

WORKSHOP MANUAL

'C-RH' ENGINES

T.S.D. Publication 3152
(1st Issue)

December 1981

Printed in England

NOTES TO USERS

This publication refers to the 'C-RH' build of engines currently being built to the following specifications:

C6-86G	C6-101G	C6-160G
C6-88G	C6-130G	C6-200G

All 'C-RH' engines have the camshaft built into the right-hand side of the crankcase, viewed from the rear. The fuel injection pump, which is mounted on the opposite side, gives external identification of this type of engine build.

The purpose of this Manual is to provide Operators with all information necessary for complete overhaul of Rolls-Royce 'C-RH' engines. For information concerning routine servicing refer to the Servicing Manual T.S.D. 3126.

Operators are strongly recommended to make use of the following services and facilities available to them:

Service

The Equipment Manufacturers and their appointed Distributors carry an approved stock of spares and have staff trained and certificated by Rolls-Royce Motors Limited. They are supported where necessary by the area-based Rolls-Royce engineer who is always available for consultation.

To assist Operators in reducing 'down time' to a minimum, Rolls-Royce Motors Limited have instituted a Service Exchange Scheme so the Equipment Manufacturers and their Distributors can speedily supply a replacement engine or major component, fully reconditioned at the Factory and guaranteed for six months. Units available are listed overleaf.

Advice and assistance can be provided more efficiently and with minimal delay if enquiries are accompanied by the following information:

- (1) In all cases, the engine Number and Designation, as stamped on the crankcase data plate (see Frontispiece for location), and the total number of E.S.C. Units recorded.
- (2) If a proprietary unit (e.g. injection pump, turbocharger) is involved, the details on its data plate, and total E.S.C. Units if different from (1).
- (3) Any other information logically connected with the subject, e.g. type of fuel, lubricating oil or coolant used; details of service history, etc.

Instruction

Two-day and five-day courses on servicing and overhaul of 'C-RH' engines are available at the Factory. For details apply to: The Superintendent, Customer Training Centre, Rolls-Royce Motors Limited, Shrewsbury.

