Leyland

MAINTENANCE AND SERVICE MANUAL

LEYLAND MOTORS LIMITED

MAINTENANCE HANDBOOK

for

LEYLAND

DIESEL INDUSTRIAL UNIT

LEYLAND MOTORS LTD. LEYLAND LANCASHIRE

SERVICE TRAINING FOR LEYLAND CUSTOMERS

The importance of good vehicle maintenance cannot be over-emphasised. To be able to give this it is essential to have first class mechanics and it is with this in mind that we are offering our assistance.

Facilities are available at the Leyland Motor Corporation Training Centre in Coventry to cover the needs of all grades of personnel, including Service Managers, Workshop Foremen and Mechanics. Each course has the common aim of improving efficiency still further in the operation of Leyland units so as to gain the maximum benefit from preventive maintenance.

A comprehensive range of units is available (engines, gearboxes, rear axles, brake layouts, power and normal steering etc.) enabling instruction to be given on any Leyland vehicle (truck or passenger) from the Leyland 90 to the Leyland Super Hippo.

The instruction given is mainly of a practical nature and is adjusted to suit the requirements of personnel attending. The majority of courses are of five-days duration and cover all aspects of vehicle maintenance, as will be seen from the syllabus shown overleaf. Shorter and more specialised courses can be arranged to suit the requirements of individual operators, for example Leyland engines installed in various types of industrial equipment.

When making application for a reservation on a course please state the type of course required. Every effort will be made to accommodate personnel on the particular dates requested but alternative dates should be given.

Application should be sent to:

SALES & SERVICE TRAINING CENTRE
LEYLAND MOTOR CORPORATION LIMITED
CAPMARTIN ROAD,
RADFORD, COVENTRY.

THE LEYLAND MOTOR CORPORATION

LIMITED

SALES AND SERVICE TRAINING CENTRE

CAPMARTIN ROAD, RADFORD, COVENTRY.

Telephone: Coventry 23581 Telegrams: Flywheel Coventry

LEYLAND and ALBION COMMERCIAL VEHICLE SERVICE TRAINING COMPREHENSIVE COURSES

Courses are of five-days duration, commencing on Mondays at 9 a.m. and concluding on Fridays at 2 p.m. The instruction given is mainly of a practical nature and is tailored to suit the personnel attending.

We have a comprehensive range of units (engines, gearboxes, rear axles, brake layouts, power and normal steering etc.) which enables us to cover all truck and passenger vehicles manufactured by Leyland and Albion, from the Leyland 90 to the Leyland Super Hippo.

The syllabus is as follows:

ENGINES	Dismantling and reassembling. Special instruction on lubrication system, oil filters, lubricants, engine breathing, crankshaft details, piston and liners, valve timing, reconditioning cylinder heads. Fault diagnosis and modifications.
FUEL INJECTION EQUIPMENT	Principle of operation ("In-line" and D.P.A.). Method of calibration and phasing. Operation and adjustment of pneumatic and mechanical governors. Fault diagnosis. Timing pump to engine. Instruction supported by C.A.V. films. Maintenance of injectors.
TRANSMISSION	Clutches and clutch adjustment. Stripping and rebuilding gearbox and final drive units. Units covered to suit the requirements of personnel attending.
BRAKES (Vehicles)	Air brakes. Principle of operation and layout of valves. Fault diagnosis and adjustment. Air/hydraulic and vacuum/hydraulic systems covered as required.
BRAKES (Trailers)	Operation of two-line air brake system. Fault diagnosis and adjustment. Instruction on vacuum-braked trailer as attached to an air-braked tractor. Special emphasis on compressor/exhauster and valves used on such an installation.
FRONT AND REAR HUBS	Stripping, rebuilding and adjustment of front hubs and rear hub-reduction units. Fault diagnosis.
STEERING	Stripping and rebuilding steering boxes. Power steering—operation, maintenance and fault diagnosis.

Conditions of Business and Guarantee

The following Conditions of Business and Guarantee apply to all orders accepted by LEYLAND MOTORS LIMITED (hereinafter called "the Company") for Motor Vehicles and chassis therefor, or engines, components, or spare parts, or repairs, or other work of any description.

CONDITIONS OF BUSINESS

1. QUOTATION.—Unless otherwise stated quotations are only open for acceptance within thirty days from their date.

2. PRICE ALTERATION.—If, and whenever, after the date of the order, tender or quotation, and before completion of manufacture of the goods for the customer the Company's prices for chassis, engines or components, and/or for bodies of the type specified are changed, or the rate of wages are altered by national agreement, or the prices of the vendors to the Company for material, parts, accessories, components or other articles are increased or decreased, the Company may give notice of such variation to the customer, and the purchase price above specified and agreed shall, in that event, be correspondingly increased or decreased. If the specification of the goods does not vary from the Company's standard specification the Company will accept notice of dissent from the customer within fourteen days, the Company having the option either to complete the contract without increasing the purchase price, or to cancel the contract and return the deposit to the customer. No cancellations shall give cause for any claim for loss or damage. If the specification calls for variation from the Company's standard types, the customer is under obligation to complete the contract at the increased price.

3. ORDERS.—No order shall be binding until accepted in writing by the Company.

4. DELIVERY.—Delivery shall be at the Company's Works at Leyland, unless otherwise agreed. Customers will be notified when goods are ready for delivery and the goods shall be deemed to be accepted and delivery shall be taken within seven days thereafter.

5. DELIVERY DATES.—The Company undertakes to make every endeavour to deliver each order within the period quoted, reckoned from the date of receipt by the Company of all instructions and information necessary for the execution of the work, but is unable to guarantee that circumstances not in the control of the Company may not interfere. No liability shall attach to the Company for delay in delivery, howsoever arising, or for any contingent or consequential loss or damage arising from such delay.

6. PACKING.—All packing is charged extra.

7. PAYMENT.—Unless otherwise agreed, payment must be made at the Company's Works at Leyland, in full in sterling before delivery.

(a) Where payment has been arranged by means of a Letter of Credit, the customer will establish a "Confirmed Irrevocable Letter of Credit" payable in sterling in London, by drafts at sight for 100% of the invoice value, all Bank and other charges being payable by the customer.

(b) Where payment is to be secured by Bills of Exchange, such Bills, unless otherwise agreed in writing, will be subject to an interest charge at the rate of 1% over Bank rate, and all charges for negotiation in London and/or abroad are payable by the customer.

(c) Where shipments are despatched "cash against documents (foreign Port)" all Bank and other charges abroad are payable by the customer.

The Company reserves the right to call for a deposit with the order. The property in the goods will not pass until payment in full has been made.

8. IMPROVEMENTS AND ALTERATIONS.—The Company, whose policy is one of continuous improvement, reserves the right to make, without notice, any changes in material, dimensions and designs, which, having regard to all the circumstances, it thinks reasonable or desirable, without affecting the validity of the contract.

9. ILLUSTRATIONS AND DESCRIPTIONS.—Illustrations, photographs and descriptions are intended as a general guide only, and must not be taken as binding in detail.

10. INSPECTION AND TESTS.—Reasonable inspection and tests will be allowed during convenient working hours at the Company's Works before acceptance, if asked for on or before the placing of an order. No claim made after delivery regarding the quality of the goods delivered will be entertained, except under any guarantee applicable to the goods.

11. CANCELLATION OR SUSPENSION OF CONTRACT.—Should the Company be delayed in or prevented from making delivery owing to strikes, lockouts, trade disputes, difficulty in obtaining workmen or material, breakdown of machinery, accident, fire, force majeure, war, civil riot, requisitioning by Government, or any other circumstances outside the Company's control, the Company shall be at liberty to cancel or suspend the contract without incurring liability for any loss or damage resulting to the customer.

12. EXCLUSION OF LIABILITY.—Customer's vehicles are driven or towed by the Company's employees at the sole and entire risk and responsibility of the customer. All goods in the hands of the Company for delivery or repair or otherwise are held by the Company at the customer's risk as regards loss or damage, howsoever arising.

13. REPAIRS.—If goods received by the Company for repair or for other work are not removed whether because of the non-payment of the Company's charges or otherwise within twenty-one days of the date of rendering the Company's account, the Company may thenceforth charge for storage, and, without further notice to the customer, may at any time thereafter sell the goods and retain all amounts due from the customer to the Company out of the proceeds, the balance of which shall be paid to the customer.

14. ERRORS.—Claims regarding errors in despatch or invoicing must be made within fourteen days after date of advice note or invoice. The Company refuses to recognise any claim not made within that period.

15. EXHIBITIONS AND COMPETITIONS.—The Company's products are sold upon the express condition that they are not without the previous written consent of the Company to be exhibited at any exhibition or used in any competition, competitive trial or collective demonstration. On any and every breach of this condition, whether by the customer or by a subsequent owner, the customer shall pay to the Company the sum of £250 (or other such sum as the Company may be ordered to pay by the Society of Motor Manufacturers and Traders), as agreed and liquidated damages. Every purchaser of the said products from the Company for resale shall obtain a like undertaking from his customer.

16. DEFAULT OF CUSTOMER.—If the customer becomes bankrupt or notour bankrupt or insolvent or compounds or make any arrangement with his creditors, or being a Company goes into liquidation or has a receiver appointed of its assets, the Company may give notice cancelling the contract and without further notice to the customer may resell the goods, and any loss and expenses sustained on the resale shall be paid to the Company by the customer.

17. AGENTS AND DISTRIBUTORS.—Motor traders selling or distributing the Company's goods, whether known in the Trade, as Agents or not, have no agency—in the legal sense—to act on behalf of, or in the name of the company. The word "agent" is used in a complimentary sense only. Sales by such traders shall be subject to these conditions (so far as applicable) and guarantee.

18. PREVENTION OF CORRUPT PRACTICES.—The Company in no circumstances commits or permits, in relation to its contracts, any act constituting or savouring of bribery or corruption, as laid down in the Prevention of Corruption Acts, 1889 to 1916, and Section 123 of the Local Government Act, 1933.

19. WAGES AND HOURS OF LABOUR.—The Company at all times observes the provisions normally found in contracts with Government Departments, Municipal Corporations or Public Bodies in regard to payment of standard rates of wages, observance of recognised hours and conditions of labour, and freedom of employees to belong to Trade Societies. Evidence of compliance with the conditions will be produced to such Authorities contracting with the Company, whenever required.

20. ARBITRATION AND INTERPRETATION.—Any dispute or difference as to the meaning or effect of these conditions or of the Company's guarantee, or as to the rights, or liabilities of either party under the contract, shall be and is hereby referred to the final decision of a single arbitrator in England to be nominated by the parties, or in default thereof by the President of the Society of Motor Manufacturers and Traders Limited. These conditions and the Company's guarantee and any arbitration hereunder shall be interpreted and governed in all respects according to the Law of England. Except where expressly stated to the contrary by the Company the trade terms incorporated in the contract shall bear the meaning set out in "Incoterms 1953" as published by the International Chamber of Commerce.

21. NOTICES.—Any notice (which expression shall include any advice note, invoice or other document) may be served on the customer (or, if more than one, on any of them on behalf of all) either personally or by leaving it at, or sending it by post or telegram to, his last known residence or place of business. Such notice shall be deemed to have been served in the case of a letter sent by post, in due course of post, and in the case of a telegram at the expiration of the time normally taken for transmission.

22. The Company will be responsible for obtaining any necessary export licence or permit that may be required for goods ordered by an overseas customer, but if the same cannot be obtained within twenty-eight days of the goods being notified as ready for delivery or if the same is cancelled before delivery has taken place the terms of Condition 10 hereof shall be deemed to apply.

23. The customer, if an overseas customer, shall be responsible for obtaining any necessary licence or permit for the import of goods to the overseas country, and shall be responsible for acquiring the necessary sterling to enable payment to be made to the Company. In the event that the customer shall fail to comply with this condition within twenty-eight days of being notified that the goods are ready for delivery the Company may declare the contract cancelled and resell the goods and any loss sustained by the resale shall be paid to the Company by the customer. The Company will not be liable for any loss or damage resulting to the customer.

24. SCOPE OF CONDITIONS.—The acceptance of any order by the Company shall incorporate these conditions into the contract and they shall supersede and exclude all general terms and conditions of contract imposed, or sought to be imposed, by the customer at any time in relation to the order, in so far as such terms and conditions are inconsistent therewith or additional thereto.

Guarantee

The Company uses its best endeavours to secure excellence of materials and workmanship and gives the following guarantee in regard to its products and repairs, namely:—

1. In the event of any defect being discovered within the period mentioned in Clause 2 hereunder in any goods supplied (whether originally or by way of replacement) or repaired by the Company, then provided that the alleged defective part is returned to the Company's Works at Chorley, carriage paid and properly labelled for identification, within seven days after discovery of the alleged defect, the Company will examine such part carefully and, if satisfied that the defect is due to faulty material or bad workmanship, will (save as mentioned in Clause 8 hereunder) repair the defective part, or supply a new one in place thereof, free of charge at Works. Any claim under this Clause must be made in writing on or before the despatch of the alleged defective part and must contain full particulars of the alleged defect together with the number of the chassis from which such part has been removed.

2. The period of guarantee is:—

(a) For chassis and bodies, twelve months or until 40,000 miles have been covered (whichever is the less) for home orders and six months for overseas orders from the date on which the vehicle is first registered or put into commercial use.

(b) For parts supplied by way of replacement or repair, either under this guarantee or voluntarily at special rates or free of charge, the unexpired portion of the period applicable to the chassis or body concerned.

(c) For parts supplied by way of replacement or repaired at normal rates of charge, twelve months or until 40,000 miles have been covered (whichever is the less) for home orders and six months for overseas orders from the date of delivery of the new or repaired part.

(d) For engines and marine and industrial units, twelve months for home orders and six months for overseas orders following the date of delivery ex Works, or 2,000 working hours, whichever is the less, on condition that

(i) An adequate supply of filtered air is provided under all conditions of operation, and

(ii) Approval of the Company is obtained of the installation of marine or industrial unit which forms the subject of this quotation/contract.

3. If the Company makes any alterations in or addition to any goods, the foregoing guarantee shall (subject as mentioned in Clause 8) extend to such alteration or addition, the period of guarantee being the period, or unexpired portion thereof, applicable under Clause 2 to the goods concerned.

4. Parts received from the customer and not repaired may be scrapped by the Company, unless the customer, within fourteen days of despatch of notification of the Company's decision in regard to the claim, asks for their return.

5. Charges for dismantling and reassembly, whether by the Company or by a third party, and for carriage, shall be borne by the customer.

6. The Company accepts no liability for any loss or damage, direct or consequential, or for any accident, or the effects of an accident, resulting from defective material, faulty workmanship or otherwise.

7. The benefit of this guarantee extends to the first registered owner only, or (in the absence of registration) to the first commercial user of the vehicle and cannot be transferred without the written consent of the Company.

8. The benefits of this guarantee do not apply to:—

(a) Bodies, coachwork and proprietary articles (such as tyres, electric lighting sets, engines, gearboxes, axles and other major and minor components) not manufactured by the Company, and spare or replacement parts therefor, but the Company will pass on to the customer the benefit of any guarantee given by the manufacturer in regard thereto.

(b) Defects due to wear and tear, racing, accident, improper adjustment, misuse (including the use of dirty or unsuitable oil), dirt or neglect.

(c) Vehicles or goods which have been (i) altered or added to without the written consent of the Company, or (ii) loaded beyond the gross laden weight specified by the Company, or (iii) fitted with a body of a type or weight for which the chassis is not designed, or (iv) subjected to alteration, obliteration, removal or concealment of the Company's identification numbers or marks, or (v) let out on hire (excluding hire purchase), or (vi) used for military purposes.

(d) Parts repaired by third parties, or by the customer.

(e) Parts damaged by reason of defects in other parts.

(f) Governed engines, or vehicles fitted therewith, which have had the setting of the governor altered otherwise than by the Company.

(g) Goods supplied by the Company as second-hand.

(h) Replacements or repairs to items (a), (c), (f) and (g) above.

(i) Defects due to faulty workmanship by a third party, or by the customer, during fitting or assembly in connection with replacements, repairs, alterations or additions.

9. The Company gives no guarantee as to performance, unless by separate agreement in writing.

10. This guarantee is in lieu of and excludes all conditions, warranties, and liabilities expressed or implied, whether under common law, statute or otherwise, in relation to all goods and repairs, whether covered by the guarantee or not.

INTRODUCTION

INTRODUCTION

This Manual has been prepared to give the user the essential information on operation, maintenance and overhaul.

While the majority of attentions are tied to a period of hours run, common sense must be the guiding factor when carrying out maintenance, as it is impossible to cover every operating condition.

This manual is arranged so that the operator can find the information he may want easily and quickly. For this reason it is divided into the following sections, each dealing with a particular aspect or part of the unit. The main headings of these sections are:

SECTION

1 - Introduction
2 - Unit Data
3 -
4 - Running Instructions
5 - Routine Inspection and Maintenance
6 - Lubrication, Lubricants and Fuel Oil
7 -
8 - Engine
9 -
10 - Electrical Equipment

UNIT DATA

U N I T D A T A

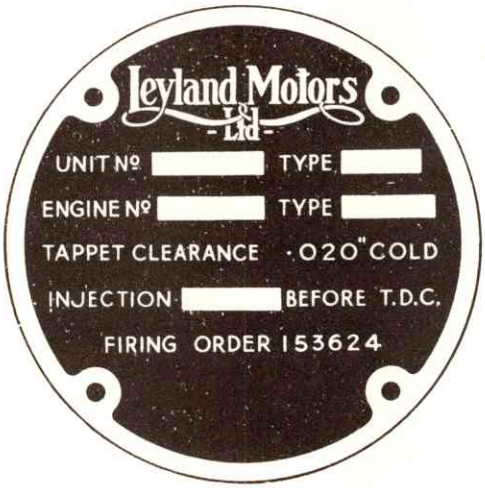


Fig. 1. Type 350 Engine Plate

Fig. 2. Type 450, 600 and 680 Engine Plate

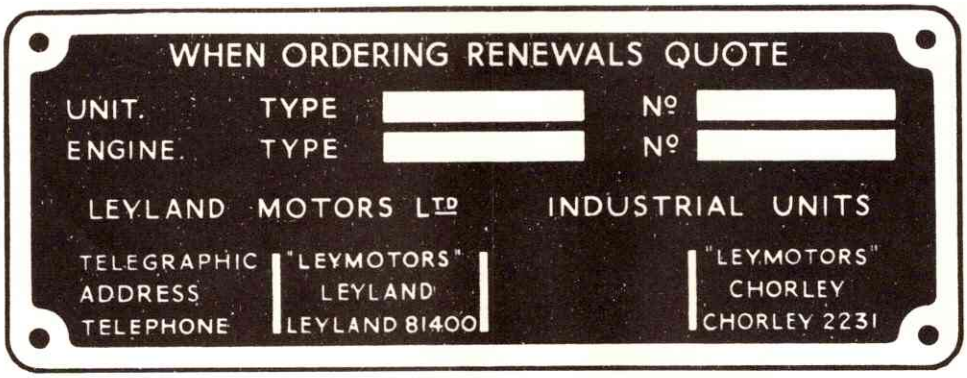


Fig. 3. Unit Plate

UNIT DATA

ENGINE AND UNIT SERIAL PLATES

Plates are attached to every unit for identification purposes. These plates are most important and on no account must they be removed from the unit they relate to. When writing for spares, guarantee claims, or in any connection whatsoever relating to the unit, always quote the unit and engine type and serial numbers.

ENGINE SERIAL PLATE

The engine plates for the 350, 450, 600 and 680 cu. in. engines installed in all power units are shown in Figs. 1 and 2. They are attached either to the inlet manifold or cylinder head cover, as the case may be.

These plates also give the tappet clearance, fuel pump timing and firing order.

UNIT SERIAL PLATE

The unit plate shown in Fig. 3. is attached to the sub-frame or engine as a permanent fixture on all power units.

EXPLANATION OF TYPE FORMULAE

To enable the user to understand the type formulae used to designate Leyland Industrial Units, a brief description is given here as to what the letters and numbers mean.

The initial letters denote the type of engine or unit, thus:

EO. - Basic Engine

UE. - Industrial Engine

PU. - Power Unit

GU. - Generating Unit

AU. - Automotive Unit

The figures following the initial letters denote the capacity of the engine in cubic inches thus:-

350 cu.in. = 3.96in. bore x 4.75in. stroke (100.68mm. x 120.65mm.).

450 cu.in. = 4.375in. bore x 5.0in. stroke (111.1mm. x 127mm.).

600 cu.in. = 4.8in. bore x 5.5in. stroke (121.9mm. x 139.7mm.).

680 cu.in. = 5.0in. bore x 5.75in. stroke (127mm. x 146mm.).

The figures and/or letters following the oblique stroke denote detail differences in designs, and should always be quoted to enable the unit to be recognised from a service point of view.

Examples are: P.U. 600/5

G.U. 600/2

RUNNING INSTRUCTIONS

4

RUNNING INSTRUCTIONS

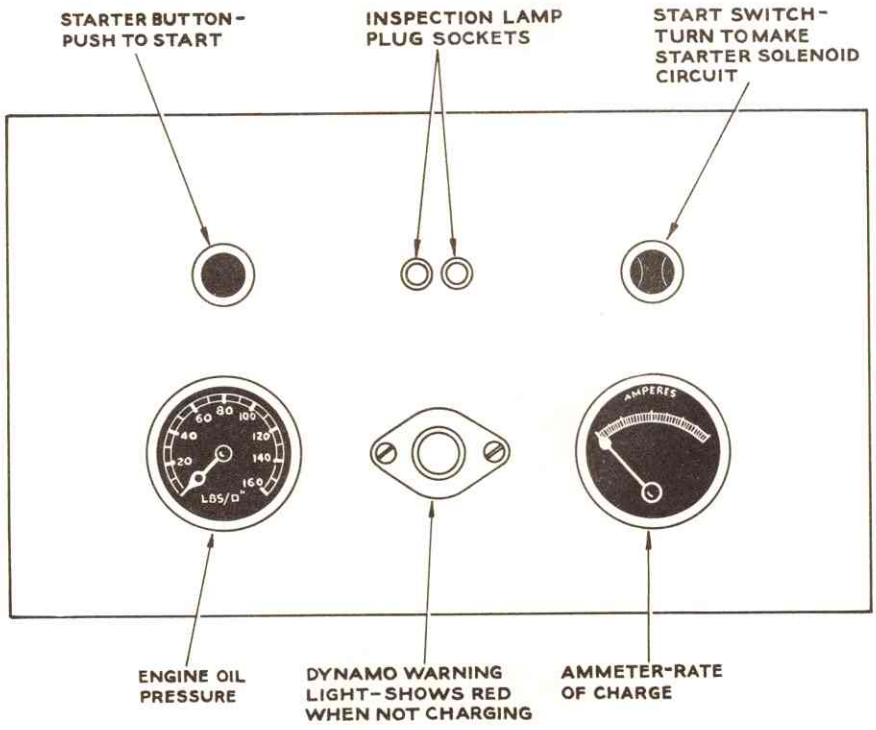


Fig. 1. Standard Panel

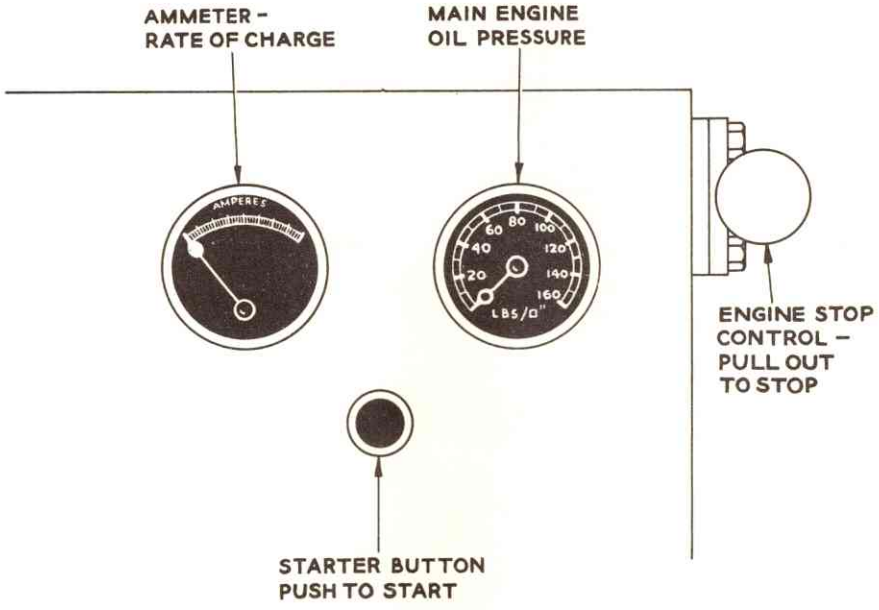


Fig. 2. Panel - Type 450 Open Power Unit

RUNNING INSTRUCTIONS

TO PREPARE FOR A START

NOTE: When starting a new unit after installation or after a major overhaul, carry out all the instructions given below.

For normal starting (at each shift) only carry out the instructions marked with a cross, thus (+).

1. Air Cleaner

Fill air cleaner bowl(s) with oil to mark inside bowl - see LUBRICATION.

+2. Radiator

Check water level and top up if necessary.

On a new unit, check radiator drain cock is shut and fill with clean water, preferably soft if obtainable.

Level should be just above bottom of filler strainer.

+3. Engine Sump

Check oil level with the dipstick. Top up if required to full mark on the dipstick - see LUBRICATION.

New units and engines are shipped overseas with the engine sump filled with a special grade of oil evolved to prevent corrosion of the engine. Before putting into service a unit which has not passed through a Leyland overseas depot or agency, this oil must be replace by the recommended lubricant. Tie-on labels bearing this information are attached to the unit before it leaves the Factory, but sometimes these become detached in transit. Users are therefore warned that the oil should be changed whether or not the unit bears a label.

There is no need for any oil change if the unit has passed through a Leyland overseas depot or agency, because the work will already have been done there.

+4. Fuel

Fill the fuel tank with diesel fuel oil - see FUEL OIL AND STORAGE for types of fuel oil and for hints on bulk storage.

For normal starting, priming of the fuel system should not be necessary if all the pipe joints have been maintained to prevent leaks.

If the unit has been standing idle with the fuel on-off tap shut for a considerable time or in storage, it is wise to prime the fuel system through from the tank to the injection pump. The procedure is given in ROUTINE MAINTENANCE AND INSPECTION.

5. Battery

See that the battery is fully charged (specific gravity between 1.270 and 1.325) and that the electrolyte level is $\frac{1}{4}$" above the separators. Top up if necessary with clean distilled water.

Check that the battery terminals are clean, tight and well smeared with vaseline.

+6. Engine Stop Control

Ensure that the knob is pushed right in to the "run" position, otherwise the engine will not start.

7. Lubrication

Check over all the lubrication points given in LUBRICATION and lubricate as instructed.

If the unit is coupled to a gearbox or reduction gear which has an oil sump dipstick, inspect the level and top up if necessary to full mark on dipstick.

+8. Disengage the clutch or drive connection to the unit if a manual means of disengaging is provided.

9. Look round the unit for any tools or parts which might have been inadvertantly left after installation work. Pull out the engine stop control and hold it out. Turn on the starting circuit switch and turn the engine over with the starter for a few seconds. Look at the whole unit while cranking. If there is no unusual noises and everything seems in order, then the unit should be ready for the first run.

TO START

NOTE: When starting a new unit after installation or after a major overhaul carry out all the instructions given in this section.

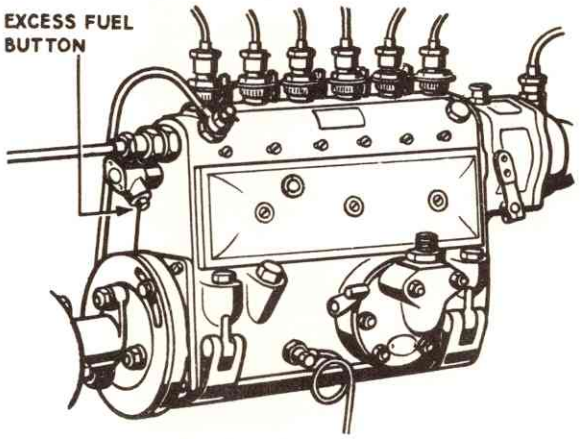


Fig. 3. Excess Fuel Control - Type 350 Engine

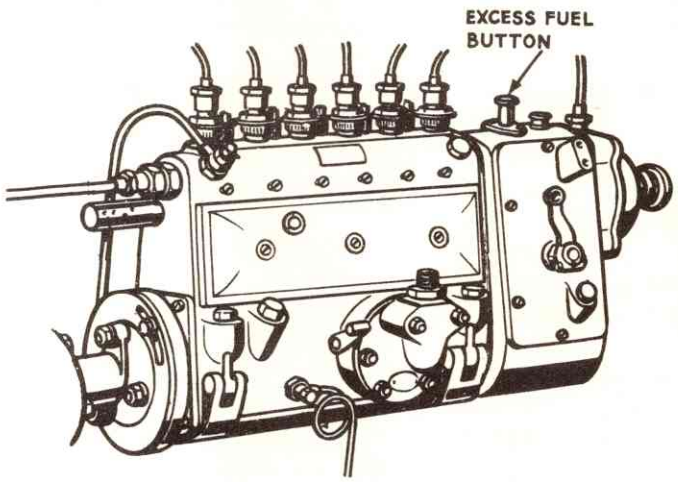


Fig. 4. Excess Fuel Control -· Type 450, 600 and 680 Engines

For normal starting (at each shift) only carry out the instructions marked with a cross +

1. Carry out all the instructions 1 to 9 given under "To Prepare for a Start".

+2. Open the engine speed control about a third of the way to full speed.

+3. Turn on the starting circuit switch, the dynamo warning light should show red, see Fig.1. On certain type 450 units this switch and light are not fitted, see Fig.2.

+4. Press the starter button firmly, see Figs 1 and 2.

+5. Release the starter button as soon as the engine starts. Do not keep the starter running more than 15 to 20 seconds if the engine does not fire, but find the cause of the failure to start. It will be found sometimes necessary, especially during cold weather, to open the speed control more or less fully for a few moments after the engine starts but as soon as it has warned up slightly, this will not be necessary.

+6. Cold Weather Starting

If the unit is operating outside and the temperature is below 30° F. or normal starting is difficult, proceed as follows:-

a. Fill the radiator with hot water to free the pistons.

b. Depress the excess fuel button on the injection pump. (type 350 units) see Fig 3, or the governor casing (type 450, 600 and 680 units), see Fig 4.

c. Turn on the starting circuit switch, see Fig.1. On certain type 450 units this switch is not fitted.

d. Set the engine speed control lever to full speed.

e. Press the starter button, see Figs 1 and 2. If necessary have a second man on the starting handle to help crank the engine if it is particularly stiff.

f. When the engines fires and will run unassisted, ease the speed control back and warm up the engine on no-load.

g. The excess fuel button should return automatically to normal as soon as the engine is running unassisted.

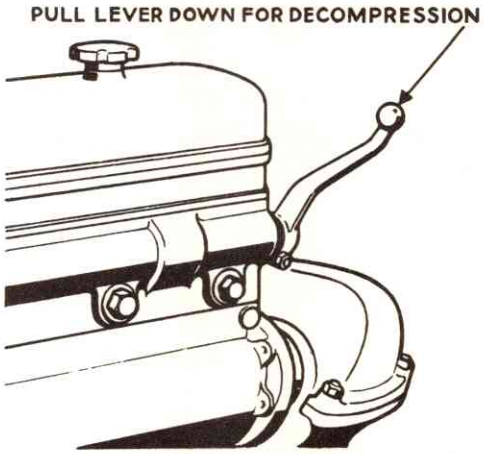


Fig. 5. Decompressor Control - Type 450 Engine Only

Check that this button has returned as soon as possible.

NOTE: If the engine is fitted with an external decompressor as on all type 450 units, crank the engine on decompression with the starter. As soon as good cranking speed is obtained knock off the decompressor smartly.

+7. Immediately after starting, check the oil pressure gauge. If no reading is shown after 15 to 20 seconds, stop the engine at once and check the engine oil system.

+8. The dynamo warning light should extinguish as soon as the engine picks up speed.

+9. Warming-up Period

After starting up, allow the engine to warm up for a few minutes at part throttle and no load. Do not abuse the ability to put the load on a cold engine, except in an emergency, in which case apply the load as soon as the oil pressure reaches normal.

+10. If the engine is operating in a closed engine house, ensure that there is ample air available for the engine. Enough ventilation should be allowed to keep the engine running at a temperature which ensures the best operating results.

RUNNING

1. Oil Pressure

The oil pressure reading should be 60 lb/sq. in. (4·2 kg/sq. cm.) at 1,000 engine r.p.m. or higher speeds, with a warm engine and it should not fall below 5 lb/sq. in. (·35 kg/sq. cm.) when the engine is idling.

2. Ammeter and Dynamo Warning Light.

The ammeter, see Figs 1 and 2, only registers the charging current into the battery. Therefore a low reading denotes a fully charged battery and a

high reading a low condition.

With a battery in good condition a charge of 1 to 2 amps will be shown. An excessive reading over a continuous period indicates either a serious fault in the electrical system or a badly run down battery which must be dealt with at once. No reading at all, together with the dynamo warning light showing red continuously, irrespective of engine speed denotes that the dynamo is not charging either through a fault in the dynamo or the dynamo control board.

3. Temperature

If either oil or water temperature gauges are fitted, these should be checked when the unit has warmed up.

The oil temperature should not exceed 85° C.

The water temperature should not exceed 95° C, the ideal working temperature is 80°/85° C.

4. Engine Sump

After 8/10 hours running, stop the engine, leave for 5 minutes and then check the oil level. If necessary top up to full mark on dipstick.

5. Radiator

After 8/10 hours running, check water level. Top up if necessary with clean soft water.

6. Check Unit

When the unit is fully warmed up, check it over for oil, fuel and water leaks. Tighten joints where necessary.

Keep the unit and operating area clean and tidy.

TO STOP

1. Disengage the clutch or drive if manual operation is provided or working conditions permit.

2. Shut down the engine speed to idling.

3. Pull out the knob of the engine stop control and hold out until engine stops. Push in knob ready for the next start.

4. Turn off the starting circuit switch.

5. Radiator

Check level and top up if necessary ready for the next shift.

6. Engine Sump

Check level and top up if necessary for the next shift.

7. Fuel Tank

Check level and fill up as required, so that there is ample fuel for the next shift.

NOTE: Do not shut off the fuel with the on-off tap, as this procedure tends to form air locks on restarting. Only use the tap in an emergency or if the unit is to be laid up for a considerable period.

8. Clean Down

Check and clean the engine thoroughly ready for the next shift.

9. Above all, carry out instructions laid down in ROUTINE MAINTENANCE AND INSPECTION.

Commonsense application of the periodical attentions will go a long way towards ensuring trouble free operation.

ROUTINE MAINTENANCE AND INSPECTION

5

ROUTINE MAINTENANCE AND INSPECTION

GENERAL NOTE

Due to the varied types of service and operation on which units are engaged, two scales of maintenance periods are given. One is for units operating with a continuous rated output, or duty, in temperate or semi-tropical climates, engine-house installations, stationary generating units, etc. The other scale is for units engaged on heavy duty and operating in a heavily dust-laden atmosphere, such as tractors, dump trucks, graders etc.

As various types of oil-, fuel-, and air-filters are fitted to Leyland engines, a description of the construction and operation of each type is given in this section.

For periods of lubrication, see LUBRICATION CHART.

BEFORE STARTING THE ENGINE

1. Check that engine oil level is correct (dipstick). Top up as required.

2. Check water level in radiator. Level should be just above the bottom of the filler strainer.

3. Check the fuel tank. If the fuel tap has been turned off, prime the system.

4. Check over driven units (generators, pumps, etc.) according to the instructions issued by the manufacturer.

5. Lubricate according to the LUBRICATION CHART.

FROST PRECAUTIONS

Severe damage from frost may result unless proper precautions are taken.

Frost precautions come under three headings:

1. The use of anti-freeze mixture.

2. The complete draining of the cooling system.

3. Periodic running of the engine to maintain the cooling system above freezing point.

The three methods are carried out as under:

1. Anti-freeze Mixture

   The addition of anti-freeze fluid to the cooling water prevents freezing at normal freezing point, but it must be remembered that even an anti-freeze mixture will freeze if the temperature is sufficiently low, or the anti-freeze mixture is too weak.

   The total capacity of the cooling water systems (with industrial-type radiators) are:

Type 350	-	10 gallons	(45.45 litres)
Type 450	-	12 gallons	(54.44 litres)
Type 600 and 680	-	14 gallons	(63.6 litres)

   It is advisable to mark the radiator filler in some way to denote that anti-freeze mixture is in use. A spare can of mixture in the

correct proportions should be carried where possible for topping up.

2. Complete Draining

This is probably the best method to adopt when the unit is to be stopped for a period.

Drain the system completely. It is important to drain off all the water in the cylinder block jacket.

When refilling the system, close the drain cocks, add the water and then start the engine. Warm up quickly but without racing the engine.

3. Periodic Running

This method may have to be adopted where anti-freeze mixture is not used and where it is not practicable to drain the system. It is wasteful owing to the fuel needed to run the engine periodically. The frequency and length of time running depends on the severity of the weather.

BATTERY FROST PRECAUTIONS

It is not always realised that frost damage to the batteries can occur. A few points of advice are given below.

1. If the electrolyte in a battery becomes frozen, the battery will be damaged beyond repair.

2. The temperature at which the electrolyte in a battery will freeze varies with the specific gravity of the electrolyte.

3. The specific gravity of the electrolyte varies with the state of charge of the battery.

4. The method of preventing damage to batteries by frost is to keep the specific gravity of the electrolyte high. This is done by keeping the battery as fully charged as possible.

5. When frost conditions prevail, see that the battery receives a charge before the engine is shut down, and do not discharge the battery by frequent or prolonged starting or by a heavy lamp load, unless provision can be made to recharge the battery.

NOTE: A battery in good condition and reasonably fully charged will not freeze at temperature above 0° Fahr. (-17.7° Cent.).

STORING

When a unit is to be laid up or stored for a six-month period or less, special precautions should be taken to guard against rust, corrosion on wearing surfaces and gumming in the fuel system. These instructions are not applicable to units which need preservation for shipment by sea or transport to different climatic conditions.

The recommended precautions are as follows:

ENGINE

1. Check the engine over generally, carrying out any overhaul due at the time. Thoroughly clean exterior and wipe down.
2. Drain the sump, renew the oil filter element. Clean and refill the air cleaner or cleaners.
3. Refill the sump with clean oil, see LUBRICATION for grade of oil.
4. Remove cylinder head cover(s) and liberally squirt the valve gear with clean engine oil.
5. Paint over all unpainted metal parts with rust inhibitor.

DRIVE UNITS (Clutches, gearboxes, belt drives etc.)

1. Check over generally, carrying out any overhaul due at the time. Thoroughly clean exterior and wipe down.
2. Drain the oil from any drive gearboxes etc. fitted, renew or clean all filter elements.
3. Refill with clean oil, see LUBRICATION for grade of oil.
4. Paint all unpainted metal parts with rust inhibitor. Exposed chain drives should be cleaned and coated with grease.

DRIVEN UNITS (Generators, pumps, etc.)

Generally the procedure is the same as for the engine and drive units in principle, but reference should be made to the unit manufacturers handbook. This is particularly important when laying up electrical equipment.

FUEL SYSTEM

1. Drain fuel tank and system completely.

2. Clean primary filter element and renew main filter cloth element. Do not forget to clean out the filter bowls.

3. Drain the fuel tank free of all sediment, water etc.

4. Put 3 to 4 gallons of a reliable rust-proofing fuel into the tank. Prime the fuel system through, start and run the engine for approximately two minutes at fast idling speed and no load. Stop the engine, but do not drain the fuel system.

NOTE: A suitable rust-proofing fuel can be obtained from any of the leading oil companies. No definite specification can be quoted as such a fuel is usually a proprietary preparation.

COOLING SYSTEM

1. Drain off all water and reverse flush the radiator clean.

2. Remove the oil cooler (if fitted) and clean the oil tubes with a degreasing solvent. Drain and wash through the tubes with clean oil. Replace cooler.

3. Leave all drain cocks open.

4. Clearly indicate with a notice on the unit - "NO WATER IN ENGINE".

BATTERY

1. Remove battery from the unit and store in a dry place above freezing point.

2. Top up with distilled water and charge fully before storing. Check charge regularly during storage.

FINAL OPERATIONS

1. If available, an engine inhibitor fluid should be sprayed into the inlet manifold as the engine is turned over by hand on decompression.

   A reliable inhibitor used in the U.K. is Inhibitor CS 1746 and is recognisable by its vivid green colouring. It can also be used to paint over all unpaintable metal parts on the unit.

2. Insert strips of grease proof paper between the engine fan belts and pulleys to prevent the rubber bonding in the pulley grooves.

   Do the same with any belt drives from the unit. It is not advisable to remove a belt or belts (particularly flat) from a drive unless there are proper facilities for storage. Never slip belts off drive pulleys and leave them hanging loose. If it is imperative that the drive is

to be disconnected, remove the belt or belts completely to store.

3. Finally seal all openings on the unit with masking tape, cardboard, plywood or metal covers. If possible sheet the whole unit over with a cover, particularly if stored in a dusty locality.

TO RESTART AFTER STORING

The unit can be restarted after removing all covers and protective measures. Carry out the instructions given in Section 4 under "To prepare for a Start" to ensure that everything is in order. No further draining or flushing need be carried out if the above storage instructions are carried out.

NOTE re SERVICE MANUAL

The manual referred to is the standard Leyland Service Manual covering the basic units built into industrial power units.

It gives the full overhaul procedure, workshop practice, and limits of permissible wear. The servicing of fuel injection equipment is also dealt with in detail.

A copy of this manual is supplied with each unit delivered and should be used as a companion to this Maintenance Handbook.

MAINTENANCE PERIODS

The suggested maintenance periods are based on the actual hours run. The shorter intervals are the same as those for lubrication, so that maintenance and lubrication can be carried out at the same time.

The shorter periods are based on an average 8-hour working shift. Therefore if the unit is operating on a 24-hour basis, the 8-hourly maintenance must be carried out three times during each 24-hour period.

Type of Duty		Maintenance required
Stationary units - Generating Sets, etc.	Automotive units - Tractors Dump Trucks Graders etc.	
Every 8 to 10 hours run	Every 8 to 10 hours run	1. Air cleaners. If conditions are very dusty, inspect and clean if necessary. Otherwise leave inspection until the 50 to 60 hours period.
Every 50 to 60 hours run	Every 50 to 60 hours run	1. Air cleaners. If conditions are very dusty, inspect and clean if necessary. If cleaning is not needed top up the oil in cleaner bowl to level mark and leave until the 200 to 250 hours period. 2. Primary fuel filter. If conditions are dusty, clean the primary fuel filter gauze, otherwise leave cleaning until the 200 to 250 hours period.
Every 100 hours run	Every 100 hours run	1. Carry out operations given under every 50 to 60 hours run. 2. Main fuel filter(s) If operating in very dusty conditions, inspect the main fuel filter(s) and renew the cloth(s) if necessary. Otherwise leave inspection until the 500 hour period. Drain off any accumulated water or sediment in the filter bowl(s) at each inspection. 3. Engine tune-up. After the first 100 hours run with a new unit, check the tappet clearances, liveliness of the engine, injection (cleanliness of the exhaust) and tension of fan belts. See ENGINE.

Type of Duty		Maintenance required
Stationary units - Generating Sets, etc.	Automotive units - Tractors Dump Trucks Graders etc.	
		4. Oil change. After the first 100 hours run with a new unit, drain and refill engine sump. See LUBRICATION for type of oil. Fit new oil filter cloth or element. The same instructions apply to any drive or reduction gearboxes fitted. 5. Battery. Check electrolyte level, terminal lugs and state of charge. See ELECTRICAL EQUIPMENT.
Every 200 to 250 hours run	Every 200 to 250 hours run	1. Carry out operations given under every 100 hours run. 2. Primary fuel filter. Clean the primary fuel filter. 3. Oil change. Drain and refill engine sump. See LUBRICATION for type of oil. Fit new filter cloth or element at each oil change. The same will apply to any drive or reduction gearboxes fitted, unless expressly stated otherwise. 4. Starter motor. Check operation and engagement of starter motor.
Every 500 hours run		1. Carry out operations given under every 200 to 250 hours run. 2. Main fuel filter(s) Drain main fuel filter(s) and renew cloth(s). On twin filters only one filter at a time need be changed. If operating under dusty conditions renew the filter felt pack, otherwise leave until the 2,000 hour period. Prime the fuel system after cleaning. 3. Dynamo. Check mounting and drive couplings.

Type of Duty		
Stationary units - Generating Sets, etc.	Automotive units - Tractors, Dump Trucks Graders etc.	Maintenance required
		4. Fuel tank. Drain any water and sediment from service tank by removing drain plug and suction strainer and replace. 5. Engine tune-up. Check tappet clearances, general liveliness and response of engine to speed control, tension of fan belts and injection (cleanliness of exhaust). Do not disturb the injectors in the cylinder head unless it is obvious that the engine performance has deteriorated or that there is visual indication that injection is faulty. Visual indication is given by white or black smoke in the exhaust. Another indication is a loss of r.p.m. from the rated governed speed; for example, if the normal governed speed is 1600 r.p.m. but with the engine speed control fully open the engine will only reach 1500 r.p.m., then it is certain that the injectors need attention. If there is reason to suspect the injector performance, remove all the injectors and replace by a tested replacement set. See ENGINE and SERVICE MANUAL. We do not advise stripping and overhauling injectors unless proper facilities and equipment are available. 6. Clutch. Check for smoothness of engagement. Inspect that there is the proper free travel before disengagement. See CLUTCH. 7. Driven units. Check according to any instructions issued by the manufacturer of the unit. 8. Timing chain. The type 450 engine is the only one fitted with a triplex roller timing chain. The tension should be checked at this period. See ENGINE and SERVICE MANUAL.

Type of Duty		Maintenance required
Stationary units - Generating Sets, etc.	Automotive units - Tractors, Dump Trucks Graders etc.	
Every 1000 hours run	Every 500 hours run	1. Carry out all operations called for under the heading "Every 500 hours run". (See "Stationary Units" column.) 2. Radiator. Drain the cooling system completely. If filled with anti-freeze mixture collect it carefully for using again after settling. Flush out the radiator and engine block, using pressure reverse flushing if possible, to clear out all deposited sediment. Inspect the tube stack for loose or leaking tubes. Replace defective tubes or ferrules. See RADIATOR. The use of a chemical descaling agent is not recommended unless it is known for certain that the agent has no detrimental effect on aluminium alloys. 3. Oil cooler (if fitted). At the same time remove the oil cooler and thoroughly degrease the oil passage with trichlorethyline or some similar agent. 4. Water pump. Check the condition of the gland by observing if there is any appreciable water leak from the pump front cover. If necessary renew the carbon gland. See ENGINE.
Every 2000 hours run	Every 1000 hours run	1. Carry out operations given under the previous heading. 2. Dynamo and starter motor. Check brush gear and commutators. Check all wiring connections. See ELECTRICAL EQUIPMENT. 3. Engine tune-up. If the engine performance is such that the usual tappet adjustment etc., will not give the standard rated performance, then a full overhaul is called for in accordance with the practice laid down in the SERVICE MANUAL.

Type of Duty		
Stationary units - Generating Sets, etc.	Automotive units - Tractors, Dump Trucks Graders etc.	Maintenance required
		4. Drain the fuel filter(s) and renew the felt pack.
Every 5000 hours run	Every 2000 hours run	1. Carry out operations given under the previous period 2. Top overhaul. Remove the cylinder heads, inspect valves, rockers, guides, etc. Remove carbon from heads and ports, touch up valves and seats. Remove all injectors and check for performance. If injector reconditioning facilities are not available, replace with a tested replacement set. See ENGINE and SERVICE MANUAL.
Every 12,500 to 15,000 (maximum) hours run	Every 5,000 (maximum) run	This is the period for full overhaul of the complete unit. In this instance pistons, connecting rods, valve gear and bearings should be removed and if not falling within the normal limits of wear, such parts should be replaced, and the unit rebuilt in accordance with the instructions laid down in the SERVICE MANUAL.

FUEL SYSTEM

Fig.1. shows in diagrammatic form the fuel system and direction of flow in the pipes

The fuel is drawn from the service tank(s) through a suction filter incorporated with the drain plug by a diaphragm-type lift pump operated by the injection pump camshaft. A combined primary filter and on-off tap is usually fitted in the tank-to-lift-pump pipe to isolate the tank during fuel system overhauls.

The lift pump delivers the fuel to the main filter, which may be either a single or twin unit as shown. After filtration, the fuel is fed to the injection pump which in turn delivers the fuel under high pressure through separate pipes to the injectors.

In every fuel system there is a fuel leak-off from the injectors which is piped through a gallery pipe back into the service tank.

The majority of main filters now fitted have permanent bleeder valves which relieve excessive pressure in the filters and vent any air trapped in the fuel. These valves reduce the need for frequent air venting or bleeding which occurs on filters not fitted with these valves. Venting will only be required after filter cleaning, disconnection of fuel pipes or if the fuel has been shut off for a long period by the on-off tap (Fig. 2.)

TO PRIME THE SYSTEM

NOTE: **Keep all filter covers, pipe unions etc, tight. Fuel leaks mean air locks in the fuel system and consequently erratic running.**

Air may be introduced into the system if the filters, injectors or any of the pipes have been removed, if the service tank is allowed to run dry or a filter is choked.

For normal priming proceed as follows:-

1. Open the air bleed valve. The Leyland type filter (Fig.3.) and C.A.V. type B.F.A. filters are not fitted with permanent bleed valves.

2. **Operate the hand primer lever on the lift pump until fuel flows free of bubbles from the valve.**

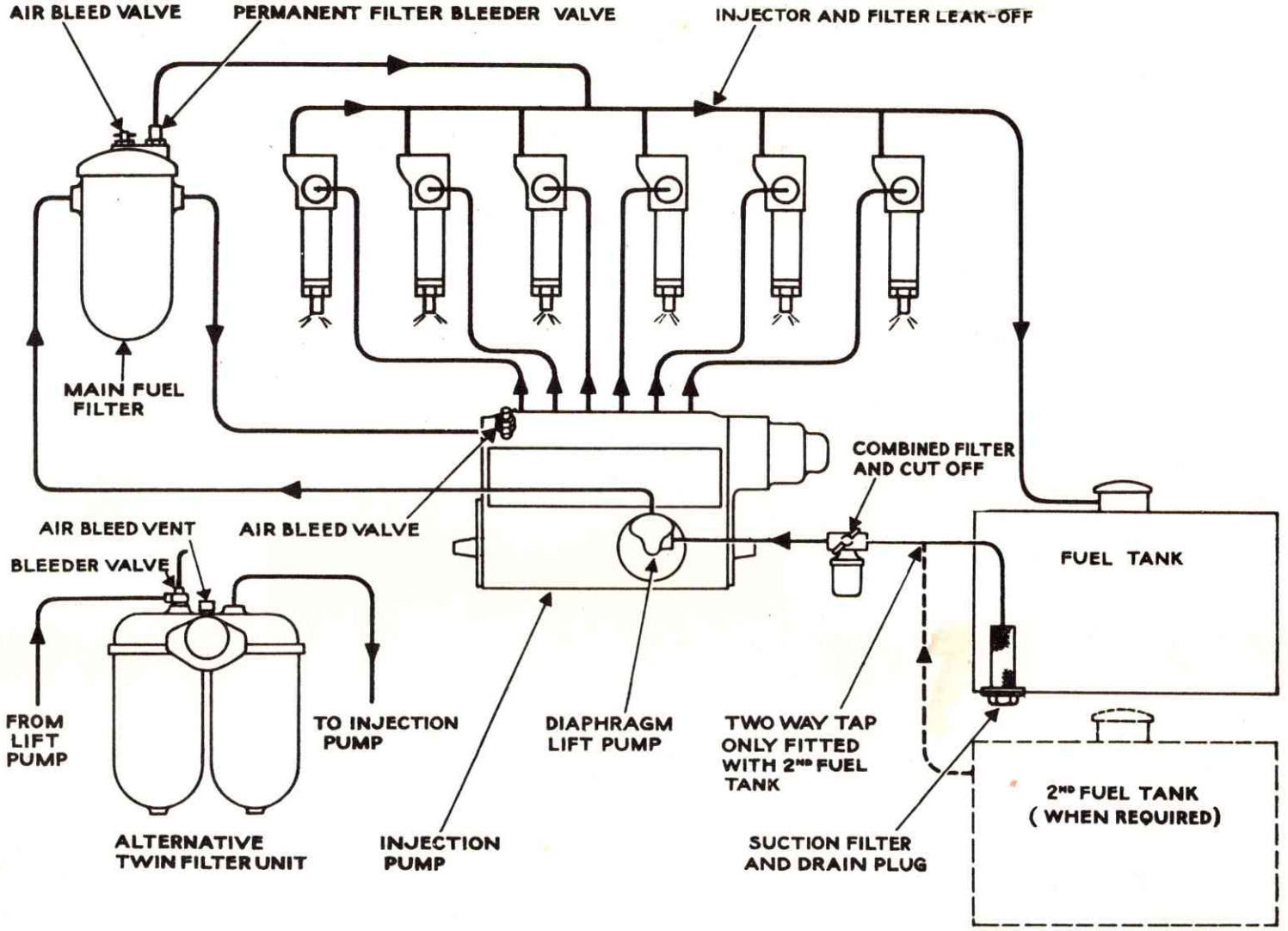


Fig. 1. Typical Fuel System Layout

On occasions it may be found that although the hand primer lever will move up and down it is not actually pumping. This will be caused by the injection pump camshaft coming to rest in such a position that the cam operating the lift pump is in the maximum lift position. A quarter turn of the engine with the starting handle will correct this and enable the primer to be operated.

3. Close the air bleed when the fuel is free from bubbles

4. Open the air bleed on the injection pump, see Fig. 1, and repeat Operations 2 and 3

The above operations are sufficient to clear the air from the system under normal conditions. If however the injectors or injector piping has been removed, the engine fails to start or misfires on starting, further priming is necessary, as follows:

5. If the engine will not start, slacken each injector pipe union nut at the injector and motor the engine round with the starter motor until fuel flows without bubbles, then tighten the union.

   If the engine will run, but misfires, this operation can be carried out with the engine running, thereby conserving the battery.

NOTE: If an external decompressor is fitted, use it while motoring the engine on the starter motor to conserve the battery.

TO CLEAN THE PRIMARY FILTER

1. Turn the tap to "off"

2. Unscrew the bowl from the tap body

3. Remove the gauze filter, by unscrewing the setscrews at the bottom

4. Wash the gauze in clean petrol or paraffin

5. Replace the filter and secure it with the setscrew

6. Rinse out the filter bowl, fill it with clean fuel oil and screw back tightly in position.

7. Open the tap and prime the system through to the injection pump.

Fig. 2. Primary Fuel Filter and Tap

FUEL FILTERS

Leyland type fuel filters are fitted to the majority of units but in certain cases C.A.V. filters are fitted to meet special requirements.

A brief description is given on the construction, operation and maintenance of the filters.

CLEANING THE FILTER

The frequency of inspection and cleaning for all types of filters is laid down under "Maintenance Periods".

The cloth elements should be renewed when it is evident that the filters need cleaning, this will vary from 200 to 500 hours run, depending on the operating conditions. The felt packs should be cleaned whenever the cloths are renewed. Replacement of the felt packs is only needed for every third or fourth renewal of the cloth elements.

Whilst the cloth elements can be cleaned, it is preferable and more economical to replace them, since spares (wrapped protectively to facilitate storage) can be obtained quite cheaply. This course is recommended, since if the cleaning process is not correctly carried out the cloths may be punctured or the dirt merely transferred from the outside to the inside of the element whence it can pass to the main filter outlets, alternatives which spell danger to the injection equipment.

FUEL FILTER - LEYLAND TYPE

CONSTRUCTION AND OPERATION

Fig. 3. shows the earlier type of filter with two chambers, one containing a cloth element with felt pack, and the second gauze and felt elements.

Fig. 4. shows the latest pattern with one chamber containing a cloth element and felt pack.

The main body of both types is an alloy casting flange mounted to a facing on the inlet manifold.

Fuel delivered by the lift pump enters the body at the top, passes through the cloth element, thence through the drilled centre stud to the second filter chamber, Fig. 3, or to the outlet connection to the injection pump, Fig. 4.

On both types drain plugs are provided to allow sediment or water to be drawn off.

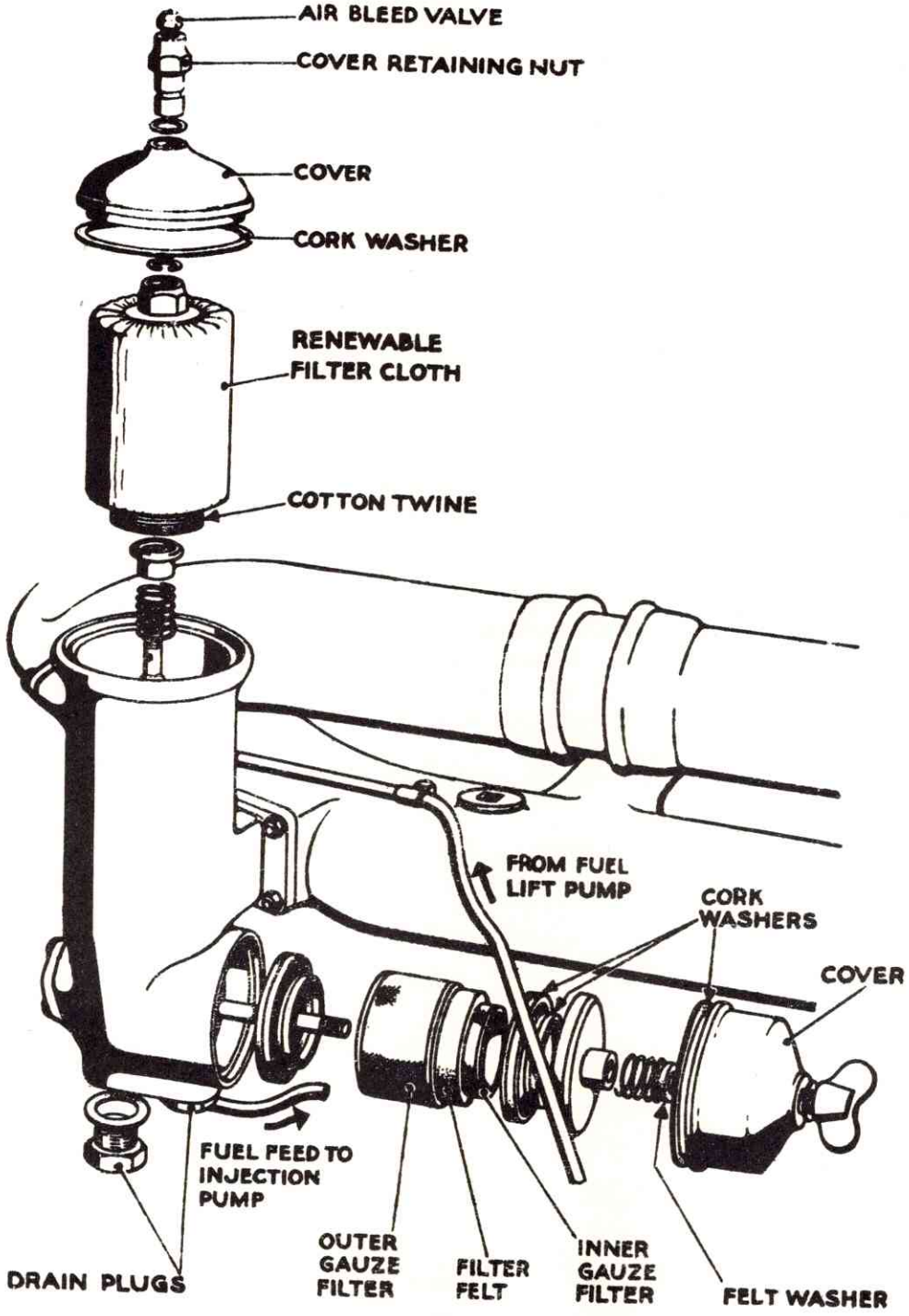


Fig. 3. Fuel Filter - Leyland Type (twin chamber)

The earlier type of filter, Fig. 3, is provided with a screw type air bleed valve in the cover retaining nut.

A permanent valve is fitted to the inlet of the latest type, Fig. 4, dispensing with the need for an air bleed screw.

TO RENEW THE CLOTH ELEMENT AND CLEAN THE FELT PACK

These instructions apply to the type of filter shown in Fig. 4. For the type of filter shown in Fig. 3, carry out only the operations marked with a cross (+)

+ 1. **Unscrew the cover retaining nut, which secures the cover to the main body. The filtering element can now be removed.**

+ 2. **Remove the nut holding the cloth to the frame.**

3. **Fit clean corks at the top and bottom of the support tube of the frame to keep dirt from entering the inside.**

+ 4. **Remove the dirty cloth**

5. **Replace the nut and washer over the cork to keep the felt pack together when washing. Do not separate the felt rings in the pack.**

6. **Wash the felt pack in clean petrol or paraffin.**

The most efficient way to clean the felt pack when immersed for cleaning is by blowing air into the support tube from either end. This can be easily done by inserting a cycle pump adapter in one of the corks and blowing air with a cycle or hand pump into the support tube. This should be done immersed in petrol or paraffin, so that the air passes from the inside to the outside of the pack thereby carrying the dirt to the outside of the pack. It is not sufficient to merely rinse or brush the pack as this may cause dirt removed to settle further into the inside of the pack and subsequently pass into the injection system when replaced in the filter.

7. **Drain the felt pack on clean paper to dry**

+ 8. **Fit a new cloth, replace the nut and tighten up**

9. **Pleat the cloth neatly round the neck of the frame and bind securely with the cotton twine provided. Trim off the surplus cloth beyond the neck of the frame. Paint round the neck of the frame to seal the twine and ensure the pleated cloth is oil-tight.**

+ 10. **Thoroughly clean out the main housing, removing all sludge. Remove the drain plug to facilitate this operation.**

+ 11. **Replace the element and re-assemble**

+ 12. **Prime the fuel system, through to the injection pump**

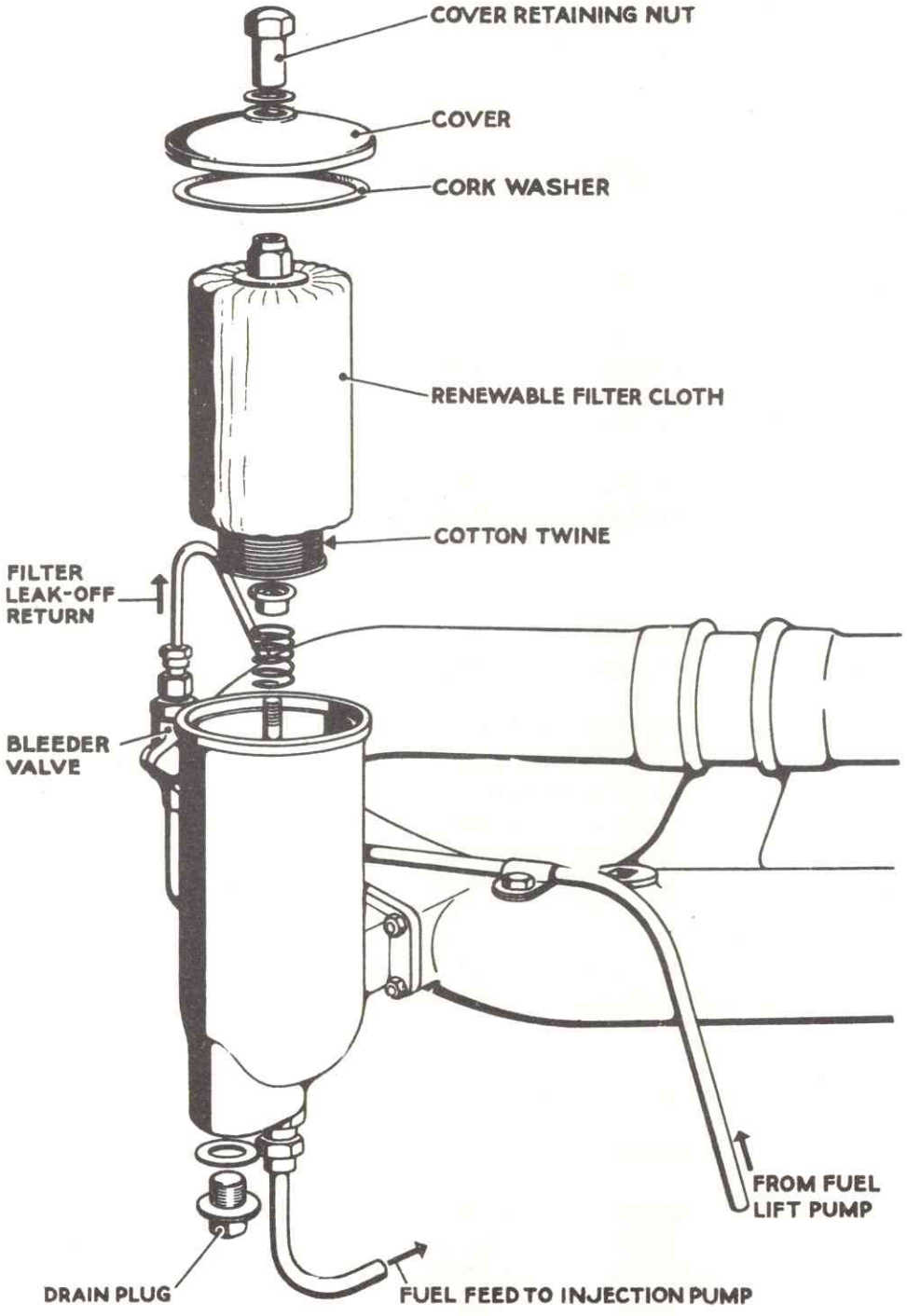


Fig. 4. Fuel Filter - Leyland Type (single chamber)

TO REPLACE THE FELT PACK

Carry out operations 1 & 2 given under "To Renew The Cloth Element and Clean The Felt Pack", then separate the frame and remove the old felt pack. Clean the frame and fit a new felt pack. Then carry out operations 8 to 12.

FUEL FILTER - C.A.V TYPE BFA

CONSTRUCTION AND OPERATION

The filter (Fig. 5.) consists of a body housing containing the filtering element and a casting forming the cover. The fuel from the lift pump enters the body housing on the outside of the element, the fuel is filtered through the element inwards and is led out at the bottom through the hollow centre bolt. This ensures that all the dirt is on the outside of the cloth, visible for inspection.

The element has two filtering mediums, a cloth on the outside and a felt pack inside the element frame. The pack is a series of thick felt rings fitted over the fframe support tube and held compressed by the nut on top of the frame.

On the latest type filters a permanent bleeder valve is fitted which relieves any excessive pressure or air trapped in the filter. This leak-off is led back to the fuel tank. Earlier type filters are not fitted with this valve and will therefore need venting more frequently.

TO RENEW THE CLOTH ELEMENT AND CLEAN THE FELT PACK

1. Disconnect the filter leak-off return pipe at the bleeder valve.

2. Unscrew the cover retaining nut, which secures the cover to the body housing. The filtering element can now be removed.

3. Remove the nut holding the cloth to the frame

4. Fit clean corks at the top and bottom of the support tube of the frame to keep dirt from entering the inside.

5. Remove the dirty cloth

6. Replace the nut and washer over the cork to keep the felt pack together when washing. Do not separate the felt rings in the pack.

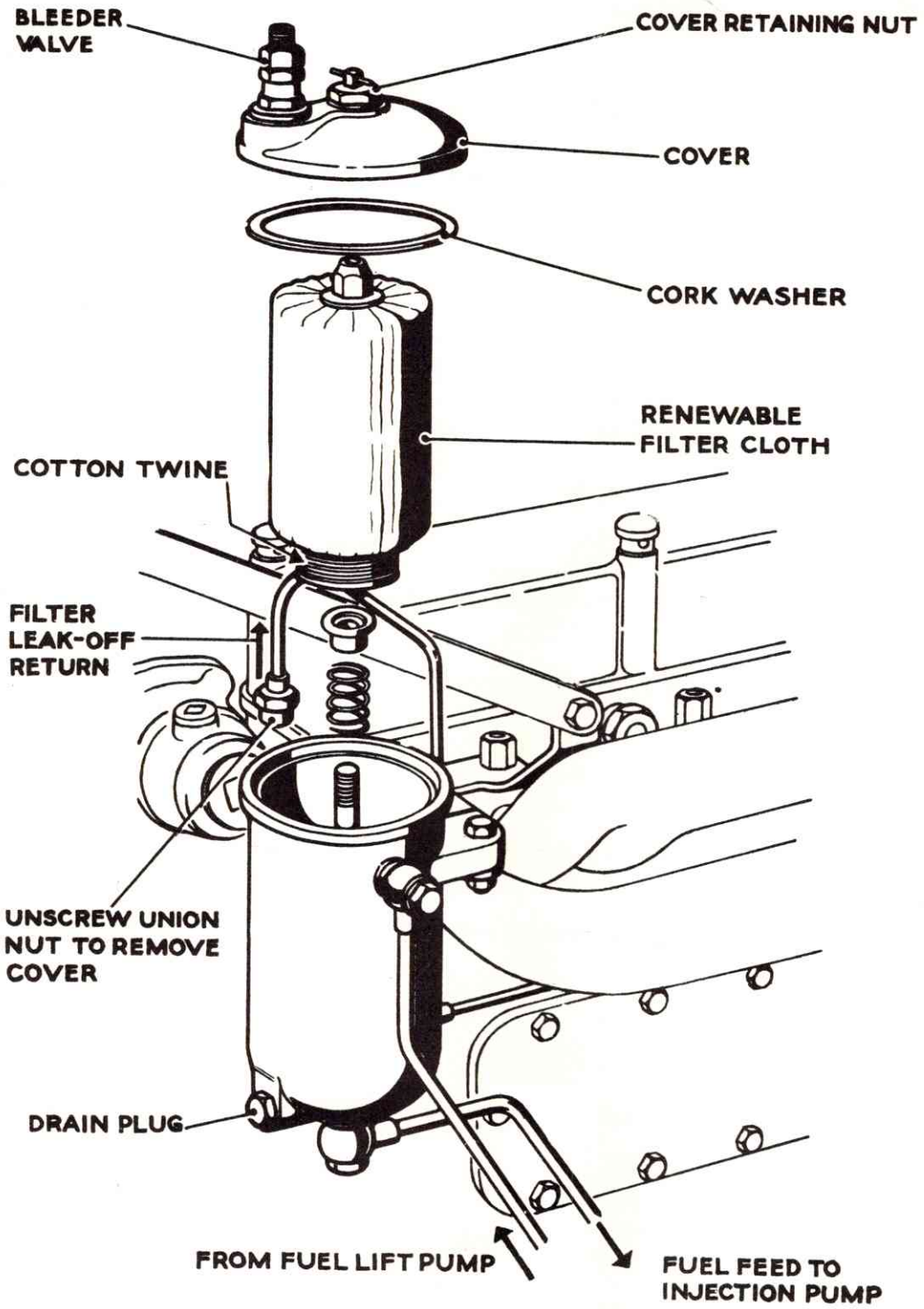


Fig. 5. Fuel Filter - C.A.V. Type BFA

7. Wash the felt pack in clean petrol or paraffin.

   The most efficient way to clean the felt pack when immersed for cleaning is by blowing air into the support tube from either end. This can be easily done by inserting a cycle pump adapter in one of the corks and blowing air with a cycle or hand pump into the support tube. This should be done immersed in the petrol or paraffin, so that the air passes from the inside to the outside of the pack thereby carrying the dirt to the outside of the pack. It is not sufficient to merely rinse or brush the pack as this may cause dirt removed to settle further into the inside of the pack and subsequently pass into the injection system when replaced in the filter

8. Drain the felt pack on clean paper to dry

9. Fit a new cloth, replace the nut and tighten up

10. Pleat the cloth neatly round the neck of the frame and bind securely with the cotton twine provided. Trim off the surplus cloth beyond the neck of the frame. Paint round the neck of the frame to seal the twine and ensure the pleated cloth is oil-tight

11. Thoroughly clean out the body housing, removing all sludge, replace the element and re-assemble

12. Prime the fuel system through to the injection pump.

TO REPLACE THE FELT PACK

Carry out operations 1 to 3 above, then separate the frame and remove the old felt pack. Clean the frame and fit a new felt pack. Then carry out operations 9 to 12.

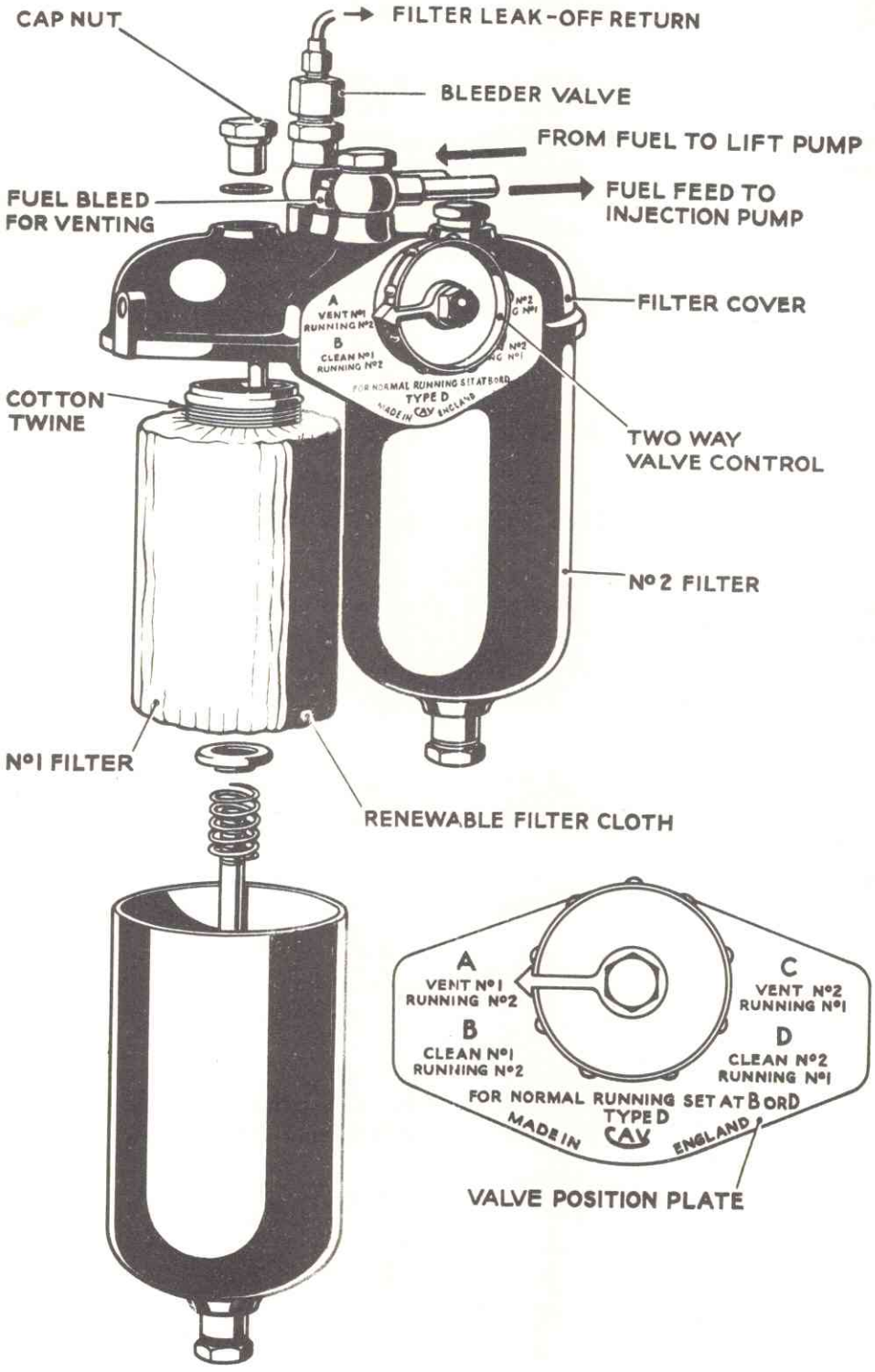


Fig. 6. Fuel Filter - C.A.V. Type D.

FUEL FILTER - C.A.V DUPLEX

CONSTRUCTION AND OPERATION

The two filter units (Fig.6.) are connected together by means of a two-way valve carried in a common casting forming the filter cover. Pressed steel housings contain the filter elements which are cloth covered.

By means of the two-way valve, which is operated by a hand wheel, either filter can be put out of action for cleaning while the engine is running on the other. Air venting of either filter is also controlled by the hand wheel operating the two-way valve, which has a pointer to mark its several position clearly, see Fig. 6.

TO RENEW THE CLOTH ELEMENT AND CLEAN THE FELT PACK

1. Turn the hand wheel pointer so that it is in line with "Clean No. 1" or "Clean No. 2", depending on which filter is to be cleaned.

2. Unscrew the cap nut which secures the filter container to the top cover casting. The filter element can now be removed.

3. Remove the nut holding the cloth to the frame.

4. Fit clean corks at the top and bottom of the support tube of the frame to keep dirt from entering the inside.

5. Remove the dirty cloth.

6. Replace the nut and washer over the cork to keep the felt pack together when washing. Do not separate the felt rings in the pack.

7. Wash the felt pack in clean petrol or paraffin.

   The most efficient way to clean the felt pack when immersed for cleaning is by blowing air into the support tube from either end. This can be easily done by inserting a cycle pump adaptor in one of the corks and blowing air with a cycle or hand pump into the support tube. This should be done immersed in petrol or paraffin, so that the air passes from the inside to the outside of the pack thereby carrying the dirt to the outside of the pack. It is not sufficient to merely rinse or brush the pack as this may cause dirt removed to settle further into the inside of the pack and subsequently pass into the injection system when replaced in the filter.

8. Drain the felt pack on clean paper to dry.

9. Fit a new cloth, replace the nut and tighten up.

10. Pleat the cloth neatly round the neck of the frame and bind securely with the cotton twine provided. Trim off the surplus cloth beyond the neck of the frame. Paint round the neck of the frame to seal the twine and ensure the pleated cloth is oil-tight.

11. Thoroughly clean out the body housing, removing all sludge, replace the element and re-assemble.

12. Turn the handwheel pointer so that it is in line with "Vent No. 1" or "Vent No. 2", depending on which filter has been cleaned.

NOTE: On early pattern twin filters no handwheel was fitted. Fig. 2. shows the various positions of the square shank of the valve operating spindle and also the vent screw, which was independant of the two-way valve.

TO REPLACE THE FELT PACK

Carry out operations 1 to 3 under "To Renew the cloth element and clean the felt pack", then separate the frame and remove the old felt pack. Clean the frame and fit a new felt pack. Then carry out operations 9 to 12.

Fig. 7. Valve Position Plate (early model twin filters)

AIR FILTERS

To enable the operator to maintain either of the two types of Air Filters fitted, a brief description on the construction and operation of each one is given.

The type fitted is dependent on the conditions under which the unit is required to operate. For instance, the heavy duty type will be fitted to units operating under bad conditions and excessively dusty atmosphere, whilst the other type of filter is fitted to units operating under reasonably good conditions such as a power house installation, etc.

AIR CLEANER (HEAVY DUTY)

CONSTRUCTION AND OPERATION

This cleaner is a heavy duty oil bath type which cleans the air in two stages. First by the reversal of the air flow impinging on the surface of the oil and secondly, by passing the oil-laden air through the screen or element.

Fig. 8. clearly shows the component parts of the cleaner

TO CLEAN

1. **Unscrew the three wing nuts securing the cover to the cleaner mounting bracket. The two outer tie-bolts will drop clear of the mounting bracket.**

2. **Slacken off the clip securing the hose connection to the cleaner cover**

3. Remove the cleaner from the unit to a suitable place for cleaning

4. **Lift off the cover and remove the element. Wash the element thoroughly in petrol or paraffin. Fuel oil can be used only in an emergency for the element.**

5. **Clean the cover, skirt, element support and bowl thoroughly with petrol or paraffin.**

6. **Examine the element carefully for punctures or damage which may affect its filtering capacity.**

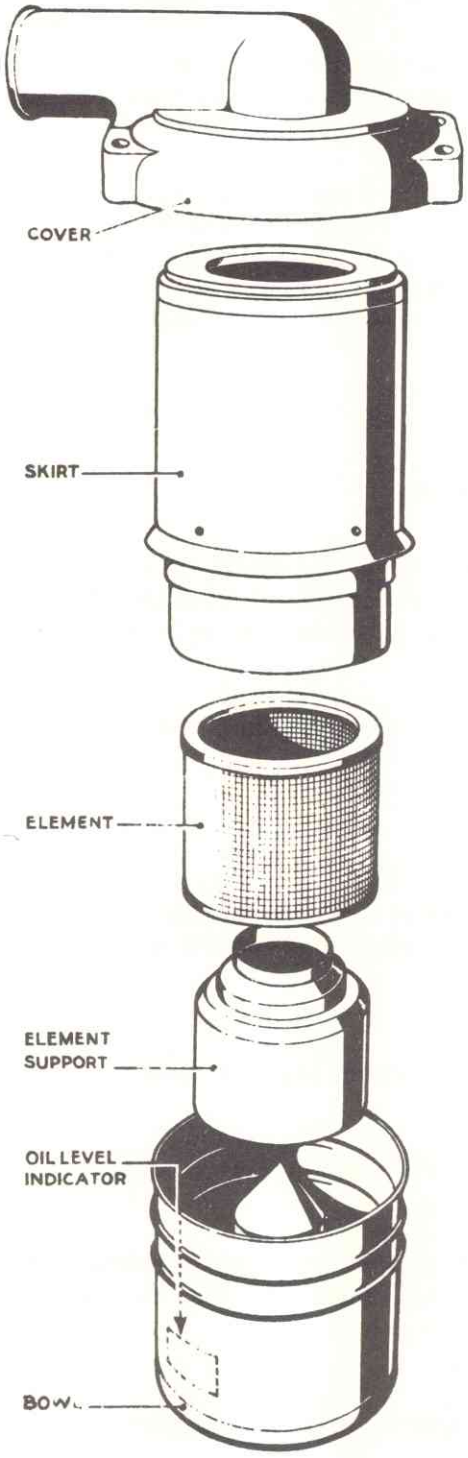


Fig. 8. Air Cleaner Components

Inspect the rest of the cleaner components for deformed baffles or a leaking bowl

7. **Re-assemble the cleaner and refill with oil to the point of the arrow on the oil level indicator inside the bowl,** see Fig. 8.

8. **Replace the cleaner on the power unit. Tighten down the tie-bolts finger tight, do not use a wrench or spanner.**

AIR CLEANER

CONSTRUCTION AND OPERATION

This type of air cleaner (Fig. 9.) is fitted either in single or twin form, depending on the engine capacity

The cleaner assembly comprises a casing containing the filtering element and a cover secured by a wing nut. The filtering element is a sheet steel cage packed with wire wool. The lower portion of the casing contains the oil and is filled to the level of the arrow point inside and casing.

