at intervals of 600 hours, or at shorter intervals if the tractor is working in extremely dusty conditions. It must be remembered that any obstruction such as a choked primary air cleaner or gauze screen in the main air cleaner, or dirty oil in the oil bath will



Fig. 4

Removing the Air Cleaner Base

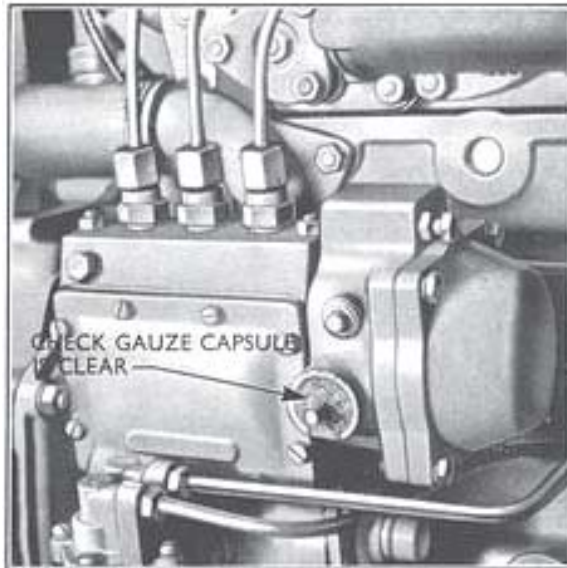


Fig. 5
Governor Filter Capsule

cause a decrease in maximum engine revolutions resulting in loss of engine power.

To Remove and Clean the Air Cleaner

1. Remove the primary air cleaner, vertical exhaust silencer (where fitted) and the engine bonnet (four nuts and screws).
2. Disconnect the battery leads and remove the battery.
3. Loosen the clamp securing the oil bath base to the main body of the air cleaner and remove the base and gauze filter (see Fig. 4).
4. Disconnect the throttle link from the outer end of the throttle friction pad lever assembly at the air cleaner bracket.
5. Loosen the clamp at the air cleaner end of the air inlet hose.
6. Remove the split pin securing the horizontal throttle operating rod to the inner end of the throttle friction pad lever assembly, and remove the flat washer and spring washer fitted behind the split pin.
7. Remove the four bolts securing the main body of the air cleaner to the battery heat baffle and remove the air cleaner.
8. Thoroughly wash out the oil bath base, removable gauze filter, primary air cleaner and the fixed gauze filter in the main body, using paraffin.

To Replace the Air Cleaner

1. Refit the main body of the air cleaner to the battery heat baffle, entering the pin on the swivel block at the end of the horizontal throttle operating rod into the hole on the inner end of the throttle friction pad lever assembly. Replace the four retaining bolts and tighten securely.

2. Replace the air inlet hose and securely tighten the clamp.
3. Reconnect the throttle link to the outer end of the throttle friction pad lever assembly.
4. Refill the oil bath base with clean engine oil of the approved grade, up to the level of the step in the base. Replace the base and gauze filter in position on the main body of the air cleaner and tighten the retaining clamp securely.
5. Replace the battery and reconnect the leads.
6. Replace the engine bonnet (four nuts and screws), vertical exhaust silencer (where fitted) and the primary air cleaner.

PNEUMATIC GOVERNOR AIR FILTER CAPSULE

To ensure satisfactory operation of the governor, the air filter capsule, fitted under the small plate on the front half of the governor case, should be inspected and cleaned if necessary, every 200 hours.

If the filter capsule is dirty it will cause sluggish operation of the governor.

To Remove, Clean and Replace

1. Unscrew the self-locking nut and remove the plate covering the filter capsule (see Fig. 5).
2. Inspect the capsule for signs of dirt and if necessary, remove the capsule, wash it thoroughly in paraffin, lubricate with engine oil and replace in position in the governor case.
3. Replace the plate and self-locking nut.

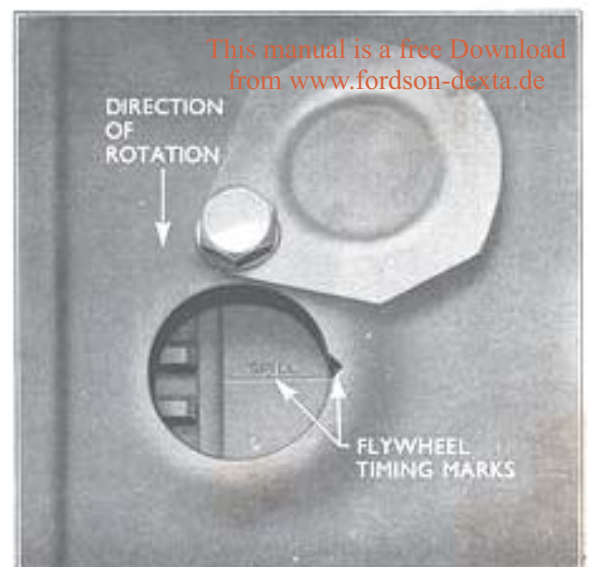


Fig. 6
Flywheel Timing Marks

CHECKING AND ADJUSTING THE INJECTION PUMP TIMING

Correct injection pump timing can be checked as follows :—

1. Remove the flywheel inspection plate located on the left-hand side of the clutch housing and turn the engine crankshaft until the line marked "SPILL" on the flywheel corresponds with the notch in the clutch housing, with No. 1 piston on its compression stroke (see Fig. 6).
2. Remove the fuel pump timing plate from the left-hand side of the timing case, and if the injection pump is correctly timed, the timing mark on the fuel pump drive gear adaptor should coincide with the timing pointer cast on the pump mounting flange (see Fig. 7). The timing mark on the adaptor must not be confused with a second mark immediately above it stamped "S" which corresponds with T.D.C.
3. If, however, the timing mark is out of alignment with the indicator, remove the four setscrews retaining the inspection plate to the front of the timing case cover, and remove the plate.
4. Slacken the three setscrews securing the fuel pump gear to the fuel pump gear adaptor (see Fig. 8), and turn the fuel pump camshaft, using a suitable spanner on the adaptor retaining nut, until the timing marks coincide.
5. Tighten the fuel pump gear setscrews securely, taking care not to move the gear relative to the adaptor.
6. Replace the inspection plate on the timing case cover, the fuel pump timing plate on the timing case, and the flywheel inspection cover on the clutch housing.

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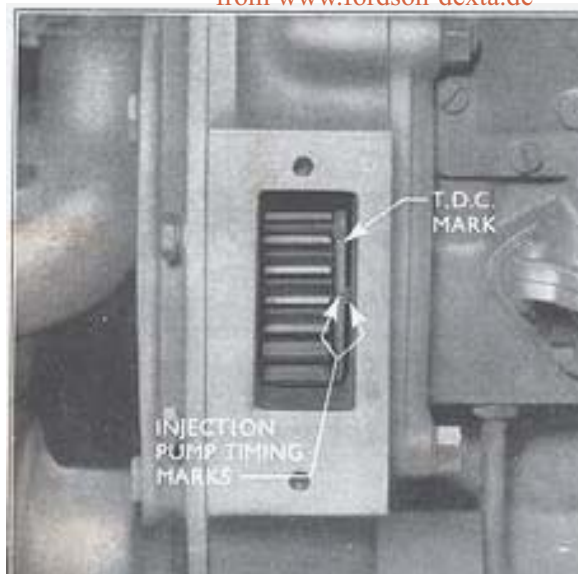


Fig. 7
Fuel Injection Pump Timing Marks

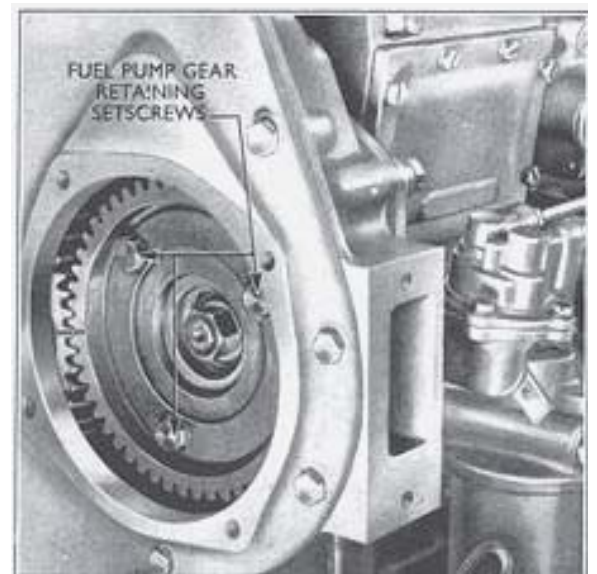


Fig. 8
Fuel Injection Pump Gear

TO RENEW THE PNEUMATIC GOVERNOR DIAPHRAGM

If it is suspected that the governor operation is faulty, the governor diaphragm can be checked for leakage by removing the governor pipe from the fuel injection pump and pulling the stop control lever rearwards to compress the diaphragm spring. Seal the governor connection, release the stop lever and there should be no movement on the control rod. If movement of the control rod is observed, it indicates a leakage past the diaphragm assembly.

1. Remove the four setscrews securing the rear half of the governor case to the front half, remove the rear half of the case and the governor spring.
2. Pull out the diaphragm assembly and remove the split pin and washer which secure it to the rocker assembly.
3. Fit the centre shaft of the new diaphragm assembly in position over the pin on the rocker assembly, and fit a flat washer and a new split pin. Push the diaphragm into position in the front half of the governor case, ensuring that the small pip on the diaphragm locates in the recess in the case (see Fig. 9).
4. Replace the governor spring and the rear half of the governor case, and tighten the four setscrews evenly. The clip for the stop control cable fits under the head of the lower right-hand screw.
5. Refit the governor pipe and test the governor operation as detailed previously.

SETTING ENGINE IDLING SPEED

With the engine at its normal operating temperature, set the idling stop screw on the inlet manifold so that the idling speed is 550 r.p.m. After adjustment secure the screw in position with the locknut.

SETTING MAXIMUM "NO LOAD" SPEED

The maximum "No Load" speed is 2,200 r.p.m., and if necessary it can be adjusted by means of the maximum speed screw on the inlet manifold. After adjustment, re-seal the screw.

The engine speed can be accurately checked and adjusted with the aid of a tachometer capable of being driven from the end of the P.T.O. shaft, rear end of the fuel injection pump camshaft or the periphery of the engine fan belt.

When checking the engine speed from the P.T.O. shaft, the P.T.O. shifter must be in the engaged position. Multiply the tachometer reading by 2.895 to obtain the engine speed.

To calculate the engine speed when the tachometer is driven from the fuel injection pump camshaft, multiply the tachometer reading by two.

If you are checking engine speed by running the tachometer from the periphery of the fan belt, divide the effective diameter of the crankshaft pulley, which is 5.2 ins. (13.2 cm.); by the diameter of the tachometer adaptor wheel. Then divide the tachometer reading by the figure thus obtained to get the equivalent engine speed.

Example—

Effective diameter of crankshaft pulley
= 5.2 ins. (13.2 cm.)

Diameter of tachometer wheel adaptor
= 2.0 ins. (5.1 cm.)

5.2 ins. (13.2 cm.) divided by 2 ins. (5.1 cm.)
= 2.6

If a tachometer reading of 5,200 is obtained, dividing this by 2.6 gives an engine speed of 2,000 r.p.m.

TO RENEW A DELIVERY VALVE AND GUIDE

The replacement of the delivery valve and guide assembly, and/or spring, should only be carried out in an emergency, as the characteristics of the new parts may slightly alter the fuel delivery from the element concerned.

The pump calibration should therefore be checked and adjusted as soon as possible after the new parts have been fitted. The delivery valve and guide are a matched assembly and must always be replaced as a pair.

1. Remove the injector pipe from the delivery valve holder of the element concerned, unscrew the delivery valve holder (use tool No. CT.9008) and extract the valve together with the spring and volume reducer.

2. With the respective plunger at the bottom of its stroke insert the expanding end of the delivery valve guide extractor (Tool No. CT.9022) into the valve guide bore, until the projecting lips of the tool locate against the underside of the valve guide. Turn the

engine slowly, and the guide, with its washer, will be pushed out of the pump body.

3. Thoroughly rinse the new delivery valve guide and washer, and press the guide and washer into the bore until it touches the top of the plunger barrel.