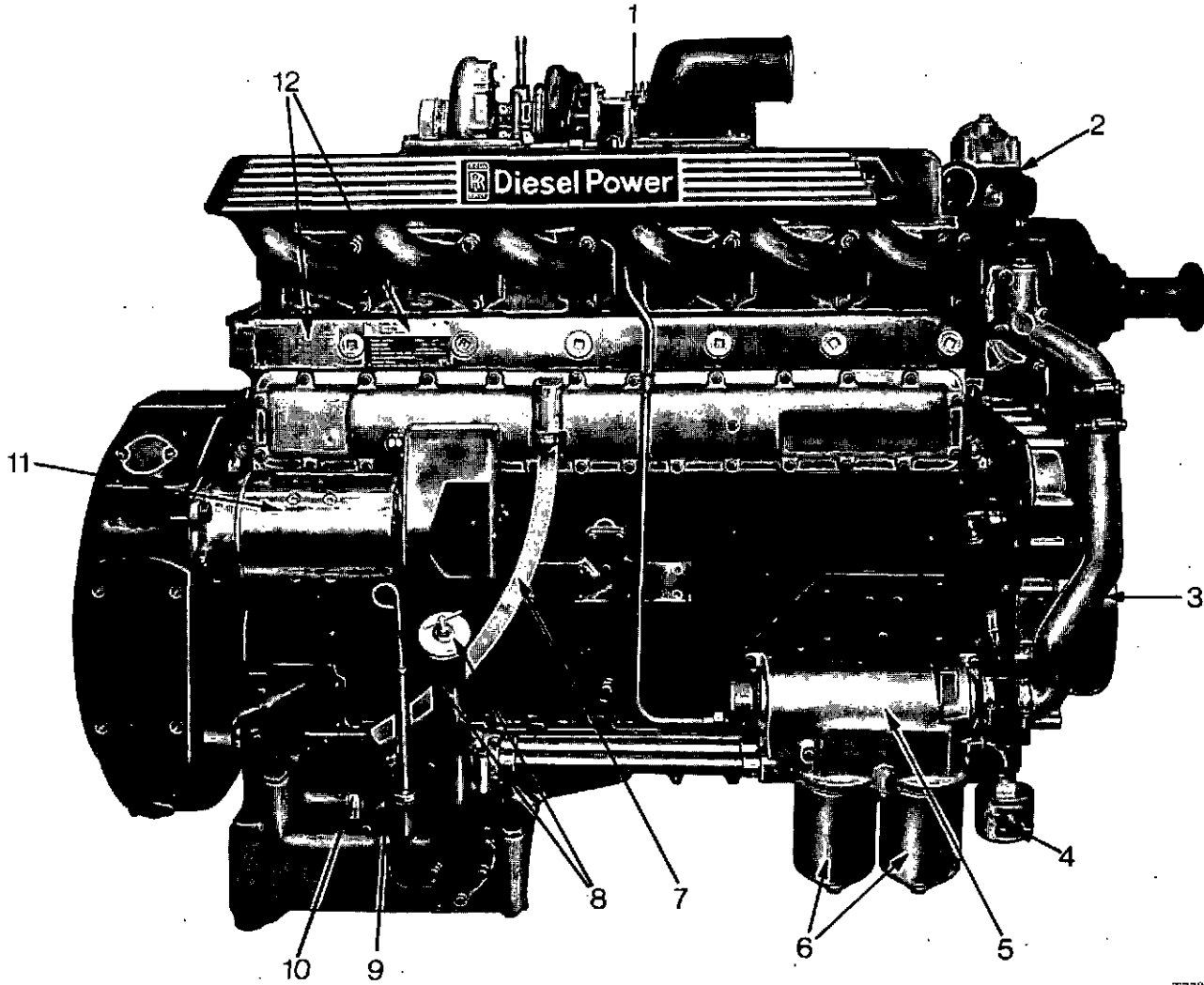
Service Instructions and Bulletins

Service techniques and engine design are under constant review at Rolls-Royce, so that from time to time it becomes necessary to revise Manuals and allied publications to include the results of this development work. Between revisions, all concerned are provided with full details of changes as they occur, the information being produced in leaflet form and sent in bulk to Equipment Manufacturers for onward transmission to Distributors and Operators as necessary:

- (1) Changes in Service Techniques are issued as Service Instructions (S.I's) for inclusion in Servicing Manuals held by Distributors and Operators.
- (2) Engine design changes are published, usually as Modifications, in Service Bulletins (O.E.B's) for information of Equipment Manufacturers and Distributors.

Associated Technical Publications for 'C-RH' build Engines

T.S.D. 3126	Servicing Manual	T.S.D. 3124	Folder, 'Operator's Guide'
—	Parts manual (Identified by Engine Number and Designation)	T.S.D. 3137	Booklet, 'Essential information for the Operator'
T.S.D. 3085	Leaflet, Diesel fuel, lubricating oil and coolant recommendations	T.S.D. 3133	Wall Charts, illustrating cooling, fuel and lubrication systems
T.S.D. 810	Leaflets, 'Service Bulletins'	T.S.D. 3132	Wall Chart, 'Torque Loadings'
T.S.D. 965	Leaflets, 'Service Instructions'	T.S.D. 3134	Wall Chart, 'Servicing Schedules'