The cleaner filters the air in two stages. Firstly, by reversal of the air flow and the impingement of the air on the surface of the oil, secondly, by passing the oil-laden air through the filtering element and depositing the grit and dust on the oil-wetted wire wool element, allowing the cleaned air to pass into the engine.

MAINTENANCE

Filter maintenance consists of keeping the element clean and the oil to the level indicated.

The frequency of cleaning required is governed by the conditions under which the unit is operating. To ensure regularity of attention under normal conditions the cleaner be cleaned at each sump oil change.

In exceptional conditions, daily cleaning will have to be carried out to ensure a clean air supply to the engine.

TO CLEAN THE FILTERS

1. Release the clip securing the cleaner to the air intake manifold and remove the cleaner complete.

2. Remove wing nut and cover and lift out the filtering element

3. Wash the element in petrol or paraffin and allow it to drain. Do not use fuel oil

4. Wash out filter casing with petrol or paraffin and replace on engine

5. Refill with oil to the level indicated, refit filter element and replace cover and wing nut

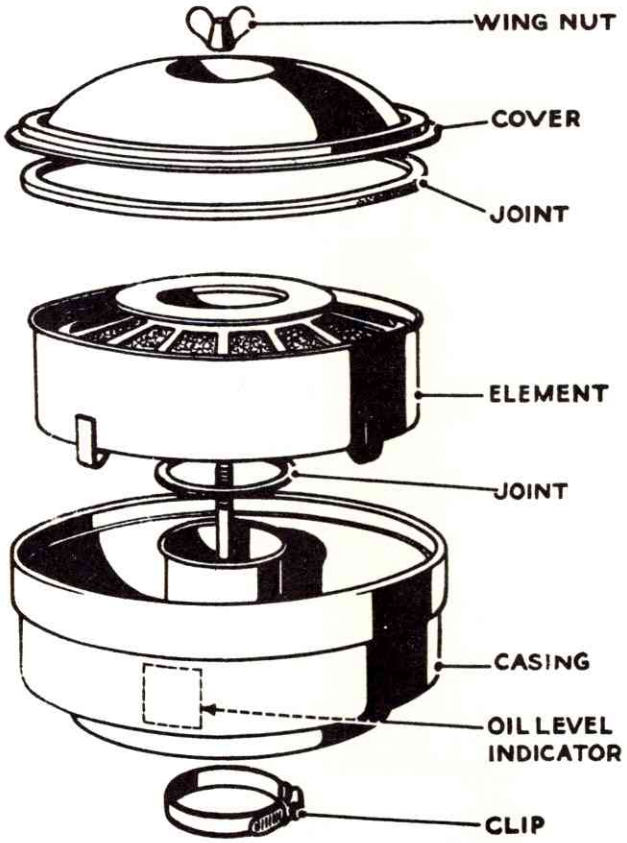


Fig. 9. Air Cleaner Components

OIL FILTERS

Various types of oil filters are fitted according to the size of engine, as set out below:

Type 350 cu. in. engine	Leyland full-flow. (Fig. 10)
Type 450 cu. in. engine	The British Filters, by pass (Fig.13) Vokes, full-flow. (Fig. 14)
Type 600 and 680 cu. in. engine.	Leyland, full-flow. (Fig. 11)

To enable the operator to maintain these filters, a description of the construction and operation of each one is given.

The frequency of inspection and cleaning is laid down in the "Maintenance Periods".

OIL FILTER - LEYLAND FULL FLOW

CONSTRUCTION AND OPERATION

This oil filter is a full-flow cloth element type, mounted at the left-hand rear of the engine block. The oil is drawn from the sump and pressure-fed into the filter housing, where it is filtered hot. After passing through the element the oil is fed to the oil cooler in the radiator bottom tank, cooled and fed back to the oil transfer block, see Figs. 10 and 11, between the filter and engine-block and discharged into the main lubrication gallery.

A by-pass valve, fitted in the top cover of the filter-housing, passes oil direct to the engine in the event of the filter becoming choked.

The by-pass valve pressure is set before leaving the factory and should not be interfered with.

The filter, a metal former covered by a sleeve-shaped filter-cloth secured with cotton twine, is designed to give maximum filtration area.

To prevent vibration the filter is spring loaded at the base and a felt washer at the top of the filter prevents unfiltered oil passing into the main system.

A drain plug is provided in the bottom of the filter housing.

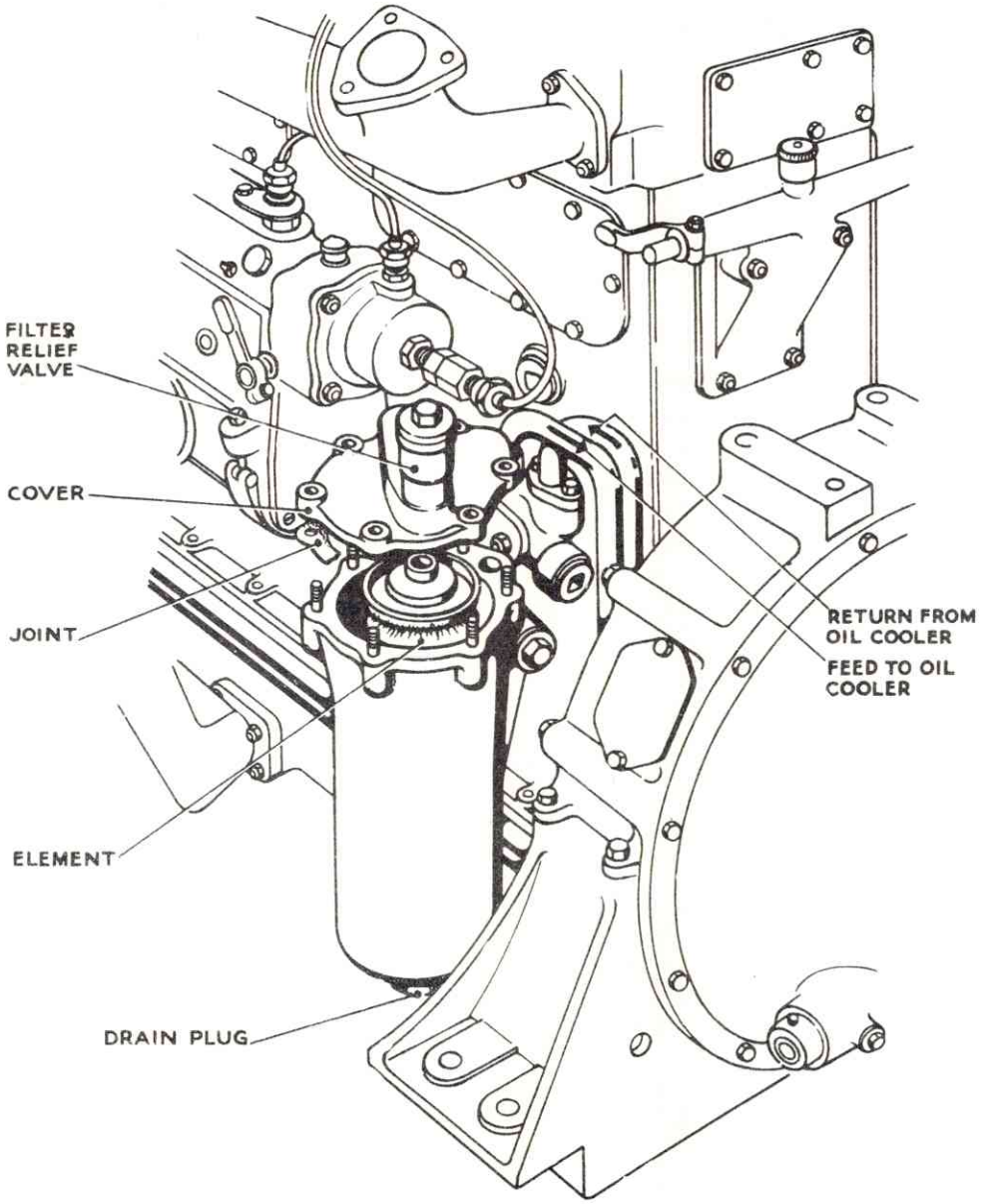


Fig. 10. Lubricating Oil Filter - Type 350

TO REPLACE THE CLOTH ELEMENT

1. Unscrew the nuts securing the filter cover to the casing and remove the cover, see figs. 10 and 11.

2. Lift the element out of the housing and cut the twine securing the cloth, see Fig. 12.

3. Thoroughly clean the metal former.

4. Take a new cloth sleeve and fit it over the metal former. Bind and tie the sleeve to bottom of the former securely with one end of the 10 foot length of twine provided with each new sleeve. Keeping the twine in one length, tie the sleeve to the former between each corrugation. It is not necessary to knot the twine between each corrugation, but simply to give the twine one full turn around the bottom of one corrugation before leading it to the next corrugation, keeping the twine taut all the time. Finally bind and tie the twine securely at the top and trim off any surplus cloth top and bottom.

5. Drain the filter housing of dirty oil by the drain plug. Swill it out with petrol or paraffin if necessary and dry it out.

6. Replace the element and fit the cover. If at all in doubt about the cover joint, replace it, as the oil in the filter is always under pressure when the engine is running.

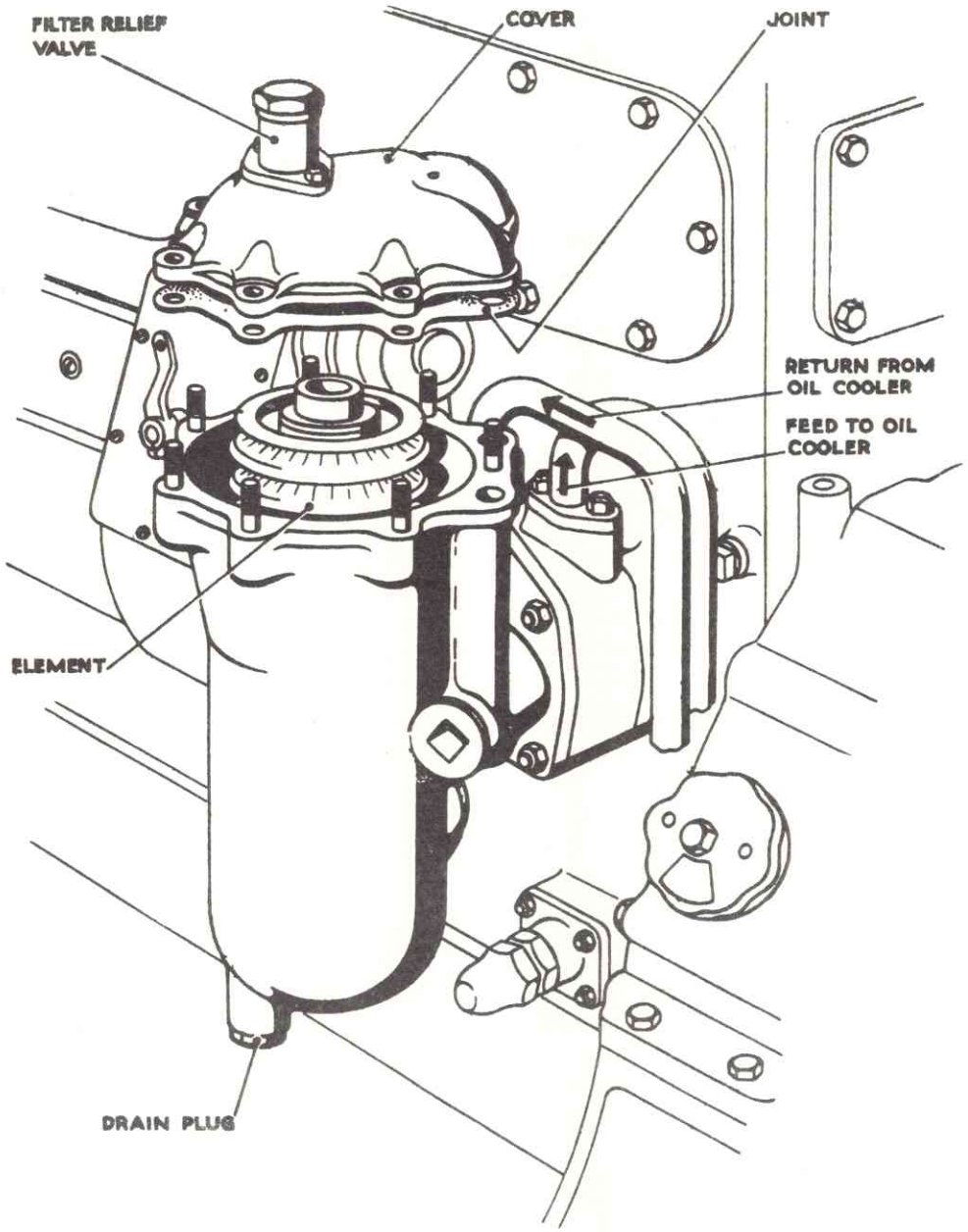


Fig. 11. Lubricating Oil Filter - Type 600

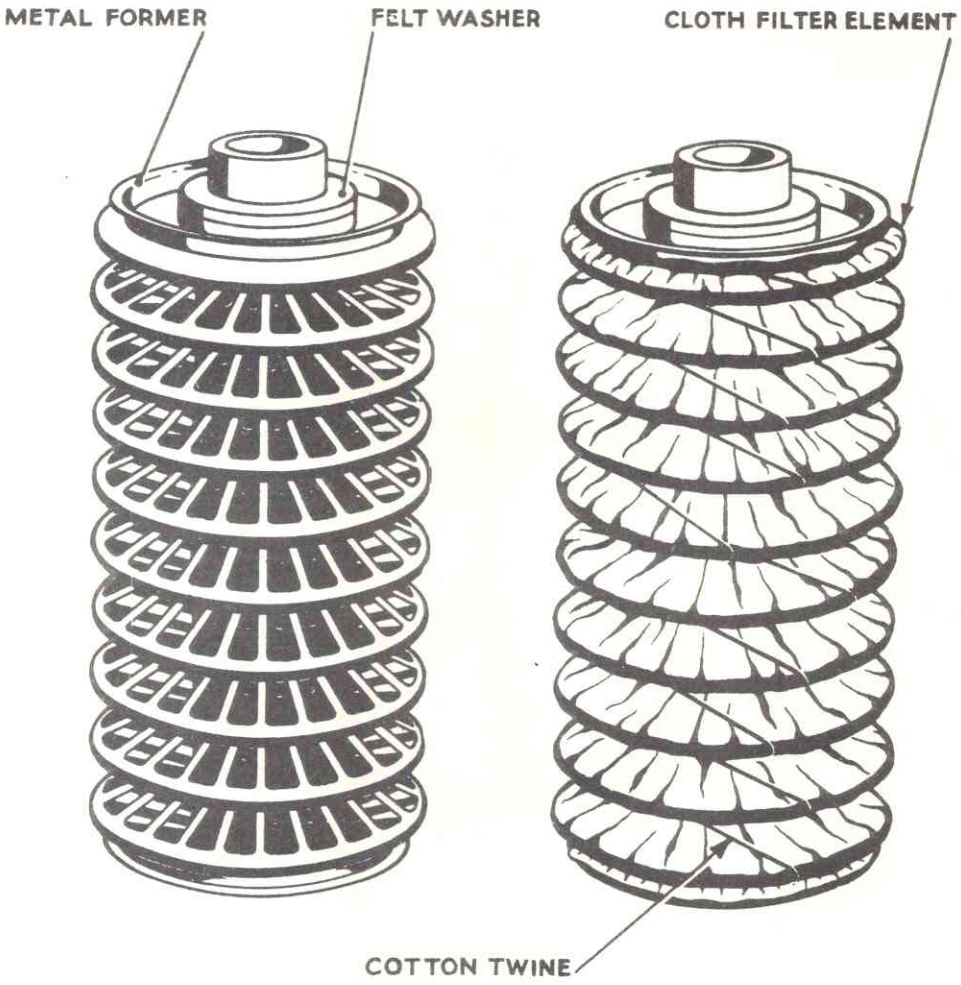


Fig. 12. Element Assembly

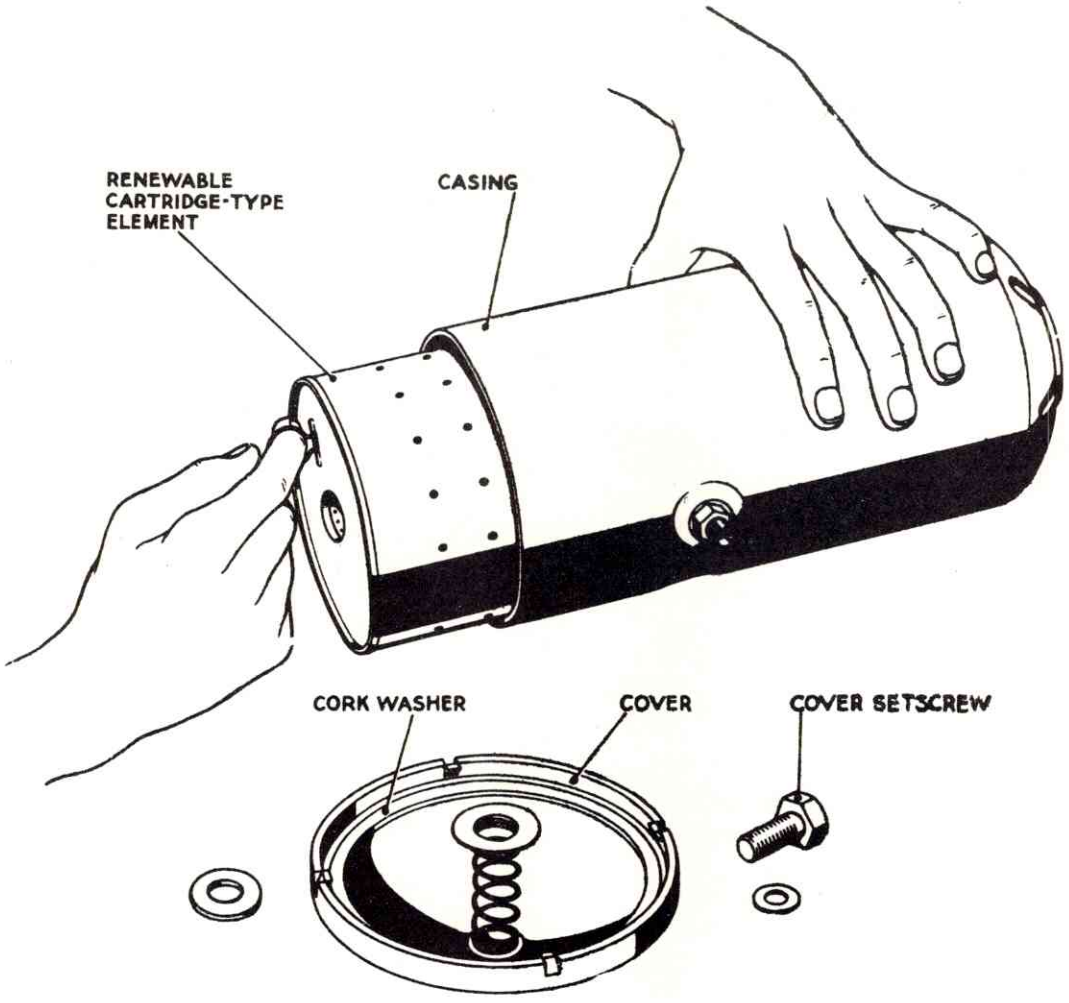


Fig. 13. Lubricating Oil Filter - Type 450

OIL FILTER - BY-PASS TYPE

CONSTRUCTION AND OPERATION

This type of filter (Fig. 13) is fitted exclusively to type 450 units not equipped for oil cooling.

A lead is taken from the engine oil relief valve to the inlet connection on the side of the filter casing. The oil passes from the outside of the cartridge type element through the filtering medium to the hollow centre bolt to the outlet at the top of the casing. From there the oil is returned to the sump via the timing case.

The filter is mounted on the front right-hand side of the timing case in a clamp type bracket.

The filter case is pressed steel with a hollow centre bolt for securing the cork seated cover. A spring under the cover keeps the element tight down a felt washer thus preventing dirty oil passing direct to the outlet.

The cartridge element cannot be cleaned or dismantled. A replacement must be fitted as laid down in the "Maintenance Periods"Inspection.

TO REPLACE THE ELEMENT

1. Disconnect the inlet and outlet connections to the filter.

2. Remove the cap from the filter mounting bracket and lift the filter clear of the engine.

3. Unscrew the cover setscrew and remove the cover. Pull the element out, see Fig. 13.

4. Clean the casing, removing all sludge.

5. Fit a replacement element, replace the cover and tighten down.

6. Replace the filter on the engine and reconnect the oil pipes.

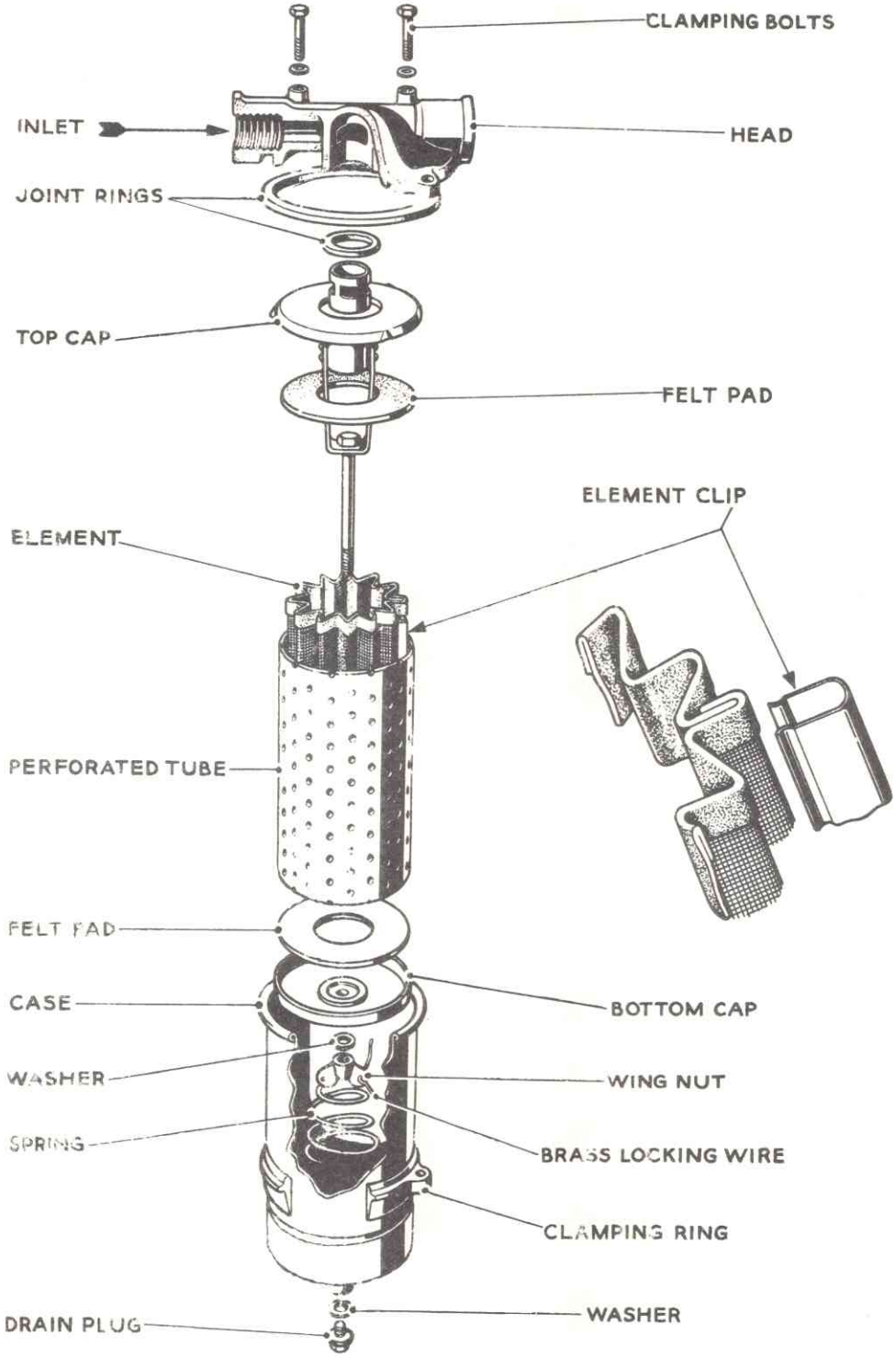


Fig. 14. Lubricating Oil Filter - Type 450

OIL FILTER - VOKES FULL FLOW

TO DISMANTLE THE FILTER

Normally it is unnecessary to remove the inlet and outlet pipes or disturb the head from its mounting in order to service this filter (Fig. 14)

1. Remove drain plug and drain oil from case.

2. Unscrew clamping bolts and remove case.

3. Lift out the element assembly and dismantle by unscrewing the wingnut on the bottom and pulling away the caps-tube etc.,

4. Remove the spring element clip and open out the element for inspection and cleaning

NOTE: If the filter has been in use for a considerable time difficulty may be experienced in pulling away the case due to sticking of the head joint ring. A light tap on the lower part of the case with a rawhide mallet (or similar) will free the joint.

TO CLEAN THE FILTER

Wash all parts of the filter in clean petrol or paraffin and allow to dry thoroughly before re-assembling.

When cleaning the element care must be taken not to damage the formation of the fins.

TO RE-ASSEMBLE THE FILTER

1. Bring the edges of the element together and rest one edge inside the other, as shown in Fig. 14, taking care that the ends are in line, and slip the spring element clip over the joint.

   It is important that the wire gauze is on the outside as this is provided to support the felt against the oil flow.

2. Slide the element into the perforated tube, replace pads in top and bottom caps and re-assemble.

3. Replace the wingnut and washer, and after firmly tightening the wingnut lock to the bottom cap by the brass wire.

4. Drop the spring into the case and place the insert assembly on top. Apply a film of mineral jelly to the surface of the head joint ring also on the lip of the case.

5. Offer the case up to the head, slide the clamping ring up, align the holes and tighten up the clamping bolts evenly.

6. Replace the washer and drain plug.

RADIATOR

CONSTRUCTION

Power unit radiators are cast construction throughout. The main assembly comprises the top and bottom tanks with separate tube plates spaced by the side standards. The tubes can be replaced individually without dismantling the radiator.

The radiator is flexibly mounted on the subframe with rubber pads interposed between the radiator and subframe, and under the mounting bolt heads. It is stayed at the top of the engine cylinder head with a tie rod.

When an oil cooler is fitted, the cooler is in the bottom tank, and is removable as a complete unit.

Drainage is by a wheel operated valve fitted under the bottom tank or at the bottom of the water inlet pipe.

GENERAL ATTENTION

1. Soft water should be used for filling the radiator whenever possible.

2. The use of desealing agents is not generally recommended due to possible detrimental effects on any alloy castings in the water system.

3. Keep the outside of the tubes and the quard free from dust and dirt. External deposits of dirt will restrict the airflow through the radiator and impair the air to cooling surface heat exchange.

4. If a tube leaks badly and no replacement is available, yet the unit must continue operating, the tube can be removed in a short space of time and the unit operated again as follows:

   a. Drain the radiator

   b. Remove the tube and ferrules, see "Overhaul".

   c. Plug the holes in the tube plates with soft wood, hard cork or rubber plugs tapped well home.

d. Refill radiator and continue operating.

e. Fit a new tube as soon as one is available.

TO REMOVE AND REPLACE THE RADIATOR

1. Drain the radiator. If anti-freeze mixture is in use, collect in cans for refilling after overhaul.

2. Remove the canopy top and side covers (if a closed type unit).

3. Disconnect the radiator tie rod and exhaust silencer support link.

4. Disconnect water temperature gauge bulb and capilliary carefully (units fitted with water temperature gauges only).

5. Detach the top and bottom water hose connections.

6. Disconnect the oil pipes to the oil cooler (if fitted).

7. Unscrew the units from the radiator mounting bolts and lift the radiator clear.

Replacement is the reverse of the above procedure.

OVERHAUL

1. During overhaul the radiator should be thoroughly cleaned internally. If hard water has been used, the top and bottom tanks should be removed and any deposit in the tubes loosened by passing a rod down each tube. The tubes should then be flushed with a hose.

2. If on inspection a damaged tube is found, it can be readily replaced.

To remove, push the tube up far enough to free the bottom end, then pull out the top end. The old rubber ferrules should be removed and the

tube-plate cavities cleaned, new ferrules being fitted when fitting the new tube. This operation can be carried out with the radiator in position, see "General Attention".

3. It is advisable if one or two ferrules have perished to replace the whole set. This will avoid unnecessary trouble later on, as it is generally found that when one or two ferrules have perished the remainder will be very nearly in the same condition.

4. When refitting the top and bottom tanks, use new joints and paint with red lead before fitting.

TO TEST THE THERMOSTAT

Although the thermostat is not fitted in the radiator (except on certain type 450, power units) it is an integral part of the water circulation system.

Generally very little attention is needed, but an occasion may arise when the operation of the thermostat is suspected. In such a case, remove the thermostat, test it as outlined below and if it does not function correctly, fit a new one. Do not attempt to repair or adjust it.

To test, proceed as follows:

Hang it in the water which is slowly being brought up to boiling point. The valve should open and begin to leave its seat at 175° to 185° Fahr. (79.5° to 85° Cent.) It should be fully open, approximately .375 in. (9.52 mm.) at 200° to 208° Fahr. (93.5° to 98° Cent.)

As the water cools the valve should be back on the seat at approximately 180° Fahr. (82° Cent.)

Renew any thermostat that does not fall within the above limits.

LUBRICATION AND LUBRICANTS

6

CHAPTER 2A

LUBRICANTS

FLUIDS

FUEL OIL

ANTIFREEZE

SECTION 1

LUBRICATION

This chapter defines the specifications and grades of lubricants recommended for Leyland units. It should be read in conjunction with the **Lubrication Chart** which indicates the recommended lubrication mileages or periods and the position of filling points.

The recommendations given are for general guidance only, and at all times close collaboration should be maintained with the oil supplier. Where different grades of lubricant are shown for various atmospheric temperature ranges, the grade chosen should be that applicable to the temperature range which is operative for a significant proportion of the season during which the oil is in use.

All filler caps, plugs or lubricators should be cleaned **before and after** attention. If units require an excessive amount of oil or if leakage from seals is noted this should be reported and action taken at the earliest opportunity.

Units should be drained while the oil is warm. Refill with fresh oil to the correct level as indicated. **Do not overfill.**

For the capacity of a unit or the amount of lubricant to be used refer to the **Lubrication Chart** and the appropriate chapter under the heading **Lubrication.**

Grease-packed assemblies should be cleaned and repacked at unit overhaul or alternatively at distances which can be determined by local experience or by periodic inspection of representative units.

All other points should be lubricated until increased pressure is noted or until lubricant is forced from a relief valve or from the part being lubricated.

Some assemblies, such as the wheel hubs, are dismantled for lubrication at docking or overhaul. These parts will require more frequent attention if the vehicle operates under exceptionally arduous conditions.

We recommend that all new and reconditioned Leyland engines be drained after the first 500 miles (800 kilometres) and refilled with oil in accordance with the recommendations given in this chapter.

SECTION 2

LUBRICANTS and FLUIDS
Unit Recommendations

ENGINES (for Industrial Engines see special instructions in appendix).

The use of additive-treated (heavy duty) engine oils is essential, and the minimum oil performance level, for operation with normal low sulphur fuel, should be not less than the requirements of the following alternative specifications:

British Ministry of Defence Specification DEF-2101-C, qualification tested with 1% sulphur fuel, or,
U.S. Military Specification former MIL-L-2104A qualification tested with 1% sulphur fuel.

Note As MIL-L-2104A Specification is now obsolete, oils conforming to U.S. Military Specification MIL-L-2104B can be considered as meeting our recommendations.

These specifications cover good quality heavy duty additive-treated oils suitable for normal operation. It is strongly recommended that the customer consult his oil supplier regarding the best oil to use for his particular conditions of service, and oils of higher additive level may be advisable for exceptionally arduous conditions or when high sulphur fuels have to be used.

Initial Fill Up Engines in chassis delivered from the works are filled with heavy duty additive-treated oil meeting the above specified performance level.

Under no circumstances should oils be used during the initial period of service for running-in purposes, which have a lower performance level than that specified.

Recommended Oil-Change Period The initial fill up oil should be replaced by oil of the correct performance level after the first 500 miles. After this a figure of 5,000 miles is recommended as a general guide, but where engines are subject to arduous conditions, it may be desirable to reduce the oil-change period to 3,000 miles.

Multigrade Oils Multigrade (multiviscosity number) lubricating oils should have a qualification engine test performance at least equal to that required of corresponding single viscosity number lubricants.

Recommended S.A.E. grades, for general guidance only :

Atmospheric Temperature Range	Recommended Viscosity Number
Below minus 20°F (below minus 30°C) ...	SAE 5W/20
Minus 20° to 0°F (minus 30° to minus 20°C)	SAE 10W/30
0° to 30°F (minus 20° to 0°C) ...	SAE 20W/20 or SAE 10W/30
30° to 90°F (0° to 30°C)	SAE 30 or SAE 10W/30
Above 90°F (above 30°C)	SAE 40

Within the atmospheric temperature range 30° to 90°F (0° to 30°C) Leyland engines, if in good condition, can be lubricated satisfactorily with SAE 20 oil.

Warning We wish to make it quite clear that we cannot accept any responsibility for trouble experienced by operators arising from any of the following causes:

(i) The use of oils of lower performance level than the minimum requirement for the operating conditions **or**
(ii) The use of oils of lower viscosity than the recommended grades **or**
(iii) The continued use of oils after the recommended oil change mileage or period.

Explanatory Note The specifications put forward, whilst military in origin, are at present the only internationally recognised means of defining the minimum oil performance level recommended.

They are based on a series of functional tests in engines, specially devised to evaluate various aspects of performance, such as high temperature stability, ring-sticking tendency, wear, etc.

It cannot be too strongly emphasized that the use of an oil of adequate performance level for the operating conditions, changed at the specified frequency, should be looked upon as a sound investment.

Units	Atmospheric Temperature Ranges		
	Below 0°F (below minus 20°C)	0° to 90°F (minus 20° to 30°C)	Above 90°F (above 30°C)
OIL-BATH AIR CLEANERS All oil-bath type air cleaners	SAE 30 Engine Oil		
HYDRAULIC CONTROLS Hydraulic throttle and clutch controls	Hydraulic Brake Fluid, heavy-duty type SAE 70 R3		
CLUTCH SPIGOT BEARINGS All clutch spigot bearings	Leyland Specification G grease		
FLUID CLUTCHES and FLUID FLYWHEELS All fluid clutches and fluid flywheels	Leyland Specification E oil—appropriate grade		
TORQUE CONVERTERS All torque converters	Leyland Specification H hydraulic fluid		
GEARBOXES All Leyland, Albion and A.E.C. crash and synchromesh gearboxes and Z.F. gearboxes	SAE 80 EP oil	SAE 90 oil or SAE 90 EP oil	SAE 140 oil or SAE 140 EP oil
Pneumocyclic gearboxes	Leyland Specification E oil—appropriate grade		
CHANGE-SPEED BOXES Leyland and A.E.C. change-speed boxes	SAE 80 EP oil	SAE 90 oil or SAE 90 EP oil	SAE 140 oil or SAE 140 EP oil
Albion change-speed boxes	Leyland Specification G grease		
PROPELLER SHAFTS All needle-bearing joints and propeller shaft splines	Leyland Specification G grease		
WORM REAR AXLES All Leyland worm-drive axles	Leyland Specification A oil—appropriate grade		
BEVEL REAR AXLES Leyland spiral-bevel axles, hypoid-bevel axles, Eaton single- or two-speed axles	SAE 80 EP oil	SAE 90 EP oil	SAE 140 EP oil
	These oils must have a performance level equivalent to that required by British Specification CS.3000 or U.S. Military Specification MIL-L-2105		

Units	Atmospheric Temperature Ranges		
	Below 0°F (below minus 20°C)	0° to 90°F (minus 20° to 30°C)	Above 90°F (above 30°C)
WHEEL HUBS			
All wheel hubs where grease lubrication is specified	Leyland Specification G grease		
SHOCK ABSORBERS			
Newton Mk.VIII shock absorbers	SAE 20 engine oil		
Newton Mk.VII shock absorbers	Newton Green Fluid (Newton recommendation)		
Luvax and Girling piston-type shock absorbers	Luvax-Girling Piston-type Thin Fluid (Girling recommendation)		
Armstrong lever-type, and telescopic shock absorbers and stabilisers	SAE 10W Engine oil or Armstrong 624 oil (Armstrong recommendation)		
STEERING GEARS			
Marles Steering boxes	SAE 80 EP oil	SAE 90 EP oil	SAE 140 EP oil
Power steering hydraulic equipment	Leyland Specification H hydraulic fluid		
Leyland worm-and-nut steering boxes	Leyland Specification A oil—appropriate grade		
Burman steering boxes	Leyland Specification A oil—appropriate grade		
Steering shaft upper bearings	Leyland Specification G grease		
BRAKES and AIR-PRESSURE EQUIPMENT			
Air-pressure brake pedal buffer	Engine oil—appropriate grade		
Clayton-Dewandre brake vacuum servo and brake cylinders	Engine oil—appropriate grade		
Air-pressure brake slack-adjusters	Leyland Specification G grease		
R.P. automatic brake adjusters	Leyland Specification D oil and Oiline S Bearing Compound (Clayton recommendation)		
Westinghouse footbrake, gear-change, charging and limiting valves	Etheringtons Paragon Arctic Grease (Westinghouse recommendation)		
Girling brakes	Zinc-oxide Grease (Girling recommendation)		
Girling brake cylinders	Girling Red Rubber Grease No. 3 (Girling recommendation)		
Hydraulic brake operating equipment	Hydraulic Brake Fluid, heavy-duty type SAE 70 R3		
GENERAL CHASSIS LUBRICATION			
Manual lubrication of chassis parts—see Lubrication Chart	SAE 90 oil and Leyland Specification G grease	SAE 140 oil	SAE 140 oil
Automatic chassis lubrication—see Lubrication Chart	SAE 80 EP oil	SAE 90 oil or SAE 90 EP oil	SAE 140 oil or SAE 140 EP oil
Rear spring-bolts on Worldmasters	Achesons YB Graphite grease		
Constant-radius brake cams, for use at brake attentions	Shell Retinax DX grease		
ELECTRICAL EQUIPMENT			
Dynamos and starters	Leyland Specification G grease or proprietary brands recommended by C.A.V. or Simms		
C.A.V. starters	SAE 20/20W engine oil		

SECTION 3

LUBRICANTS and FLUIDS

Leyland Specifications

Leyland Specification A Oil (revised January 1964) for worm-gear axles and other applications as shown on the lubrication chart.

The oil used for worm-gear axles should be a good quality mineral oil to the requirements of the following SAE viscosity numbers:

Atmospheric temperatures above 0°F (above minus 20°C)	SAE 140
,, ,, below 0°F (below minus 20°C)	SAE 90

Additionally, the oil should have a viscosity index of not less than 80 and may contain anti-oxidant additives, but should not contain hypoid or extreme-pressure additives.

Under certain circumstances, alternative types of lubricant may be advantageous, but these should be used only with the fullest co-operation of the oil supplier under controlled conditions. Leyland Motors Ltd., cannot accept responsibility for difficulties which may arise through the use of oils not conforming to Leyland Specification A.

Leyland Specification D Oil for R.P. automatic brake adjusters.

The oil used should be a good quality heavy mineral oil of the SAE 250 type. It should not contain extreme-pressure or compounding additives.

Leyland Specification E Oil (revised January 1964) for pneumocyclic gearboxes, fluid flywheels and fluid clutches.

Oils used for the above applications must be consistent with the requirements of high quality hydraulic or turbine lubricants.

The oils should be based on mineral oil with a viscosity index of not less than 90, and be fully inhibited against corrosion, oxidation and foaming. The pour point should be well below the anticipated lowest atmospheric temperature.

The resistance to oxidation should be such that, when tested by I.P. Method 114/56T, the increase in acidity of the oil does not exceed 0.1 mg KOH/g., and the total acidity after oxidation does not exceed 0.2 mg KOH/g.

The table below is given as a guide to the viscosity requirements:

Atmospheric Temperature Range	Viscosity Redwood No. 1, Seconds at 140°F	Equivalent Viscosity Saybolt Universal, Seconds at 140°F
Below 0°F (below minus 20°C)	75—100	85—112
0° to 90°F (minus 20° to 30°C)	100—135	112—150
Above 90°F (above 30°C)	135—180	150—200

Leyland Specification G Grease (Lithium-base) for road wheel bearings and other applications.

All greases used for the lubrication of road wheel bearings must conform to the British Timken Specification for Lithium-base greases, originally issued under reference ALG.1/57. The proprietary grade must have been approved by British Timken Limited.

It is most important that Lithium-base greases should not be mixed with greases of other types in road wheel bearings, as this would have the effect of producing a melting-point lower than either of the constituent greases.

When changing the type of grease, the road wheel bearings should be thoroughly cleaned out.

When packing wheel hubs with Lithium-base grease, care should be taken to ensure that the bearings and cage assemblies are fully packed, but the hub itself should not be over-packed with grease—see the appropriate chapter of the service manual for the correct amount to be used.

Leyland Specification H Hydraulic Fluid (revised January 1964) for torque converters and power steering hydraulic equipment.

Fluids used for the above applications should be based on highly stable mineral oils, fully inhibited against corrosion, oxidation and foaming.

In order to maintain the hydraulic characteristics over a wide temperature range, they should have a high viscosity index (preferably not less than 130) and a low pour point (preferably not above minus 40°F).

The viscosity, Redwood No. 1, of suitable fluids will be normally between 300 and 400 seconds at 70°F, and between 45 and 50 seconds at 200°F (equivalent Saybolt Universal viscosities 340 to 400 at 70°F, and 50 to 56 at 200°F)

A widely distributed fluid meeting the above requirements is known as "Automatic Transmission Fluid Type A".

Under certain circumstances, the use of alternative types of hydraulic fluid of suitable characteristics may be recommended by the oil supplier.

Warning Although this is a hydraulic fluid, it is not suitable for use in hydraulic brake systems.

Leyland Specification J Grease formerly for clutch spigot bearings.

This specification is discontinued.

SECTION 4

FUEL OIL

for Leyland Diesel Engines

(first issued October 1949, revised May 1958, March 1960 Oct. 1964)

The fuel oils which are suitable for use in Leyland Diesel Engines are generally known as Diesel fuel oil, distillate Diesel fuel, automotive gas oil or Derv fuel, Users are recommended to obtain their supplies from a source which can be depended upon to maintain a consistent standard of quality and service. Waste or residual oils of any sort are to be avoided.

Attention is called to the necessity for special care in the storage and handling of fuel oil. It should be free from water and dirt when delivered, and after delivery care should be taken by the user to protect it from contamination with these or other impurities. Suitable precautions should be taken by the user during storage of the fuel to ensure the separation and periodical removal of any foreign matter which may collect on standing, and the fuel should be strained through a fine and efficient filter on its way from storage tank to vehicle tank.

The specific gravity of suitable oils usually falls within the range 0.820 to 0.860. The fuel should be free from any substance which is likely to cause corrosion of the parts of the fuel system with which it comes in contact It should not deposit wax or other substances likely to cause trouble at the lowest temperature encountered under service conditions. The asphalt content should not exceed 0.10 per cent.

In other respects the fuel should conform to the requirements of British Standard 2869 : 1957, Oil Fuels, Class A Fuel. This specifies that the fuel shall meet the following requirements:

Cetane Number	Not less than 45
Viscosity, Kinematic, centistokes at 100°F (37.8°C)	Between 1.6 and 7.5
(Viscosity, Redwood No. 1, seconds at 100°F	Between 30 and 45)
Carbon Residue, Conradson, per cent by weight	Not more than 0.1
Distillation, per cent by volume recovered at 357°C	Not less than 90
Water, per cent volume	Not more than 0.1
Sediment, per cent by weight	Not more than 0.01
Ash, per cent by weight	Not more than 0.01
Sulphur, per cent by weight	Not more than 1.3
Acidity, inorganic	Nil
Sulphur, corrosive copper strip test	Not more than slight tarnish
Flash point, P.M. closed cup °F	Not less than 130 (54.4°C)

Users are referred to B.S.2869 for full details of the specification and methods of test.

Whilst British Standard 2869 quotes not more than 1.3 per cent sulphur by weight, we prefer a sulphur content less than 0.7 per cent.

We advise that the user should satisfy himself regarding the suitability of a fuel by making a practical test in an engine

SECTION 5

ANTIFREEZE FLUIDS

Antifreeze recommended for Leyland Engine Cooling Systems

The use of antifreeze in cooling systems is recommended if the atmospheric temperature is likely to fall to 32° F (0° C) or less

The following comments are intended for guidance only:

Antifreeze compositions based on ethylene glycol (ethanediol) are preferred. Lower alcohols having a boiling point less than 212°F (100°C) are not recommended.

Many inhibitors can be used in commercial antifreeze to retard corrosion in engine cooling systems. In general, antifreeze formulations based on British Standard 3151 or 3152 should prove satisfactory for use in Leyland engines.

Warning Local overheating, or gas leakage from cylinder head gaskets, can cause antifreeze to become actively corrosive to engine cooling systems.

Fluid recommended for Antifreezers on Air-pressure Systems

When Leyland vehicles are operated in atmospheric temperatures below 32°F (0°C) the use of a volatile antifreeze fluid in the air-pressure-system antifreezer unit is recommended. This will prevent the operation of the system being affected by frozen atmospheric moisture.

The recommended fluid is methanol (methyl alcohol) but if this is unobtainable, ethanol (ethyl alcohol) or industrial methylated spirits may be used. The initial water content of any fluid used should not exceed 1%. Suitable fluids are usually referred to by their alcoholic strength of 74 Over Proof (British system) or 198 Proof (American system).

Warning Non-volatile antifreeze fluids such as ethylene glycol (ethanediol) must not be used in the antifreezer units of air-pressure systems.

NOTES

LEYLAND MAINTENANCE HANDBOOK

APPENDIX TO CHAPTER 2A

FOR

LEYLAND INDUSTRIAL UNITS

SPECIAL FLUIDS

Certain installations with hydraulic converters or fluid couplings require the fluid recommended by the maker. Wherever possible the recommendation in such cases will be given as a supplement to this Section.

The same will apply to any hydraulic controls.

LUBRICATION PERIODS

The periods are based on actual hours run, so that the lubrication can be co-ordinated with the maintenance. Generally the periods are:

1. Every 8 Hours Run

   Usually confined to inspection of oil, water and fuel levels, together with attention to special points needing frequent lubrication.

2. Every 24 Hours Run

   On some units lubrication will be required at this interval.

3. Every 50 to 60 Hours Run

   This interval is where the majority of auxiliaries need lubrication.

4. Every 200 to 250 Hours Run

   The most important task at this interval is the engine oil change and filter replacements.

5. Every 500 Hours Run

   Usually confined to points which only require infrequent but regular lubrication.

The shorter periods are based on an average 8 - Hour working shift. Therefore if the unit is operating on a 24 hour basis, then the 8-hourly attentions must be carried out three times during that 24-hour period. At the end of the third shift, i.e. the beginning of the second day, carry out any attention required at the 24-hour interval.

If the unit is only operating one shift daily, the 24-hourly attention need only be carried out every 2nd or 3rd day, dependent on whether the shifts are 8 or 12 hours duration.

The other periods are all more or less multiples of the shorter periods, therefore in addition to the attentions particular to a given period, the attentions for the shorter periods should be carried out at the same time where applicable. This means that all the attentions needed can be carried out at one time depending on the frequency of attention needed.

EXAMPLE: The 50/60 - hour period attention coincides with every fourth 8 - hour period and every second 24 - hour period attentions.

ENGINE

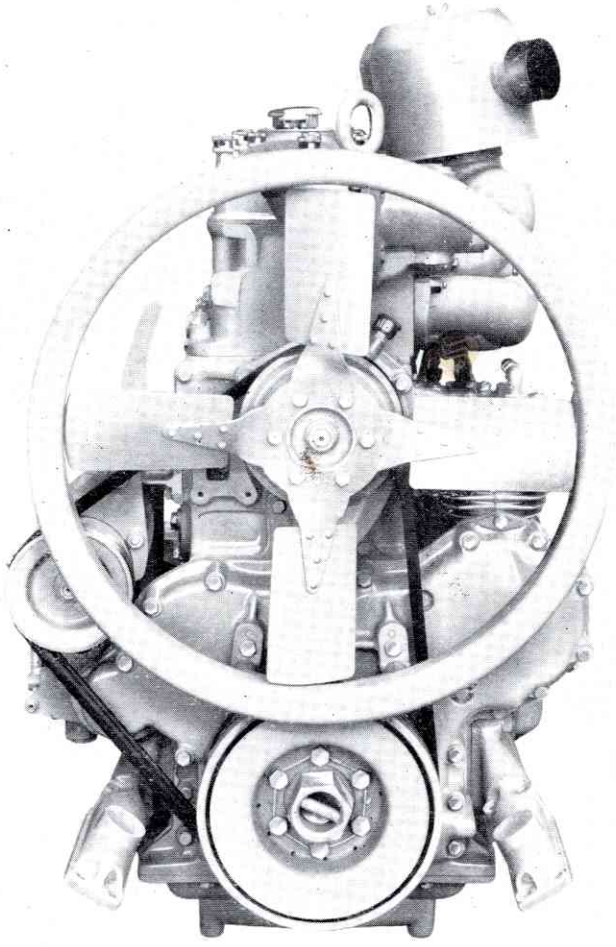
8

CHAPTER 3W

ENGINE

CHAPTER 3W

ENGINE



66140

FIG. 1. 0600 POWER-PLUS DIESEL—FAN END

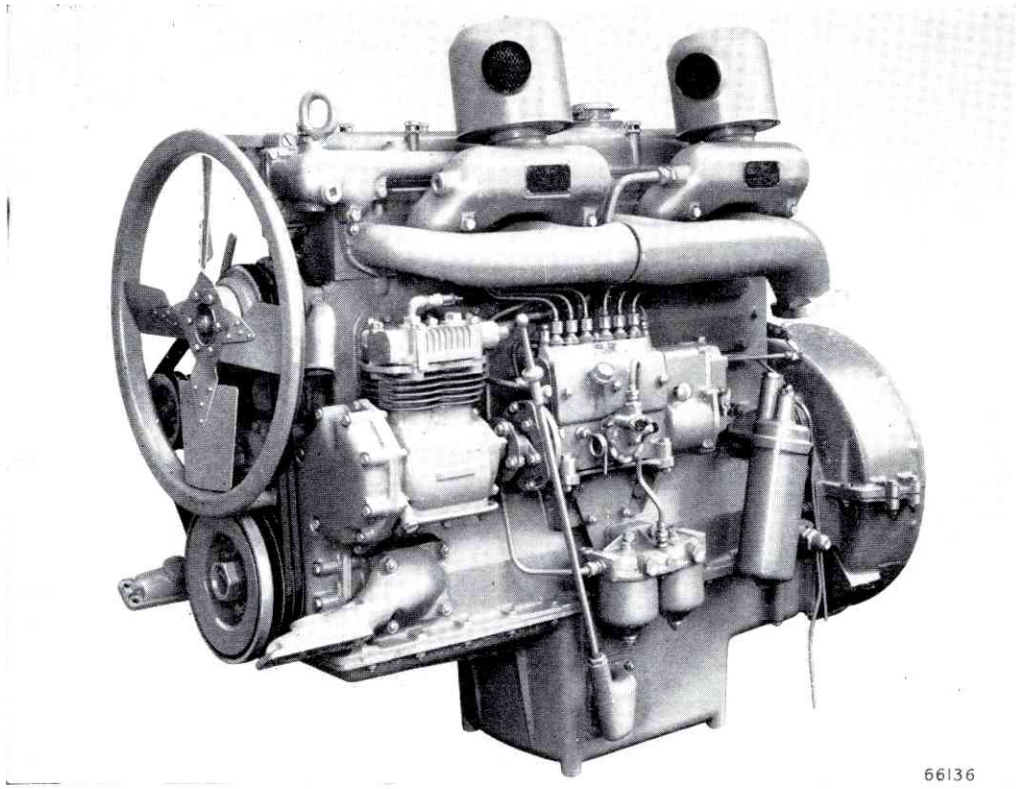


FIG. 2

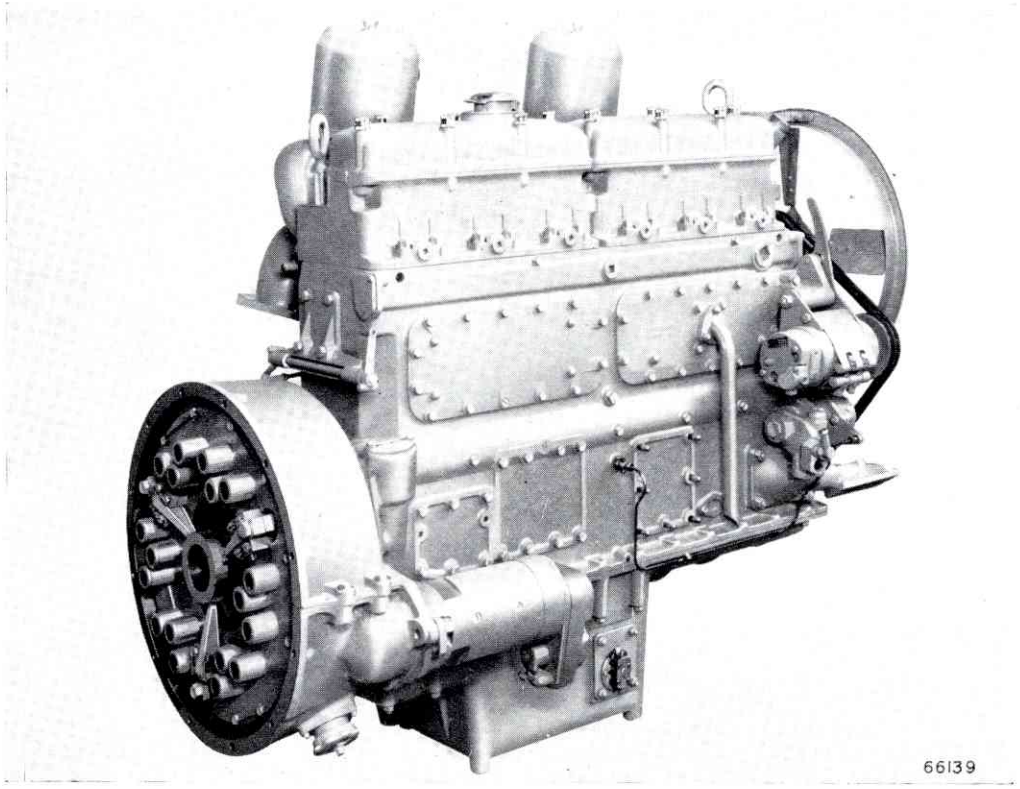


FIG. 3

0865

0600 POWER-PLUS DIESEL—GENERAL VIEWS

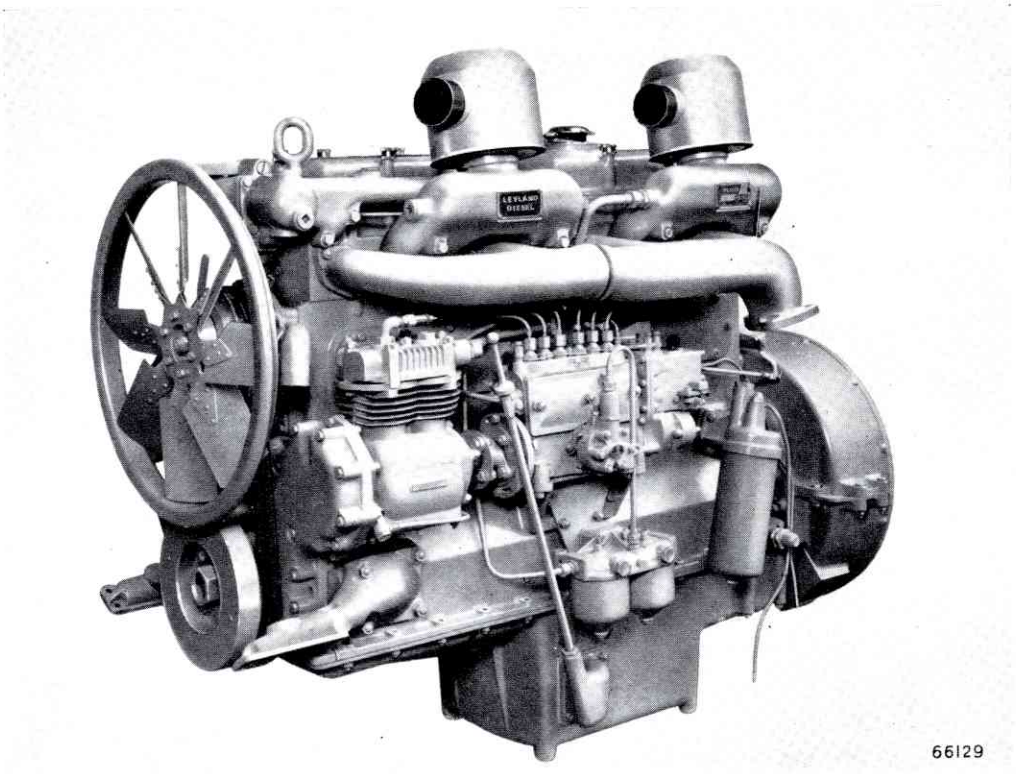


FIG. 4

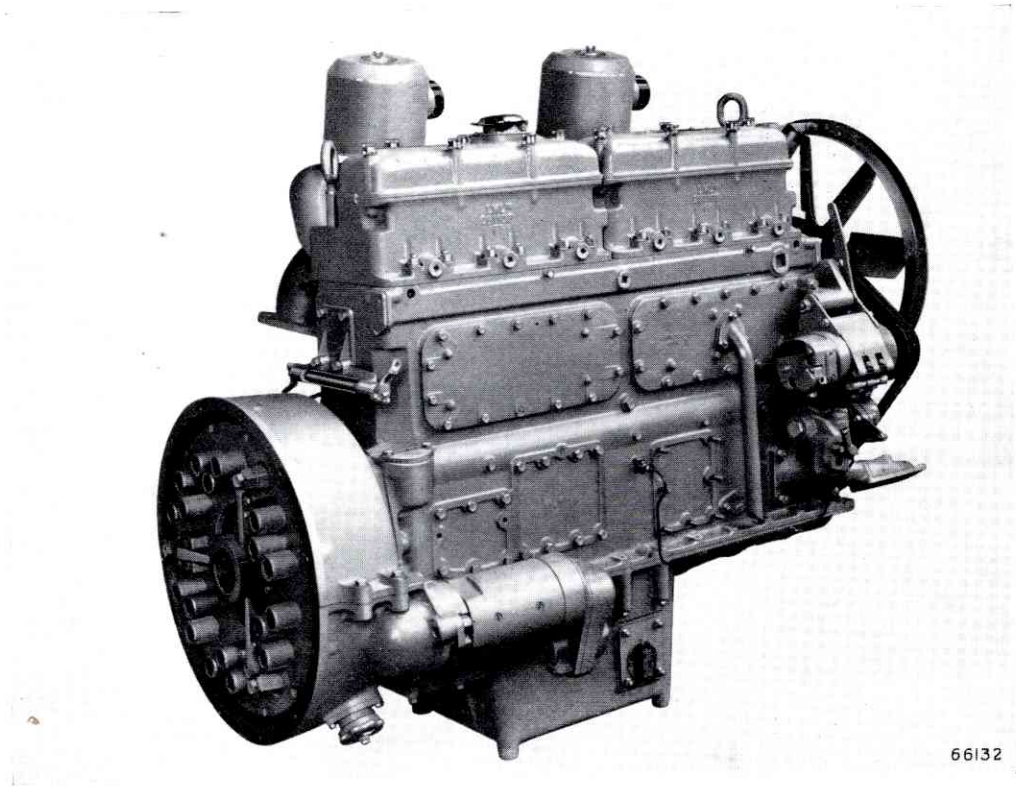


FIG. 5

0680 POWER-PLUS DIESEL—GENERAL VIEWS

ENGINE

DATA

GENERAL

	E.0600	E.0680
Marks		
Type	Leyland 0600 vertical Diesel engine (9.8 litres).	Leyland 0680 vertical Diesel engine (11.1 litres).
Main features	Six-cylinder vertical, compression-ignition, direct-injection, overhead-valve, water-cooled.	
Bore	4.80 in. (121.92 mm.).	5.000 in. (127 mm.).
Stroke	5.50 in. (139.70 mm.).	5.75 in. (146.05 mm.).
Cubic capacity	597 cubic inches (9,783 c.c.).	677 cubic inches (11 093 c.c.).
Gross h.p.	146 b.h.p. at 1,700 r.p.m.	210 b.h.p. at 2,200 r.p.m.
Net installed h.p.	140 b.h.p. at 1,700 r.p.m.	200 b.h.p. at 2,200 r.p.m.
Maximum torque	438 lb./ft. at 1,200 r.p.m. (60.55 kg. m.)	548 lb./ft. at 1,200 r.p.m. (75.76 kg. m.)
Compression ratio	15.75 to 1.	
Firing order	1, 5, 3, 6, 2, 4.	
Rotation	Clockwise when viewed from the timing case end.	

LUBRICATION

Type	Wet sump, gear-type pump.
Sump capacity	26 pints (14.8 litres) approx.
Pump data	Interference of pump gear on shaft, .0003/.0013 in. (.0076/.0330 mm.). Initial diametral clearance between idler-gear and spindle, .0012/.0022 in. (.0305/.0559 mm.). Backlash between gears, .022/.026 in. (.5588/.6604 mm.).
Oil pressure	60 p.s.i. (4.2 kg. s.cm.) at 1,000 r.p.m. or higher speeds with warm engine. Not below 5 p.s.i. (.35 kg. s.cm.) with engine idling.
Pump delivery	40 pints (22.7 litres) approx. per min. at 1,000 r.p.m. crankshaft speed.
Filter	Leyland, full-flow, cloth-type filter element.

	E.0600	and	E.0680
CYLINDER HEADS			
Type	Detachable, 2 per engine, each covering 3 cylinders.		
Material	Cast iron.		
Valve guide interference in head ...	.001/.002 in. .0254/.0508 mm.		
ENGINE BLOCK			
Type	Cylinders and crankcase in one-piece casting.		
Material	Cast iron.		Cromard.
Liners	Pre-finished, dry, press-fit, shoulder-located.		
Initial bore of liner before fitting to engine block	4.8017/4.8025 in. 121.963/121.984 mm.		5.0017/5.0025 in. 127.043/127.064 mm.
PISTONS AND RINGS			
Piston type	Spheroidal cavity.		
Piston material	Aluminium alloy		
Compression rings			
Top groove			
Type of ring	Parallel sides, chrome-plated straight-cut gap.		Parallel sides, hardened and tempered, straight-cut gap. **Note:** Chrome-plated rings should not be fitted under any circumstances.
Width (nominal)	.0937 in. (2.381 mm.).		
Initial ring gap (closed)	.025/.032 in. (.6350/.8128 mm.).		
Renew ring when gap exceeds ...	.100 in. (2.54 mm.).		
2nd and 3rd grooves			
Type of ring	Parallel sides, hardened and tempered, straight-cut gap.		
Width (nominal)	.125 in. (3.175 mm.).		
Initial ring gap (closed)	.025/.032 in. (.6350/.8128 mm.).		
Renew ring when gap exceeds ...	.100 in. (2.54 mm.).		
Scraper Rings			
Number of rings	One (4th groove).		
Type of ring	Parallel sides, slotted, straight-cut gap.		
Width (nominal)	.250 in. (6.350 mm.).		
Initial ring gap (closed)	.020/.027 in. (.5080/.6858 mm.).		
Renew ring when gap exceeds ...	.100 in. (2.54 mm.).		

Note : The dimension quoted for ring gap will vary dependent upon manufacturing tolerances.

E.0600 and **E.0680**

CONNECTING RODS AND GUDGEON PINS

Gudgeon pin	1.625 in. dia. hollow, fully-floating 41.275 mm.
Pin retained by	Two circlips in piston.
Connecting rod type	I-section.
Small-end bearing	Phosphor-bronze bush.
Initial diametral clearance of pin in small end bush (cold)	.0045/.001 in. 01143/.0254 mm.
Renew small-end bush when diametral clearance exceeds	.0025 in. .0635 mm.
Interference of small-end bush in connecting rod	.00225/.00425 in. .05715/.107950 mm.
Big-end bearing type	Pre-finished, lead-bronze, steel shell, bearing surface indium-coated.
Big-end initial diametral clearance ...	.0018/.0037 in. .04572/.09398 mm.
Renew when diametral clearance exceeds	.008 in. .2032 mm.
Undersize big-end bearings available	Prefinished in five steps of .010 in. each. .254 mm.

Do not grind sides of crankpins

CRANKSHAFT AND MAIN BEARINGS

Number of main bearings	Seven.
Main bearing type	Prefinished strip bearings.
Type of bearing	Lead-bronze, steel shell, bearing surface indium-coated.
Crankshaft type	Forging, incorporating balance weights.
Crankshaft material	Alloy-steel, nitrided.
Thrust taken on	Thrust washers at centre journal.

TABLE OF CRANKSHAFT DIMENSIONS : 0600/0680 ENGINES with 3.500 in. dia. JOURNAL CRANKSHAFT

TYPE	PART NUMBER	CRANKPIN DIAMETER		CRANKPIN WIDTH		JOURNAL DIAMETER		JOURNAL WIDTH							
								FRONT		CENTRE		REAR		OTHERS	
Standard Service	Part Number as stamped on front web	in. 3.0005 2.9998	mm. 76.213 76.195	in. 2.203 2.200	mm. 55.956 55.880	in. 3.5005 3.4998	mm. 88.913 88.895	in. 2.000	mm. 50.800	in. 2.702 2.700	mm. 68.631 68.580	in. 2.705 2.695	mm. 68.707 68.453	in. 1.710 1.700	mm 43.434 43.180
1st Service	Part Number /S.1	2.9905 2.9898	75.959 75.941	2.203 2.200	55.956 55.880	3.4905 3.4898	88.659 88.641	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
2nd Service	,, /S.2	2.9805 2.9798	75.705 75.687	2.203 2.200	55.956 55.880	3.4805 3.4798	88.404 88.387	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
3rd Service	,, /S.3	2.9705 2.9698	75.451 75.433	2.203 2.200	55.956 55.880	3.4705 3.4698	88.151 88.133	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
4th Service	,, /S.4	2.9605 2.9598	75.197 75.179	2.203 2.200	55.956 55.880	3.4605 3.4598	87.897 87.879	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
5th Service	,, /S.5	2.9505 2.9498	74.943 74.925	2.203 2.200	55.956 55.880	3.4505 3.4498	87.643 87.625	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180

Note 1. When re-grinding crankpin and journals the sides must not be ground unless they have been damaged. If the location faces of the centre main bearing have been damaged, the width should be increased to 2.710/2.712 in. (68.834/68.885 mm.); otherwise the dimension should remain unchanged.

Note 2. The crankshaft should be re-nitrided at service sizes S.2 and S.4.

	E.0600 and E.0680
Centre journal initial end clearance...	.004/.010 in. .1016/.254 mm.
Renew thrust washers when end clearance exceeds	.014 in. .3556 mm.
Oversize thrust washers available ...	One set .010 in. thick (.005 in. each washer). .254 mm. .1270 mm.
Regrind journals and crankpins ...	When .003 in. oval. .0762 mm.
Undersize main bearings available ...	Five, in steps of .010 in. each. .254 mm.
Main bearing initial diametral clearance	.0020/.0042 in. .0508/.1067 mm.
Renew when diametral clearance exceeds	.009 in. .2286 mm.
Maximum run-out on shaft ...	.003 in., total clock reading .006 in. .0762 mm. .1524 mm.
Maximum run-out between two adjacent bearings	.003 in. total clock reading. .0762 mm.
Crankshaft damper	Rubber-bonded type or viscous type

CAMSHAFT

Number	One.
Camshaft type	Forged with integral cams.
Camshaft material	Steel.
Type of drive	Single-helical gear.
Number of bearings	Seven.

	E.0600 and E.0680
Material	Front and rear—leaded gunmetal; intermediate—carobronze.
Thrust taken on	Front bearing only.
Interference fit of all bearings in engine block	.005/.0025 in. .01270/.06350 mm.
Journal diameters	2.396/2.397 in. 60.858/60.883 mm.
Initial diametral clearance in all bearings	.004/.0055 in. .1016/.1397 mm.
Renew bearings when clearance exceeds	.010 in. .254 mm.
Camshaft renewal	See Fig. 6, cam wear diagram.

TIMING GEARS

Type	Single-helical gears.
Gear material	Hardened and ground steel.
Permissible backlash between each pair of gears	.002/.004 in. .0508/.1016 mm.
Idler gears, initial diametral clearance between bush and gear	.001/.00325 in. .0254/.0826 mm.

	E.0600 and E.0680
Diametral clearance between bush and idler spindle	.001/.00325 in. .0254/.082550 mm.
End float between thrust washers and idler gear	.004/.0095 in. .1016/.2413 mm.
Renew thrust washers when end clearance exceeds	.012 in. .3048 mm.
Interference fit of timing gear on crankshaft	.00075/.00225 in. .019050/.057150 mm.

VALVES

Type	Overhead poppet.	
Valve material	Stellite-faced, hard-chrome-plated stems.	
Number per cylinder	One inlet, one exhaust.	
Stem diameter:		
Inlet	.43475/.43425 in. 11.0425/11.0300 mm.	
Exhaust	.43325/.43275 in. 11.0046/10.9918 mm.	
Stem clearance in guide:		
Inlet	.0025/.00375 in. .06350/.09525 mm.	
Exhaust	.004/.00525 in. .1016/.13335 mm.	
Valve head diameter:		
Inlet	2.10 in. 53.34 mm.	2.20 in. 55.88 mm.
Exhaust	1.80 in. 45.72 mm.	1.90 in. 48.26 mm.

	E.0600 and E.0680
Angle of valve seat	30°.
Angle of valve face	29½°.
Valve lift	0.5 in. 12.70 mm.
Number of valve springs	Two per valve, concentric.
Maximum spring pressure (valve open)	134 lb. 60.782 kg.
Free length of spring:	
Inner	2.130 in. 54.102 mm.
Outer	2.50 in. 63.50 mm.
Renew springs when	Inner spring will compress to 1.25 in. under a load less than 35 lb. 31.750 mm. 15.87 kg.
	Outer spring will compress to 1.50 in. under a load less than 74 lb. 38.100 mm. 33.56 kg.
Initial diametral clearance of rocker shaft in rocker	.0005/.00175 in. .01270/.04445 mm.
Renew rocker shaft bushes when diametral clearance exceeds ...	.003 in. .0762 mm.
Initial diametral clearance of tappet in engine block	.00175/.00375 in. .04445/.09525 mm.
Renew tappet when diametral clearance in engine block exceeds ...	.005 in. .1270 mm.
Tappet clearance:	
Inlet	.020 in., engine cold. .508 mm.
Exhaust	.020 in., engine cold. .508 mm.

E.0600 and **E.0680**

VALVE TIMING

Inlet opens	10° before T.D.C.=1.72 in. on flywheel rim. 43.688 mm.
Inlet closes	50° after B.D.C.=8.61 in. on flywheel rim. 218.694 mm.
Exhaust opens	46° before B.D.C.=7.92 in. on flywheel rim. 201.168 mm.
Exhaust closes	14° after T.D.C.=2.41 in. on flywheel rim. 61.214 mm.

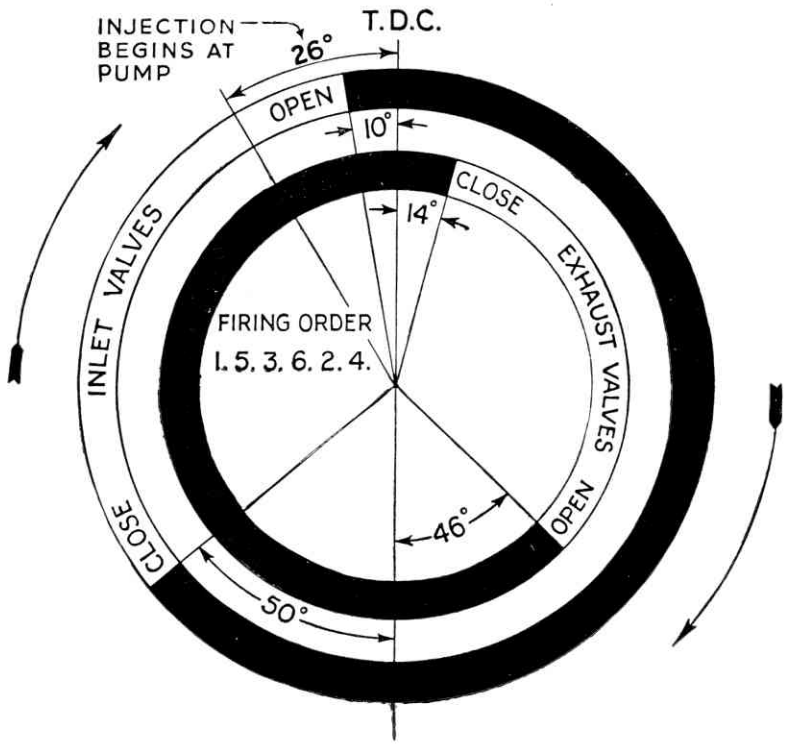


FIG. 6. VALVE TIMING DIAGRAM

E.0600 C.A.V. EQUIPMENT E.0680

INJECTION PUMP

Make	C.A.V.	C.A.V.
Type	NNL 6G 80	NNL 6F 100
Number of deliveries	6	6
Plunger diameter	8.0 mm.	10 mm.
Plunger stroke	9.0 mm.	10 mm.
Helix	Right-hand.	Right-hand.
Drive	Flexible adjustable coupling, clockwise rotation, half engine speed.	
Timing	Injection begins at the injection pump 26° before T.D.C. (see Fig. 6)	

GOVERNOR

Make	C.A.V.	C.A.V.
Type	SFRNN 2	GRHF 60 C
Cutting-in speed	1,700 r.p.m. engine speed.	2,200 r.p.m. engine speed.
Runaway speed	1,960 r.p.m. engine speed.	2,470 r.p.m. engine speed.
Idling speed	400 r.p.m.	

FUEL FEED PUMP

Make	C.A.V.	
Type	DFP 3/2	DFP 3/10S
Pressure maintained	4/5 p.s.i. (.28/.35 kg. s.cm.).	
Operation	Operated by arm in contact with eccentric on injection pump camshaft.	
Air Bell	C.A.V. 7092/239.	

FUEL OIL FILTER

Make	C.A.V.
Type	2F.3/13L twin, paper element

INJECTORS

	E.0600	and	E.0680
Make		Leyland.	
Type	N.53		N.54
Discharge pressure	145/150 atmospheres. 2,130/2,204 p.s.i. 150/155 kg. s.cm.		160/165 atmospheres. 2,351/2,425 p.s.i. 165/170 kg. s.cm.

Discharge pressure adjusting washer — Available in the following thicknesses:

Part Number	Thickness	Part Number	Thickness
601663/ 1	.130 in. (3.3020 mm.)	601663/12	.152 in. (3.8608 mm.)
,, / 2	.132 in. (3.3528 mm.)	,, /13	.154 in. (3.9116 mm.)
,, / 3	.134 in. (3.4036 mm.)	,, /14	.156 in. (3.9624 mm.)
,, / 4	.136 in. (3.4544 mm.)	,, /15	.158 in. (4.0132 mm.)
,, / 5	.138 in. (3.5052 mm.)	,, /16	.160 in. (4.0640 mm.)
,, / 6	.140 in. (3.5560 mm.)	,, /17	.162 in. (4.1148 mm.)
,, / 7	.142 in. (3.6068 mm.)	,, /18	.164 in. (4.1656 mm.)
,, / 8	.144 in. (3.6576 mm.)	,, /19	.166 in. (4.2164 mm.)
,, / 9	.146 in. (3.7084 mm.)	,, /20	.168 in. (4.2672 mm.)
,, /10	.148 in. (3.7592 mm.)	,, /21	.170 in. (4.3180 mm.)
,, /11	.150 in. (3.8100 mm.)		

Needle valve lift ... ... — .010/.012 in. (.2540/.3048 mm.)

Needle valve lift adjusting button ... — Available in the following thicknesses:

Part Number	Thickness	Part Number	Thickness
601664/ 1	.220 in. (5.5880 mm.)	601664/ 8	.234 in. (5.9436 mm.)
,, / 2	.222 in. (5.6388 mm.)	,, / 9	.236 in. (5.9944 mm.)
,, / 3	.224 in. (5.6896 mm.)	,, /10	.238 in. (6.0452 mm.)
,, / 4	.226 in. (5.7404 mm.)	,, /11	.240 in. (6.0960 mm.)
,, / 5	.228 in. (5.7912 mm.)	,, /12	.242 in. (6.1468 mm.)
,, / 6	.230 in. (5.8420 mm.)	,, /13	.244 in. (6.1976 mm.)
,, / 7	.232 in. (5.8920 mm.)	,, /14	.246 in. (6.2484 mm.)

Angle of sprays ... ... — 140°.

Valve spring free length ... ... — .755/.785 in. (19.177/19.939 mm.)

Valve spring length under a load of 42/47 lb. (19.06/21.34 kg.) ... ... — .70 in. (17.78 mm.)

E.0600 and **E.0680**

COMPRESSOR

Make	Clayton Dewandre.
Type	PCGA.223/9.
Bore	2.625 in. (66.875 mm.).
Stroke	1.75 in. (44.45 mm.).
Piston displacement	10 cu. ft. (0.283 cu. m.) per minute at 1,000 r.p.m.
Drive	Gear type dog coupling, driven from timing gear train at half crankshaft speed, clockwise rotation.

COMPRESSOR

Make	Westinghouse.
Type	E.11V.
Bore	2.50 in. (63.5 mm.)
Stroke	1.75 in. (44.45 mm.).
Piston displacement	10 cu. ft. (0.283 cu. m.) per minute at 1,000 r.p.m.
Drive	Gear type dog coupling, driven from timing gear train at half crankshaft speed, clockwise rotation

AIR CLEANER ... ... Paper element type, twin.

DYNAMO DRIVE

Drive	Belt-driven from pulley on crankshaft.
Rotation	Clockwise.
Dynamo runs at	1.72 × engine speed.

COOLING SYSTEM

Controlled by	Thermostat, opening at 165°F. (74°C.). Fully open at 185°F. (85°C.).
Water pump and fan drive	Belt-driven from pulley on crankshaft.

ENGINE LUBRICATION

We recommend that all new and reconditioned Leyland engines be drained after the first 500 miles (800 kilometres) and refilled with oil in accordance with the recommendations given in Lubrication Chapter 2A.

DESCRIPTION

Engine lubrication is on the wet sump system, the oil being circulated by a gear type oil pump.

The oil sump capacity is approx. 26 pints (14.8 litres) as shown by the full mark on the dipstick. The oil should be changed every 5,000 miles (8,000 kilometres).

Oil is drawn from the bottom sump well, through the suction filter, and pressure fed by the pump through a full-flow cloth element filter into the main lubrication system, which is provided with an adjustable relief valve.

Oil is fed to the crankshaft main bearings, big end bearings, idler-gear and camshaft bearings through oilways drilled in the crankcase. The cylinder walls and gudgeon-pin bushes are lubricated by splash.

The rocker gear is also lubricated by an intermittent feed from the second and fifth camshaft bearings via vertical oilways drilled in the engine-block and heads, up through the centre rocker shaft support bracket on each head, along the tubular rocker-shafts to the rocker levers.

Oil which escapes past the relief valve, spills back into the bottom sump well, via a short stand pipe below oil level to prevent aeration.