4. Thoroughly clean the delivery valve, spring and volume reducer and fit them to the valve guide.

5. Replace the delivery valve holder and tighten to a torque of 30 lbs. ft. (4.15 Kg.m.).

6. Replace the injector pipe and ensure that each end is seating correctly before the union nuts are tightened.

FUEL INJECTION PUMP

The injection pump is of the fully enclosed camshaft, self-contained, constant stroke type, and is gear driven at half engine speed from the crankshaft gear, by an idler gear.

The pump has three elements, each consisting of a barrel and plunger, operated by a camshaft through roller tappets. Helical springs return the plungers on their downward stroke.

An arm at the lower end of each plunger engages with a fork mounted on the control rod, and movement of this rod causes the plungers to turn within their barrels. The barrels are prevented from rotating by screws locating them in the pump housing. Attached to the control rod at the rear end by a rocker assembly are the pneumatic governor and the stop control device.

Above each pumping element is a delivery valve and guide which act as a non-return and unloading valve.



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Fig. 9
Removing the Governor Diaphragm



Fig. 10
Injection Pump Element

Fuel from the filter enters the pump at the inlet adaptor and then passes into the injection pump gallery. Fuel fills the barrels through the ports when the plungers are in their lowest positions.

The plunger and barrel assembly are of hardened steel, ground and lapped to each other to give a small working clearance. One of the two diametrically opposite ports in the barrel, through which fuel is supplied to the plunger can be seen in Fig. 10. This illustration shows the barrel on the left-hand side and the plunger on the right. The arm at the bottom of the plunger allows the plunger to be rotated in the barrel.

THE PNEUMATIC GOVERNOR

The pneumatic governor shown diagrammatically in Fig. 11, consists of two units; the throttle unit in the inlet manifold connected by the suction pipe to a diaphragm unit mounted on the rear of the fuel injection pump.

When the engine is stopped, the governor spring pushes the diaphragm and the control rod to the left, the maximum fuel delivery position. As soon as the engine starts, the high air speed past the almost closed throttle plate and suction pipe orifice creates a high vacuum in the diaphragm chamber which causes the diaphragm and fuel pump control rod to be drawn towards the right, reducing the fuel delivery.

When the engine is operating under load with the throttle plate fully open, the vacuum in the diaphragm chamber is low, due to the low air speed past the throttle valve, and the diaphragm and control rod is held in the maximum fuel delivery position by the governor spring.

Any variation in the setting of the throttle plate or engine load causes a variation in the air speed past the throttle plate, and consequently, a change in vacuum in the diaphragm chamber, and so varies the fuel delivery.

REMOVING THE INJECTION PUMP

1. Hold the delivery valve holders (tool No. CT.9008), and remove the injector pipes by unscrewing the union nuts evenly at each end.
2. Turn the fuel tap to the "OFF" position and remove the fuel feed pipes, oil level drain pipe and the governor pipe from their locations on the injection pump.
3. If a proofmeter is fitted, remove the drive cable from the rear end of the fuel injection pump camshaft.
4. Disconnect the stop control inner and outer cables from the stop control lever and outer cable retaining clip on the fuel injection pump.
5. Unscrew the five retaining nuts and spring washers, and remove the pump from its location on the timing case.

NOTE.—Protect the pump and disconnected pipes against the entry of dirt by fitting suitable dust caps and plugs.

PRELIMINARY CHECKING

It is advisable to remove the fuel injection pump and check the phasing and calibration whenever the engine is undergoing major attention. Inaccuracies in either can then be corrected and the highest possible performance maintained.

Full details of phasing and calibrating are given on

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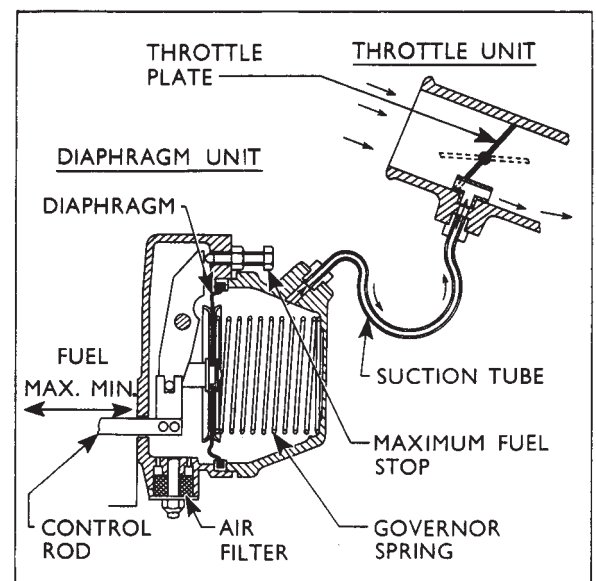


Fig. 11
Pneumatic Governor

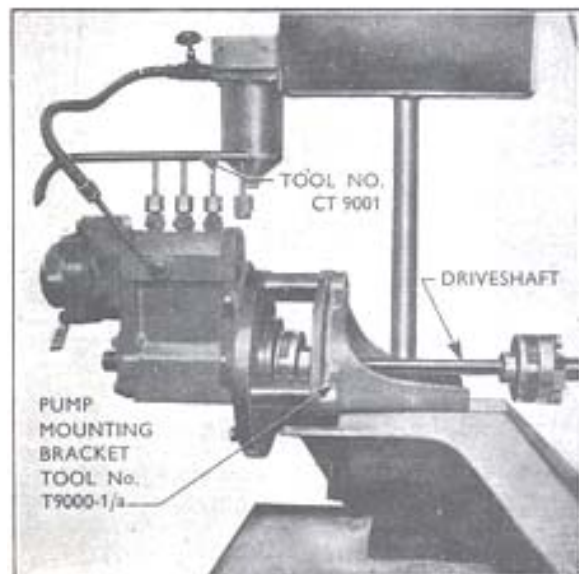


Fig. 12
Injection Pump Flushing Pipe

page 11. It should be noted, however, that it is not necessary to remove the plunger springs in order to check the phasing of a completely assembled pump.

Before carrying out any checking operations on the pump, ensure that it is thoroughly clean—internally and externally—making use of the pump flushing pipe.

Seal all unions on the pump with dust plugs and caps, and wash the exterior of the pump in clean fuel or substitute oil. Mount the pump on the calibrating machine and fit the pump flushing pipe (tool No. CT.9001) to the delivery valve holders (see Fig. 12). A blanking plug is required in the unused union on the pipe to prevent leakage at this point.

Run the pump for a short time to clear any dirt that may be present which could damage the master injectors on the calibrating machine. The fuel removed during the flushing operation must not be re-used for testing purposes.

Every precaution must be taken after cleaning the pump to ensure that dirt does not enter the pump, i.e. seal all unions with the appropriate dust plugs and always check and overhaul the pump in a dust-proof room.

Dismantling the Fuel Injection Pump

1. Unscrew the two nuts and remove the fuel lift pump from the fuel injection pump.
2. Remove the governor diaphragm as described on page 4.
3. Drive out the groove pin securing the stop control lever to the stop control shaft (see Fig. 13).
4. Remove the spring clip from the outer end of the stop control shaft (lift pump side) and if fitted, remove the shim or shims from behind the clip.

5. Pull the governor link over towards the stop control lever, compressing the return spring, and remove the spring clip which is fitted on the stop control shaft adjacent to the governor link.

6. Remove the stop control shaft from the governor housing taking care to note the number of shims fitted at the cranked end of the shaft. The shims fitted here and at the other end of the shaft are to ensure the rocker assembly is centrally located in relation to the maximum fuel stop screw.

7. Remove the governor link, stop control lever and return spring.

8. Unscrew the eight setscrews and remove the inspection cover and gasket from the front of the pump.

9. Remove the control rod after loosening the screws on the control rod forks.

10. Remove the two setscrews and the countersunk screw, retaining the front half of the governor case to the cambox, and remove the case.

11. To assist subsequent removal slacken the three delivery valve holders.

12. Lay the pump on its side and remove the four nuts and spring washers, retaining the pump body to the cambox and lift off the body complete with plungers, spring discs and springs.

NOTE.—Plungers and barrels are a lapped fit to one another. They should be kept as matched assemblies and under no circumstances must they be interchanged.

13. Remove the plungers, springs and spring discs from the barrels. The shims between the plunger foot and the lower spring disc should be retained on each plunger. Keep the plungers in sequence so that

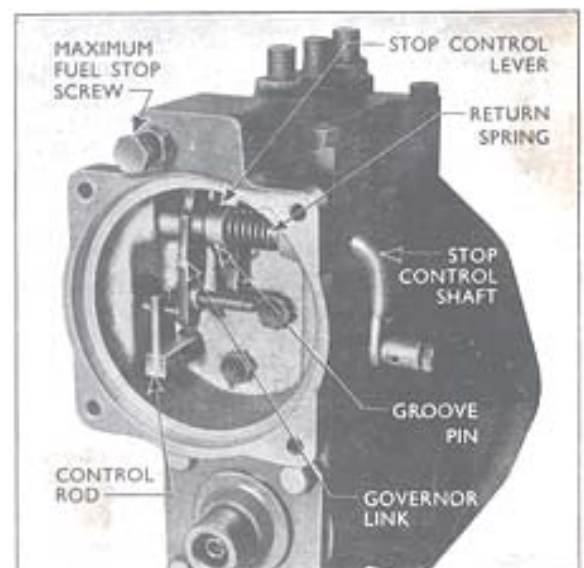


Fig. 13
Pneumatic Governor Linkage

they can be paired up with their respective barrels when they are removed.

14. Unscrew the delivery valve holders, and lift out the volume reducer, spring and delivery valve from each element.

NOTE.—Delivery valves and their guides are a lapped fit to one another and should be kept as matched assemblies and never interchanged.

15. Unscrew the barrel locating screws, one at a time and push the barrels upwards, forcing out the delivery valve guides and washers. Then extract the barrels.

NOTE.—The delivery valves should now be paired with their respective guides and the plungers with their barrels.

16. Lift the roller type tappets from the cambox and retain them in correct sequence. Tappets should not be interchanged as the phasing spacers at their top ends have been selected to provide the correct phase angles between injections.

17. Unscrew the three setscrews retaining the injector pump gear to the adaptor, and remove the large retaining plate and gear.

18. Remove the pump gear adaptor retaining nut using a suitable spanner and the adaptor holding handle (tool No. T.9040).

19. With the thrust button (T.9041 d) located over the adaptor end of the pump camshaft, remove the adaptor, using the puller (tool No. T.9041) and the three screwed adaptors (T.9041 b). Remove the Woodruff key from the camshaft.

NOTE.—It is advisable at this stage to check the camshaft end-float as described on page 9.



Fig. 14
Removing the Camshaft Outer Races

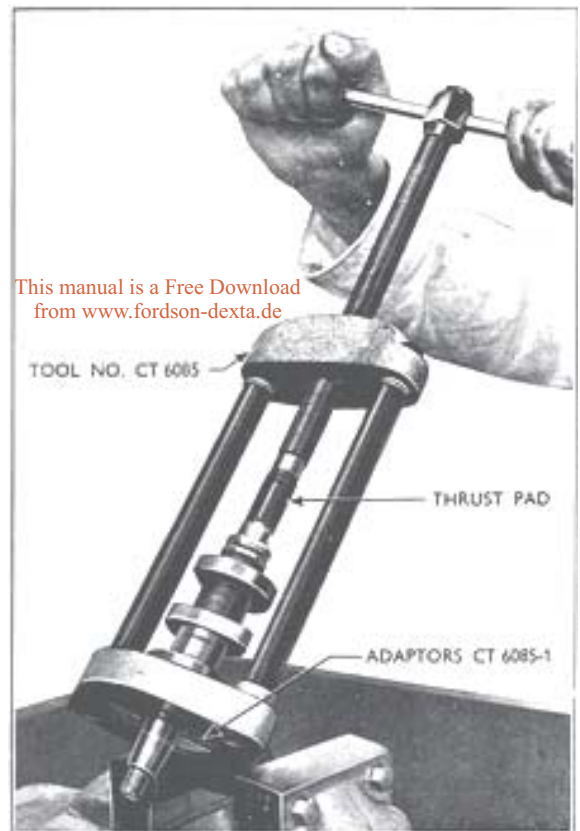


Fig. 15
Replacing the Camshaft Inner Races

20. Remove the four bolts retaining the proofmeter drive end bearing housing to the cambox, and with the thrust button (CT.6085-2b) over the mounting flange end of the camshaft, tap this end of the camshaft to remove the bearing housing from the cambox.