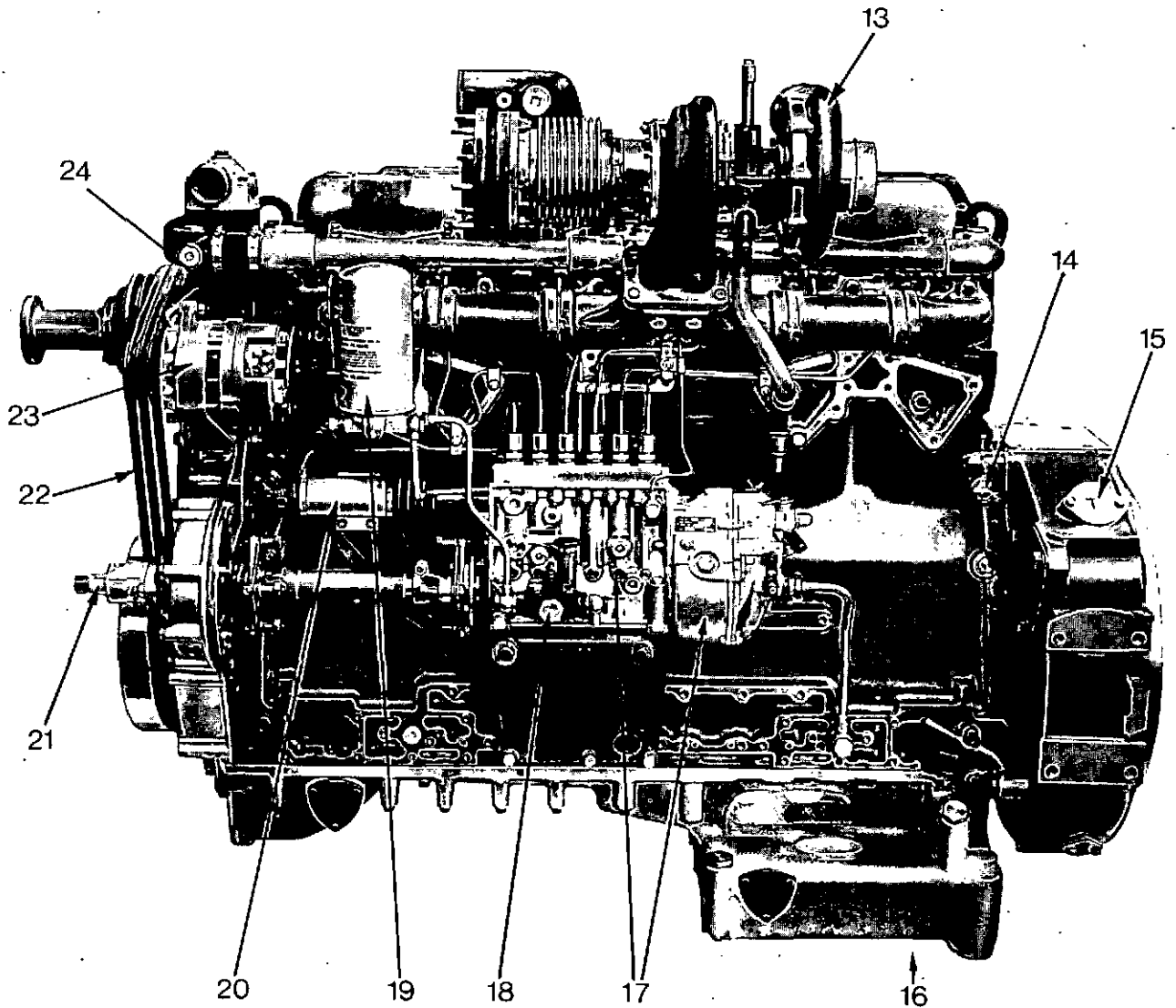


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RIGHT-HAND VIEW OF ENGINE

- | | |
|--|----------------------------------|
| 1. Coolant temperature switch | 7. Crankcase breather pipe |
| 2. Thermostat housing | 8. Dipstick and oil filler |
| 3. Crankshaft damper and barring adaptor | 9. Oil pressure gauge connection |
| 4. Oil pressure switch | 10. Oil pressure relief valve |
| 5. Oil-to-coolant heat exchanger | 11. Starter motor |
| 6. Lubricating oil filters | 12. Engine data plates |

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LEFT-HAND VIEW OF ENGINE

- | | |
|--------------------------------------|----------------------------|
| 13. Turbocharger | 19. Fuel filter |
| 14. Coolant drain tap | 20. Shutdown solenoid |
| 15. Timing pointer cover | 21. Engine Service Counter |
| 16. Sump drain plug | 22. Driving belts |
| 17. Fuel injection pump and governor | 23. Alternator |
| 18. Feed pump and priming pump | 24. Coolant pump |

SERVICE EXCHANGE SCHEME

The information in this Manual will assist the Operator to carry out any work, from minor repair to complete overhaul, on 'C-RH' engines but on occasions the personnel, equipment or time may not be available, resulting in delay before the unit returns to service.

Therefore, Rolls-Royce Motors Limited have instituted a Service Exchange Scheme so that Distributors and Dealers can speedily supply a replacement engine or major component, fully reconditioned at the Factory and guaranteed for six months. Prices are listed in Publication T.S.D. 3035E.

The units available through this Scheme are listed below. Further details may be obtained from Distributors and Dealers; all enquiries should quote the engine Number and Designation, as stamped on the data plates affixed to the crankcase above the starter. When applicable, the details on the data plate of a proprietary unit (e.g. turbocharger) should be included.

ENGINE (Complete)
 'SHORT ENGINE' (See illustrations)
 COOLANT PUMP
 CRANKSHAFT
 CYLINDER HEAD
 OIL PUMP

AIR COMPRESSOR
 ALTERNATOR
 INJECTORS
 INJECTION PUMP (Complete)
 STARTER MOTOR
 TURBOCHARGER

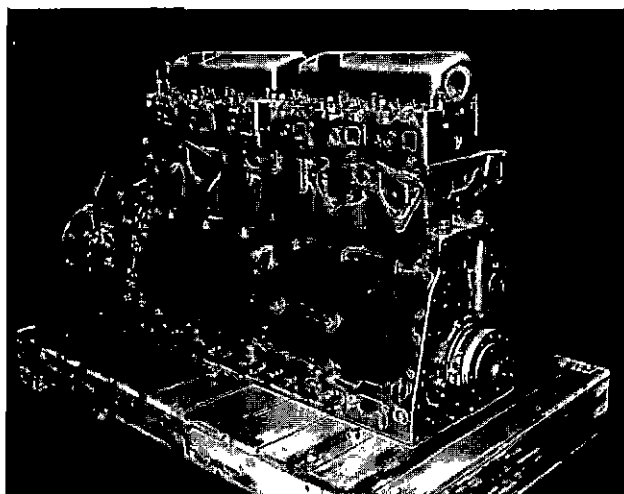


Fig. 1 Servex engine—L.H. view

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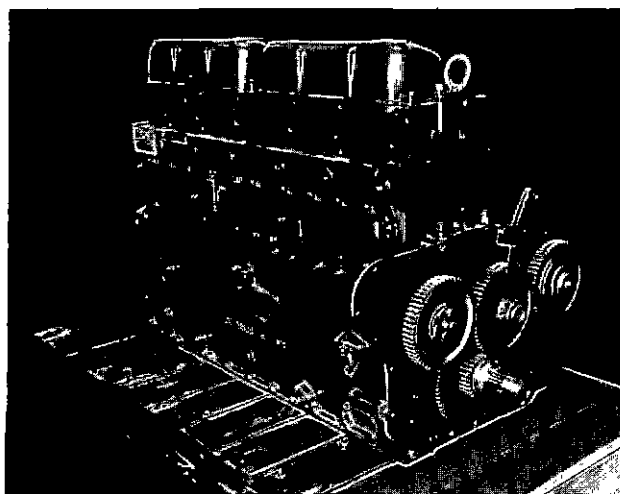