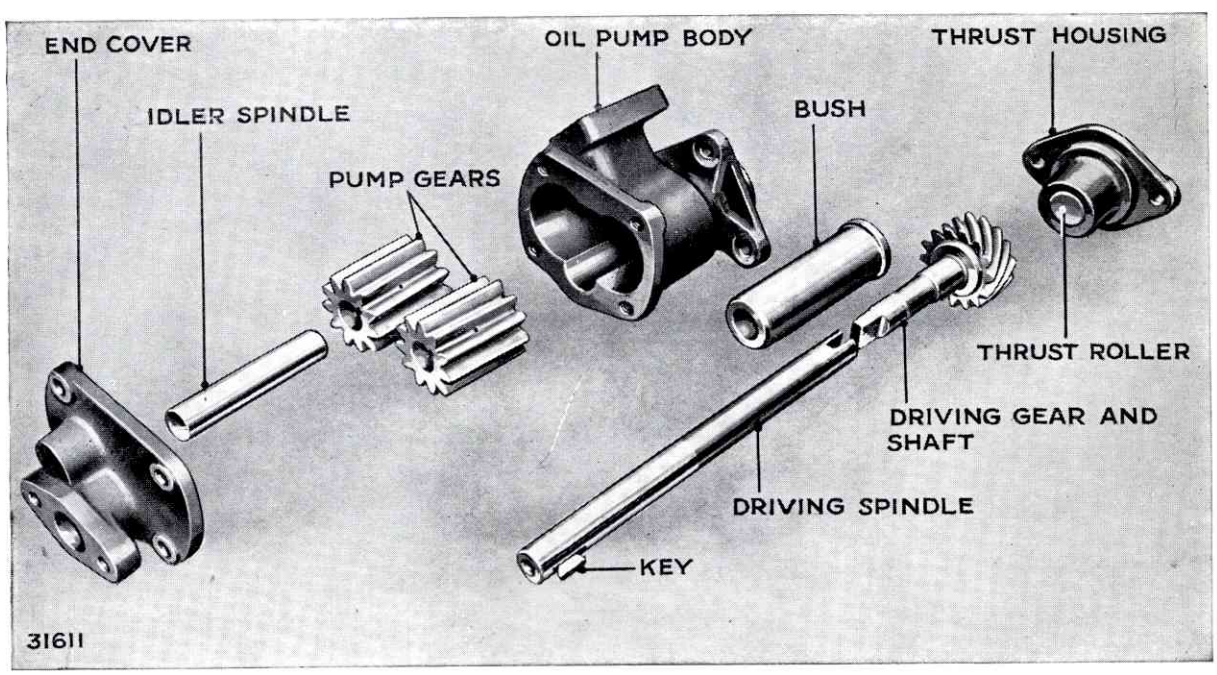


FIG. 7. OIL PUMP AND DRIVE DISMANTLED

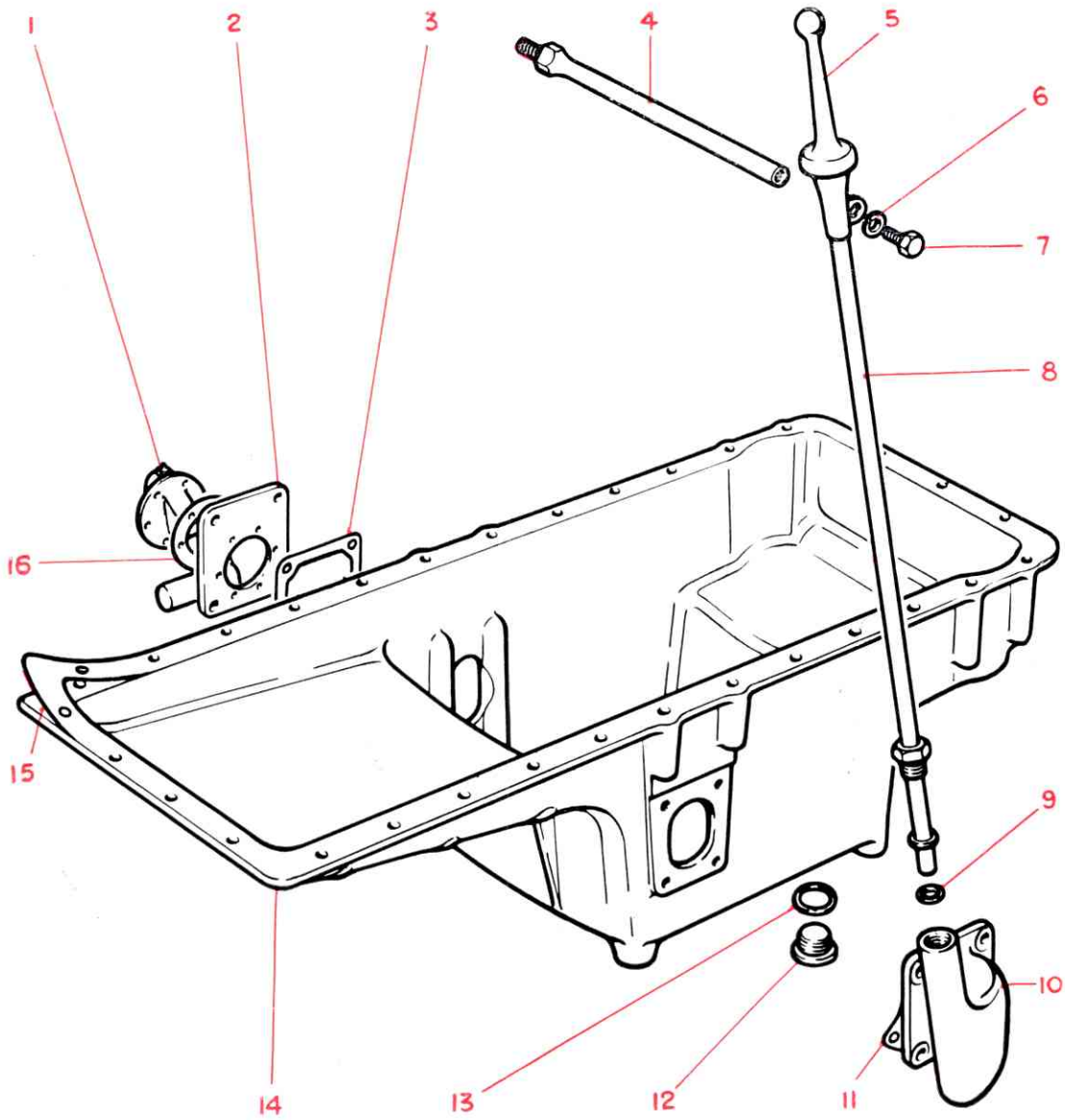


FIG. 8. THE ENGINE SUMP AND COMPONENTS

1. Oil gauge.
2. Mounting plate.
3. Joint.
4. Pillar stud.
5. Dipstick.
6. Washer.
7. Setscrew.
8. Dipstick guide.
9. Sealing ring.
10. Dipstick housing.
11. Joint.
12. Drain plug.
13. Washer.
14. Sump.
15. Joint.
16. Joint.

To remove the suction filter, it is only necessary to drop the bottom sump and remove the two setscrews securing the filter basket to the oil suction pipe.

The lead to the oil pressure gauge is taken from the oilway feeding the centre main bearing and is connected to the gauge pipe through a tap on the left-hand side of the engine block. At all times the tap should remain open, but, in the event of a broken pipe or leaking gauge, the tap can be closed and serious loss of oil prevented.

Crankcase breathing is effected through holes drilled in the cylinder-head cover holding down bosses and vented to atmosphere from a breather attached to the front tappet gallery cover.

OIL PUMP

The oil pump is housed in the right-hand rear of the engine block and consists of spur gears, shaft driven from the camshaft by spiral gears. At the lower end of the camshaft driven-gear, a tongue transmits the drive to the pump spindle, on which is pressed a spur gear, the woodruff key being used only to position the oil hole supplying lubrication to the spiral gears and thrust face.

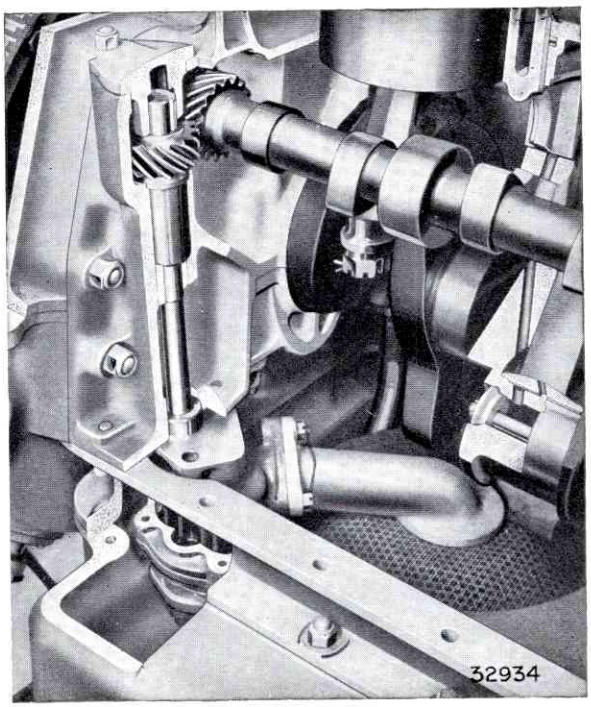


FIG. 9. OIL PUMP DRIVE FROM CAMSHAFT

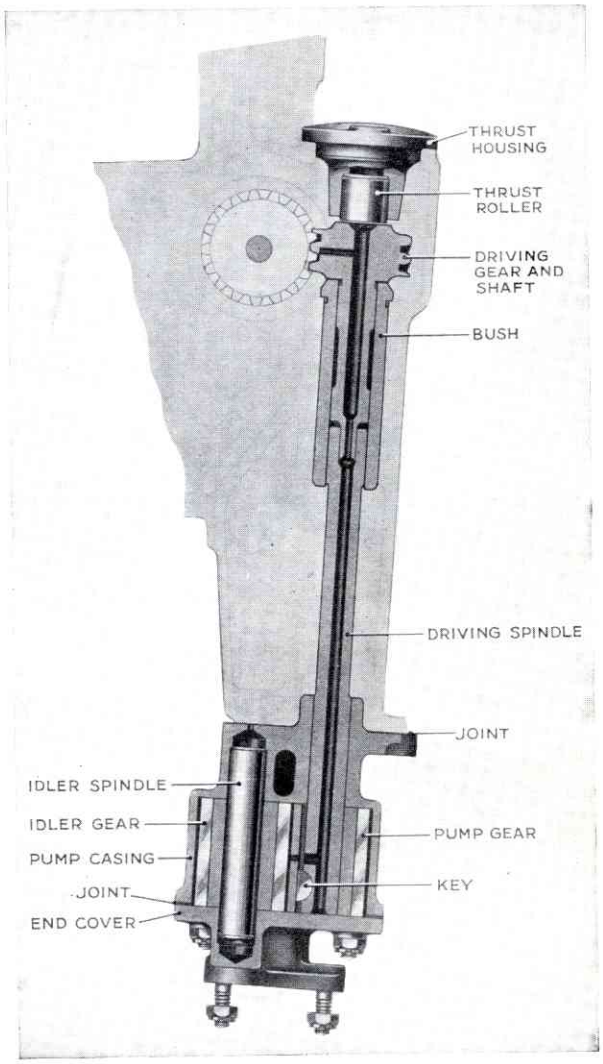


FIG. 10. OIL PUMP AND DRIVE

OVERHAUL

To Remove the Oil Pump

1. Drop the sump and remove the suction filter. Disconnect the oil feed pipe from the crankcase bottom face.

2. Remove the three nuts securing the pump body to the crankcase and withdraw the oil pump.

To Dismantle the Pump

1. Remove the oil pump end cover and withdraw the gear and spindle.

2. All parts should be examined for wear and checked against the limits as laid down in the **Data.**

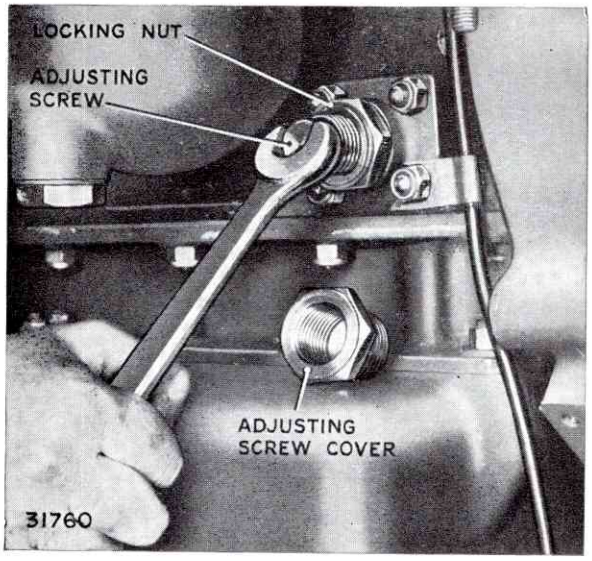


FIG. 11. ADJUSTING OIL RELIEF VALVE

3. To inspect the oil pump driving gear. Remove the thrust housing on the rear right-hand side of the engine block and withdraw the gear, Fig. 12. Backlash between the two gears should be .004/.008 in. (.1016/.2032 mm.).

To Assemble and Refit Oil Pump

Reverse the operation for removing and dismantling oil pump. Ensure that an oil-tight joint is made between the pump end cover and casing.

FIG. 12. FITTING OIL PUMP DRIVE GEAR AND THRUST HOUSING

To Adjust the Relief Valve

The oil pressure relief valve, Figs. 11 and 13, mounted at the rear left-hand side of the engine block, consists simply of a spring-loaded valve, provided with an adjusting screw.

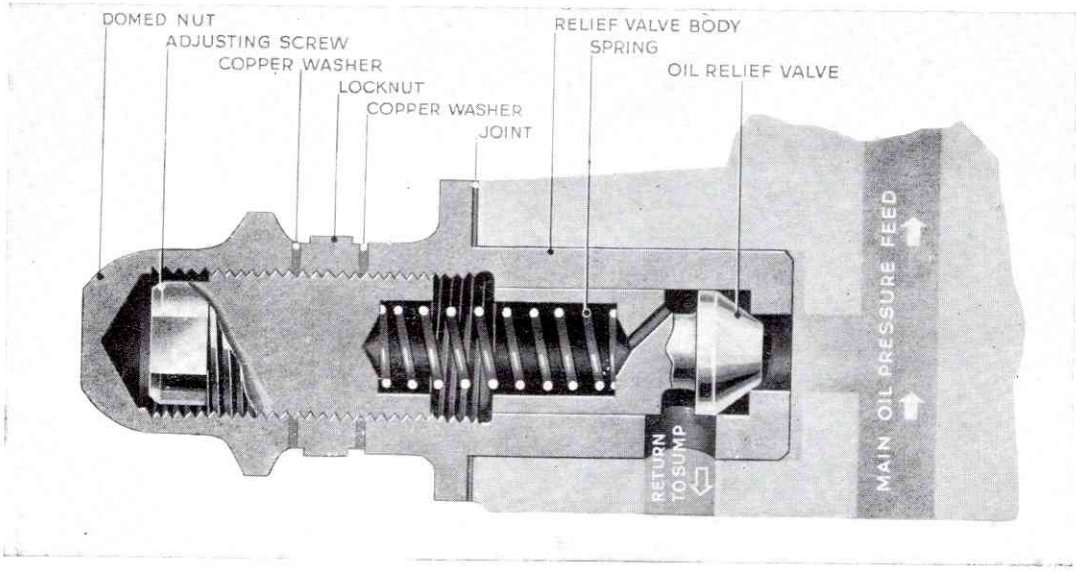


FIG. 13. OIL PRESSURE RELIEF VALVE

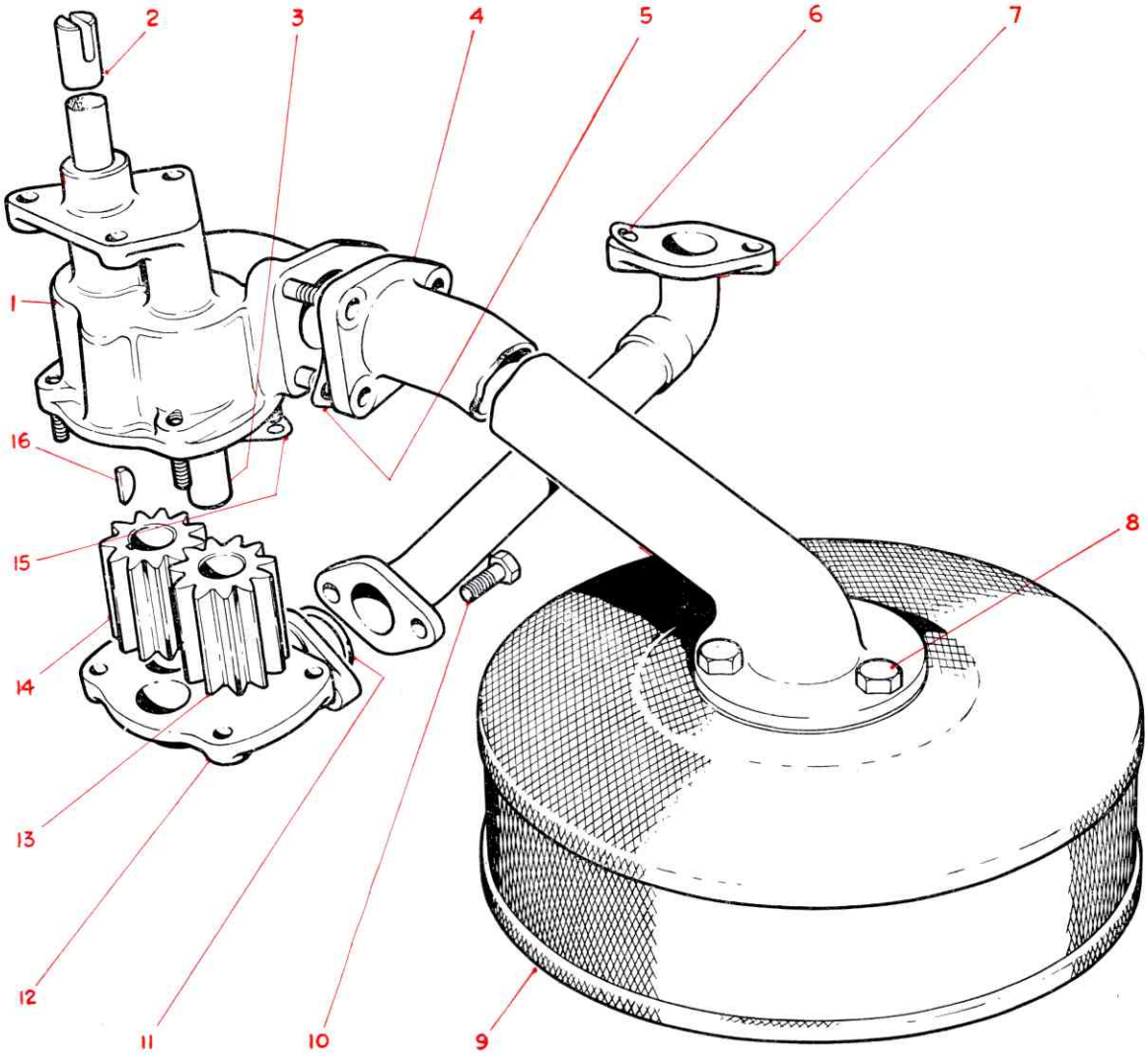


FIG. 14. EXPLODED VIEW OF THE OIL PUMP COMPONENTS

1. Oil pump body.
2. Driving shaft.
3. Shaft, idler gear.
4. Suction pipe.
5. Joint.
6. Joint.
7. Delivery pipe.
8. Setscrew.
9. Filter.
10. Setscrew.
11. 'O' ring.
12. Cover.
13. Idler gear.
14. Drive gear.
15. Joint.
16. Key.

ENGINE OIL FILTER

The engine oil filter is of the full-flow cloth-element type and is mounted at the left-hand rear of the engine-block Figs. 2 and 4. The oil is drawn from the sump and pressure-fed into the filter housing, where it is filtered and discharged into the main lubrication system. A by-pass valve in the filter housing passes oil direct to the engine in the event of the filter element becoming choked.

The by-pass valve pressure is set before leaving the factory and should not be interfered with.

The filter element, Fig. 15, consists of a metal former covered by a sleeve-shaped filter-cloth secured with cotton twine and housed in a cylindrical-shaped housing which is secured by a central dome-headed bolt to a combined cover and mounting bracket, in which are formed oil circulation and by-pass passages.

To prevent vibration the filter is spring-loaded at the base, and a felt washer at the top of the filter prevents unfiltered oil passing into the main system.

The filter cloth should be changed every 5,000 miles (8,000 kilometres).

It is important that only filter cloths approved by Leyland Motors Limited and obtainable only through the Leyland organisation should be used.

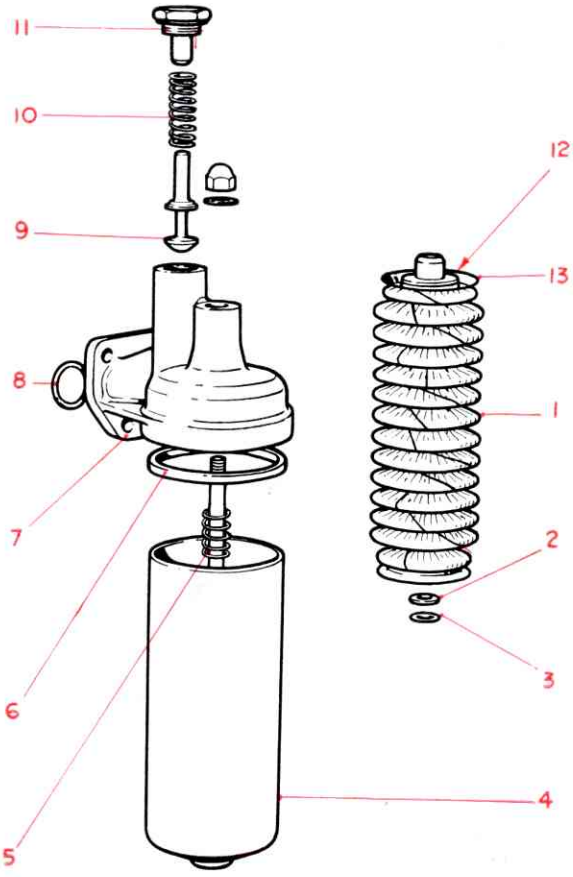


FIG. 15. THE OIL FILTER

1. Filter cloth.
2. Felt washer.
3. Steel washer.
4. Bowl.
5. Spring.
6. Seal.
7. Filter head.
8. 'O' ring.
9. Valve.
10. Valve spring.
11. Retainer.
12. Felt washer.
13. Element.

SUCTION FILTER

To detach the suction filter, it is necessary to remove the sump and the two setscrews securing the filter basket to the oil suction pipe.

SUMP

The oil sump capacity is approximately 26 pints (14.8 litres) as shown by the full mark on the dipstick which should be checked daily, see **Lubrication Chart.** The engine oil should be changed every 5,000 miles (8,000 kilometres).

CYLINDER HEADS AND VALVE GEAR

CYLINDER HEADS

The two cylinder heads are interchangeable, each head covering three cylinders.

On 0600 engines, shrunk in type Valmet valve seat inserts are fitted in both the exhaust and inlet recesses, whilst on 0680 engines the exhaust seat is a Valmet insert and the inlet seat is cut in the cylinder head, see Figs. 24 and 29.

To Remove and Replace Cylinder Heads

1. Drain the radiator and engine block by opening the drain tap situated in the bottom elbow adjacent to the radiator and the drain tap situated at the rear left-hand side of the engine block.

2. Drain and disconnect the main fuel filter.

3. Remove the air cleaner (cylinder head mounted type).

4. Disconnect the inlet, exhaust and water manifolds and remove them from the heads.

5. Remove valve covers and uncouple and remove the fuel pipes.

6. Take off the nuts securing the rocker shaft brackets. Lift off the rocker assembly then withdraw the push rods.

7. Remove all cylinder head nuts and raise the heads by unscrewing the special lifting nuts, Fig. 16. The two lifting nuts are provided for each of the heads to prevent damage to the gaskets when lifting. Both nuts should be screwed evenly as far as they will go, then lift the head off the studs. If the heads are tight on the studs, a further lift can be obtained by screwing long $\frac{1}{2}$ in. (12.7 mm.) B.S.F. bolts into the lifting nuts.

8. Before replacing the cylinder heads, wash out all water spaces. Clean all rust and carbon from the studs and engine block face. If this is left on, the heads may scrape some down and prevent a good bed being obtained when the nuts are tightened.

9. New gaskets should always be fitted prior to replacing the cylinder heads, ensure that the corrugated crests of the gaskets are uppermost. **Do not use jointing compound on the gaskets.**

10. Lower each head on to the lifting-nut studs and screw down the nuts evenly a little at a time, keeping the heads parallel with the engine block.

11. To ensure freedom from distortion and gasket leaks, the cylinder head nuts should be tightened down evenly in a definite order, starting at the centre and working outwards, as shown in Fig. 34. First tighten down with a short spanner, then with a torsion spanner set at 150/160 lb./ft. (20.7/22 kg.m.), see Fig. 19.

    A torsion spanner set at 80/85 lb./ft. (11/11.7 kg. m.), should also be used for the $\frac{7}{16}$ in. (11.1125 mm.) dia. B.S.F. nuts along the right-hand of the cylinder-heads.

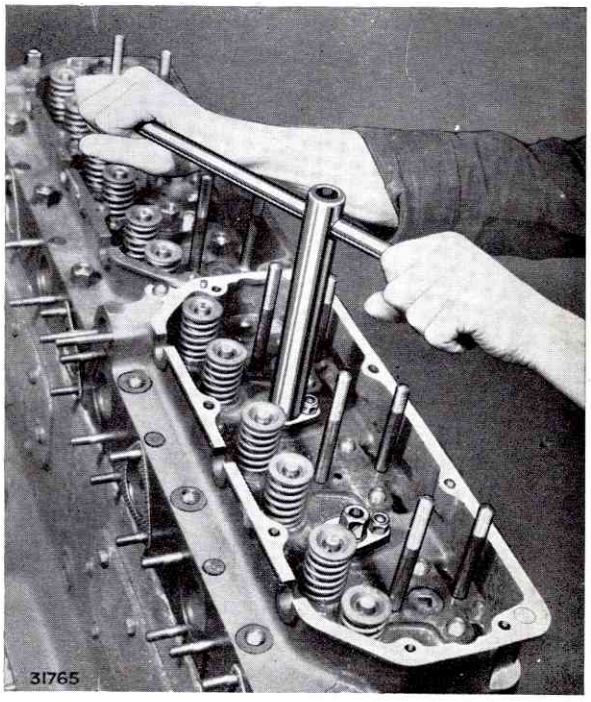


FIG. 16. TIGHTENING LIFTING NUTS

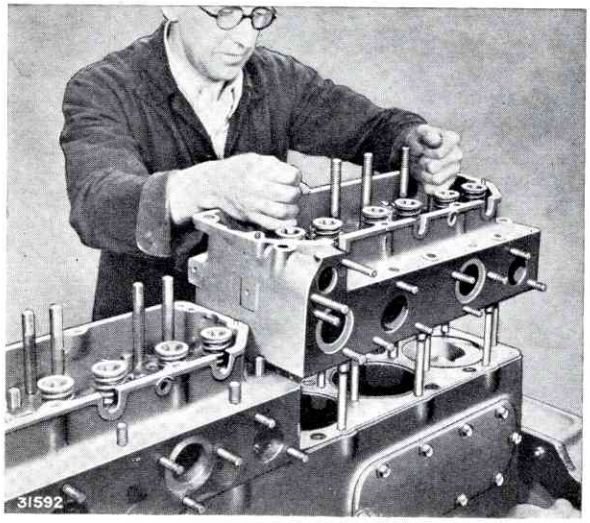


FIG. 17. FITTING CYLINDER HEAD

12. Replace push rods and fit rocker gear. Set inlet and exhaust valve clearance to .020 in. (.508 mm.) cold. Replace fuel pipes and manifolds.

Notes: Injector clamping nuts should be tightened with a torque spanner having a setting of 30/35 lb./ft. (4.2/4.8 kg. m.).

Ensure that the manifold gaskets are fitted with the metal face next to the cylinder head.

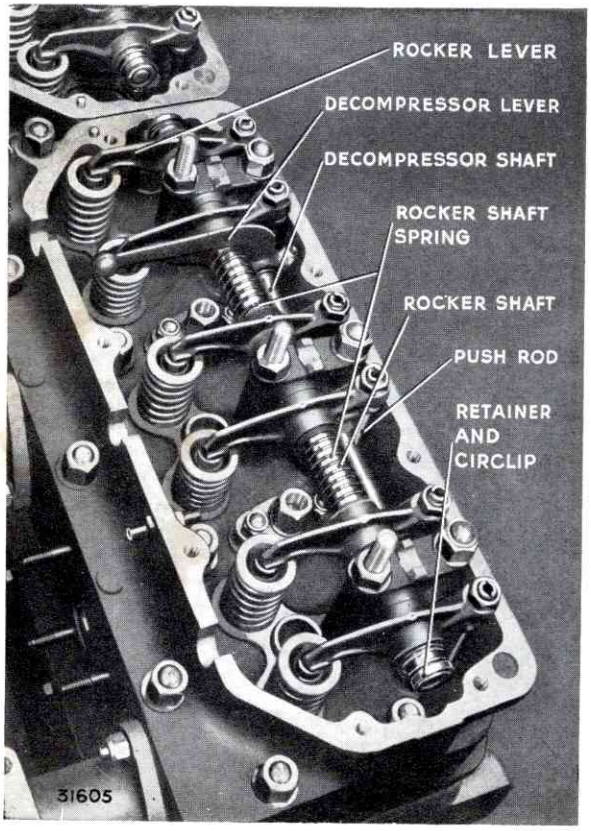


FIG 18. THE ROCKER SHAFT ASSEMBLY

13. Do not over-tighten the exhaust manifold nuts.

14. Check tappet clearances after the engine has had a short run.

VALVES AND ROCKER GEAR

The rocker levers, Fig. 18, are bushed and carried on hollow shafts. Each shaft is held in position by three support brackets which also carry the decompressor shaft. The number one bracket on each head carries a spring-loaded plunger which comes into contact with a flat, formed on the decompressor shaft, and holds it in the **off** position.

Lubrication is effected by an intermittent feed from the second and fifth camshaft bearings, via oilways drilled in the engine block and heads, up through the centre rocker-shaft support brackets, and along the rocker-shafts to the rocker levers.

The correct tappet clearance is .020 in. (.508 mm.) cold, for both inlet and exhaust valves. When checking the clearances, make sure the tappets are on the backs of the cams. Turn the engine until the valve is fully open, then turn through one complete revolution to bring the tappet on the back of the cam.

Both valves are stellite-faced and have hard-chrome-plated stems. The valves can be distinguished by the difference in size across their heads. For dimensions see **Data**.

When removing the valves and springs for inspection and refacing, it is important that subsequently they are replaced in their original positions. Do not mark the valve heads by centre-popping.

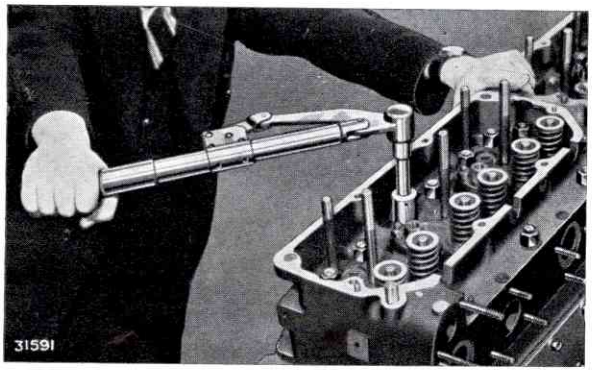


FIG. 19. TIGHTENING CYLINDER HEAD NUTS USING A TORSION SPANNER

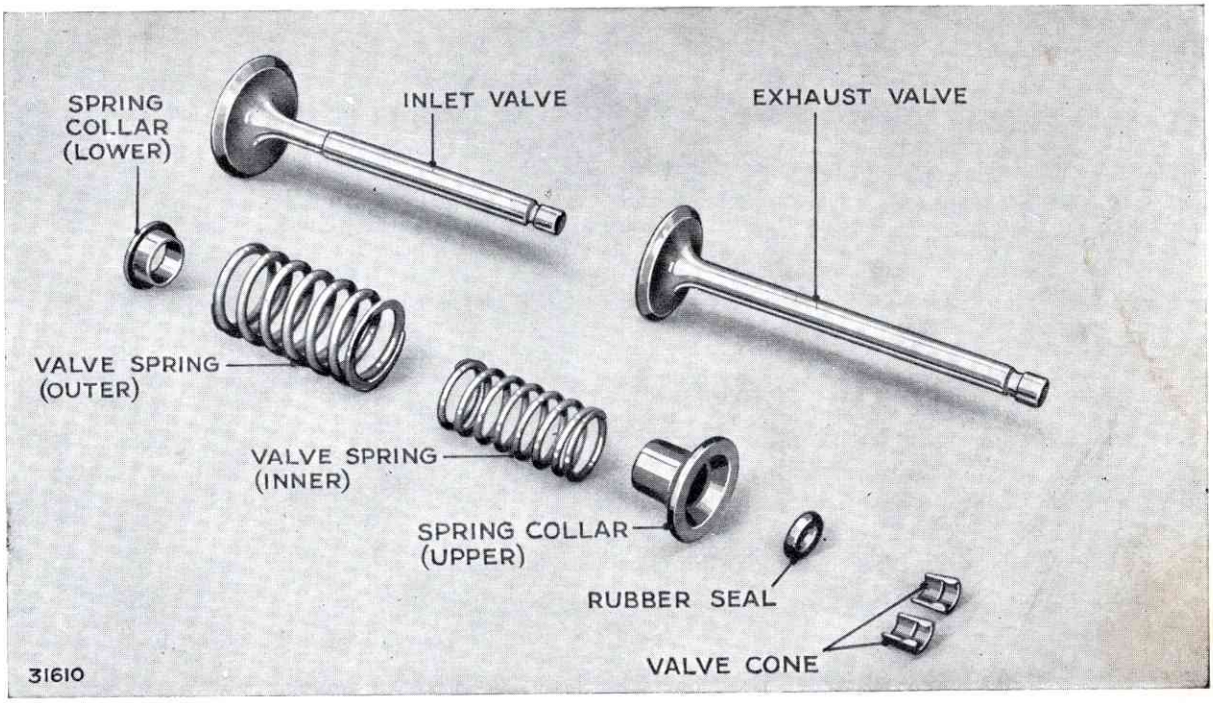


FIG. 20. VALVES AND SPRINGS

To Remove and Replace Valves

1. Remove the cylinder head and place it face downwards on the bench.
2. Extract the split cone, Fig. 20 and 21, and remove the valve collar together with the rubber sealing ring and valve springs, Fig. 20.
3. The rubber sealing rings should be inspected and renewed if perished.
4. Check valve springs for length, see **Data.**

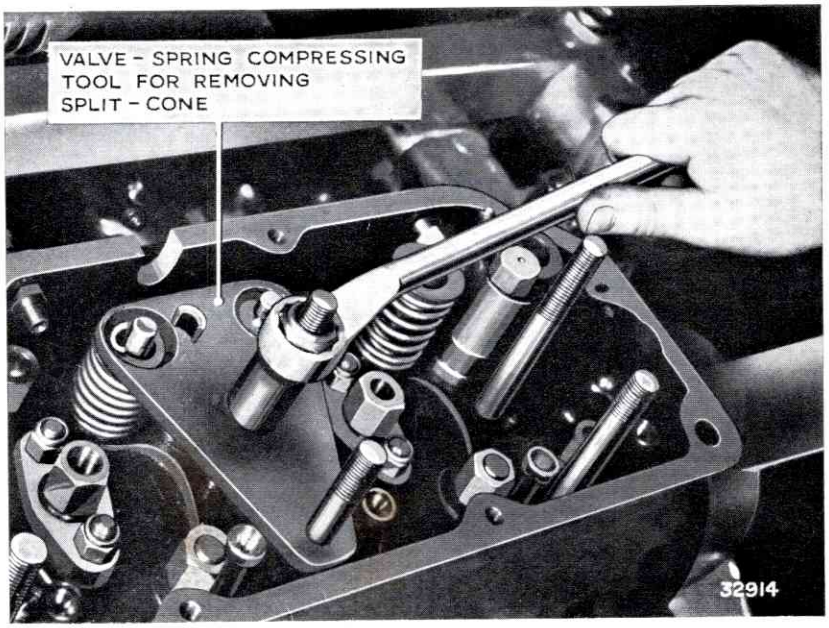


FIG. 21. VALVE SPRING COMPRESSING TOOL

DECARBONISING, VALVE GUIDE RENEWAL AND VALVE GRINDING

Decarbonising

Remove the heads and valves as previously described. Carefully scrape off the carbon deposit on the heads and pistons, but on no account must any form of abrasive be used. Do not disturb the ring of carbon at the top of the bore, as it will help to restrict the passage of oil into the combustion chamber if the bores are worn.

Renewal of Valve Guides

1. Check the valve guides for stem clearances. If this is excessive, .010 in. (.254 mm.) or over, renew the guide. If the stem is worn, renew the valve. Always check the fit of a valve in the new guides. They must have .0025/.00375 in. (.0635/.0953 mm.) clearance for the inlet valves and .004/.00525 in. (.1016/.1334 mm.) clearance for the exhaust.

2. The valve guides are an interference fit in the heads and must be pressed in and out when replacements are necessary. See Fig. 24 for position of valve guide in head.

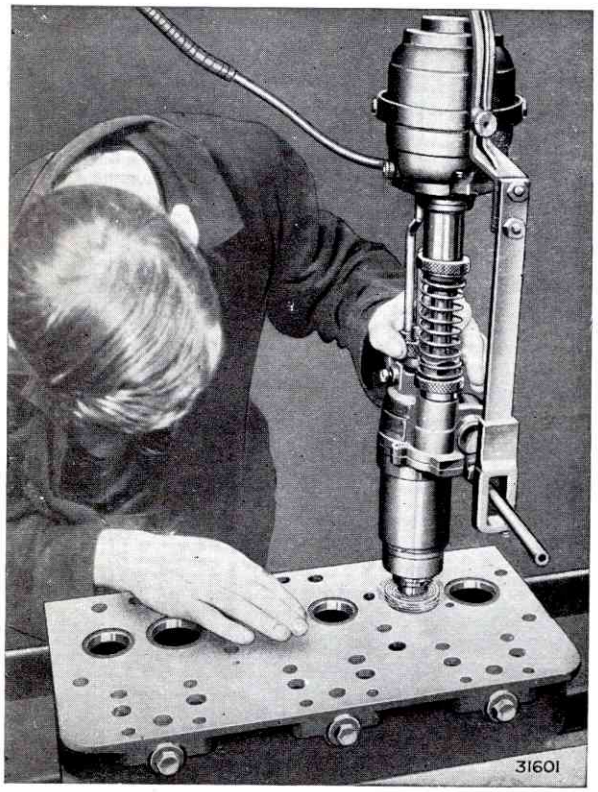


FIG. 22. GRINDING VALVE SEATS

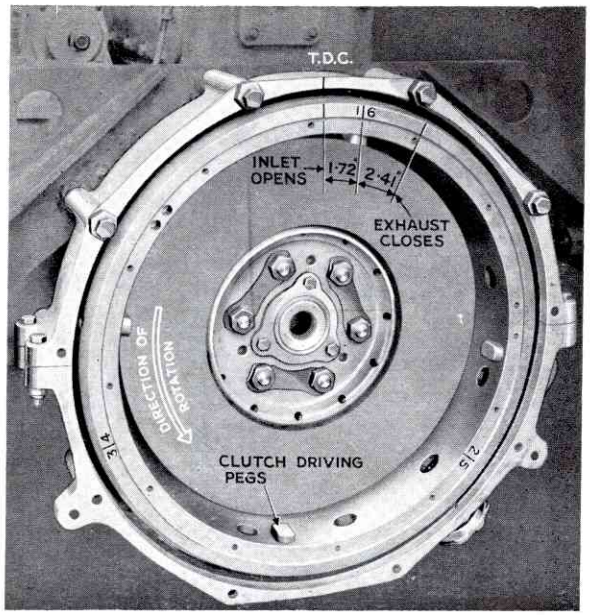


FIG. 23. VALVE TIMING MARKS ON FLYWHEEL

3. After fitting a new valve guide, always regrind the valve seat so that it is concentric with the guide.

Valve Grinding

1. Examine the valve facings and seats. If the valve seats are at all pitted and require grinding, a special carborundum tool must be used. This must have a working face of 30° (the accuracy of this angle is important), and must be accurately positioned by a spindle located in the valve guide. The stone must be rotated at high speed. **The face of the seat should be concentric with the valve guide bore to within .001 in. (.0254 mm.) (total clock reading).**

2. If the valves require refacing, this should be done in a valve-facing machine with the stone set at an angle of 29½°. **The valve facing must be concentric with the valve stem to within .001 in. (.0254 mm.) (total clock reading).**

3. On no account must badly pitted valves and seats be lapped together, as this will cause excessively wide seats.

4. When the valves and seats have been re-cut, or when the valves and seats are in good condition, they should be lightly lapped together to give a perfect seating. The seating mark should be a thin line towards the top of the seat, Fig. 24.

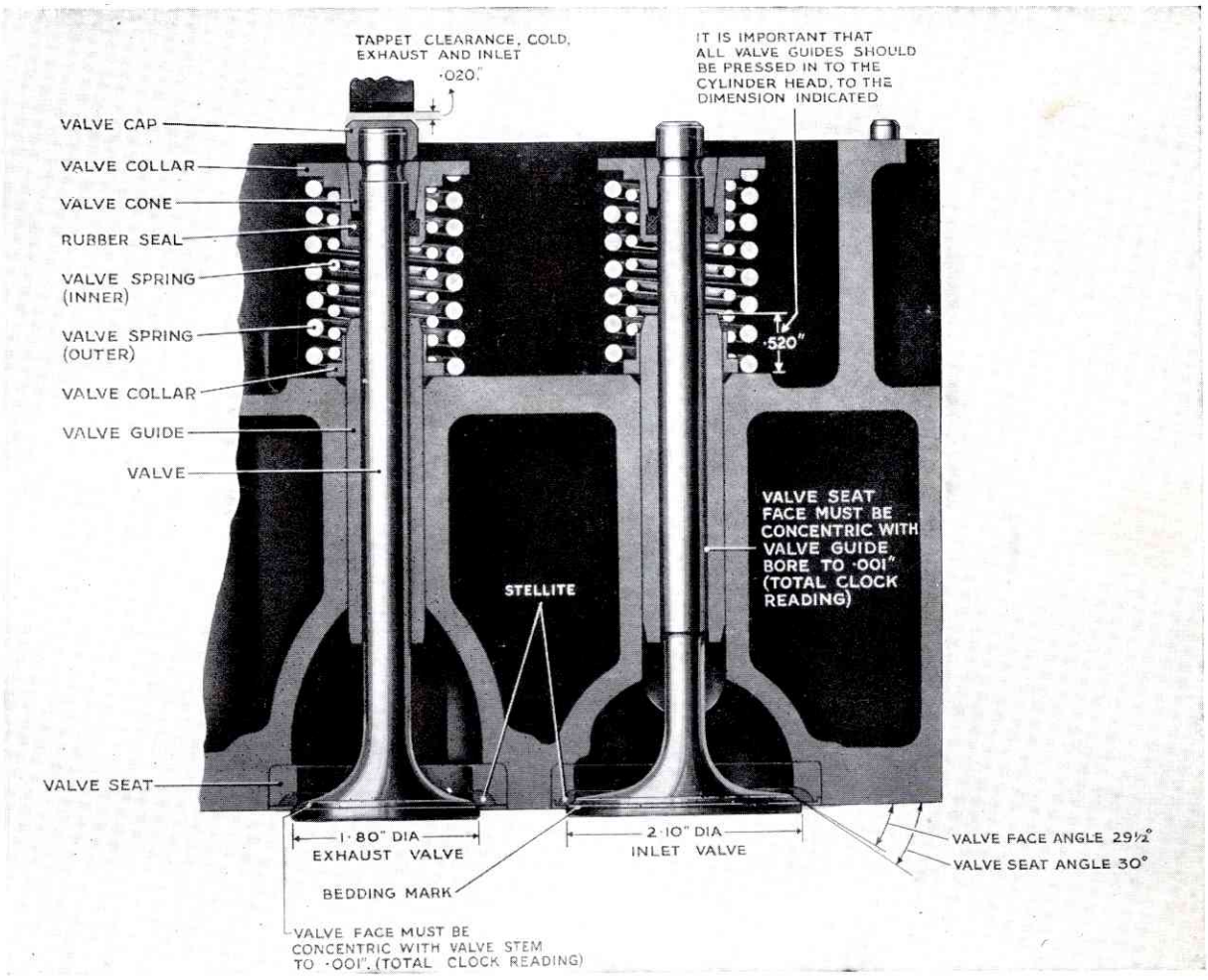


FIG. 24. VALVES, SPRINGS AND VALVE SEATS IN POSITION ON 0600 ENGINE

5. To lap in the valves, put a thin layer of fine grade carborundum paste on the valve seat and rotate the valve to and fro on the seat, occasionally lifting the valve off the seat. Do not rotate the valve through a complete revolution before lifting as this will groove the seat. All traces of grinding compound must be removed before assembly.

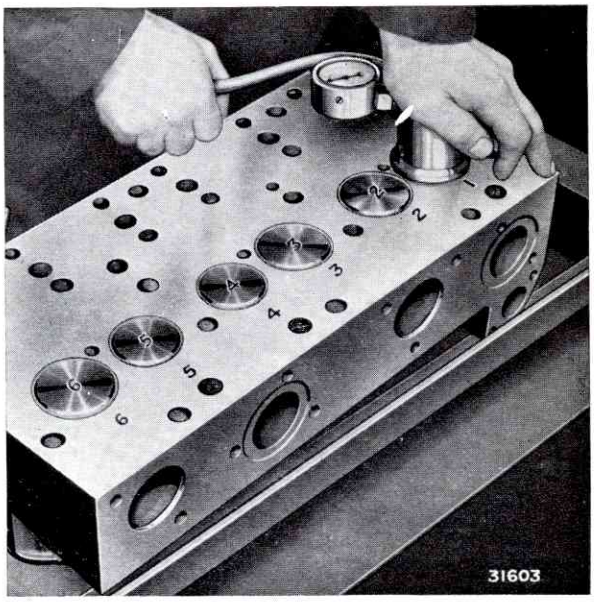


FIG. 25. TESTING GAS-TIGHTNESS OF VALVE ON ITS SEAT

VALVE TIMING

The valve timing is shown in Fig. 6, under **Data**.

To Check Valve Timing

1. To check the valve timing, set the tappet clearances of all cylinders to .020 in. (.508 mm.), cold.

2. Turn the engine until the timing-plunger engages in the flywheel, and No. 1 piston is on T.D.C. of the firing stroke. At this point the inlet and exhaust valves are closed.

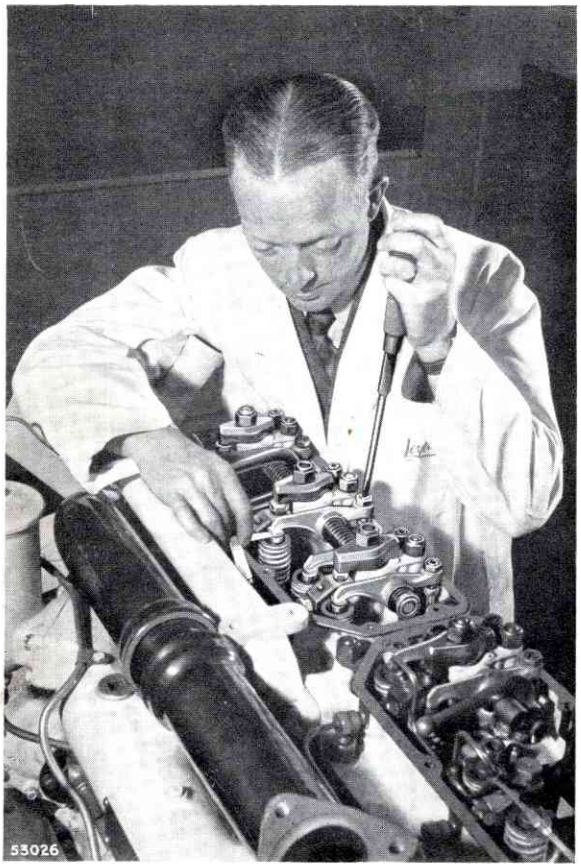


FIG. 26. ADJUSTING THE TAPPETS

3. Now turn the engine until the inlet valve of No. 6 cylinder just opens. To check when the inlet valve is just opening, rotate the push-rod of the inlet valve between thumb and forefinger. When the valve just opens the push-rod will cease to rotate, If the timing is correct, the valve should open 10° before T.D.C. measured on the flywheel rim, Fig. 23.

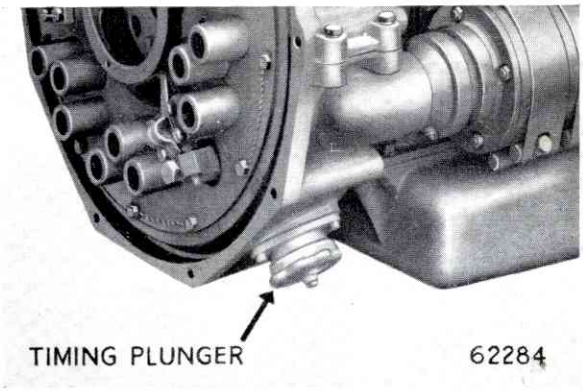


FIG. 27. POSITION OF TIMING PLUNGER UNIT

TIMING PLUNGER

This is fitted to facilitate finding T.D.C. for Nos. 1 and 6 pistons and also the fuel pump injection positions which is 26° before T.D.C. of No. 1 piston (both valves closed). The plunger fitted at lower right-hand side of flywheel housing, Fig. 27, has three positions: **T.D.C., INJ.** and **OFF** as shown in Fig. 30. To operate the plunger, lift and turn until the required position is shown, then turn the engine slowly until the plunger is felt to drop into the appropriate hole in the flywheel. **Never use the starter to turn the engine when using the plunger.**

Set the plunger in the OFF position when engine has been correctly timed.

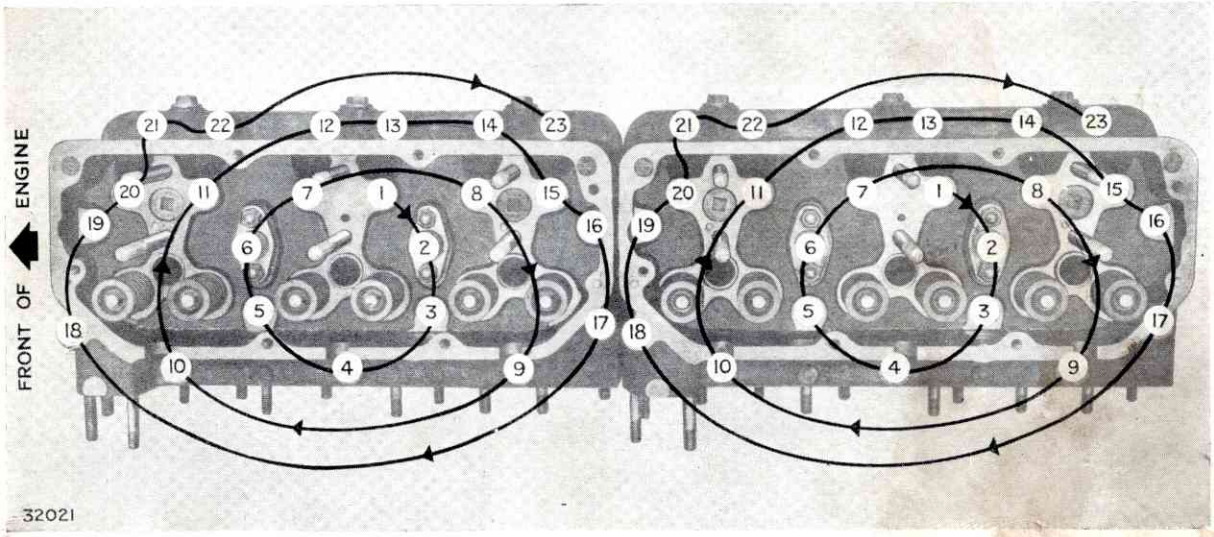


FIG. 28. CORRECT SEQUENCE OF TIGHTENING CYLINDER HEAD NUTS

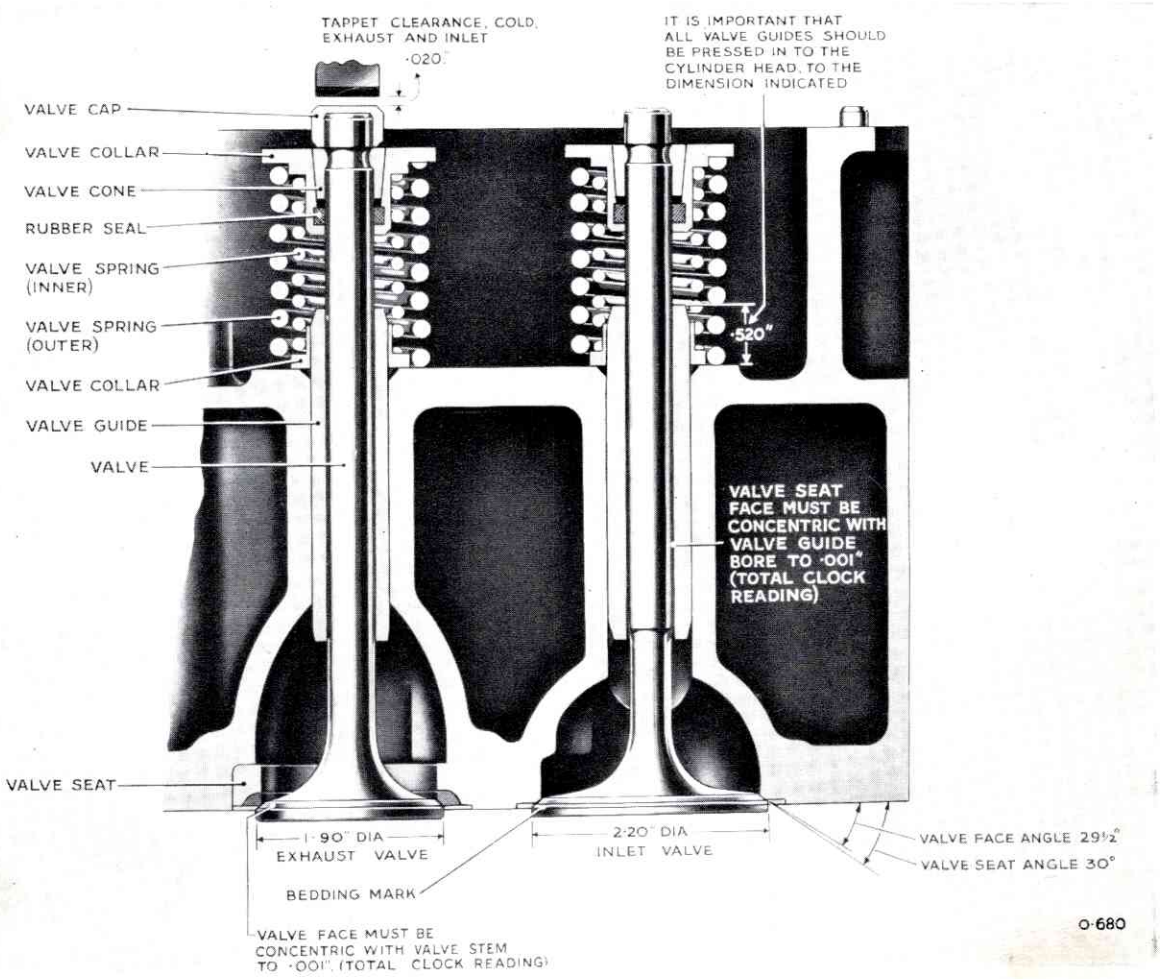


FIG. 29. VALVES SPRINGS AND VALVE SEATS IN POSITION ON 0680 ENGINE

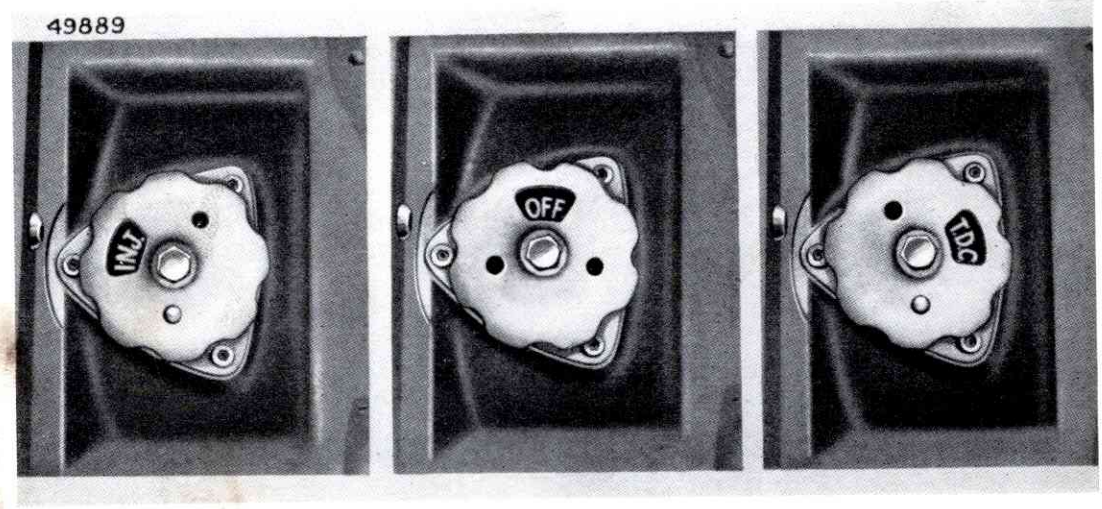
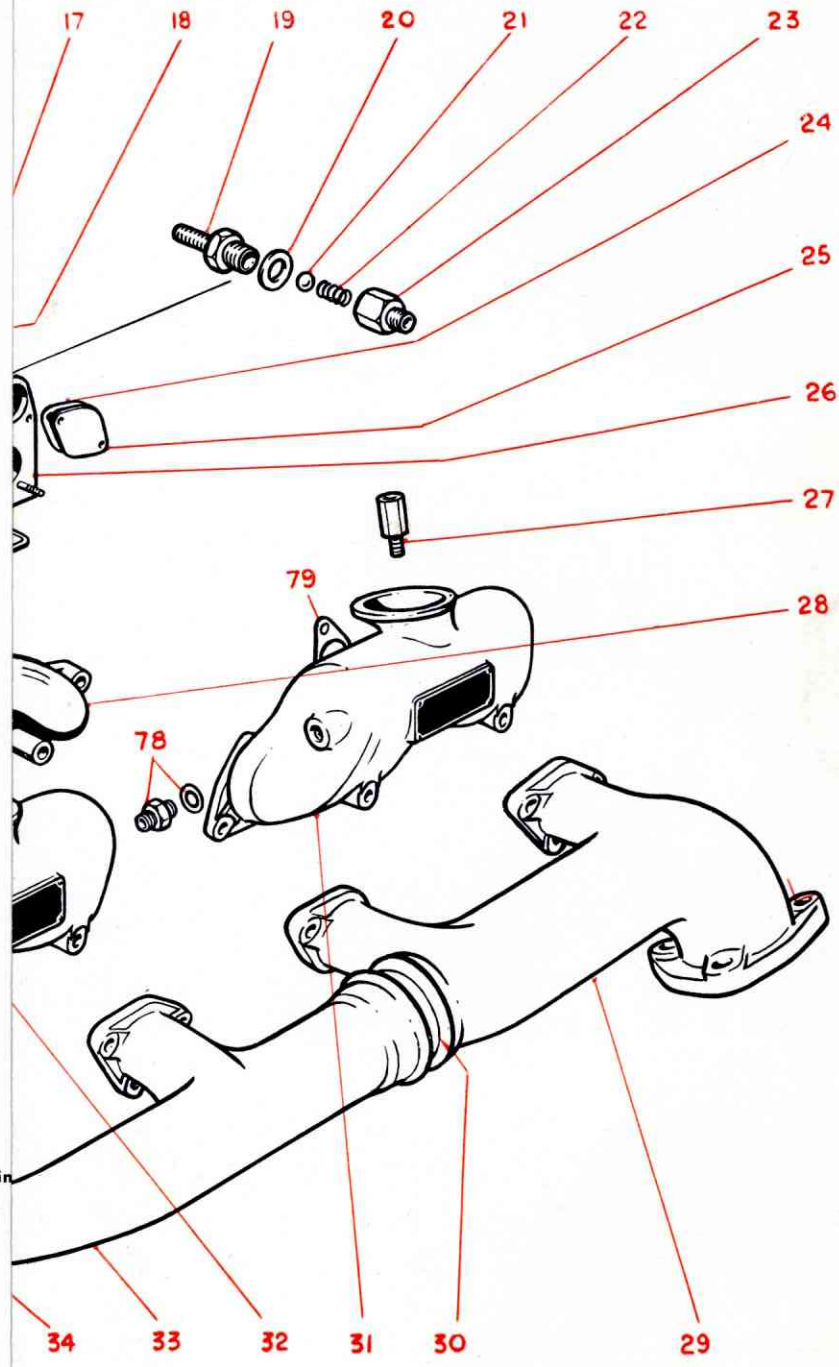


FIG. 30 THE TIMING PLUNGER POSITIONS

1. Decompressor shaft.
2. Rocker shaft.
3. Washer, spring.
4. Spring, long.
5. Rocker lever, inlet.
6. Plug and washer.
7. Plug and washer.
8. Valve seal.
9. Valve spring collar.
10. Valve spring, outer.
11. Nut.
12. Clamp.
13. Setscrew.
14. Lifting plate.
15. Sleeve, injector holder.
16. Eye bolt.
17. Adapter nut.
18. Cover.
19. Union.
20. Washer.
21. Ball.
22. Spring.
23. Union adapter.
24. Joint.
25. Cover plate.
26. Cylinder head.
27. Stud, air filter.
28. Water outlet pipe.
29. Exhaust manifold, rear.
30. Centre tube.
31. Inlet manifold, rear.
32. Inlet manifold, front.
33. Exhaust manifold, front.
34. Plug and washer.
35. Plug and washer.
36. Joint.
37. Valve seat, inlet (0600 engin
38. Valve seat, exhaust.
39. Valve, inlet.
40. Valve, exhaust.



1. Decompressor shaft.
2. Rocker shaft.
3. Washer, spring.
4. Spring, long.
5. Rocker lever, inlet.
6. Plug and washer.
7. Plug and washer.
8. Valve seal.
9. Valve spring collar.
10. Valve spring, outer.
11. Nut.
12. Clamp.
13. Setscrew.
14. Lifting plate.
15. Sleeve, injector holder.
16. Eye bolt.
17. Adapter nut.
18. Cover.
19. Union.
20. Washer.
21. Ball.
22. Spring.
23. Union adapter.
24. Joint.
25. Cover plate.
26. Cylinder head.
27. Stud, air filter.
28. Water outlet pipe.
29. Exhaust manifold, rear.
30. Centre tube.
31. Inlet manifold, rear.
32. Inlet manifold, front.
33. Exhaust manifold, front.
34. Plug and washer.
35. Plug and washer.
36. Joint.
37. Valve seat, inlet (0600 engine only).
38. Valve seat, exhaust.
39. Valve, inlet.
40. Valve, exhaust.
41. Valve cones (2 halves).
42. Valve cap.
43. Liner.
44. Thermostat.
45. Setscrew, washer.
46. Hose.
47. Clip.
48. Water outlet elbow.
49. Rocker lever, exhaust.
50. Bush.
51. Spring, short.
52. Circlip.
53. Welch washer.
54. Washer.
55. Ball end.
56. Locknut.
57. Decompressor lever.
58. Dowel.
59. Ball.
60. Spring.
61. Screw.
62. Stud, nut.
63. Stud, nut.
64. Rocker bracket.
65. Valve spring, inner.
66. Valve spring collar, lower.
67. Dowel.
68. Valve guide.
69. Spring plunger.
70. Plunger.
71. Lifting nut.
72. Joint.
73. Plug, washer.
74. Gasket.
75. Cylinder head gasket.
76. Joint.
77. Joint.
78. Adapter, washer.
79. Joint.
80. Joint.

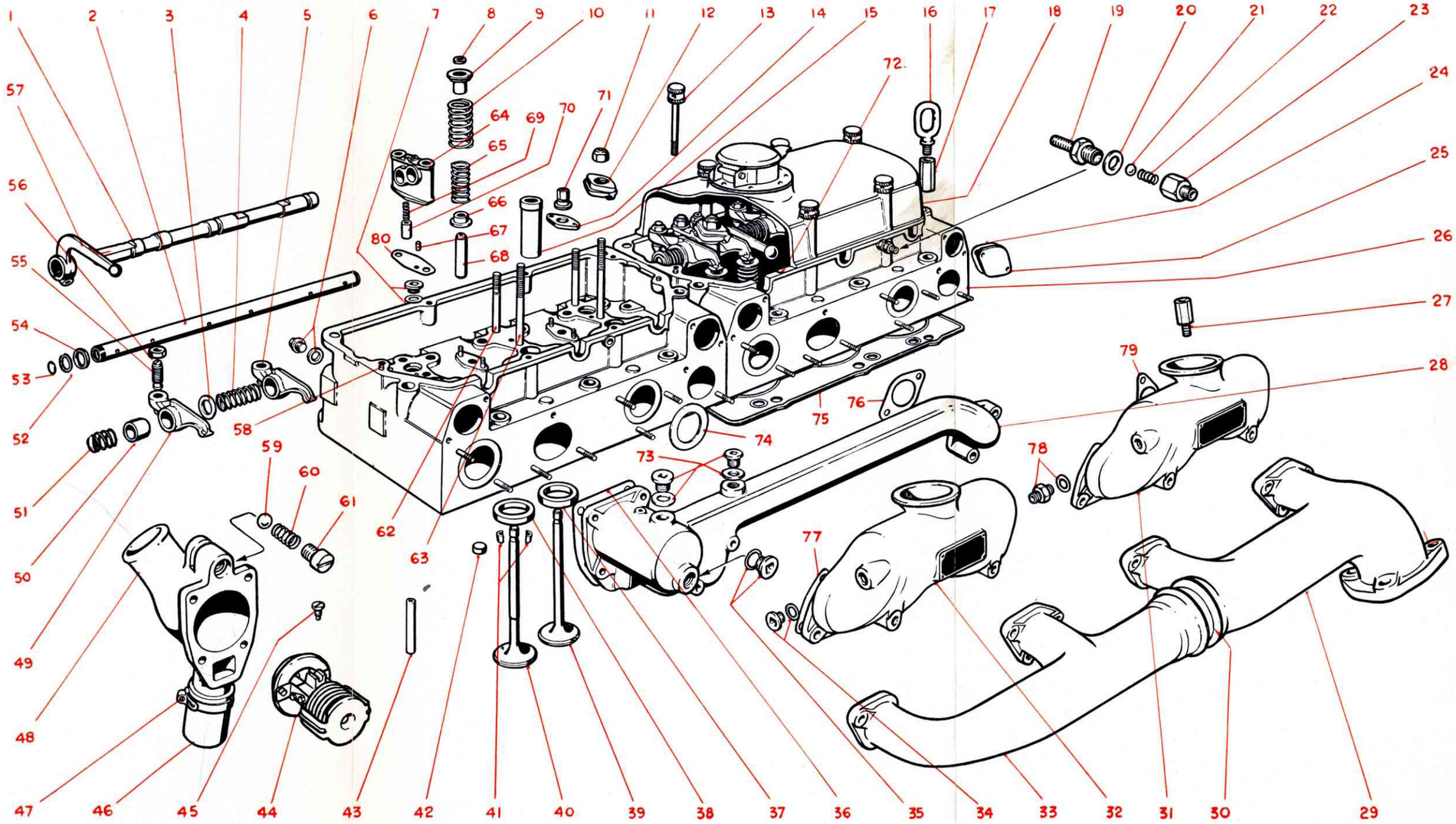


FIG. 31. TYPICAL ILLUSTRATION OF CYLINDER HEAD COMPONENTS

ENGINE BLOCK AND CAMSHAFT

DESCRIPTION

The cylinders and crankcase are cast integral; the cylinders being fitted with:
0600 Engine: Dry press fit, cast iron liners, shoulder located.
0680 Engine: Dry press fit, Cromard liners, shoulder located.

The camshaft is carried in seven pressure lubricated bearings which are setscrew located on the lower offside of the engine block, the thrust being taken on the front bearing only. The drive is transmitted from the front of the crankshaft through helical gearing.

OVERHAUL

To Remove Camshaft

1. Remove the rocker gear and extract the push rods

2. Remove dynamo and driving belts.

3. Remove side covers and extract the cam followers.

4. Remove vibration damper from pulley then remove pulley with the special tool.

5. If fitted with an exhauster, disconnect the exhauster oil feed pipe from the timing case side, and remove all securing bolts and setscrews from timing case.

6. Remove timing case, taking care not to damage the oil seal housed in the bore surrounding the crankshaft end.

7. Remove the four setscrews and locking plates securing the gear to the camshaft and withdraw the gear, taking care to note the position of the timing mark on the gear in relation to the mark on the timing back plate when No. 1 piston is on T.D.C. of firing stroke Figs. 33, 34.

8. Remove the four setscrews fixing the camshaft thrust washer, and withdraw the camshaft Fig. 34.

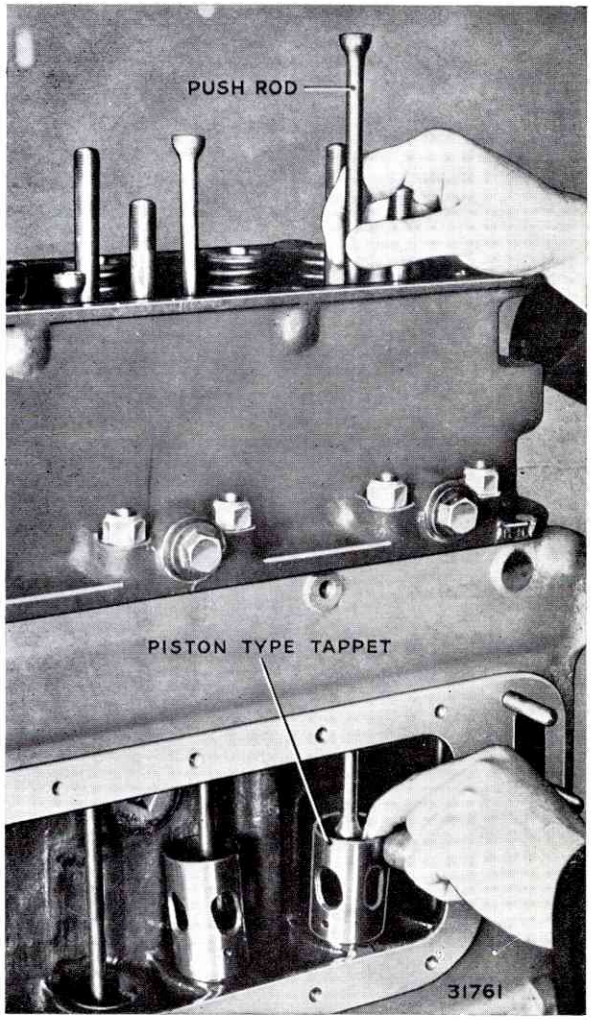


FIG. 32. REMOVING PUSH ROD AND CAM FOLLOWER

9. To remove the camshaft bearings, take out the locating setscrews and drive out the bearings with a suitable drift. The intermediate bearings are interchangeable.

10. To drive out the rear bearing, it is necessary to remove the clutch, flywheel and top half of flywheel housing.

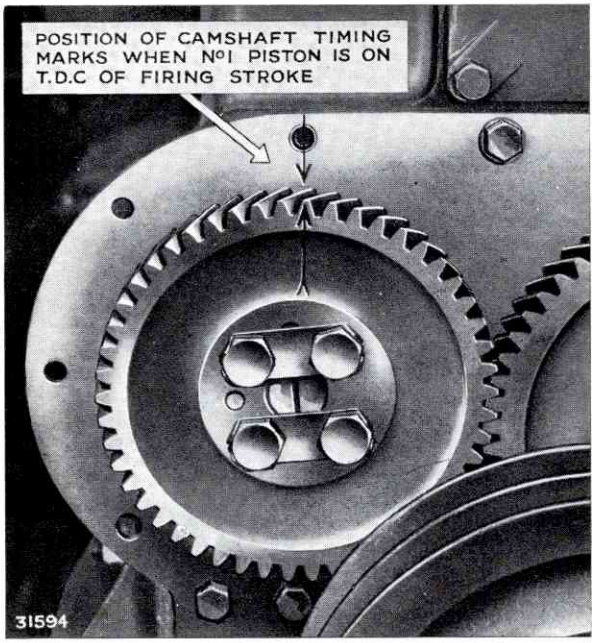


FIG. 33. CAMSHAFT TIMING MARKS

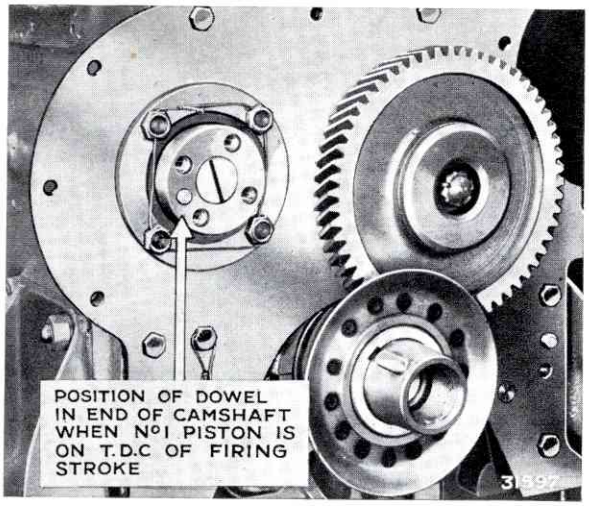


FIG. 34. GEAR LOCATING DOWEL IN CAMSHAFT END

11. Check all bearings for wear and renew when diametrical clearance exceeds .010 in. (.254 mm.). Normal end-play of the camshaft with the retaining plate tight up and adjusting shim in position is .004 in. (.1016 mm.). If the end-play is .008 to .010 in. (.2032 to .254 mm.) the shim should be removed.

To Refit Camshaft

Refitting the camshaft is a reversal of the previous procedure.

Take care that the bearings are not burred when replacing them.

To Time the Camshaft

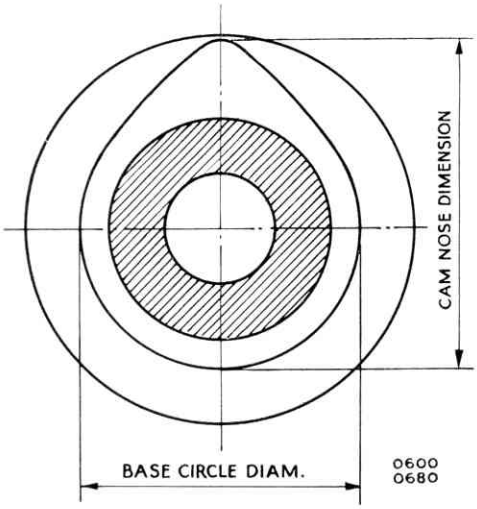
1. Turn the engine until No. 1 piston is on T.D.C. of the firing stroke.

2. Fit the camshaft gear so that when the dowel hole in the gear locates on the dowel in the camshaft end, the arrows on the gear face and timing back plate are in line Fig. 34, that is, 90° to the top face of the engine block.

3. Refit the locking plates and tighten the setscrews securely. Make sure that the locking plate tabs are turned over after the setscrews have been tightened.

Cylinder Liners

At overhaul the liner bores should be measured and new liners fitted if the diameter at the top of the bore exceeds 4.80+.020 in. (121.92+.508 mm.) on the 0600 engine, and 5.00+.020 in. (127+508 mm.) on the 0680 engine.



THE CAMSHAFT SHOULD BE RENEWED WHEN THE DIFFERENCE BETWEEN THE BASE CIRCLE DIAMETER AND THE NOSE DIMENSION IS ·358 in. (9·1m.m.) OR LESS

FIG. 35. CAM WEAR DIAGRAM

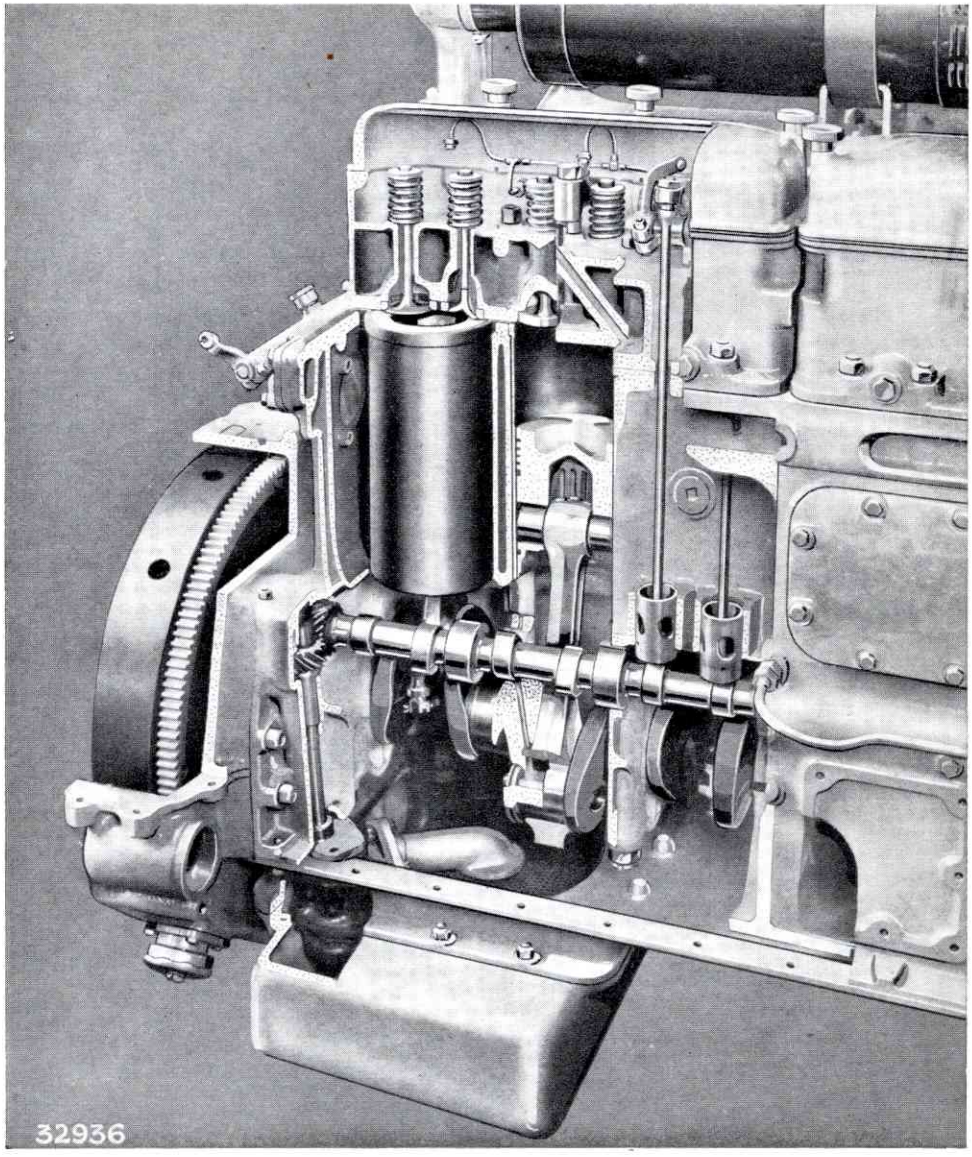


FIG. 36. TYPICAL CUT-AWAY SECTION OF REAR OF ENGINE

To Remove and Insert Liners

1. The cylinder liners are pre-finished ready for inserting in the engine-block. Special tools have been designed both to extract and to insert the new liners in the block.

Part No. 259467 for the 0600 engine.

Part No. 509601 for the 0680 engine.

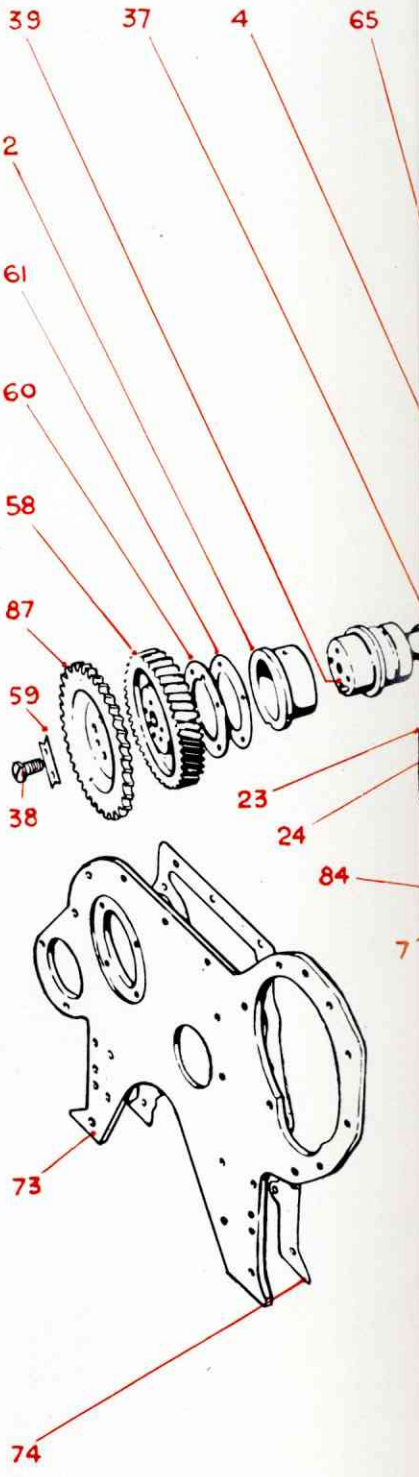
2. The projection of cylinder liners above the top face of the engine block should lie within the limits —.000+.002 in. (—.000+.0508 mm.).

3. Before fitting new liners thoroughly clean out the cylinder bores then invert the liners, placing the liner flange in the recess of the cylinder and, using a straight-edge and feelers, check that the projection figures are within the limits stated.

Note: If necessary, to ensure that the liners are correctly positioned within the limits stated, shims .002 in. (.050 mm.) are available for fitting beneath the liner shoulder.

4. When installing the liners, lightly smear the bores of the block with thin oil. This will facilitate subsequent removal of the liners.

1. Crankcase and bearing caps.
2. Camshaft bearing, front.
3. Camshaft bearing, rear.
4. Camshaft bearing, intermediate.
5. Locating screw.
6. Locating screw.
7. Dowel.
8. Plug.
9. Extension nut.
10. Bush.
11. Dowel.
12. Dowel.
13. Cylinder liner.
14. Shim.
15. Side cover, R.H. front.
16. Bush.
17. Shield.
18. Retainer bar.
19. Ferrule.
20. Side cover, R.H. rear.
21. Retainer bar.
22. Ferrule.
23. Front cover.
24. Joint.
25. Side cover, L.H.
26. Joint.
27. Cover.
28. Joint.
29. Joint.
30. Joint.
31. Flywheel housing.
32. Timing plunger.
33. Housing.
34. Cap.
35. Spring.
36. Sealing ring.
37. Plug.
38. Dowel.
39. Dowel.
40. Body.
41. Oil relief valve.
42. Spring.
43. Adjusting screw.
44. Domed nut.
45. Locknut, washer.
46. Housing.
47. Thrust button.
48. Drain pipe.
49. Control bracket.
50. Cross shaft.
51. Control lever.
52. Control lever.
53. Main bearing, front.
54. Main bearing, intermediate.
55. Main bearing, centre and rear.
56. Thrust washer, upper.
57. Thrust washer, lower.
58. Camshaft drive gear.
59. Tab washer.
60. Thrust washer.
61. Shim.
62. Push rod.
63. Breather pipe.
64. Clip.
65. Tappet.
66. Intermediate gear.
67. Bush.
68. Spindle.
69. Bolt.
70. Nut.
71. Washer.
72. Thrust washer.
73. Timing back plate.
74. Joint.
75. Dowel.
76. Oil pump drive shaft.
77. Joint.
78. Joint.
79. Joint.
80. Joint.
81. Air and oil separator.
82. Stop tap and washer.
83. Engine suspension bracket, L.H.
84. Engine suspension bracket, R.H.
85. Joint.
86. Joint.
87. Drive gear, power steering.
88. Anchor plate.



45. Locknut, washer.
46. Housing.
47. Thrust button.
48. Drain pipe.
49. Control bracket.
50. Cross shaft.
51. Control lever.
52. Control lever.
53. Main bearing, front.
54. Main bearing, intermediate.
55. Main bearing, centre and rear.
56. Thrust washer, upper.
57. Thrust washer, lower.
58. Camshaft drive gear.
59. Tab washer.
60. Thrust washer.
61. Shim.
62. Push rod.
63. Breather pipe.
64. Clip.
65. Tappet.
66. Intermediate gear.
67. Bush.
68. Spindle.
69. Bolt.
70. Nut.
71. Washer.
72. Thrust washer.
73. Timing back plate.
74. Joint.
75. Dowel.
76. Oil pump drive shaft.
77. Joint.
78. Joint.
79. Joint.
80. Joint.
81. Air and oil separator.
82. Stop tap and washer.
83. Engine suspension bracket, L.H.
84. Engine suspension bracket, R.H.
85. Joint.
86. Joint.
87. Drive gear, power steering.
88. Anchor plate.