21. Unscrew the five bolts retaining the mounting flange bearing housing to the cambox, and with the thrust button (CT.6085-2a) over the proofmeter drive end of the camshaft, tap the camshaft at this end to remove the bearing housing.

NOTE.—A rubber "O" ring is fitted in a recess at the back of the mounting flange to prevent oil leakage at this point.

22. Withdraw the camshaft from the cambox and remove the bearing ball cages from each end of the camshaft ; these are finger-tight.

23. Remove the inner races of the bearings from the camshaft, using the puller (tool No. CT.6085) and the split adaptors (CT.6085-1). Use a thrust pad on the camshaft to avoid damage to the ends of the shaft. The long thrust pad (CT.6085-2a) fits the proofmeter drive end of the camshaft, and the short pad (CT.6085-2b) the adaptor end. Shims are fitted behind the inner races for adjusting camshaft end-float, and care should be taken to ensure that these shims are returned to their original positions on the camshaft when the pump is reassembled.

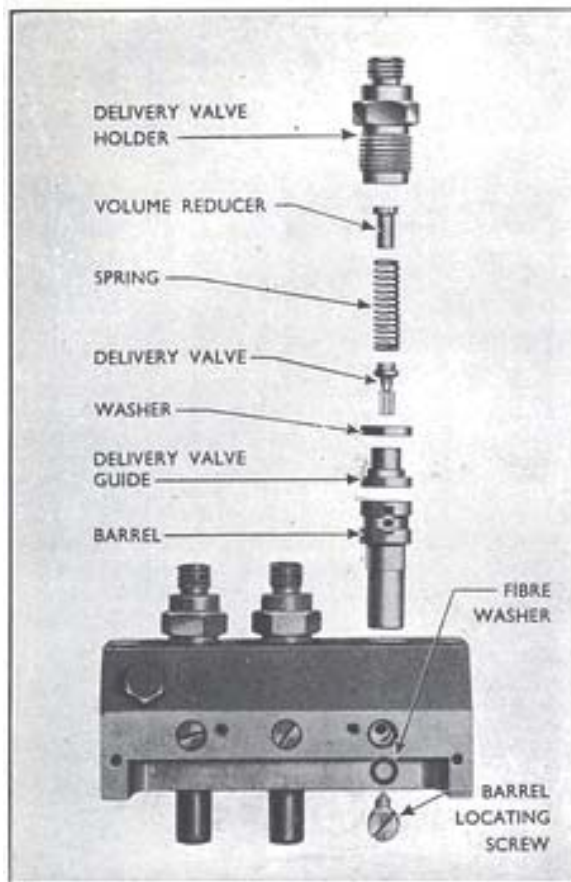


Fig. 16
Delivery Valve and Guide

24. Remove the camshaft bearing outer races from both the bearing housings using the puller (tool No. CT.9018), as shown in Fig. 14.

25. Remove the oil baffle washers and oil seals from the housings. The oil seals are a light press fit in the housings.

NOTE.—All the component parts of the pump should be thoroughly washed in clean fuel or substitute oil, inspected for wear, and new parts fitted where necessary.

Reassembling the Injection Pump

1. Fit new oil seals to the bearing housings with the seal springs facing inwards.

2. Replace the oil baffle washers with the inner step towards the oil seal and fit the outer races of the camshaft bearing into the bearing housings, using the driver (tool No. CT.9019).

3. Fit the camshaft bearing inner races with the same shims fitted behind them as were removed, using the replacer (tool No. CT.6085), split adaptors (tool No. CT.6085-1), and the appropriate thrust pad (see paragraph 23 above) as shown in Fig. 15.

4. Push the ball cages into position on the inner races by hand.

5. Refit the rubber “O” ring in the recess in the mounting flange bearing housing and replace the bearing housing. Replace the camshaft and the proofmeter drive end bearing housing, and secure both housings in position with the appropriate bolts and spring washers.

6. Using the adaptor (tool No. CT.9017-1) and a dial indicator gauge (CT.9017), check the camshaft end-float (see Fig. 17). This should be between .002 to .006 in. (.051 to .152 mm.). Shims .004 to .008 in. (.1 to .2 mm.) thick are available for correcting end-float.

When the end-float is satisfactory, remove the two bearing housings and pack the bearings with light grease. Smear the bearing housing mating faces with jointing compound and replace the housings. Retain securely in position with the appropriate bolts and spring washers.

7. Fit the Woodruff key to the end of the camshaft, replace the gear adaptor, and secure with a nut and spring washer. Tighten the nut to a torque of 45 lb. ft. (6.22 Kg.m.).

8. Refit the rollers, bushes and pins to the tappet bodies and install the tappets in their original bores in the cambox.

NOTE.—If the original plungers and barrels are being refitted to the pump there is no need to change the phasing spacers in the tappets, provided they do not show signs of wear. If, however, new plungers and barrels are being fitted, a spacer of intermediate thickness, marked 3, should be fitted in each tappet.

Use the special pliers (tool No. 7065) to remove the tappet circlip. When refitting the circlip its convex face should be adjacent to the spacer.

The following phasing spacers are available and are identified by a number stamped on their underside.

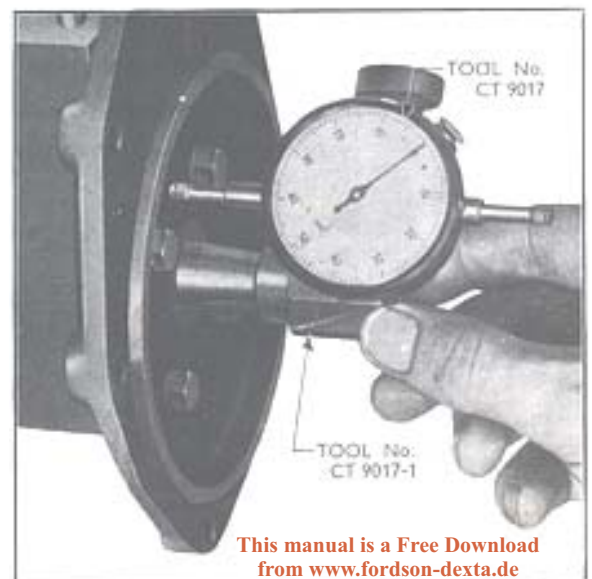


Fig. 17
Checking Camshaft End-float

Identification No.	Thickness
1	0.179 in. to 0.181 in. 4.55 mm. to 4.60 mm.
2	0.183 in. to 0.185 in. 4.65 mm. to 4.70 mm.
3	0.187 in. to 0.189 in. 4.75 mm. to 4.80 mm.
4	0.191 in. to 0.193 in. 4.85 mm. to 4.90 mm.
5	0.195 in. to 0.197 in. 4.95 mm. to 5.00 mm.

It is essential that even when original barrels, plungers and tappet phasing spacers are refitted to a pump, the phasing of all elements is checked and adjusted where necessary.

9. Rinse the barrels thoroughly in clean fuel or substitute oil and fit them into their appropriate bores whilst wet. Fit the barrel locating screws, with new fibre washers, to the pump housing. Before tightening the screws, ensure that they locate in the slots in the barrels, so as to ensure that the barrels cannot rotate. Fully tighten the screws and check that the barrels are free to move up and down slightly.

10. Fit the delivery valve guides, with new sealing washers, to the pump housing after rinsing thoroughly in clean fuel or substitute oil (see Fig. 16).

11. Fit the delivery valves, springs and volume reducers to their respective guides, and loosely screw in the delivery valve holders after washing all parts in clean fuel or substitute oil.

12. Rinse the plungers, then insert them in their respective barrels and check that they are perfectly free. Refit each plunger, omitting the shim, lower spring disc, spring and upper spring disc at this stage so that the phasing may be checked more easily.

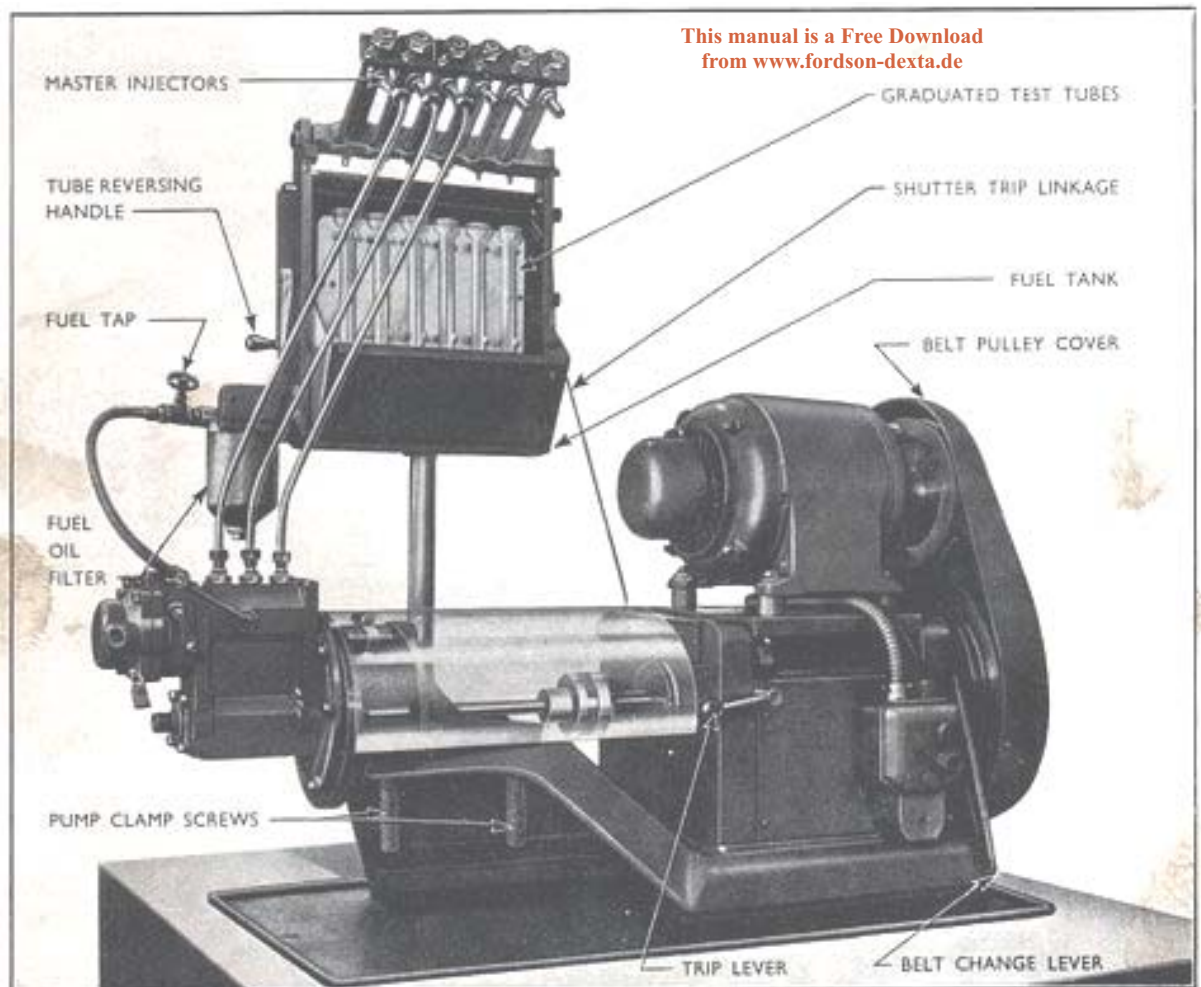


Fig. 18
Calibrating and Phasing Test Equipment

Holding the lower ends of the plungers, fit the pump housing to the cambox ensuring that with the pump laying on its side the plunger arms face upwards into their slots in the tops of the tappets. Securely tighten the four nuts, fitted with spring washers, securing the housing to the cambox.

13. Mount the pump on the calibrating machine (see Fig. 18). Ensure that there is approximately .010 in. (.25 mm.) end-float of the pump drive shaft, and that the grub screw on the movable coupling is tightened fully.

14. Refit the fuel lift pump and gasket, and secure with two nuts and spring washers. Add engine oil to the cambox until it runs out of the oil level hole at the base of the pump.

15. Check that there is sufficient clean fuel or substitute oil in the fuel container on the calibrating machine and connect the fuel feed pipe to the fuel lift pump inlet connection. Fit the special flexible pipe (tool No. T.9000-1N) between the outlet side of the fuel lift pump and the fuel injection pump gallery inlet connection. Turn on the fuel tap and bleed the system at the two air bleed screws on the filter and the one on the pump. Tighten all delivery valve holders to a torque of 30 lbs. ft. (4.15 Kg.m.).