Fig. 2 Servex engine—R.H. view

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GENERAL INFORMATION

The following information, if kept in mind during repair or overhaul work, will help to ensure that the engine returns to duty in first-class order and can be relied on to give long and trouble-free service, provided that it is properly used and maintained.

Cleanliness

The importance of this cannot be over-emphasised. Foreign matter such as dirt, metal swarf and fluff entering an engine may be sufficient to block fuel passages and oilways. Hard particles will damage bearing surfaces, producing quantities of metal fragments which continue the process. The results are faulty running, rapid wear and possible engine failure.

If an engine in service is to be partly dismantled for repair, first clean the vicinity of the component concerned. During dismantling, blank off all openings and disconnected pipes without delay, and protect each component against dirt and damage until it is refitted.

When reassembling, take care that foreign matter does not enter the engine. Ensure that the atmosphere is as dust-free as possible, and inspect each part immediately before it is fitted. Blow through all pipes and oilways with dry compressed air before making connections.

Special tools

These are provided for specific jobs and should be used, when recommended, to save time and prevent damage. A list of appropriate tools is given at the end of each Section.

Crack detection

Highly stressed components should be tested at overhaul or when they have been subject to shock or impact. Ferrous parts such as crankshafts, connecting rods and gearwheels are tested on an electro-magnetic

rig. For non-magnetic components such as valves and pistons a dye penetrant is suitable; a recommended process is Ardrex 996, available from Ardrex Limited, Commerce Road, Brentford, Middlesex.

Fits and clearances

At the end of each Section dealing with inspection and assembly of a component will be found a table of relevant fits and clearances. A part falling within the dimensions given is acceptable for a full period of service. Certain parts, if worn beyond limits, may be reconditioned under approved Service Reclamation Schemes which are circulated to authorised Dealers and Distributors.

Torque loadings

These are specified for certain setbolts and nuts where defect or failure could result from incorrect tightening. For certain joints (e.g. cylinder head to crankcase) it is also essential that tightening is done in the sequence given in the assembly instructions.

Locking devices

Split pins, tabwashers, and stiffnuts having fibre or nylon inserts should be used once only. All-metal stiffnuts may be re-used, provided that they offer noticeable resistance to movement against normal spanner leverage. At least one full thread should protrude through a stiffnut.

Joints, hoses and 'O' rings

It is false economy to re-use these items; their cost is trifling compared with the expense of rectifying leaks when the engine is back in service.

When making joints a non-setting compound such as 'Wellseal' is recommended for general use. Jointing compound should be applied thinly to avoid the possibility of oilways being obstructed by the excess.

To assist in fitting new hoses, use water, glycol or an approved rubber lubricant such as Carbowax 600 or Duckhams Q.4590. Never use mineral oil or grease, which are injurious to rubber.

Lightly coat 'O' rings with rubber lubricant to prevent 'trapping' during assembly.

Exchange units

Unserviceable units should be returned complete to the same build as the replacement, and protected against damage and corrosion.

Spares

To comply with the terms of the Rolls-Royce Motors Guarantee, **USE ONLY GENUINE ROLLS-ROYCE PARTS**, obtained from the Factory or an authorised Dealer. These parts fully conform to Rolls-Royce standards and are themselves guaranteed for six months.

The use of counterfeit spares, notably filter elements, may invalidate any current Guarantee and can seriously reduce engine life and performance.



SECTION 1—DESCRIPTION AND DATA

General

The 'C-RH' build engine is a development of the 'Eagle' automotive and 'C' range industrial engines with which it shares, to a great extent, the advantage of component rationalization.

The 6 cylinder in-line, charge-cooled, 4 stroke, compression ignition engine is pressure charged by a single turbocharger and has conventional liquid cooling.

The cylinder units are numbered 1 to 6 from the front (free) end to the rear (flywheel) end of the engine.

Data plates, affixed to the crankcase, are stamped with the Engine Number, Designation and Build Number.

Crankcase

The crankcase is cast in nickel-chrome iron as a monobloc unit and dipped in a special compound to seal all non-machined surfaces against contamination. Oilways are drilled to ensure cleanliness and uniformity.