FIG. 37. TYPICAL ILLUSTRATION OF ENGINE BLOCK COMPONENTS

CONNECTING RODS AND PISTONS

DESCRIPTION

The connecting rods are alloy steel stampings of exceptionally rigid design, drilled to provide intermittent oil spray for cylinder wall lubrication. The big ends have steel-shell type, lead-bronze bearings with the bearing surface indium-coated. The small ends are bushed.

Note: On later production engines the connecting rods have no oil spray hole in the big ends and no balancing boss on the big end caps.

When reconditioning engines it is desirable (but not essential) that all connecting rods should be of one type.

0600 Engine

The pistons are of special aluminium alloy, fitted with three compression and one scraper ring, the top compression ring is chromium-plated.

0680 Engine

The pistons are of special aluminium alloy, fitted with three compression and one scraper ring. Chromium-plated rings should not be fitted under any circumstances.

A spheroidal cavity in the piston crown forms the combustion chamber. The hollow gudgeon pins are located in the pistons by circlips.

OVERHAUL

To Remove Connecting Rods and Pistons

The dimensions of the crankshaft are such that the pistons cannot be withdrawn through the crankcase; they can, however, be withdrawn through the cylinder bores.

Care should be taken not to scratch the bores when removing or replacing the connecting rod assemblies.

To Separate Pistons from Connecting Rods

1. Remove the gudgeon pin circlips.

2. Heat the pistons in boiling water and tap or push the pin out while the piston is hot.

Note: The gudgeon pins must not be forced in or out of the pistons when cold. The pins are an interference fit in the piston bosses when cold and an easy push-fit in the small-end bushes.

To Assemble Piston and Connecting Rod

1. Heat the pistons in boiling water or in an oven before the gudgeon pins are inserted. The oven temperature must not exceed 150°C. (302°F.).

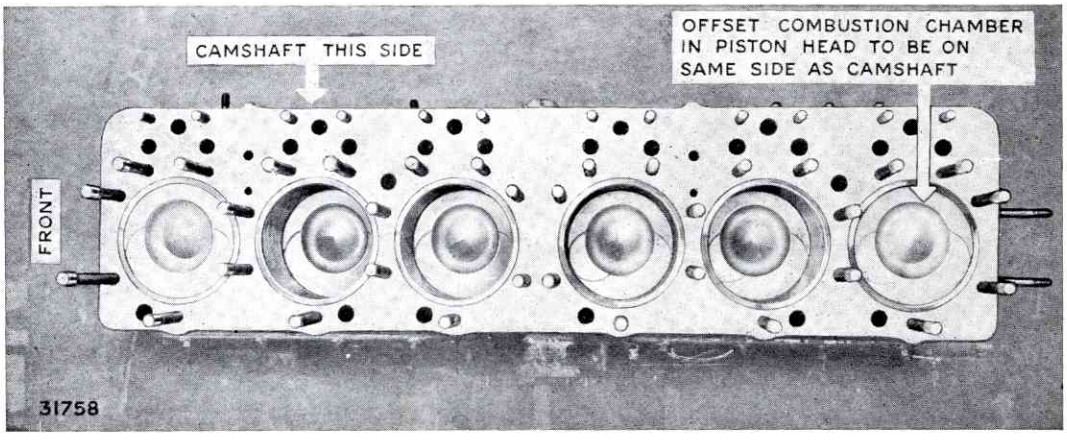


FIG. 38. POSITION OF OFFSET COMBUSTION CHAMBERS IN PISTON HEADS, IN RELATION TO THE CAMSHAFT

2. On engines fitted with connecting rods having oil spray holes in the big ends, fit pistons to connecting rods with the offset combustion chamber in the piston heads on the same side as the oil spray hole in the connecting rod big-end.

To Fit Piston and Rings

0600 Engine

1st groove

Fit compression ring, chromium-plated, parallel sides, straight-cut gap.

2nd and 3rd grooves

Fit compression rings, parallel sides, straight-cut gap.

These rings have a face angle of 1/1½° and it is imperative that the rings are fitted the correct way up as indicated by the word **top** etched on the upper face.

4th groove

Fit scraper ring, parallel sides, slotted, straight-cut gap.

0680 Engine

1st groove

Fit compression ring, parallel sides, straight-cut gap.
Note: Chromium-plated rings should not be fitted under any circumstances.

2nd and 3rd grooves

Fit compression rings, parallel sides, straight-cut gap, these rings have a face angle of 1/1½° and it is imperative that the rings are fitted the correct way up as indicated by the word **top** etched on the upper face.

4th groove

Fit scraper ring, parallel sides, slotted, straight-cut gap.

The initial piston ring gap is .020/.027 in. nominal (.508/.686 mm.). Renew rings when gap exceeds .100 in. (2.54 mm.).

Note: The dimension quoted for ring gap will vary according to manufacturing tolerances.

To Replace Connecting Rods and Pistons

1. Wipe the crankpin and bearing surfaces with a clean rag and lightly smear with clean engine oil both crankpin and lead-bronze surface of bearing shells.

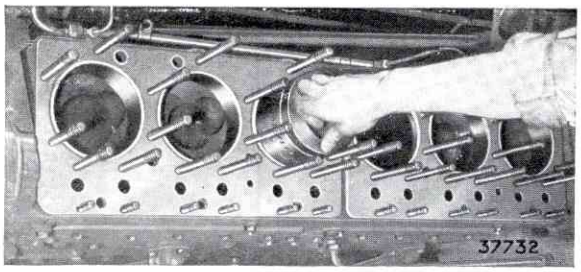


FIG. 39. FITTING THE PISTON

2. Fit the connecting rod assemblies with the offset combustion chamber in the piston heads and if applicable the oil spray hole in the big ends on the same side as the camshaft.

3. The connecting rod bolts must be tightened to a total elongation of .006/.008 in. (.1524 mm. to .2032 mm.). This dimension should be measured by micrometer.

4. On no account must the nuts be slacked off to bring the pin holes into line. If the pin holes will not line up with the correct bolt elongation, the nut must be filed to bring the pin holes into line, care being taken to keep the faces true. Fit the split pins and slack off nuts just sufficiently to "nip" the split pins.

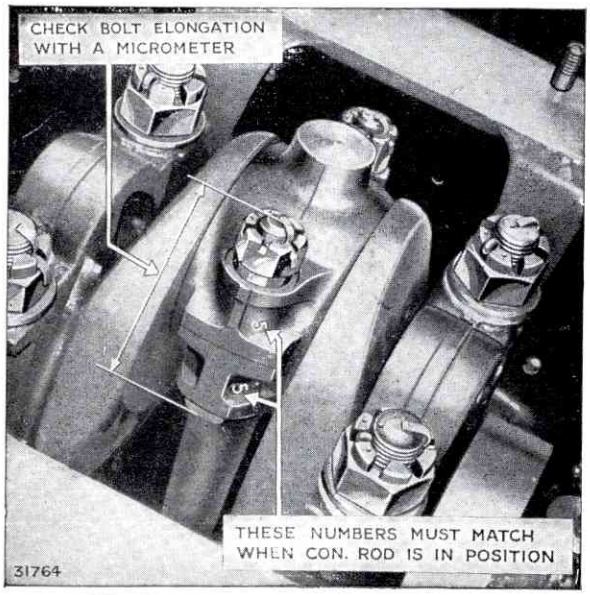


FIG. 40. CONNECTING ROD IN POSITION

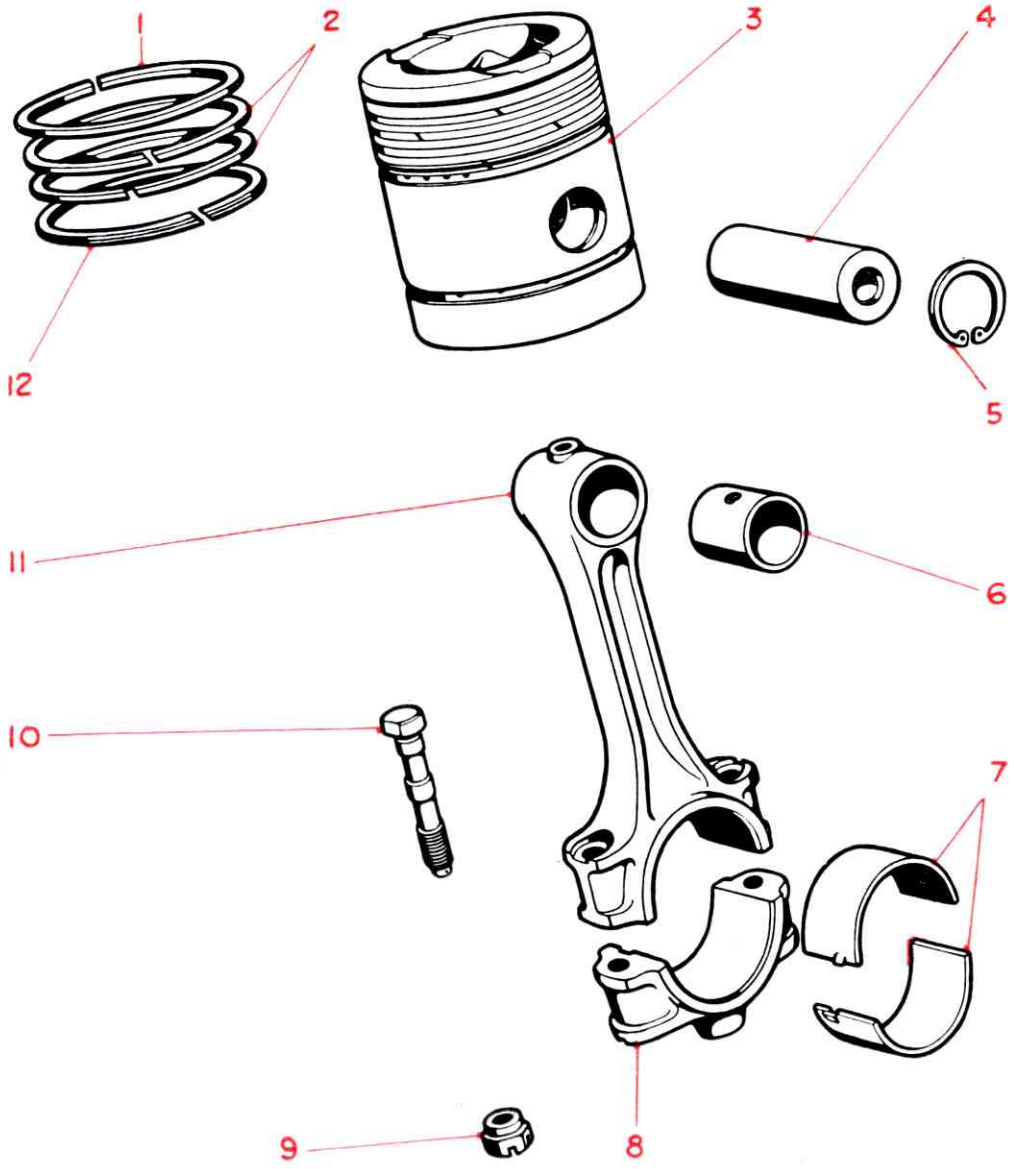


FIG. 41. EXPLODED VIEW OF THE CONNECTING ROD AND PISTON

1. Piston ring, top groove.
2. Piston ring, 2nd and 3rd grooves.
3. Piston.
4. Gudgeon pin.
5. Circlip.
6. Bush, small end.
7. Bearing, big end.
8. Connecting rod cap.
9. Nut.
10. Bolt.
11. Connecting rod.
12. Piston ring, scraper.

CRANKSHAFT AND MAIN BEARINGS

DESCRIPTION

The crankshaft is supported in seven lead-bronze, steel-shell, indium-coated, main bearings. The oil holes in the crankpins are drilled eccentrically to reduce centrifugal loading and also to act as sludge traps to protect the big-end bearings.

A labyrinth oil seal at the rear end of the crankshaft prevents loss of oil from the lower half of the engine-block and a felt sealing ring fitted in the upper and lower halves of the flywheel housing prevents engine breathing, Fig. 43. A large diameter flywheel, fitted with a renewable cast iron clutch facing, is bolted to the crankshaft rear end flange. The bolt holes in the flange and fly-

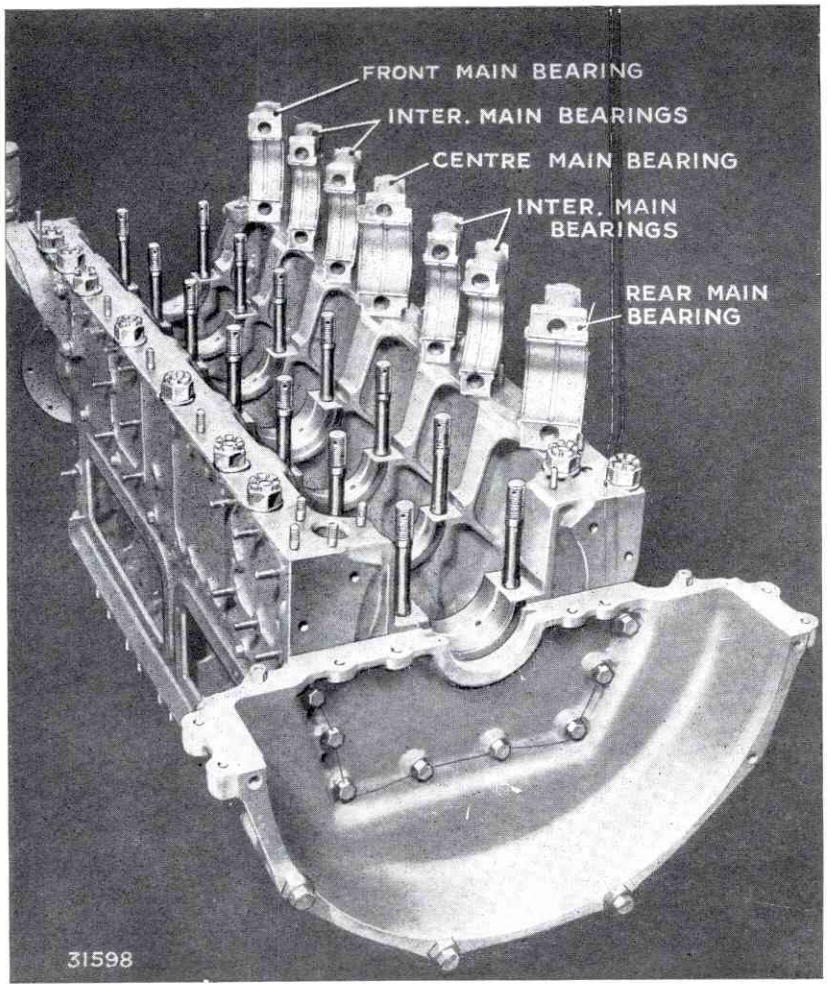


FIG. 42. ENGINE BLOCK AND MAIN BEARINGS

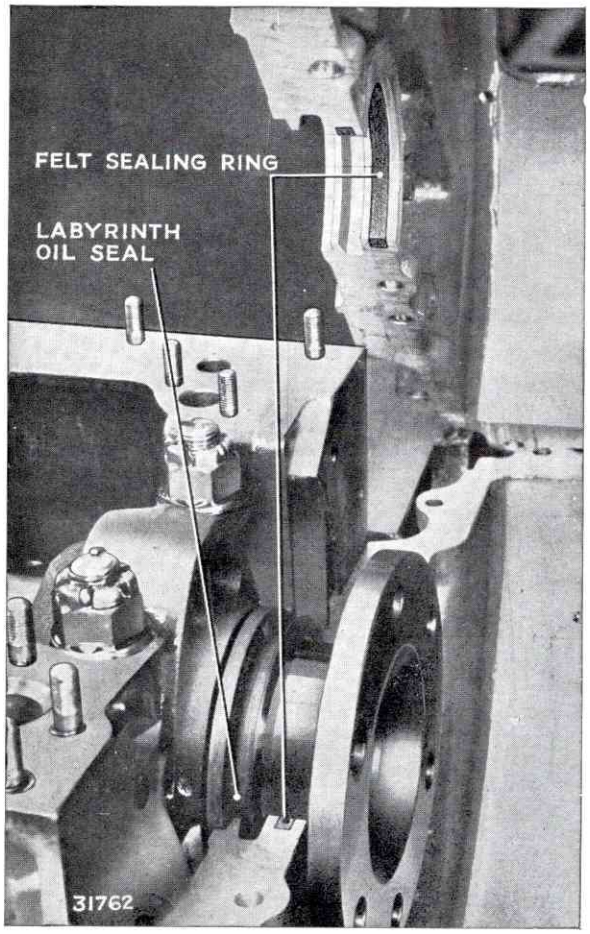


FIG. 43. LABYRINTH OIL SEAL

wheel are drilled out of pitch, so that the flywheel can only be mounted with the timing plunger holes in the flywheel rim, in correct relation to the throws of the crankshaft, for timing purposes.

A rubber-bonded or viscous type vibration damper is bolted to the pulley at the front end of the crankshaft.

The starter gear ring, Fig. 52, is spigoted and bolted to the flywheel so that its position can be changed as local wear takes place. It is reversible and can be turned completely over to obtain further service.

OVERHAUL

To Fit New Bearings and Thrust Washers

Normally by the time the main bearings require replacing, the crankshaft will need to be removed for regrinding, the instructions for these two latter operations being detailed in the sections headed **To Regrind the Crankshaft.**

However, if at any time one or more bearings should have to be renewed or removed for inspection, this can be done satisfactorily without the necessity of removing the engine from the vehicle.

1. Remove the sump and oil pump.

2. To renew or inspect an individual bearing only, take off the cap of the bearing in question.

3. Slacken all the remaining bearing cap nuts one of two turns to facilitate removal of the top halves or the bearings.

4. Remove the lower half of the bearing from the cap, push out the top half of the bearing by rotating it on the crankshaft, using Leyland tool No. 245872, which should be placed in the oil hole in the journal as shown in Fig. 46. For the centre main bearing use Leyland tool No. 245869, this is placed on the bearing cap stud, Fig. 47.

5. Inspect the old bearing shells and if they require renewing insert a new half-bearing in the top and also fit a new half-bearing in the cap. If the old bearings are under size, replace by a new bearing of the same size.

6. The thrust washers are also renewable. The bottom halves of the washers are tongue-located in the bearing caps and care must be taken to ensure that the tongue fits correctly in the caps.

To Remove Crankshaft

1. Remove engine from vehicle, and place in a suitable stand.

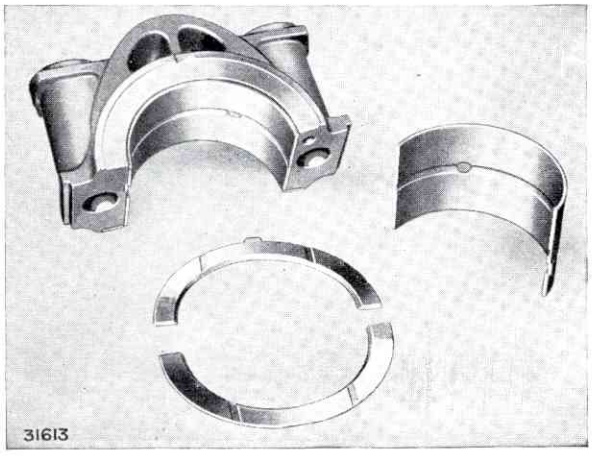


FIG. 44. CENTRE MAIN BEARING AND THRUST WASHERS

2. Remove the cylinder heads, push-rods and tappets.

3. Invert the engine and remove the sump, oil pump, flywheel and connecting rod assemblies.

4. Remove bottom half of flywheel housing.

5. Withdraw driving pulley from end of crankshaft.

6. Disconnect the exhauster or compressor oil feed pipe if fitted from timing case side and remove timing case.

7. Remove main bearing caps, and lift out the crankshaft.

To Replace the Crankshaft

Main bearing caps, bearings and nuts must be refitted in their original positions and, for this purpose, the caps and engine-block nuts are stamped with index marks A, B, C, etc., starting from the front of the engine. When correctly assembled all marks must correspond.

1. Fit the top halves of the main bearings in their correct seatings; check that the shells bed down correctly.

2. Remove the oil seal plugs, Fig. 48, and flush out the oil passages and oil holes. Replace the seal plugs and bolts, **do not** use sealing compound on these plugs. Ensure that the nuts are split-pinned and smear the main bearing journals with clean engine oil.

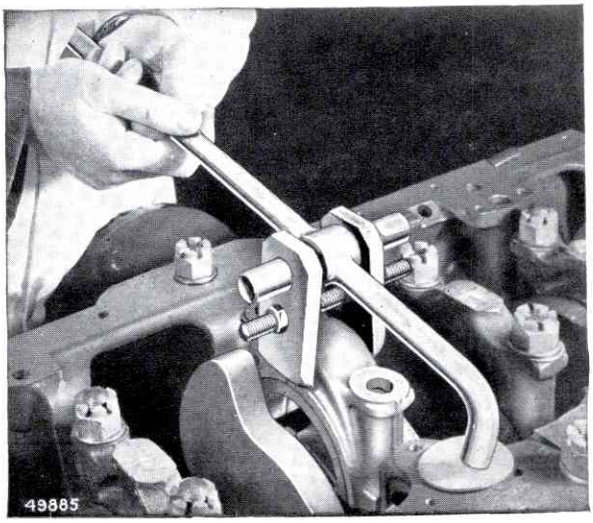


FIG. 45. REMOVAL OF BEARING CAPS

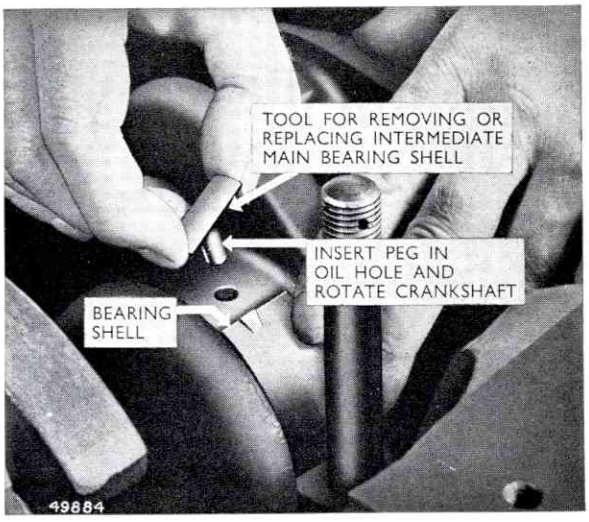


FIG. 46. REMOVAL OF INTERMEDIATE BEARING SHELL

3. Lower the crankshaft carefully into position, replace the main bearing caps in their correct positions, and tighten down, fitting the nuts to their original studs when possible. A torsion spanner set at 215/225 lb./ft. (29.7/31 kg. m.) should be used to tighten the bearing cap nuts.

4. Ensure that the timing gear mounted at the front main bearing is correctly meshed with the gear on the crankshaft.

5. Check the crankshaft end-play. This should not exceed .014 in. (.3556 mm.), Fig. 50.

6. Fill the crankshaft oilways with clean engine oil.

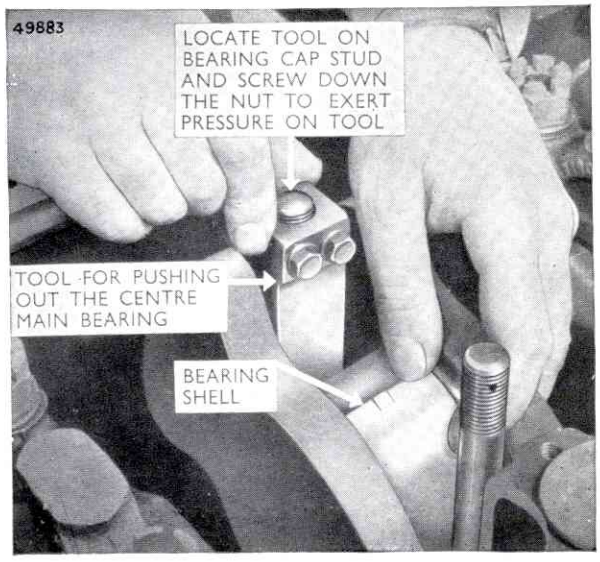


FIG. 47. REMOVAL OF MAIN BEARING SHELL

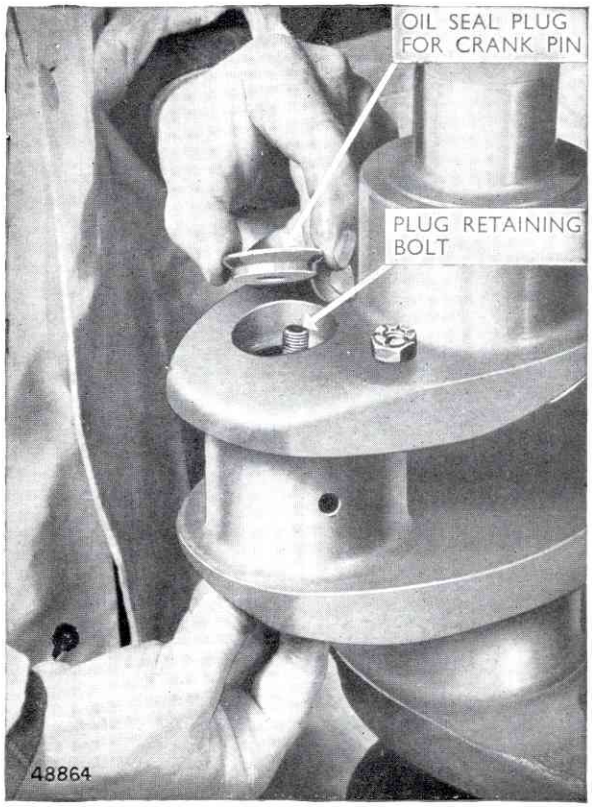


FIG. 48. REMOVAL OF OIL SEAL PLUG

7. Refit the connecting rods. The initial big-end clearance should be .0018/.0037 in. (.0457/.0939 mm.) and should be renewed if it exceeds 008 in. (.2032 mm.).

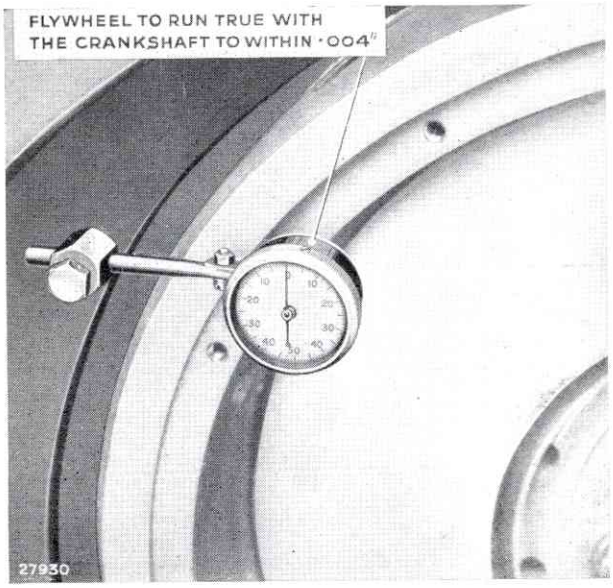


FIG. 49. CHECKING FLYWHEEL FOR RUNNING TRUE

Important

It cannot be emphasised too strongly that, in cases where the operator regrinds a crankshaft without re-nitriding, extreme care should be taken to ensure that an excessive amount of case is not removed from the fillets by using a grinding wheel having a corner radius considerably less than the designed radius between the journal and web of the crank, Fig. 51.

A grinding wheel having a radius of 0.15/0.17 in. (3.810/4.318 mm.) should be used.

If the operator has any doubt on this point, crankshafts should be re-nitrided after regrinding irrespective of the amount of case which has been removed from the pin or journal diameter.

Check the main bearing diametral clearance. This should be within the limits .0020/.0042 in. (.0508/.1067 mm.) when new bearing shells are fitted. Bearings should be renewed when diametral clearance exceeds .009 in. (.2286 mm.).

When refitting the flywheel to the crankshaft, check that the flywheel runs true with the crankshaft to within .004 in. (.1016 mm.) as shown in Fig. 49.

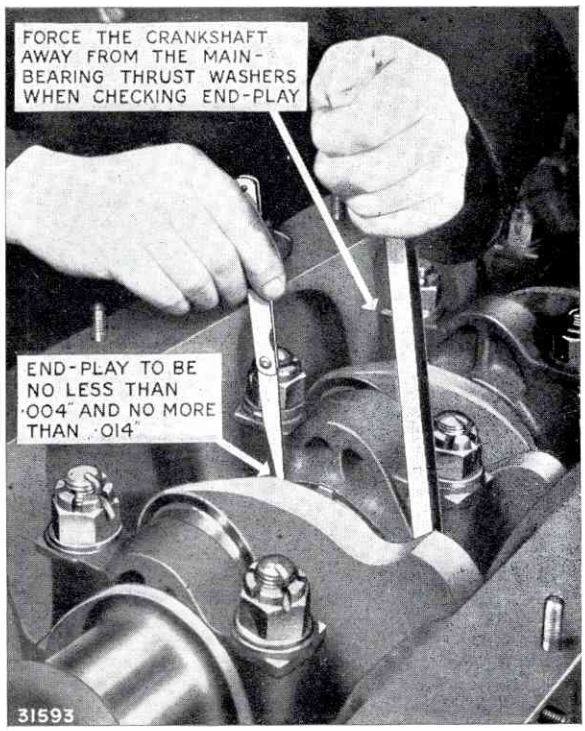
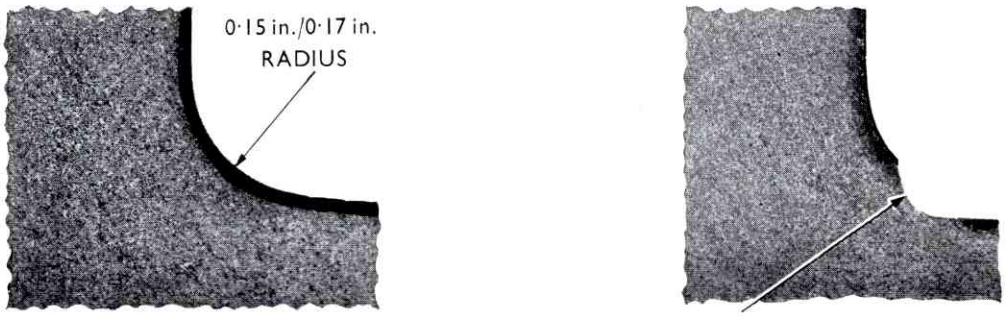


FIG. 50. CHECKING CRANKSHAFT END-PLAY



USE GRINDING WHEEL WITH
0·15 in./0·17 in. (3·810 mm. /4·318 mm.)
RADIUS

NITRIDED CASE REMOVED
OWING TO INCORRECT RADIUS
OF GRINDING WHEEL

FIG. 51. SECTIONS OF JOURNAL-TO-WEB FILLETS

To Regrind the Crankshaft

When regrinding journals and crankpins, the end faces must not be ground. If the location faces of the centre bearing have been damaged, the width should be increased to 2.710/2.712 in. (68.834/68.885 mm.) otherwise the dimensions should remain at 2.700/2.702 in. (68.580/68.631 mm.).

After grinding, support the crankshaft at the front and rear journals. Check the relative eccentricity of the centre main journal; this must not exceed .003 in. (.0762 mm.) in radius—total run-out of .006 in. (.1524 mm.). The permissible error between one bearing and its neighbour must not exceed .003 in. (0.762 mm.) (total clock reading).

It is not permissible to straighten a crankshaft in a press. The crankshaft should be re-nitrided at the second and fourth regrinds.

To Skim the Clutch Facing Plate

If the clutch facing plate is deformed it may be skimmed down. It is permissible to skim off .0313 in. (.7950 mm.) after this figure is exceeded compensation must be made by fitting skim plates .064 in. (1.6256 mm.) thick between the clutch facing plate and flywheel. A maximum number of three skim plates may be fitted, if two or more are fitted the standard retaining setscrew, Fig. 52, must be replaced by setscrews .125 in. (3.175 mm.) longer. It is not advisable to skim more than .100 in. (2.54 mm.) from the clutch facing plate, but when considering the number of skim plates required it is important to allow for the amount skimmed from the clutch back plate, see **Clutch** Chapter.

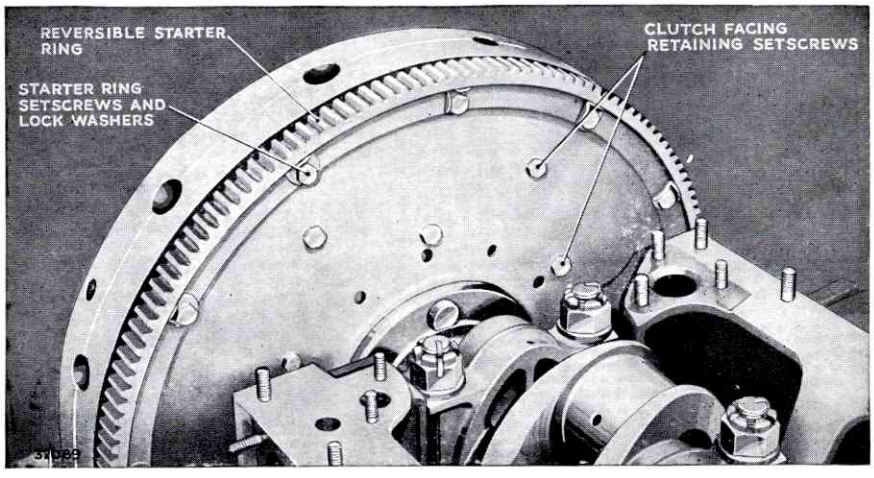


FIG. 52. REAR VIEW OF FLYWHEEL AND STARTER RING

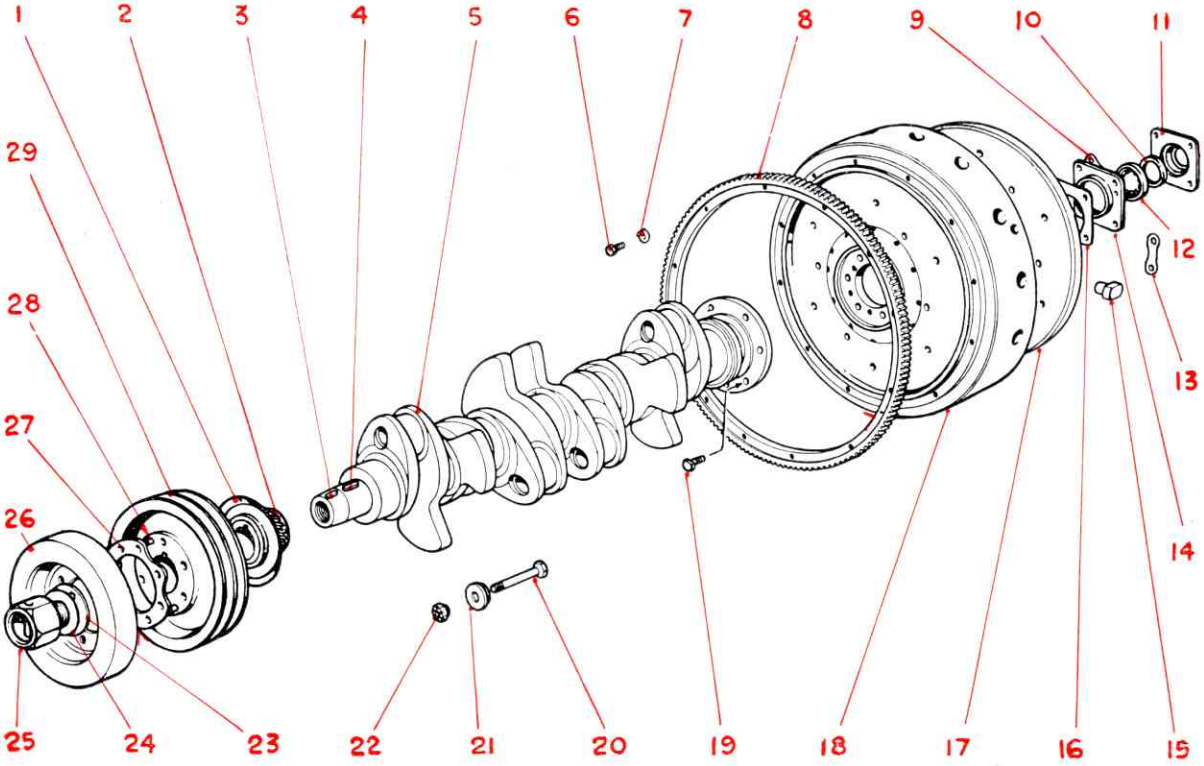


FIG. 53. TYPICAL ILLUSTRATION OF CRANKSHAFT COMPONENTS

1. Oil thrower.
2. Timing gear.
3. Key, pulley.
4. Key, timing gear.
5. Crankshaft.
6. Bolt, starter ring.
7. Lockwasher.
8. Starter ring.
9. Joint.
10. Oil seal.
11. Cover.
12. Spigot bearing.
13. Locking plate.
14. Bearing housing.
15. Clutch driving peg.
16. Joint.
17. Clutch facing.
18. Flywheel.
19. Bolt.
20. Bolt.
21. Plug.
22. Nut.
23. Lock washer.
24. Shim.
25. Starting clutch.
26. Damper.
27. Spacing ring (with viscous damper only).
28. Dowel.
29. Pulley.

TIMING GEARS

DESCRIPTION

The timing gears, Fig. 54, are single-helical hardened and ground gears, the drive to the camshaft and compressor being transmitted from the timing gear on the crankshaft through an idler gear.

The gear on the crankshaft is an interference fit, the key being used only to locate the gear for timing purposes.

The idler gear, mounted on a spindle bolted to the engine block, runs on a floating bush, thrust being taken by two special washers, Fig. 55. The washers should be renewed when end float exceeds .012 in. (.305 mm.). To remove the idler gear it is only necessary to remove the split pin and nut from the end of the fixing bolt and withdraw the gear and spindle.

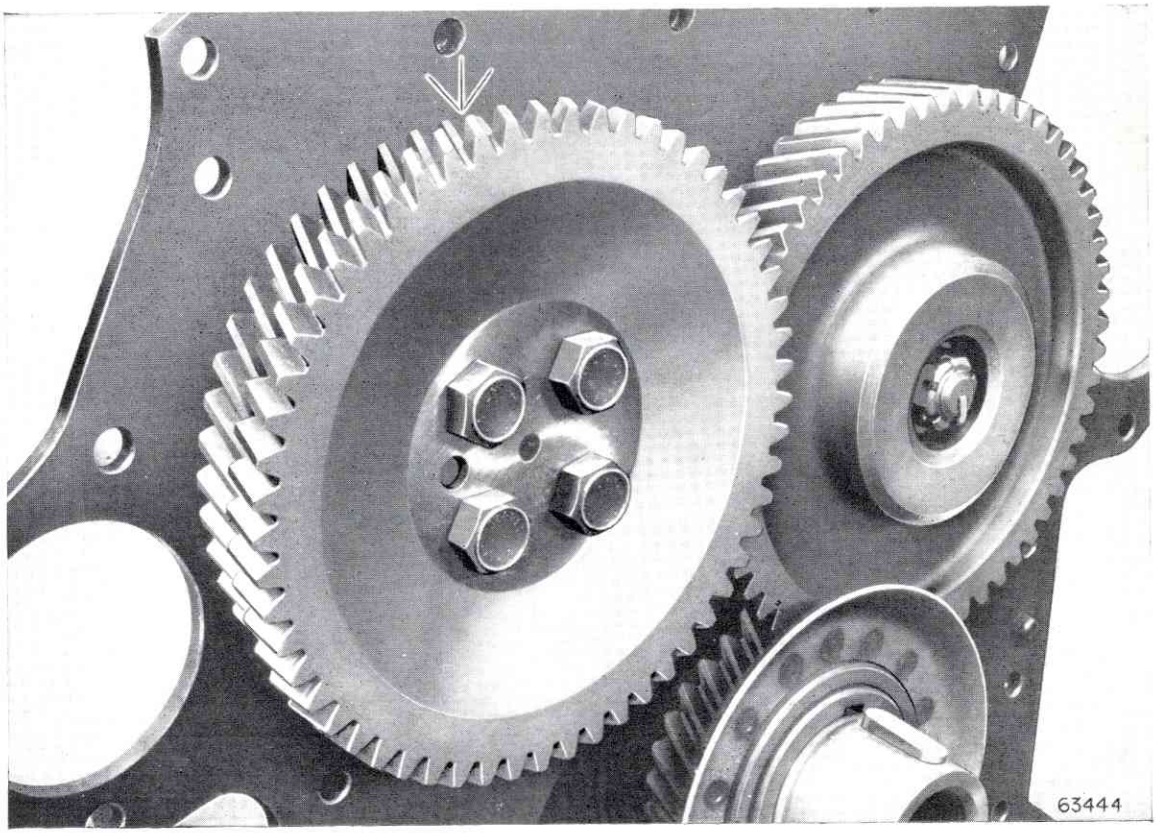


FIG. 54. THE TIMING GEARS

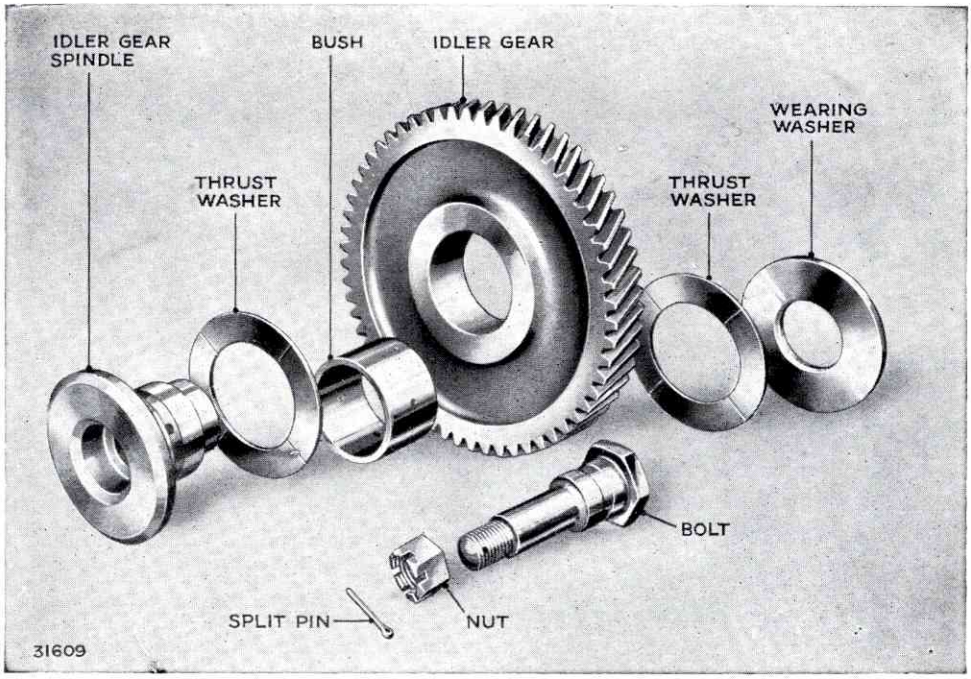


FIG. 55. IDLER GEAR DISMANTLED

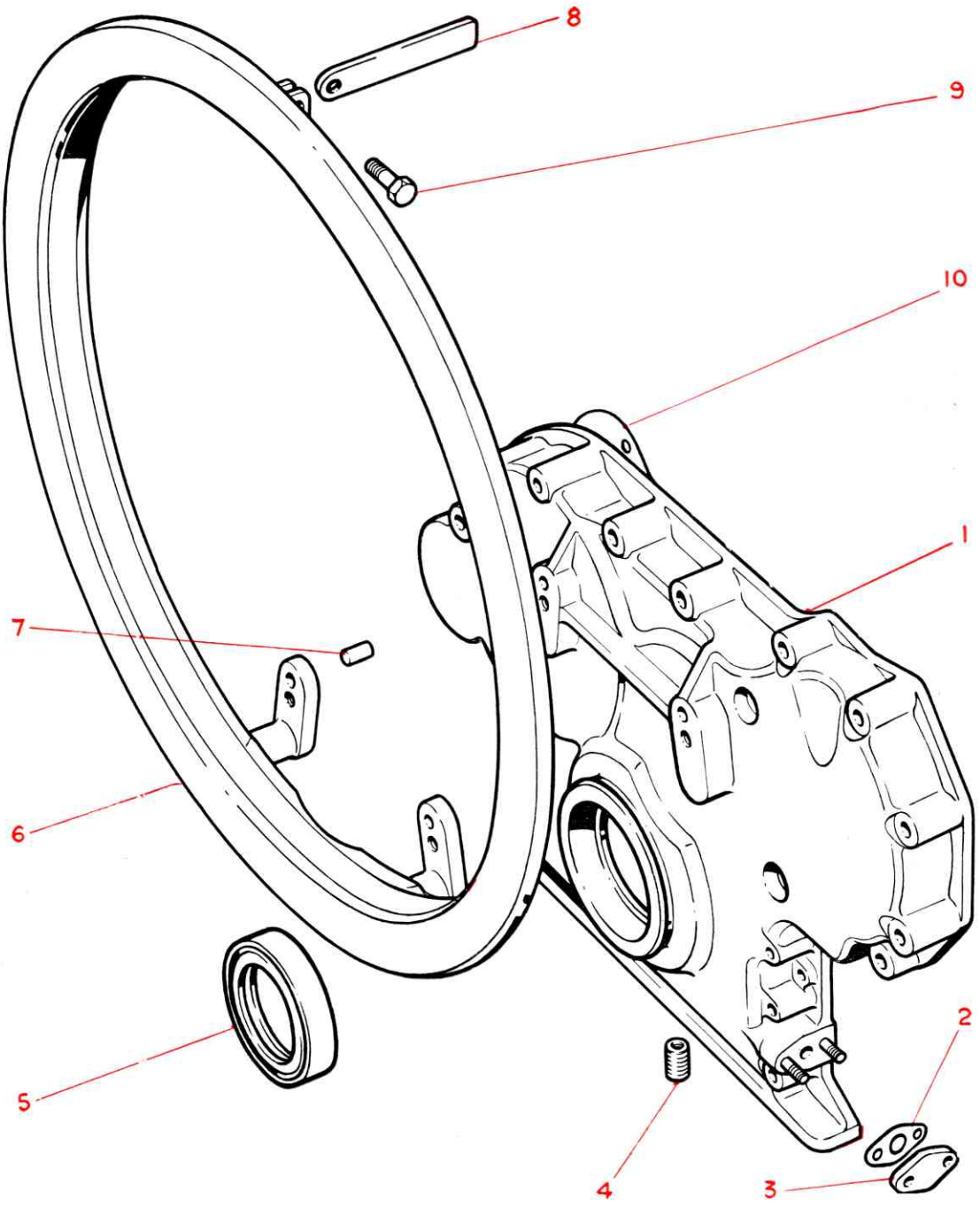


FIG. 56. THE TIMING CASE COMPONENTS

1. Timing case.
2. Joint.
3. Cover.
4. Ferrule.
5. Oil seal.
6. Fan cowl.
7. Dowel.
8. Pivot link.
9. Bolt.
10. Joint.

THE COOLING SYSTEM

DESCRIPTION

The cooling system is a thermosyphon impeller-assisted system.

The impeller-type pump with driving pulley and fan is mounted at the upper front end of the engine block and driven from the crankshaft by pulley and twin belts, Fig. 58.

A thermostat fitted in the front end of the coolant outlet manifold enables the engine to reach the correct working temperature in the shortest possible time.

The thermostat valve seals the outlet to the radiator while the coolant is cold, but allows it to circulate through the block and heads until the temperature rises to 165° F. (74°C.), when the valve commences to open and brings the radiator into full operation when the valve is fully open at 185°F. (85°C.).

OPERATION

Coolant drawn by the pump from the bottom tank of the radiator, is circulated through the block and heads, up through the outlet manifold at the front end of each cylinder-head, and back to the top tank of the radiator, where it is cooled as it flows through the radiator by air drawn through the cooling stack by the fan.

MAINTENANCE

The coolant level should always be checked daily before starting up.

Avoid, if possible, the use of 'hard' water, as this will deposit lime in the hotter parts of the engine coolant jacket and in restricted passages, causing cracks in the former and interfering with circulation in such places as the thermostat and radiator tube block.

The cooling system should be drained and thoroughly flushed out with clean water every six months, or more frequently in areas where the use of 'hard' water is unavoidable.

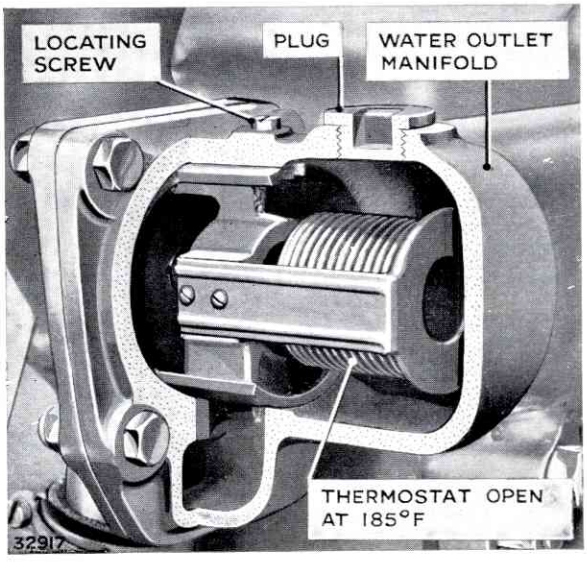


FIG. 57. TYPICAL VIEW OF THERMOSTAT IN POSITION

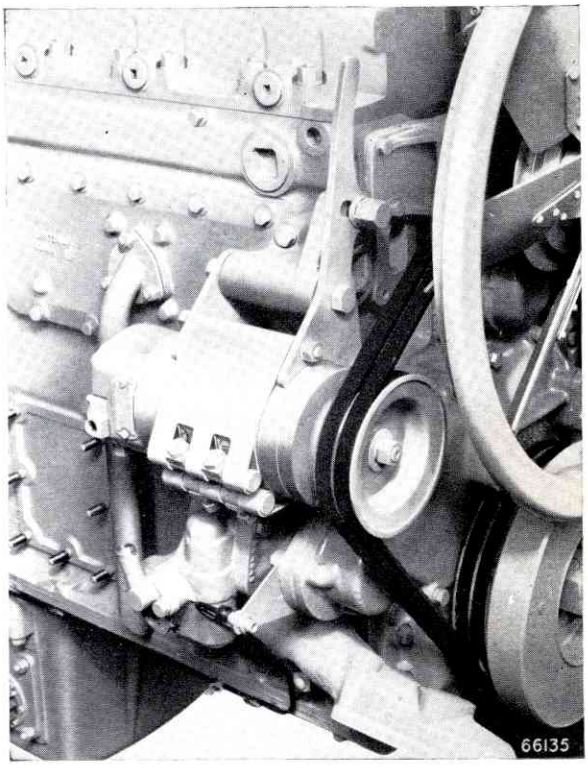


FIG. 58. FAN AND GENERATOR DRIVING BELT ADJUSTMENT

If the system contains anti-freeze solution, it should be drained into clean containers, so that the solution can be strained and used over again.

It is important to note that, where anti-freeze solution is used in the cooling system, additional solution of the same strength as the original must be used for topping up, as, if water is used, it will cause dilution and reduction in the degree of frost protection.

Adjustments in Vehicle

Check the tension and condition of the coolant pump and dynamo driving belts, adjust or replace as required.

The belt tension is correct if there is approximately 1 in. (25.4 mm.) total movement on the longest run of the belts.

To Adjust the Belt Tension

Slacken the dynamo mounting locking screw and the strap bolts Fig. 58 and move the adjusting handle in the desired direction to adjust the tension, and finally re-tighten the locking screw and strap bolts.

To Remove a Fan Belt

1. Disconnect the pivot link (8), Fig. 56, at the fan cowl.

2. Slacken the dynamo mounting locking screw and the strap bolts and move the dynamo towards the engine to relieve belt tension.

3. Remove the fan belt from the dynamo and crankshaft pulleys and pass the lower end of the belt upwards between the faces of the crankshaft damper, fan cowl and the radiator rubber surround.

4. Remove the upper end of the belt from the fan pulley and lift to clear the top of the fan cowl.

5. Complete the removal by passing the belt between the rubber surround and the fan cowl.

The method of refitting a fan belt is a reversal of the above procedure.

FROST PRECAUTION

During winter months when atmospheric temperatures approaching freezing point may be anticipated, some protection is necessary to prevent frost damage to the engine coolant jacket and radiator.

Complete protection is ensured if the cooling system is filled with a solution of ethylene glycol, or similar anti-freeze agent which will lower the freezing point below the minimum temperature likely to be experienced.

Before filling with anti-freeze solution, the cooling system should be checked over thoroughly to ensure that all joints and hose connections are sound and perfectly tight. This is important, as anti-freeze solutions have a much more searching action than water and leak therefore much more readily.

New hose connections can be fitted with advantage, and the cooling system should always be drained and flushed out thoroughly.

The solution should be prepared in clean containers by mixing the chosen anti-freeze agent with water in the proportions recommended by the suppliers for the desired degree of protection.

After filling up, the engine should be started and warmed up and a further check should then be made for leaks.

If anti-freeze solution is not in use and the vehicle is to remain standing in the open with temperatures approaching freezing point, the cooling system must be completely drained by opening the drain cock.

Drain taps should be tested at frequent intervals by inserting a length of wire to ensure that they are clear. This should be done immediately they are opened so that any obstruction freed by the wire may be flushed out by the coolant. Clear any blocked pipes and unions.

Drain when the engine is hot, and close the drain tap when the system is completely drained.

After draining, place a notice on the steering wheel or similar conspicuous place to the effect that the cooling system is empty.

Vehicles with anti-freeze mixture in the engine cooling system should be marked accordingly and if the vehicle is so marked **do not** drain the cooling system.

When climatic conditions are normal, it is recommended that anti-freeze mixtures should not be used in the cooling system longer than necessary.

When changing the coolant, the cooling system should be thoroughly flushed with clean water. It may also be advantageous to make one or two changes of coolant at short intervals afterwards.

Draining the cooling system as a precaution against frost.

1. Park the vehicle on level ground.
2. Open the drain tap to drain the system.
3. Display a notice marked **No coolant in radiator** in a prominent position on the vehicle.
4. When all the coolant has been drained off, close the drain tap.

WATER PUMP

The impeller-type water pump mounted at the front end of the cylinder head is driven from the crankshaft by pulley and twin belts. A spring-loaded self-adjusting seal unit is carried on the driving shaft and completely isolates the impeller chamber from the bearing assembly. The shaft and bearings are packed with grease on assembly, a screw-type greaser being fitted for further lubrication.

To Remove the Pump

1. Remove the driving belts and drain the cooling system.
2. Slacken the hose retaining clips and ease each hose connection clear of the pump.
3. Remove the nuts securing the pump to the engine block and remove the unit for dismantling.

To Dismantle the Water Pump

1. Remove nut from pulley end of shaft and withdraw the hub, pulley and fan complete.
2. Remove the nuts securing the impeller casing to the body, and remove the casing complete with shaft, bearings and impeller.
3. Release the tabwasher and remove the nut at the impeller end of the shaft, then remove the impeller and woodruff key from the shaft.
4. The sealing gland unit can now be removed for examination.
5. To remove the shaft and bearings from the cover, first ease the oil seal from its location, then remove the circlip. The shaft and bearings can now be pressed out of the cover for examination or renewal.

Clean and degrease the pump components and check the following:

1. That the bearings are in good condition and free from excessive play.
2. That the felt oil retainers are in good condition.
3. That the face of the carbon seal unit is free from score marks or scratches. Renew the seal unit if this condition is apparent.
4. That the rubbing face of the metal insert in the impeller hub is not scratched or scored. Renew or reface the insert if necessary.

To Reassemble Water Pump

To reassemble the water pump, reverse the procedure for dismantling.

COOLANT MANIFOLD AND THERMOSTAT

DESCRIPTION

Coolant, after passing through the jacket, enters the manifold, which is bolted to the left-hand side of the cylinder heads and incorporates a thermostat of the bypass type at its front end.

The thermostat consists of a valve carried on a spindle attached to a thermostatic bellows Fig. 57.

OPERATION

When the engine is cold, the valve is down on its seat, thus closing the intake to the radiator, and coolant flows instead through the bypass pipe into the pump for recirculation.

At 165°F., expansion of the bellows gradually opens the valve and allows circulation to an increasing degree through the radiator. At the same time, flow through the bypass is progressively restricted and is finally shut off when the top of the bellows butts on the base of the thermostat body. This occurs at 185°F. (85°C.) and the valve is then fully open giving maximum flow through the radiator. The effect of this arrangement is to provide rapid warming up and, by automatic control, to maintain an appreciably constant engine working temperature.

To prevent excessive pressure or steam accumulating in the engine water jacket, and also to eliminate air locks, a $\frac{3}{16}$ in. (4.76 mm.) diameter bleed hole is drilled in the valve head.

MAINTENANCE

The coolant manifold requires no attention other than to see that the joints are kept thoroughly tight, and the only attention required by the thermostat is occasional cleaning, more frequent attention being necessary in areas where the use of 'hard' water is unavoidable.

Should conditions indicate that the thermostat is not operating correctly (engine overheating) it should be removed and tested.

No adjustments or repairs are possible and, in the event of damage being discovered, the only cure is to fit a new unit. Note, however, that where no replacement is immediately available, removal of the thermostat does not immobilise the vehicle, though for efficient running a new unit should be fitted at the first opportunity.

To Remove and Refit the Thermostat

1. Drain the cooling system.

2. Slacken the clips on the bypass to pump hose and the outlet to radiator hose if the operation is being performed with the radiator in position.

3. Remove the four bolts securing the bypass and outlet pipe to the coolant manifold and remove the pipe.

4. The thermostat can now be removed by using the two 2BA tapped holes in the valve seat flange to withdraw the thermostat from its location in the coolant manifold.

5. When refitting the thermostat make sure that the location slot on the body locates on the locating screw in the coolant manifold.

To Test Thermostat Operation

1. Remove the thermostat as described and suspend it in a pan of water.

2. Heat the water gradually, stirring continuously to ensure uniformity of temperature.

3. With the help of a thermometer, observe the temperature and note that the valve should start to lift off its seat at 165°F. (74°C.).

4. Continue heating to 185°F. (85°C.), when the valve should be fully open, the total valve lift being .375 in. (9.53 mm.).

1. Intake casing.
2. Joint washer.
3. Jubilee clip.
4. Tabwasher.
5. Locknut.
6. Impeller.
7. Insert.
8. Hose.
9. Seal.
10. Driving shaft.
11. Roller journal.
12. Distance piece, inner.
13. Distance piece, outer.
14. Ball journal.
15. Circlip.
16. Key.
17. Key, Woodruff.
18. Locknut.
19. Fan and pulley hub.
20. Pulley.
21. Oil seal.
22. Impeller casing.
23. Joint.
24. Grease cup.
25. 'O' ring.
26. Joint.

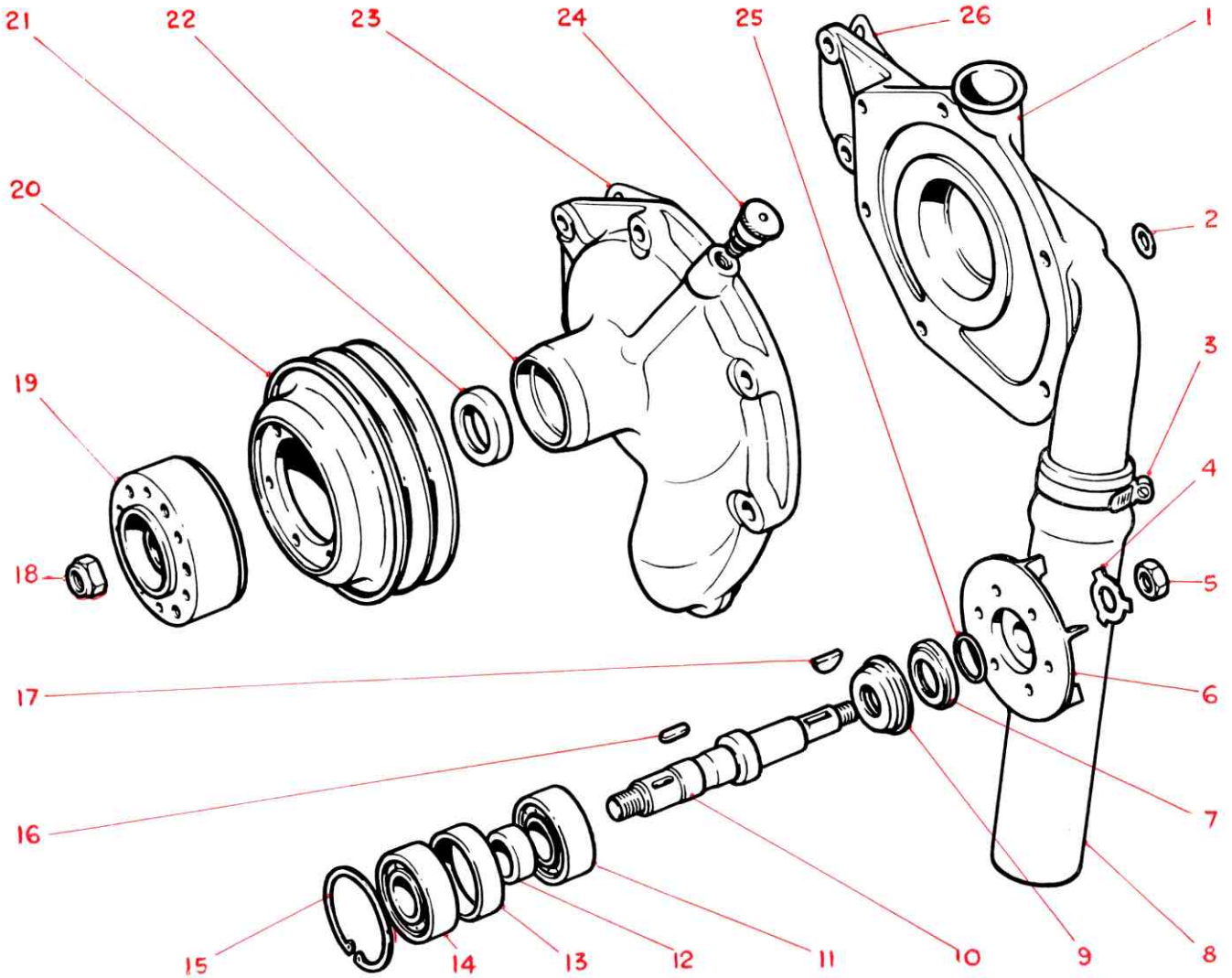


FIG. 59. EXPLODED VIEW OF THE WATER PUMP

THE FUEL INJECTORS

DESCRIPTION

The fuel is delivered at high pressure to the injectors, Fig. 62, which break up the fuel into a fine mist and distribute it in the combustion chamber. They also ensure a snap-start and finish to injection and prevent air from entering the pipe lines during the compression stroke.

The inlet adapter is fitted with an 'edgewise' type filter.

Fuel enters the injector at the inlet adapter and is fed through a drilled passage in the injector body to the nozzle.

When the required pressure is reached, the needle valve snaps open against pressure from the valve spring and allows fuel to be sprayed into the combustion chamber through four small, equally spaced holes in the nozzle tip. Although the needle valve is a very fine fit in its bearing in the injector body, a small quantity of fuel leaks past the valve stem and this is led away through a drilled passage in the injector body to a branch pipe and thence to the main leak-off gallery pipe and return pipe to the fuel tank.

The injectors will give long periods of efficient service. Special equipment is required for reconditioning the injectors and special lapping tools are obtainable. If, however, no equipment is at hand, injectors should be returned to Leyland Service Department and a replacement set fitted.

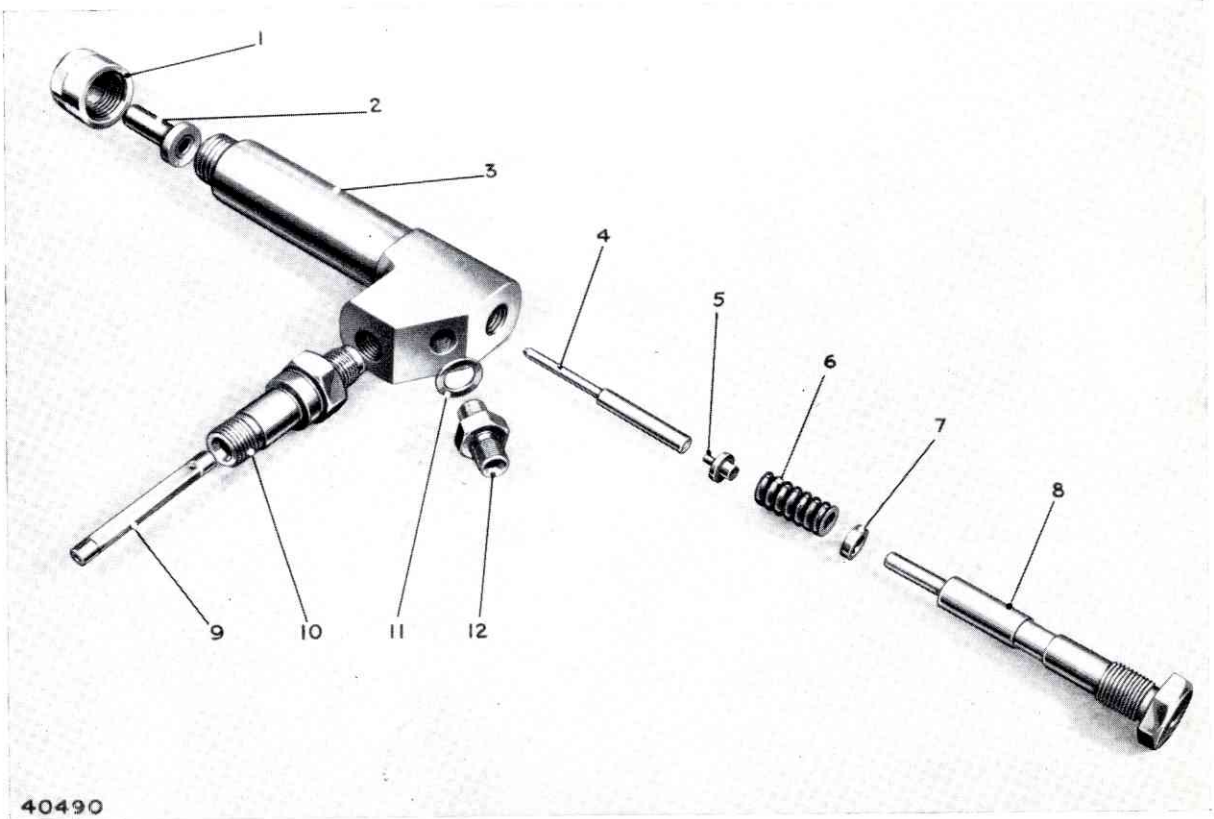


FIG. 60. EXPLODED VIEW OF THE INJECTOR UNIT

1. Locknut.
2. Nozzle.
3. Injector body.
4. Needle valve.
5. Needle valve-lift-adjusting button.
6. Valve spring.
7. Discharge pressure adjusting washer.
8. End plug.
9. Edgewise filter.
10. Inlet adapter.
11. Copper washer.
12. Leak-off adapter.

FIG. 61. PART SECTIONED VIEW OF INJECTOR UNIT

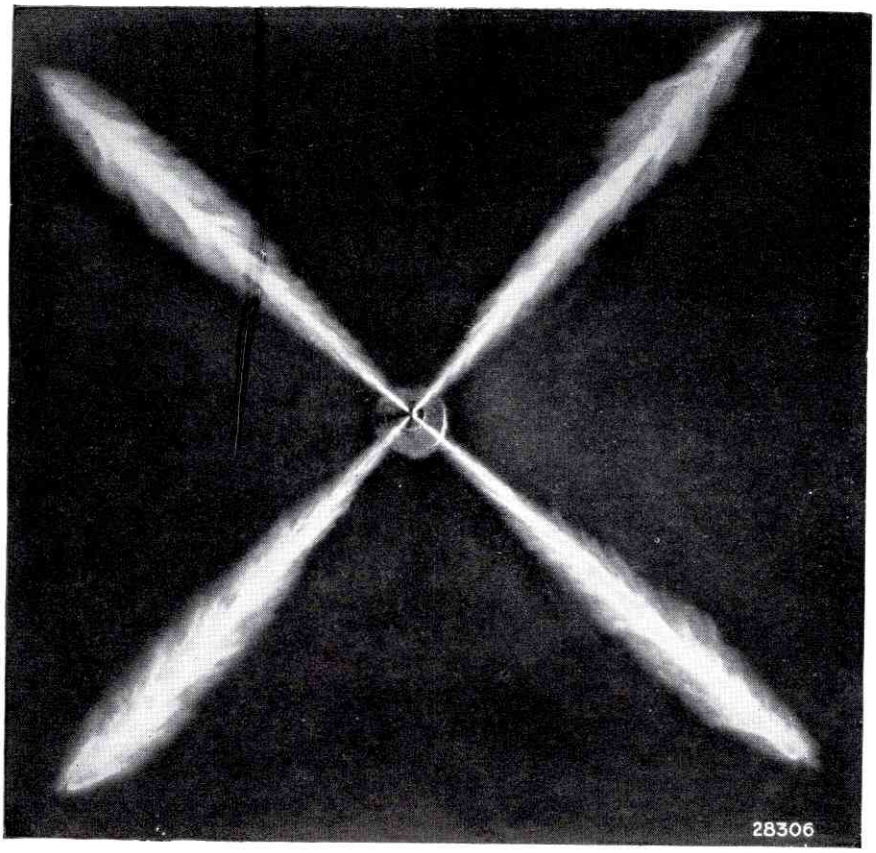


FIG. 62. INJECTOR SPRAY AS SEEN BY THE HIGH-SPEED CAMERA

Diagnosis of Injector Trouble

Provided the fuel filters receive regular attention, thereby ensuring that only clean fuel is fed to the injectors, no attention is likely to be required for long periods. Any inefficiency can usually be detected by one of the following symptoms:

1. Pronounced knocking on one (or more) cylinders.
2. Complete or intermittent misfiring.
3. Smoky exhaust (black), injector discharging unvaporised fuel; (blue), denotes a choked injector.
4. Increased fuel consumption.
5. Engine overheating.

To locate a faulty injector, slacken off the injector pipe union nut two or three turns and allow the fuel to leak past the threads while the engine is running slowly. This cuts out the injector and if no change in engine performance can be detected, it is reasonable to assume that the injector is faulty and should be removed for examination.

Note: It is important that the leak-off pipe is not bent when removing a single injector. To ensure that no damage is caused to the leak-off pipe, the complete assembly should be removed.

Faulty injection may be due to any of the following:

1. External carbon on nozzles.
2. Choked nozzle spray holes.
3. Loose nozzle lock-nut.
4. Dirt on the joint face between nozzle and body.
5. Dirt or carbon on needle valve seat.
6. Needle valve sticking in body.
7. Faulty valve spring adjustment.
8. Broken needle valve spring.
9. Cracked injector body.

To Remove an Injector Unit

1. Disconnect and remove the leak-off pipe.
2. Remove the nut securing the injector clamp and the clamp.

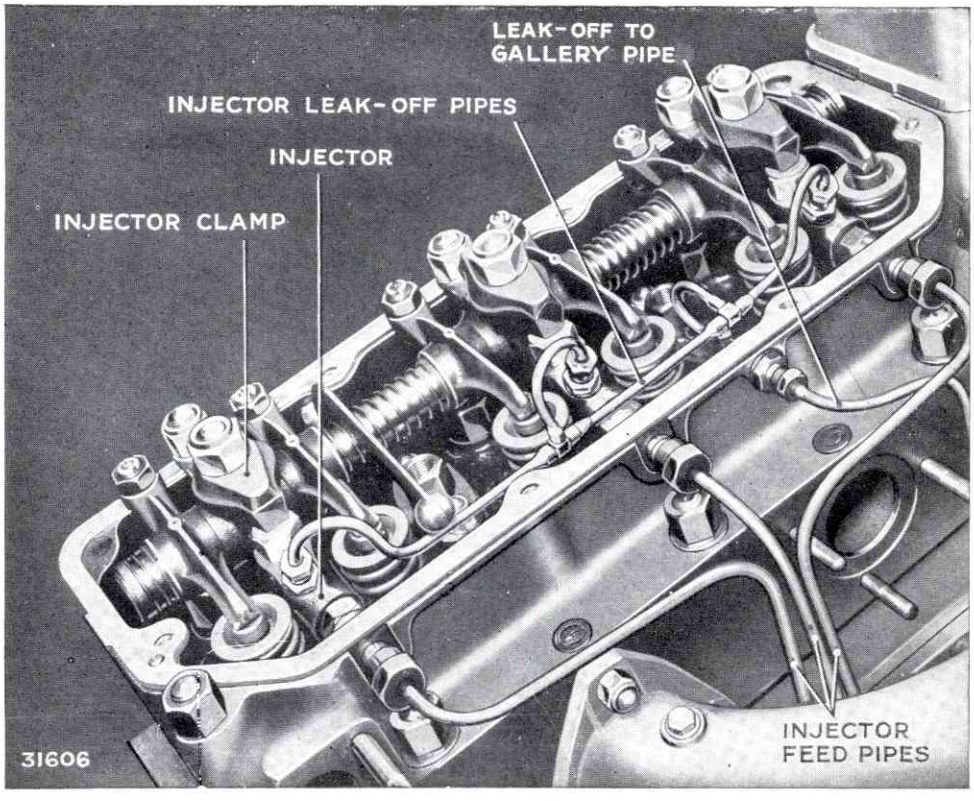


FIG. 63. INJECTORS AND LEAK-OFF PIPES IN POSITION IN CYLINDER HEAD

3. Disconnect the fuel injection pipe.

4. Remove the injector end plug.

5. Fit the removal tool.

6. Screw the withdrawal screw into the injector body and withdraw the injector by screwing down the nut on the tool.

To Replace an Injector Unit

Before replacing an injector it is always advisable to clean and remove any carbon from the sealing faces and the copper sealing washer, located at the bottom of the hole in the cylinder head which carries the injector unit.

Note: It is important that injector clamp nuts should be tightened with a torque spanner having a setting of 30/35 lb./ft. (4.15/4.84 kg. m.).

To Test Injectors

Connect the injector to an injector test pump, give the handle about ten strokes to expel all air, and observe the nature of the spray when pumping at about 2 strokes per second. If no test pump is available, connect the injector to the injection pump, so that the spray can be observed. Slacken the unions on the remaining injectors to prevent unburnt fuel being sprayed into the cylinders. Turn the engine, and observe the spray.

When the injector is operating correctly, the spray from the nozzle spray holes should appear alike, and of equal length and free from streaks or jets of undivided fuel, Fig. 62.

A sharp, high-pitched, metallic squeak should be heard whilst the injector is spraying.

The nozzle tip must remain dry after fuel cut-off.

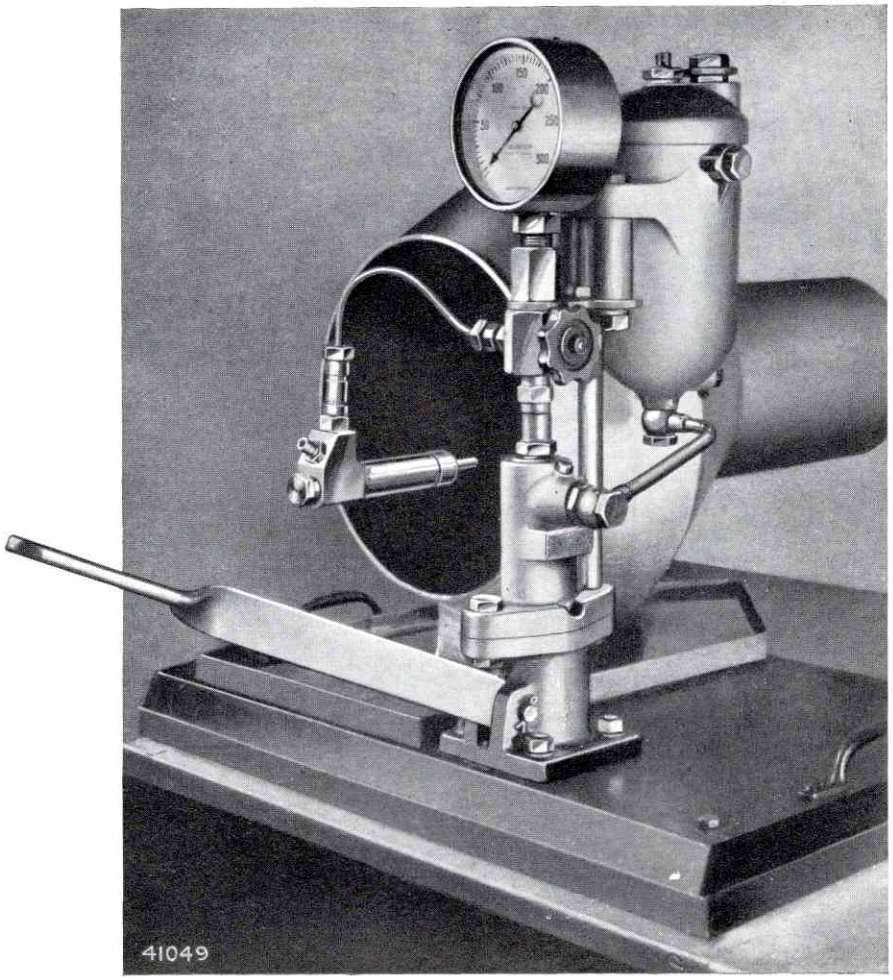


FIG. 64. INJECTOR UNIT TEST RIG

OVERHAUL

To Dismantle and Clean Injectors

When dismantling injectors absolute cleanliness is essential. **Needle valves are not interchangeable,** care must be taken when dismantling to keep all parts with their original injectors.

1. Remove the injector end plug and withdraw the valve spring, discharge pressure adjusting washer, needle valve lift distance button and needle valve. If the needle valve is tight screw a piece of 6BA screwed rod into the tapped bore of the needle valve and draw it out.
2. Remove the nozzle lock-nut and nozzle.
3. Wash the needle valve, nozzle and injector body in clean fuel oil. Both faces of the nozzle flange, the inner face of the lock-nut and face of the body should be bright and without trace of damage. They must bed perfectly to ensure a pressure-tight joint.
4. The stem of the needle valve must be free from high spots or scratches. If dirty or coked, clean with a fine brass wire brush.

   Discoloration of the needle barrel can be removed by gripping the needle in a machine chuck, smearing with metal polish and whilst the needle is revolving grip lightly between two pieces of wood hinged at one end, as shown in Fig. 66.
5. Clean the nozzle seat thoroughly and clear the spray holes with a pricker. Brush through injector body bores and inlet adapter. Flush out the inlet port drilling and nozzle with fuel oil. Finally, rinse in clean, white spirit before assembly.

To Relap Nozzle and Valve Seats

Use only the special fine grade lapping compound known as "2A.700.O.F." supplied by the Carborundum Co., Ltd., Trafford Park, Manchester, 17.

When lapping, only use **very** light pressure.

Never give the needle or nozzle lapping jigs more than a **few** twists at a time between each test.

Wash away every trace of lapping compound, assemble the injector and test for a dry seat with a sustained pressure of 125 atmospheres. 1,827 p.s.i. (129 kg. s.cm.). If the seat does not remain dry, repeat the lapping operations until such a condition is obtained.

When power lapping a nozzle, smear a small amount of lapping compound on the end of the nozzle lap and this must be repeated at intervals of thirty seconds.

Hold the seat with a gentle pressure against the lap whilst it is revolving but never allow the seat to be in contact with the lap for more than five seconds at a time.

The lapping process may take up to five minutes, the time varying according to the condition of the nozzle being reclaimed. The lap for the nozzle seat must be ground at an angle of 62°—18′/24′.