PHASING THE FUEL INJECTION PUMP

Phasing is an adjustment whereby each successive element of the pump is timed to commence injection at the correct angle relative to the preceding one. As this is a three cylinder pump each successive element must be phased so that its spill cut-off is at 120° to the preceding one. This can be arranged by varying the thickness of the phasing spacers interposed between the camshaft roller tappet and the plunger.

The injection order of the pump is 1, 2, 3 ; No. 1 element being at the drive end.

The principle of spill timing is shown in the diagrammatic illustration (Fig. 19). Phasing operations are given in their correct sequence on this page and are followed by the method of calibrating.

SPILL CUT-OFF SETTING

Spill cut-off is the point at which the plunger top just covers the barrel ports ; this point can be set accurately by the following method:—

The left-hand view of Fig. 19 shows the pump plunger at the bottom of its stroke. Fuel can flow into the barrel through both ports and out through the spill pipe attached to the delivery valve holder.

When the camshaft is rotated, the plunger rises until it eventually just covers the supply ports, as shown in the right-hand view, cutting off the fuel supply and terminating the flow from the spill pipe.

If the camshaft is rotated very slowly, the precise point at which the fuel ceases to flow from the spill pipe can be ascertained. This is the spill cut-off point.

PHASING OPERATIONS

1. Commence phasing the injection pump at No. 1 element (nearest to the drive end). Open the belt pulley cover of the calibrating machine at right-angles so that the brake mounted behind the lower pulleys is operated against them. Then ensure that the driving belt is fitted to the 200 r.p.m. pulley (see Fig. 20).
2. Unscrew No. 1 delivery valve holder and remove the delivery valve, spring and volume reducer. Replace the delivery valve holder and tighten all the holders to a torque of 30 lbs. ft. (4.15 Kg.m.).
3. Fit the spill cut-off pipe (tool No. CT.9023) to No. 1 delivery valve holder.

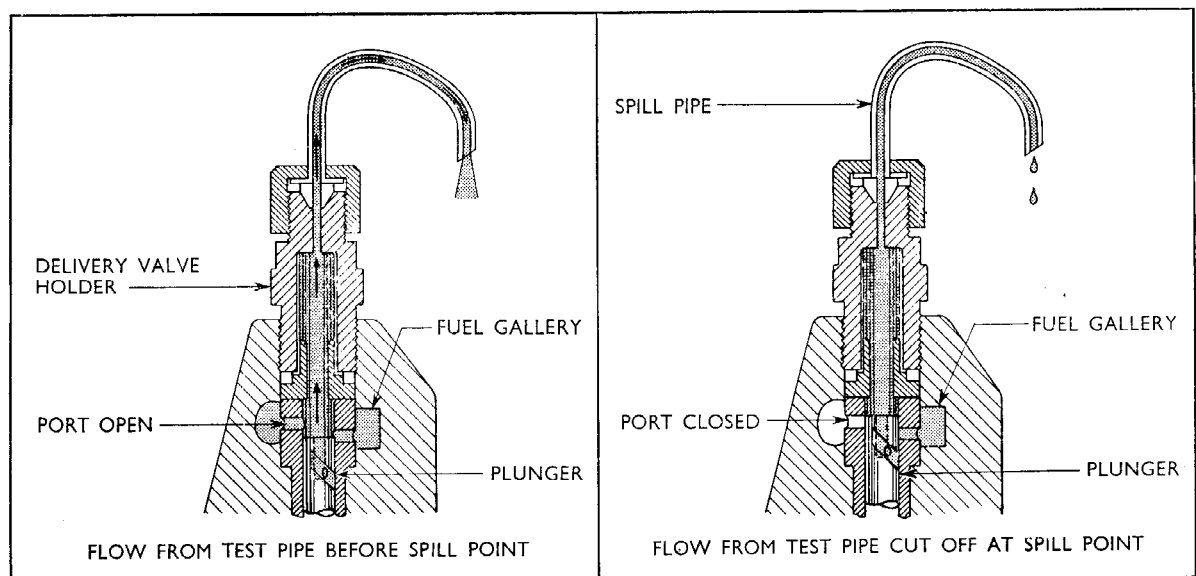


Fig. 19
Principle of Spill Timing

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4. Set the arms at the lower end of the plungers fully to the left—the maximum fuel delivery position—and rotate the camshaft until No. 1 plunger is at the bottom of its stroke. Turn on the fuel supply tap and, whilst operating the priming lever on the lift pump, rotate the pump camshaft slowly clockwise by means of the pulley on the motor shaft.

5. As the plunger in No. 1 element begins to rise, fuel will flow freely from the spill pipe until such time as the plunger covers the ports. Stop rotating the camshaft as soon as the fuel flow from the spill pipe ceases, (spill cut-off point) and set the phasing ring on the end of the lower pulleys so that one of the graduation lines marked 6C is in line with the fixed pointer (see Fig. 20).

It is advisable to repeat the above procedure to check that the phasing ring has been set accurately.

NOTE.—During phasing the spill cut-off point must always be ascertained when the plunger is rising, otherwise inaccuracies will result.

6. Turn off the fuel, remove the spill pipe and fit the delivery valve, spring and volume reducer to No. 1 element. Tighten the holder to a torque of 30 lbs. ft. (4.15 Kg.m.).

7. Phasing numbers 2 and 3 elements may now be carried out in the injection sequence 1, 2, 3. Remove the delivery valve, spring and volume reducer from No. 2 element. Refit the delivery valve holder and spill pipe, turn on the fuel and rotate the camshaft slowly clockwise as before until the spill cut-off point is reached on No. 2 element. The phasing ring should now have revolved through 120° and a graduation line marked 6C should be in line with the fixed pointer. A limit of 1° either side of the 6C mark is permitted.

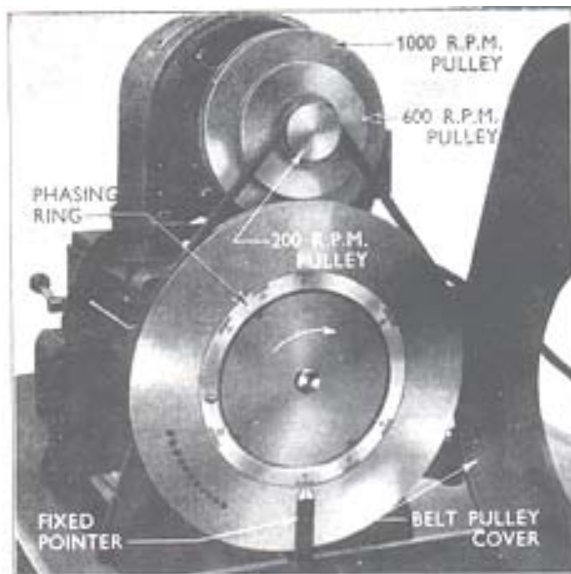


Fig. 20
Checking Pump Phasing

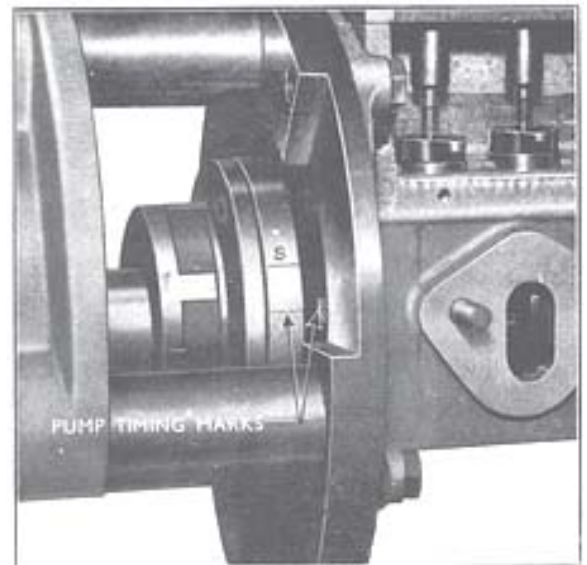


Fig. 21
Checking No. 1 Element Spill Point

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NOTE.—If the phasing is outside the above limits it will be necessary to change the phasing spacer of the element which is phased incorrectly (see paragraph 9).

It is advisable, however, to note the extent of the phasing inaccuracy, as the remaining element is phased, working to the 6C marks throughout and without moving the phasing ring on the pulley. In this way the phasing of all elements can be corrected at the same time, as it necessitates removing the pump housing and plunger tappets. Finally, check No. 1 again to ensure the original setting of the phasing ring has not been disturbed.

8. Check that when No. 1 element is at the spill cut-off position the timing marks on the drive gear adaptor and the timing pointer coincide (see Fig. 21). If not, obliterate the line on the adaptor and re-mark as necessary. The other line on the adaptor stamped "S" should also be obliterated and re-marked the appropriate distance from the line indicating the spill cut-off position.

9. If it is necessary to change the phasing spacers (as mentioned in paragraph 7) remove the pump body (four nuts and spring washers) taking care not to drop the plungers from their barrels. Lift out the tappets, one at a time, and remove the phasing spacers after extracting the circlip with the special circlip pliers (tool No. 7065).

When refitting, the convex face of the circlip should be adjacent to the phasing spacer.

There are five thicknesses of spacers available (see page 10) in steps of .004 in. (.1 mm.) which affect the phase angle in each case by approximately a $\frac{1}{2}^\circ$. Fit a thinner spacer to increase the phase angle and vice versa.



Fig. 22

Checking Plunger Head Clearance

10. Refit the pump body to the cambox, omitting the plunger springs at this stage. Turn the pump camshaft until No. 1 element tappet is at the top of its stroke. Lift the plunger arm upwards to ascertain that there is clearance between the top of the plunger and the underside of the delivery valve guide (see Fig. 22). Repeat on all the other elements.

NOTE.—If there is no clearance on any plunger, fit a thinner tappet spacer to establish the clearance on this plunger and phase the others to this element.

11. Withdraw the plungers, after removing the pump body from the cambox. Fit three plunger shims and the lower spring disc to each plunger (see Fig. 23). Locate the foot of the plunger on the centre of the tappet spacer, press the lower spring disc down against the tappet body, and check for free movement of the plunger. Remove shims until free movement is felt. Each plunger must be checked on its respective tappet and the free movement reduced to a minimum.

Refit the spring and upper spring disc (see Fig. 23), and refit the plungers to their respective barrels.

Holding the lower ends of the plungers, fit the pump body onto the cambox ensuring that the plunger arms face outwards into their slots in the tops of the tappets. Before finally tightening the four nuts securing the body to the cambox, ensure that the machined faces which contact the inspection cover are in alignment so that a perfect seal is obtained when the cover and gasket are fitted.

12. Refit the front half of the governor case, secure with two bolts fitted with spring washers, and one countersunk screw fitted with a shakeproof washer.

13. Enter the control rod from the governor end, with the slot in the fork facing upwards, and pass the control forks over the rod, engaging them with the

plunger arms (see Fig. 24). Check that the plunger arms do not bind in the forks.

14. Loosen the locknut for the maximum fuel stop screw (see Fig. 13) and remove the stop screw.

15. Push the control rod in so that it comes into contact with the face of the fuel injection pump mounting bracket on the calibrating machine. With the control rod in this position set No. 3 control fork (one nearest governor) so that it is approximately .9 in. (21 mm.) away from the inner face of the control rod bush fitted at the governor end of the cambox, and lightly tighten the fork screw. Set No. 1 and 2 plunger arms at the same angle as No. 3 plunger arm and lightly tighten the fork screws.

The control rod and forks are now set in an approximate position for maximum fuel delivery, which will be of assistance in subsequent calibrating operations.

16. Replace the original shims on the cranked end of the stop control shaft and enter the shaft into the governor housing, from the back of the pump. Fit the return spring, stop control lever, and governor link to the shaft as it is passed through the housing. The pin at the lower end of the governor link locates in the fork on the end of the control rod.

17. Move the governor link over towards the stop control lever, compressing the return spring, and fit a spring clip in the groove in the stop control shaft adjacent to the governor link.

18. Replace the shims that were removed from the outer end of the stop control shaft and refit the spring clip in the groove at the end of the shaft.