The seven main bearing caps are of forged steel. The two outer and the central caps, being double width, are attached with four studs and nuts. The intermediate bearing caps are attached with two studs and nuts. Lateral setbolts, fitted through the crankcase walls, into the front, central and rear bearing caps give added rigidity to the crankcase.

Cylinder bores are machined to accept the push-fit 'wet' liners which are of centrifugally cast iron, differentially hardened and tempered. The liners are machined to fine tolerances with honed bores.

Crankshaft

The crankshaft is a chrome-molybdenum steel forging, fully machined and balanced, with all the bearing surfaces nitride hardened and lapped to size. Drillings in the shaft provide pressure lubrication to the seven main journals and the six crankpins, each crankpin being bored to form a centrifugal sludge trap, with removable sealing plugs.

Axial location is by steel-backed, lead-bronze, thrust washers, carried in recesses machined on either side of the centre main bearing.

The seven main journals run in steel-backed, lead-bronze bearing shells, indium flashed on the bearing surfaces. Each half bearing being positioned by locating tangs pressed out from one end.

At the front end of the crankshaft, detachable gearing provides drive for the lubricating oil pump and main gear train whilst at the rear end, a flange with nine tapped holes and three dowel holes provides a mounting for the flywheel and starter ring assembly.

Pistons and connecting rods

The pistons are cast from high silicon aluminium alloy with the crowns machined to form open toroidal combustion chambers. Each piston carries three-compression and one oil control ring in machined grooves above the gudgeon pin. The top ring is carried in an austenitic iron insert. Ring sequence is as follows:

Top	—	Inlaid molybdenum surface
Second	—	Chrome plated
Third	—	Ferrox treated surface
Bottom	—	Composite chrome plated oil control ring.

Each piston is tin plated on all surfaces after machining apart from the gudgeon pin bore. The gudgeon pin, which is fully floating, is offset to the vertical axis of the piston and is retained by the conventional circlip method.

Connecting rods are forged from chrome-molybdenum steel and drilled longitudinally for pressure lubrication of the small end bearing. Small holes, drilled into the eye of each rod, provide cooling oil jets to the underside of the piston crown.

Two steel-backed, lead-bronze bushes, pressed into the small end eye, form the small end bearing, the big end bearing being steel-backed, lead-bronze half

shells, indium flashed on the inner surfaces. Location is by tangs pressed out at one end of each half bearing shell.

All connecting rods in a production engine are within a weight group of 4 ozs (113 grammes) range. Markings on each rod assembly give rod to cap correlation, weight and when allocated, the cylinder number.

Connecting rod big ends are designed to pass through the liner bore to facilitate overhaul procedures.

Camshaft

The camshaft is made of carborised steel. An oil gallery, bored axially through the shaft, is closed at the front end with an alloy plug and 'O' ring seal and at the rear end by a hexagon headed steel plug secured with a tab washer. Drillings in the periphery of each of the seven camshaft journals, direct pressurised oil to the bearing surfaces.

Five tapped and five dowel holes in the front end face of the camshaft are provided for securing the cam drive gear.

The seven journals run in the parent crankcase metal without conventional bushes. Axial location is by a thrust plate, bolted to the crankcase, bearing on a collar machined on the end of the camshaft front journal.

Pushrods and tappets

The pushrods are made from medium carbon steel bar, induction hardened, with a cup machined in the upper end. The lower end of the rod has a machine polished, spherical foot.

The tappets, made of cast iron alloy, are fully machined with chill-hardened bases and finally phosphate treated to provide an oil retaining finish.

Cylinder heads

Two identical cylinder heads in high duty, close grained cast iron, each covering three cylinders, are machined across the upper and lower faces for a close tolerance fit between the rocker gear cover and the cylinder block respectively. Machined joint faces accommodate the induction and exhaust manifolds on the side walls of each cylinder head. Internal coolant passageways are cast around the valve guides and injector pockets.

The cast iron valve guides are inserted under

pressure into each cylinder head casting. A 'ptfe' oil seal is fitted around the top of each exhaust valve guide. Valve seat inserts of chrome iron alloy, are frozen into position against shoulders machined into the cylinder flame face.

Two valves are fitted over each cylinder. The forged steel inlet valves have stellite seats and hardened stem tips. Exhaust valves are made of bi-metallic material with hardened stem tips, forged steel or Nimonic material. The forged steel exhaust valves have stellite seats and hardened stem tips, but differ from the inlet valves by having chambers part filled with sodium in their stems. Sodium filled valves are identified by a 'V' groove machined around the stem near the tip. Disposal of worn or damaged sodium filled valves is described in Publication S.I. 105. All valves in an engine have chrome flashed stems.

Each valve operates with double springs, in a conventional spring seat and collet arrangement, valve rotators being used in place of the lower spring seat on the exhaust valves.

Rocker gear

Each rocker shaft, supported by three pedestals on the cylinder head, is bored axially for oil transmission to the rocker arm bushes. A hole drilled longitudinally through each rocker arm provides lubricating oil to the contact faces between the rocker arm pad and valve stem tip at one end and the adjusting screw and pushrod at the other.