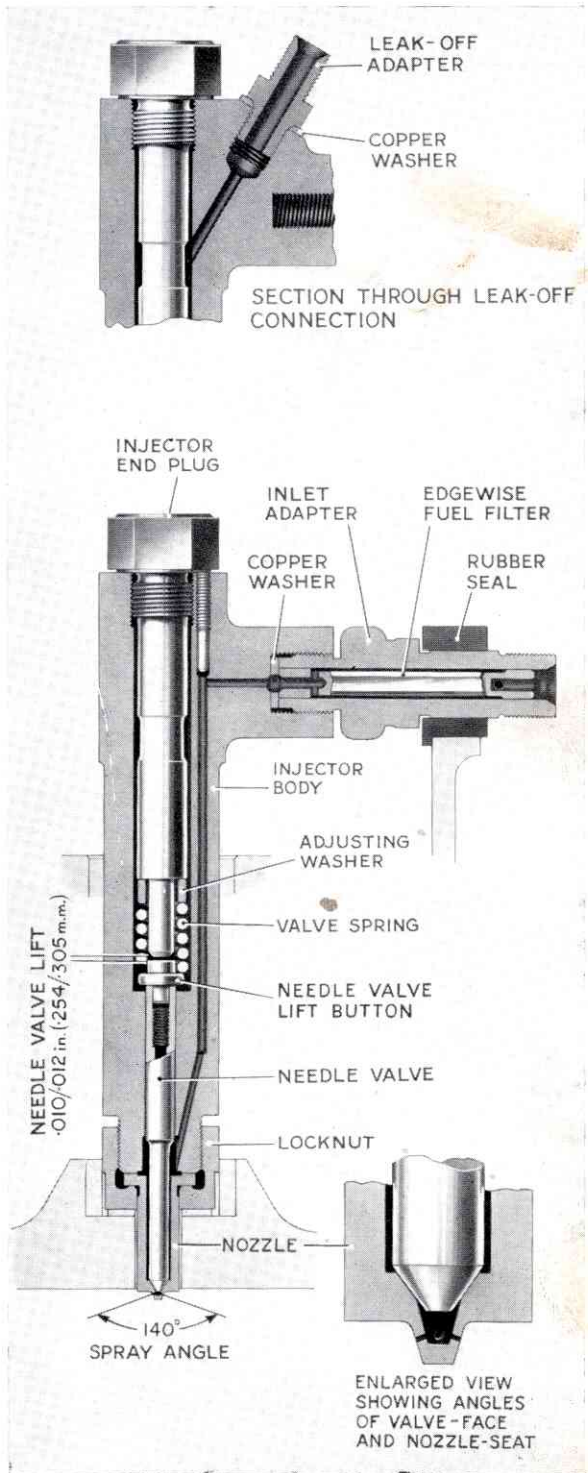


FIG. 65. THE INJECTOR UNIT

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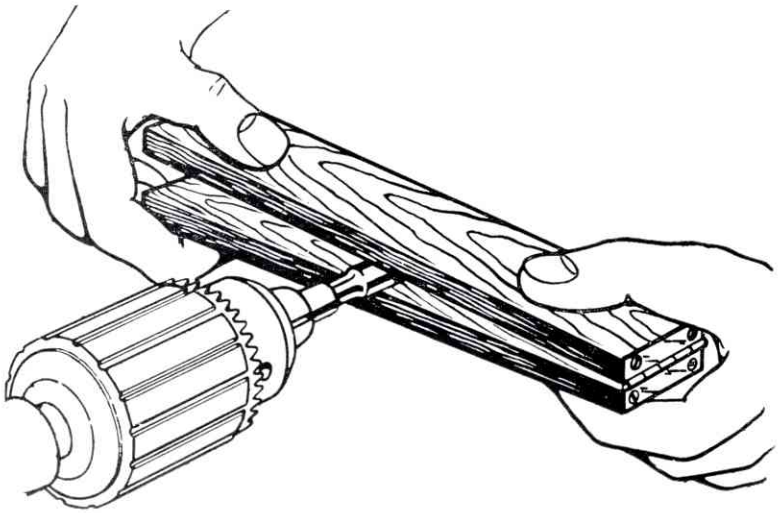


FIG. 66. METHOD OF REMOVING DISCOLORATION FROM INJECTOR-NEEDLE BARREL

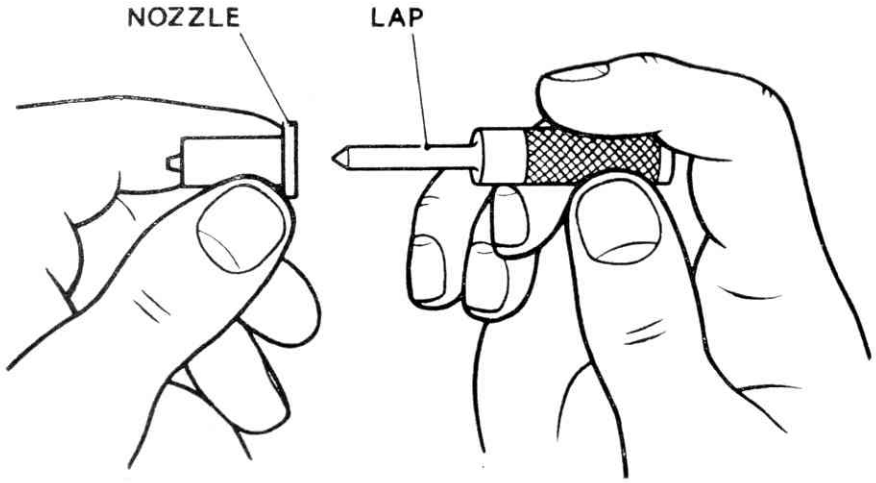


FIG. 67. HAND LAPPING THE NOZZLE SEAT

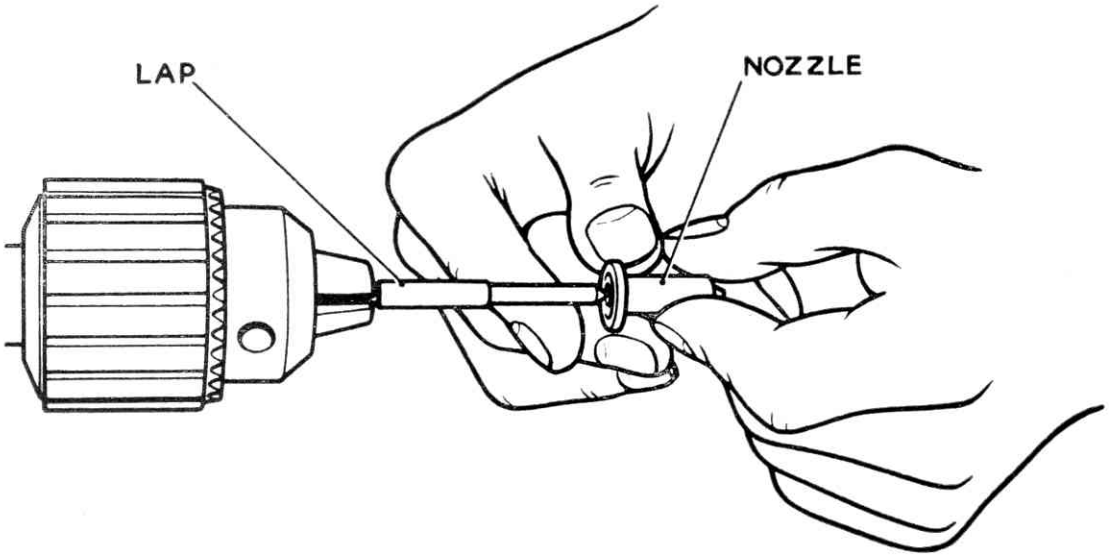


FIG. 68. POWER LAPPING THE NOZZLE SEAT

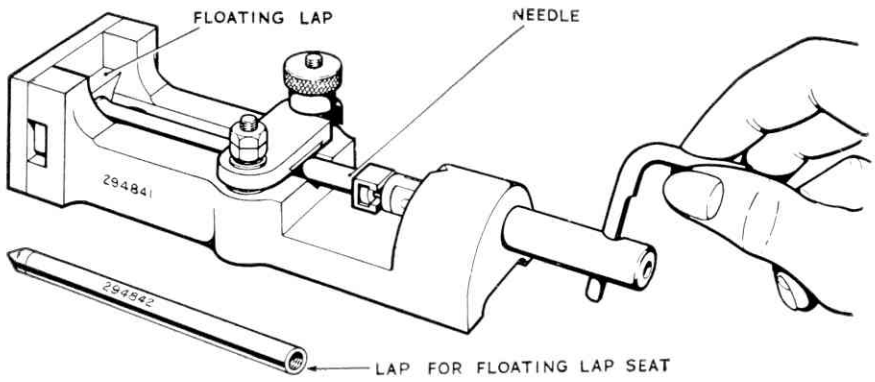


FIG. 69. INJECTOR NEEDLE LAPPING JIG

Assembly and Test of Injectors

The most important point to check when assembling an injector unit is the correct alignment of the nozzle in relation to the bore in the injector body. If the alignment is not correct the unit will not function properly and failure will occur at very low mileages. The components should be thoroughly washed in white spirit or fuel oil and kept free from grit or dirt throughout the entire operation.

Fluffy material should not be used to wipe the components.

To Reassemble Injectors

1. Check that all parts are perfectly clean and dry.
2. Fit the injector body in the jig, Fig. 70.
3. Fit the nozzle and lock-nut and screw up the lock-nut so that the nozzle can just be rotated with the fingers.
4. Screw the 6BA rod into the needle valve bore and insert the valve into the injector body.
5. Rotate the nozzle slowly and carefully with the fingers, at the same time using the screwed rod to bounce the needle valve rapidly on the nozzle seat, Fig. 71.

This ensures perfect centralisation of the nozzle and needle, without which the injector will not operate correctly. When the needle valve bounces freely on its seat, tighten the jig clamp screw to hold the nozzle in position, Fig. 72, and finally tighten the lock-nut with the ring spanner, Fig. 73, taking great care not to knock the nozzle when fitting the spanner. When the lock-nut has been securely tightened a further and most important check that the needle valve operates freely, is the "Inverted Test" carried out as follows:

1. Remove the injector from the jig.
2. Hold the injector vertically in an inverted position, Fig. 74.

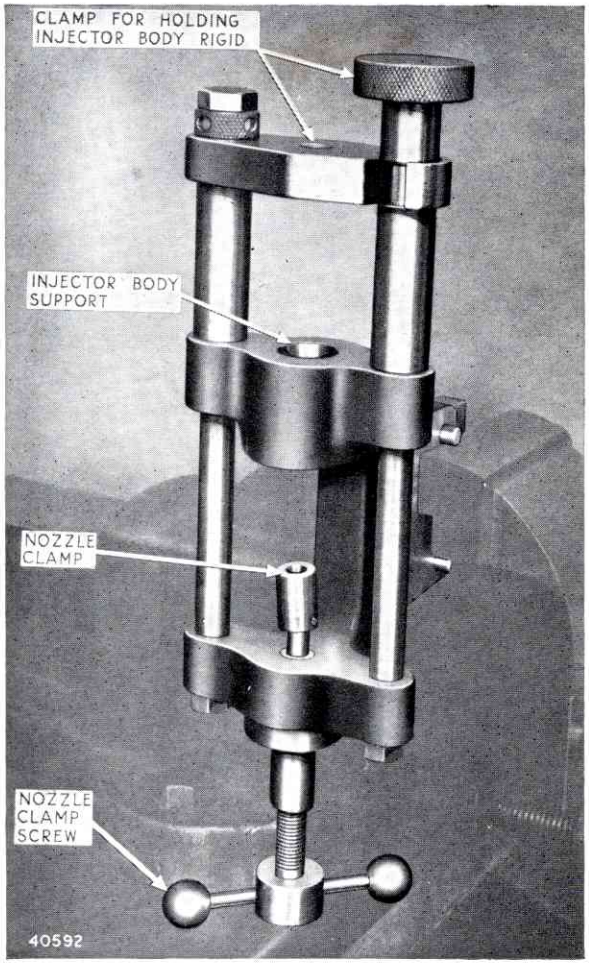


FIG. 70. NOZZLE AND NEEDLE ALIGNING JIG

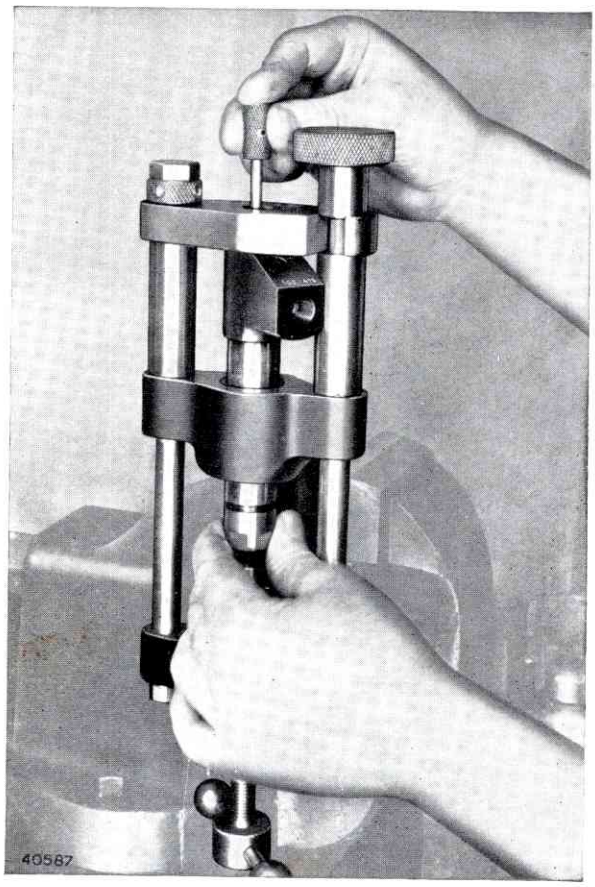


FIG. 71. CENTRALISING THE NEEDLE VALVE AND NOZZLE

3. With the needle valve attached to the screwed rod, insert the needle valve into the injector body and push it firmly on to the nozzle seating.
4. Release the rod smartly for an instant, and check that the needle valve breaks cleanly from the nozzle seat without sticking or binding.

Make this test with the needle valve in at least four different positions on the nozzle seat. If the needle valve sticks in any one position, then:

(a) Check that the needle valve slides freely in the injector body.

(b) Check that the end face of the injector body and the end face of the nozzle are clean and fit flush.

(c) After these checks, re-align the injector body and nozzle in the jig, and again carry out the "Inverted Test" until the condition described in paragraph 4 is obtained.

5. Now insert the needle valve lift distance button, valve spring and discharge pressure adjusting washer in the injector body and replace the injector and plug.

Note: A special tool for inserting the needle valve lift adjusting button is available, Pt. No. 571349.

To Check and Adjust Injectors

This can only be done successfully with a specially designed injector test pump, Fig. 64.

1. Connect the injector to the test pump; expel all air from the pump by pumping the handle for about ten strokes.
2. Carefully note pressure at which spray breaks when the pump handle is operated. The correct pressure is:

0600 Engine

145/150 atmospheres (2131/2205 p.s.i.) (150/155 kg. s.cm.).

0680 Engine

160/165 atmospheres (2351/2425 p.s.i.) (165/170 kg. s.cm.).

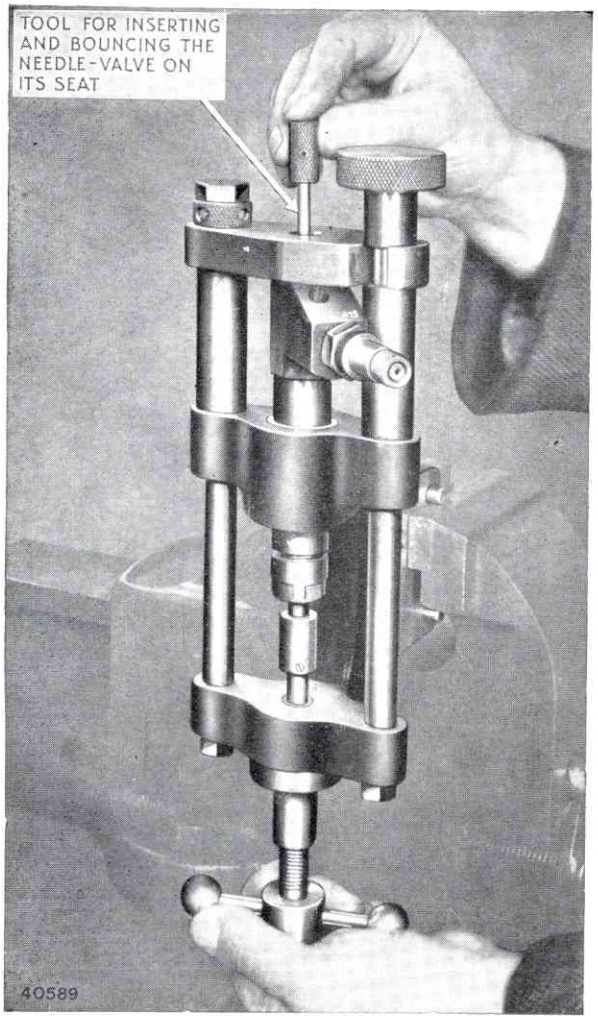


FIG. 72. CLAMPING THE NOZZLE AFTER CENTRALISING THE NEEDLE VALVE

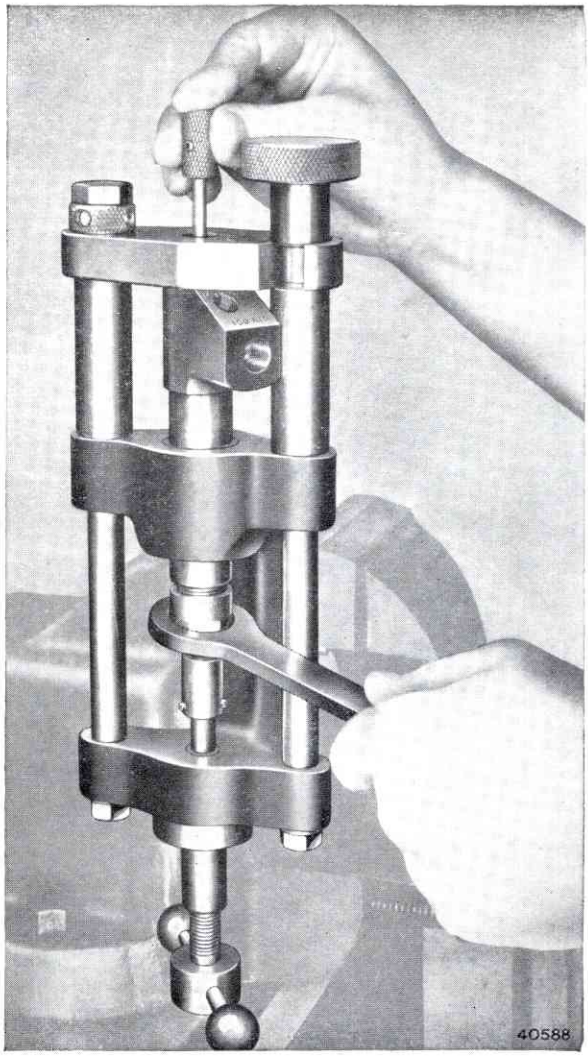


FIG. 73. TIGHTENING THE NOZZLE CLAMP NUT AFTER CENTRALISING THE NEEDLE VALVE

3. The seat must remain dry with a sustained pressure of 125 atmospheres (1,837 p.s.i.), 129 kg. s.cm. and also after three smart discharges.

4. If the discharge pressure is not correct, check that the needle is free in the body; if this is in order, adjust the spring pressure by inserting a discharge pressure adjusting washer of a different thickness (see **Data** under heading **Injectors,** for washer thicknesses). Re-check the discharge pressure.

5. Check that the needle lift is between .010 in. and .012 in. (.254 mm. to .305 mm.). To do this remove the injector end plug, and discharge pressure adjusting washer and spring. Insert a .100 in. (2.540 mm.) thick shim on top of the needle valve lift distance button and replace the end plug. Screw down the plug by hand and measure the gap between the end plug and injector body, using a feeler gauge, .088/.090 in. (2.235/2.286 mm.) thick, Fig. 76.

If this gap does not lie within the limits quoted, fit a different thickness of distance button and re-check (see **Data** under heading **Injectors,** for button thicknesses), when a needle valve lift distance washer of the correct thickness has been obtained, remove the .100 in. (2.540 mm.) thick shim and assemble the injector for test.

6. Check the time for the pressure to fall from 90 to 40 atmospheres (1,323 to 588 p.s.i., 93 to 41.4 kg. s.cm.). The limits for rejection are as follows (at room temperature 40°F. to 70°F.) (5°C. to 21°C.):

Using fuel oil		$4\frac{1}{2}$ to 14 secs.
Using Shell Fusus oil (A)	New injectors ...	9 to 20 secs.
	Used injectors ...	7 to 17 secs.

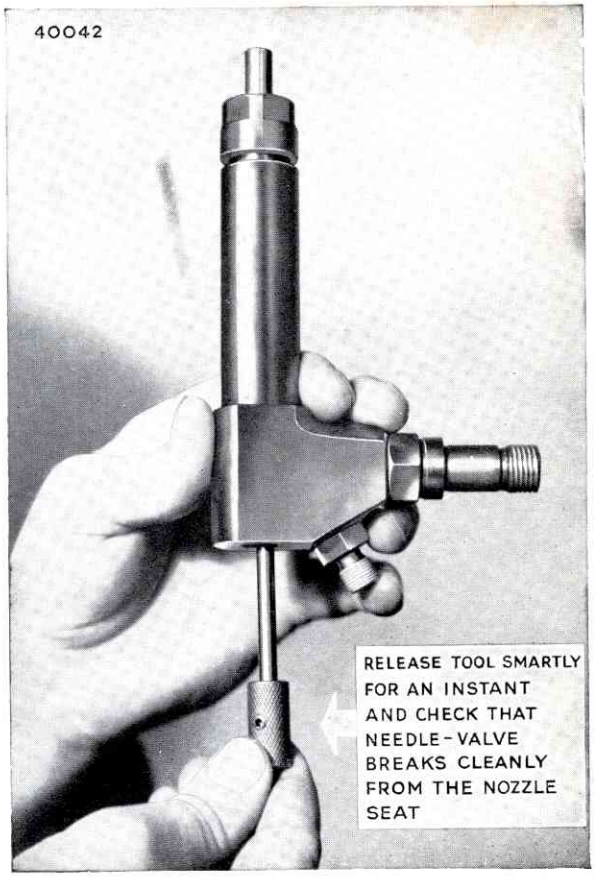


FIG. 74. THE INVERTED TEST

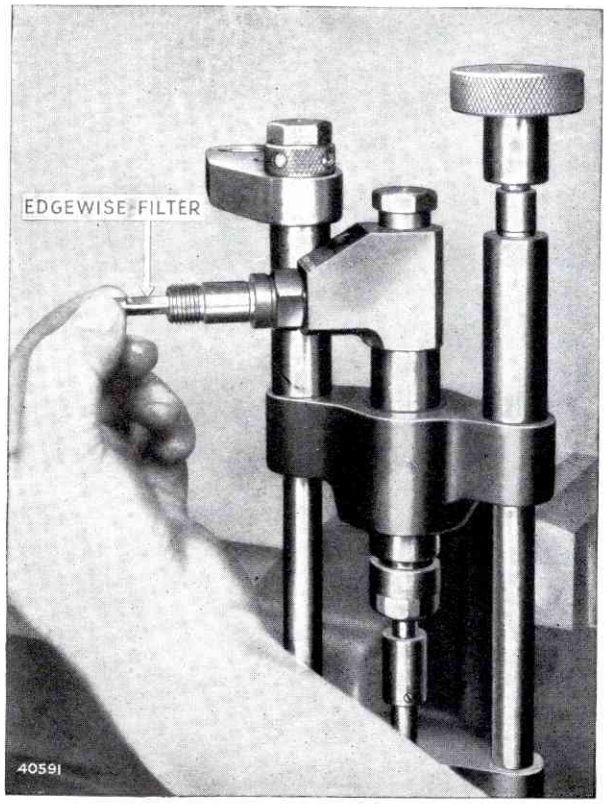


FIG. 75. FITTING THE EDGEWISE FUEL FILTER

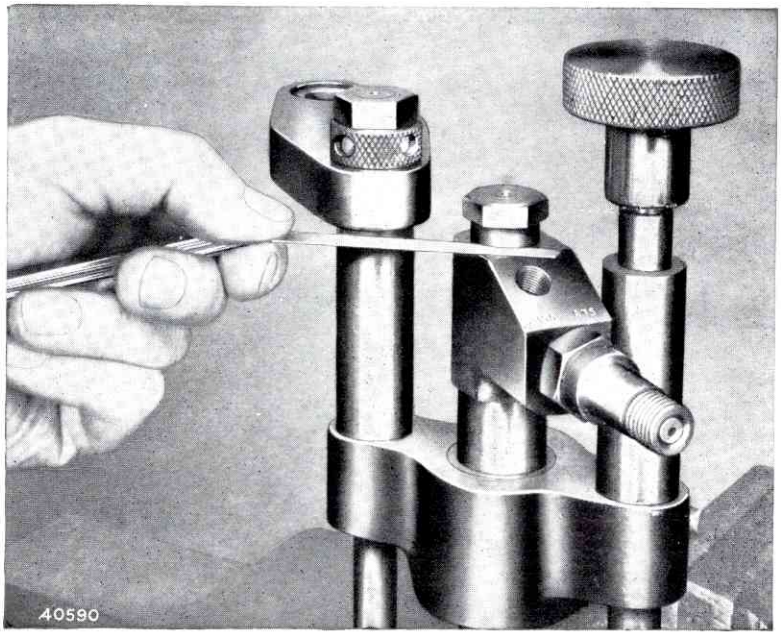


FIG. 76. CHECKING THE NEEDLE VALVE LIFT

THE FUEL INJECTION PUMP

C.A.V. Type NN Pump

DESCRIPTION

0600 Engine

The fuel injection pump, Fig. 78, is of the constant-stroke, cam-actuated, lapped plunger type and incorporates a small flyweight all speed mechanical governor and a baulking type excess fuel device for easy starting. The pump consists of a body with a camshaft compartment at the bottom and with six individual pumping elements occupying the middle and upper portions. All the six elements are linked together by a control rod connected to the mechanical governor.

0680 Engine

The fuel injection pump, Fig. 79, is of the constant-stroke, cam-actuated, lapped plunger type and incorporates a hydraulic governor and a baulking type excess fuel device for easy starting. The pump consists of a body with a camshaft compartment at the bottom and with six individual pumping elements occupying the middle and upper portions. All the six elements are linked together by a control rod connected to the hydraulic governor

In the middle and upper portions of the pump housing are located the plunger and barrel assemblies, metering control sleeves with regulating toothed quadrants, plunger springs and control rod. The upper portion of the housing contains the fuel chamber, delivery valve assemblies and delivery valve holders for connection to the injection feed pipes. Built into the rear of the housing is a secondary fuel filter composed of felt pads intended to supplement the main fuel filter.

Each pumping element comprises of a barrel (F) and plunger (G), see Fig. 83, and are of highly ground and hardened steel, finished to a high degree of accuracy to permit operation at high speeds and pressures. Thus, each pair must be regarded as inseparable and not interchangeable.

Fuel oil is fed to each element from a common gallery; the stroke of the plunger is constant, but the effective pumping stroke, i.e., that portion of the stroke during which oil is actually forced into the combustion chamber, is variable by means of a control helix on the plunger which operates in conjunction with ports in the barrel.

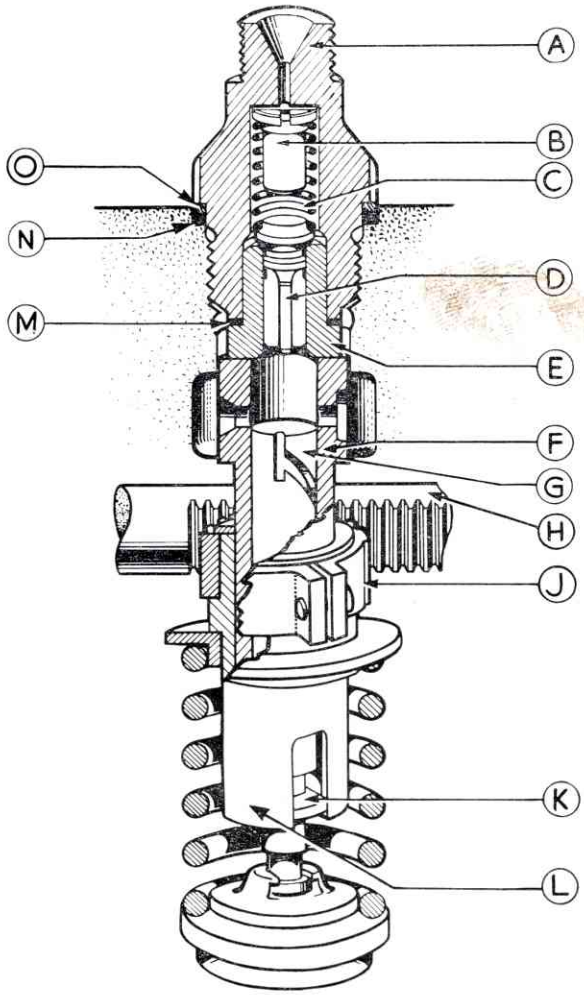


FIG. 77. THE PUMPING ELEMENT ASSEMBLY

A. Delivery valve holder.
B. Spring peg.
C. Delivery valve spring.
D. Delivery valve.
E. Valve seating.
F. Element barrel.
G. Plunger.
H. Control rack.
J. Control quadrant.
K. Plunger locating lug.
L. Control sleeve.
M. Washer.
N. Rubber seal ring.
O. Washer.

0865

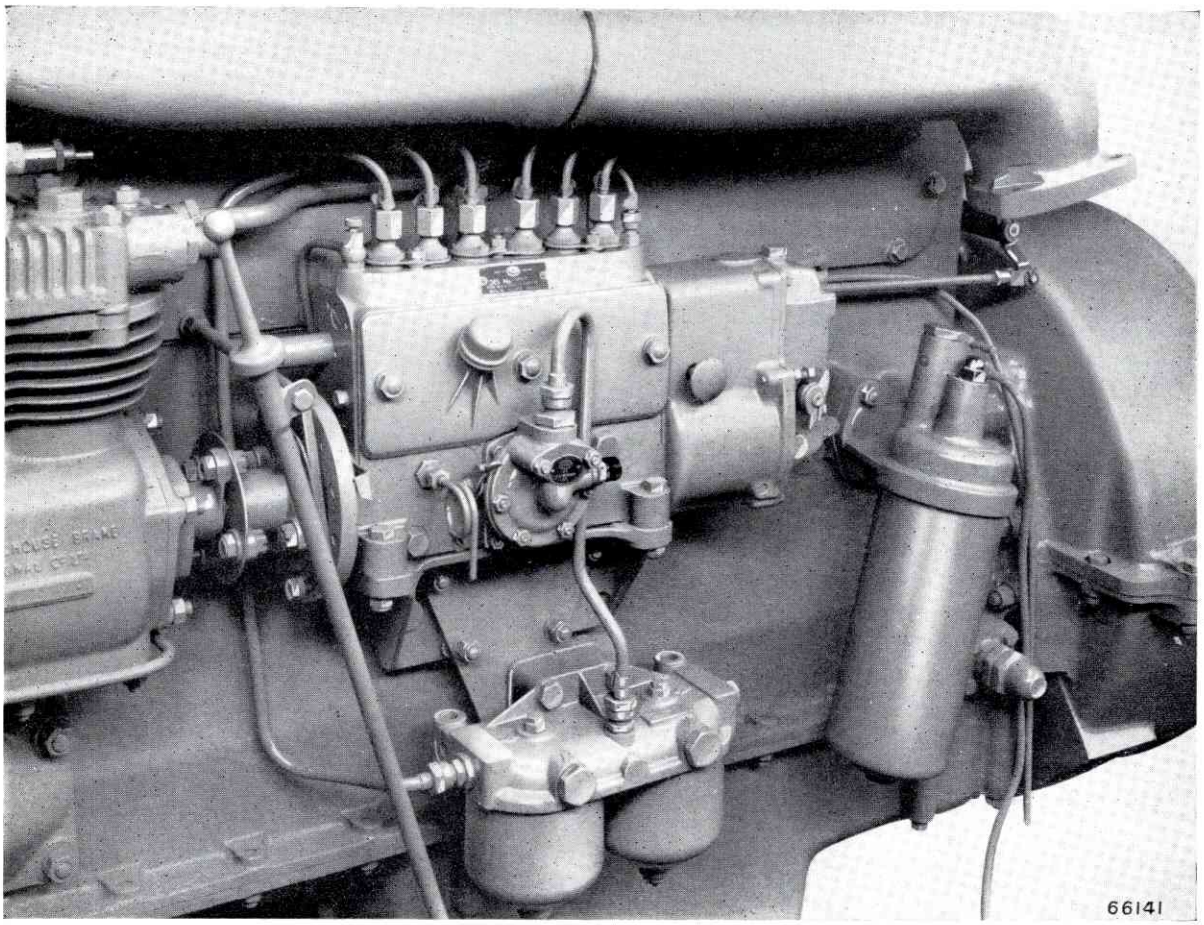


FIG. 78. THE FUEL INJECTION PUMP AND GOVERNOR
0600 POWER-PLUS DIESEL

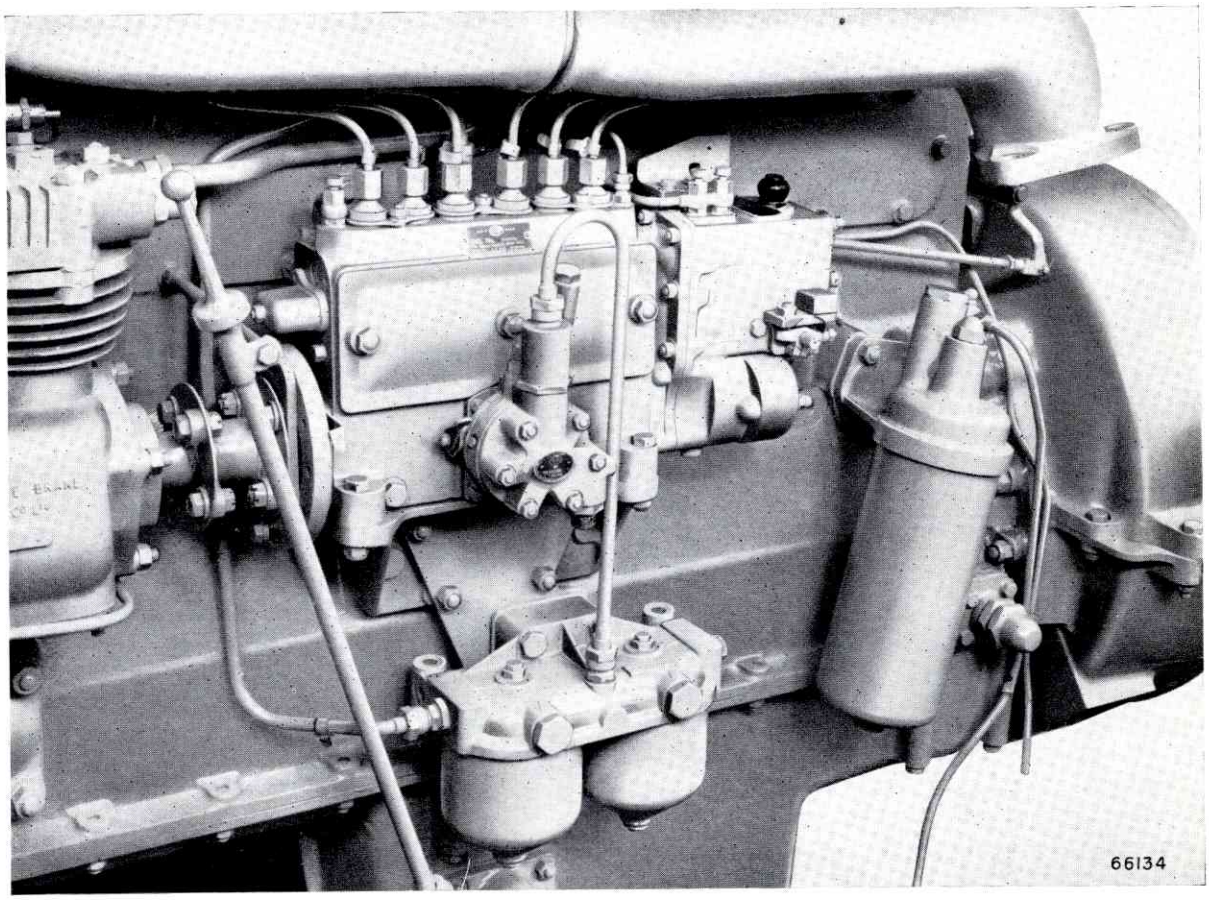


FIG. 79. THE FUEL INJECTION PUMP AND GOVERNOR
0680 POWER-PLUS DIESEL

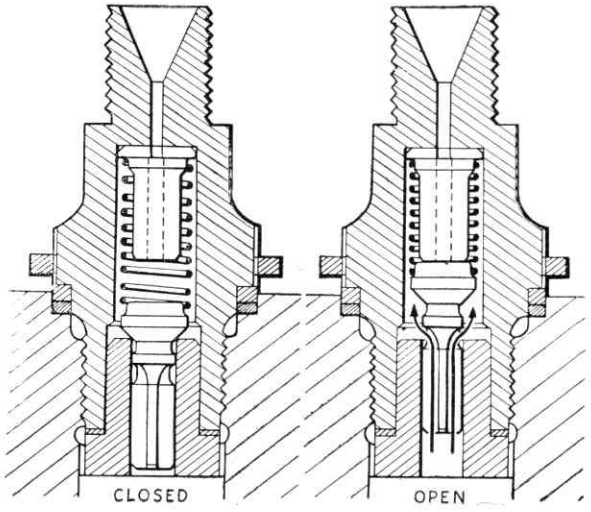


FIG. 80. INJECTION PUMP DELIVERY VALVE

Referring to Fig. 81, the form of the helix and its relation to the ports and oil passages of the element are clearly shown. It will be seen that when the plunger is at bottom dead centre (B.D.C.) oil can enter the barrel through the inlet port. As the plunger is raised by the cam, the top edge of the plunger covers the ports, sealing off escape for the oil, which is then forced out through the delivery valve and high-pressure piping to the injector, as in Fig. 81b. As the plunger rises higher, pumping continues until the edge of the control helix reaches the lower edge of the ports. This allows oil to escape via the spill port, as in Fig. 81c, releasing the pressure in the element and piping and thus terminating the pumping stroke. The plunger can now complete its stroke without any further pumping, and is then returned by the plunger spring to bottom dead centre ready for the next cycle.

The quantity of fuel oil pumped is dependent on the length of pumping stroke between the points shown in Fig. 81 (b and c). This effective stroke is varied by rotating the plunger to bring a higher, or lower, portion of the control helix into line with the spill port. Compare Fig. 81c, d and e, which show approximately the positions for full load, half-load and idling respectively.

At its upper end the control helix emerges into an axial groove running up to the top face of the plunger. If this axial groove is in line with the spill port, then the oil in the barrel has a continuous line of escape to the spill port, and obviously no pumping stroke is possible. This represents the **Stop** position in pump operation, when no oil is delivered at all, as in Fig. 81f.

Rotation of the plunger, to give any required delivery position between **Full Load** and **Stop,** is effected in the following way:

The lower end of the plunger (G), Fig. 77, carries a lug, or toe (K). This engages in a slot in the skirt of the control quadrant (L). Around its upper flange, the quadrant is machined to form gear teeth, and these engage with similar teeth on the control rack (H), the latter running the length of the pump and engaging the quadrant of each pumping element. Thus movement of the rack causes all the plungers to rotate in unison and selects the position of the helices corresponding to the fuel delivery required.

The control rack is coupled to and operated by the governor unit.

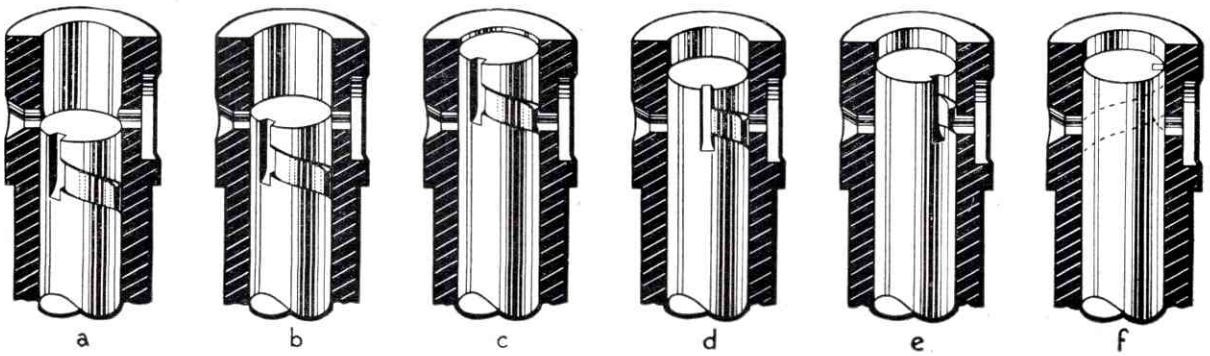


FIG. 81. THE PRINCIPLE OF FUEL METERING

In order to ensure complete and instantaneous relief of pressure in the fuel line after the pump plunger has completed its injection stroke, a delivery valve with the well-known "unloading collar" used in previous types of C.A.V. pumps is fitted immediately above the element, as shown in Fig. 80.

The delivery valve seating is held against the top of the element barrel (F), Fig. 77, both faces of this joint being lapped flat. The seating is held down by the delivery valve holder (A) which is screwed in to the pump body, a washer (M) being inserted between the valve seating (E) and the holder (A), to prevent leakage of high-pressure oil down the inside of the holder. Leakage of oil at low pressure up the threads in the pump body is prevented by a synthetic rubber seal ring (N), with a steel slip washer (O), which is trapped in a counterbore in the pump body by the delivery valve holder.

A steel peg (B) is used to centralise the upper end of the valve spring (C) and also to help reduce the fuel capacity of the holder. This fuel capacity has been kept to a minimum, as it is known that reduction of capacity between pump plunger and injector seat gives improved injection control under many conditions.

In operation, when the pump element barrel ports are closed and delivery occurs, the delivery valve is lifted from its seat so that the unloading collar is clear of the seat bore and the oil passes through. Fig. 80. When delivery is ended by the operating of the spill port, the sudden collapse of pressure in the pump element causes the valve to "snap" on to its seating sharply. As the lower edge of the unloading collar enters the seat bore, it stops any flow of oil past the collar so that the capacity above the valve is sealed off.

Further movement of the valve on to its seat now causes an increase of the capacity above the valve. The resultant sharp drop in pressure speeds up the closing of the injector, giving very positive shut-off and preventing dribble with its attendant troubles of carbon-formation and nozzle deterioration.

LUBRICATION

On fitting the pump to the engine, pour into the cambox approximately $\frac{1}{8}$ pint (0.07 litre) of engine oil, through the filler plug. This oil level will be maintained by the back leakage from the pumping elements as this leakage is all led back to the pump sump, any surplus being taken away by the scavenge pump which is incorporated in the fuel feed pump.

Although the original lubricating oil will be thinned out by the back leakage fuel oil, experience has proved that the pump will run in perfect safety with fuel oil as a lubricant.

OVERHAUL

To Remove the Injection Pump

Immediately pipes are disconnected from the fuel pump, the end of the pipes, together with the unions on the pump, must be protected against the ingress of foreign matter. **On no account must dust be allowed to fall into the injection pump.**

1. Disconnect the pipes to the governor.
2. Disconnect the engine stop control rod.
3. Uncouple the pipe from the main filter to the pump and the suction and delivery pipes to the diaphragm fuel feed pump.

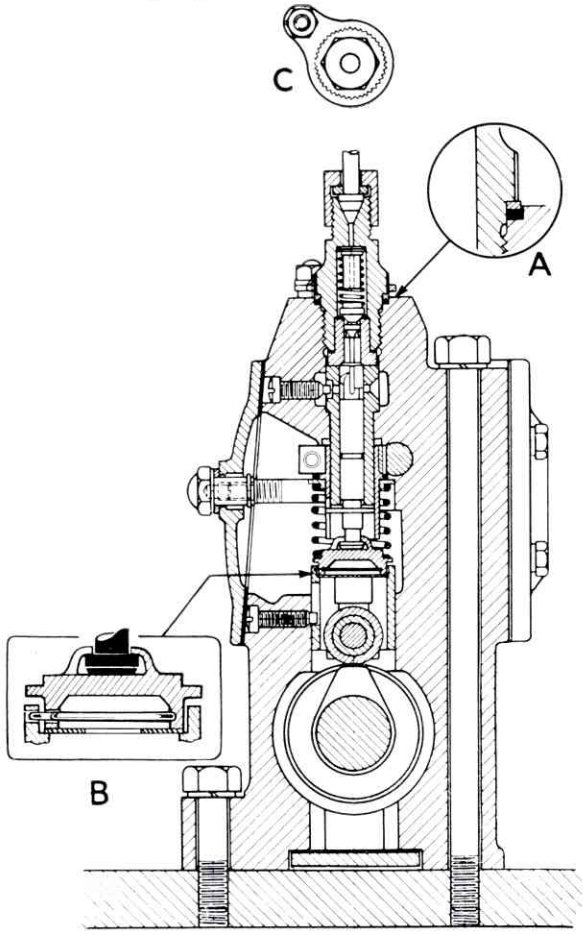


FIG. 82. SECTION THROUGH THE C.A.V. TYPE NN FUEL PUMP

A. Low pressure joint. B. Phasing shim.
C. Delivery valve locking plate.

4. Disconnect the delivery pipes to the injectors.

5. Remove the two setscrews connecting the coupling to the pump flywheel.

6. Remove the bolts fixing pump to bracket and remove the pump.

To Replace the Injection Pump

1. Set the engine to the **No. 1 INJ** mark on the flywheel, so that **No. 1** piston is on the **compression** stroke (that is, both valves closed).

2. Turn the pump camshaft until the mark on its flywheel is in line with the pointer on the pump body.

3. Place the pump on its bracket and connect up to the drive coupling.

4. Check that all timing marks are in line.

5. Bolt the pump to its bracket.

If a replacement pump is being fitted and its flywheel has no timing mark, proceed as follows:

1. Set the engine to the **No. 1 INJ** mark on the flywheel, so that **No. 1** piston is on the **compression** stroke.

2. Fit the pump to the engine and couple up the main feed pipes, but only No. 1 cylinder delivery pipe and injector.

3. Prime the injection pump through to No. 1 injector.

4. Turn the pump flywheel **clockwise** until resistance becomes solid.
   At this point No. 1 injector starts injecting fuel; fit the coupling locking setscrews and tighten up.

5. When the pump is correctly timed, mark the pump flywheel opposite the timing pointer on the pump body, so that the pump can easily be fitted if subsequent removal is necessary.

6. Fit and tighten all fuel delivery pipes to injectors.

Air Venting

On assembly, or whenever the fuel system has been disturbed in any way, the system should be thoroughly vented before re-starting. A screw-down venting valve is fitted on the injection pump. If this is opened by partially unscrewing, the air can be removed by means of the hand primer on the fuel feed pump.

High pressure pipes should be vented by running the engine for a few seconds with the delivery pipe to injector connection slackened back.

Particular care must be taken to vent the hydraulic governor circuit to ensure removal of air. Operation of the hand primer on the fuel feed pump, with the two vent valves on the top of the governor housing loosened, will quickly expel air from the circuit. This action must be taken at the time of initial installation, or at any subsequent time if the fuel supply runs dry, or if the pump or fuel pipes have been removed from the engine.

To Dismantle the Injection Pump

In the event of the injection pump being faulty in service, it should normally be removed complete and replaced by a spare pump, the faulty unit being despatched to the nearest C.A.V. or Leyland Service Depot or agent. As a replacement pump may not always be available, details whereby emergency repairs can be carried out are given in the following paragraphs:

Warning: Strict cleanliness must be observed when preparing to dismantle fuel injection pumps, care being taken that all filings, dust, dirt and grit, etc., have been removed from the bench on which work is to be done. The bench should then be covered with clean grease-proof paper and a number of clean containers provided for the various parts removed. It is also an advantage to have a supply of clean, fresh fuel oil for washing these parts.

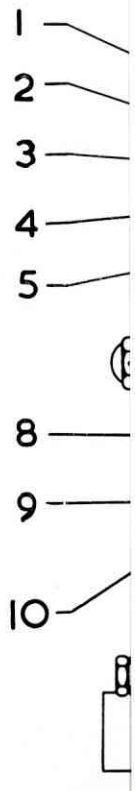
The various parts of one pumping element should never be interchanged with another, particularly the barrel, pump plunger, delivery valve and seating. To keep the six elements isolated they should be placed in separate containers. The surfaces of these parts must never at any time be touched with a file, scraper, or other hard tool or any abrasive compound.

Procedure is as follows, the components being removed in the sequence given:

1. Remove the governor (see **To Remove the Governor**).

2. Remove the fuel feed pump by unscrewing the fixing screws.

3. Remove the inspection cover-plate (32), Fig. 83, by unscrewing nuts (31).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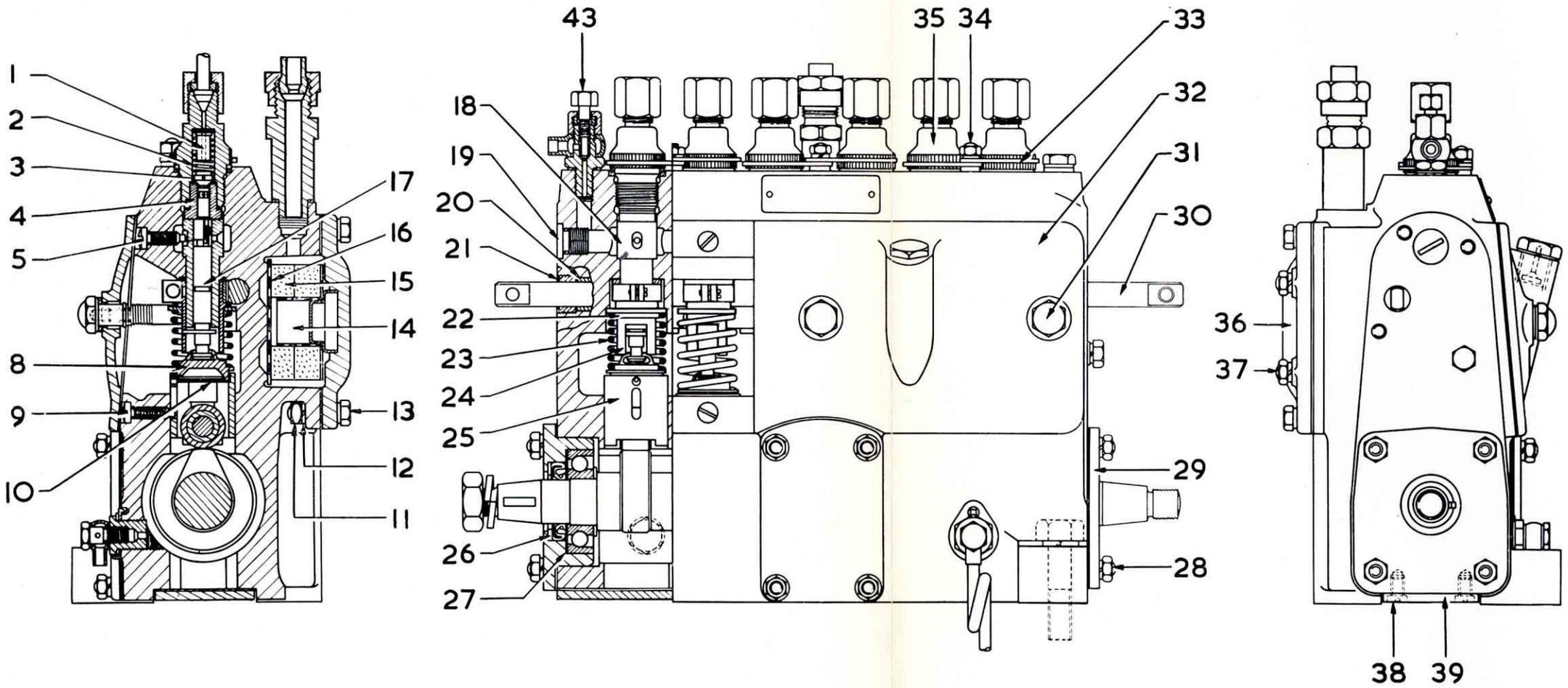


FIG. 83. SECTIONED VIEWS OF THE C.A.V. TYPE NN FUEL INJECTION PUMP

1. Delivery valve spring peg.
2. Delivery valve spring.
3. Delivery valve.
4. Delivery valve seat.
5. Barrel locking screw.
8. Lower spring plate.
9. Tappet locking screw.
10. Phasing washer.
11. Nut.
12. Washer.
13. Bolt.
14. Support pipe.
15. Filter pad.
16. Backing plate.
17. Plunger.
18. Barrel.
19. Closing plug.
20. Control rod bush.
21. Locking collar.
22. Upper spring plate.
23. Spring.
24. Control quadrant.
25. Tappet.
26. Oil seal.
27. Shim plate.
28. Nut.
29. Bearing end plate.
30. Control rod.
31. Nut.
32. Inspection cover.
33. Delivery valve holder locking plate.
34. Nut.
35. Delivery valve holder.
36. Filter cover.
37. Nut.
38. Setscrew.
39. Base sealing plate.
43. Air vent cock.

4. Rotate the camshaft to raise each cam in turn to top dead centre position and insert tappet holder under the lower spring plate.

5. Remove the injection pump flywheel using the withdrawal and holding tool. The removal of the flywheel from the tapered end of the camshaft must never be done by the use of a hammer or drift.

6. Remove the four nuts (28) and remove one bearing end plate (29) by tapping the opposite end of the camshaft, keeping the end plate square and avoiding damage to joint face and gasket. The camshaft can now be drawn from the open end of the cambox, note the position of the notch on the end of the camshaft before withdrawing. This marks the end to end position of the camshaft to give the correct firing order. Camshaft notch position is indicated on the symbol plate.

7. To remove the bearing inner race from the camshaft use the special extractor. Shims, to adjust the end float of the camshaft when assembled in the pump, are trapped on the shaft, behind the bearing inner race. This end float should be maintained at 0.05/0.10 mm. (0.002/0.004 in.) for ball bearings and 0/0.05 mm. (0/0.002 in.) for taper roller bearings, and if a shaft or bearing is changed the necessary shims should be equally divided between both ends of the shaft.

8. To remove the bearing outer race from the end plate use the appropriate extractor tool. Behind the outer race (27) is a shim plate, Fig. 83, then the oil seal (26) which is a push-fit in its location, and should not be removed unless it is intended to renew, as removal may cause damage.

9. Remove the delivery valve holder locking plates (33), the holders (35) can then be removed by using a serrated box spanner, and the spring (2), spring peg (1), and delivery valve (3) can be lifted out. The delivery valve seat (4) can be removed by using the extractor.

10. Remove the base sealing plate (39) by releasing screws (38).

11. Remove the tappet locking screw (9). Then hold up the tappet (25) against the plunger spring (23) with forceps and withdraw the tappet lifters, and allow the tappet to come away slowly under control. The tappet (25), phasing washer (10) and lower spring plate (8), with the plunger (17), can now be withdrawn. The plunger should be steadied to prevent it falling and being damaged, the plunger spring, upper spring plate (22) and quadrant (24) should next be removed. Do not separate quadrant from control sleeve.

12. Withdraw control rod (30) endwise, after removing location plate from the governor end of the pump housing.

13. If the control rod bushes (20) are worn and need renewing, the locking collars (21) should be unscrewed, using special key. The bearing bushes, which are a press-fit in the pump housing, can be removed with extractor tool.

14. Remove the barrel locking screw (5). The barrel (18) can then pushed out from the bottom, using a fibre or copper drift. The plunger should be immediately replaced in the barrel for protection.

15. To dismantle the built-in filter, unscrew bolts (13), remove nuts (11) and spring washers (12). Release nuts (37) and remove the filter cover (36) together with filter packs. The filter pads (15) can now be removed from their support pipe (14) and replaced by new ones. Remove perforated backing plate (16). The fuel gallery closing plugs should not normally be removed, but if it is required to rejoint these plugs (19), a special key should be used for removal and replacement.

To Reassemble the Injection Pump

The greatest cleanliness must be exercised in every assembly operation. Each part should be thoroughly washed in clean paraffin and dipped in clean, light oil immediately before assembling. **No rags or fabric should be used on working parts.**

1. If control rod bushes have been removed, replace and lock in position with locking rings. Check for alignment by freedom of control rod. If new bushes are being fitted, they must be line-reamed.

2. Insert barrels from above, check that the slot for the locking screw is in line with the screw-hole in the housing. Insert and tighten the locking screws. No sealing washer is necessary on these screws.

3. Fit the assembly base plate and lay pump on its back. Slide in the control rod, the longer plain end of the control rod should be on the opposite end to the governor.

4. The control quadrants should be fitted to control sleeves (L), Fig. 77, and locked by the clamp screws, after the scribed lines on quadrant and sleeve are coincident. They should be assembled in the pump with the control rod in the mid-position and with the clamp screws lying parallel with the front of the pump.

5. Insert the upper spring plate and the plunger spring.

6. Insert the plunger with the lower spring plate hooked to its head and the tappet with the phasing washer held in position by a spot of thick grease and hooked to the spring in the lower spring plate.

7. Use the tappet forceps to push the tappet right up, after locating the plunger toe in the quadrant slot. Now turn the tappet so that its slot is in line with the locking screw hole in the housing and insert tappet locking screw and tighten up. No sealing washer is necessary on this screw.

8. With tappet still pushed home insert tappet lifters.

9. Replace base sealing plate (39).

10. Insert camshaft, taking care that the notch on the camshaft is fitted at the correct end of the pump housing. Assemble and tighten the end-plate, ensuring that the end-plate gasket is in good condition. Care is necessary to avoid damage to the oil seals when entering the camshaft. The use of a protection cap facilitates this operation. Check rotation and firing order. Check camshaft end float, using the end-play gauge; this should be 0.05/0.10 mm. (0.002/0.004 in.). If necessary, adjust by alteration to shims trapped on shaft behind the inner race, equalising shims at each end.

11. After assembling camshaft check to see that it rotates freely when the tappets are lifted clear of the cams. Check clearance between the control rod and the locating plate. This should be 0.0015 in. (0.038 mm.) when the stop plate is tightened. Remove the tappet lifters and check that the control rod moves freely. Stand the pump upright.

12. Place the delivery valve and seat on top of element barrel, with a new joint ring above the delivery valve seat flange. Put the delivery valve spring on the head of the delivery valve, then insert spring peg in the upper end of the spring. A new low-pressure sealing ring, with the steel slip washer above, should be fitted on the shank of the delivery valve holder which can now be screwed into place. Care should be taken that the valve spring and peg are not knocked out of position.

    The delivery valve holder is tightened by using the two-handed serrated box spanner. A torque wrench should be used, and the holder tightened to a torque of 40 lb./ft. (5.3 kg. m.).

    The flat serrated ring spanner is intended only for use if it is necessary to remove or tighten the delivery valve holders when the pump is on the engine, in a position where the two-handed box spanner cannot be used.

13. Fit and tighten delivery valve holder locking plates.

14. Fit new filter pads on the support pipes and place these in position in the filter cover. Then after putting in perforated plate and gasket, assemble to pump, making sure that cover gasket is in good condition. Replace bolts and nuts and tighten down evenly.

15. Refit fuel feed pump.

16. Replace the governor (see **To Replace Governor Assembly**).

PUMP ADJUSTING

To ensure regular and accurate metering and injection of the fuel, the setting of the pump elements must be done with care and utmost precision. The adjustments fall into two operations, phasing and calibration. Phasing is necessary to ensure that the injections occur at equal angular intervals of camshaft rotation. Calibration, on the other hand, provides for the correct setting of the helices in relation to the ports, that is to say, it ensures that the amount of fuel injected into each cylinder will be equal.

Phasing

Adjustment of phase is performed by changing the phase washer between the lower spring plate and tappet

These phase washers are available in thicknesses from 0.3/1.4 mm. (0.012/0.055 in.) in steps of 0.1 mm. (0.004 in.).

1. To change the washer, turn the camshaft to top dead centre.

2. Insert tappet lifter and rotate camshaft 180°, then with the tommy bar press in the spring catch through the small hole in the tappet to release the bottom spring plate from the tappet. The washer can now be lifted from the recess in the tappet by use of the special hook tool and the new washer guided into place with the same tool.

3. Having changed the washer turn the camshaft back slowly towards top dead centre until the top of the tappet touches the spring catch. Press in the catch and at the same time turn camshaft to full top dead centre when spring catch should click into the hole in the tappet. Remove tappet lifter.

The Method of Phasing

1. Mount the pump on a test machine which has a suitable angular scale of degrees marked on the driving member. Couple pump to suitable oil supply, giving about 2 feet (0.6 metre) head of oil.

2. Vent all air from the pump, including the built-in filter by means of the air vent cock (43), Fig. 83.

3. Shut off oil supply and hold the control rod in mid-position.

4. Remove No. 1 delivery valve holder and delivery valve complete.

5. Check the height of the top face of the plunger, when at top of stroke, using the special tool or a dial gauge. The top face of the plunger should be 0.5 mm. (0.020 in.) below the top face of the element barrel. If the special tool is used, screw into the position normally occupied by No. 1 delivery valve and holder until tight against the top face of the pump barrel.

6. With the centre pin of the tool resting on the top face of pump plunger adjust, by means of phasing washers, so that the small cross-pin is level with centre land on top of tool body.

7. All other cylinders are adjusted in a similar manner.

8. The cross-pin should not come above the top land or below the bottom land. As a guide, the three lands represent the following plunger head clearances: top land 0.35 mm. (0.014 in.), centre land 0.5 mm. (0.020 in.) and bottom land 0.65 mm. (0.025 in.).

9. Replace the delivery valve seat, joint rings and holder, but leave out the delivery valve, spring and spring peg.

10. Fit the spill pipe, Fig. 84, and turn on the fuel oil.

11. Note from the angular scale, the angular reading of the point at which the oil flow ceases whilst turning No. 1 cam from B.D.C. towards T.D.C., that is the point of spill cut-off.

12. For each element in turn carry out operations (i) and (ii) as follows:

    (i) Remove delivery valve spring and spring peg, fit spill pipe and supply oil. Check angular reading of spill cut-off. Adjust this point to correct relationship with No. 1 by changing the phasing washer. All elements should be within 0.5 degree overall error.

FIG. 84. THE SPILL PIPE

(ii) Remove delivery valve holder and seat and check plunger height as in **paragraph 5.** These readings must all be within 0.5 mm. ±0.15 mm. (0.020 in.±0.005 in.). Replace and tighten delivery valve and holder complete.

13. Fit and tighten delivery valve holder locking plates.

To Recalibrate the Injection Pump

After the phasing operation, calibration should be carried out on a power-driven calibration machine, using "Fuses" fuel with a gravity feed.

Pintle-type injectors type BDN 12 SD 12 should be used, with 6 mm. outside diameter by 2 mm. bore pipes having a length of 600 mm. (24 in.).

The injectors should be set at 175 atmospheres (2572.5 p.s.i., 180.8275 kg. s.cm.) and periodically they should be re-serviced by agencies having special reconditioning equipment for this work.

The plunger toe is located in the axial slot in the skirt of the control sleeve, so that the sleeve and plunger rotate together. Alteration of calibration setting is carried out by slackening the control quadrant clamp screw and moving the control sleeve within the quadrant, thus moving the plunger to the required position.

This adjustment is very accurately carried out at the factory and a line is scribed across both control sleeve and quadrant to indicate the correct setting. Wear on the element may necessitate a slight alteration to the setting after several hundreds of hours' running, but this deviation should be very slight.

Before testing it is advisable to see that the calibration marks are lined up as this will considerably reduce the amount of adjustment to be made. If, however, the pump has been overhauled and the control sleeves and/or quadrant have been replaced, this guide will not be available, in which case the pump will have to be very carefully readjusted with proper apparatus, and new marking lines scribed.

The calibration figures are:

0600 Engine

17.6/18.6 c.c. per 200 shots at 600 r.p.m.

0680 Engine

28.3/29.7 c.c. per 200 shots at 600 r.p.m.

THE MECHANICAL GOVERNOR

C.A.V. Type SF

DESCRIPTION

The small flyweight all-speeds governor mounted on the fuel pump shaft is located in the governor housing which is attached directly to the rear of the fuel injection pump.

The hardened gear-tooth shaped contact points of the flyweights operate in hardened and polished slots of the governor sleeve and together with the small travel of the flyweights ensure a smooth yet flexible action at all times, especially so at engine idling.

A maximum fuel stop which also incorporates a baulking type excess fuel device for ease of starting is also located in the governor housing.

OPERATION

The centrifugal force of the small flyweights rotating at fuel pump camshaft speed and acting against the main and idling speed springs is used to achieve governing at all speeds.

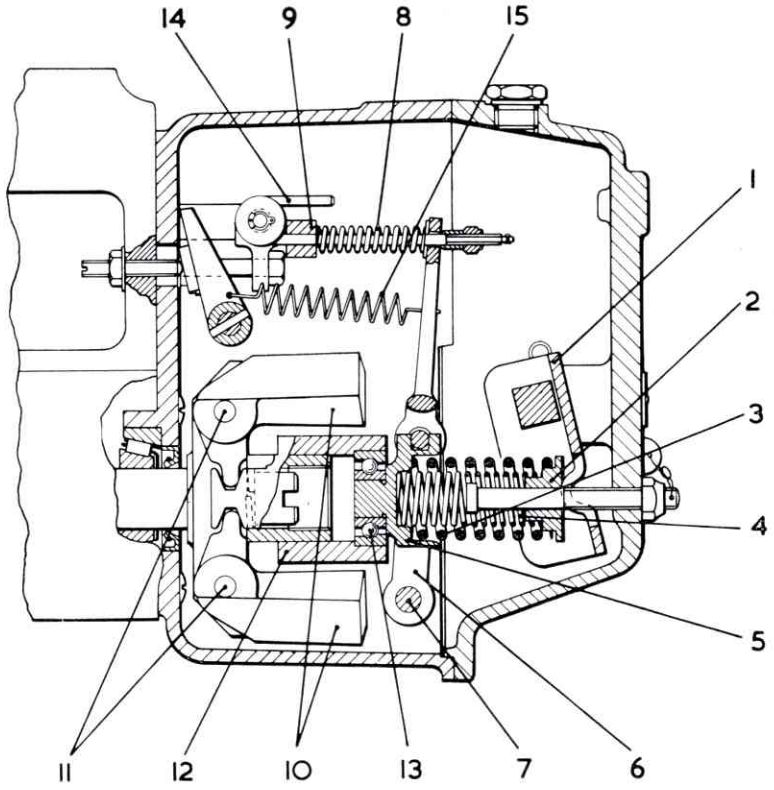


FIG. 85. SECTION THROUGH THE S.F. GOVERNOR

1. Lever.
2. Spring plate.
3. Main speed spring.
4. Idling speed spring.
5. Thrust block.
6. Actuating lever.
7. Spindle.
8. Spring.
9. Spring collar.
10. Governor weights.
11. Spindles.
12. Sleeve.
13. Ballrace.
14. Link hook
15. Spring.

Under normal conditions the operation of the governor is as follows:

To increase speed from idling the accelerator pedal is depressed, pulling back the accelerator lever which is mounted on the same cross-shaft as the lever (1) and the lever displaces the spring plate (2) towards the pump. This force is transmitted through the main and idling speed springs (3) and (4) to the thrust race block (5) which in turn moves the actuating lever (6) which pivots on the spindle (7) towards the pump. This movement is transmitted through spring (8) and spring collar (9) and pushes the control rod in the direction of the pump thus increasing the quantity of fuel delivered to the engine.

As the engine and pump speed increases the governor weights (10) which pivot on the spindles (11) fly outwards and exert a force away from the pump. This force is transmitted through the gear-tooth sections of the flyweights to sleeve (12) and ball race (13) mounted on the thrust race block (5) and thus moves the actuating lever (6) away from the pump.

This movement is transferred to link hook (14), connecting the actuating lever and control rod which is now pulled in the same direction away from the pump, thus reducing the quantity of fuel delivered, according to the engine requirements.

Starting

To start the engine, the accelerator pedal is fully depressed, moving the control rod to the maximum fuel position. As soon as the engine is running the accelerator pedal can be released and the control rod will then be brought back to the idling position by the action of the flyweights.

The idling position is pre-set by the external adjustable stop.

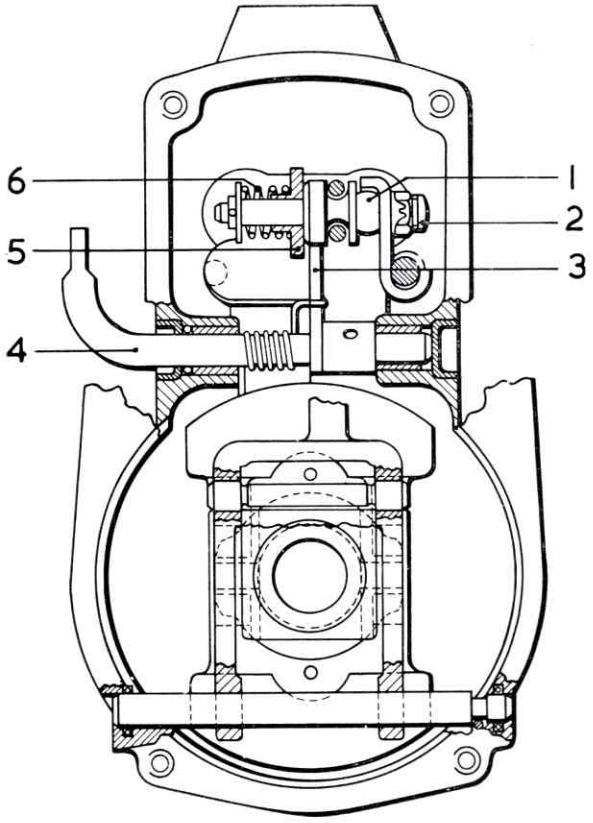


FIG. 86. SECTION THROUGH THE BAULKING TYPE EXCESS FUEL DEVICE

1. Control rod.
2. Excess fuel bolt.
3. Maximum fuel lever.
4. Stop shaft and excess fuel lever.
5. Collar.
6. Spring.

EXCESS FUEL DELIVERY

Refer to Fig. 86.

With the engine stationary and the accelerator pedal fully depressed the control rod (1) is in the normal maximum fuel position, e.g. the step on the excess fuel bolt (2) which is attached to the control rod, abuts against the face of the maximum fuel lever (3). To obtain excess fuel for starting purposes, the stop shaft and excess fuel lever (4) is pulled outwards, the maximum fuel lever (3) moving outwards also against collar (5) to compress spring (6). The control rod can now travel beyond the normal maximum fuel position until the excess fuel bolt abuts against the face of the maximum fuel lever.

To Stop the Engine

Refer to Fig. 85.

The stop shaft and excess fuel lever is pulled backwards through 40°. This causes the edge of the maximum fuel lever to contact the step on the excess fuel bolt attached to the control rod, which is thus pulled back to the no fuel position, compressing spring (8) mounted on link hook (14).

THE HYDRAULIC GOVERNOR

C.A.V. HYDRAULIC GOVERNOR—RHF 60C

EXPLANATION OF TYPE NOMENCLATURE

R	Governor fitted at right-hand end of injection pump.
H	Hydraulic type.
F	Design change number.
60	Symbol number denoting special features.
C	Rotation looking at driving end of injection pump (C=clockwise).

GOVERNOR DATA

Relief valve setting at 100 r.p.m.	High pressure 47/51 p.s.i. (3.3/3.6 kg. s.cm.). Low pressure 25/27 p.s.i. (1.8/1.9 kg. s.cm.).
Idling closing pressure	18±0.5 p.s.i. (2.7±0.035 kg. s.cm.).
Governor maximum hystereses	30.

DESCRIPTION

The governor is attached directly to the rear of the fuel injection pump, Fig. 79.

The maximum fuel stop, which also incorporates a baulking type excess fuel device for ease of starting, is located in the governor housing.

Safety is ensured by the employment of a shut-down lever that can be operated manually against the operation of the governor. In addition, the servo spring will take the control rod back to zero if for any reason the oil pressure fails.

The governor uses the normal fuel oil, drawn from the injection pump, as its operating medium. A duct connects the fuel oil gallery of the pump with the inlet to the governor gear pump which provides the operating pressure.

The gear pump, mounted on the lower extension of the main casing, is of simple construction employing two hardened and ground gears of normal involute form. It is driven from a sleeve on the camshaft through a self-aligning coupling to relieve the gears of side loading due to the drive. The gear pump is constructed in three parts, one carries the bearings for the spindles, the intermediate portion, of cast iron and face ground to close limits, contains the gears, and the assembly is completed by a plain aluminium cover, the three being dowelled and held together by studs passing through to the mounting face. No gaskets are used at the joint faces.

All the moving parts of the governor are carried in inserted sleeves or bushes, those for the main pistons and plungers being fully floating to avoid distortion, compressible synthetic rubber rings being employed to seal against leakage. The materials used for their construction are specially selected for the suitability for operation in fuel oil and no special provision for lubrication is made. Thus, the governor calls for no routine maintenance whatsoever, beyond the normal attention to the fuel filters. Scrupulous cleanliness of fuel is essential, as the performance of the governor can be seriously impaired by the presence of dirt, but the standard of filtration necessary is no higher than is in any case demanded by the injection pump itself.

OPERATION

The governor embodies a principle of hydraulic governing which enables extreme accuracy and sensitivity of control to be achieved. This principle, resulting from careful analysis of the behaviour of hydraulic mechanisms has been evolved after considerable development, during which many promising systems were tried and discarded. The problem was finally solved by the principle of the "inverted hydraulic amplifier" by which a small change in pressure in one part of the system produces in another part an opposite change of much greater magnitude.

The application of the above-mentioned hydraulic principle can be seen by reference to Fig. 87.

The gear pump (A) picks up fuel oil from the fuel gallery of the injection pump and delivers it under pressure through a diffuser (D) to the amplifier chamber, from which the fuel oil escapes through the orifice in the amplifier piston (F). The pressure drop through the orifice will set up an endwise thrust on the amplifier piston, depending upon the amount of fuel oil flowing, i.e., upon the gear pump, which in turn is proportional. to engine speed, since the gear pump is directly driven from the camshaft of the injection pump.

The fuel oil after passing through the amplifier piston, is led to the servo piston (G), where it moves the servo piston against the servo piston spring (H). This servo piston is coupled to the control rod of the injection pump (J), and the movement referred to has the effect of moving the injection pump control rod towards the "open" position and so increasing the pump delivery. The pressure generated at this point is limited by the high pressure relief valve (C). Excess of pressure causes oil to be released through this valve to the inlet connection of the gear pump.

The end thrust on the amplifier piston, previously referred to, causes this piston to bear against the stem of the amplifier valve (E), tending to open this valve. This tendency is resisted by the load on the control spring (T). The control spring loading is varied by the control pawl (U), which is keyed to the control shaft (W) and operated by the selector pedal linkage through lever (Y). Depressing the accelerator forces the outer plunger (S) towards the inner control plunger (R), thus compressing the control spring (T) to increase the load on the amplifier valve. The amplifier valve will thus open at a pressure dependent upon the control pawl

A. Gear pump.
B. Low-pressure relief valve.
C. High-pressure relief valve.
D. Diffuser.
E. Amplifier valve.
F. Amplifier piston.
G. Servo piston.
H. Servo piston spring.
J. Injection pump control rod.
K. Drag link.
L. Swing link.
M. Idling valve inner spring.
N. Idling valve.
O. Idling valve outer spring.
P. Idling valve outer plunger.
Q. Adjusting screw.
R. Inner control plunger.
S. Outer control plunger.
T. Control spring.
U. Control pawl.
V. Idling valve lever.
W. Control shaft.
X. Maximum speed stop-screw.
Y. Control lever.
Z. Idling speed stop-screw.
Al. Vent plugs.

A. Gear pump.
B. Low-pressure relief valve.
C. High-pressure relief valve.
D. Diffuser.
E. Amplifier valve.
F. Amplifier piston.
G. Servo piston.
H. Servo piston spring.
J. Injection pump control rod.
K. Drag link.
L. Swing link.
M. Idling valve inner spring.
N. Idling valve.
O. Idling valve outer spring.
P. Idling valve outer plunger.
Q. Adjusting screw.
R. Inner control plunger.
S. Outer control plunger.
T. Control spring.
U. Control pawl.
V. Idling valve lever.
W. Control shaft.
X. Maximum speed stop-screw.
Y. Control lever.
Z. Idling speed stop-screw.
A1. Vent plugs.

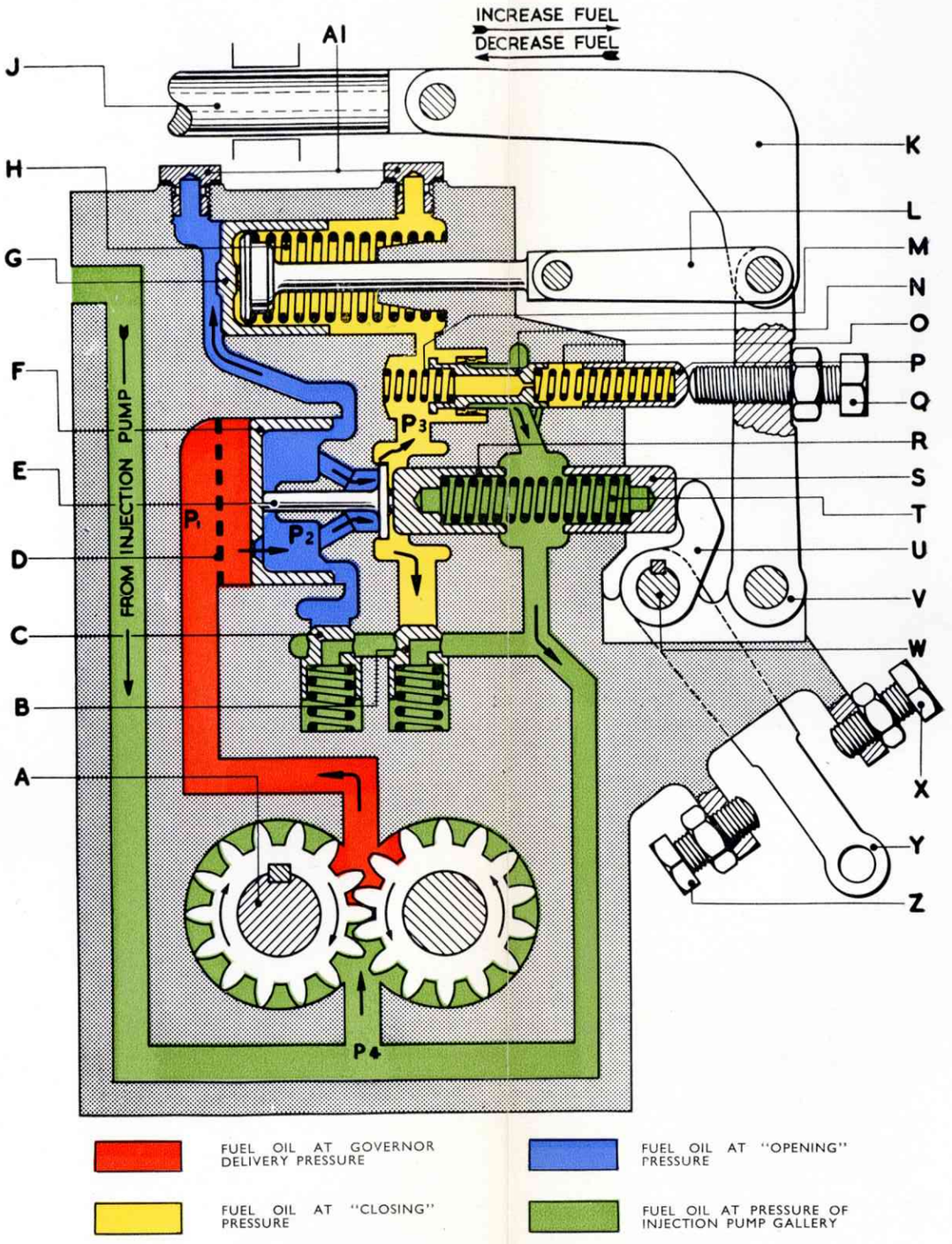


FIG. 87. DIAGRAM SHOWING PRINCIPLE OF OPERATION OF THE H-TYPE GOVERNOR

position selected by the driver. The fuel oil which flows through this valve is led to the inside of the servo piston, where it acts to assist the servo piston spring (H) in opposing the "opening pressure" and brings the servo piston to a state of balance, depending on the difference between the "opening pressure" and "closing pressure".

This "closing pressure" is limited by the low pressure valve (B) which opens under excess pressure and returns fuel oil to the inlet side of the gear pump. Also in communication with the "closing valve" is the idling valve (N). This valve can allow fuel oil to escape to the gear pump inlet through slots in the idling valve body which are opened and closed by a collar on the valve piston.

The idling valve is designed to give greater sensitivity under idling conditions that can be given by the amplifier alone, with the lower rates of fuel oil flow obtained at idling r.p.m.

It will assist the explanation of the operation of the idling valve if we first study the governor lever (V). This is pivoted at its lower end. At the upper end it is coupled, through a swing link (L), to the servo piston. The upper end also carries a drag link (K), which is connected to the injection pump control rod. At an intermediate point the lever carries an adjusting screw (Q), against which the idling valve outer plunger (P) bears. Thus, the plunger (P) also has a motion proportional to those of the servo piston and control rod.

The two plungers (N) and (P) of the idling valve assembly are held apart by the outer spring (O), while the inner spring (M) is placed between the inner plunger (N) and the governor housing, holding both plungers towards the governor lever and the adjusting screw.

A small orifice through the inner plunger (N) allows fuel oil at "closing pressure" to fill the space between the plungers, but restricts the passage of fuel oil in or out of this space. In other words, a dash-pot action is obtained.

For rapid movement of the control rod, governor lever and outer plunger (P), such as are usual under "idling" conditions, the restriction causes the fuel oil to be trapped between the two plungers and, in consequence they move as one solid plunger. This gives the idling valve assembly a high momentary rate, such as is suitable to maintain steady idling.

For slow movements and permanent changes of position, the fuel oil pressures on either side of the orifice can equalise themselves, due to the steady flow of oil through the orifice. In this case, since there is no hydraulic unbalance, the inner plunger (N) will take up a position which depends not only on the position of the outer plunger (P), but also on the rate of the inner and outer springs (M) and (O), since their loads must be equalised.

The outer spring (O) has one-half the rate of the inner spring (M). Thus a permanent change of position of the outer plunger (P) will cause the inner plunger (N) of change its position by one-third of the movement to (P).

The effect of this is to reduce the effective permanent rate of the governor, so that for any change of load or resistance at idling, the resultant change of idling r.p.m. is small.

Returning to the flow through the idling valve, it will be seen that a movement of the control rod and idling valve plunger towards the "open" position will allow the idling valve to move outwards, so that the inner plunger (N) closes off the slots. This restricts the flow of fuel oil through the valve, raises the "closing" pressure and brings the servo piston and control rod back towards the "closed" position. Thus the valve tends to hold the control rod, and also the engine speed, at a steady position depending upon the adjustment.

The actual speed of the engine, from idling to top speed, is selected by the position of the control pawl (U), as determined by the accelerator pedal position and linkage. The governor will adjust the fuel supply to bring the engine speed to the selected value, subject of course, to the limitation imposed by the maximum power available.

The idling valve adjusting screw (Q) referred to as being carried midway on the governor level, is used to adjust the sensitivity of the governor at idling.

To complete this explanation of operations a short account of the sequence of events from starting to running on load is now given.

Starting

The accelerator pedal is pressed to full travel; this has the effect of loading the amplifier valve and keeping it off its seat. The engine is now rotated by the starter motor and the gear pump begins to deliver fuel oil to the governor. The quantity of oil flowing is small at

this speed, and the pressure drop across the orifice of the amplifier is also very small; in consequence, no appreciable end thrust is developed. Thus the amplifier valve stays closed, and the fucl is trapped against the servo piston. As the "opening pressure" rises, the servo piston will force the control rod open and fuel is delivered to the engine; this continues until the engine fires.

First Firing

The engine fires and runs up to speed. The increased flow of fuel oil sets up a pressure difference across the amplifier piston, which thrusts against, and opens, the amplifier valve. This admits fuel oil to the "closing" side of the servo piston, which moves over and also operates the control rod, reducing the fuel supply to the engine. If the accelerator pedal is now released, the governor will steady the engine to run at idling speed through the influence of the idling valve.

Running Up

Engine speed will now respond to pedal movement. Pedal depression causes a load to be put on the amplifier valve through the control spring and control pawl, which will cause the valve to close either partially or completely, depending on the amount of depression of the accelerator pedal. This cuts off the supply of fuel oil to the "closing" side of the servo piston, and at the same time causes a sharp rise of pressure on the "opening" side, since the fuel oil there cannot escape. The result is to move the servo piston sharply to the "open" direction and with it the control rod, increasing the fuel delivery until the engine accelerates to the new speed selected. When this speed is reached, the amplifier piston will again force open the amplifier valve against the increased control spring load, thus admitting fuel oil to the "closing" side of the servo piston. The servo piston and control rod will again be brought back to the balance position required to hold to new engine speed.