19. Position the stop control lever so that the drilled hole in the lever is in line with the drilled hole in

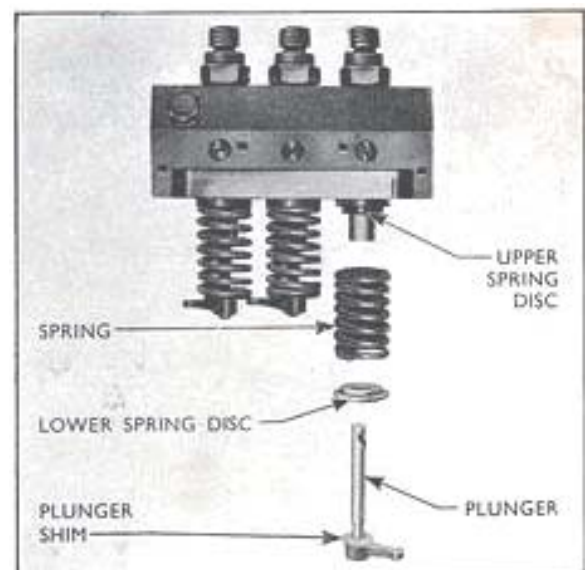


Fig. 23

Fitting Springs and Plungers

the stop control shaft, and retain the lever to the shaft with a groove pin. **Ensure that the control rod and rocker assembly are free to move fully in both directions.**

20. Move the control rod fully to the left holding it against the injection pump mounting bracket on the calibrating machine, and replace the maximum fuel stop screw, screwing it in until it just contacts the top of the governor link. Tighten the locknut fully taking care not to move the stop screw.

The injection pump mounting bracket on the calibrating machine has a shallow recess machined in it to give the correct setting for the control rod in the maximum fuel position, therefore, after the above procedure has been carried out the maximum fuel stop screw should not be disturbed.

21. Replace the governor diaphragm as described on page 4.

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CALIBRATING

Calibrating is an adjustment to ensure that each element of the pump delivers the same amount of fuel at any position of the control rod. Fuel delivered by each element over a definite number of injections is collected and measured in graduated test tubes.

When checking deliveries, use the same set of test tubes throughout, and give a constant drain period of 10 seconds when emptying on each occasion. Also allow fuel to settle in the tubes for 10 seconds after delivery has ceased, before taking the readings, which must be read from the bottom of the meniscus. This will provide constant conditions and ensure greater accuracy.

Any necessary adjustments are made by altering the position of the forks on the control rod. Moving the forks towards the right (the governor end)

decreases, and towards the left (driving end) increases the fuel delivery (see Fig. 25).

1. Connect the injector pipes between the injection pump and the master injectors of the calibrating machine.

2. Fit the driving belt to the 600 r.p.m. pulleys. Turn on the fuel tap and allow fuel to flow from the bleed screw on the injection pump body. Tighten the bleed screw when all air bubbles in the fuel disappear. Run the calibrating machine at 600 r.p.m. for 10 minutes to allow the injection pump and the oil to warm up.

NOTE.—It is essential that the belt pulley cover is always in the closed position before running the calibrating machine.

3. Collect 200 injections of fuel from each element in the graduated test tubes. It will be necessary to hold the trip lever of the calibrating machine downwards when a slight click will be heard as the injectors start delivering into the tubes. The lever should not be released until a second click is heard, otherwise only 100 injections will be collected.

4. Calibrate the pump by adjusting the forks, starting at No. 1 element so that the average of four deliveries, each of 200 injections from all elements is from 9.6 to 10.0 c.cs. When calibrating always disregard the first set of readings after adjustments have been made.

5. When the calibration is satisfactory, fit the driving belt to the 200 r.p.m. pulleys, run the pump at this speed and check the delivery over 200 injections. Delivery drop on each element should not exceed 2 c.c. below the figure obtained at 600 r.p.m. If the drop exceeds 2 c.c. it indicates a worn element or the angled face of the delivery valve is not seating correctly. If the delivery at 200 r.p.m. exceeds that obtained at 600 r.p.m., it indicates that the piston portion of the delivery valve is worn. In either case fit new parts as required and recheck at 200 r.p.m.

6. At 200 r.p.m. check that when the stop control device is operated, all elements cease delivery just before the control rod reaches the end of its travel towards the stop position at the governor end of the pump.

7. Fit the pump inspection cover and gasket and secure in position with eight setscrews and spring washers.

8. Wire and seal the maximum fuel stop screw.

9. Turn off the fuel tap and remove the fuel injection pump from the calibrating machine.

10. Replace the injection pump gear so that the tapped holes in the adaptor are positioned centrally in the slots in the gear. Fit the large retaining plate, replace the set-screws and spring washers, and tighten securely.

Injection Pump Storage

If after overhaul, an injection pump is being stored it should be left filled with substitute oil and all connections sealed with dust plugs and caps.

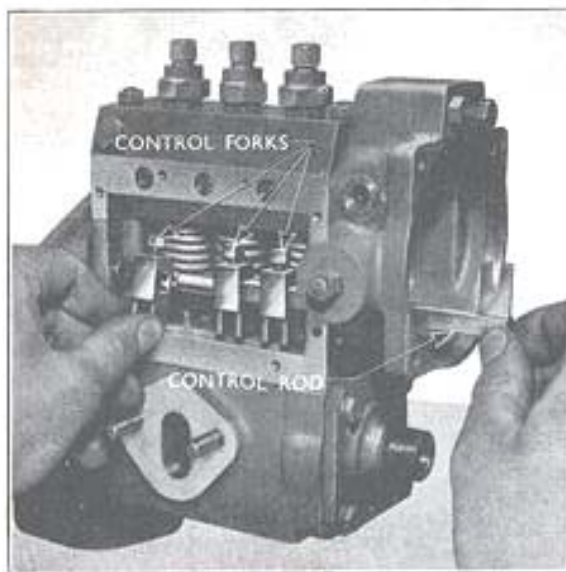


Fig. 24
Fitting the Control Rods and Forks

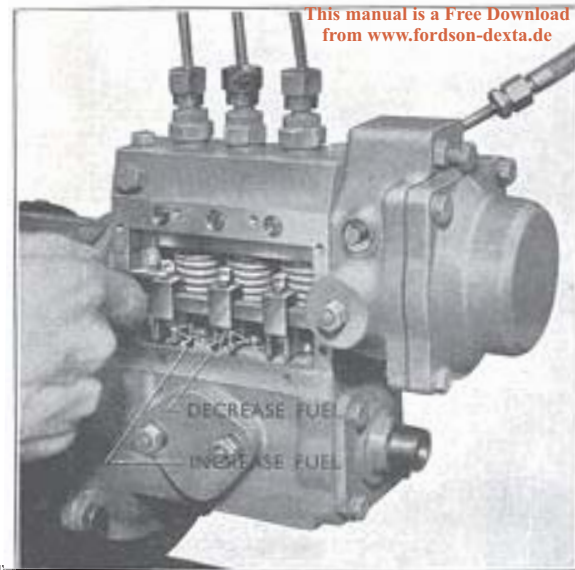


Fig. 25

Adjusting the Forks**FITTING THE INJECTION PUMP**

1. Move the flywheel inspection plate on the left-hand side of the clutch housing to one side, to gain access to the flywheel timing marks. With No. 1 piston on its compression stroke, turn the crankshaft until the line marked "SPILL" on the flywheel is in line with the notch in the clutch housing (see Fig. 6).
2. Remove the inspection cover from the front of the timing case cover (four set-screws and spring washers).
3. Fit the injection pump and a new gasket to the timing case (six nuts and spring washers) so that the pump gear is in mesh with the idler gear and the pump timing marks (see Fig. 7) coincide or approximately coincide to within the nearest tooth. If the pump timing marks coincide no further adjustment is necessary, but if they are slightly out of line the procedure outlined in the next paragraph should be adopted.
4. Slacken the three setscrews retaining the fuel pump gear to the gear adaptor (see Fig. 8) and with a suitable spanner to the adaptor retaining nut turn the pump camshaft until the pump timing marks are in line. Tighten the three setscrews taking care to ensure that the gear adaptor does not turn. Replace the inspection cover and gasket onto the front of the timing case cover, and secure with four setscrews and spring washers.
5. Replace the stop control inner and outer cables onto the stop control lever and outer cable retaining clip respectively. Set the cables so that there is approximately .25 in. (6.4 mm.) free movement of the control at the dash panel.
6. If a proofmeter is fitted replace the drive cable in the square hole at the rear of the pump camshaft

and tighten the knurled retaining nut securely.

7. Refit the fuel feed pipes, oil level drain pipe and the governor pipe to the injection pump ensuring that they are perfectly clean.
8. Fit the fuel injector pipes ensuring that they are perfectly clean and that the olives on the ends of the pipes are in good condition, and seat correctly before tightening the union nuts. Under no circumstances must the pipes be bent.
9. Remove the injection pump inspection cover (eight screws and spring washers) and add clean engine oil to the camshaft chamber until oil flows from the oil level drain pipe at the base of the pump. Replace the inspection cover and securely tighten the eight screws.
10. Bleed the fuel system as described on page 2, start the engine, and check the idling and maximum "No Load" engine revolutions as described on pages 4 and 5.

INJECTORS

A section through an injector is shown in Fig. 26. Fuel from the injection pump enters the injector inlet and passes through a drilling in the nozzle holder before reaching the needle valve seat. The pressure of the fuel when the ports in the injector pump barrel are closed causes the needle valve to open against the action of the injector spring. Fuel is then forced, in a highly atomised state, through the two holes in the nozzle tip. A small amount of fuel leaks up between the needle valve stem and the nozzle body, providing lubrication. The leak back fuel rises to the top of the injector where it is returned to the fuel tank by the injector leak-off pipe.

The injectors should normally be removed for testing and servicing, at intervals not exceeding 600 working hours.

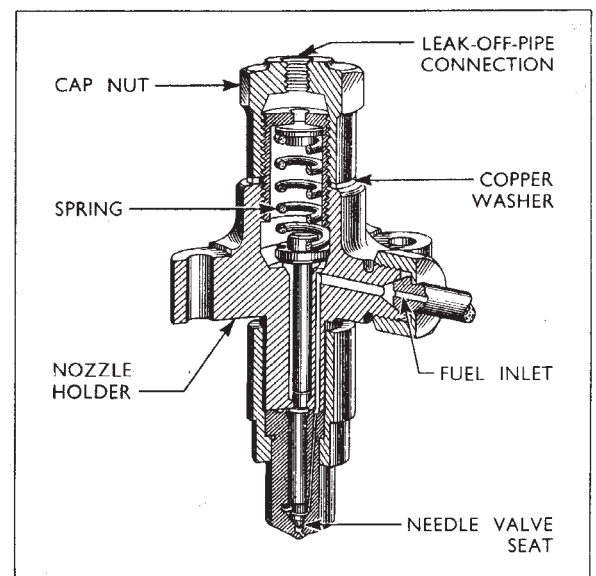


Fig. 26

Sectioned View of Injector

Removing an Injector

1. Remove the injector leak-off pipe by unscrewing the union nut at the rear of the cylinder head, and the three special slotted bolts connecting the leak-off pipe to the injectors.
2. Remove the fuel injector pipe by unscrewing the union nuts at each end of the pipe. Fit the appropriate size blanking plugs to the delivery valve holder and injector inlet.
3. Unscrew the two nuts securing the injector to the cylinder head, and carefully withdraw the injector, ensuring that no dirt or foreign matter drops down into the injector seat in the cylinder head (see Fig. 27).

Testing an Injector

Care should be taken when testing an injector to prevent the hands contacting the fuel spray. The human skin is easily penetrated by the spray which is discharged at a pressure of approximately 2,000 lbs. per sq. inch.

Before testing or dismantling an injector clean the exterior with a soft brass wire brush and substitute or fuel oil.

Fit the spacing washer (tool No. T.9025-1a), to the injector holding arm of the injector testing machine, and locate the injector on the two pegs of the spacing washer (see Fig. 28). Fit the high pressure pipe (T.9025-1b) between the injector and the injector testing machine, and slacken the injector cap nut.

Before commencing to test the injector, isolate the gauge from the injector by closing the valve on the testing machine, and turn the flywheel to ensure that the holes in the injector are not blocked.