A cast aluminium rocker cover for each cylinder head is secured by eight setbolts, with an oil resistant gasket fitted between the joint faces.

Gear train

The wheelcase, mounted on the front (free) end of the engine, houses the gear train. The crankshaft pinion drives a large idler gear which, in turn, provides drive for the camshaft and auxiliary drive gears. The pinion, idler and both drive gears have machined spots on the front edge of the teeth, to enable correct engagement of the teeth to be made during engine build or overhaul.

A large narrow gear, directly behind the crankshaft pinion, meshes with the oil pump drive gear.

Fuel system

Fuel injection is by a plunger-type pump with individual elements, via multi-hole injectors direct

into open combustion chambers in the piston crowns. A mechanical governor is mounted on the rear of the injection pump with the complete unit being driven at 0.5 x engine speed and lubricated by oil from the main engine system. The feed pump is of the spring-loaded plunger type, mounted on the injection pump and operated by a double eccentric on the fuel pump camshaft.

Lubrication system

Lubricating oil is drawn from the sump by a spur-gear pump driven from a gear-wheel behind the crankshaft pinion, and is delivered at controlled

pressure via a heat exchanger and full-flow filters to the main bearings and thence throughout the engine, returning to the sump by gravity.

Cooling system

The approved coolant is a mixture of inhibited ethylene glycol and clean drinking water circulated by a belt driven pump to which is fitted a cooling fan. A triple-element wax-capsule thermostat, with radiator by-pass, ensures rapid warming up and an oil-to-coolant heat exchanger maintains the lubricating oil at a constant temperature.

GENERAL ENGINE DATA

TYPE Vertical, 6-cylinder, in-line, liquid-cooled
 4-stroke diesel, turbocharged, charge cooled

BORE 5.125 inches (130.17 mm)

STROKE 6.000 inches (152.4 mm)

CAPACITY (Swept volume) 742.64 cu. inches (12.17 litres)

COMPRESSION RATIO: Normally aspirated 16 to 1
 Turbocharged 15 to 1

VALVE TAPPET CLEARANCE
 (Engine stopped, hot or cold)

Inlet 0.015 inch (0.38 mm)
Exhaust 0.025 inch (0.63 mm)

FUEL INJECTION TIMING As stamped on engine data plate

CYLINDER NUMBERING From front to rear

ENGINE FIRING ORDER 1, 4, 2, 6, 3, 5

DIRECTION OF ROTATION Anti-clockwise, viewed on flywheel

DRY WEIGHT (Approximate)

Bare engine 2950 lb (1340 kg)
Engine radiator unit 3460 lb (1570 kg)

COOLING SYSTEM

APPROVED COOLANTS See leaflet T.S.D. 3085 in rear cover pocket

CAPACITY (Engine/radiator unit) 15.5 Imp. galls (70.5 litres)

SYSTEM PRESSURE 7 to 10 lbf./sq. inch (50 to 70 kN/sq.m.)

OPERATING TEMPERATURE (At sea level)

Normal 90 deg. C
Maximum intermittent 95 deg. C

THERMOSTAT Western-Thomson, triple-element wax capsule type
 with radiator by-pass

OIL-TO-COOLANT HEAT EXCHANGER See 'Lubrication System'

SYSTEM CLEANING COMPOUNDS

I.C.I. Ltd. Lissapol 'N', 1% (45 cc. per gallon)
 Lissapol NDB, 2% (90 cc. per gallon)

FUEL SYSTEM

APPROVED FUELS	See leaflet T.S.D. 3085 in rear cover pocket
RELIEF VALVE SETTING	20 to 30 lbf./sq. inch (140 to 210 kN/sq.m.)
INJECTION PRESSURE	220 ats (22000 kN/sq.m.)
FEED PUMP	Bosch FP/KD
INJECTION PUMP	Bosch-PE6P
GOVERNOR	Bosch-PA386R or Ambac
INJECTORS	CAV long-stem, multi-hole Holder (all engines): BKBL 96S 5348 Nozzle (N/A engines): BDLL 150S 6690 (T/C engines) : BDLL 150S 6691
FILTER	Spin-on, expendable single canister

LUBRICATION SYSTEM

RECOMMENDED LUBRICATING OIL	See leaflet T.S.D. 3085 in rear cover pocket
SYSTEM TYPE	Wet sump, with spur gear pressure pump
*SYSTEM CAPACITY FOR OIL CHANGE	6.5 Imp. gallons (29.5 litres) or 5.5 Imp. gallons (25 litres)
OIL PRESSURE (At working conditions)	
Normal.....	50 to 70 lbf./sq. inch (350 to 480 kN/sq.m.)
Minimum for continuous operation (to protect turbocharger).....	30 lbf./sq. inch (206 kN/sq.m.)
FILTERS	Full flow, twin bowl, expendable elements
OIL-TO-COOLANT HEAT EXCHANGER	Serck