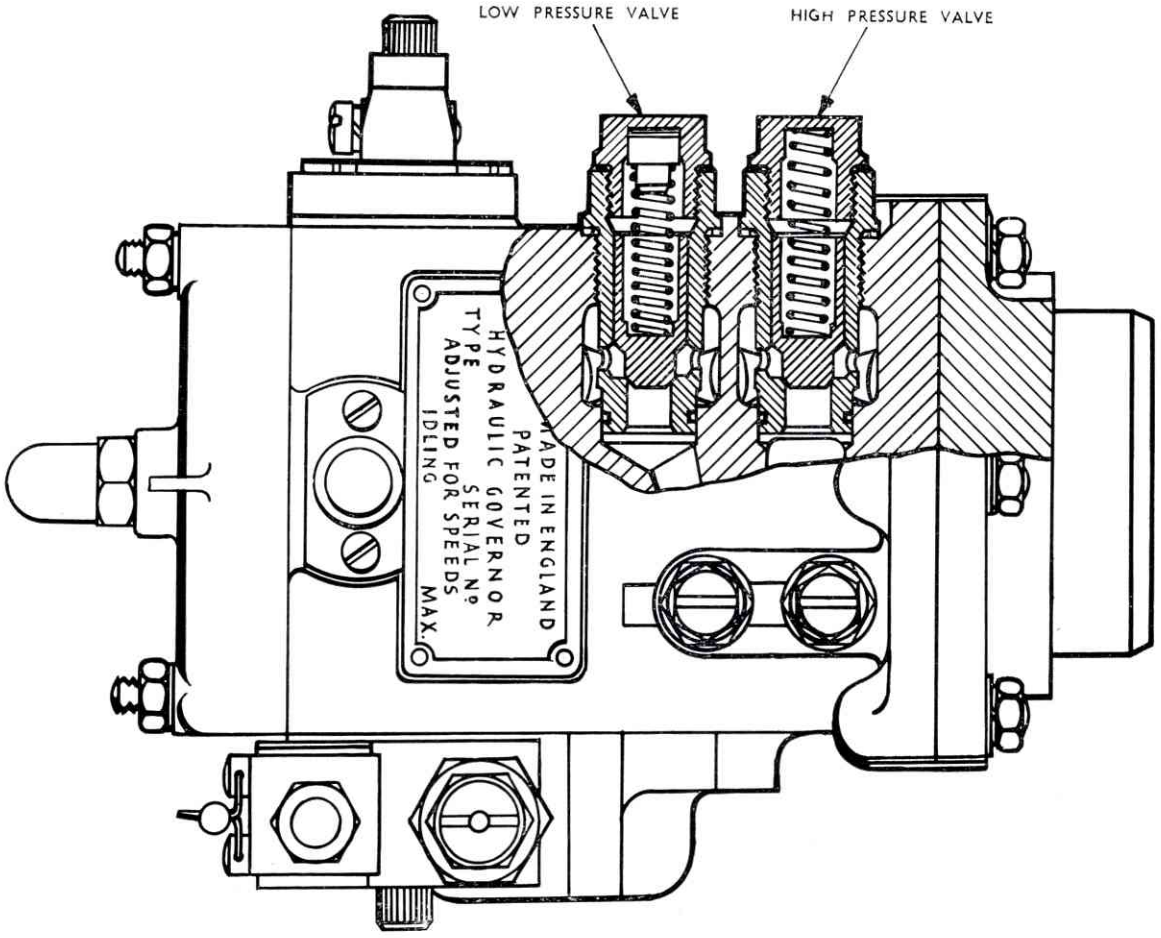
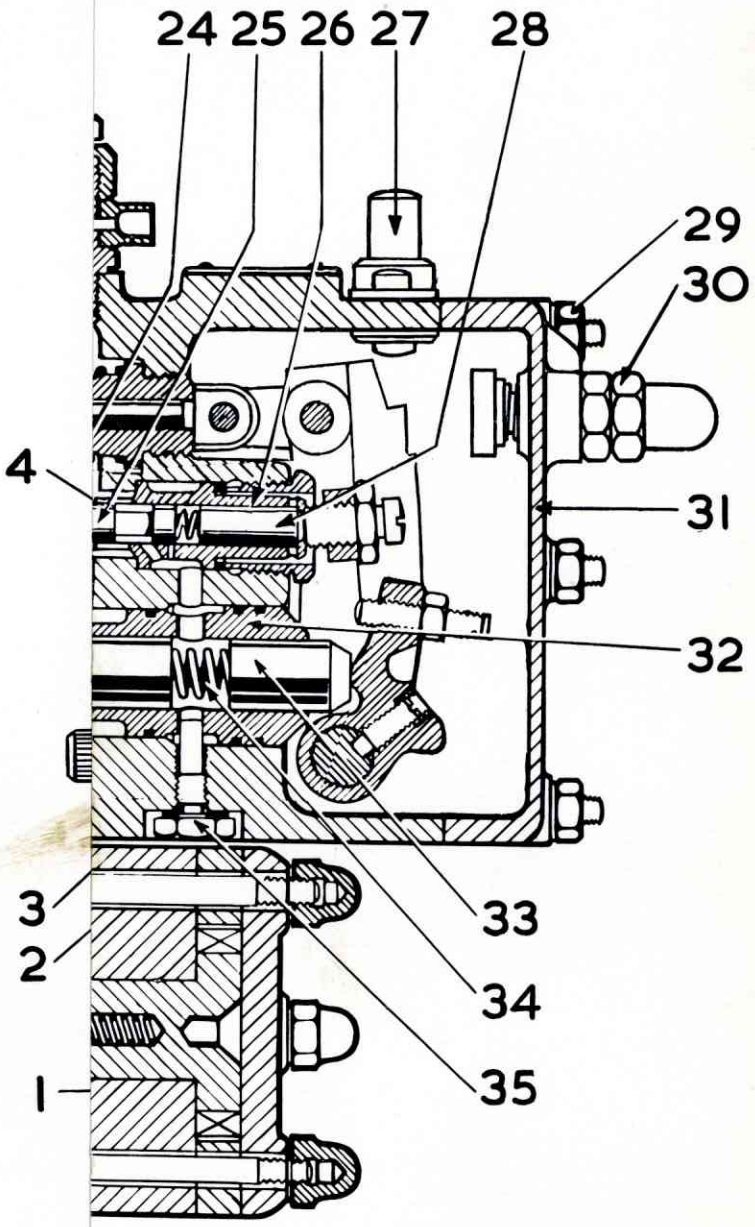


FIG. 88. CUT-AWAY VIEW OF THE GOVERNOR SHOWING RELIEF VALVES

1. Gear pump assembly securing nuts
2. Bearing flange.
3. External pawl.
4. Control pawl.
5. Tab washer for (6).
6. Link adjustment nut.
7. Stopping control lever.
8. Control rod connecting link.
9. Accelerator lever.
10. Cross shaft.
11. Bearing flange.
12. Governor lever.
13. Sleeve for (16).
14. Amplifier valve assembly.
15. Amplifier valve assembly.
16. Orifice piston.
17. Diffuser assembly.
18. Sleeve for (19).
19. Servo piston.
20. Governor securing nuts.
21. Circlip.
22. Spring collar.
23. Servo spring.
24. Compression spring for (25).
25. Inner idling plunger.
26. Idling valve body.
27. Excess fuel device plunger.
28. Outer idling plunger.
29. Securing nuts for (31).
30. Maximum fuel stop assembly.
31. Housing cover.
32. Control plunger sleeve.
33. Control plunger.
34. Compression spring for (33).
35. Locating screw for (32).
36. Compression spring for (37).
37. Coupling dog.



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2. Bearing flange.
3. External pawl.
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9. Accelerator lever.
10. Cross shaft.
11. Bearing flange.
12. Governor lever.
13. Sleeve for (16).
14. Amplifier valve assembly.
15. Amplifier valve assembly.
16. Orifice piston.
17. Diffuser assembly.
18. Sleeve for (19).
19. Servo piston.
20. Governor securing nuts.
21. Circlip.
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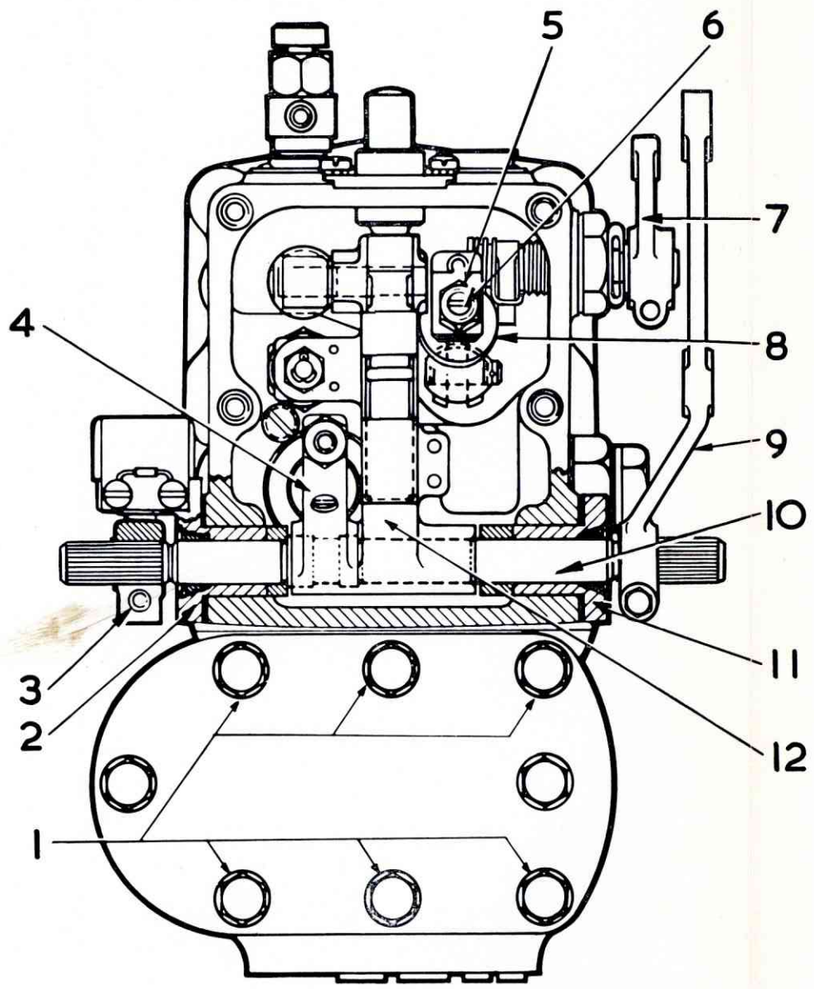
35. Locating screw for (32).
36. Compression spring for (37).
37. Coupling dog.



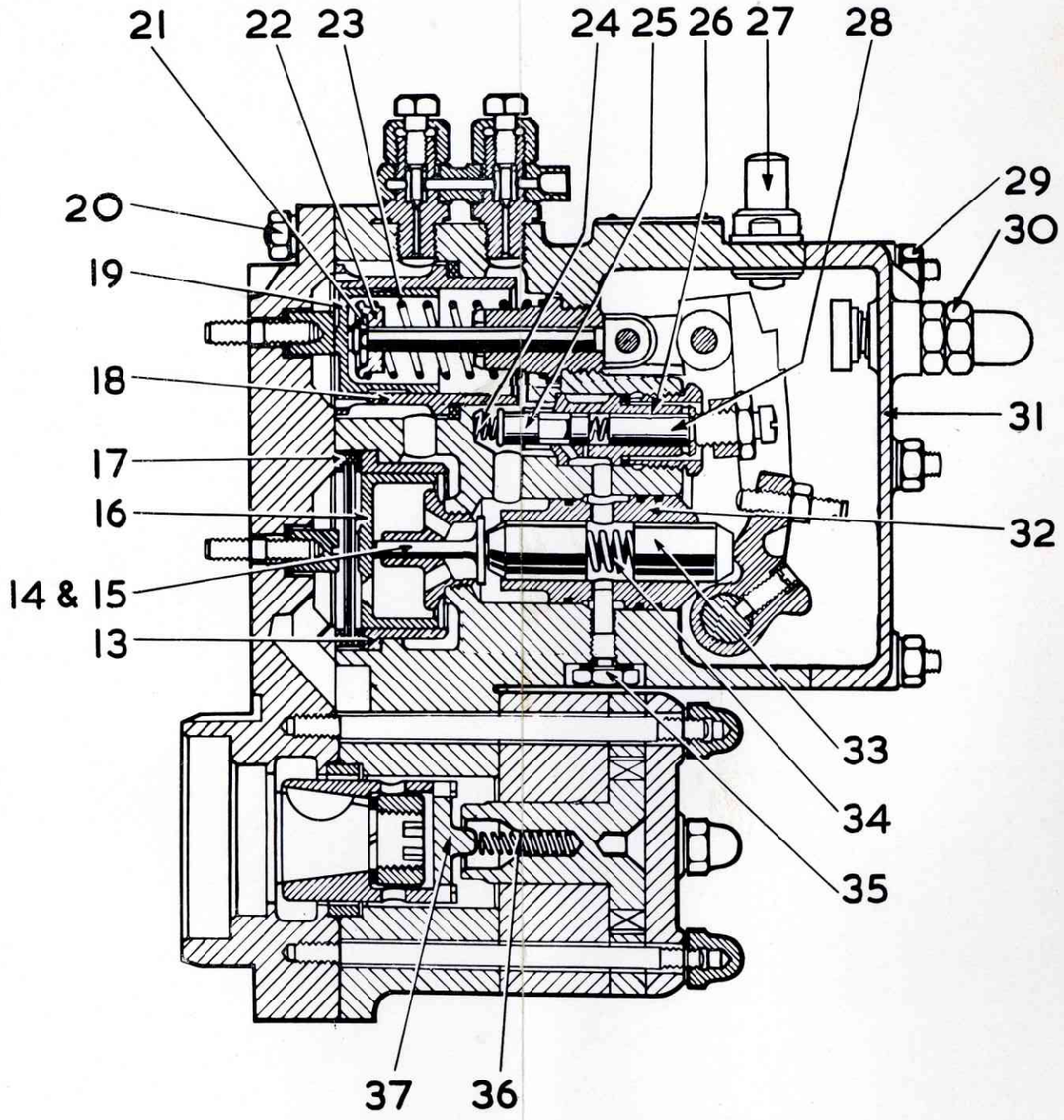


FIG. 89. SECTIONS THROUGH THE H-TYPE HYDRAULIC GOVERNOR

Running on Load

If load is now applied to the engine, the governor will endeavour to maintain the engine speed constant. If the speed drops slightly, due to increase of load, the reduced fuel oil flow lowers the amplifier piston end thrust, allowing the amplifier valve to close a little. This restriction increases the "opening pressure" so that the piston opens a little further. This increases the fuel delivery and the engine speed until the loss of engine speed has been recovered. Further depression of the accelerator pedal will increase the speed at which the engine runs, and more power will then be available at the higher speed.

The process may be repeated until the maximum fuel stop on the pump prevents further opening of the rack, at which point the engine will be giving the maximum power and torque available at the speed setting selected.

Top Speed Limitations

The engine speed depends upon the selected position of the control pawl (U). The motion of this pawl is limited by a control lever (Y), both lever and pawl being keyed to the control shaft (W).

Screw stops (X) and (Z) bearing against the arms of the stop pawl, are used to set limits of motion. Screw (X) is set to allow the maximum r.p.m. desired while (Z) selects the idling r.p.m. In actual practice the latter screw is spring-loaded.

MAXIMUM FUEL STOP AND BAULKING TYPE EXCESS FUEL DEVICE

The construction of the excess fuel device is shown in Fig. 90. Basically, the device consists of a control lever (6) connected to the control rod link and pivoted on a shaft (8). Free to slide in a shroud (5) riveted to the control lever is a stop block (2) acted upon by two springs (3) and (7). A stepped portion of the stop block is engaged in an aperture in the shroud. At the top of the governor housing a spring-loaded plunger is protected at its upper end by a rubber cap (14) and can be depressed to engage the excess fuel device.

An adjustable stop (12) is screwed into the housing cover. Spring-loaded shims (11), located between the

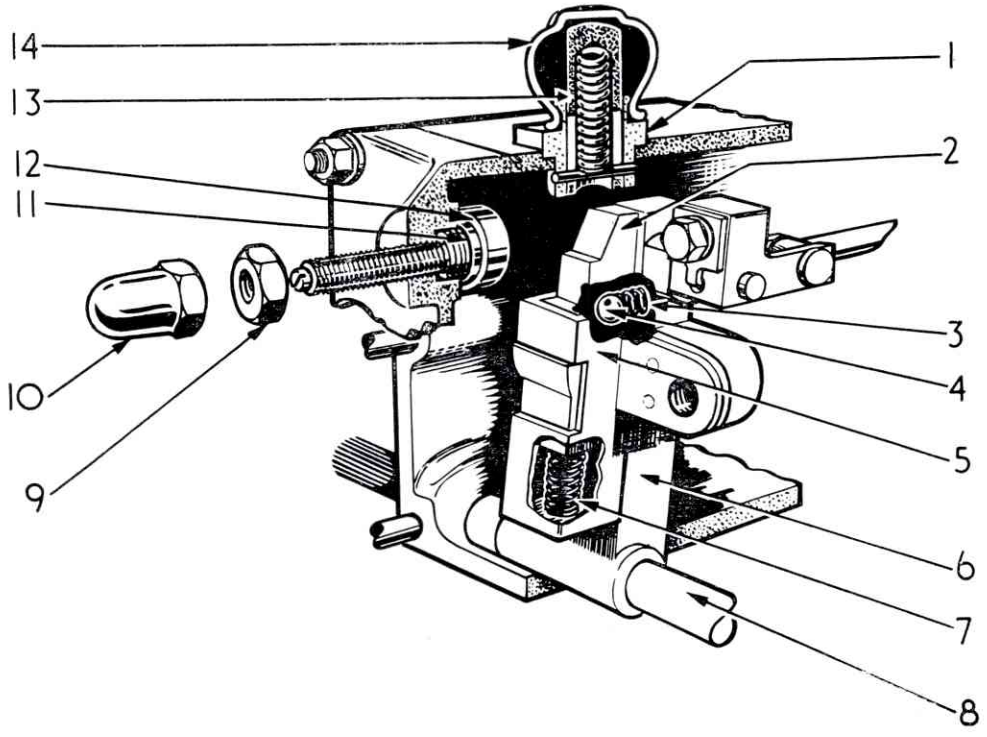


FIG. 90. MAXIMUM FUEL STOP AND BAULKING TYPE EXCESS FUEL DEVICE

1. Bush.
2. Stop block.
3. Spring.
4. Ball.
5. Shroud.
6. Control lever.
7. Spring.
8. Shaft.
9. Locknut.
10. Cap nut.
11. Shim.
12. Adjustable stop.
13. Plunger, spring-loaded.
14. Rubber cap.

head of the stop and the housing cover limit the maximum setting that can be obtained by adjusting the stop. The stop is locked by means of a locknut (9), the setting being protected from unauthorised adjustment by a capnut (10) suitably drilled to receive wire seals.

The excess fuel selecting button is mounted on the top of the governor housing and has a spring return action. On depressing the button, a sliding block mounted on the internal operating lever is tripped into the excess fuel position. The button is then allowed to return to its normal position under the influence of its return spring.

When the engine starts, the sliding block attached to the internal operating lever moves towards the governor rear cover, through which is screwed a fuel stop. On making contact with this stop the sliding block is released and returns to the normal maximum fuel position.

The maximum fuel stop can be adjusted from outside the governor after removing the domed nut and releasing the locknut. **Screw in to decrease** or **screw out to increase** maximum fuel. The stop screw has a head on the internal side of the cover which prevents removal of the screw from the outside. Shims are fitted under the head of the stop screw when the governor is initially set so that the vehicle operator cannot increase the maximum fuel excessively without breaking the seals and removing the cover.

Note: It is not possible to select excess fuel when the engine is running, nor is it possible to start the engine while the operating button is depressed.

On no account should the engine be accelerated with the end cover removed, otherwise the control rod will move almost its complete travel and thereby seriously over-fuel the engine.

The operation of the excess fuel device is illustrated diagrammatically in Fig. 91.

In **View A,** the excess fuel device is shown in the normal maximum fuel position, with face (M) of the stopblock (3) and opposite the stop (2).

To obtain excess fuel for starting, plunger (1), **View B,** is depressed, forcing stop block (3), down shroud (5), and engaging lip (4) against the top of the aperture in

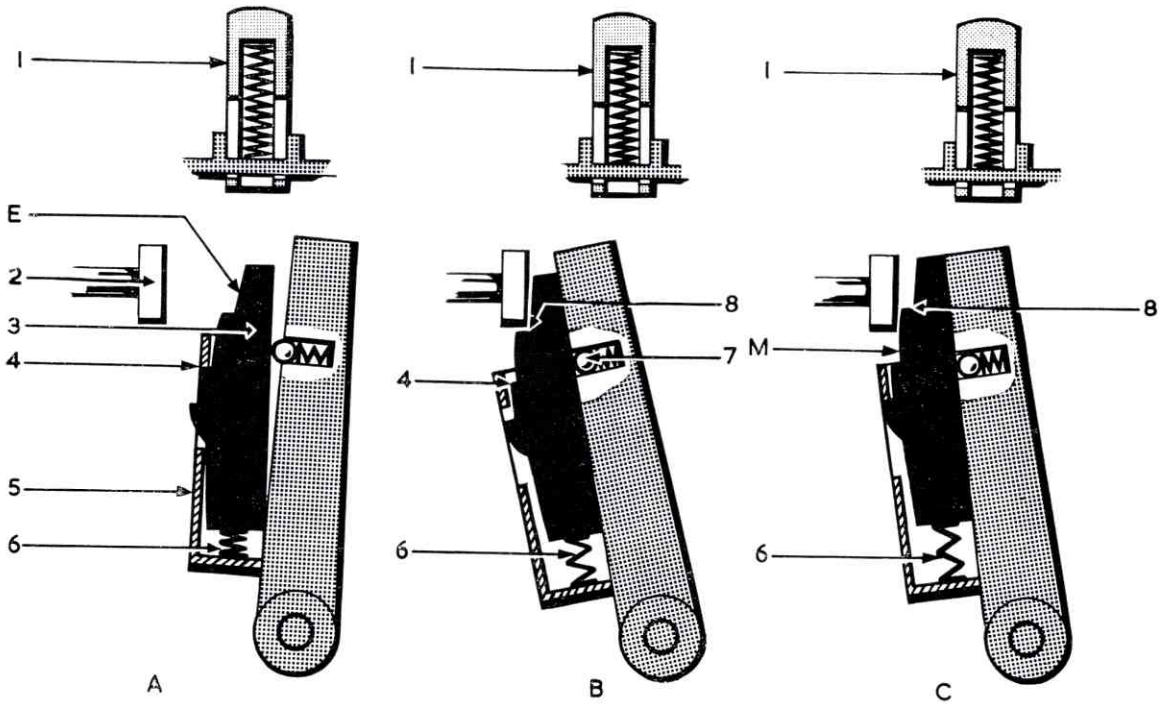


FIG. 91. DIAGRAM SHOWING THE OPERATION OF THE EXCESS FUEL DEVICE

1. Plunger.
2. Stop.
3. Stop block.
4. Engaging lip.
5. Shroud.
6. Spring.
7. Spring-loaded ball.
8. Lip.

the shroud, as shown. This maintains face (E) of the stop block opposite the stop (2) and enables the control lever to be rotated to the excess fuel position.

When the control lever is moved to the excess fuel position, as shown in **View C,** the stop block butts against the stop and is forced slightly to the right, against the lateral thrust of spring-loaded ball (7). Lip (4) is disengaged from the slot in the shroud and, under the effect of spring (6), the stop block moves upwards until lip (8) bears against the underside of the stop, as indicated.

As the engine speed increases, the governor moves the control lever assembly to the right, towards the no-fuel position. This trips lip (8) from the underside of the stop and allows spring (6) to move the stop block. Face (M) will now be opposite the stop (2) so as to satisfy normal maximum fuel requirements.

TESTING AND ASSEMBLING PROCEDURE

With normal usage and maintenance the governor will operate effectively for exceptionally long periods without trouble. If any difficulty is experienced, or repairs and adjustments are ultimately necessary it is recommended that the work should be placed in the hands of the nearest C.A.V. Depot or Agent.

Where adequate facilities exist for servicing, together with the necessary tools and skilled labour, the work of adjustment, dismantling, assembly and testing can be carried out by adhering carefully to the following instructions.

EQUIPMENT FOR TESTING

To test the governor a power-driven test machine as used for testing the injection pump is necessary. In addition to this a number of special fitments are required as detailed:

1. 1 off—0/80 p.s.i. (0/6 kg. s.cm.) gauge (4 in. (102 mm.) diameter).

2. 1 off—0/40 p.s.i. (0/3 kg. s.cm.) gauge (4 in. (102 mm.) diameter).

3. 2 off—3 ft. 6 in. (1 m.) flexes or synthetic hoses with connections.

4. 2 off—adaptors for governor housing.

5. 2 off—restrictors with air vents for the gauges.

6. 1 off—"F" type filter.

7. 1 off—gravity vent valve in "F" type filter.

8. 1 off—measuring glass 0/22 c.c.

9. 1 off—pair pump supports.

10. 1 off—0/25 p.s.i. (0/2 kg. s.cm.) gauge.

The first two gauges with restrictor valves should be firmly mounted 18/24 in. (0.5/0.6 m.) above the governor. Fix the two adapters into the governor housing in place of the vent valves. Attach the 0/80 p.s.i. (0/6 kg. s.cm.) gauge to the high pressure side and the 0/40 p.s.i. (0/3 kg. s.cm.) to the low pressure side, by means of the two 3 ft. 6 in. (1 m.) flexes or hoses. It is important to mount the gauges above the governor at the specified height as any appreciable alteration in this height will affect the pressures obtaining in the governor for a given gauge reading.

Furthermore, as limits on pressures are small, the gauges should be checked frequently to maintain an accuracy of plus or minus 0.5 lb. (0.035 kg.).

Restrictor valves with air vents should be fitted to prevent violent fluctuations in pressure, and to enable the system to be thoroughly air vented. Fit the 0/25 p.s.i. (2 kg. s.cm.) gauge to the air vent in the pump suction gallery.

The "F" type filter is secured to the test machine. With a lift pump in circuit the filter should be connected between the lift pump and injection pump. This simulates the same conditions as when operating on the engine.

The measuring glass is used to obtain the total back leakage, which is obtained by fixing a pipe to the pump housing drain union and leading the fuel to the measuring glass.

The pump supports are fitted to the test machine bed to support the pump and governor.

C.A.V. Tool list No. 1067 illustrates the various special tools.

Attachments for converting the Hartridge test machine are available from the manufacturers.

METHOD OF TESTING

The injection pump must be calibrated and phased before these tests are carried out.

Preparing the Unit for Test

1. Remove the end covers from the governor and pump control rod or from excess fuel device if fitted at pump end. Remove the guard plates from external speed stops.

2. Mount the pump on the test machine. Connect the pump outlets to the test machine by the delivery pipes. The feed delivery should be via a pressure filter type "F" with gravity vent valve. In this case the pipe from the lift pump to the pressure filter should not be more than 2 ft. 6 in. (0.8 m.) long and the effective head not more than 2 ft. (0.6 m.) above the feed pump. The suction side to the feed pump should not exceed 3 ft. (0.9 m.).

3. Connect, via the adaptors, the 0/80 p.s.i. (0/6 kg. s.cm.) gauge to the vent nearest the pump and the 0/40 p.s.i. (0/3 kg. s.cm.) gauge to the vent farthest from the pump. Connect feed pressure gauge 0/25 p.s.i. (0/2 kg. s.cm.) to pump.

4. Supply with test oil and bleed pump suction gallery, also thoroughly bleed the governor by running the machine at 100 r.p.m. with vents open and moving the control rod sharply several times.

5. Check that the feed pressure in the pump gallery is 3/5 p.s.i. (2/3.5 kg. s.cm.) at 200 r.p.m.

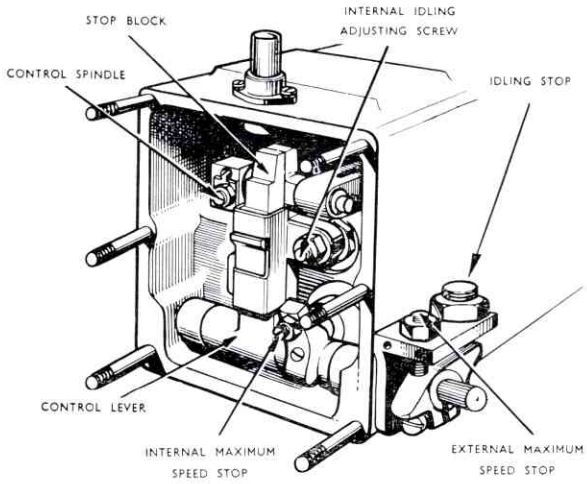


FIG. 92. DETAILS OF THE GOVERNOR STOPS

6. Remove the internal and external maximum speed stop screws and screw back the idling speed stop screw, Fig. 92. Screw the maximum full stop outwards to give maximum control rod travel and lock.

TEST PROCEDURE

Relief Valve Setting

7. Run the machine at 100 r.p.m. with the accelerator lever (9), Fig. 89, at full maximum position. All the gear pump delivery will now pass through the high pressure relief valve.

8. Observe the pressure on the 0/80 p.s.i. (0/6 kg. s.cm.) gauge and adjust the relief valve to the pressure required, 47/51 p.s.i. (3.3/3.5 kg. s.cm.) by means of shims in the counterbore only of the closing plug, and finally check that the valve has the correct lift in the body; this should be a minimum of 1 mm. (0.039 in.).

9. Run the machine at 100 r.p.m. with the accelerator lever in the lowest speed position, and now close the idling circuit, by using tool C.A.V. Part No. 7044/606 to pull fully open the governor internal control lever, Fig. 92. All the pump gear delivery will now pass through the low pressure relief valve.

10. Observe the pressure on the 0/40 p.s.i. (0/3 kg. s.cm) gauge and adjust the relief valve to the required pressure 25/27 p.s.i. (1.7/1.8 kg. s.cm.) by means of shims C.A.V. Part No. 7095/143 in the counterbore only of the closing plug and finally check that the valve has the correct lift in the body; this should be a minimum of 1 mm. (0.039 in.). Remove high pressure valve connections and replace vent valve.

Governor Link Adjustment

11. Run the machine at 1,000 r.p.m. with the accelerator lever in the lowest speed position and "open" the pump control rod by screwing the governor link adjustment (6), Fig. 89, through the governor lever until a trace of fuel is injected. Now screw the adjustment back towards the control rod closed position 1/1½ turns to cut off fuel delivery. Check that injection ceases at the shut-off position within the prescribed limits of 130/150 r.p.m.

Idling Setting

12. Run the machine at the correct speed for idling setting (170 r.p.m.) with both the external idling speed stop screw and idling valve adjusting screw fully unscrewed, Fig. 92. Screw in the idling valve adjusting screw to bring the servo closing pressure on the 0/40 p.s.i. (0/3 kg. s.cm.) gauge to the correct setting of 18 p.s.i. (1.3 kg. s.cm.). Adjust the idling speed stop to give correct idling delivery of 3.6/4.4 c.c. per 200 shots.

This will probably alter the servo closing pressure and further adjustment of the idling stop screw will be necessary.

By simultaneous adjustment of both stops the correct pressure and idling fuelling can be obtained.

The threads of the idling stop screw should now be just showing through the bracket. Check that the idling pawl is on the correct serration.

13. Remove the low pressure gauge and replace the vent valve.

Maximum Fuel Setting

14. Check that the excess fuel device is in normal (free of excess) position. Run the machine at 600 r.p.m. with accelerator lever in full speed position and adjust maximum fuel stop screw to give the calibration figure. See **To Recalibrate the Injection Pump.** When the baulking type excess fuel device is fitted inside the governor instead of the excess fuel device at pump end, check also that it is in normal maximum position and fit governor end cover. Carry out adjustments of maximum fuel stop screw which projects through the cover to give the specified delivery, and lock the stop temporarily.

Maximum Speed Setting

15. Test on the machine at maximum governed speed with the accelerator lever at full speed position. Remove end cover and adjust the internal maximum speed stop so that the control rod is just beginning to move towards no fuel position at the correct speed. The control rod movement can be observed at the pump end. Lock the internal maximum speed stop, Fig. 92.

Governor Checking

16. Run the machine speed up from 50 r.p.m. below the specified maximum speed with the accelerator lever (9), Fig. 92, at full speed position, and check that the governor commences to cut-off at the specified maximum speed and is completely cut off within the prescribed "over-run" figures of 130/150 r.p.m.

17. Check the difference between cut-off and commencement of pumping when increasing or decreasing speed with the accelerator lever at full speed position (i.e., the hysteresis). The difference should not be more than 30.

18. Check that at 1,200 and 1,300 r.p.m. the governor will not allow any fuel delivery and the control lever remains on the closed position abutment.

19. Set the external maximum speed stop to contact the stop pawl when the internal maximum speed stop meets its abutment. Lock the stop.

Internal Stop Setting

20. When the baulking type excess fuel device is fitted, the stop screw in the governor requires setting as follows:

Measure the distance of the head of stop screw from the cover and pack with shims. C.A.V. Part No. 5339-290 A.H., if necessary, so that control rod travel cannot be exceeded.

Excess Fuel Device Operation

21. Set the machine to run at 80 r.p.m. Depress the knob of the excess fuel device.

Place the accelerator lever in the full fuel position. Start the machine and observe that the control rod moves to the excess fuel position with 3 or 4 revolutions; also, that when the control rod is allowed to return, the excess fuel device returns to normal maximum fuel position. The control rod movement can be observed at the pump end.

22. Stop the machine. Check that the difference in the control rod position between normal maximum fuel and excess fuel is 3.5/4.0 mm. (0.137/0.157 in.).

23. Check that all adjustments are locked.

24. Replace and tighten the control rod cover; also the guard plate on the external stop.

Emergency Stopping Device

25. Adjust the emergency stopping device as follows:

Slack the nut clamping the stopping lever to the stop lever sleeve. Pull the lever right forward and partly tighten the clamp nut. Fit complete cover to governor, with gasket in place, and secure firmly the four bottom nuts.

Pull the accelerator lever to the **Stop** position with sufficient force to overcome the spring-loaded idling stop (if fitted). Remove the cover and tighten the clamping nut without movement of the lever. Replace and tighten the cover.

Check that operation of the accelerator lever (or manual stopping lever, if fitted) will push the control rod on to the **Stop** position. Check that at idling position the stop pawl is not held off the idling stop, and the control rod can be pushed by hand to the normal maximum fuel position without disturbing the accelerator lever from the idling position.

Hot Leakage Test

26. Mount the pump on the test machine which holds the pump, if possible on a longitudinal slope of 10° (governor end lowered). Fill the cambox with approximately ½ pint (0.07 litre) of good quality lubricating oil. Supply with fuel oil heated to 140°F. (60°C.). Run at full delivery at 800 r.p.m. Inspect for leaks and rectify, then recommence test. Test should be of 60 minutes' duration.

Draining Rate

27. The pump element back leakage test will have been carried out during the pump test, but the normal fuel oil leakage from the hydraulic governor system must also be checked. This drains into the cambox and the total leakage from the cam box drain should be measured during the second half-hour period of the **Hot Leakage Test,** which must not exceed 30 c.c. in 30 minutes or 30 c.c. per minute where internal gravity vent valve is fitted. The pump must run steadily during the test period and for at least five minutes before the test period starts. The accelerator lever should be moved occasionally during the test.

TESTING THE GEAR PUMP

Stalled Pressure Test

1. The gear pump requires a special test rig which is mounted on the test machine.

2. The flow control cock is opened, the motor started up and speed adjusted to 25 r.p.m.

3. Time must be allowed with the control cock wide open to allow all air to be pumped from the complete system.

4. The control cock must now be carefully closed down until the pressure gauge attached below the cock shows at least 50 p.s.i. (3.5 kg. s.cm.) pressure.

5. If the pump will not develop at least 50 p.s.i. (3.5 kg. s.cm.) pressure with the cock fully closed, the pump must be rejected.

This maximum pressure attained with outlet closed off is known as the "stalled" pressure. If it is too low at slow speeds the governor will not open up to the excess fuel position at engine starting speeds.

A low stalled pressure indicates too much clearance between the outside diameters of pinion and the pump housing shroud plate internal bores and/or between the end faces of pinions and internal faces of pump body and cover plate.

Note: On no account must the pinions rub on the cast-iron shroud plate when the pressure is developed.

Pressure Fluctuation Test

If the pump passes the stalled pressure test the pressure fluctuation test is then carried out as follows:

1. The control cock is opened again and the speed is increased to 50 r.p.m.

2. The control cock is then carefully and slowly closed down until the pressure gauge shows a mean reading of 40 p.s.i. (3 kg. s.cm.).

3. Under this condition the pressure fluctuation must not exceed 10 p.s.i. (0.7 kg. s.cm.), i.e., the pressure gauge must not fluctuate above 45 p.s.i. (3.2 kg. s.cm.) nor below 35 p.s.i. (2.5 kg. s.cm.) readings.

4. If the fluctuation is outside these limits the pump must be rejected as it would cause the governor and injection pump control rod to oscillate badly at camshaft r.p.m. frequency, and this effect would persist up to fairly high speeds.

   This in turn would cause the fuel injection quantities to fluctuate and the engine would have an objectional "beat" at camshaft frequency.

5. A large pressure fluctuation shown on the test rig indicates that the pump gear has one or more of three possible faults:

   (a) Non-uniform oil displacement during each revolution due to tooth spaces being of unequal volume, e.g., one cause of this could be eccentricity of tooth pitch line.

   (b) Non-uniformity of slip or oil leakage around pinions during each revolution owing to eccentricity of pinions outside diameters giving a variation of clearance between the pinion and shroud plate bores.

   (c) Non-uniformity of slip across pinion faces owing to faces not being square with the pump spindles and pinion faces not being parallel to each other.

Note: If the special test rig is not available it is advisable to obtain a reconditioned gear pump from the nearest C.A.V. Agent.

GRAVITY VENT VALVE

The gravity vent valve automatically air vents the low pressure side of the fuel injection system. While air is present in the system a mixture of air and fuel will pass through this valve until all air is expelled.

The vent valve is fitted to the main filter and the fuel piped back to the main fuel tank.

DIAGNOSIS AND RECTIFICATION OF FAULTS IN GOVERNOR

STATIC TESTS USING FEED PRESSURES ONLY

These static tests may be omitted if the running tests are to be carried out.

For Tests A, B and C

Leave gear pump at rest. Fix accelerator lever in full-on position to close amplifier valve. Manually operate feed pump continuously.

TEST A

Open both air vents and pull internal control lever slowly to full-out position, by means of tool C.A.V. Part No. 7044/696, then let it return slowly to full-in position. Repeat this operation several times.

Observe the motion of outer idling valve plunger and rate of fuel flow from low pressure (L.P.) vent.

1. The plunger should move in and out smoothly, keeping in contact with its adjusting screw on the internal control lever.

2. The flow should be heavy when plunger is in full-in position.

3. The flow should decrease progressively as plunger moves out and increase progressively as plunger moves in.

4. The flow should not be more than a slight trickle when plunger is in full-out position.

Note 1

If any of these four results are not obtained the most likely causes are:

Idling valve plungers sticking. Idling valve springs out of order or incorrect length. Examine idling valve assembly for these faults and rectify if found. Then repeat test (A). Results (1) and (2) should now be obtained.

Note 2

If results (3) and (4) are not now also obtained the most likely cause is:

L.P. relief valve not seating. This can be due to:

Foreign matter on seat. Valve sticking owing to foreign matter in clearance between valve and body. Valve sticking owing to distortion of body when assembled into housing. Examine L.P. relief valve assembly for these faults and rectify if found. Then repeat test (A3) and (A4).

Note 3

If results (3) and (4) are still not obtained the remaining possible causes are:

Bad face joint between idling valve body and housing. Rubber sealing rings on main control plunger sleeve and on a L.P. relief valve body not sealing. Any other bad face joints between L.P. spaces and feed pressure spaces. Slack fitting inner idling valve plunger. Inner idling valve plunger not covering off slots when in closed position. Slack fitting inner main control plunger. Examine assembly for these faults and rectify any found. Then repeat tests (A3) and (A4).

TEST B

With C.A.V. Tool Part No. 7044/696 hold internal control lever in full-out position to close idling valve and prevent loss of feed pressure.

Observe the rate of flow from high pressure (H.P.) air vent.

The flow should not be more than a slight trickle.

If flow is more than this remove gear pump, plug feed holes of the governor and repeat test.

Note 4

If the flow is more than this the most likely cause is:

H.P. relief valve not seating. This can be due to:

Foreign matter on seat. Valve sticking owing to foreign matter in the clearance between valve and body. Valve sticking owing to distortion of body when assembled into housing. Examine H.P. relief valve assembly for these faults and rectify if found. Then repeat test (B).

Note 5

If the flow is still excessive the remaining possible causes are:

Rubber sealing ring on H.P. relief valve not seating. Any bad face joints between H.P. and feed pressure spaces. Examine assembly for these defects and rectify any found. Then repeat test (B). When all correct results are obtained from tests (A) and (B) proceed to test (C).

TEST C

Keep internal control lever in full-in position to open idling valve and close the L.P. air vent to allow feed pressure to build up in the L.P. spaces. Leave H.P. air vent open.

Observe the rate of flow from H.P. air vent again.

The flow should not be more than a trickle.

Note 6

If the flow is more than this the most likely cause is:

Amplifier valve not seating. This can be due to:

Foreign matter on seat. Valve seized in body. Seat out of square. Examine amplifier valve for these faults and rectify if found. Then repeat test (C).

Note 7

If the flow is still excessive the remaining possible causes are:

Bad joint face between amplifier valve body and housing. Rubber sealing ring on servo piston sleeve not sealing. Any other bad joint faces between H.P. and L.P. spaces. Slack fitting servo piston. Clearances in gear pump too large. Examine for these defects and rectify any found. Test (C) will then be passed.

RUNNING TEST USING FULL GOVERNING PRESSURES

These tests should be done in preference to the static feed pressure tests.

Check leakage through H.P. relief valve statically as leakage through this valve cannot be observed while running. See test (B).

For Tests D, E and F

Connect a 0/80 p.s.i. (0/6 kg. s.cm.) pressure gauge to the governor H.P. air vent.

Connect a 0/40 p.s.i. (0/3 kg. s.cm.) pressure gauge to the governor L.P. air vent.

These pressure gauges should be fitted with air vent valves which may be opened to atmosphere when necessary.

Drive the gear pump at 100 r.p.m.

Close air vent valve on the H.P. gauge.

For Tests D and E

Hold the internal control lever in full-out position to keep idling valve closed.

TEST D

Open the air vent on the L.P. gauge.

Move accelerator lever from full-off position to full-on position and hold it there, to close the amplifier valve. Whilst doing this:

Observe the H.P. gauge and the rate of fuel flow from the open air vent on the L.P. gauge.

1. The high pressure should build up quickly to correct opening pressure of the H.P. relief, 47/51 p.s.i. (3.3/3.5 kg. s.cm.).

2. The fuel flow from the open air vent on the L.P. gauge should reduce to a trickle (3.5 c.c. per minute maximum).

3. With the air vent on the L.P. gauge closed, repeat the test, when the low pressure should build up very slowly or not at all.

Note 8

If result (1) is not obtained but results (2) and (3) are, the most likely cause is:

(a) H.P. relief valve not seating. This can be due to:

Foreign matter on seat.

Valve sticking owing to foreign matter in clearance between valve and body.

Valve sticking owing to distortion of body when assembled in housing.

(b) Pressure setting of H.P. relief valve incorrect.

(c) Rubber sealing ring on H.P. relief valve not sealing.

(d) Any bad face joints between H.P. and feed pressure spaces.

(e) Clearance in pump gear too large.

Examine for these defect and rectify any found.

Note 9

If the fuel flow from the open air vent valve on the L.P. gauge remains excessive and the low pressure builds up quickly when the valve is closed to a value exceeding feed pressure, the most likely causes are:

(a) Amplifier valve not seating, which can be caused by:

Foreign matter on seat.

Valve seized in body.

Seat out of square.

(b) Bad joint face between amplifier valve body and housing.

(c) Rubber sealing ring on servo piston sleeve not sealing.

(d) Any other bad joint faces between H.P. and L.P. spaces.

Examine for these defects and rectify any found.

Note 10

If the result (1) is obtained but the fuel flow from the open air vent on the L.P. gauge remains excessive and the low pressure builds up quickly when the valve is closed to a value equal to feed pressure, the most likely causes are:

(a) Idling valve not closing, which can be due to:

Idling valve sticking.

Idling valve spring out of order or incorrect length.

Examine idling valve for these faults and rectify if found.

(b) L.P. relief valve not seating, which can be due to:

Foreign matter on seat.

Valve sticking owing to foreign matter in clearance between valve and body.

Valve sticking owing to distortion of body when assembled in housing.

Examine relief valve for these faults and rectify if found.

(c) Bad face joints between idling valve body and housing.

(d) Rubber sealing rings on main control plunger sleeve and on L.P. relief valve body not sealing.

(e) Any other bad face joints between L.P. and feed pressure spaces.

(f) Slack fitting inner idling valve plunger.

(g) Inner idling valve plunger not covering slots when in closed position.

(h) Slack fitting inner main control plunger.

Examine assembly for these faults and rectify any found.

TEST E

Keep air vent on L.P. gauge closed. Allow accelerator lever to move to idling stop. Pull internal control lever to fully open position.

Observe the L.P. gauge.

The low pressure should now build up quickly to the correct opening pressure for the L.P. relief valve.

Note 11

If the low pressure does not build up as stated, check L.P. relief valve setting and correct if necessary.

TEST F

Allow the internal control lever to move slowly to the **full-in** position, then pull it out slowly to the **full-out** position. Do this several times to slowly open and close the idling valve and whilst doing so:

Observe the motion of the idling valve plunger and the L.P. gauge.

The plunger should move in and out smoothly, keeping in contact with its adjusting screw on the internal control lever.

The low pressure should decrease progressively to a low value (a few p.s.i. above feed pressure) when the control lever moves inwards to the full-in position. It should increase progressively to the correct opening pressure of the L.P. relief valve when the control lever is pulled to the full-out position.

Note 12

If the above results are not obtained the most likely causes are:

(a) Idling valve plungers sticking.

(b) Idling valve springs out of order.

The tests in this section are not to be used when generally testing but can be used to diagnose all trouble arising during general test.

REMOVING GOVERNOR FROM INJECTION PUMP

Refer to Figs. 89 and 90 during this operation.

1. Remove the six nuts, do not remove the two horizontally opposed nuts, and withdraw the gear pump assembly, with gasket complete from the studs, taking care not to drop the spring (36).

   Remove coupling dog (37).

2. Remove the six nuts (29) and withdraw housing cover (31).

3. Remove nut (6) and tab washer (5) from the spindle block.

4. Push spindle through spindle block and allow control rod connecting link (8) to swing down.

5. Push spindle in opposite direction and allow control lever (12) to swing clear.

6. Undo and remove internal nut (10), Fig. 93, remove outer idling plunger (28) and spring.

7. Unscrew seven nuts (20) and slowly remove governor assembly. Lay governor assembly on its back to ensure operating pistons do not fall out.

DISMANTLING GOVERNOR AFTER REMOVAL FROM PUMP

1. Remove the diffuser assembly (17), Fig. 89, then lift out orifice piston (16) and sleeve (13).

2. Remove servo piston (19) and sleeve (13).

3. Press back collar (22) against spring (23), remove circlip (21), then withdraw collar and spring and remove servo rod complete with link.

4. Remove both L.P. and H.P. relief valve assemblies, Fig. 88.

5. Unscrew amplifier valve assembly (14) and (15), Fig. 89, then remove control plunger (33) and spring (34).

6. Remove external pawl (3) and accelerator lever (9), then remove bearing flanges (2) and (11).

7. Remove grub screw from control pawl (4) and withdraw cross-shaft (10) and remove control pawl and control lever (12).

8. Using tools C.A.V. Part No. 7044/692 and Part No. 7044/712, remove plunger sleeve (32) after removing screw (35).

9. Remove gland nut, then with tool C.A.V. Part No. 7044/693 withdraw idling valve body (26), inner idling plunger (25) and spring (24).

After removal all mated parts should be immersed in clean paraffin or test oil.

Do not split the gear pump unless it has been found faulty.

ASSEMBLING THE GOVERNOR UNIT REMOVED FROM PUMP

1. Fit control plunger sleeve (32), Fig. 89, using tools C.A.V. Part No. 7044/692 and 7044/712. Remove the tools and fix sleeve with screw (35).

2. Fit idling valve body (26) with inner idling plunger (25) and spring (24). Replace gland nut, tighten and lock with screw. Check that idling plunger is still free.

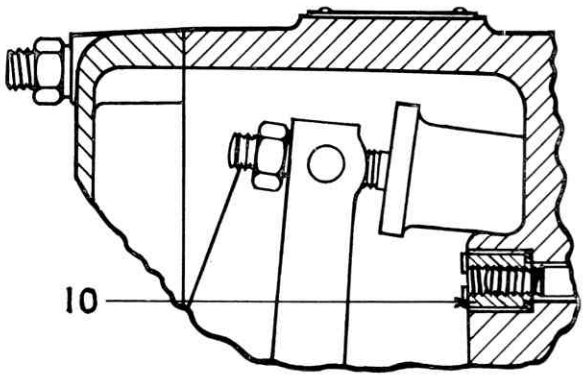


FIG. 93. THE INTERNAL SECURING NUT

3. Fit cross-shaft (10) complete with control lever (12) and control pawl (4). Check control lever is free on cross-shaft and that pawl is not tight on its serrations.

4. Fit bearing flanges (2) and (11) complete. Tighten up and check that cross-shaft is still free.

5. Enter servo rod complete with link into guide, fit spring (23), then secure with collar (22) and circlip (21).

6. Enter the two control plungers (33) and spring (34) in control plunger sleeve (32) and fit amplifier valve assembly (14) and (15).

7. Fit H.P. and L.P. relief valves, Fig. 88.

8. Fit servo piston (19) and sleeve (18), Fig. 89. Ensure that piston is free for the complete length of sleeve by using C.A.V. Tool No. 7044/696.

9. Fit orifice piston (16) and sleeve (13). Before the governor is fitted to the injection pump a check must be made that the servo sleeve is pressing correctly into the synthetic rubber housing unit. To do this, place a new joint on the assembled governor, place a test diffuser C.A.V. Part No. 7044/733 in place of the normal diffuser and bolt on plate C.A.V. Part No. 7044/703 firmly

   Now ensure both servo and orifice pistons are free. Remove plate and test diffuser.

   The servo sleeve should have marked a complete ring on the synthetic rubber joint, proving it is sealing through 360°.

10. Place normal diffuser assembly (17) in position (gauze side uppermost).

11. Fit governor to sandwich plate on pump and secure with internal nut (10), Fig. 93.

12. Secure all external nuts holding governor to sandwich plate, fit outer idling plunger (28) and spring, Fig. 89. Swing up governor lever complete with spindle, push spindle through servo rod link and then move in opposite direction into link block, fit tab washer (5) and nut (6).

13. Fit sundries.

14. Fit gear pump assembly to give correct rotation.

Note: If new bearing flanges are fitted, line reamer these in position with reamer C.A.V. Part No. 7044/705.

FAULT FINDING

These notes cover various faults which may arise in the operation of the "H" governor in service.

It is strongly recommended that thorough venting of pump and governor should be carried out as a general practice before commencing any detailed checking.

Fault	Possible Cause	Action Suggested
1. Engine will not start	A. Air in governor and pump	Vent thoroughly both pump and governor. If this fault occurs whenever the vehicle is idle for a period, inspect the system for leaks which could allow fuel to drain from pump to governor, or for air leaks on the suction side of the feed pump.
	B. Pump control rod jammed	Check. If control rod is jammed or tight, examine governor linkage stopping lever, servo piston rod, etc., followed by check on freedom of pump quadrants, plungers, etc.
	C. Control pawl not operating control plunger	Examine connections from accelerator pedal to governor lever; if the parts have been disturbed, check that the control pawl is in the correct position relative to stop pawl.
	D. H.P. relief valve open	Check this valve for freedom, correct pressure, and condition and fit of sealing rings.
	E. Gear pump not pumping	Fit new gear pump, after checking that the gear pump drive end clearance is sufficient. A simple check can be carried out as follows:—Offer the gear pump to the governor housing minus the joint and if the gear pump will go right home, then it will be seen that once the joint is fitted it will have further clearance. When this check is being carried out it will be clear that the tongue drive must be fitted.
	F. Diffuser screen blocked	Remove unit from governor, fit new part and retest.
	G. Servo piston sticky Amplifier piston stuck Amplifier valve stuck open Inner control plunger stuck Control spring broken or collapsed. Amplifier valve seat loose.	Remove unit from governor, fit new part or free existing part and retest.
2. Engine top speed very low	A. Speed stop out of adjustment	Check internal and external stops and readjust as necessary.
	B. Pedal linkage errors	Check linkage to governor operating lever from accelerator pedal.
	C. Diffuser screen blocked	Remove unit from governor. Fit new diffuser and retest.
	D. H.P. relief valve sluggish	Check on test rig for pressure as laid down in test schedule.

3.	Engine top speed too high	A. Speed stop out of adjustment	Check internal and external stops and readjust as necessary.
		B. Stop bracket loose	Tighten up fixing screws.
		C. Air in governor	Vent thoroughly.
4.	Engine will run at top speed, but not at intermediate speeds	Emergency stopping lever set too far forward, prevents control rod from opening unless control pawl is in position for high speed	Reset stopping device.
5.	Engine surges at part load	A. Air in governor	Vent thoroughly.
		B. Interference with normal movement of pump control rod	Check freedom of movement. If control rod is tight, check freedom of quadrants, plungers, etc., also governor linkage motion of governor lever on cross-shaft, etc.
		C. Stickiness on hydraulic plungers	Remove unit, strip governor and check freedom of amplifier piston and valve, inner control plunger, servo piston and rod, and idling valve and plunger.
		D. Faulty gear pump	Fit new gear pump.
		E. Servo spring out of square	Fit new spring, making sure of correct length and rate. Replace and test unit.
		Note: Surges due to B or C will be slow and heavy.	
6.	Engine stalls on deceleration	A. Idling speed too low	Adjust to speed recommended for the engine. It is possible that an engine will be able to idle at speeds much below normal when fitted with a hydraulic governor, but the speed should not be allowed to go much lower than that recommended.
		B. Amplifier valve not seating correctly	Remove unit, strip governor, remove amplifier valve and check seat.
		C. Adjustment of linkage between governor and pump is incorrect	Adjust as instructions.
		D. Stopping device not correctly adjusted	Adjust as instructions.
		E. Idling pressures not correctly adjusted	Remove unit and adjust governor on test machine as recommended for the particular type.
		F. Pump or governor motion sticky	Treat as for Items 5B and 5C.
		G. Idling valve plungers sticky	Remove and free the plungers.
		H. H.P. relief valve leaking	Check for pressure setting, seat tightness and seals.
7.	Engine idling speed unsteady	A. Air in pump or governor	Vent thoroughly.
		B. Idling pressures not correctly adjusted	Remove unit and adjust governor on test machine as recommended for the particular type.
		C. Governor motion sticky	Treat as for Items 5B and 5C.

	D. Idling valve plunger sticky	Remove and free the plungers.
	E. Incorrect adjustment of idling valve	Reset as testing instructions.
8. Engine will not stop	A. Stopping device not adjusted correctly	Adjust as testing instructions.
	B. Linkage incorrectly adjusted	Check linkage.
9. Engine will not give full power	Adjustment of linkage between pump and governor is incorrect	Adjust governor link as instructions.

Note: If the fuel tank has run dry a thorough venting of the system is needed after refilling. Use the priming lever of the lift pump.

THE FUEL FEED PUMP

The diaphragm type feed pump, Fig. 94, is mounted on the side of the injection pump housing and provides an uninterrupted supply of fuel oil at constant pressure to the injection pump inlet.

Basically, the pump consists of a diaphragm (14), clamped between the cover (7) and scavenge pump (13). The diaphragm is displaced, during the suction stroke of the pump, by a cranked lever (9) following an eccentric on the injection pump camshaft.

OPERATION

As the camshaft turns, the thrust imposed on the cranked lever (9) by the eccentric displaces the diaphragm and causes a depression above the inlet valve disc (5). The disc valve lifts against its spring and fuel is drawn from the inlet (1) into the cavity in the cover.

The camshaft, during completion of its revolution, relieves the thrust on the cranked lever and the diaphragm is returned to its former position by the spring (11). The return movement of the diaphragm enables disc valve (5) to close and forces fuel out of the cavity and past the ball valve (2). Fuel is thus fed through the pump outlet to the injection pump fuel gallery, via the filter in the supply line.

The maximum pressure exerted on the fuel is determined by the strength of spring (11). When the supply piping and injection pump gallery are full the fuel pressure in the cavity will tend to balance the pressure exerted by the spring and limit the return movement of the diaphragm. In consequence, smaller quantities of fuel will be delivered by the lift pump until the engine requirements increase.

To prevent excessive wear, the extremities of the cranked lever are provided with hardened steel surfaces where they contact the spring plate and eccentric. In addition, the lever (9) is provided with a spring to ensure close contact with the eccentric and eliminate hammering when the diaphragm is not making its full stroke.

SCAVENGE PUMP

The scavenge pump, Fig. 95, consists of a plunger (19) and ball valves (15) and (18) housed in a sandwich plate (17), which is fitted between the feed pump cover and body. The pump plunger is operated by the lower arm of the compound bell-crank lever.

When the oil in the injection pump sump rises above its normal level, the excess oil flows through a passage to the underside of ball valve (18). During the downward stroke of the spring-loaded plunger the oil is transferred to the top side of the ball valve. Then on the upward stroke of the plunger the oil is forced past spring-loaded ball valve (15) and thence through piping to the main fuel tank.

Depression of the small lever on the left-hand side of the fuel feed pump, displaces the diaphragm a full stroke as in normal running. The small lever is spring-loaded to keep the priming mechanism out of engagement during normal operation of the feed pump. The priming mechanism is inoperative when the foot of the bell-crank lever is on the lobe of the cam.

OVERHAUL

Refer to Fig. 94.

The feed pump is simple in design and there is little possibility of trouble arising during operation. In the unlikely event of complete failure or spasmodic fuel delivery, the following points should be checked:

1. Wash in clean petrol or paraffin the ball valve (2) and disc valve (5).

2. Check pipe connections for leakage, and ensure that there are no air leaks at the two faces which sandwich the diaphragm.

3. Examine the diaphragm and renew if necessary.

4. If there appears to be excessive back leakage in the injection pump cambox, examine diaphragm and scavenge pump before suspecting the pump elements.

To Remove and Replace Valves

1. Unscrew union (1), Fig. 94, to detach disc (5) and spring (4), the ball valve (2) can then be dismantled by unscrewing valve seat (3) from union (1).

2. Replace the valves in the opposite order to that given above.

To Remove the Diaphragm

1. Unscrew six nuts (6) and remove spring washers, and remove the cover (7).

   Note: Do not attempt to remove diaphragm complete with spindle but carry out the following operations:

2. Ease edges of diaphragm leaves from sandwich plate.

3. Press back diaphragm towards the body to expose flats on the back end of spindle (10), and using the flats to prevent spindle from turning, remove nut (8) and washer. Remove diaphragm and support plates as a unit.

To Replace the Diaphragm

1. Separate the support plates from the diaphragm leaves and clean all the old sealing compound from spindle, plates and sleeve.

2. Apply sparingly gold size, Hermatite or a similar

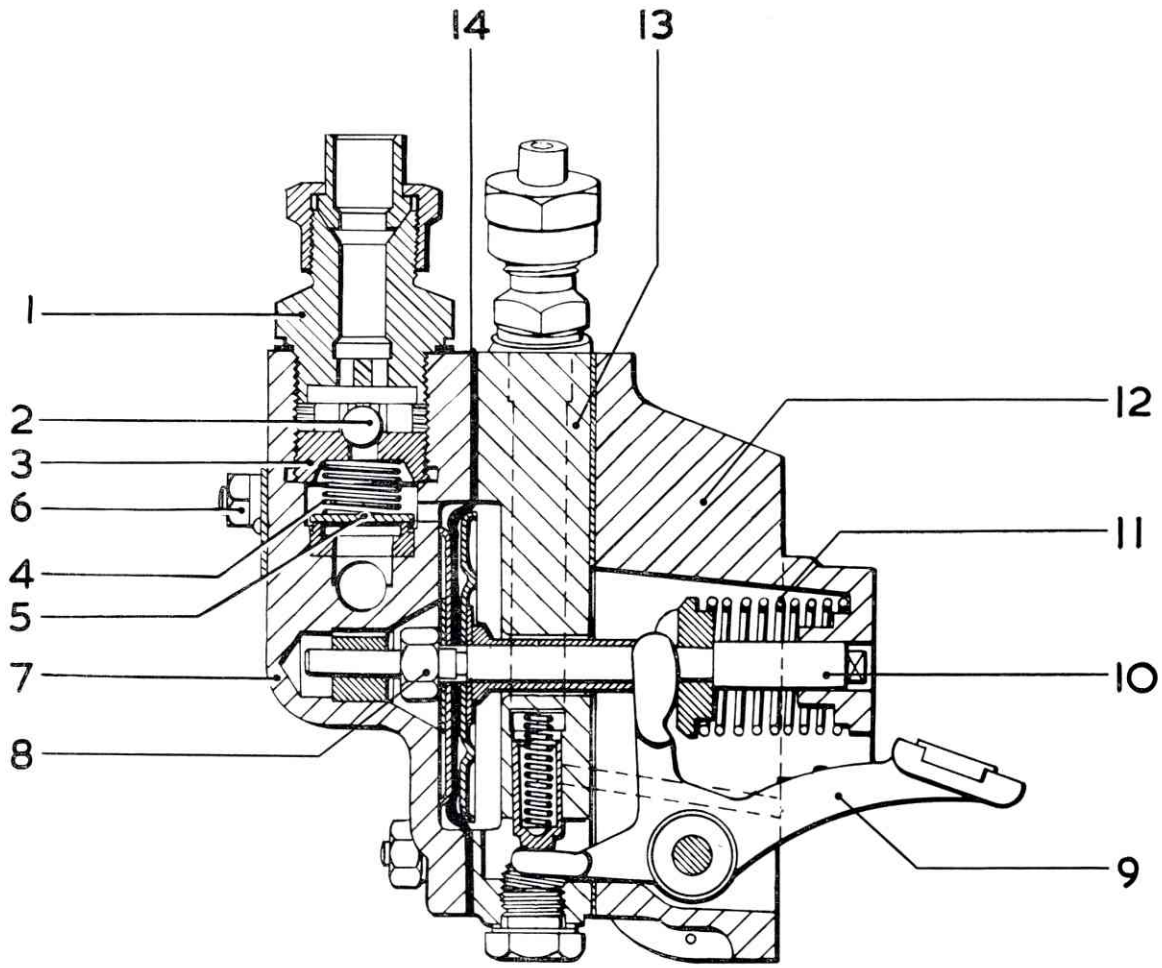


FIG. 94. SECTION THROUGH THE FUEL FEED PUMP

1. Inlet union.
2. Ball valve.
3. Valve seat.
4. Spring.
5. Inlet valve disc.
6. Nut.
7. Cover.
8. Nut.
9. Lever.
10. Spindle.
11. Spring.
12. Body.
13. Scavenge pump.
14. Diaphragm.

compound to the spindle thread, the large end of the sleeve and to the inner of the support plates on a diameter of approximately 1 in. (25.4 mm.).

3. Fit the sleeve with the large end turned away from the operating lever.

4. Fit the washer, and large support plate with turned-over edge towards sleeve.

5. Fit the diaphragm leaves (ensuring, when these are of the corrugated type, that the outer corrugations register over the large support plate).

6. Fit the small support plate with its flat side towards diaphragm pack, and fit also the remaining washer.

7. Lock together by means of nut (8), taking care that the diaphragm pack is not twisted or distorted in the final tightening.

8. Ensure that no leakage can take place between diaphragm and spindle.

Note: When flat diaphragms are fitted the operating lever must be pushed to the full stroke position before all the parts are clamped together.

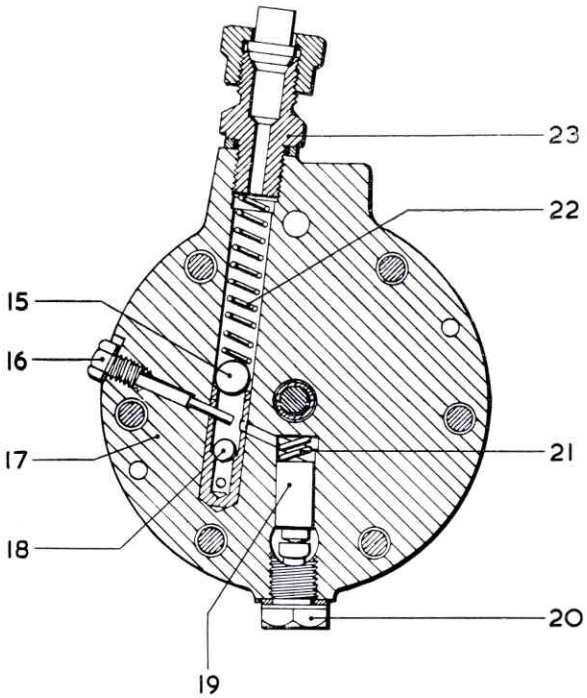


FIG. 95. SECTION THROUGH THE SCAVENGE PUMP

15. Ball valve.
16. Plug.
17. Sandwich plate.
18. Ball valve.
19. Plunger.
20. Plug.
21. Spring.
22. Spring.
23. Union.

To Dismantle the Scavenge Pump

Refer to Fig. 95.

1. Unscrew the adapter (23) and remove spring (22) and ball (15).

2. Unscrew plug (16) and remove ball (18).

3. Remove the plug (20) and withdraw the plunger (19) and spring (21).

4. Wash parts in clean petrol or paraffin and inspect for damage or wear. Do not wipe with cloth or small particles of rag may adhere to them.

5. Reassemble by reversing the dismantling procedure.

Note: The ball (18) must be inserted before ball (15), as the plug (16) restricts the movement of the ball (18).

Testing the Scavenge Pump

Refer to Fig. 95.

1. Remove the plug (20), plunger (19) and spring (21).

2. Test the ball (15) by applying air pressure 10 p.s.i. (0.7 kg. s.cm.) to union (23) and immerse the sandwich plate in oil. Any wear or deterioration of the valves will be indicated by bubbles.

3. Withdraw the ball (15) and spring (22), insert a synthetic rubber plug in the plunger bore and repeat the above-mentioned procedure to test the ball (18).

Note: Check scavenge pump operation if there appears to be excessive back leakage in the injection pump cambox.

FEED PUMP FILTER

A small filter is located in a recess in the pump cover. This filter should be removed and cleaned by means of a stiff brush dipped in petrol or fuel oil when the pump is dismantled.

THE FUEL OIL FILTER

The fuel oil filter is fitted to the crankcase directly below the fuel injection pump, Fig. 78.

DESCRIPTION

The filter, Fig. 98, is of the cross-flow type, the inlet and outlet connections (16) and (2) being carried on the cover (1) which also incorporates a bracket for support. The filter bowls (20) are of pressed steel and form oil-tight containers for the paper elements (9), air vent plugs (4) are fitted to the cover (1). Drain plugs (14) are provided at the bottom of the filter bowls.

The paper elements, wound round a circular core in the form of a spiral, are contained in a thin metal canister. The winding is done in such a manner as to provide a very large filter area within minimum filter bowl dimensions, and actually each element gives six times the filter area of the normal cloth filter within a bowl of approximately two-thirds the size. The method of construction and the direction of flow of the fuel oil are shown in Figs. 96 and 97.

Fig. 96 shows diagrammatically the way in which the paper spiral is constructed. Dirty oil is confined to the undersides of the paper coils and filtered oil to the upper sides. The large filtering surface will be apparent.

Fig. 97 shows the path taken by the fuel in passing through the element. The actual number of turns of paper is, of course, much greater than depicted in the diagram, the paper being wound closely but allowing continuous oil space between adjacent turns.

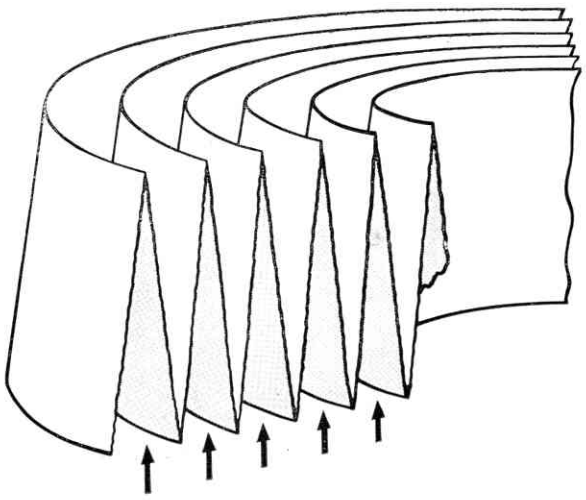


FIG 96. THE METHOD OF CONSTRUCTION

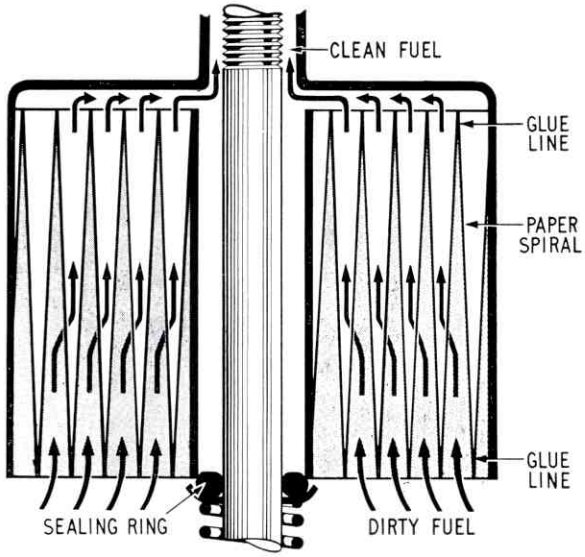


FIG. 97. THE DIRECTION OF FLOW

OPERATION

The fuel oil enters the filters through the inlet connection (16), Fig. 98, and passes down outside the element canisters, then up through the element filters (9) and finally emerges via the central outlet at the top of the elements and so out through the outlet connection (2).

Dirty fuel oil is excluded from the clean side of the elements by means of oil seals (11) at top and bottom of the element core, oil tightness of the seals being maintained by the pressure of spring (13).

MAINTENANCE

The importance of care in replacing the element, avoiding dirt on the clean side of the filter, cannot be over-emphasised, as many complaints of fuel pump element wear can be traced to lack of care in the servicing of filters. When choking takes place, this is usually found to be due to a waxy sludge which is deposited from the fuel. If filters are found to choke in an unreasonably short time this will probably point to an unsatisfactory fuel supply or storage tank installation, and steps should be taken to find how, and at what point, an undue amount of impurities can enter the system.

Paper elements are not intended to be cleaned and must be discarded when choked.

Due to the widely differing conditions of operation which have to be catered for, precise instructions for servicing intervals cannot be stated for paper elements.

The period at which it will be found necessary to change the filter element will, naturally, vary according to the type of fuel used, provision made for bulk storage, settling or pre-filtering before filling the vehicle tank, and the local conditions under which the engine concerned is operating.

To Service the Paper Element Filter

1. Thoroughly clean the outside of the filter bowls and cover.
2. Slacken off drain plugs to allow oil to drain from filter bowls (the vent plugs must also be slackened off). The plugs need not be removed for this purpose. If the sludge holes are blocked, retighten the plugs.
3. Unscrew central top cap nuts to release filter bowls.
4. Withdraw bowls containing filter elements from cover.
5. If draining through the bottom plugs was found to be impossible, push each filter element down against the spring until the top is level with the edge of the bowl, swill round the contents and pour out to

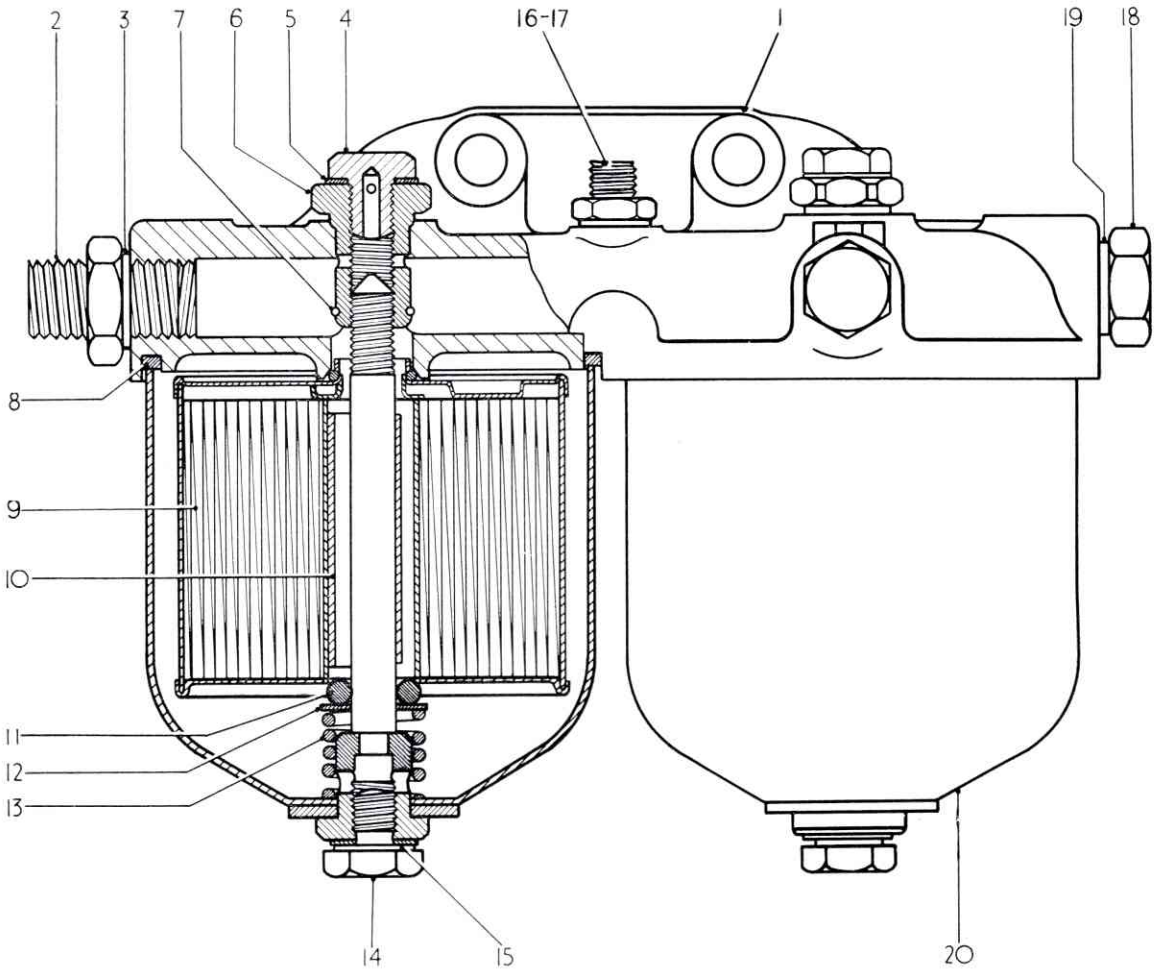


FIG. 98. SECTION THROUGH THE FUEL OIL FILTER

1. Housing cover.
2. Outlet union.
3. Washer.
4. Vent plug.
5. Washer.
6. Cap nut.
7. Circlip.
8. Joint.
9. Filter element.
10. Locating sleeve.
11. Seal ring, lower.
12. Washer.
13. Spring.
14. Plug, sludge.
15. Washer.
16. Inlet union.
17. Washer.
18. Closing plug.
19. Washer.
20. Housing.

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waste. Drain holes in drain plug and filter body boss should be cleared by means of a wire. Oil should then be run through until all sludge is cleared.

6. Remove dirty filter elements and throw away. No attempt should be made to clean a paper element.

Any appreciable deposit of solid matter in the bowl should be removed, taking care not to allow any to foul the "clean" portion of the centre spindle above the bottom sealing ring.

7. Fit new paper elements complete with upper rubber sealing rings to filter bowls. (A new sealing ring is supplied with each new element.) Ensure that the sealing rings are correctly in position and in good condition (not cut or split).

8. Replace filter bowls containing new elements.

9. Engage the cap nuts with the centre stud and screw up tightly. Undue force should not be applied in an attempt to stop leakage.

10. Tighten the oil drain plugs at bottom of filter bowls.

11. Operate the hand priming lever of the feed pump until air-free oil appears from the vent plugs at the top of the cap nuts followed by air venting at the injection pump, and tighten the cap nuts.

THE AIR COMPRESSOR

WESTINGHOUSE TYPE E.11V

DESCRIPTION

The compressor, Fig. 99, is mounted at the timing case end of the engine and driven by the timing gear train at half-crankshaft speed.

It is a two-cylinder, single-stage, air-cooled machine, having a bore of 2.50 in. (63.50 mm.) and 1.75 in. (44.45 mm.) stroke, with a piston displacement of 11 cu. ft. (0.311 cu. m.) when running at 1,000 r.p.m. The cylinder block and crankcase are formed from a single casting and is fitted with removable liners. The cylinders and detachable cylinder head are provided with ample cooling fins. No sump is provided as the crankcase is mounted on the engine crankcase, with a large opening for drainage of oil back into the engine oil sump.

The detachable cylinder head incorporates two each suction and delivery valves, one pair being provided for each cylinder. These valves are of the plate disc type, held on their respective seats by a single coil spring.

Each piston is provided with two internally stepped compression rings (3) and one scraper ring (4), above the fully floating hardened gudgeon pin (7), which is retained in the piston by two circlips (6). All bearings surfaces are of ample dimensions, the small-end bushes (28), in the H-section steel connecting rods being of bronze and the big-end bearings (27) being steel backed white metal half-shells.

The crankshaft (25) is of heat-treated steel and is carried at either end in steel-backed white metal lined bushes (13) and (33).

The oil enters under pressure through a pipe from the engine lubricating system into a port in the compressor crankcase at the driving end of the crankshaft, flowing into a circular space in the end flange, thence through holes in the end bearing (33), to the drilled crankshaft and so to the big-end bearings (27), and the other main bearing (13). The pistons and gudgeon pins are splash lubricated, the surplus oil draining back through the end flange into the engine sump.

MAINTENANCE

The only maintenance normally required is at vehicle overhaul periods.

Every 50,000 miles (80,000 kilometres) or every twelve months, whichever occurs first, or if at any time the compressor is slow in building up pressure in the reservoir fails to do so, and provided there is no leakage in other parts of the system, the valves should be removed and examined.

To remove the delivery valves, unscrew the caps (50), lift out the springs (49) and valve discs (48). In the case of the suction valves, remove the cylinder head (45), unscrew the suction valve insert (46), lift out the springs (47) and valve discs (48). If the valve springs are in bad condition, they must be renewed, and similarly the valve discs. The discs can be refaced by rubbing them on a flat surface lightly coated with a very fine grinding paste diluted with oil. All traces of paste must be removed before reassembly.

The valve seats in the head may be refaced with a cutter (details provided on request). If it is found impossible to recut the seats due to wear, a replacement head should be fitted, and the original head may be returned to Westinghouse Brake & Signal Co. Ltd., for sleeving.

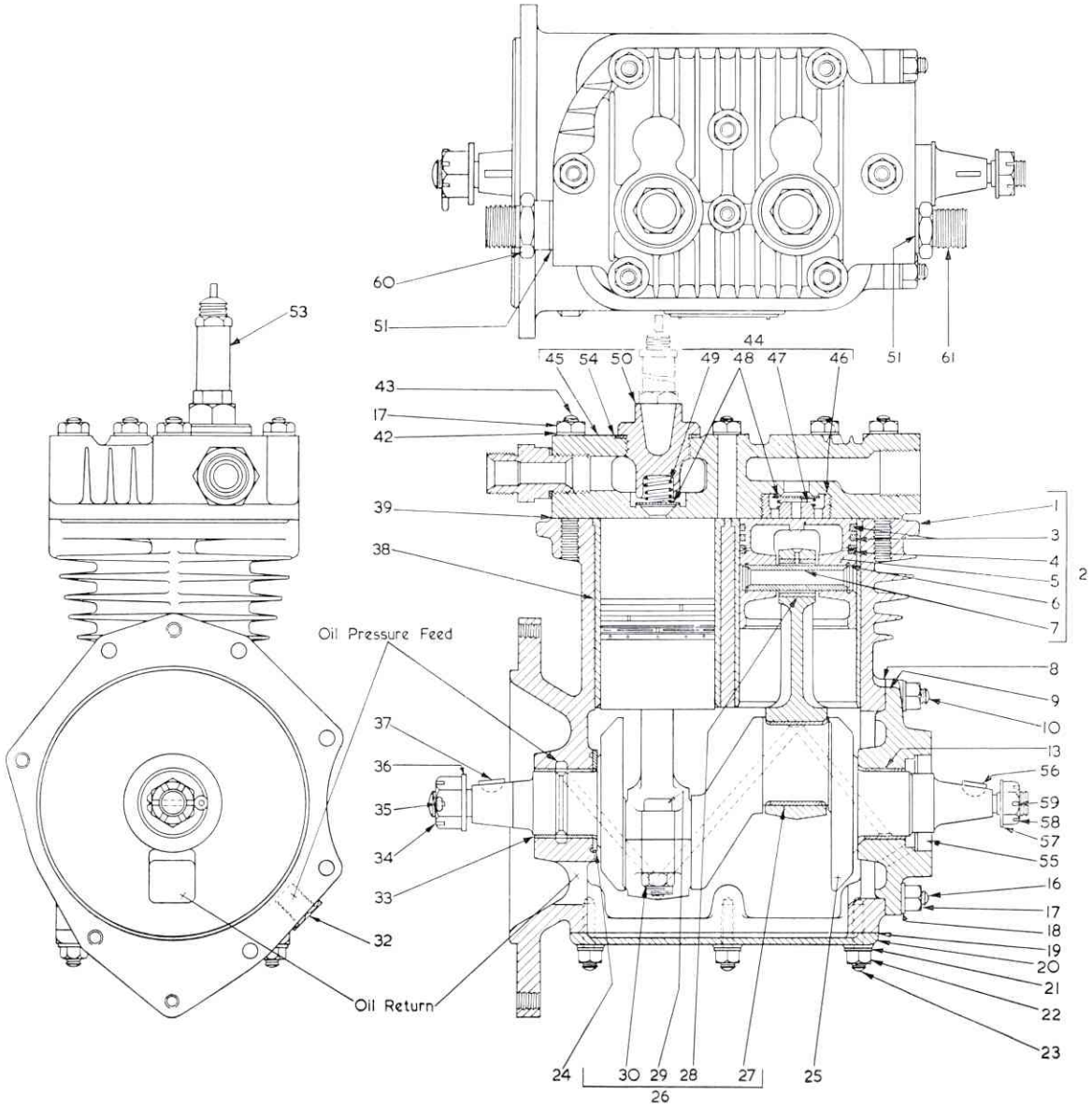


FIG. 99. SECTIONS THROUGH THE WESTINGHOUSE TYPE E.IIV COMPRESSOR

1. Crankcase.
2. Piston, complete.
3. Compressing ring.
4. Scraper ring.
5. Piston.
6. Circlip.
7. Gudgeon pin.
8. Gasket.
9. Bearing housing.
10. Stud.
13. Bearing bush.
16. Stud.
17. Nut.
18. Washer.
19. Gasket.
20. Bottom plate.
21. Washer, plain.
22. Nut.
23. Stud.
24. Thrust washer.
25. Crankshaft.
26. Connecting rod.
27. Bearing, big end.
28. Bush, small end.
29. Bolt.
30. Locknut.
32. Adapter.
33. Bearing bush.
34. Nut, slotted.
35. Split pin.
36. Washer, plain.
37. Key.
38. Cylinder liner.
39. Gasket.
41. Plug.
42. Washer, spring.
43. Stud.
44. Cylinder head, complete.
45. Cylinder head.
46. Suction valve insert.
47. Suction valve spring.
48. Valve disc.
49. Delivery valve spring.
50. Delivery valve cap.
51. Washer.
53. Safety valve.
54. Washer.
55. Oil seal.
56. Key.
57. Washer, plain.
58. Nut, slotted.
59. Split pin.
60. Adapter.
61. Adapter.