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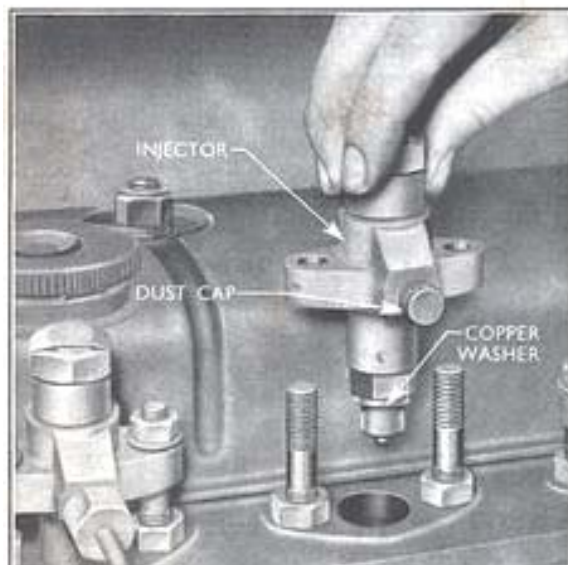
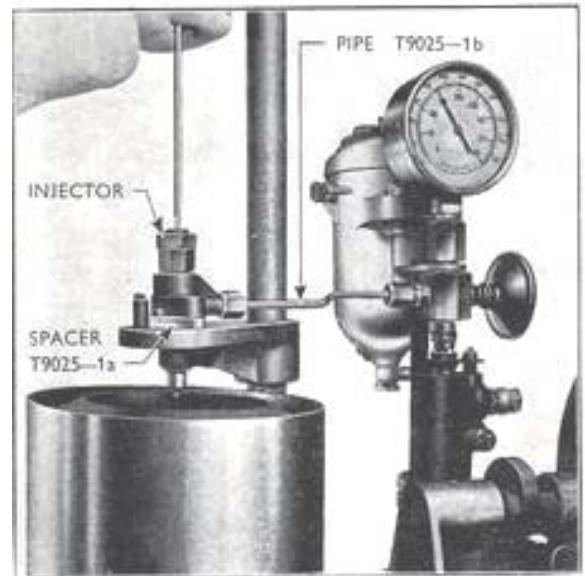


Fig. 27
Removing an Injector



Removing an Injector

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Before commencing to test the injector, isolate the gauge from the injector by closing the valve on the testing machine, and turn the flywheel to ensure that the holes in the injector are not blocked.

striking the side of the container. The injector should break with a hard note.

NOTE.—When checking the atomisation the valve on the nozzle tester must be kept closed to prevent damage to the gauge.

If the injector satisfactorily passes the above tests, and the nozzle opening pressure is set correctly the injector can be refitted to the engine. If, however, it fails the needle valve leakage test (seat leakage or valve stem back leakage) or if the spray is distorted or does not atomise properly, the injector should be completely dismantled, cleaned, reassembled and tested once again.

Dismantling and Cleaning an Injector

1. Fit the injector to the injector testing machine but do not connect the fuel pipe.
2. Remove the injector cap nut and copper washer, then with a screwdriver, unscrew the spring adjusting nut. Lift off the upper spring disc, injector spring and spindle.
3. Unscrew the nozzle nut, using the special socket (tool No. T.9042) and remove the nozzle and its needle valve.

NOTE.—As nozzles and their needle valves are a lapped fit, they should never be interchanged.

4. Wash all the injector parts in clean fuel or substitute oil, and using a soft brass wire brush remove all carbon from the nozzle and the needle valve.
5. Using the tools in the nozzle cleaning kit, remove all carbon from the interior of the nozzle.

If necessary, the spray holes in the nozzle can be cleaned out, using a wire probe fitted in the small hand chuck. Only use wire suitable for a .0137 in. (.35 mm.) diameter hole, and have just a small amount of the wire probe protruding from the chuck to prevent breakage. Rotate the chuck slowly without applying undue pressure to the wire probe.

When a hard carbon deposit is formed in the spray holes, it may be softened by immersing the nozzle in "Acetone" for a short period; half an hour is usually sufficient.

It is important that immediately the nozzle is removed from the fluid, it must be rinsed in clean fuel or substitute oil to prevent corrosion on the highly finished surfaces.

WARNING

"Acetone" is a highly inflammable liquid and must not be brought near a naked flame.

6. With the reverse flush adaptor (tool No. T.9043) fitted to the injector testing machine, flush out the interior of the nozzle (see Fig. 29). The nozzle fits into the body of the adaptor, tip first and is held in position by the large knurled nut. When all particles of carbon have been removed, enter the needle valve into the nozzle and ensure that it is quite free.

Reassembling an Injector

All injector parts should be reassembled wet, after rinsing in clean fuel or substitute oil. Do not use rag to clean any of the internal parts.

1. Fit the nozzle and its valve to the injector body, ensuring that the dowels in the body enter their correct location in the nozzle. Screw on the nozzle nut and tighten securely to a torque of 60 to 75 lbs. ft. (8.29 to 10.37 Kg.m.) with the special nozzle nut socket (tool No. T.9042).

NOTE.—It is essential that this torque figure is not exceeded otherwise distortion of the nozzle assembly may occur.

2. Fit the injector spindle, spring, upper spring disc and spring adjusting nut. Screw down the adjusting nut until pressure can be felt on the spring.
3. Fit the injector cap nut and copper washer, but do not tighten the cap nut.
4. Connect the injector to the testing machine pipe and test the injector as previously outlined.

NOTE.—If, after cleaning, the injector fails to pass these tests it should be replaced by a serviceable injector and the faulty one reconditioned. On no account should attempts be made to reclaim injector nozzles and valves through hand-lapping with metal polish or other abrasives.

Replacing an Injector

1. Check the injector seating in the cylinder head to ensure that it is clean and free from any carbon deposit, and locate a new copper washer in the seat.



Fig. 29
Reverse Washing the Nozzle

2. Fit the injector into its bore in the cylinder head, and tighten the holding down nuts evenly. A flat washer is located under each nut.
3. Fit the injector leak-off pipe and secure in position with three special slotted bolts. Small copper washers are fitted on either side of the banjo unions on the injector leak-off pipe. Reconnect the leak-off pipe to the union at the rear of the cylinder head.
4. Fit the fuel injector pipe, ensuring that it is perfectly clean, and check that the olives at either end are in good condition and are seated correctly. Tighten the union nuts securely.
5. Run the engine for a short time to ensure that the injector is making a gas-tight seal on its seating, and that there are no leaks from the leak-off pipe and the injector pipe unions.

THE FUEL LIFT PUMP

The fuel pump is mounted on the injection pump cambox and is driven by means of a rocker arm from an eccentric on the injection pump camshaft.

On rotation of the engine, the eccentric on the camshaft pivots the fuel pump rocker arm and link and pulls the diaphragm downwards against the pressure of the return spring. This creates a partial vacuum in the pump chamber, causing the inlet valve to open and draw fuel from the tank, through the pipe line, into the diaphragm chamber.

Further movement of the camshaft eccentric allows the rocker arm to return and the diaphragm is pushed up by the return spring, causing the inlet valve to close and the outlet valve to open. The fuel is then forced through the replaceable element filter to the injection pump.

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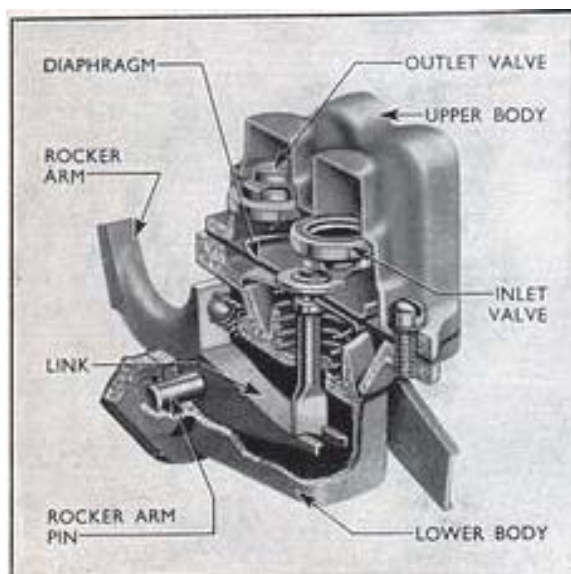


Fig. 30
Sectioned View of Fuel Lift Pump

When the injection pump gallery is filled with fuel, back pressure is created in the diaphragm chamber which holds the diaphragm down against the action of the return spring until the fuel in the injection pump gallery is delivered to the injectors.

During the time the diaphragm is held down by the fuel pressure, the rocker arm idles on the camshaft eccentric without operating the link.

Testing the Fuel Lift Pump

Providing there are no air leaks or obstructions in the fuel system, a quick check on the pump efficiency can be made as follows :—

1. Remove the air bleed screw from the inlet side of the fuel filter.
2. Operate the hand priming lever in the normal manner when there should be a well defined surge of fuel for each working stroke of the pump. If there is no resistance of the diaphragm spring it is likely that the diaphragm is held down, due to the rocker arm being held on the high point of the eccentric, and it will be necessary to rotate the engine approximately one turn.

If the pump does not operate correctly, check the inlet depression and delivery pressure, using the Diagnosis Test Set, the Gang Gauge Set No. 500-X or a suitable vacuum/pressure gauge.

Fuel Lift Pump Inlet Depression Test

1. Operate the lift pump hand priming lever to fill the injection pump gallery.
2. Disconnect the fuel inlet pipe from the lift pump and connect the vacuum gauge to the pump inlet union.
3. Start the engine and allow it to run at idling speed. The vacuum reading should be at least $8\frac{1}{2}$ in. of mercury.
4. Stop the engine and the needle should take at least a minute to drop from $8\frac{1}{2}$ in. of mercury to zero. Should the reading drop quicker than this, it indicates an air leak or faulty outlet valve.
5. Disconnect the vacuum gauge, replace the fuel inlet pipe and bleed the fuel system as described on page 2.

Fuel Lift Pump Delivery Pressure Test

1. Operate the lift pump hand priming lever to fill the injection pump gallery.
2. Disconnect the fuel outlet pipe from the lift pump and connect the pressure gauge to the pump outlet union.
3. Start the engine and observe the pressure at idling speed. Increase the speed and check throughout the speed range that the pressure is between 6 and 10 lbs./sq. inch (.42 to .70 Kg./sq. cm.).

NOTE.—Low fuel pump pressure may affect engine performance due to lack of fuel.

4. Disconnect the pressure gauge, replace the fuel outlet pipe and bleed the system as outlined on page 2.

OVERHAULING THE FUEL LIFT PUMP

To Remove

1. Turn the fuel tap to the "off" position and disconnect the fuel inlet and outlet pipes from the fuel lift pump.
2. Unscrew the two nuts securing the pump to the injection pump cambox and detach the pump. Remove the pump gasket.

To Dismantle

1. Mark the upper and lower body flanges to facilitate their correct reassembly and remove the five screws securing the fuel pump upper body to the lower body. Remove the upper body, taking care not to damage the diaphragm when separating these parts.
2. Push down the diaphragm and turn it 90° in either direction when the diaphragm pull rod will be disconnected from the operating link and the diaphragm can then be detached.
3. Remove the fabric oil seal from the diaphragm pull rod. Turn the oil seal washer through 90° and detach the washer and diaphragm return spring. The diaphragm and pull rod are riveted together and should not be dismantled.
4. The inlet and outlet valve assemblies are retained by a plate secured by two round-headed screws. Remove the two screws, lift off the plate, valve assemblies and gasket.
5. Should it be necessary to dismantle the lower half of the pump body, remove the staking from around the rocker arm pin retainers and pull them from the slots in the body. The rocker arm pin, rocker arm, link, spring and thrust washers will then be freed and may be removed, leaving the priming lever in position.

Reassembly

If the lower body has been dismantled, replace the rocker arm and link as follows :—

1. Insert the rocker arm pin, rocker arm, link, spring and thrust washers into the lower pump body, replace the rocker arm pin retainers in their slots, and securely stake them in position.

Test the operation of the rocker arm and link by moving the rocker arm towards the body when the link should be moved downwards. Depress the link, and the rocker arm should move freely without transmitting movement to the link. Ensure that the priming lever operates correctly and returns freely to the normal position.

2. Locate the diaphragm return spring on the pull rod, fit the oil seal washer, depress the washer and turn it through 90° to lock it on the pull rod. Fit a new fabric oil seal washer.

3. Enter the diaphragm pull rod in the slotted end of the link and turn it through 90° to lock it in position. Check that when assembled the small tab on the diaphragm is located directly below the outlet port in the top body.

4. Inspect the valve assemblies to see that the valves are seating correctly. Locate a new gasket in the upper body and replace the valve assemblies. Secure the valves in position with the retaining plate and two round-headed screws. The retaining plate fits with the bowed centre towards the diaphragm.

5. Fit the upper body to the lower body so that the mating marks, previously made, line up. Fit the five securing screws and spring washers, operate the rocker arm to compress the spring and tighten the screws evenly and securely.