*Depending on the type of sump fitted. (See Section 11)

INDUCTION SYSTEM

AIR CLEANER	Donaldson 'Cyclopac' FHG 14
AIR RESTRICTION INDICATOR	Donaldson, 25 inches w.g.
TURBOCHARGER	Holset 4LGK
CHARGE COOLER	Serck or Coventry Radiators, air to air, integral with coolant radiator

ELECTRICAL SYSTEM

- ALTERNATOR**.....C.A.V. AC5B, 24 volt, 31 amp
or AC5R
- CONTROL BOARD**.....C.A.V. Type 440
- STARTER MOTOR**.....C.A.V. SP6A or S130L
- STOP CONTROL**.....C.A.V. solenoid operated, Type 368
- SHUTDOWN SWITCHES**
- Oil pressure.....Drayton, Type EP
or Teddington-Type DCA/BC/152
22 lbf/sq. inch (152 kN/sq.m.) setting
- Coolant temperature.....Drayton, Type ET
or Teddington-Type DCA/AB/096
96 deg. C. setting

AUXILIARY EQUIPMENT

- COLD STARTING AIDS**.....'Start Pilot' or 'Fleetguard'

**RECOMMENDED PROPRIETARY PRODUCTS FOR USE
DURING SERVICING AND OVERHAUL**

(Equivalents of alternative manufacture are acceptable)

	Manufacturer	Brand or specifications
ALTERNATOR		
Diode cleaning fluid	Applied Chemicals Ltd. Uxbridge, Middlesex	Fluid, Grade 8-23
COOLING SYSTEM		
Hose and 'O' ring lubricant	Isaac Bentley & Co. Ltd. Naylor St., Liverpool	Linalube
Pump bearing grease	Shell	Retinax 'A'
Thermostat spindle grease	Midland Silicones Ltd. Temple Row, Birmingham 2	Valve Seal 'A'
EXHAUST SYSTEM		
Screw thread anti-seize compound -	Rocol Ltd. Swillington, Leeds	Rocol J 166
JOINTS		
Jointing compound (general use)	Wellworthy Ltd. Lymington, Hants	Wellseal
Sealant and thread locking, where specified	Douglas Kane Sealants Welwyn, Herts	Loctite 270, 241, 225
STARTER MOTOR		
Drive end bearing oil SP6A	Various	Mineral, SAE 10W/30W
Clutch assembly grease SP6A	Shell	Nerita
End shield bush (S130L)	Shell	Turbo 41 oil
Cleaning fluid	I.C.I. Limited	Genklene 'N'

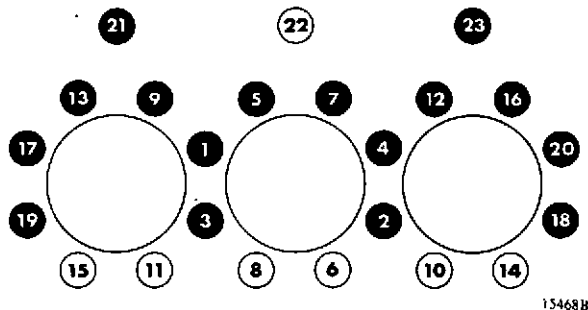
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TORQUE LOADINGS

These torque loadings apply to oil-wetted threads on R-H build engines, subject to the following conditions:

1. It must NOT be assumed that application of the specified torque is, in itself, sufficient to ensure that the components concerned are adequately secured together. The recommended method of assembling and, where applicable, the tightening sequence as given in this manual must also be observed.
2. Where the bolt or nut is locked by a tabwasher, lockplate or splitpin, the specified torque may be exceeded, if necessary, by the MINIMUM amount required to reach a locking position.

	TORQUE	
	lbf. ft.	Nm
ALTERNATOR PULLEY NUT		
C.A.V. AC5 alternator	40	55
CAMSHAFT		
Drivegear setbolts	45	60
Thrustplate setbolts	40	55
CONNECTING RODS		
Big end setbolts and nuts	160	220
CRANKSHAFT HUB RETAINING NUT*	700	950
*If no torque wrench is available, use spanner GA.736 as described in E.S.I. 22		
CRANKSHAFT DAMPER RETAINING SETBOLTS	30	40
CYLINDER HEADS		
Setbolts in black circles in illustration below	175	240
Setbolts and nut in white circles in illustration below	150	205
Rocker pedestal setbolts	30	40
Tappet screw locknuts	30	40
Injector flange nuts	8.5	11