To Dismantle the Compressor

1. Remove the cylinder head (45).

2. Remove the bottom plate (20).

3. Dismantle both connecting rod caps, care being taken that the caps are replaced as marked during manufacture and withdraw pistons and connecting rods through the top of the cylinder bores.

4. Remove nuts (17) holding the bearing housing (9) in position, remove bearing housing, and remove crankshaft.

5. The cylinder head, and piston assemblies can now be dismantled as required, and all parts thoroughly cleaned and examined.

Cylinder Head

Remove all carbon deposit and fit new valve discs and springs.

Pistons and Liners

Check piston play and if in excess of 0.010 in. (0.254 mm.) the piston (5), or liners (38), whichever are worn, should be renewed. Check the ring gap and side play and renew the rings if the gap is greater than 0.010 in. (0.254 mm.), the minimum gap being 0.003 in. (0.0762 mm.) with 0.001/0.002 in. (0.0254/0.0508 mm.) side play. These limits apply to both compression and scraper rings (3) and (4) respectively.

When replacing compression rings, **ensure that the internal step is at the top.**

If any gudgeon pin play is felt, renew the piston, gudgeon pin or small-end bush, whichever may be worn.

Should new small-end bushes (28) be required, these are supplied less oil hole and slightly undersize on the inside diameter. Ensure that the oil groove is in line with the hole in the connecting rod. After pressing the bush into the connecting rod, drill out the hole to 0.125 in. (3.175 mm.) dia. and ream the bush to 0.6255/0.626 in. (15.88/15.90 mm.) parallel to the big-end bearing.

If the big-end bearings should appear faulty, or any play is felt, the bearing shells (27) must be renewed.

Note: 0.003/0.004 in. (0.0762/0.1016 mm.) side play is permissible.

No scraping is permissible and care must be taken to ensure that the nicks provided in each half-bearing are correctly located in the corresponding rod or cap. These are arranged to prevent any possibility of the bearings revolving when assembled.

The main bearings are plain bushes which should be renewed if worn. It is most important that no wear exists in the bearing (33), at the driving end as such wear will result in loss of oil pressure to the big-end bearings. The oil seal on through-drive machines should also be renewed.

The crankshaft (25), when replaced, should have 0.003/0.015 in. (0.0762/0.3810 mm.) end float. If less than 0.003 in. (0.0762 mm.) use additional gasket (8).

When reassembling the machine, any gaskets that have been removed should be renewed, for the cylinder head use an Oakenstrong gasket 0.0156 in. (0.3969 mm.) thick, any other gaskets may be made from brown paper 0.005/0.006 in. (0.1270/0.1514 mm.) thick if standard gaskets are not available. Jointing compound should not be used on the cylinder head.

When replacing the cylinder head, draw down evenly, tightening the centre nuts first.

It is recommended that the pumping up times for given engine speeds are taken when the machine is first placed in service, as these figures will provide a useful check on the efficiency of the machine at any future date or overhaul.

THE AIR COMPRESSOR

CLAYTON DEWANDRE TYPE PCGA 223-9

DESCRIPTION

The air compressor, Fig. 100, is an air-cooled twin-cylinder reciprocating piston type having a bore of 2.625 in. (66.675 mm.) and 1.75 in. (44.45 mm.) stroke, giving a nominal capacity of 10 cu. ft. (0.283 cu. m.) of free air per minute at 1,000 r.p.m.

The combined crankcase and cylinder block is in aluminium with cast-iron liners for the cylinder bores. The one-piece forged steel crankshaft runs in ball bearings with two in the drive housing to take the drive load. The piston connecting rods are white metalled at the big ends and bronze bushed for the gudgeon pins. The compressor pistons are of orthodox design with two compression rings and scraper ring at the piston skirt. The pistons are secured to the connecting rods by fully floating gudgeon pins positioned by a circlip at each end.

The cast-iron cylinder head embodies the inlet and delivery valve assemblies. The inlet valves (9) are hardened and lapped steel discs, lightly sprung against a narrow seat formed integrally by the valve keepers (11). The delivery valves (5) are similarly constructed, but the valve seats (6) are inserted, and can be removed if required.

The delivery valve caps (7) locate the valve springs (8) and also control the lift of the valve discs.

LUBRICATION

Lubrication is by pressure feed from the engine system, being supplied through a lubricator strap which is fitted to the crankshaft centre bearing. The crankshaft is drilled from the centre bearing to provide a feed to the crankpin bearings. Gudgeon pins, cylinder walls and crankshaft bearings are lubricated by oil thrown out from the crankpins. Scavenge oil drains direct to the engine sump.

MAINTENANCE

Weekly

Make a general visual check of all joints unions, etc., for leakage or looseness and rectify where, necessary.

If the cylinder head has recently been removed, check that the cylinder head bolts are fully tightened down.

Yearly or Every 50,000 miles (80,000 kilometres)

1. Remove the cylinder head for detailed examination. Unscrew the delivery valve caps (7) and withdraw the delivery valve springs (8) and the disc valves (5). Remove any carbon deposits. If the delivery valve discs are ridged or distorted, replace during assembly. The delivery valve seats (6) should be removed and relapped if necessary.

2. If the delivery valve springs are not broken, the free length should be checked to ensure that they are not broken, the free length should be checked to ensure that they are not fatigued. This free length should be 1.1094 in. (28.178 mm.) but if found to be 1.0625 in. (26.988 mm.) or less, renew on assembly.

3. Withdraw the inlet valve keepers (11) and remove the inlet valve springs (10) and valve discs (9). Remove any carbon deposits and examine the valve discs for ridging or distortion, renewing as necessary. Relap the valve seats if necessary.

Note: It is good practice, if springs are available, to renew the inlet and delivery valve springs if the valve discs are renewed.

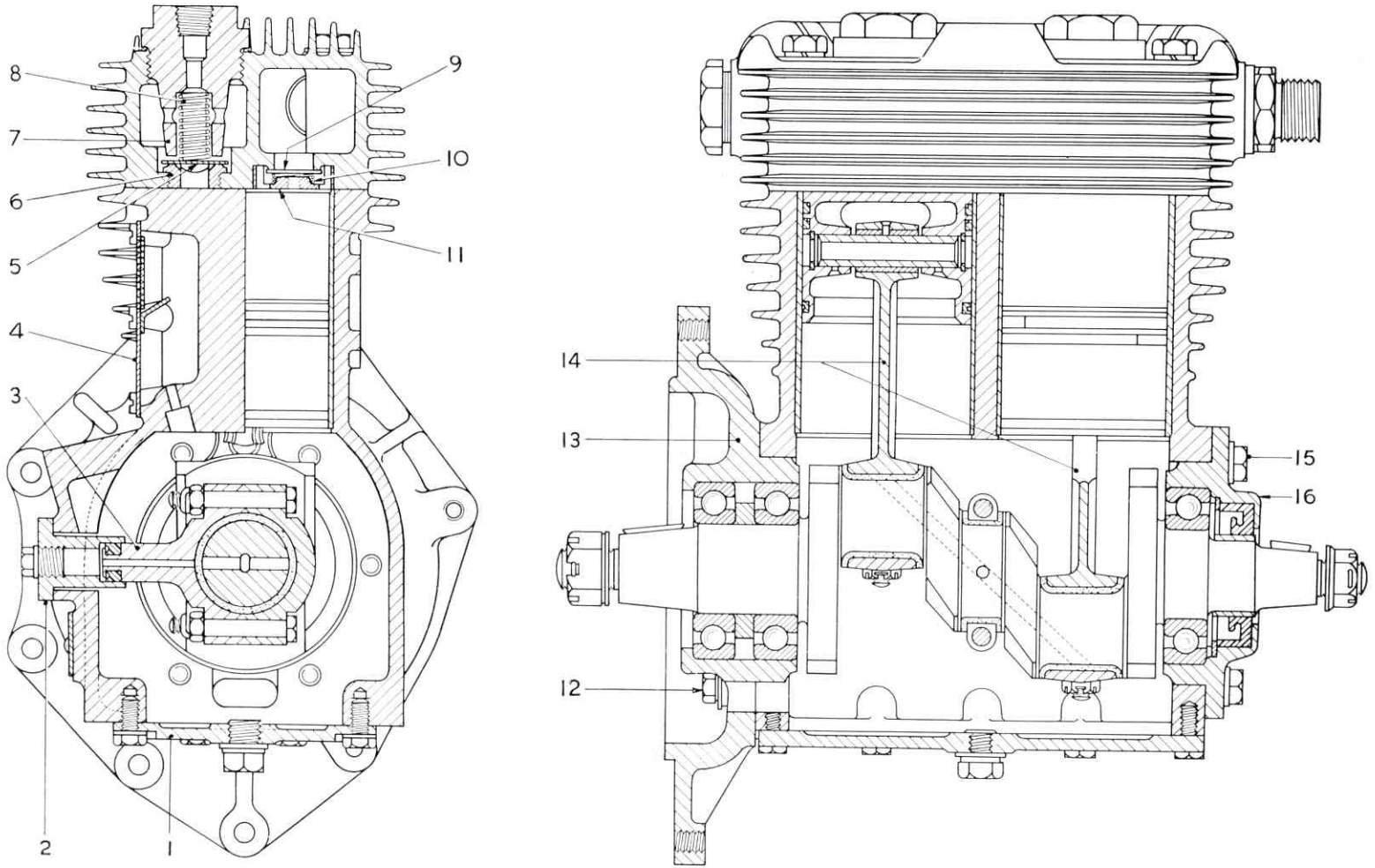


FIG. 100. SECTIONS THROUGH THE CLAYTON DEWANDRE TYPE PCGA 223/9 COMPRESSOR

1. Base cover.
2. Oil inlet supply flange.
3. Lubricator strap.
4. Breather assembly.
5. Delivery valve disc.
6. Delivery valve seat.
7. Delivery valve cap.
8. Delivery valve spring.
9. Inlet valve.
10. Inlet valve spring.
11. Inlet valve keepers.
12. Setscrew.
13. Drive housing.
14. Connecting rod.
15. Setscrew.
16. Rear end cover.

To Dismantle the Compressor

1. Remove dirt and grease from the exterior of the compressor and clean with solvent and brush.

2. Remove the coupling and keys from the ends of the crankshaft.

3. Unscrew the safety valve complete from the cylinder head.

4. Unscrew the setscrews securing the cylinder head and remove the head, discarding the gasket.

5. Dismantle the breather assembly.

6. Remove the base cover (1) and the oil inlet supply flange (2).

7. Unbolt the lubricator strap (3) from the centre bearing of the crankshaft.

8. Mark the connecting rods (14) and their corresponding caps. Remove the caps and withdraw the piston and connecting rod assemblies through the top of the cylinder bores.

9. Remove the setscrews (12) and (15) securing the drive housing (13) and the rear end cover (16). Dealing with the rear end cover first, tap the cover evenly away from the crankcase. Whilst holding the crankshaft, tap the drive housing away from the crankcase and then withdraw the crankshaft from the crankcase.

10. Withdraw the crankshaft from the drive housing.

11. When dismantling the cylinder head, unscrew the delivery valve caps (7) and withdraw the valve springs (8) and discs (5).

    Unscrew the delivery valve seats (6), by using the special square-ended tool.

    Withdraw the inlet valve spring keepers (11), using the special extractor.

    Remove the valve springs (10) and discs (9).

Cleaning and Inspection

Carefully clean all parts in paraffin and blow dry with compressed air. Wash bearings in flushing oil or white spirit and dry with compressed air blown through the bearings, but preventing the bearings spinning, otherwise damage to balls or rollers and races will occur. Lubricate the bearings with light engine oil and protect from dirt ready for inspection.

The limits of wear and service instructions are tabulated below:

Wear in Bore	Service Instructions
+0.005 in. (0.1270 mm.)	Fit new standard rings.
+0.005/0.010 in. (0.1270/0.254 mm.) ...	Bore out to +0.010 in (0.254 mm.) and fit new 0.010 in. (0.254 mm.) oversize pistons and rings.
+0.010/0.015 in. (0.254/0.3810 mm.) ...	Fit new 0.010 in. (0.254 mm.) oversize rings.

Note: The re-machining of the cylinder bores must not exceed +0.010 in. (0.254 mm.) on the diameter.

The liners are pressed into the block during the manufacturing process and then the cylinder bores are machined to size. Due to the difficulties involved, it is not normally recommended that liners be replaced, and in the event of cylinder bore wear in excess of +0.015 in. (0.3810 mm.), it is suggested that the complete compressor or the cylinder block should be returned to Clayton Dewandre Company Limited for reconditioning.

Piston and scraper rings gaps should not exceed 0.012 in. (0.3048 mm.). Gaps on new rings should be between 0.003/0.006 in. (0.0762/0.1524 mm.) on butt-jointed types and 0.002/0.004 in. (0.0508/0.1016 mm.) on scarf-jointed rings.

Bearings should be fitted to good automobile practice, with particular attention to the clearance at the sides of the crankpins. It should not be possible to insert a feeler thicker than 0.003 in. (0.0762 mm.) between crankpins and journal shoulders.

In the event of the connecting rod big-ends being remetalled it is important to maintain the correct connecting rod length of 4.127/4.123 in. (104,826/104.724 mm.) between centres.

Examine the ball bearings for discoloration, pitting, wear and cracked races. Rotate slowly to check for roughness. Unserviceable bearings should be renewed.

Inspect the oil seal in the rear end cover, ensuring that the sealing edge is sharp and intact. If oil leaks have been observed at the crankshaft rear end, a new seal should be fitted.

Examine the crankcase, cylinder head, base cover and oil supply flange for damage and cracks. Inspect the keys and keyways, renew inlet and delivery valve springs and discs.

Inspect the inlet valve keepers and delivery valve seats. The seats may be relapped or renewed as necessary and renew all joints.

To Reassemble the Compressor

During reassembly, lubricate all internal parts with clean engine oil to prevent possible damage when the engine is starting and until the oil supply is functioning.

1. If the rear seal has been removed, press the seal into the housing with the lip facing inwards. Fit the retaining circlip.

2. If the bearings have been removed, press the faces on to the crankshaft, ensuring that they abut the crankshaft shoulder. Fit the spacer ring between the two drive end bearings.

3. Fit the crankshaft into the drive housing. Insert the crankshaft into the crankcase and secure the drive housing using a new joint between the faces.

4. Refit the rear end cover with a new joint. During this operation it is recommended that a guide bush should be placed over the crankshaft end to protect the oil seal. In an emergency, stiff paper may be wrapped around the sleeve in place of the guide bush.

5. Insert the connecting rod and piston assemblies through the top of the respective bores and locate the connecting rods on the crankshaft bearings, placing the correct cap on its connecting rod. Refit the nuts and bolts and split pin.

6. Assemble the lubricator strap to the centre bearing of the crankshaft. Replace the oil inlet supply flange with new joint, taking care when inserting the lubricator strap into the seal housing to avoid damaging the seal.

7. Check the crankshaft for free rotation. Tighten the end cover setscrews securing the drive housing and rear end cover.

8. Refit the base plate with joint.

9. Assemble the breather with joint to the crankcase.

10. When reassembling the cylinder head, locate the new inlet valve discs and springs in the cylinder head and press in the inlet valve keepers.

    Screw in the delivery valve seats.

    Insert the spread coil of the delivery valve springs into the delivery caps, using a screw-in motion.

    Insert the delivery valve discs and fit the valve caps with copper washers.

    Using a new gasket, assemble the cylinder head on the cylinder block, tightening down the setscrews evenly and in rotation.

    Assemble the safety valve.

THE AIR CLEANERS

DESCRIPTION

The air filter unit consists of a metal container in which is housed a special dry paper type filtering element.

The units are mounted on the air inlet manifolds as shown in Figs. 2, 4.

Cold air drawn from the atmosphere enters the filter through the intake trunk and passes through the filter element depositing grit and dust on the element allowing the cleaned air to pass into the engine.

MAINTENANCE

Filter maintenance consists of keeping the element clean.

The frequency of cleaning required is governed by the conditions under which the vehicle is operating. For normal conditions once monthly or every 5,000 miles (8,000 kilometres) is sufficient. To ensure regularity of attention under normal conditions it is advised that the filter be cleaned at each sump oil change.

In exceptional conditions, daily cleaning will have to be carried out to ensure ample air supply to the engine.

To clean the element, unscrew the centre nut and remove the cover and filter element.

Apply a flow of low pressure air which should be free from oil and water through the element, blowing off the accumulated dirt.

Replace the element, fit the cover and tighten the nut.

Elements which have been cleaned in this manner several times will finally clog and the air flow to the engine will be restricted, it is then necessary to fit a replacement.

Elements should never be washed in liquid.

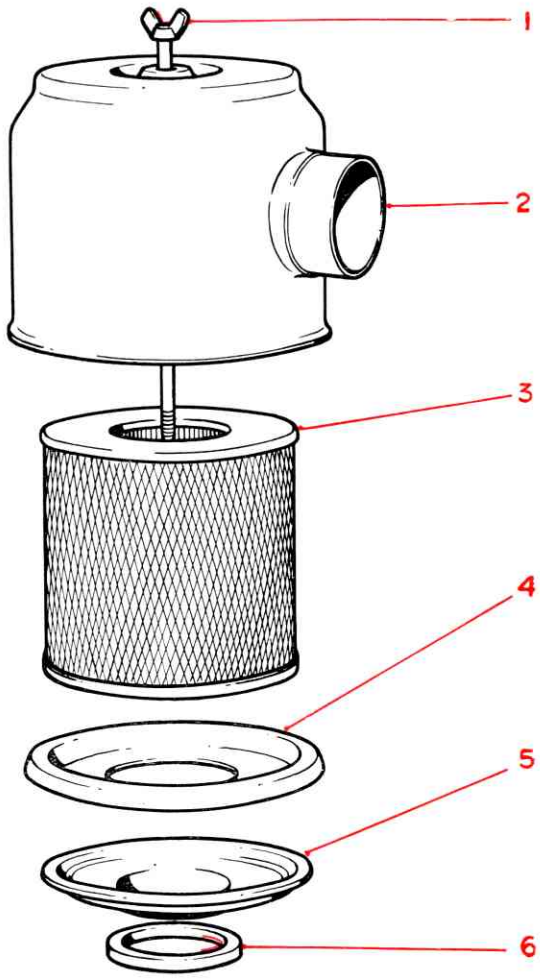


FIG. 101. EXPLODED VIEW OF THE AIR CLEANER

1. Centre nut.
2. Filter casing.
3. Element.
4. Sealing ring.
5. Bottom plate.
6. Sealing ring, lower.

HOBOURN-EATON ROTOR TYPE STEERING PUMP

DESCRIPTION

The pump consists mainly of a body, cover, inner rotor, outer rotor and shaft. The outer rotor is driven by the inner rotor which is keyed to the driving shaft. Fitted to the driving shaft is a gear which meshes with the driving gear fitted to the engine timing gear train. A combined flow control valve and relief valve is fitted which can be set to pre-determine flow and pressure requirements.

The pump intake is supplied directly from the reservoir, and the oil returned from the steering system is passed through the filter into the reservoir.

OPERATION

The oil from the reservoir enters the pump via a venturi shaped flow director and flows into the intake port. The outer rotor, Fig. 104, has one more tooth space than the inner rotor has teeth. When the pump is driven in the direction indicated the tooth space (A) on the outer rotor has rotated through 180° to the position (B) displacement has occurred through the inner rotor tooth withdrawing from mesh.

During this part of the cycle the tooth space has traversed the inlet port and the space has filled with oil. The oil in the chamber thus formed at (B) is now cut off from the inlet port and further rotation will bring the contained oil into communication with the discharge port.

During the second part of the cycle, as the tooth space returns to the original position (A), an inner rotor tooth re-enters the tooth space causing oil to be discharged under positive pressure.

The completed cycle described is repeated by each consecutive tooth space, the result is a continuous flow of oil from the inlet to the discharge port.

Flow Control Valve

OPERATION

The oil passes from the discharge port into the flow control valve chamber, Fig. 105, then through two metering holes in the flow control valve, and passes through the centre of the hollow relief valve to the discharge connection.

Owing to the restriction of the metering holes to the oil passage a pressure difference is created, and is effectively applied to opposite ends of the valve. The pressure difference increases with increased flow until a point is reached when it is sufficient to urge the valve forward against the spring. This movement uncovers a by-pass channel enabling oil in excess of that passing through the metering holes to return to the intake side of the pump, as the pump speed increases, the output through the metering holes to the circuit remains constant and the excess oil is re-circulated within the pump.

Relief Valve

OPERATION

The relief valve is operated by the oil pressure acting on differential areas on opposite ends of the valve, and is housed inside the flow control valve. When the valve opens it provides a path for oil through the wall of the flow control valve into the by-pass channel, the oil then being re-circulated within the pump.

To Remove the Pump Assembly

1. Disconnect the hoses at the unions on the pump assembly and place the end of the hoses in a raised position to prevent drainage of oil, or drain into a container.
2. Remove the bolts, nuts and washers which secure the pump to the timing backplate, remove the joint.

To Dismantle, Inspect and Assemble the Pump

Note: Thoroughly clean the exterior of the pump and ensure that no dirt enters the intake or outlet holes.

Refer to Fig. 108.

1. Hold the pump in a vice using soft jaws.
2. Remove the setscrew and lockwasher, withdraw the gear and key from the shaft.
3. Remove the two setscrews and washers (4) holding the intake adapter (5). Remove the sealing ring (6).
4. Remove the four screws (21) holding the cover (16) to body (9) and separate the pump body from the cover.
5. Remove the sealing rings (11) and (10) from the grooves in the body housing.
6. Remove the rotor assembly (13) and drive pin (14) from the shaft (20). Do not reverse inner rotor in the outer rotor.
7. Using pin nose pliers remove the circlip (17) which secures the ball bearing (18) and shaft assembly.
8. Carefully press or tap the ball bearing shaft from the pump housing.
9. Inspect the ball bearing (18). If worn or damaged, remove from the shaft using a press against the inner race of the bearing.
10. Drive out the bearing seal (19) from the body using a punch if the seal is worn or damaged.
11. Remove the valve cap adapter (29) and seal (28) from the pump cover, remove the flow control valve spring (27) and flow control valve (23).

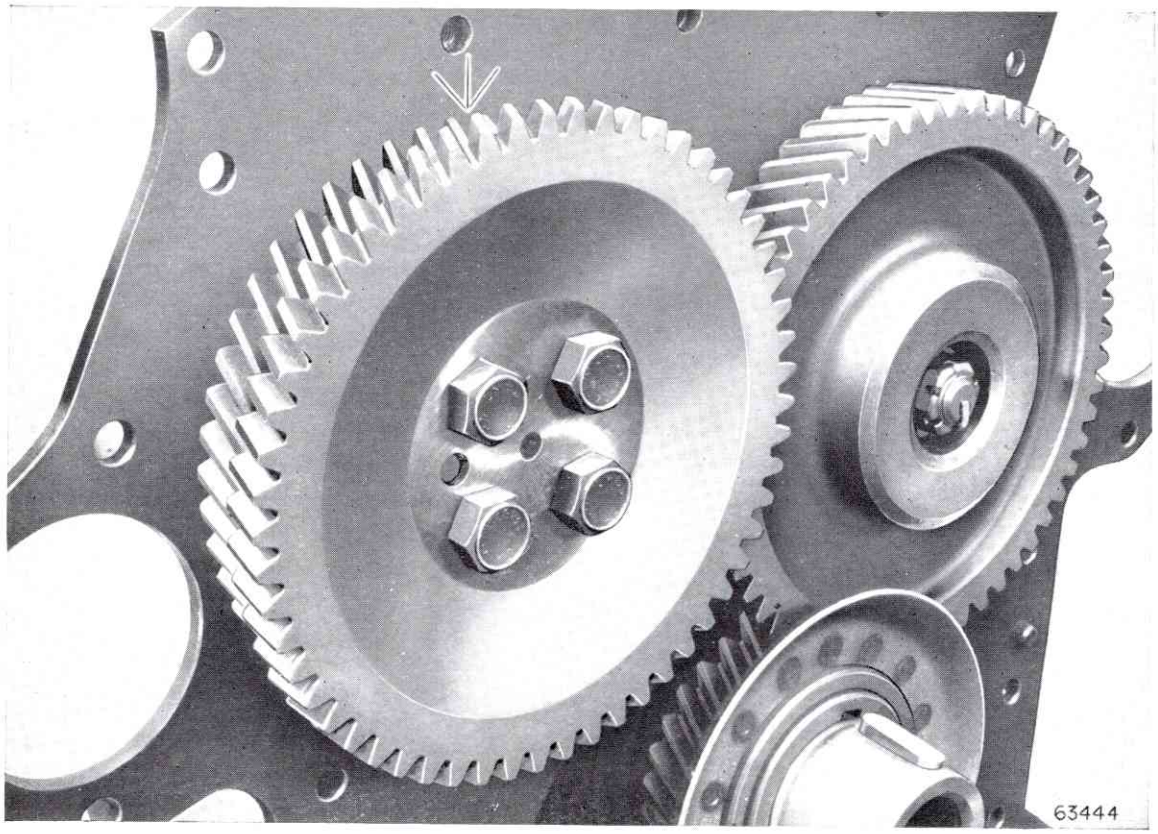


FIG. 102. THE PUMP DRIVING GEAR

12. Using pin nose pliers, remove the circlip (26) from the flow control valve (23). Remove the relief valve (25) and relief valve spring (24).

13. Wash all parts except the oil seal (19) and bearing (18) in a suitable solvent and wipe dry with clean lint-free cloth. Wipe the oil seal (19) and bearing (18) with clean cloth. Do not soak the bearing in solvent as the lubricant sealed in the bearing may be diluted.

14. Check the pump body and cover for wear caused by the rotors, replace either part if surface is scored or worn.

15. Grease the lip of the new seal (19) and assemble seal with the lip towards the rotor, a press is generally employed with a 1.218 in. (31.956 mm.) dia., piece of steel used as a piloting tool. Press in the seal solid but do not distort.

16. Carefully install shaft (20) and bearing (18) in the pump body and secure with the circlip (17), ensure that the circlip is fitted correctly against the outer race of the bearing and in the groove machined in the body.

17. Inspect the drive and driven rotors (13), if noticeably worn or scored replace both parts (serviced in match sets). If the rotors appear satisfactory place over the shaft in the pump body and check the clearance between the rotors at all points with feeler gauges. Replace the rotors if the clearance exceeds .006 in. (.1524 mm.).

18. Using a straight edge and feeler gauges check the side clearances of rotors in the pump body. Replace body if the side clearance exceeds .0025 in. (.0635 mm.).

19. Check the clearance between the driven rotor and bush in the pump body and replace the body if the clearance exceeds .008 in. (.2032 mm.).

20. Replace the drive pin (14) fitted in the shaft (20) and drive rotor.

21. Carefully inspect the relief valve (25) and ensure that the valve is not sticking, all burrs should be removed with a fine oil stone. Replace the valve spring in the flow control valve.

22. Install relief valve (25) in the control valve (23).

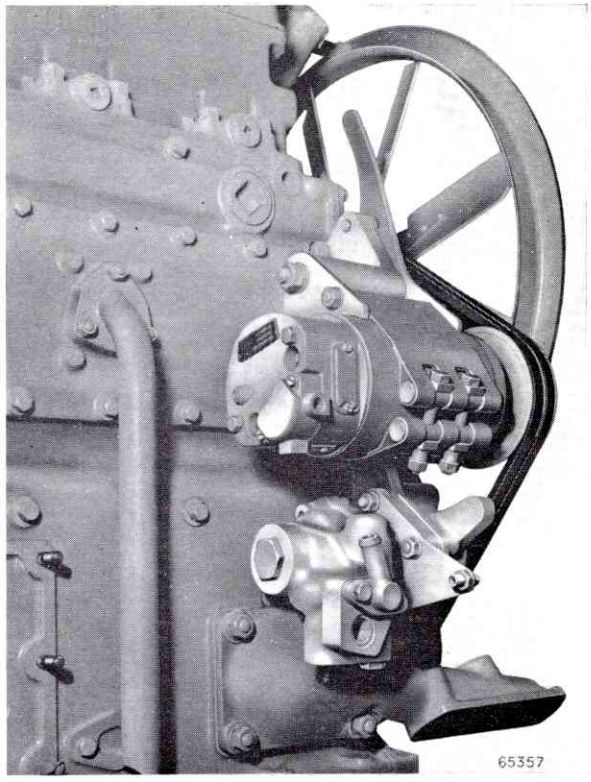


FIG. 103. VIEW OF THE STEERING GEAR PUMP

23. Secure the relief valve spring (24) and relief valve (25) in the flow control valve (23) with the circlip (26).

24. Install flow control valve and the spring (27) in the body cover.

25. Fit the valve cap adapter (29) and seal (28) and screw in the adapter securely.

26. Renew the 'O' rings (10) and (11), fit the pump body and cover together and tighten the four screws evenly. Check the shaft rotation for freeness after tightening the screws. There should be no tightness.

27. Install new sealing ring (6) in the groove machined in the inlet face, replace the intake adapter (5) and secure with the screws and lockwashers (4).

Note: The plug (1) and oil seal (2) are used for blanking and if removed, care should be taken to ensure that the oil seal is replaced if damaged.

28. Fit the key and the gear, and fit the locking washer and setscrew and tighten securely.

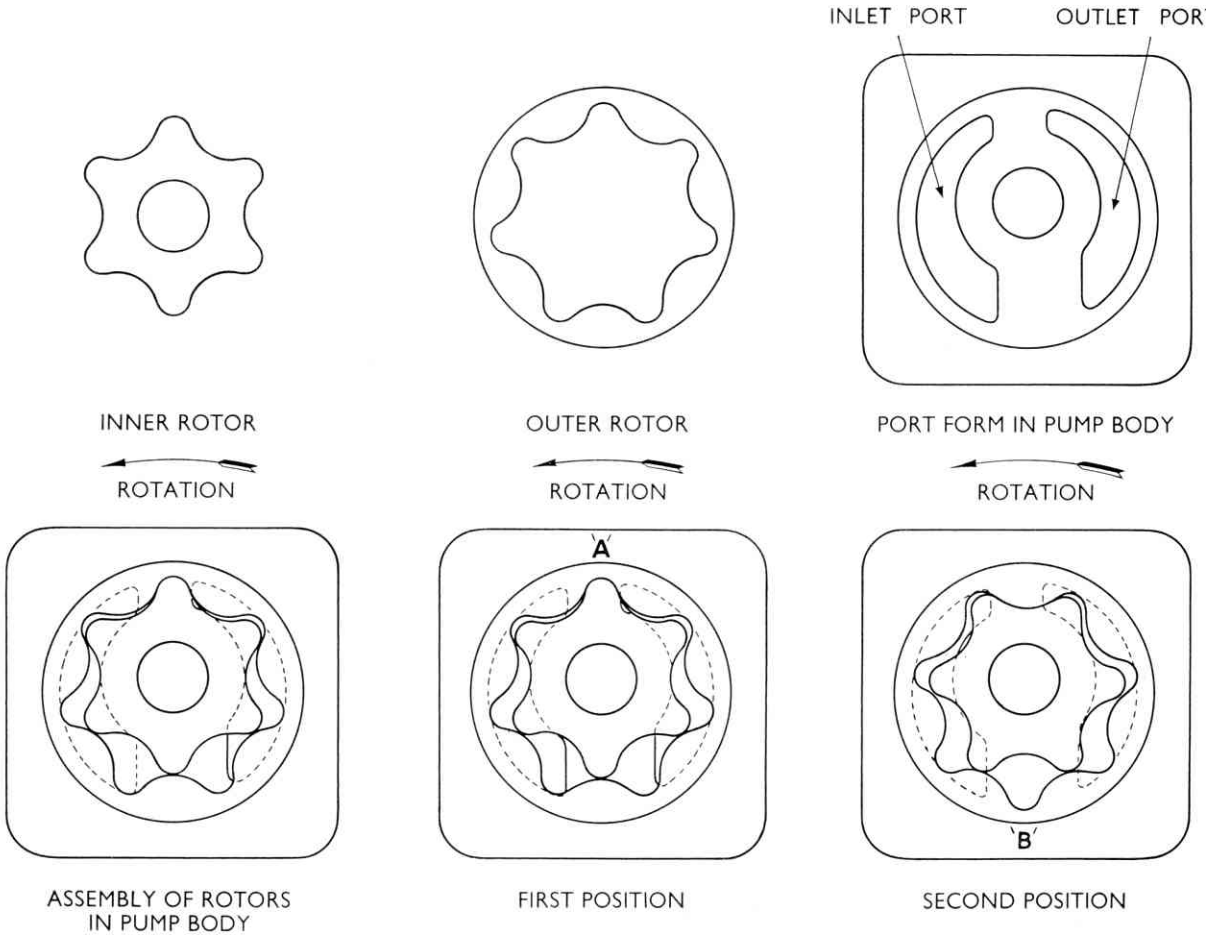
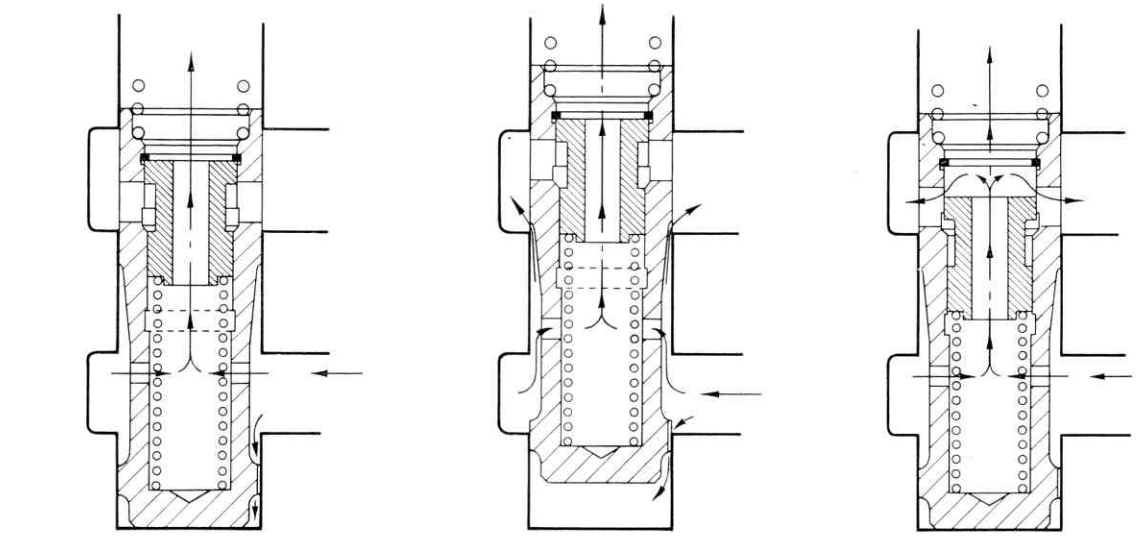


FIG. 104. ASSEMBLY OF ROTORS IN PUMP BODY



FLOW THRO' METERING HOLES WITH FLOW VALVE NOT IN OPERATION

FLOW THRO' METERING HOLES WITH FLOW VALVE IN OPERATION

FLOW THRO' METERING HOLES WITH FLOW VALVE NOT IN OPERATION RELIEF VALVE OPEN

FIG. 105. OPERATION OF FLOW CONTROL AND RELIEF VALVES

To Refit the Pump

1. Fit the pump assembly to the timing backplate and secure with the bolt, nuts and washers and tighten securely.

2. Connect pressure and return hose fittings to the pump.

3. Fill the reservoir to the correct level with oil and bleed the system as follows:

   (a) Start the engine and run at idling speed for minutes. Recheck oil level and inspect hose connections for leaks.

   (b) Increase the engine speed to 1,000 r.p.m. approx., and turn the road wheels from right to left five or six times.

   (c) Recheck for leaks.

   (d) Check oil level in reservoir and refill as required.

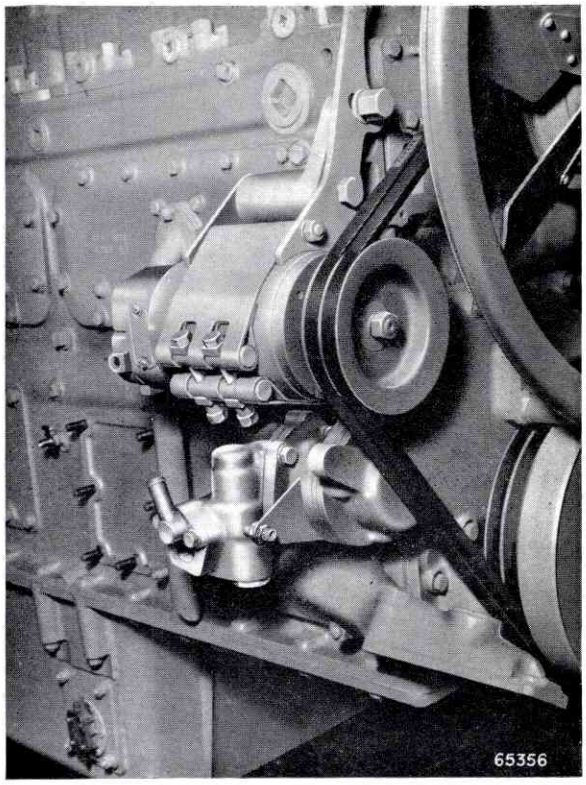


FIG. 106. VIEW OF THE STEERING GEAR PUMP

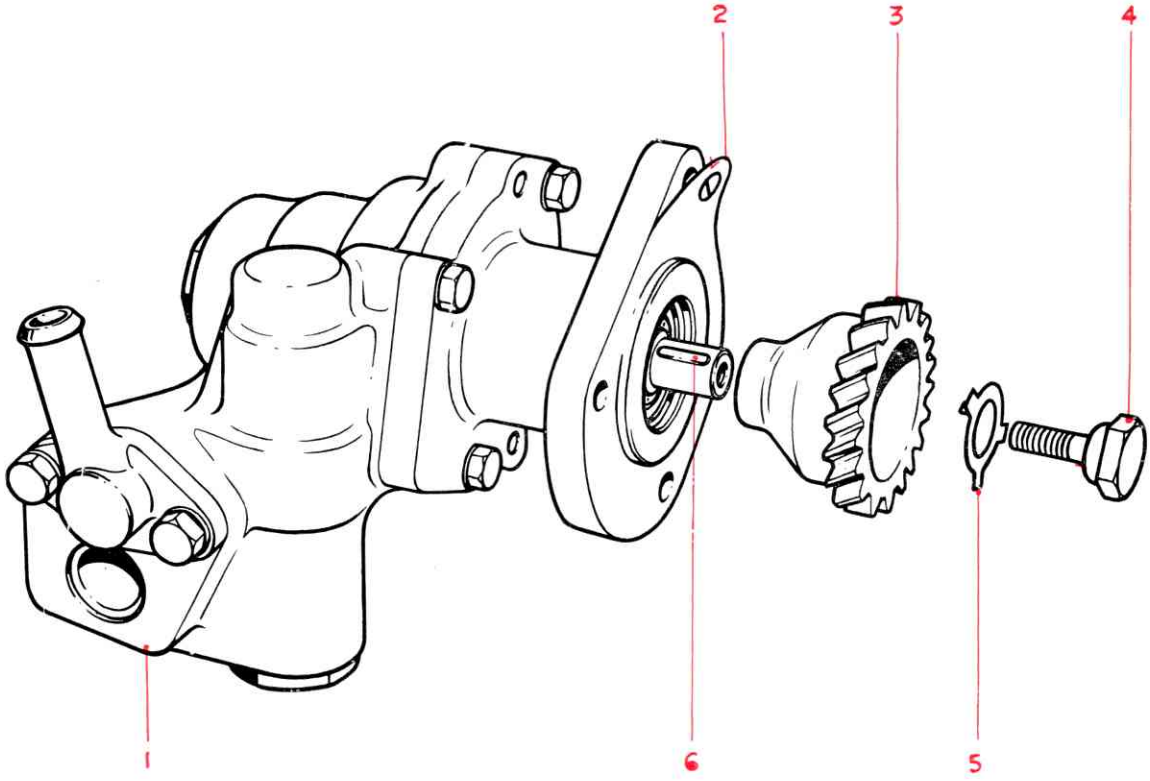
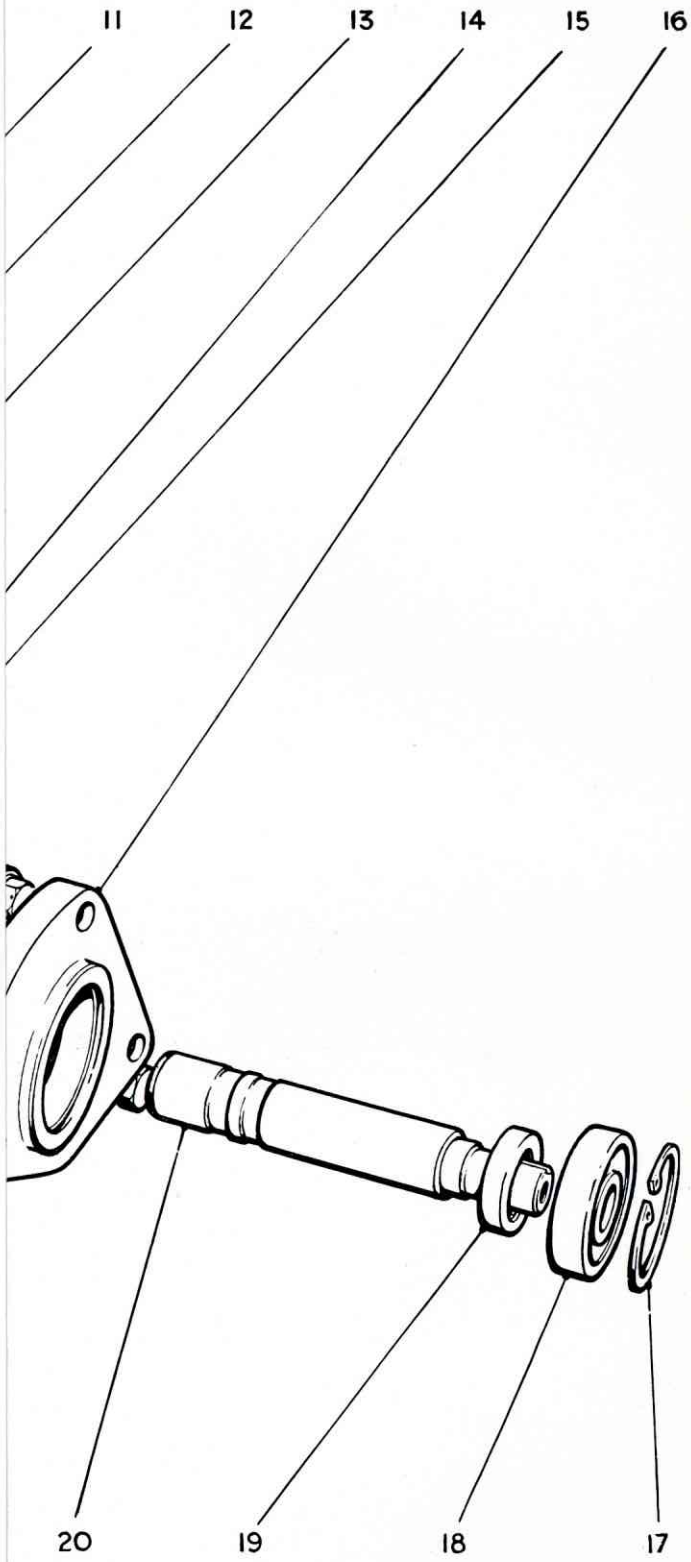


FIG. 107. THE STEERING GEAR PUMP

1. Pump.
2. Joint.
3. Gear.
4. Setscrew.
5. Lockwasher.
6. Key.

1. Sealing plug.
2. 'O' ring.
3. Bush.
4. Setscrew, washer.
5. Body adapter.
6. Gasket.
7. Gasket retainer.
8. Venturi.
9. Body.
10. 'O' ring.
11. 'O' ring.
12. Bush.
13. Rotor Assembly.
14. Drive pin.
15. Bush.
16. Cover.
17. Circlip.
18. Bearing.
19. Oil seal.
20. Shaft.
21. Setscrew, washer.
22. Dowels.
23. Flow control valve.
24. Relief valve spring.
25. Relief valve.
26. Retaining ring.
27. Flow control valve spring.
28. 'O' ring.
29. Adapter.



1. Sealing plug.
2. 'O' ring.
3. Bush.
4. Setscrew, washer.
5. Body adapter.
6. Gasket.
7. Gasket retainer.
8. Venturi.
9. Body.
10. 'O' ring.
11. 'O' ring.
12. Bush.
13. Rotor Assembly.
14. Drive pin.
15. Bush.
16. Cover.
17. Circlip.
18. Bearing.
19. Oil seal.
20. Shaft.
21. Setscrew, washer.
22. Dowels.
23. Flow control valve.
24. Relief valve spring.
25. Relief valve.
26. Retaining ring.
27. Flow control valve spring.
28. 'O' ring.
29. Adapter.

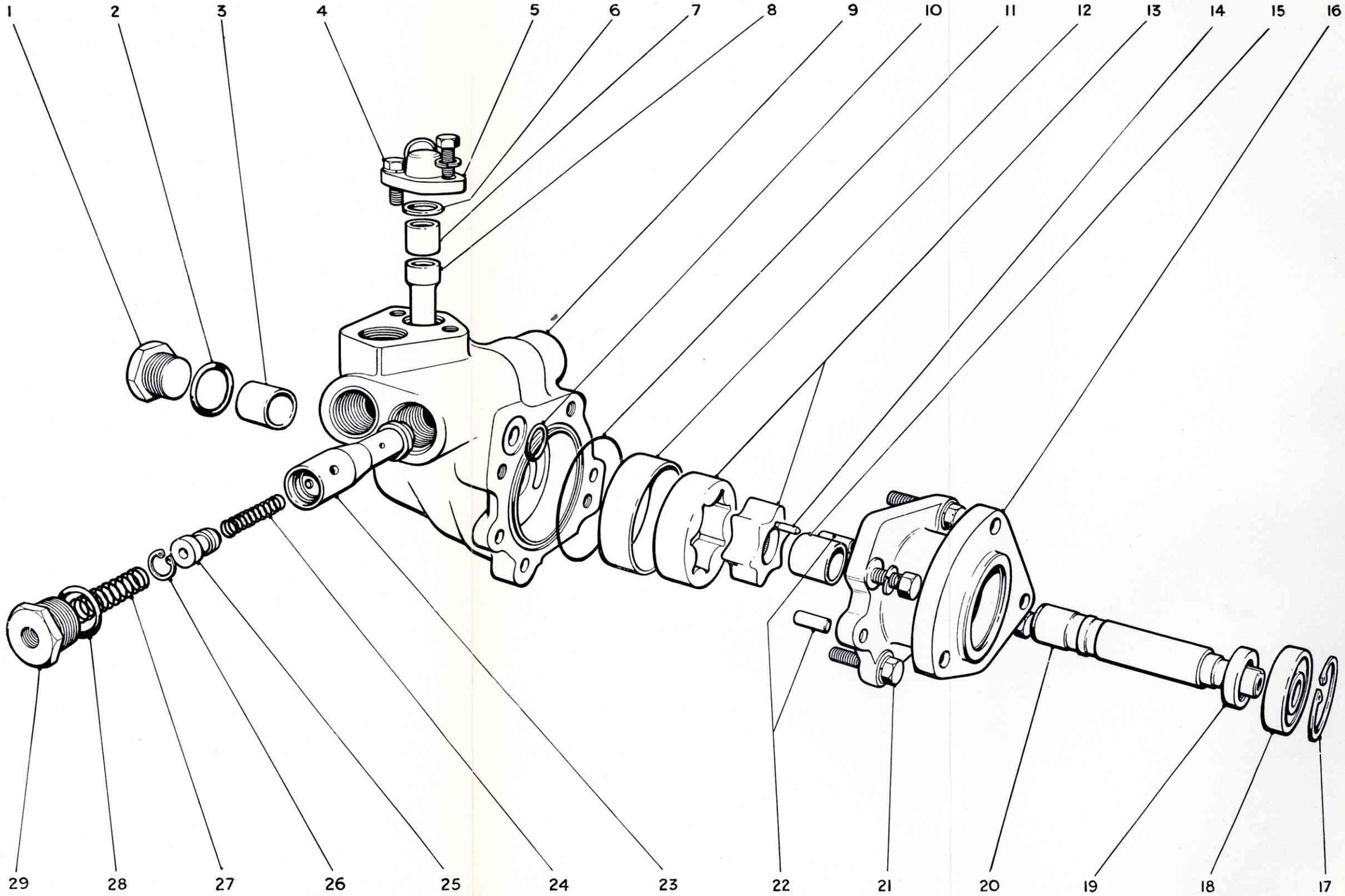
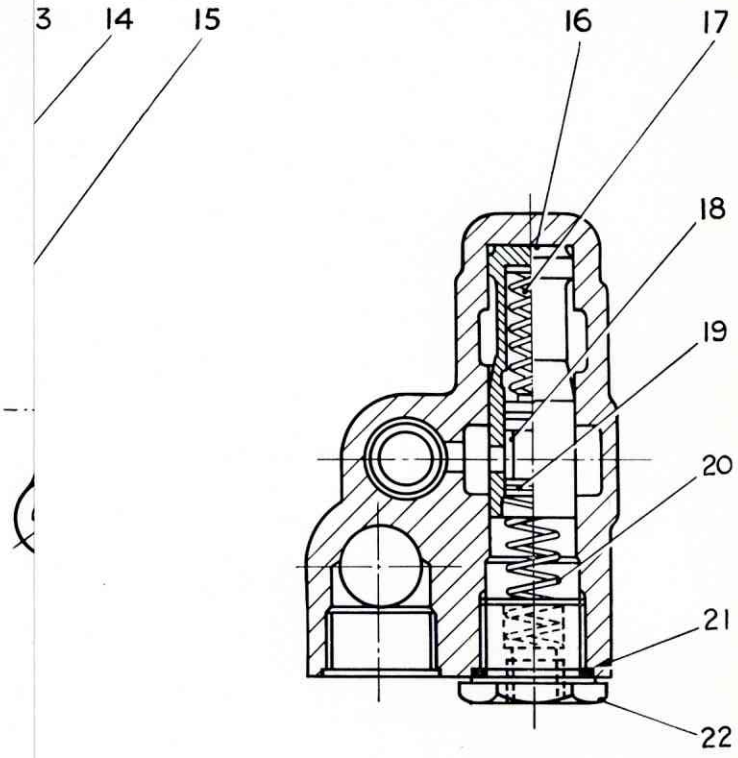
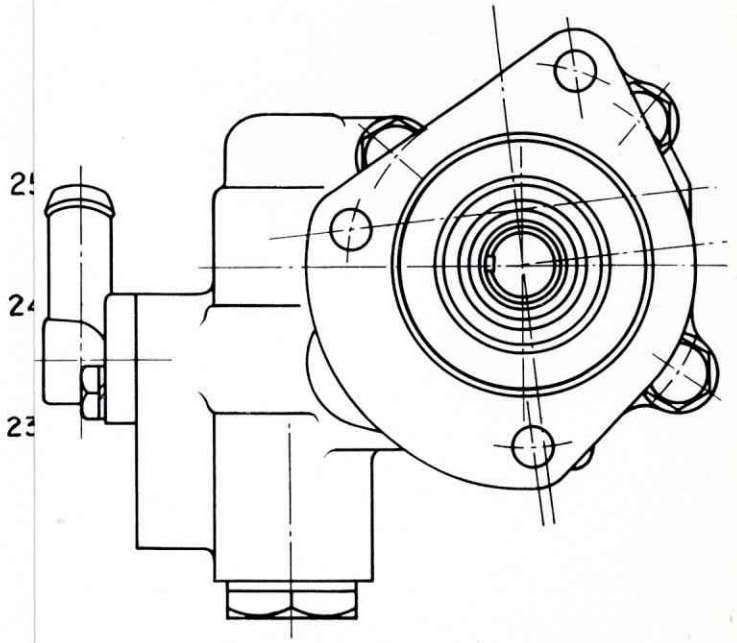


FIG. 108. EXPLODED VIEW OF THE HOBOURN-EATON PUMP



1. Body adapter.
2. Setscrew, washer.
3. Sealing plug.
4. 'O' ring.
5. Bush.
6. Bush.
7. 'O' ring.
8. Outer rotor.
9. Inner rotor.
10. Bush.
11. Cover.
12. Oil seal.
13. Bearing.
14. Circlip.
15. Shaft.
16. Flow control valve.
17. Relief valve spring.
18. Relief valve.
19. Retaining ring.
20. Flow control valve spring.
21. 'O' ring.
22. Adapter.
23. Venturi.
24. Gasket retainer.
25. Gasket.



1. Body adapter.
2. Setscrew, washer.
3. Sealing plug.
4. 'O' ring.
5. Bush.
6. Bush.
7. 'O' ring.
8. Outer rotor.
9. Inner rotor.
10. Bush.
11. Cover.
12. Oil seal.
13. Bearing.
14. Circlip.
15. Shaft.
16. Flow control valve.
17. Relief valve spring.
18. Relief valve.
19. Retaining ring.
20. Flow control valve spring.
21. 'O' ring.
22. Adapter.
23. Venturi.
24. Gasket retainer.
25. Gasket.

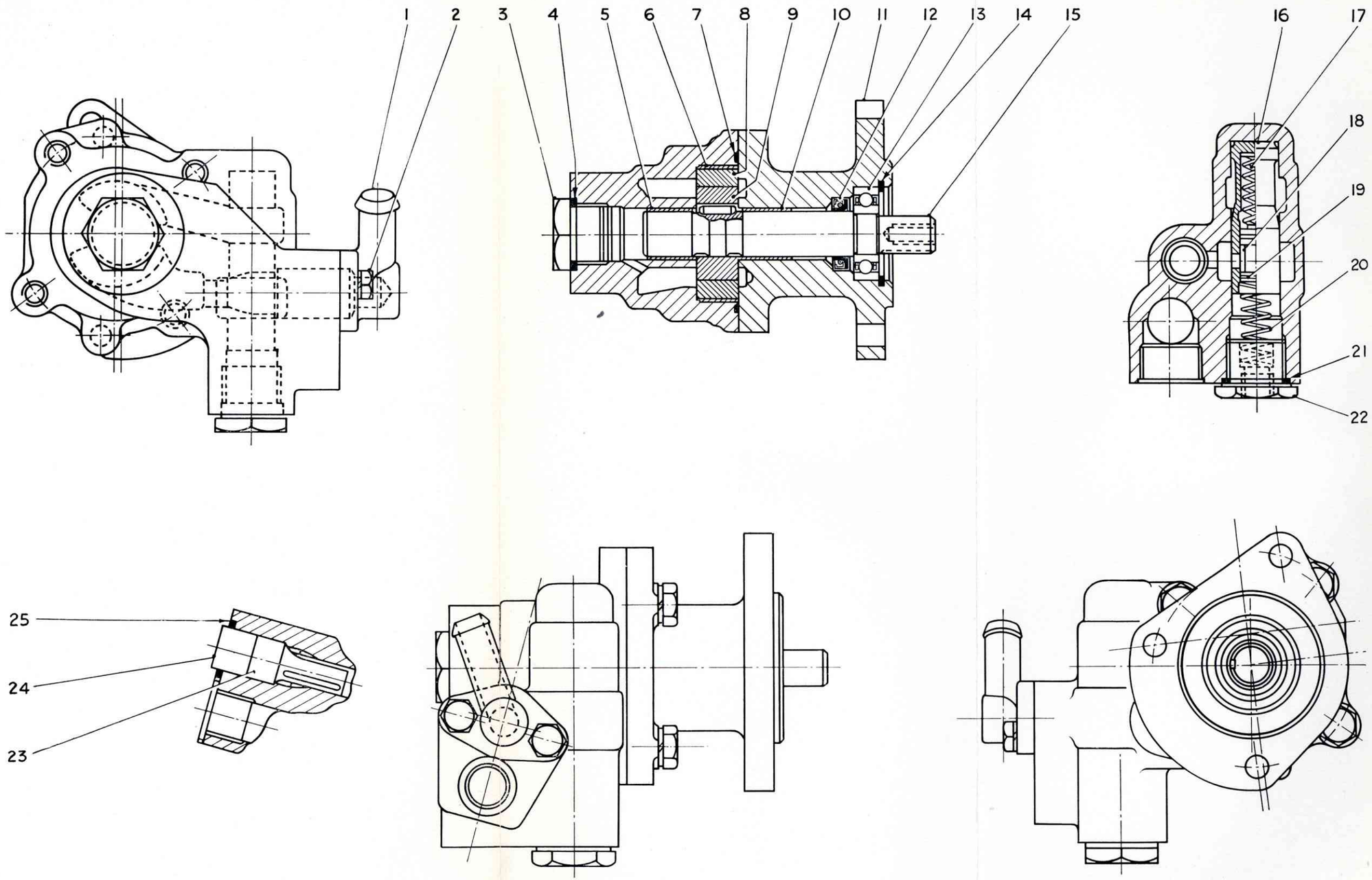


FIG. 109. SECTIONS THROUGH THE HOBOURN-EATON PUMP

THE DYNAMO

SIMMS TYPE 45 D

DESCRIPTION

The dynamo Fig. 110 is a four pole shunt wound generator with field coils connected in series with one common connection for the field and armature.

In the compensated voltage system of battery charging the dynamo output at any particular time depends on the state of charge of the battery and the load in circuit. It is independent of variations in the speed of the dynamo above the initial speed at which the maximum output is generated.

An ammeter connected in the main battery lead only gives the behaviour of the compensated voltage unit if the state of charge of the battery is known, and a low ammeter reading does not necessarily imply that there is any fault in the equipment, since the battery may be fully charged. In such a case, the value of the current (known as the "trickle charge") is determined by the voltage at which the regulator is set.

The maximum current output from the dynamo is controlled and limited by a series winding on the regulator, across which is connected a "diverter strip", and by altering the thickness of the strip, the dynamo output may be modified as desired.

A section through the dynamo is shown in Fig. 110. The dynamo is swung-mounted low down on the front right hand side of the engine. The dynamo end mounting plates permit the whole unit to be swung in an outward direction to give the necessary belt tension, as shown in Fig. 58.

LUBRICATION

No routine lubrication is required.

Repack the bearings with Leyland Spec. G grease at overhaul only.

In general, Simms dynamos are not fitted with lubricators, the intention being that new grease should be

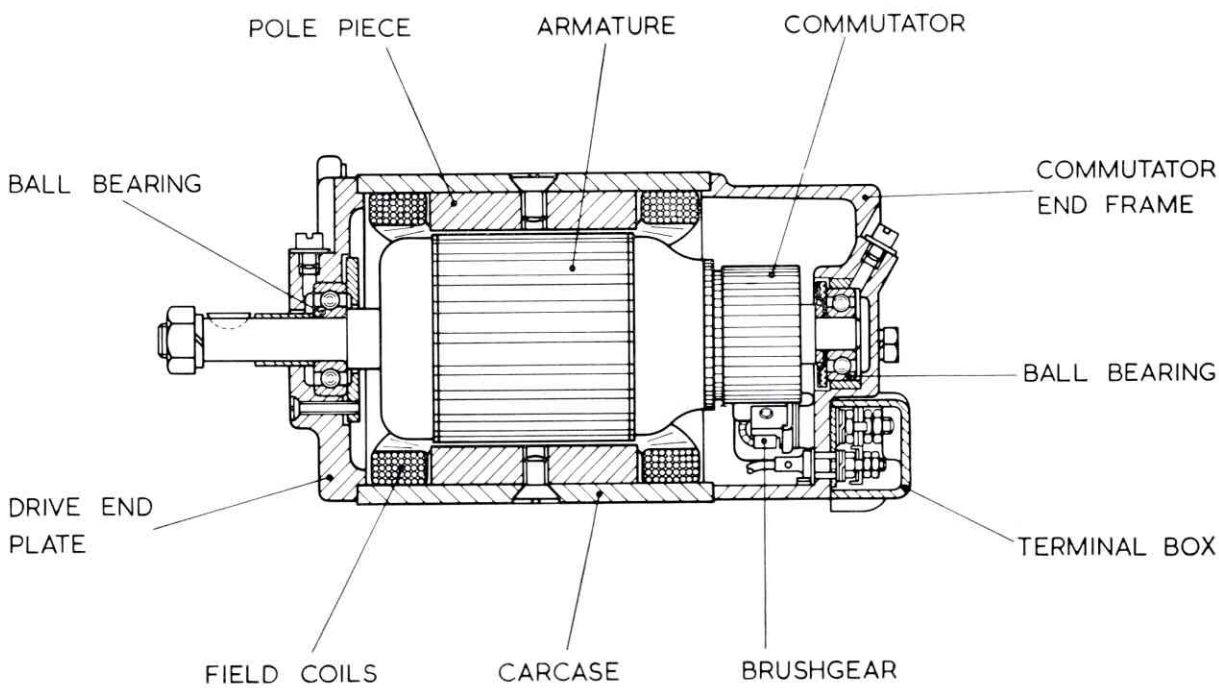


FIG. 110. SECTION THROUGH THE DYNAMO

inserted when the machine receives a complete overhaul. The ball races should then be removed from the shelf and housing, thoroughly cleaned in spirit, and packed with Leyland Spec. G grease for half the circumference of the cage. On no account should ordinary grease be used, as it melts when warm, eventually finding its way out of the bearings, and if allowed to penetrate to the commutator, may prevent the machine generating on models where lubricators have been fitted, never force grease into the bearings with a pressure lubricating system.

MAINTENANCE

There is no routine maintenance between overhaul except to occasionally check the tension of the driving belts which should be approx. 0.75/1.00 in. (19.05/25.4 mm.) slack.

Current Limiting Voltage Control System

Under this system of control, the charge into the battery is controlled by a current regulator until a certain voltage on the battery is reached, after which the charge is maintained at a trickle under the control of the voltage regulator.

In order to ensure that the battery always receives a charge, lamp load must not exceed 85 per cent of the current setting.

An advantage of this system is that the generator cannot be overloaded even with a fully discharged battery and the lamp load connected, furthermore, the battery may receive a charge under these conditions and it allows the full output of the generator to be used for longer periods.

Maintenance

While the dynamo is fitted to the engine it should be inspected every six months. The commutator should be smooth and polished with even colouring and there should be no signs of solder thrown from the commutator connections.

Brushes should be polished over the whole face, be free in their boxes and should be checked for wear. If badly worn they should be re-bedded or replaced.

The radial length of a new brush is 0.625 in. (15.875 mm.) and the brush spring pressure should be 15/20 oz. (425/567 grm.).

Brush spring pressure may be checked with the finger to see if they appear adequate. If readily accessible they should be checked with a spring balance.

All parts should be free from dust and all connections be clean and tight.

OPERATION TESTS IN THE VEHICLE

Open Circuit Test

1. With the engine at rest, disconnect the battery positive lead.

2. Connect an accurate voltmeter (of switch range) across the terminals D+ and D— on the dynamo.

3. Switch off all lamps and other load and start the engine. Run the engine to give approximately 1,000 r.p.m. dynamo speed, and check the voltage. This should be in accordance with the open circuit voltage setting, see Control Board.

   If the voltage is steady but outside these limiting figures, the regulator should be removed from its location and the setting checked, on the other hand, if the volts are zero or if they are unsteady a fault in the field circuit may be indicated and the dynamo and regulator should be examined.

Lamp Load Test

Re-connect the battery lead with a suitable ammeter in circuit, with the engine at rest, switch on all lamps and other load and read ammeter. This indication will give the total load on the battery and should not exceed the figure specified for the set under test.

Battery Charging Test

With the ammeter still in circuit start the engine and run the dynamo at approximately 1,500 r.p.m. If the maximum load is switched on and the battery is fully charged and gassing, there may be a slight discharge or the battery will float. If the lamp load is then disconnected a small charge should be obtained.

Should the battery be in a discharged state however, and the maximum load be switched on, a trickle charge will be indicated on the ammeter. On removing the load, the charge may rise initially to the maximum output of the generator.

OVERHAUL

To Remove and Replace the Dynamo

1. Isolate the batteries by disconnecting the main battery terminals.
2. Disconnect the cables from the dynamo after removing the terminal cover.
3. Slacken off the belt tensioner adjuster and unscrew and remove the strap bolts.
4. Lift the dynamo clear of the belts.

Replacement is the reverse of removal, but the belts must be tensioned correctly.

1. Replace the dynamo but do not tighten up the mounting bolts.
2. Adjust the belt tension to approx. 0.75/1.00 in. (19.05/25.4 mm.).
3. Tighten the mounting bolts securely when the desired tension is obtained.

To Dismantle the Dynamo

1. Remove the driving pulley and key from the armature shaft.
2. Remove the covers from the carcase parts.
3. Lift the brushes from the commutator and wedge in raised position with their springs.
4. Unscrew and withdraw the hexagon headed through bolts and slide out the armature complete with driving end plate.
5. The commutator end plate and brush gear may be removed after disconnecting the field leads.
6. Remove the countersunk head screws holding bearing cap in drive-end plate and withdraw the armature.

Armature

The armature should be maintained clean and free from grease and dust. It will be found in service that the commutator assumes a polished surface with a dark chocolate colour. This should not be cleaned off but any particles of dust from the brushes should be blown away or removed with a clean dry cloth. The binding bands should be examined for signs of loosening and thrown solder.

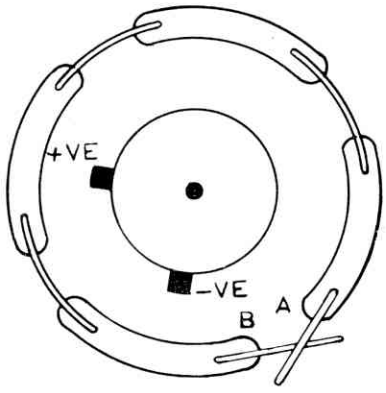


FIG. 111. FIELD CONNECTIONS AND BRUSH POSITIONS VIEWED FROM COMMUTATOR END

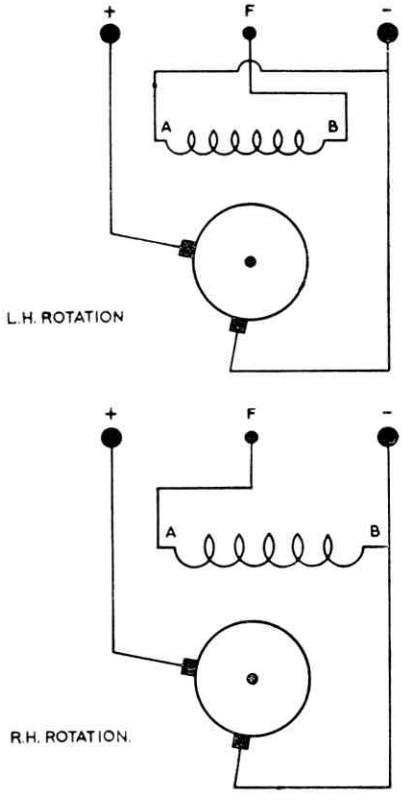


FIG. 112. TYPICAL WIRING DIAGRAM

If the commutator has been neglected and is in very bad condition, it should be set up in a lathe and skimmed, using a diamond tool for preference. It is of great importance that after skimming the commutator surface should be concentric with the bearing diameter and to ensure this the armature should be supported in the lathe between the bearing outer races fitted to the shaft ends rather than between centres.

Only a very light cut should be taken and the tool should be sufficiently keen to leave a smooth surface. The final high polish should be secured by employing a strip of very fine carborundum or glass (not emery) paper. The slots between the segments should be cleared of turnings with the aid of an under-cutting knife (or, in an emergency, with an old hacksaw blade), and the under-cutting of the micas should be maintained at about 0.8 mm., (0.031 in.). Care must be taken to see that no mica is left level with or projecting above the surface of the copper segments.

If a short in the windings is suspected the armature should be tested by means of a "growler". If during the test a hacksaw blade is rested on the core laminations whilst the armature is rotated, a short is indicated when the blade is attracted to the core.

The armature coils should be tested for continuity by passing current from a battery through the armature via two brushes (set at 90 deg.) pressing on the commutator, and noting on a millivoltmeter the voltage drop between every adjacent pair of segments. A variable resistance should be incorporated in the circuit to limit the voltage passing through to about 2 volts. As the armature is slowly rotated, the voltage drop indicated on the meter should be substantially the same for any pair of adjacent segments. A low reading, or none at all, would indicate a partially shorted coil or commutator segment, and a high reading, a high resistance in the coil circuit, probably a badly soldered joint at the commutator riser.

A mains voltage lamp test may be employed to test the commutator insulation. If the lamp lights when it is connected between any segment and the shaft, a short is indicated. Faulty armatures should be returned to a Simms Depot for re-winding.

Field Coils

The field coils should be maintained clean and free from dust and moisture. The flexible leads should show no signs of abrasions and the tags should be clean and well soldered.

A mains voltage test lamp connected in series between the windings and the yoke of the dynamo will indicate any short to earth. An ammeter in series with the winding will indicate, by a high reading, if a short between turns is present. In the latter event, individual coils should be isolated and tested for resistance until a fault is discovered. The field coil resistance per coil at 60 deg. F. (16 deg. C.) is 3.1/3.45 ohms.

Brush Gear

The brushes should always slide freely in their boxes, and the contact faces should be smooth and polished over the whole face. The brush springs must be free from corrosion, move freely, and the springs or brush triggers, which ever are applicable should seat squarely on top of the brushes. All screws must be tight and the connections clean and well soldered. When spiral fibre insulation is provided for the brush leads, see that it is not burnt or loose. Make certain when fitting a new brush that it is of the same grade as the original one.

It is very necessary to "bed in" new brushes so that they bear evenly over the section of the commutator which they cover. This operation can easily be carried out by removing all brushes and wrapping a thin strip of very fine carborundum or glass (not emery) paper round the commutator with the abrasive face uppermost. The new brush is then inserted and the spring placed in position. Rotate the commutator by hand in the direction of the drive, the brush will accurately ground to the correct radius.

When the abrasive is removed, any dust, caused by the grinding process should be blown out. Do not reverse the brushes when replacing them, and always replace them in the original boxes from which they were removed. Check springs for correct tension, of 15/20 oz. (425/567 grm.).

Any time the commutator end plate is reassembled care should be taken that the arrows or other assembly marks stamped on the carcase and end plate line up exactly. On machines which have no arrows stamped, the brush gear must be fixed 0.25 in. (6.35 mm.) in advance of the neutral position. This ensures that the position of the brush gear is set correctly.

The machine should be reassembled, mounted on a running bench and tested.

To Reassemble the Dynamo

Generally reassembly is a reversal of the dismantling process, but care must be taken regarding the following points.

1. Lift brushes and wedge in raised position before re-fitting commutator end plate.

2. Fasten bearing cap in drive end plate before inserting the armature.

3. When reassembling commutator end plate line up assembly marks on carcase and end plate assembly.

No-load Cutting-in Speed and Full-load Tests

1. Connect the dynamo as a plain shunt machine by completing the field circuit to either the positive or negative main terminals through a 3 ampere meter.

2. Speed up the machine until it generates its normal voltage (24 volts) measured by a voltmeter connected across the output terminals and the speed at which this occurs should correspond approximately to the cutting-in speed (1.150 r.p.m.). The field ammeter should read approximately 1.5/1.9 amperes at these speeds.

3. Connect the output terminals Fig. 113 through an ammeter to a variable resistance capable of carrying full load current (7 amperes). Adjust the resistance and speed until the machine is generating full load current at its nominal voltage.

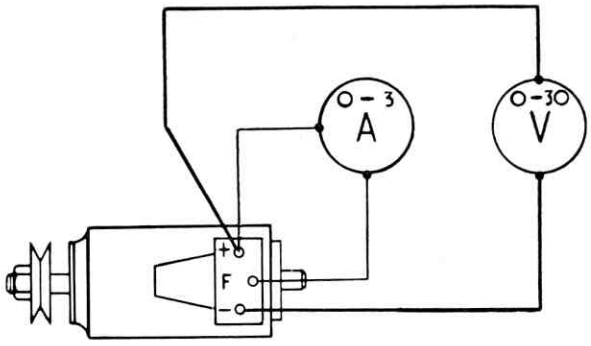
The figure for load and speed should be:

Cutting-in Speed	Max. Amps.	R.P.M.
1150	15	1470

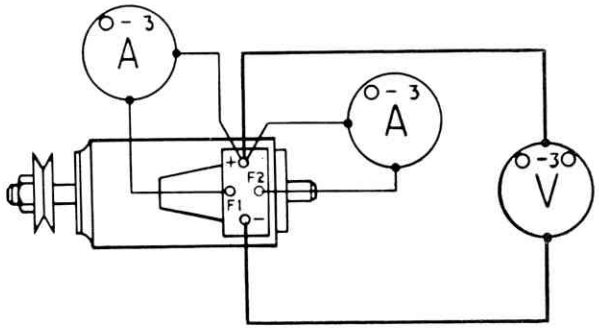
After completing No-Load Cutting-in speed and Full-Load tests, check the insulation to earth with the aid of a mains voltage test lamp. If these tests are satisfactory and the machine is running smoothly, it may be returned to service.

Suppression against Radio Interference

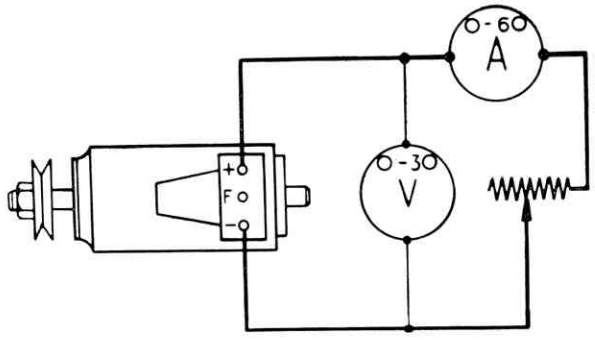
Apparatus is fitted to certain equipment to ensure that no interference is caused to the reception of radio.



Cutting-in speed test.



Cutting-in speed test (split field)



Full load test

FIG. 113. CONNECTIONS FOR TESTS

In some instances, the radio receiving set is actually installed on the vehicle, in others no radio equipment is fitted but the electrical apparatus is suppressed to prevent interference on adjacent vehicles which may be so fitted.

In the case of radio-carrying vehicles, the dynamo and control apparatus, where this is included, is fully

screened with metallic screens, and metal braided screened cable is normally used throughout. In such cases it is essential that the bonding between the various screens be clean and tight, presenting as low an electrical resistance throughout the circuit as possible. Where earth connections are made from the screening, these should be maintained clean and tight.

The dynamo terminal box is fitted with glands or clamping plates to clamp together the metallic screening on the cables and the dynamo, these should also be maintained tight.

It is usual to fit condensers of one microfarad capacity across the dynamo positive and negative terminals and across the output terminals (battery positive and battery negative) when control apparatus is included. In such cases the negative terminal(s) may or may not be directly earthed to the frame, although double-pole wiring will be invariably used.

The condensers, the cases of which constitute poles connected to negative and earth (the centre connections going to positive) can be tested in a simple manner by disconnecting and applying a D.C. voltage up to about 250 volts, momentarily across their terminals in turn. If the condensers are in order, shorting the terminals afterwards will result in a discharge spark in each case.

For vehicles which do not actually carry radio equipment but which have the electrical apparatus suppressed it is usual to fit suppression condensers across the dynamo terminals, and the appropriate remarks given above are applicable.

The dynamo is not normally screened, and screened cable is not usually employed, but the negative pole is invariably earthed throughout the circuit. The normal precautions should be taken to keep such connections to earth clean and tight.

FAULT FINDING

Fault	Possible Location	Possible Cause
No charge	Drive	Broken coupling.
	Armature	Core seized in pole shoes, grease on commutator, coils burnt out, or short-circuited.
	Brush gear	Brushes stuck in boxes or lifted, broken connections.
	Field winding	Broken wire in field circuit, or short-circuited.
	Connections	Broken wire in field lead or common main lead.
	Control panel	Open circuit in field connections, regulator resistance points oxidised, cut-out shunt coil circuit broken, main fuse blown.
	External wiring	Broken wire in field lead or common main lead, field wire shorted to common lead, battery disconnected.
	Bearings	Seized.
Low charge (battery not full)	Armature	Damaged commutator or winding.
	Brush gear	Badly worn brushes.
	Field winding	Intermittent open circuit in winding.
	Control panel	Low voltage regulator setting, bad connection in field circuit, diverter strip broken, regulator swamp resistance shorted.
	External circuit	Bad connection in field circuit, corroded battery terminals, bad connection in main circuit.
	Battery	Sulphated.
High charge (battery full) ...	Control unit	Regulator voltage setting too high, points welded, field lead shorted to live dynamo lead—that is, no regulation. Regulator shunt coil circuit broken.
	Dynamo connections	Field lead shorted to live dynamo lead—that is, running as plain shunt machine.
	External circuit	Field lead shorted to live dynamo lead—that is, running as plain shunt machine.
	Battery	One or more cells internally shorted.
Overheating	Armature	Excessive output machine running as plain shunt dynamo, armature rubbing poles, commutator dirty.
	Brush gear	Brushes sparking due to insufficient tension or overworn or not advanced from neutral position.
	Bearings	No grease, or defective.
	Field windings	Shorted turns or coils allowing excessive field current.
	Grease retainers	Fouling end plates and covers.
Noisy	Bearings	No grease or badly worn by excessive end thrust from coupling.
	Brush gear	High micas, causing brushes to jump and squeak, brushes worn.
	Armature	Core rubbing poles.
	Drive	Out of alignment, loose mounting or worn coupling.

THE STARTER MOTOR

SIMMS TYPE 524 SGRH

DESCRIPTION

The starter motor Fig. 114, mounted at the rear right-hand side of the engine, Figs. 3 and 5, is of 24 volt having four field windings which are in series parallel, the armature is lap wound.

The drive is transmitted through a spring clutch which assists engagement and disengagement of the pinion.

Engagement of the pinion with the flywheel is effected by an axial movement of the pinion against a return spring, the movement being obtained through push rods and a shock spring, operated by an electromagnet, or solenoid. The latter is mounted at the commutator end of the starter and has two windings, one for engagement and one for holding the pinion until the engine fires.

Above this engagement solenoid is fitted a two stage switch, the coil of which is energised through a push button on the switchboard. Operation of the push button closes the first contact of the switch, a trip gear preventing full operation. The first stage connects the engagement coil of the electromagnet in series with the armature, field coils and battery. The pinion is thus brought into mesh with the flywheel gear spring by an axial movement and a slow rotation of the armature. The shock spring, positioned between the push rods, safeguards the pinion against jamming should the pinion and gear ring meet tooth to tooth.

Near the position of full pinion engagement, the lower contacts of the switch are released by the movement of the engaging solenoid. This action short circuits the engaging coil and puts into circuit the holding winding, responsive to variations in load on the starter. At the same time, full voltage is applied to the motor circuit and maximum power is available to rotate the engine.

When the engine fires the current taken from the battery is reduced to a minimum, and the battery holding coil, which is in series with the armature and battery, loses its effect. The pinion is then smartly returned to the free position by the spring, rotating freely until the starter button is released. It should be noted that the pinion cannot re-engage until the starter button has first been released to reset the switch mechanism.

MAINTENANCE

The ball races are packed with Leyland Spec. G. or recommended grease during assembly and should not need attention until overhaul.

No other lubrication is necessary except at overhaul periods.

The commutator and brushes should be examined every six months to check for wear or other defects, such as accumulation of dust around the brush boxes, or traces of grease on the commutator. The removal of these, if present, may prevent trouble at a later date.

The opportunity should be taken at the same time to examine the switch to ensure that it is working freely and that the contacts are not unduly burnt.

It is essential to disconnect the battery before operating the switch for test purposes.

No further work can be carried out on the starter until it is removed from the engine.

TO REMOVE THE STARTER MOTOR

Disconnect the three cables from terminals on the starter, remove the straps securing it in the cradle, draw out towards front of engine.

TO DISMANTLE THE STARTER MOTOR

1. Remove the end cover and gasket.

2. Remove the four countersunk screws and remove front plate assembly, this will release the trip plunger assembly which can then be removed.