To Replace

1. Ensure that both the lift and injection pump mounting faces are clean, fit a new gasket, and secure the pump to the injection pump cambox with two nuts and spring washers.
2. Reconnect the fuel inlet and outlet pipes.
3. Bleed the fuel system as described on page 2.

FUEL TANK

The fuel tank is located at the rear of the engine above the gearbox housing, and is of seven gallons capacity (one gallon reserve).

A combined fuel supply tap and induction priming pump assembly (for cold starting) is located at the base of the tank on the left-hand side.

The tap has three positions, i.e. closed, main supply and reserve supply. When the tap is screwed in completely, the fuel supply is cut off; with the tap two turns open the main fuel supply comes into operation and, when unscrewed fully the reserve supply of one gallon is available.

To Remove the Fuel Tank

1. Remove the primary air cleaner, vertical exhaust pipe (if fitted) and the bonnet (four screws, flat washers and nuts).
2. Disconnect the battery leads.
3. Unscrew the four self-tapping screws in each control panel side plate and remove the plates.
4. Drain approximately half-a-gallon (2.5 litres) of water from the radiator drain tap so as to bring the water level below the temperature gauge bulb unit in the cylinder head water outlet connection, and remove the bulb. Detach the temperature gauge capillary tubing from the clips on the engine.
5. Ensure that the fuel tap is fully closed, disconnect the main fuel pipe and induction primer pipe from the fuel tap, and the injector leak-off pipe from the front of the fuel tank.

6. Unscrew the cap nut retaining the steering wheel in position and remove the steering wheel and steering column dust cap.
7. Push out the tension pin securing the throttle lever to the vertical throttle rod and remove the lever.
8. Unscrew the four instrument panel securing screws, lift the panel from its location and remove the warning light bulb holders from their sockets in the instrument panel. Use a length of cord to secure the bulb holders to the upper end of the steering column.
9. Unscrew the three bolts securing the fuel tank to the support brackets (two bolts at front, one at rear). If necessary, unscrew the two bolts securing the control panel to the fuel tank rear support and move the panel rearwards prior to removing the rear fuel tank mounting bolt.
10. Draw the temperature gauge unit up through the centre of the fuel tank, moving the tank slightly to one side if necessary, and remove the instrument panel and temperature gauge as an assembly.
11. Lift the fuel tank over the steering column and away from the tractor.

To Replace the Fuel Tank

1. Place the fuel tank on its support brackets passing it carefully over the steering column, vertical throttle rod and wiring.
2. Pass the bulb unit of the temperature gauge down through the centre of the fuel tank and locate the instrument panel and temperature gauge onto the top of the steering column.
3. Fit the three rubber mounting pads between the fuel tank and the brackets, and replace the three mounting bolts and spring washers.

Refit the two control panel to fuel tank support bracket bolts.
4. Refit the warning light bulb holders in their appropriate sockets on the instrument panel (the purple wire should be connected to the oil pressure warning light on the right-hand side, and the yellow and white wire to the generator charging light on the left).
5. Enter the instrument panel over the throttle rod and replace the four instrument panel securing screws. Ensure that the instrument panel gasket seats correctly and the small rubber sealing ring in

the throttle rod support bush is not displaced.

6. Replace the throttle lever and secure it to the throttle rod with a tension pin. A thin dished washer fits between the throttle lever and the instrument panel.
7. Replace the steering column dust cap, fit the steering wheel in position and tighten the cap nut securely.
8. Reconnect the main fuel feed pipe and the induction primer pipe to the fuel tap and priming pump assembly, and the injector leak-off pipe to the union on the front of the fuel tank. It will be necessary to bleed the fuel system as detailed on page 2, before re-starting the engine.
9. Refit the control panel side plates securing each with four self-tapping screws.
10. Reconnect the battery leads and operate the main control key to ensure that both warning lights are working correctly.
11. Refit the temperature gauge bulb unit in the cylinder head water outlet and the capillary tubing into the retaining clips on the engine.
12. Top-up the cooling system with water or anti-freeze as required.
13. Replace the bonnet and secure with four screws, flat washers and nuts.
14. Replace the primary air cleaner and vertical exhaust pipe (if fitted).

THE FUEL TAP AND PRIMING PUMP ASSEMBLY

This comprises the three-position fuel supply tap and the push button operated induction priming pump.

The push button of the priming pump operates on a spring-loaded rubber diaphragm in the sealed body of the pump, and injects fuel through the atomiser located in the inlet manifold, when starting under cold conditions.

The fuel tap valve seals can be replaced with the tap in position by removing the valve retaining spring and unscrewing the valve from the body.

If it is necessary to remove the tap and priming pump assembly to renew it, or to clean the filter gauze, the tank must be raised (as outlined in "To Remove the Fuel Tank" on page 19) to facilitate removal of this assembly.

FAULT DIAGNOSIS

Fault diagnosis on the diesel engine is a straightforward operation if carried out methodically.

To distinguish between a mechanical knock and a fuel knock, run the engine at maximum speed and pull the stop control, if the knock is no longer present it is due to the fuel; if it is audible, it is due to mechanical reasons. When the fuel supply to the engine is cut off, the mechanical knock will be reduced in volume, but will still be present.

Running faults will be due mainly to faults arising in one or more of the following sections. By checking through as outlined, the faulty component or section can be isolated.

Fuel System

1. Bleed all air from the fuel system in the normal manner, if it cannot be eliminated, check back over the pipe line from the lift pump to the fuel tank.
2. Loosen off the injector pipes at the injector end, and operate the starter motor, observing approximate equal delivery from each fuel pipe.
3. Pull the stop control with the pipes still disconnected from the injectors and operate the lift pump hand primer. Any flow of fuel indicates a faulty delivery valve or broken delivery valve spring.
4. Reconnect the pipes to the injectors and start the engine if possible. As a rough check of injector condition, run the engine just above the idling speed, and loosen the injector pipes one at a time. As each injector is cut out in this way, a definite drop-off in speed should be noticed if the injector is operating correctly.

Timing

1. Check the fuel injection pump timing by turning the engine crankshaft as described on page 4, and adjust if necessary.
2. If any doubt arises as to the accuracy of the timing marks on the fuel injection pump gear adaptor, the fuel injection pump should be spill timed to the engine.

To carry out this operation, set the engine on the spill point for No. 1 cylinder as described above. Disconnect No. 1 injector pipe, remove the delivery valve holder and extract the volume reducer, delivery valve and spring. Refit the delivery valve holder to the pump body, tighten to a torque of 30 lbs. ft. (4.15 kg.m.) and fit the spill pipe (tool No. CT.9023) to the holder.

Unscrew the four set-screws and remove the inspection cover from the front of the timing case cover. Slacken the three set-screws securing the fuel pump gear to the gear adaptor and with a suitable socket spanner on the adaptor retaining nut, fully retard the adaptor by turning it anti-clockwise.

Operate the hand primer on the fuel lift pump and fuel should run from the end of the spill pipe. Slowly advance the gear adaptor until the flow of oil from the spill pipe just ceases, and tighten the three set-screws securing the gear to the adaptor. The injection pump is now timed correctly to the engine.

Refit the delivery valve, spring and volume reducer, tighten the delivery valve holder to a torque of 30 lbs. ft. (4.15 kg.m.) and reconnect the injector pipe.

Air Supply

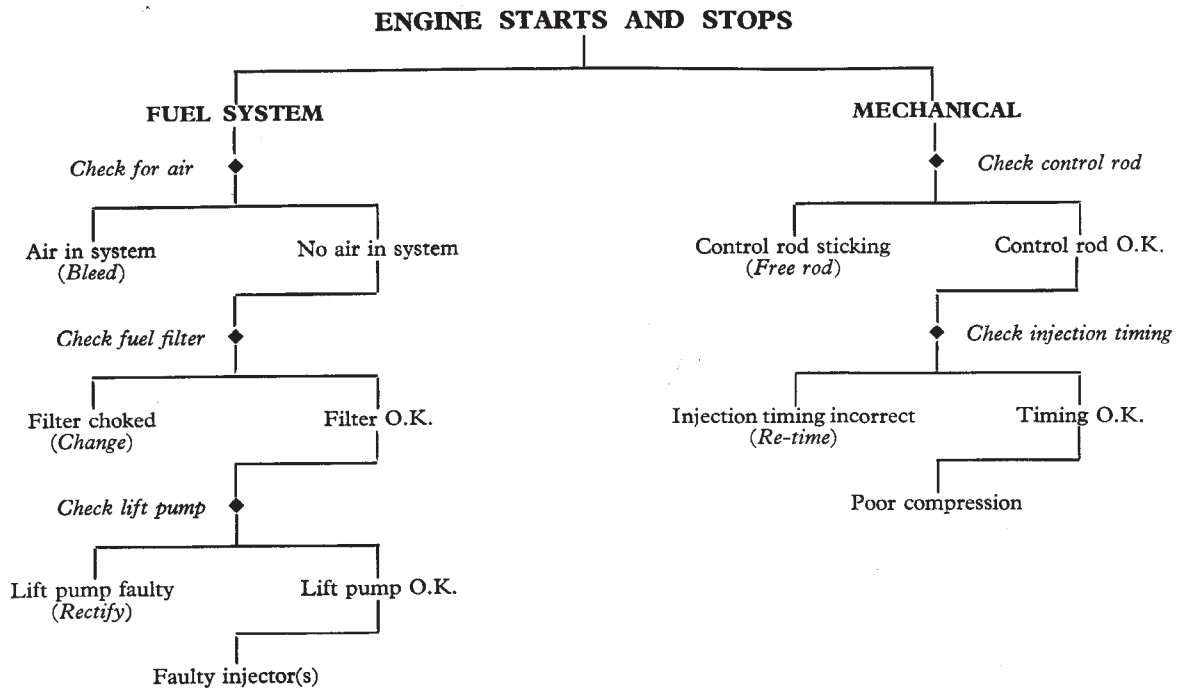
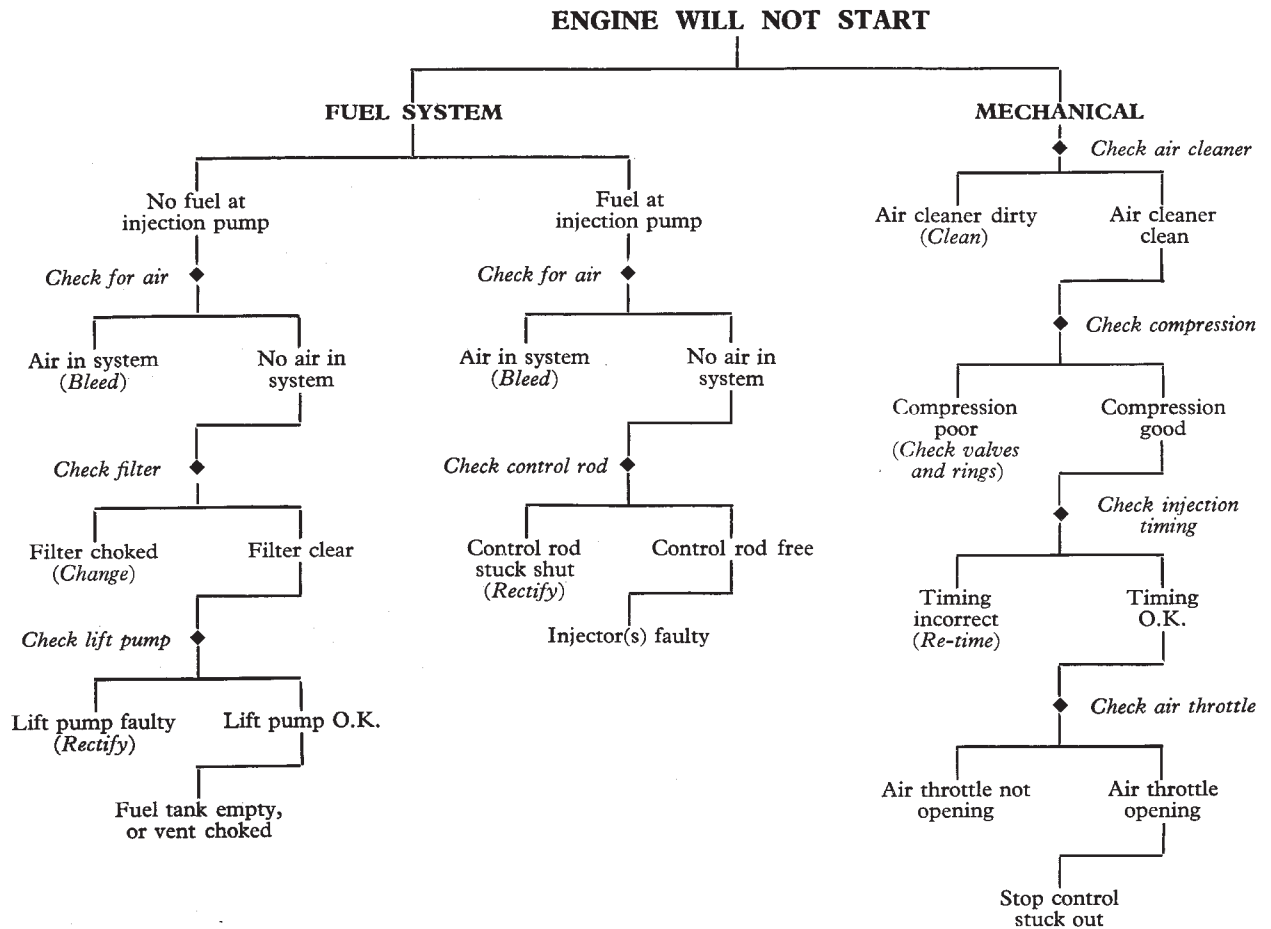
1. Remove and clean the air filter as described on page 3.
2. Remove the rubber hose between the main air cleaner and the inlet manifold, check for obstructions and operate the throttle lever to ensure that the throttle plate travels as far as its stop, giving sufficient opening at the throttle.
3. Check all valve clearances.
4. Check the evenness of the cylinder compressions by turning the crankshaft with the starting handle.

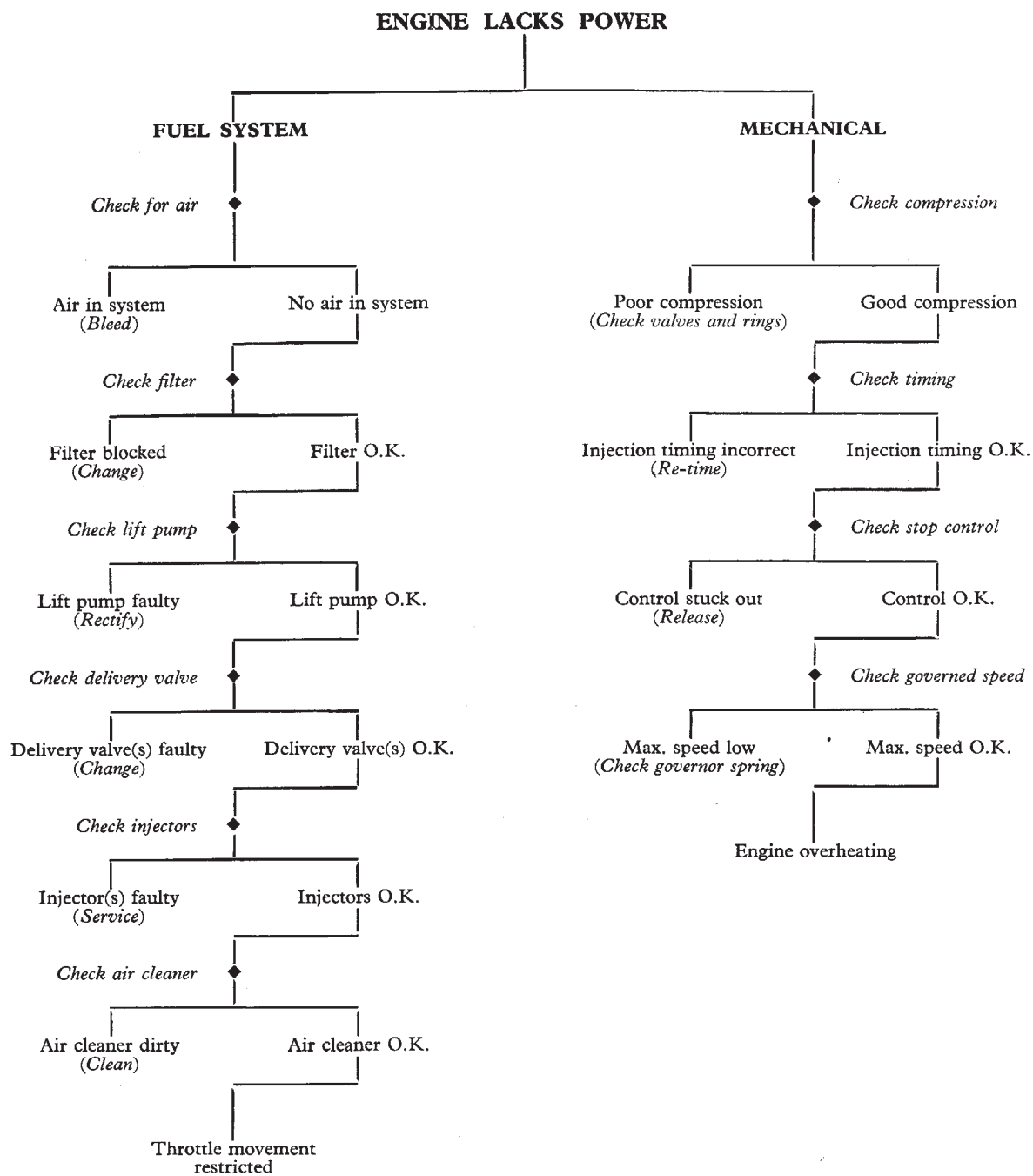
Governing

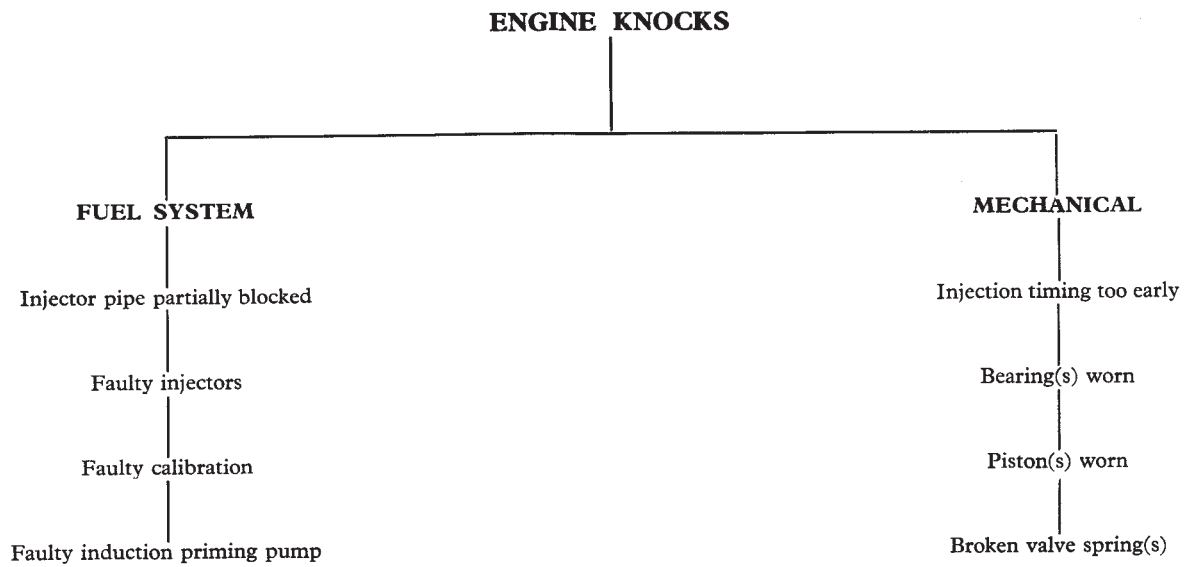
1. Check the maximum "No Load" speed of the engine. This should be 2,200 r.p.m. If the air system has previously been checked as outlined, and the maximum "No Load" speed is low, check the governor main spring. The length of the spring should be as outlined in the Specification Section on page 25.
2. If the air supply has not previously been checked, and the maximum "No Load" speed is low, it is advisable to carry out the complete check as outlined.
3. If erratic running is experienced under load conditions, check the fuel injection pump control rod for stickiness.
4. If the engine "No Load" speed is too high, check for leaks in the system between the inlet manifold and the governor diaphragm.

To check the governor diaphragm for leaks, disconnect the suction pipe from the governor housing. Pull the stop control lever to the "stop" position, and seal the hole in the governor housing, release the stop control lever and there should be no movement on the control rod. If movement of the control rod is observed, it indicates a leaking diaphragm.

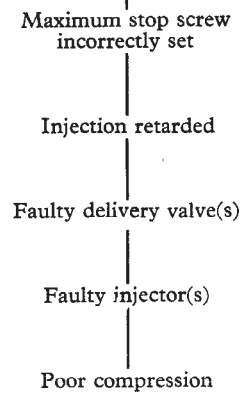
The foregoing is intended as a guide for a complete diagnosis of running faults. By carrying out the checks as outlined, faulty components, such as injectors or injection pumps, can be easily and accurately diagnosed.







ENGINE EMITS EXCESSIVE SMOKE



FUEL SYSTEM SPECIFICATION

Fuel Tank

Capacity 7 Imp. gallons (31.8 litres) including 1 gallon (4.55 litres) reserve

Fuel Lift Pump

Type Diaphragm with hand primer. Mechanically operated from the injection pump camshaft
 Delivery pressure 6 to 10 lbs./sq. in. (421 to 703 gm/sq. cm.)

Fuel Oil Filter

Type Replaceable paper element

Air Cleaner

Type Oil bath
 Oil capacity Approx. 1 Imp. pint (.57 litre)
 Grade of oil As for engine

Fuel Injection Pump

Type Enclosed camshaft with pneumatic governor
 Plunger stroke and diameter 7 mm. × 6 mm.
 Camshaft rotation Clockwise from drive end
 Lubrication Self-lubricating after initial filling
 Camshaft end-float002 to .006 in. (.051 to .152 mm.)
 Camshaft end-float shims004 and .008 in. (.1 and .2 mm.) thick
 Phasing spacers :—
 No. 1179 to .181 in. (4.55 to 4.60 mm.) thick
 No. 2183 to .185 in. (4.65 to 4.70 mm.) thick
 No. 3187 to .189 in. (4.75 to 4.80 mm.) thick
 No. 4191 to .193 in. (4.85 to 4.90 mm.) thick
 No. 5195 to .197 in. (4.95 to 5.00 mm.) thick
 Phasing tolerance 1° (pump) between elements
 Plunger head clearance031 to .051 in. (.8 to 1.3 mm.)
 Plunger arm shims009 in. (.229 mm.) thick
 Fuel delivery, control rod set 2 mm. proud of face of mounting flange :—
 200 injections at 600 r.p.m. 9.6 to 10.0 c.cs.
 Tightening torques :—
 Delivery valve holders 30 lbs. ft. (4.14 kg.m.)
 Fuel pump drive gear adaptor retaining nut 45 lbs. ft. (6.21 kg.m.)

Fuel Injectors

Number of spray holes 2
 Diameter of spray holes013 in. (.35 mm.)
 Spray holes 30° and 80° to vertical axis
 Setting pressure 160 ats.
 Back leak test Time for pressure to fall from 125 to 90 ats. should be between 6 secs. and 45 secs.
 Needle seat leakage Hold pressure at 150 ats. for 1 min. with blotting paper at nozzle tip and spot on paper should not exceed ½ in. (12.7 mm.) diameter
 Injector pipes :—
 Inner diameter06 in. (1.5 mm.)
 Outer diameter233 to .238 in. (5.9 to 6.06 mm.)
 Nozzle nut tightening torque 60 to 75 lbs. ft. (8.29 to 10.37 kg.m.)

Governor

Type Pneumatic
 Maximum speed :—
 “ No Load ” 2,200 r.p.m.
 Under load 2,000 r.p.m.
 Idling speed 550 to 600 r.p.m.
 Governor spring test length (L1) 1.969 in. (50 mm.)
 Governor spring test load 3 lbs. 13½ ozs. to 4 lbs. 1 oz. (1.744 to 1.843 kg.)
 Governor spring length (L2) to be 1.693 in. (43 mm.)
 with a test load of 4 lbs. ½ oz. to 4 lbs. 4 ozs. (1.829 to 1.928 kg.)
 Difference between load at L1 and L2 3 ozs. (.085 kg.)