3. Disconnect the light and heavy series coils and remove from solenoid body.

4. Remove the two countersunk screws holding the solenoid body and remove the body.

5. It is not necessary to remove the two stage switch unless it requires attention as this switch cannot be removed as a complete assembly. If it is required to remove the switch proceed as follows:

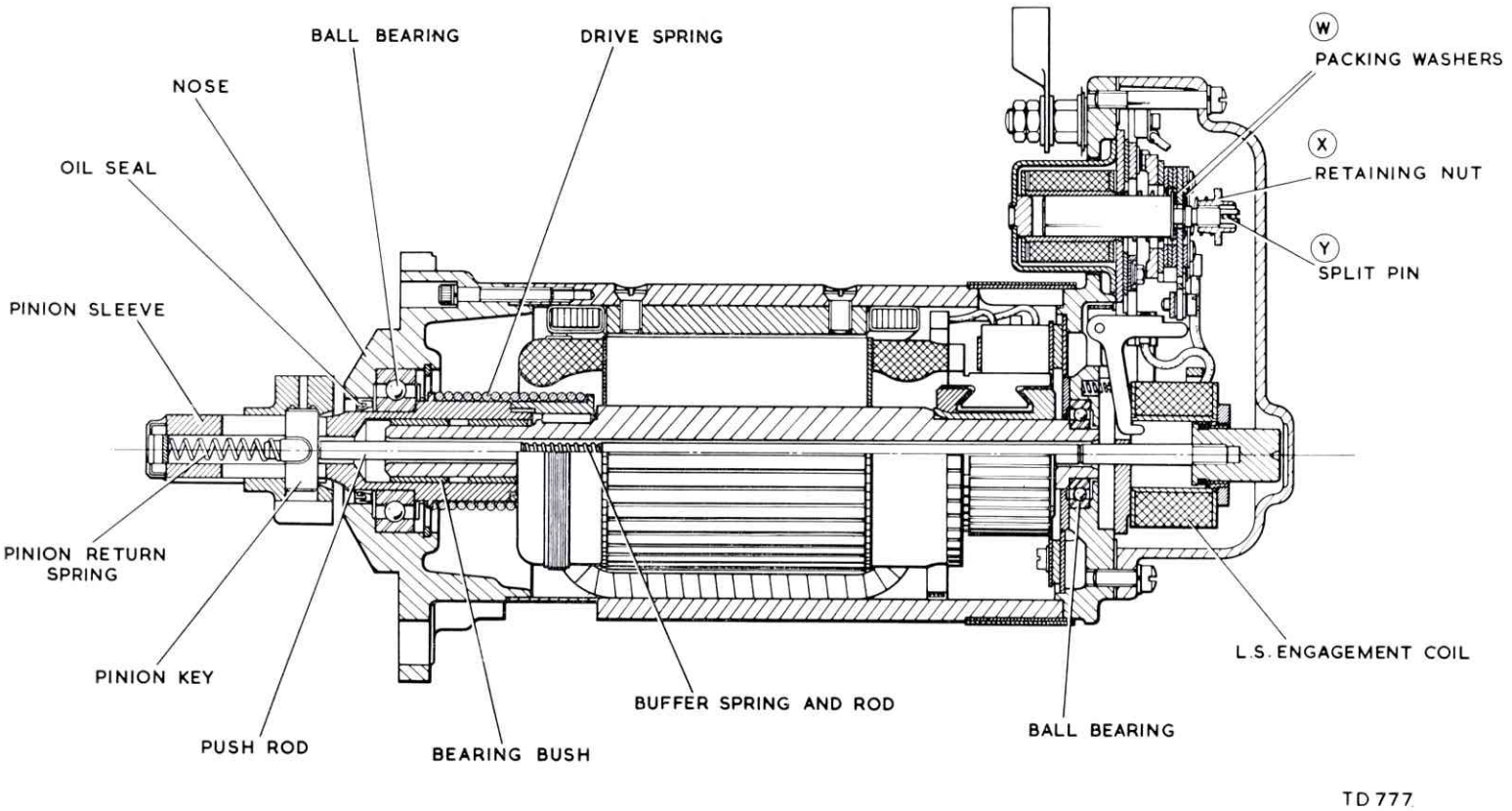


FIG. 114. SECTION THROUGH THE STARTER MOTOR

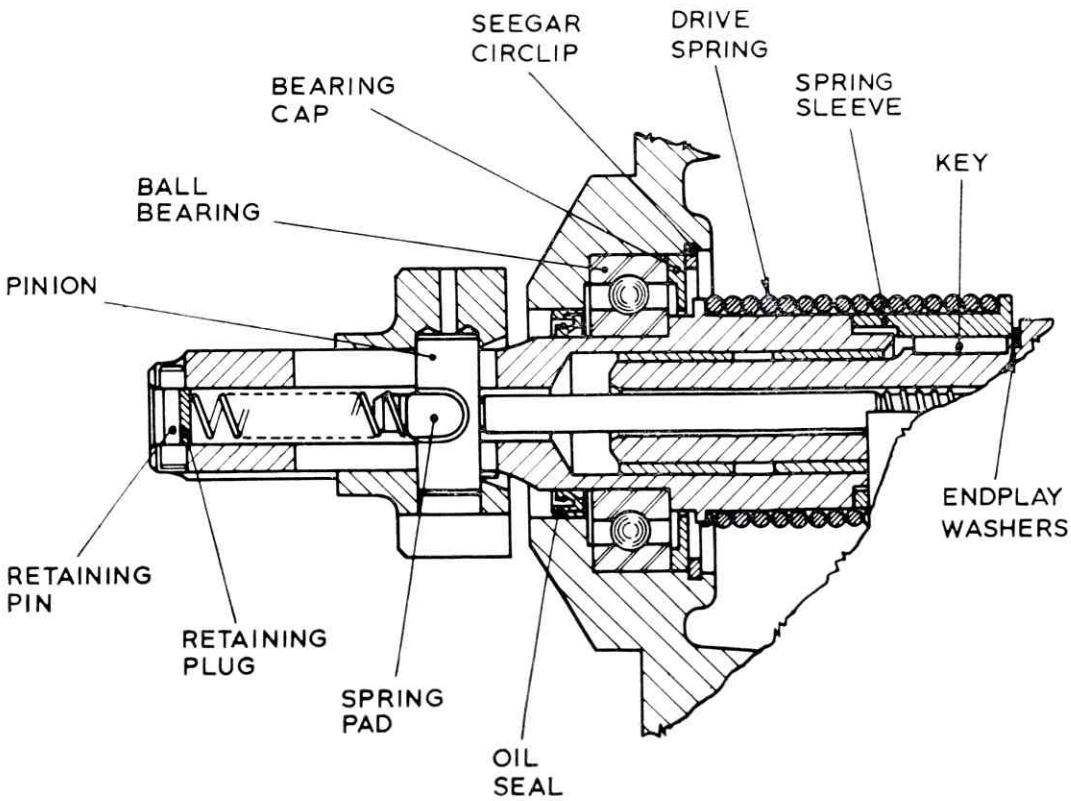


FIG. 115. SECTION THROUGH THE STARTER MOTOR PINION

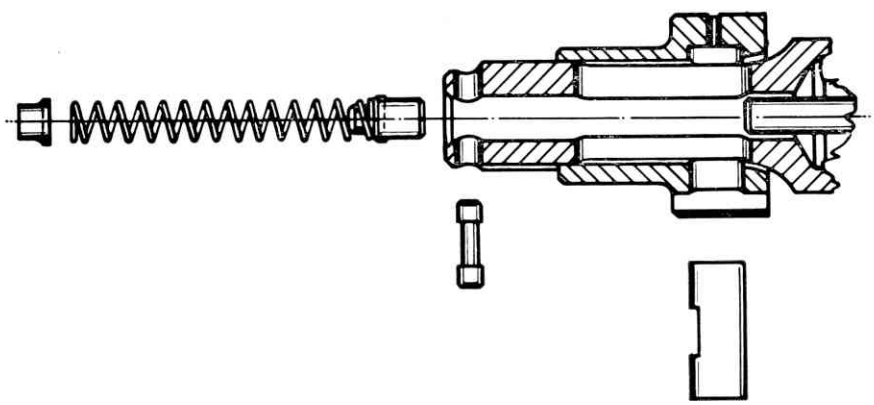


FIG. 116. EXPLODED VIEW OF THE STARTER MOTOR PINION

Remove all connections to the switch, comprising two leads from the armature solenoid and two leads from the supply terminals.

6. Remove the locking nuts and the cone nuts from the switch pillars and lift off the switch contact gear complete. This will expose the 1st and 2nd contact plates.

7. Remove the fixing screws holding the 1st and 2nd contact plates, this will allow the switch coil to be withdrawn.

To Dismantle the Armature

1. Remove commutator cover, lift the brushes off the commutator and wedge them in their boxes by means of the brush springs. Do not remove them from their boxes at this stage.

2. Remove the four countersunk screws spaced around the armature shaft at the commutator end.

3. At the pinion end of the starter remove the socket-headed screws and withdraw the nose section complete with drive spring and pinion.

4. The bush rod gear can now be removed by tilting the commutator end upwards.

5. The armature can now be withdrawn with the assistance of a light tap with a soft mallet on the commutator end.

6. The brush gear and end plate may be lifted off after the removal of the end plate fixing screws, at this stage the two field coil brushes must be removed from their boxes.

To Dismantle the Hose and Pinion Sleeve Assembly

1. Hold the pinion sleeve stationary and rotate the spring drive in the direction of starter rotation pulling simultaneously, the drive spring will then come away. The drive spring sleeve is separated from the drive spring in the same way.

2. To remove the pinion, press in the retaining plug in the end of the pinion sleeve to release the retaining pin. Withdraw pinion return spring and pad, this will free the pinion key which can be removed.

3. To remove the pinion sleeve from the nose section, remove the large circlip from the inside of the nose and push out the pinion sleeve and ball-race. The ball-race may be removed from the pinion sleeve with a suitable press.

Brush Gear

The brush gear should be examined for looseness of brush boxes on the end plate, and for freedom of brushes in their boxes. Bush springs should be checked for pressure and replaced if this is below 1 lb. (.45 kg.). Brushes that have worn to less than .357 in. (9.525 mm.) in length should be replaced.

Note: Spring pressure must be taken with the brushes resting on the commutator.

It is important that the correct grade of brushes (CM5H) is used for any replacements that are made.

The commutator may be skimmed if it shows signs of wear or roughness. The inter-segment micas must be undercut approximately 0.31 in. (0.8 mm.) if the commutator is skimmed, and the brush track finally polished, preferably with fine carborundum paper.

A drop test should be applied to the armature after skimming to ensure that there are no short-circuits between segments or bad joints due to thrown solder. Incidentally, it is advisable to examine the armature for signs of thrown solder before skimming.

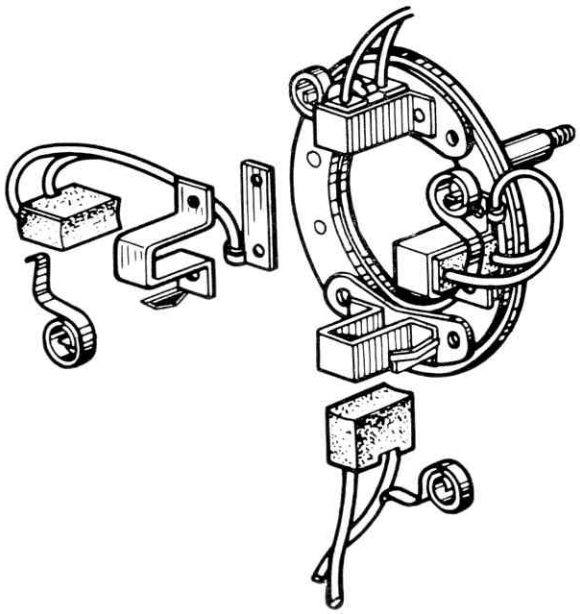


FIG. 117. THE BRUSH GEAR

The pinion should be replaced if the teeth are badly worn, and the pinion return spring replaced if worn or distorted.

The field and engagement coils should be examined for abrasions and tested for shorts between turns or to the frame.

Shorts to the frame can be detected with the usual mains voltage test lamp, and shorts between turns by measuring the volt drop on individual coils when passing a known current, 100 amperes is a suitable current for the field coil test, and 20 amperes for the engagement coil.

The correct resistance and volt drop at normal temperature for the various coils is given below:

Field Coils

Volt drop at 100 amps	.475
Resistance in ohms	.00475

Engagement Coils

Volt drop at 20 amps	3.45
Resistance in ohms	.1725

Lubrication Prior to Reassembly

High melting point grease lubrication is used throughout, Leyland Spec. G. grease is recommended.

The ball-races should not be more than half filled with grease, the push rods and trip mechanism should be lubricated with S.A.E. 20 oil, and the drive spring fairly liberally greased before assembly.

TO REASSEMBLE THE STARTER MOTOR

1. Mount the commutator end plate on the carcase and replace the field coil brushes in their respective boxes, holding them clear of the commutator as in dismantling instructions.

2. Slide the armature into the carcase after making sure that all the brushes are wedged in the boxes to avoid being damaged.

3. Adjust end play of pinion sleeve:

   (a) Assemble the nose section without the oil seal, circlip, drive spring end play washers and keys, Fig. 115.

   (b) Assess end play and fit the required number of end play washers to give 0.15/0.4 mm. (0.004/0.015 in.). These washers are available in thicknesses of 0.1 mm. (0.004 in.), 0.2 mm. (0.008 in.), 0.3 mm. (0.012 in.).

   (c) Check end play and assemble oil seal, circlip, drive spring, drive spring sleeve and keys.

4. Replace the drive spring on the pinion shaft, the nose assembly can now be fitted over the armature, the drive spring assembly engaging with the drive spring keys.

   Replace the solenoid body, light and heavy series coils, trip plunger assembly and front plate assembly.

5. The push rods can now be inserted into the armature shaft from the nose end, long thrust rod first, then buffer spring and rod followed by short push rod.

6. Slide the pinion on to the pinion sleeve so that the keyway in the pinion registers with the keyway in the sleeve. Replace the key ensuring that it is fitted correctly with the stepped side of the key facing away from the armature.

7. Push the pinion return spring with the spring pad attached into the pinion sleeve and ensure that the slot in the spring pad embraces the key. Press in the retaining plug against the spring sufficiently to enable the retaining pin to be inserted into its hole.

   Release the retaining plug, so that it engages in the waist of the retaining pin.

TESTING THE STARTER MOTOR

It is difficult to lay down any specific instructions regarding test, for so much depends on the available facilities.

If a complete test rig is available, including adjustable brake, torque measuring device, and tachometer, then a complete power characteristic can be taken from zero speed (lock torque) up to maximum safe operating speed, (see test data). Failing this, the simplest and most informative test is to measure lock torque in lb. ft. (kg. m.) and current in amperes.

An arrangement as shown in Fig. 118 can be used for this purpose, the results obtained should be similar to those given in the following table:

Lock Torque	26 lb. ft. (3.4 kg. m.)
Amps at Locked Torque	730
Maximum, h.p.	4.0
Torque at max. h.p. lb. ft. (kg. m.)	12.0 lb. ft. (1.7 kg. m.)
Amps at max. h.p. ...	435
R.P.M. at max h.p. ...	1,750
Battery size	24V. 100 AH.

It must be borne in mind that the torque shown will be obtained only if the corresponding current is flowing. This current, in turn, will depend upon the state of the battery used for the test, and the resistance of the leads and connections. However, the figures given will serve as a guide, as the torque is directly proportional to the current over a limited range.

In addition to lock torque test, the machine may run up to speed on reduced voltage and no load, to ensure that the armature is free and not rubbing on the pole pieces or elsewhere. The speed should not be allowed to exceed about 7,000 r.p.m.

STARTER SWITCH

DESCRIPTION

As indicated in the complete starter operation details, the switch functions in two stages. In the first stage the top contacts close and complete the battery circuit through the pinion engagement coil and motor. In the second stage, which is controlled by the pinion engagement mechanism, the lower contacts close, short circuiting the engagement coil and applying the full battery power to the motor through the holding coil.

MAINTENANCE

The switch should be inspected periodically to ensure that the solenoid plunger is free in its guide. It is essential that the battery be disconnected before carrying out any maintenance or inspection work on the switch. When pressed in by hand the moving contact assembly should be returned quickly and freely under the action of the return spring when released.

The contact faces should not be touched if the switch is functioning satisfactorily, as contacts that are well burnt

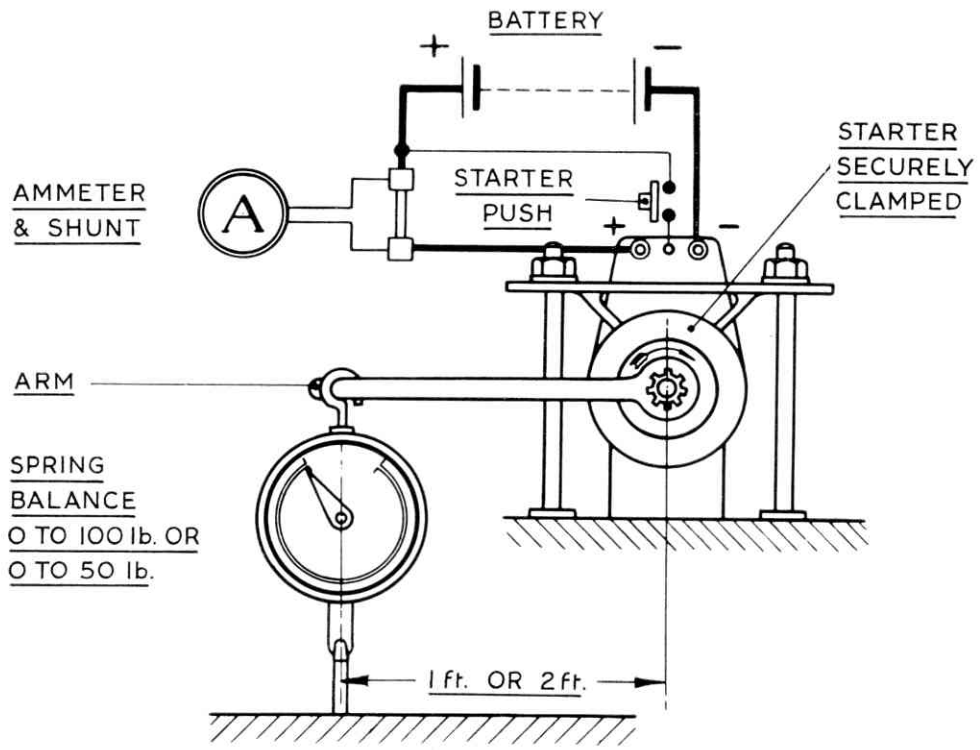


FIG. 118. LOCKED TORQUE TEST ARRANGEMENT

are more reliable than when newly machined or re-surfaced. Only when there are beads of copper adhering to the contact faces should an improvement of the surfaces be undertaken and the work should then be confined to the removal of these beads.

The resistance of the solenoid coil should be 5.05 ohms.

TO DISMANTLE THE STARTER SWITCH

1. Unscrew the locknuts and coned nuts, which will allow the whole of the moving system, including the plunger, to be removed as a unit from the frame. The release of the trip lever will free the return spring, which is liable to jump out.

2. It is not normally necessary to dismantle the moving contact assembly from the plunger, but this can be carried out if required by removing the split pin and unscrewing the spring retainer.

3. All traces of stale or dried grease should be removed from the plunger and guide.

Setting Data

1. With both contact faces of moving contact assembly closed on fixed contacts, armature to travel on an additional 1.0/1.3 mm. (0.039/0.051 in.), adjust by varying the number of washers (W) Fig. 119.

2. Assemble contact pressure spring and retaining nut (X), screw nut down until just touching spring, then screw down a further two turns. Temporary lock by passing the split pin (Y) through hole in nut and slot in armature.

3. Trip lever stop group is to be assembled in position shown.

4. Adjust gap (A) by varying number of washers so that the gap is 1.4/1.8 mm. (0.055/0.070 in.) when the moving gap is closed and trip lever is engaged with the trip lever stop.

5. The armature is to travel fully home in one movement with coil current not exceeding 3.0 amps. If necessary slacken back the retaining nut (X) by a quarter turn to obtain the single closing movement required, and complete the locking of pin (Y)

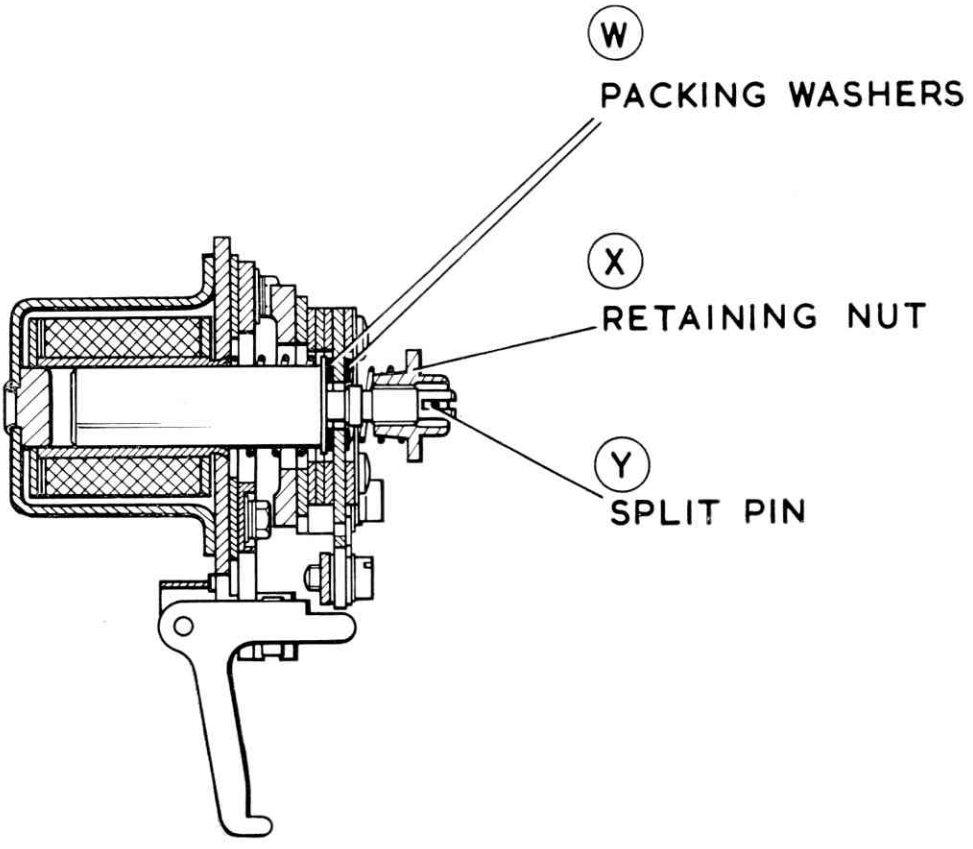


FIG. 119. THE STARTER SWITCH

TEST DATA

Preliminary Examination

1. Check armature end play 0.15/0.4 mm. (0.005/0.015 in.).

Check the pinion setting relative to spigot face on nose section 47.3/47.9 mm. (1.86/1.88 in.).

Check that the pinion moves freely.

Check that the brushes are free in their boxes.

Check that the switch armature is free in its guide.

Check switch tripping position between lever and plate 1.4/1.8 mm. (0.055/0.070 in.).

Check that the switch armature travels fully home in one movement with a coil current not exceeding 3 amps.

Check that the solenoid armature moves freely.

2. Insulation Test

The insulation between the terminals and earth to be not less than 1 megohm when measured with a D.C. voltage of 220/260 volts applied for a sufficient time to allow needle of testing instrument to become stationary.

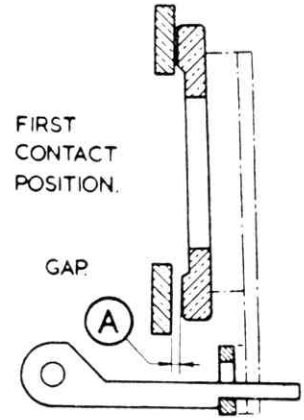


FIG. 120. STARTER SWITCH FIRST CONTACT POSITION

Note: This test should only be carried out when the machine is free of carbon dust.

3. Condition of Test

For subsequent tests, numbers 4, 6 and 7 use a 24 volt battery with a capacity of 110 ampere hours or its equivalent. For a test number 6 use a 12 volt battery of 220 ampere hours or its equivalent. Test to be made in the minimum possible time and in the sequence given.

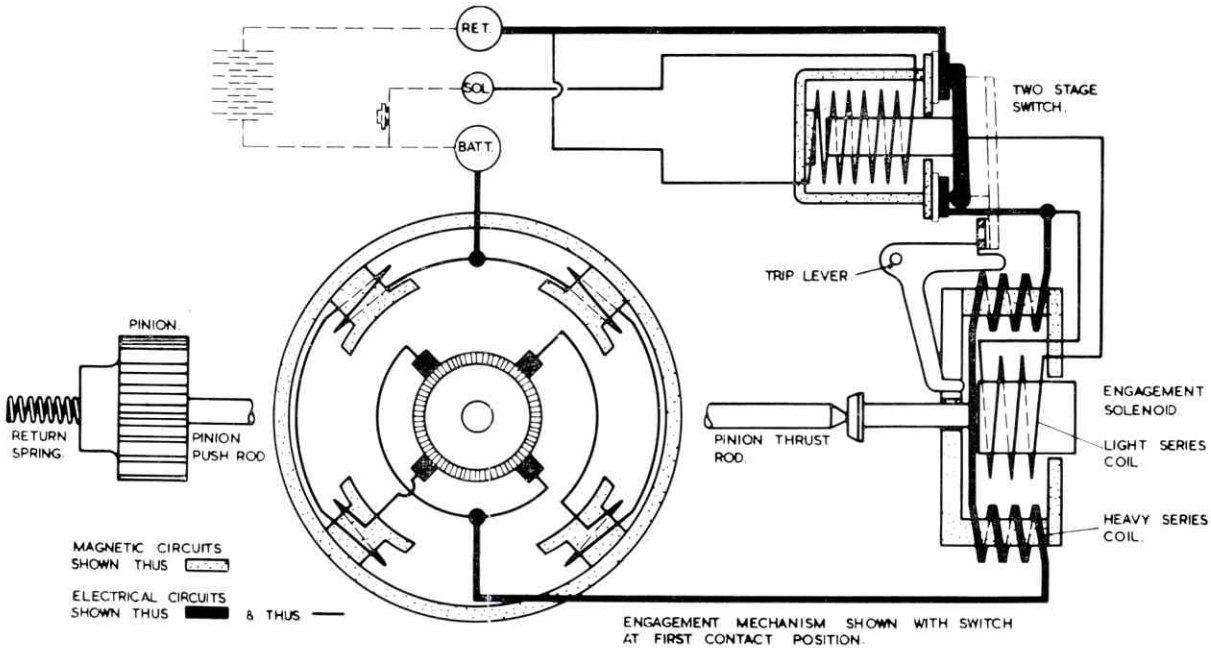


FIG. 121. THE CIRCUIT DIAGRAM

4. Free Running Test

Run starter up to full speed with no load. Check for any undue sparking of brushes on commutator. Check for any excessive noise caused by armature rubbing on poles or by high commutator bars.

5. Test Rig

Fit starter with a suitable slave pinion. Transfer starter to a test rig, which should consist of a brake wheel directly coupled to a suitable gear ring, with a mounting positioned in relationship to the gear ring, simulating engine conditions of tooth clearance and clearance between the engaging faces of gear ring and pinion.

6. Locked Armature Test

The current passed by the light series engagement coils when the switch makes its first contact to be 100/120 amps. The torque exerted by the starter when the switch makes final contact to be not less than the number of lb. ft. quoted for a given current input as shown on the graph, Fig. 122.

7. Engagement Test

(a) Set the load on the brake wheel to give the starter an operating speed of 1,500/2,000 r.p.m.

(b) With load set, switch the starter on and when engagement is complete allow the starter to reach a speed in the range of 3,500/4,000 r.p.m.

(c) When this speed is attained, switch off. Repeat tests (a) and (b) six times, checking for satisfactory engagement and drive, and ensuring that the pinion does not disengage below a starter speed of 4,500 r.p.m.

8. Switch Tripping Check Test

Re-check tripping position 1.4/1.8 mm. (0.055/0.070 in.) reset if necessary.

In the event of resetting being necessary, test No. 7 should again be carried out.

9. Final Test

Remove slave pinion and refit original pinion. Repeat Test No. 2 with end cover removed.

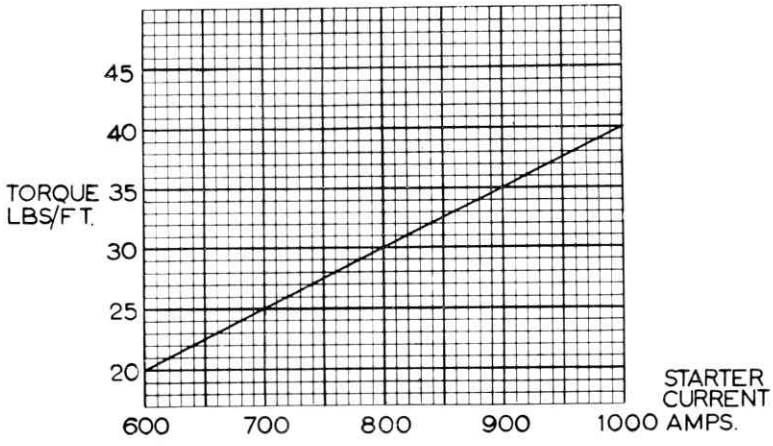


FIG. 122. GRAPH TO SHOW TORQUE EXERTED BY STARTER MOTOR

FAULT FINDING

Indication of Trouble	Trouble	Action
Pinion engages but no power ...	Discharged battery	Charge battery or use slave battery.
	Bad connections in external circuit or cables too thin	Check all connections or refit heavier cables.
	Faulty armature	Return machine for repair.
	Brushes worn, spring pressure low or wrong grade of brush	Replace brushes and check spring pressure.
	Switch not making on 2nd contact, contacts burnt or trip pin worn or broken	Clean contacts, check gaps on 1st and 2nd contacts. Replace trip pin.
	Clutch slip due to worn or broken drive spring or nose bearing seized up	Replace drive spring or ease nose bearing and lubricate.
	Engine seized up	Free the engine.
No operation of starter motor ...	Leads to starter button broken	Remake connection.
	Battery disconnected	Check isolator switch.
	Battery discharged	Charge battery or use slave battery.
	Corroded or loose connections	Clean and remake connections.
Pinion fails to engage	Engagement coil burnt out or leads unconnected	Replace coil and/or connect leads.
	Brushes lifted or stuck in boxes	Clean brushes and refit.
	Starter switch not making on first contact	Return starter for repair
	Worn or burred pinion or gear ring	Renew damaged parts.
	Push rod mechanism sluggish	Return starter for repair.

THE DYNAMO

C.A.V. TYPE GL 4524-1

DATA

Type	GL4524-1, totally enclosed, two brush, earth or insulated return.
Rotation	Clockwise.
Voltage	24 volts.
Output	15 amps.
Field	2 pole.
Cutting-in speed	1,150 r.p.m.
Maximum Load Speed	1,550 r.p.m.
Brush type	EG.12.
Commutator skimming minimum diameter	1.643 $\pm$ 0.005 in. (41.73 $\pm$ 0.13 mm.).
Brush wear limit (min. length)	0.425 in. (10.8 mm.).
Drive shaft key	Woodruff. NKI-6.
Drive end bearing	NC. 216.
Comm. end bearing	NC2-4.
Field resistance	15.4 $\pm$ 0.75 ohms.
Net weight dynamo	22 lb. (10 kg.) net.
Brush spring loading	25/30 oz. (709/850 gr.).
Control box	RB310/37361 pos. earth return.

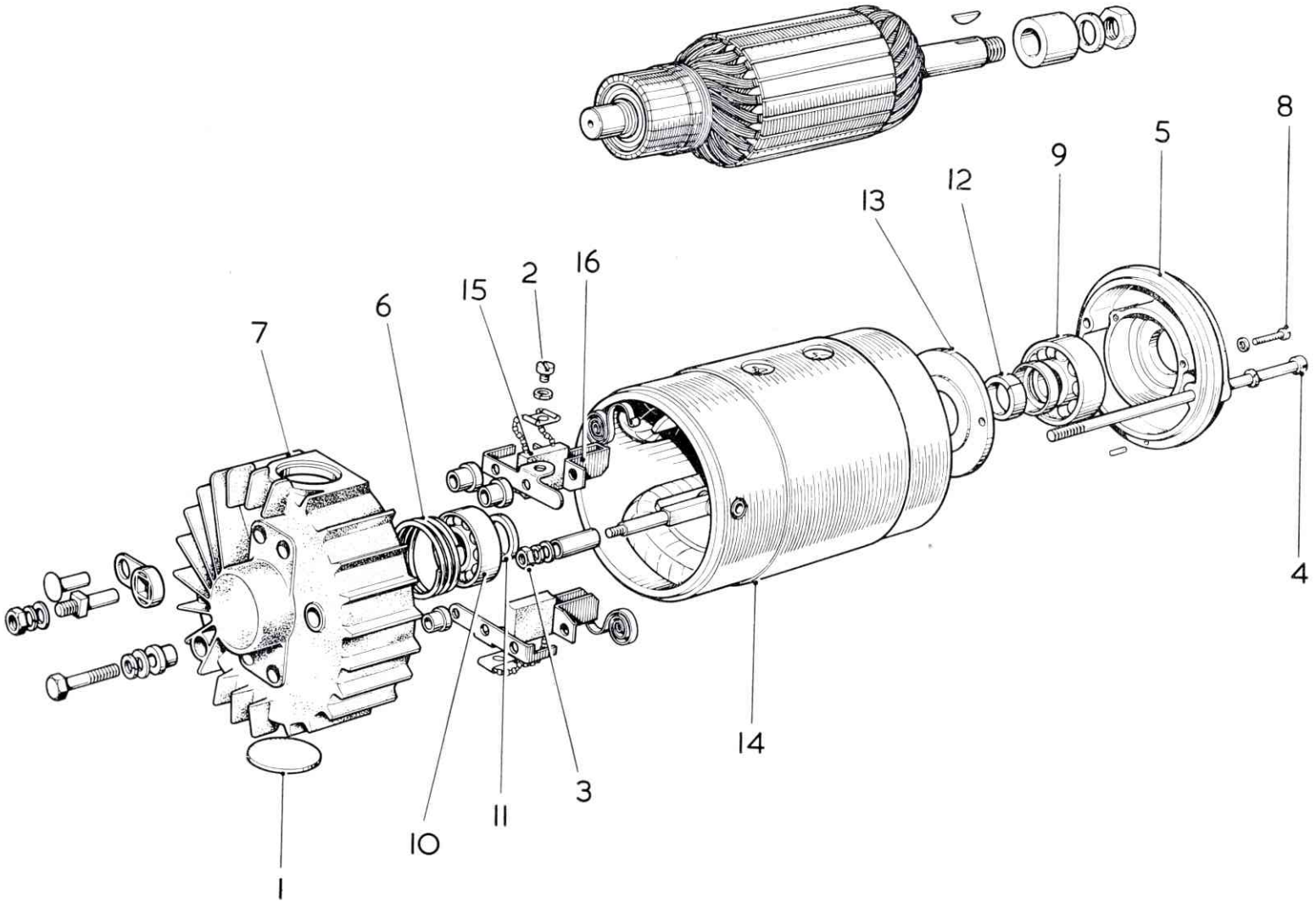


FIG. 123. EXPLODED VIEW OF THE DYNAMO

1. Welch washer.
2. Screw.
3. Nut.
4. Through bolt.
5. Drive end shield.
6. Spring.
7. Commutator end shield.
8. Clamp screw.
9. Bearing.
10. Bearing.
11. Distance washer.
12. Retainer.
13. Clamp plate.
14. Dynamo frame.
15. Brush.
16. Brush box.

DESCRIPTION

The dynamo is a totally enclosed, 2 pole, 2 brush, 24 volt machine with an output of 15 amps and can be used with earth or insulated return systems. It is designed for clockwise rotation and is cradle mounted.

Commutator End Shield

The cast aluminium, commutator end shield is generously finned for rapid heat dissipation. The commutator end bearing and the helical thrust washer are housed within the end shield. The use of the helical thrust washer with the commutator end bearing gives a longer service life and automatically maintains the correct bearing end float. The bearing is sealed on the commutator side only to enable a grease change to be made quickly at specified overhaul periods.

Brush boxes, spun riveted to the end shield, are insulated from the rest of the machine and access to the brushes is through the end shield access holes. These holes are sealed against the ingress of dirt and water by welch washers and with the washers removed the brushes and brush springs are readily examined.

Through-bolts from the dynamo drive end secure the commutator end shield to the dynamo yoke.

Drive End Shield

The cast-iron drive end shield houses the clamped, drive end bearing and is secured to the dynamo yoke by the through-bolts.

Field Coils

The two field coils are series connected and are located in the yoke by the two pole pieces. One lead of the field is connected to the insulated F terminal post and the other lead is connected to the brush box in line with plug 'A' shown on the commutator end shield illustrated Fig. 124. An insulator bush under plug 'A' enables the machine to work on earth or insulated return systems.

For earth return systems the insulator bush is removed and plug 'A' is tightened down on to the commutator end shield.

For insulated return systems the insulator bush remains in place and the insulated return lead is connected to the brush box terminal.

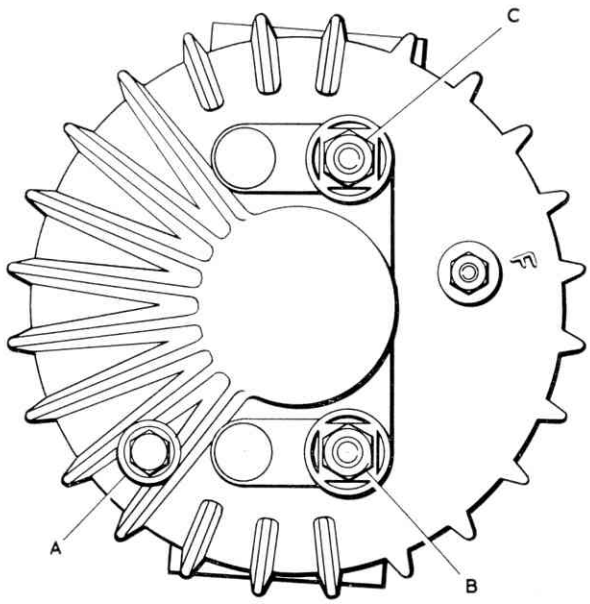


FIG. 124. THE TERMINAL IDENTIFICATIONS

Terminal A

Remove insulator bush under screw A for earth return machines. Fit bush (if not already fitted for insulated return machines).

Terminal B

Red for insulated return and positive earth return. Black for negative earth return.

Terminal C

Black for insulated return and positive earth return. Red for negative earth return.

Terminal F

Used as field connection for all types of return.

TO TEST WHILE IN POSITION ON VEHICLE

Before attempting to carry out tests on a faulting dynamo make sure first that the drive belts are correctly tensioned. Approx. 0.75/1.00 in. (19.05/25.4 mm.) slack. A slipping drive belt is the most obvious fault when the dynamo is not charging, or the battery is flat after a long run. Next examine all screws and bolts for security and re-tighten if necessary.

1. Make sure the main fuse (if fitted) in the dynamo circuit is in good order and is held securely in the fuse holder.
2. Examine all connections in the charging circuit for security. Pay particular attention to the dynamo leads.

3. Run the engine and observe the charging rate.

4. If there is still no charge disconnect the leads from the dynamo.

5. Short out the field on the dynamo by connecting a shorting lead between the F and black terminal on positive earth and insulated return machines.

6. Connect a 0 to 50 d.c. voltmeter across the red and black terminals.

7. Run the engine at idling speed and observe the voltage indicated on the voltmeter.

8. Gradually increase the speed to 1,200 r.p.m. until a reading of 24 to 27.0 volts is indicated on the voltmeter.

9. If a voltage within this range is indicated on the voltmeter the dynamo is charging and the fault lies elsewhere in the circuit.

10. Stop the engine, disconnect the voltmeter, remove the field shorting cable and replace the dynamo leads.

MAINTENANCE

If no voltage is indicated during in-position testing take out the welch washers and check the brushes for free movement in the holders. Also examine the commuter segments for cleanliness and pitting.

Remove any carbon dust from within the brush gear housing and make sure the brushes are not worn below the specified limit 0.425 in. (10.8 mm.). The 'bedding' of the brushes should also be checked and if necessary the brushes should be re-bedded as described in the **Repair Notes.**

If the commutator requires skimming the dynamo must be removed from the engine and dismantled as described in **Dynamo Dismantling.** Do not skim the commutator below the minimum diameter 1.643 ±0.005 in. (41.13±0.13 mm.).

If the brush gear and commutator are in good condition and any dust present has been cleaned out, retest the dynamo using the test sequence already described under **To Test While in Position on Vehicle.**

If still faulty the dynamo requires further tests.

Field Coil Tests

1. Disconnect the leads from the dynamo.

2. Lift the brushes out of the brush boxes and make sure the brushes and leads do not touch any part of the dynamo frame.

3. (i) For positive earth machines connect a 24-volt test lamp and battery between the F terminal and earth (B+to earth B—to F).

   (ii) For insulated return machines connect the test leads between the F terminal and the red painted terminal.

   The lamp will light if there is continuity through the field coil. Failure to light indicates an open circuit.

   Note: Observe correct polarity of battery connection otherwise dynamo polarity may be reversed.

4. If an ohmmeter is available test the field coils for short circuits by disconnecting the test lamp and connecting an ohmmeter in place.

   For positive earth return machines connect between the F terminal and earth.

   For insulated return machines connect between the F terminal and the red terminal.

   A reading of 15.4 ± 0.75 ohms should be obtained. If after testing the field coils are found to vary appreciably from this figure the coils require replacement.

   See **Repair notes** for details of this operation.

BENCH TESTING

Further testing of the dynamo will require its removal and dismantling. After dismantling remove dirt, dust and grime from the dynamo parts.

Armature testing and repair

Place the armature in a "growler" type test machine and check the armature windings for short or open circuits.

If an armature testing machine is not available use a 24 volt test lamp, fitted with testing prods, connected to a 24 volt battery. Place the test prods on adjacent commutator coils and work round the commutator checking each successive pair of bars in turn. The test lamp will not light on open circuited windings and should an open or short circuit be discovered the armature will require replacement.

Examine the commutator bars for pitting, scoring and damage. Any faults discovered will require skimming of the commutator. Take care when skimming the commutator that the permitted minimum diameter 1.643 in. (41.73 mm.) is not exceeded and that only the minimum amount of metal is removed. Do not use the armature shaft centres to mount the armature in a lathe but mount the armature using the armature bearing journals.

A general check should also be made of the commutator risers for signs of overheating, usually indicated by charring of the riser insulation and disturbed solder on the soldered connections of the commutator segments. The commutator will require undercutting after skimming.

With the foregoing checks completed the armature should be given an insulation test with a 100 volt insulation tester, the acceptance figure with the armature hot being 2 megohms.

Field Coil Testing

Check the field coils for continuity by connecting an ohmmeter between the F terminal post and the field coil lead. A reading of 15.4±0.75 ohms should be obtained. Readings at variance to this figure will require field coil replacement.

To check the insulation resistance connect a 100 volt insulation tester between the F terminal and the generator yoke. With the field coils hot the minimum acceptance figure is 2 megohms.

In the absence of measuring instruments the field coils can be checked for continuity with a 24 volt test lamp. The test lamp can also be used to check the insulation between the field coil and the dynamo frame. If a complete breakdown of the insulation has occurred the lamp will light when the test leads are connected between the F lead terminal and the dynamo yoke.

Note: If a low resistance reading is obtained make sure the F terminal post insulator bushes are not at fault. Unsolder the field connection to the terminal post and connect the insulation tester between the post and the dynamo yoke. A low resistance or zero reading indicates insulator breakdown and the bushes should be renewed. With the field connection unsoldered the field can be checked independently and the insulation tester should be connected between the dynamo yoke and one of the field leads. A reading below 2 megohms indicates field coil insulation failure and the coils should be changed.

Brush Gear

On earth return machines remove screw 'A' Fig. 124 and connect the insulation tester to the brush boxes and the end shield on which they are mounted.

On insulated return machines connect the insulation tester between the brush boxes and the end shield. Screw 'A' need not be disturbed on insulated return machines.

A reading appreciably lower than 2 megohms indicates a breakdown of the brush box insulation and the bushes and insulators must be replaced. After testing earth machines do not forget to replace screw 'A'.

Reassembly Check

When the tests described have been carried out reassemble the dynamo as described in **Dynamo Reassembly.** Carry out the following operations before reassembling the machine.

1. Check the brushes for wear, minimum length 0.425 in. (10.8 mm.) and replace as necessary.

2. Check the brushes for freedom of movement in the brush boxes.

3. Where necessary particularly if the commutator has been skimmed, bed-in the brushes. See **Repair Notes** for brush bedding operation.

4. Reassemble the dynamo and if a variable speed test rig is available mount the machine in the rig.

5. (i) On positive earth return machines connect a shorting lead between the F terminal and the black terminal post.

   (ii) On insulated return machines connect the shorting lead between the F terminal and the red terminal.

6. Connect a d.c. voltmeter across the red and black terminals and run the dynamo up to a speed of 1,200 r.p.m.

7. The voltmeter should read approximately 24 to 27 volts.

8. If the reading is correct check the brush lead holding screws for security and replace the welch washers.

9. Remove the shorting lead between F and black or red terminals.

10. Remove the dynamo from the rig and replace on the engine.

Note: If a variable speed test rig is not available the dynamo can be motor tested. Connect a shorting lead between the F and black terminal for insulated return and positive earth machines and between F and red terminal for negative earth return. Place the dynamo in a soft-jawed vice and connect a 24-volt battery across the red and black terminals. Connect the B+ lead to the red terminal and the B— lead to the black terminal. If the dynamo faults have been corrected the armature should 'motor' in the direction of the generator rotation. **Observe correct polarity of battery connection to the dynamo terminals otherwise the dynamo polarity may be reversed.**

MAINTENANCE

Because of the totally enclosed design of the dynamo servicing is reduced to a minimum.

25,000 Miles (40,000 kilometres) Check

1. Examine the brushes for wear and blow out any carbon dust present in the housing. Note that welch washers used to seal the access holes can only be used once. Each time the washers are removed they should be renewed.

2. Check the brushes for freedom of movement in the brush boxes.

3. Check all dynamo connections for security and signs of fraying.

4. Check all securing nuts and bolts for security.

5. Check the drive belt tension (approx. 0.75/1.00 in. 19.05/25.4 mm.).

6. Start the engine and listen for unusual noises originating from the dynamo. Rectify any faults discovered.

50,000 Miles (80,000 kilometres) Check

1. Remove the dynamo from the engine.

2. Clean external dirt and grime from the dynamo.

3. Dismantle the dynamo. See paragraph on dynamo dismantling.

4. Examine the commutator for signs of pitting and corrosion.

5. Examine commutator risers and the soldered connections for signs of overheating. Rectify any faults discovered.

6. Re-grease the commutator end bearing.

7. Examine the brushes for wear (minimum length 0.425 in. or 10.8 mm.) and for freedom of movement in the brush boxes.

8. Check the loading of the brush springs 25/30 oz. (709/850 gr.).

9. Check all terminal posts for security.

10. Check for excessive movement of the bearing outer races.

11. Test the field coils and the armature for continuity and insulation resistance.

To Dismantle the Dynamo (See Fig. 123)

1. Remove the welch washers (1).

2. Disconnect the brush lead connecting screws (2) and remove the brushes. Move the field connecting lead to one side.

3. Remove the nuts and spring washers from the terminal posts.

4. Take out the through bolts (4) from the drive end shield.

5. Remove the drive end shield (5) complete with the armature end bearings from the dynamo frame.

Note: Make sure the helical thrust spring (6) housed in the commutator end shield (7) does not spring out of the dynamo during this operation.

6. Remove the commutator end shield (7).

7. Take out the bolts (8) holding the drive end shield to the bearing clamp plate (13) and remove the drive end shield.

   Both the armature bearings are now exposed for examination and test.

Bearings

The drive end and the commutator end bearings are a push fit on the armature journals. They can be pressed out on a mandrel press or removed with a bearing extractor tool. When removing the bearings take care not to lose the distance washer from the commutator end or the bearing ring retainer from the drive end. **Keep dirt and grit out** of the bearings otherwise premature bearing failure may occur.

Ensure that the bearings are prepacked with Leyland Spec. G grease at overhaul.

To Reassemble the Dynamo

1. Replace bearings (9 and 10) on the armature shaft. Make sure that distance washer (11), commutator end, and the bearing ring retainer (12) and bearing clamp plate (13), drive end, are positioned on the shaft before the bearings are pressed home.

2. Fit the drive end shield to the armature by fitting and tightening down the bearing clamp screws (8).

3. Fit the helical spring (6) into the housing in the commutator end shield (7).

4. Fit the commutator end shield to the dynamo frame (14) by placing the end shield flat on the bench and lowering the frame into the end shield.

   Note: Make sure the field connecting lead is not trapped between the frame and the end shield when the frame is lowered on to the end shield.

5. Fit the insulator sleeved bushes to the projecting terminal post and fit the terminal nuts and washers (3).

6. Lower the armature and drive end shield assembly into the dynamo frame. Make sure the armature, commutator end, enters squarely into the bearing housing and that the dowel hole is correctly positioned in relation to the dynamo frame dowel.

7. Fit and tighten down the through-bolts (4) from the dynamo drive end.

   The through-bolts tighten down into the commutator end shield.

8. Fit the brushes (15) into the brush boxes and connect the brush leads to the brush box (16).

9. Connect the field connecting lead to the brush box. After reassembly the dynamo should be checked as laid down in the **Reassembly Check.**

REPAIR NOTES

Welch Washers

Welch washers used in the access holes can only be used once. They must be renewed after removal.

When fitting the washers they should be lightly tapped in position with a small ball-pane hammer to make sure the washer is spread sufficiently to seal the access hole.

When removing washers tap the washers with a ball-pane hammer and apply sufficient force to loosen the washer in the access hole. It should be loosened sufficiently to drop out under its own weight when the dynamo is turned to bring the access hole to the bottom.

Field Coils

When renewing field coils a pole shoe expanding tool should be used to ensure a good surface contact between the pole pieces and the dynamo frame.

Fit the coils to the pole pieces and place in position in the yoke. Insert the pole screws loosely in the pole pieces.

Operate the pole shoe expanding tool to make sure there is no air gap between the pole pieces and the frame.

Tighten down the pole screws with a wheel operated screwdriver.

When connecting the leads take care to connect the leads to the correct terminals otherwise the dynamo polarity will be reversed.

"Bedding-in" brushes

When the commutator has been skimmed the brushes will require "bedding-in". This operation should be done with the dynamo dismantled.

Place a strip of fine glass paper round the commutator. The paper must not be smaller in width than the commutator and must be the exact length required to cover the whole of the commutator bars. The strip ends should be cut to meet at an angle of 45 deg. to avoid brush lift whilst the brushes are being "bedded". Attach the glass paper strip to the commutator with a water soluble glue. **Do not use a non water-soluble proprietary quick setting cement or glue** otherwise difficulty will be experienced in removing it from the commutator after the "bedding-in" operation. Make sure the strip is a tight fit over the commutator and allow time for the glue to set. When the strip is fixed securely to the commutator place the armature in a Vee-block. Place the commutator end shield on to the armature and make sure the bearing (10) is entered squarely in the housing.

Fit the brushes into the brush boxes and place the brush springs centrally on the brushes to press them on to the glass paper. Revolve the end shield around the armature in a clockwise direction until the brush contact face is smooth and shaped to the contour of the commutator. With this achieved lift the brushes and remove the end shield from the armature. Pull the glass paper strip away from the commutator and remove all traces of glue from the bars.

Note: Segment undercutting should be completed before attempting to "bed-in" the brushes.

THE STARTER MOTOR

C.A.V. AXIAL TYPE

DATA

Type	C.A.V. 'Axial' 24 volt.
Mounting, R.H....	Flange SL5/24/4.
L.H....	Flange SL5/24/Y2.
Rotation	Clockwise.
Return	Insulated.
Nominal b.h.p.	6.
Current at maximum b.h.p.	550 amps.
Solenoid current	3.5 amps.
Solenoid type	BBNG.
Terminals	Post type.
Number of brushes	4.
Number of poles.	4.
Brush type	DM. 100.
Field resistance	Shunt, 0.7±0.04 ohms. Auxiliary, 0.42±0.025 ohms.
Brush spring pressure	3.5 lb. (1.63 kg.).
Permissible commutator dia. after skimming...	1.81 in. (46 mm.).
Solenoid air gaps	First contacts: 0.40±0.004in. (1.00±0.100 mm.). Second contacts: 0.142±0.008 in. (3.6±0.200 mm.).
Solenoid trigger clearance.	0.079±0.004 in. (2.00±0.100 mm.).
Bearings	Drive end—white metal. Commutator end—sintered iron.
Lubrication—Method	Oil plug at drive end.
Oil grade	Temperate climate 10W/30W Cold climate 5W/20W.
Starter net weight	43 lb. (19.5 kg.).

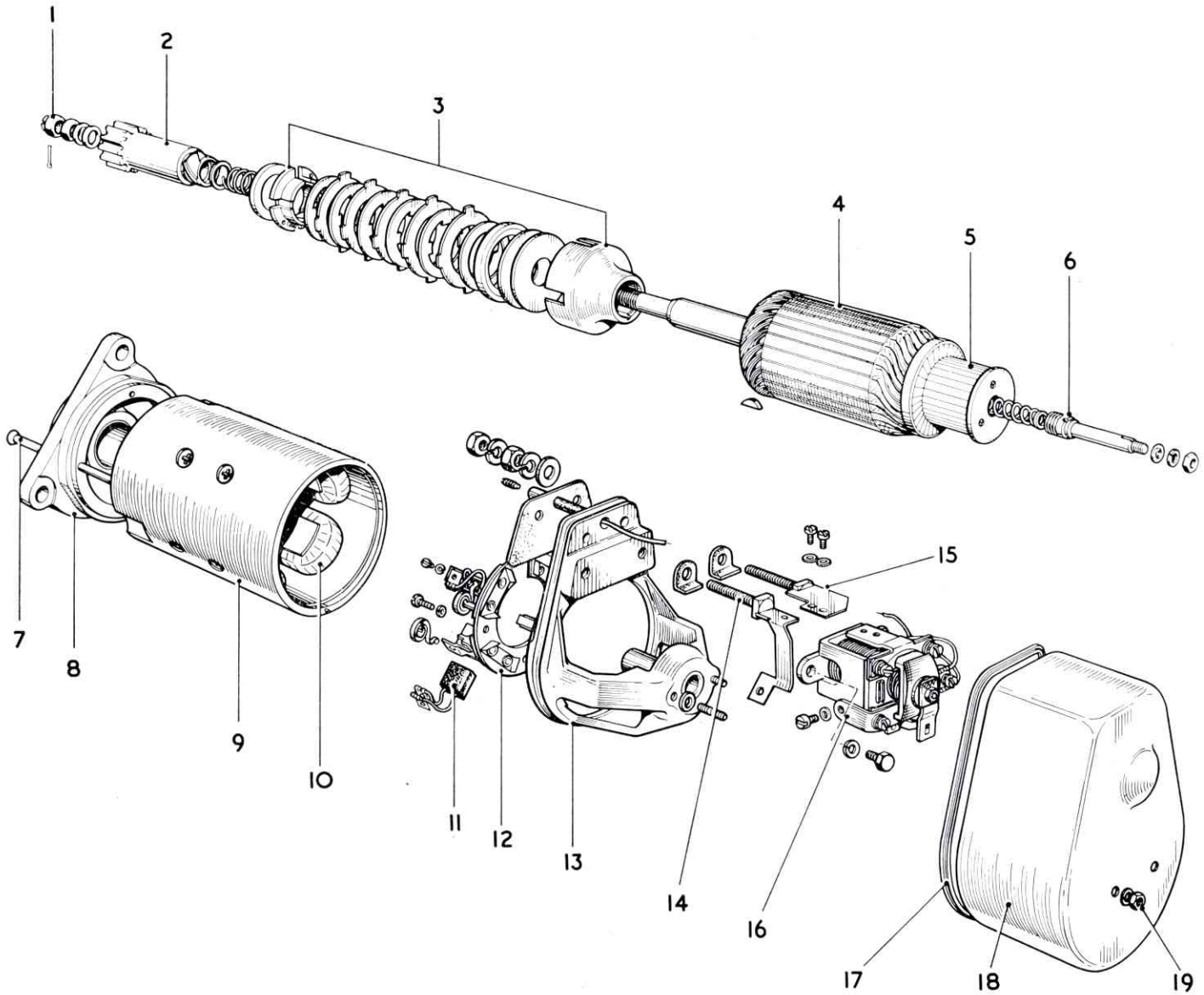


FIG. 125. EXPLODED VIEW OF THE STARTER MOTOR

1. Pinion nut.
2. Pinion.
3. Clutch assy.
4. Armature.
5. Commutator.
6. Plunger assy.
7. Through bolts.
8. Drive end shield.
9. Yoke.
10. Field coils.
11. Brushes.
12. Brush gear.
13. Commutator end shield.
14. Negative terminal.
15. Positive terminal.
16. Solenoid switch assy.
17. Gasket.
18. End cover.
19. Nut.

DESCRIPTION

The starter motor is a 24-volt, 5 inch diameter machine of the 'Axial' type and is designed for R.H. (right-hand) or L.H. (left-hand) mounting, clockwise or anti-clock rotation. A built-in heavy duty solenoid is housed under the commutator end cover.

The starter is known as an 'Axial' type because the complete armature assembly and pinion move forward to engage the pinion with the flywheel gear ring. Like other C.A.V. 'Axial' starters the drive pinion makes a positive low speed engagement with the flywheel gear ring, and because of the low engaging speed practically eliminates damage caused by faulty pinion meshing. Normally the armature is held in the disengaged position by a return spring at the commutator end of the machine, and in this position the armature is axially out of register with the pole shoes.

The starter field winding consists of an auxiliary and main series, together with a shunt winding. A solenoid operated switch forms an integral part of the starter, so that only a small push switch, to handle the solenoid current, is required. 'Holding-on' windings are incorporated to prevent the risk of premature ejection of the pinion due to spasmodic firing before the engine is running normally.

A spring-loaded multiplate clutch is incorporated in the starter and provides an effective safeguard against damage in the event of an engine back-fire, or an excessive starter overload.

OPERATION

When the externally mounted control push button is operated, the heavy duty solenoid built into the starter will be energised and will cause the first stage contacts to close. With these contacts closed the auxiliary series and shunt windings are brought into circuit causing the armature o revolve slowly and move axially forward to register wtith the pole shoes.

As the armature moves forward to mesh the slowly rotating pinion with the engine flywheel gear ring, a trigger catch, projecting into the starter body from the solenoid, is operated by a projecting collar on the moving armature as it safely meshes the pinion at the end of its forward travel. When the trigger catch is tripped, the solenoid second stage contacts close and bring the main series winding into circuit, thus enabling the starter to develop its full power and turn the engine over.

The starter pinion will remain in mesh until the engine fires normally and as long as the control button is held down. Premature ejection of the starter pinion, caused by spasmodic engine firing, is prevented by the holding-on' windings which keep the pinion in mesh, until the push button is released.

Should the engine back-fire, the multiplate clutch, fitted to the starter, slips to prevent damage being incurred. The clutch will also operate if the starter is subjected to an excessive overload.

If the armature overspeeds a 'free-wheel' device built into the clutch assembly automatically operates to prevent damage to the armature.

As soon as the control push button is released, the pinion disengages and returns to the disengaged position, where it is held by the pinion return spring.

OPERATION TESTS

If the starter does not operate satisfactorily, certain tests can be carried out whilst it is on the vehicle.

1. Check that battery is fully charged.

2. See that cable connections are securely made.

3. Push starter button; if starter does not operate, connect voltmeter between SOL terminal on starter and—terminal. Push starter button again. If no reading on the voltmeter, the fault is between the button and starter.

4. Push starter button; if solenoid clicks it indicates that the switch is working on first contacts only and full load current is not being applied to starter. Faulty armature adjustment or worn switch trigger can cause this.

5. If starter crashes into engagement, the switch trigger Fig. 125 and plate may be worn on the step and slotted portions.

6. Intermittent starter operation with the starter button held down can be caused by second contacts on solenoid switch being burnt or starter brushes worn. Faulty connections on starter button or battery terminal posts can also cause this.

7. Worn bearing at driving end of starter will cause slow engagement and loss of power by the armature fouling the pole pieces.

8. If the starter operates but does not turn the engine, clutch may be slipping or teeth may be worn.

TO REMOVE THE STARTER MOTOR

Disconnect the three cables from terminals on the starter, remove the straps securing it in the cradle, and withdraw the starter motor.

TO DISMANTLE THE STARTER MOTOR

Armature, Clutch and Pinion

1. Remove nuts and take off commutator end cover, see Fig. 125.
2. Remove nut on plunger with tool C.A.V. 5693/45.
3. Remove screws securing brush tags and lift brushes in their boxes and secure by wedging with brush springs.
4. Remove driving end shield screws, free end shield from yoke and gently withdraw armature assembly.
5. Hold armature securely, remove nuts in front of pinion, and withdraw pinion and end shield together.
6. Take out pinion spring.
7. Withdraw clutch and pressure plates from housing.
8. To remove armature spring and plunger, unscrew nut with spanner C.A.V. 5693/106.

Solenoid Switch

1. Remove screws securing positive terminal connector, Fig. 125, main and auxiliary field connections to switch.
2. Remove nut on SOL terminal and take off switch connection, also the screw and flex connected to negative cable.
3. Remove fixing nut and take off switch without connections.

Commutator End Shield and Brush Gear

1. Remove the screw holding connector to brush holder.
2. Remove three screws securing brush holders, taking care not to break or lose the mica washers and three small bushes.
3. Remove the two brush holders.
4. Remove large insulating bush and two large washers, noting the position of the shaped washer.
5. Remove main positive and solenoid terminals.

Field Coils

Remove pole screws, see Fig. 125, and take off field coils. Pole pieces are marked 1, 2, 3 and 4 to correspond with numbers on the commutator end of yoke. They must be replaced in the same positions.

OVERHAUL

Armature Bearings

The bushes in the commutator end shield and driving end shield are machined in position. For replacement it is desirable that end shields complete with bushes are used as supplied for spares.

A special tool is required for removing and replacing internal bush in commutator end of armature.

Commutator

The commutator surface must be clean and free from uneven discoloration. There must be no deposit bridging between the bars.

Clean with fine grade glass paper, not emery. If in a badly pitted condition, skim up in a lathe. Take a very light cut and use preferably a diamond tool to obtain high finish.

After turning, or if mica is high, undercut mica to a depth of 0.031 in. (0.794 mm.); start with a three-cornered file and finish with a hacksaw blade ground to width of mica.

Testing Armature

Place armature in "growler" and test in same way as dynamo, see **Testing Dynamo Parts.**

Clutch and Pinion

Renew clutch plates and pinion if worn.

Test the clutch for slip torque by rigging up as shown in Fig. 128.

Insert the clutch plates, alternately bronze and steel, five of each, starting with a bronze plate so that the last one will be steel to take the pressure of the small springs. Smear the parts lightly with grease (Leyland Spec. G grease or proprietary brand recommended by C.A.V.).

Check that a new pinion has the same number of teeth as the old one, and test thread in the inner race of clutch for smooth action. See that the pinion spring has not lost compression.

Fit the small initial pressure spring with the large diameter end in the clutch race holes. Fill the pinion with grease (Leyland Spec. G grease or proprietary brand recommended by C.A.V.).

Feed the pinion through the end shield, lifting the felt lubricating pad to prevent damage.

Replace pinion spring and engage pinion with inner race of clutch.

Push the pinion home against spring pressure and replace the nut and locking nut on the shaft. Check that the nuts are up against the shoulder on the shaft before inserting split-pin.

To Test Clutch for Slip Torque

After assembly the clutch must be tested for slip torque.

Rig up the clutch as shown in Fig. 128, with an arm one foot long and apply weight to the end.

When newly assembled the clutch must be adjusted to slip at 100/115 lb. ft. (13.8/13.9 kg.m.) and tested ten times. Then adjust to slip at 80/100 lb. ft. (11.0/13.8 kg.m.).

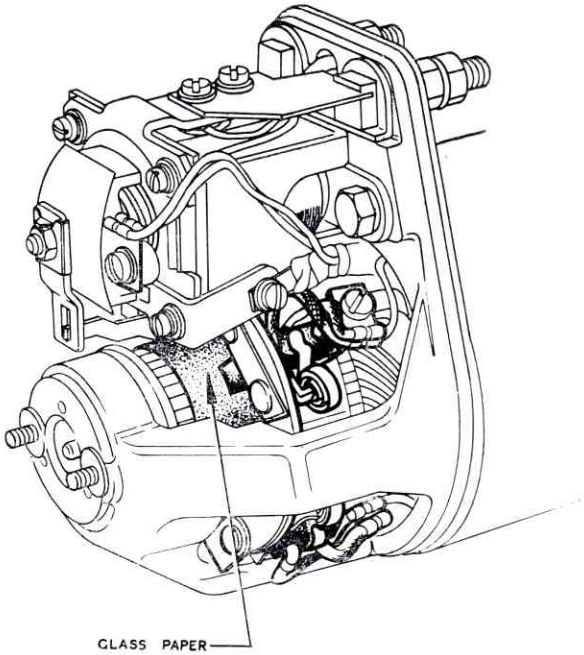


FIG. 126. BEDDING STARTER MOTOR BRUSHES

If the clutch slips at less than 80 lb. ft. (11.0 kg.m.) torque, a compensating washer, Fig. 127, must be fitted between clutch plates and back ring. Washers are available 0.004 in. and 0.006 in. (0.1016 mm. and 0.1524 mm.) thick, and one or more must be inserted as required.

To Renew Pinion Without Dismantling Starter

If pinion teeth are badly worn, a new pinion can be fitted without dismantling starter if considerable care is used.

1. Remove split-pin and castellated nut, Fig. 125, from shaft.

2. Stand starter on end, pinion uppermost. Loosen thin shaft nut, keep pinion held down firmly against spring pressure and take off the nut.

3. Remove lubricator (if fitted), Fig. 130, and spring.

4. Whilst still maintaining resistance against spring, turn pinion slowly in opposite direction to rotation when driving, anti-clockwise from pinion end. Gradually release pressure whilst turning until pinion is unscrewed from clutch and free to remove from end shield.

   It is essential to do the operation slowly and carefully to avoid disturbing the clutch plate.

5. Check that pinion has the same number of teeth as the old one.

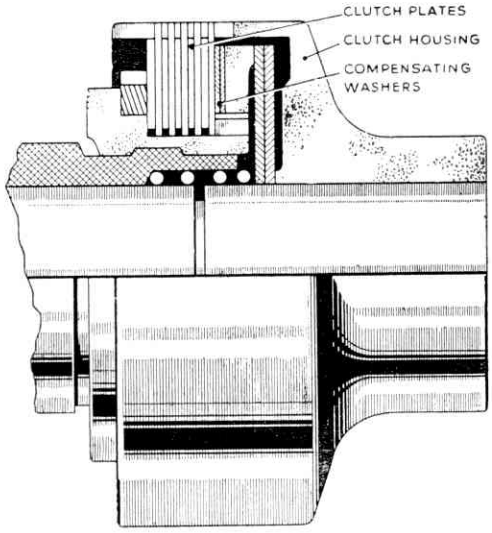


FIG. 127. STARTER MOTOR CLUTCH

6. Carefully insert pinion into end shield until it meets resistance, then turn slowly in direction of starter rotation, clockwise until forward movement is felt. This indicates that the pinion has engaged with clutch plates.

7. Push pinion into end shield to full extent against spring pressure. Hold in position and screw on thin shaft nut. Screw on castellated nut, tighten and insert split-pin.

8. Replace small spring and lubricator.

Field Coils

Test field coils without removing them from yoke.

Connect them in series with a 24-volt battery and a 24-volt 12-watt bulb. The bulb should light to indicate unbroken connection through field windings when:

1. Prods are applied to negative brush arm connector and moving switch contact.

2. To positive brush gear arm and moving switch contact.

3. To positive brush gear arm and fixed switch contact to which field coil is attached.

Bulb should not light when:

4. Prods are applied to starter yoke and any ends of field coils. This shows earthed coils.

There is no easy way of testing for internal shorts as resistance is already very low. If a short is suspected fit a new set of coils and compare performance.

When replacing coils, see that auxiliary coils are assembled on pole pieces 1 and 3. Fit coils over pole shoes so that they bed down as close as possible at the tips.

Replace pole pieces with numbers corresponding with numbers on yoke. Place the pole shoe expander between the shoes and tighten to fullest extent. Drive the fixing screws right home with a wheel-operated screwdriver.

Brush Gear

Check that the brushes are free in their guides and flex leads are free for movement.

Positive and negative brush holders must be insulated from one another and from rest of starter.

Test insulation with test lamp in same way as dynamo, see **Testing Dynamo Parts.**

Check brush spring pressures by hooking spring balance under spring. The correct tension is 3.5 lb. (1.63 kg.).

Replace brushes if worn so that the flexibles nearly touch the bottom of the slot in the brush holders.

Bed brushes to commutator with fine glasspaper or carborundum paper. Don't reverse brushes after bedding.

SOLENOID SWITCH

1. To dismantle switch, release locking washer (B), Fig. 129, remove nut (F), catch holding plate (A), trigger catch (G), bridge piece (K) with flat spring and insulating washer. Take care that trigger spring (N) does not fall out when catch is removed.

Note position of washers (Q) and (R), Fig. 131, as the thin ones are used for adjustment. The washer (S) acts as a spigot for return spring.

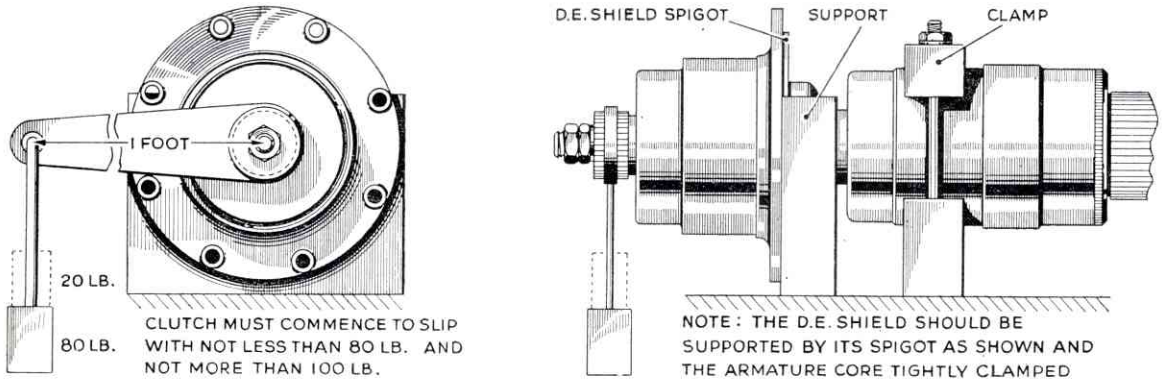


FIG. 128. TESTING CLUTCH SLIP TORQUE

2. Remove fixed contacts by taking out retaining screws (C), Fig. 129.

If contacts are dirty, clean with spirit or fine carborundum paper.

Badly pitted fixed contacts may be refaced once after packing up the contacts with 0.032 in. (0.794 mm.) insulating plates, C.A.V. parts 5632/29A and 5632/30A, behind the existing insulation. The dimension from the top of the contact to the underside of the solenoid end plate should be from 0.333/0.337 in. (8.458/8.559 mm.).

Check pressure of return spring (L). When compressed to 0.500 in. (12.70 mm.) length it should have a pressure of 5 lb.±5 oz. (2.3 kg.±142 grm.), renew if not within limits.

Check pressure of trigger spring; it should have pressure 12.5/16 oz. (354/453 grm.) when compressed 0.2187 in. (5.55 mm.).

Check that insulating bush (H) is an easy fit in bridge piece and is not distorted.

If winding is damaged or broken, fit a new switch. Lightly smear the plunger (O) with vaseline at point of entry into body, also at point of contact between flat spring and bridge piece.

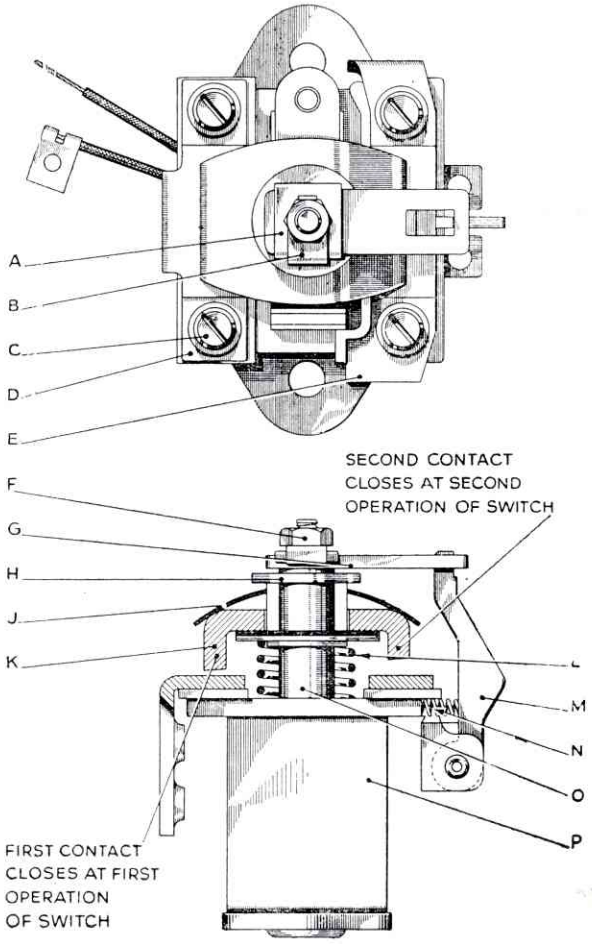


FIG. 129. SOLENOID SWITCH

Reassembly and Adjustment

If contacts have been refaced, air gaps will require adjustment.

Adjusting washers (Q), Fig. 131, must be removed and replaced until correct air gaps are obtained. Washers are available 0.004, 0.008 and 0.0012 in. (0.1016, 0.2032 and 0.3048 mm.).

The air gaps are shown in Fig. 129.

First contacts 0.040±0.004 in. (1.066±0.1016 mm.).

Second contacts 0.142±0.008 in. (3.606±0.2032 mm.).

Trigger clearance 0.079±0.004 in. (2.006±0.1016 mm.).

Fit new locking washer (B) for the armature nut.

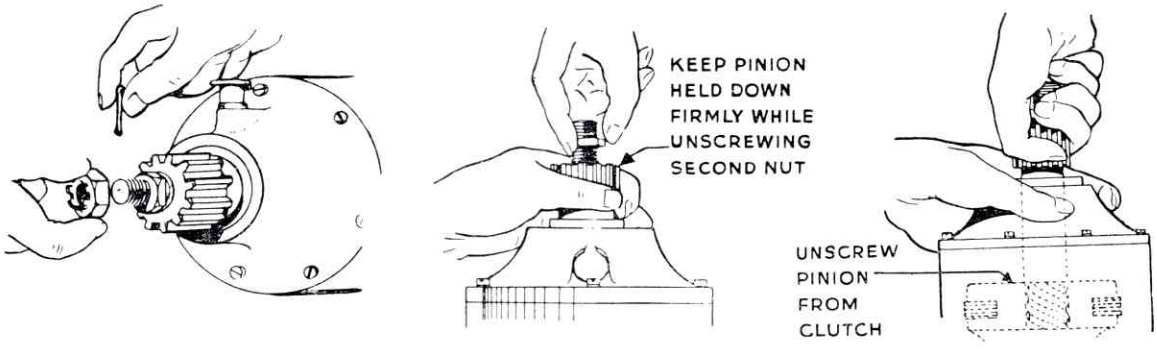


FIG. 130. RENEWING STARTER MOTOR PINION

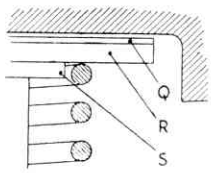


FIG. 131. ARRANGEMENT OF PACKING WASHERS OF BRIDGE PIECE

Testing Solenoid Switch

After assembly apply the following tests with the switch in a horizontal position:

Force to overcome return spring in OFF position
5 lb.±5 oz.
2.3 kg.±142 grm.

Force to overcome return spring in ON position
29 lb.±2 lb.
13 kg.±0.90 kg.

Force to overcome spring tension of trigger (M) applied at peak of tripping face with switch in OFF position, 16±1½ oz. (453±42.5 grm.).

Switch must operate on both contacts at 12±1 volts.

Give switch a test of a few seconds' duration at twice normal voltage to ensure that trigger operation is correct. Faulty assembly or rounding of step will cause the catch to slip.

TO REASSEMBLE THE STARTER MOTOR

To reassemble, reverse the dismantling operations.

Assemble brush gear on commutator end shield and fit assembly to yoke. See that securing screws are tight.

Fix the solenoid switch in position and join up the field connections.

Feed the armature and clutch assembly into the casing. The brushes must be raised in their boxes to allow commutator to pass.

Check that all connections, both internal and external, are clean and tight.

CHECKING PERFORMANCE

Before fitting starter to engine a rough test may be made.

Connect a 24-volt battery to the main starter terminals, battery positive to starter positive. Connect a lead from battery positive to SOL terminal through a push-button switch. Insert a piece of paper between the second contacts, Fig. 129, of the solenoid switch.

Operate the push-switch and starter should revolve in a clockwise direction, viewed from pinion end, and the pinion move approximately one inch forward, where it will remain revolving slowly so long as the push-switch is closed. Don't prolong the test.

Release the switch and remove the paper from the solenoid contacts. Operate the push-switch again momentarily and the starter should work as before but at a higher speed.

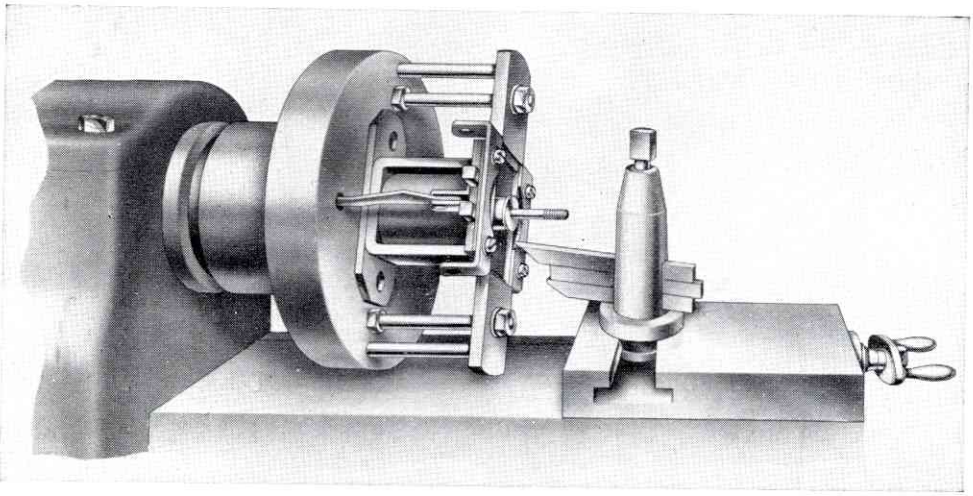


FIG. 132. SIMPLE FIXTURE FOR HOLDING SWITCH IN LATHE

APPENDIX TO CHAPTER 3w

E.0600/E.0680 POWER-PLUS VERTICAL ENGINES

This Appendix has been prepared to cover the modifications which have been introduced since Chapter 3W was first issued.

E.0600 and **E.0680**

PAGE 8

PISTON AND RINGS

Scraper Rings

Number of rings	One (4th groove)
Type	Spring-loaded parallel sides, straight-cut gap.
Width (nominal)	0.249/0.250 in. (6.3246/6.3500 mm.)
Initial gap (closed)	0.020/0.027 in. (0.5080/0.6858 mm.)
Renew rings when gap exceeds ...	0.100 in. (2.54 mm.)

PAGE 9

CONNECTING RODS AND GUDGEON PINS

Initial diametral clearance of pin in small-end bush	0.0015 in. (0.0381 mm.)

PAGE 10

CRANKSHAFT

Table of Crankshaft Dimensions

On certain 0680 engines the journal diameter of the crankshaft has been increased to 4.250 in. (107.950 mm.).

A table of crankshaft dimensions applicable to this crankshaft is included in this appendix.

The clearance and renewal figures are similar to those stated in Chapter 3W.

E.0600 and **E.0680**

PAGE 11

CRANKSHAFT AND MAIN BEARINGS

Oversize thrust washers available ...

S1. 0.096/0.098 in. (2.4384/2.4892 mm.)

S2. 0.102/0.103 in. (2.5908/2.6162 mm.)

S3. 0.111/0.113 in. (2.8194/2.8702 mm.)

Applicable only to crankshafts having 4.250 in. (107.950 mm.) dia. journals.

Main bearing initial diametral clearance ... ...

0.003/0.0052 in. (0.0762/0.1321 mm.)

Applicable only to crankshafts having 4.250 in. (107.950 mm.) dia. journals.

PAGE 13

VALVES

Valve head diameter

Inlet and Exhaust ... ...

On certain 0680 engines the valve head diameters are similar to those of the 0600 engine.

PAGE 14

Angle of valve face ... ...

In Chapter 3W all references to the angle of the valve face should read 30°.

PAGE 16

GOVERNOR

GRHF. or SFRNN.

PAGE 17

INJECTORS

Make	Leyland or C.A.V.	
Type	N.65	N.66

E.0600 and **E.0680**

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COMPRESSOR

Make	Clayton Dewandre
Type	PCGA 390
Bore	2.625 in. (66.875 mm.)
Stroke	2.375 in. (60.235 mm.)
Piston displacement	15 cu. ft. (0.42 cu. m.) per minute at 1,000 r.p.m.
Drive	Gear-type dog coupling, driven from timing gear train at half crankshaft speed, clockwise rotation.

COMPRESSOR

Make	Westinghouse
Type	KZ.139/1
Bore	2.625 in. (66.875 mm.)
Stroke	2.172 in. (55.165 mm.)
Piston displacement	13.5 cu. ft. (0.38 cu. m.) per minute at 1,000 r.p.m.
Drive	Gear-type dog coupling, driven from timing gear train at half crankshaft speed, clockwise rotation.

COMPRESSOR

Make	Leyland
Type	Part No. 810001
Bore	2.625 in. (66.875 mm.)
Stroke	2.375 in. (60.235 mm.)
Piston displacement	15 cu. ft. (0.42 cu. m.) per minute at 1,000 r.p.m.
Drive	Gear-type dog coupling, driven from timing gear train at half crankshaft speed, clockwise rotation.

AIR CLEANER

Later engines are fitted with Coopers oil-bath type.

E.0600 and **E.0680**

PAGE 45

CRANKSHAFT AND MAIN BEARINGS

To Replace the Crankshaft

Paragraph 2 ... ... Oil seal plugs are not fitted to 4.250 in. (107.950 mm.) journal diameter crankshafts.

Paragraph 3 ... ... On later engines, the main bearing caps are secured by setscrews, each setscrew being lock-wired individually to the bearing cap.

The torsion spanner setting is similar to that shown in paragraph 3.

TABLE OF CRANKSHAFT DIMENSIONS: 0680 ENGINES with 4.250 in. dia. JOURNAL CRANKSHAFT

TYPE	PART NUMBER	CRANKPIN DIAMETER		CRANKPIN WIDTH		JOURNAL DIAMETER		JOURNAL WIDTH							
								FRONT		CENTRE		REAR		OTHERS	
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
Standard Service	Part Number as stamped on front web	3.0005 2.9998	76.213 76.195	2.203 2.200	55.956 55.880	4.2505 4.2498	107.963 107.945	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
1st Service	Part Number /S.1 602050	2.9905 2.9898	75.959 75.941	2.203 2.200	55.956 55.880	4.2405 4.2398	107.709 107.691	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
2nd Service	,, /S.2	2.9805 2.9798	75.705 75.687	2.203 2.200	55.956 55.880	4.2305 4.2298	107.454 107.437	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
3rd Service	,, /S.3	2.9705 2.9698	75.451 75.433	2.203 2.200	55.956 55.880	4.2205 4.2198	107.201 107.183	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
4th Service	,, /S.4	2.9605 2.9598	75.197 75.179	2.203 2.200	55.956 55.880	4.2105 4.2098	106.947 106.929	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180
5th Service	,, /S.5	2.9505 2.9498	74.943 74.925	2.203 2.200	55.956 55.880	4.2005 4.1998	106.693 106.675	2.000	50.800	2.702 2.700	68.631 68.580	2.705 2.695	68.707 68.453	1.710 1.700	43.434 43.180

Note 1. When re-grinding crankpin and journals the sides must not be ground unless they have been damaged. If the location faces of the centre main bearing have been damaged, the width should be increased to 2.710/2.712 in. (68.834/68.885 mm.); otherwise the dimension should remain unchanged.

Note 2. The crankshaft should be re-nitrided at service sizes S.2 and S.4.

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