FLYWHEEL RETAINING SETBOLTS	85 to 90	115 to 120
FLYWHEEL HOUSING, BOLTS TO CRANKCASE	45	60
INJECTION PUMP		
Camshaft hub nut	85 to 90	115 to 120
Pump-to-mounting bolts	30	40
Spring drive bolts	85	115
INJECTOR NOZZLE CAPNUT	50	70
LUBRICATING OIL FILTERS		
Centre bolts, retaining bowls to header	20	27
LUBRICATING OIL PUMP DRIVEGEAR		
RETAINING NUT	50	70
MAIN BEARINGS		
Front, centre and rear bearing nuts*	160	220
Intermediate bearing nuts	200	270
Lateral setbolts	70	95
*On external capnuts at front and rear use extension spanner GA.21 at 140 lbf. ft. (190 Nm)		
SUMP		
Insert for drain plug	225 to 250	305 to 340
Drain plug insert	80 to 85	110 to 115
TURBOCHARGER 'V' BAND NUT	10	14



SECTION 2—DISMANTLING THE ENGINE

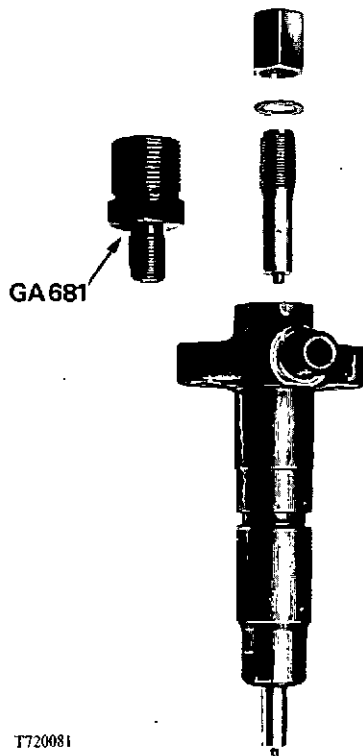
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The engine will stand upon its sump, with suitable wood packing for levelling and stability, or alternatively may be fitted with simple feet of angle section, bolted to the four mounting faces. In this position, most of the external components may be removed, but for complete dismantling a turnover stand is desirable.

Before dismantling, clean the engine thoroughly and ensure that the coolant and lubricating oil systems are completely drained. Coolant drain taps are fitted at the rear of the crankcase on the left-hand side and, on some engines, at the rear of the heat exchanger. To open the taps, turn them anti-clockwise. The sump is drained by removing a wire-locked hexagonal plug at the base of the pannier.

Where dismantling involves removal of a proprietary item (e.g. turbocharger), or a sub-assembly (e.g. cylinder head), instructions for reducing these units to their component parts and subsequent re-assembly are given in their appropriate Sections.

Because these engines are built to suit individual installations, certain components may be mounted in different positions and therefore the dismantling sequence will vary slightly between models. The following sequence is for guidance, additional information being given when the work is other than simple and straightforward.



T720081

Fig. 1 Injector—exploded view



T720085

Fig. 2 Using extractor GA 627

DISMANTLING SEQUENCE

1. Turbocharger, taking care not to damage its oil feed and drain pipes.
2. Inlet manifold, after disconnecting boost control pipe and cold start aid, if applicable.
3. Starter motor.
4. Oil pressure relief valve casting from sump.
5. Heat exchanger and oil filters. Remove coolant pipes and unscrew the four setbolts which secure the assembly to its mounting plate.
6. Heat exchanger mounting plate.
7. Cooling fan.
8. Coolant rail and thermostat housing.
9. Exhaust manifold, after removing the fuel filter element.
10. Alternator and fan belts. Release tension of belts before removing them; do not lever belts away from pulleys.
11. Fuel filter header bracket.
12. Fuel supply, spill and injection pipes. Treat high-pressure pipes with special care. Blank off all connections immediately.
13. Injection pump and its mounting bracket.

Sling the engine by the eyes at front and rear, and install it in a turnover stand.

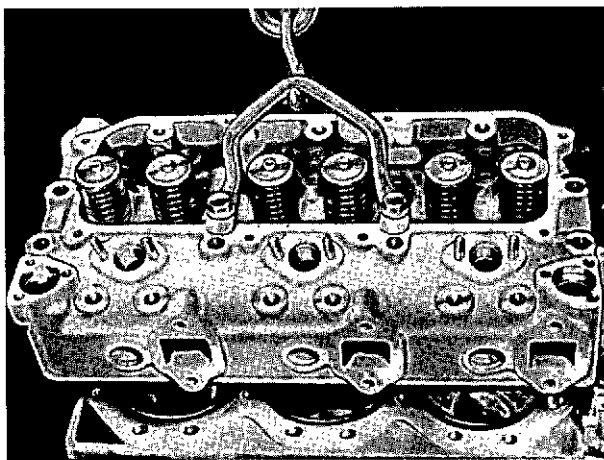


Fig. 3 Lifting cylinder head

T51124A

14. Rocker covers, valve gear and pushrods. Unlock and fully slacken the tappet adjusting screws before slackening the rocker pedestal setbolts.
15. Injectors. A sticking injector may usually be freed by gentle leverage beneath the flange, using tool GA.454. In obstinate cases, remove the injector capnut and adjusting screw (fig. 1), fit adaptor GA.681 and use the sliding weight extractor GA.627 (fig. 2).

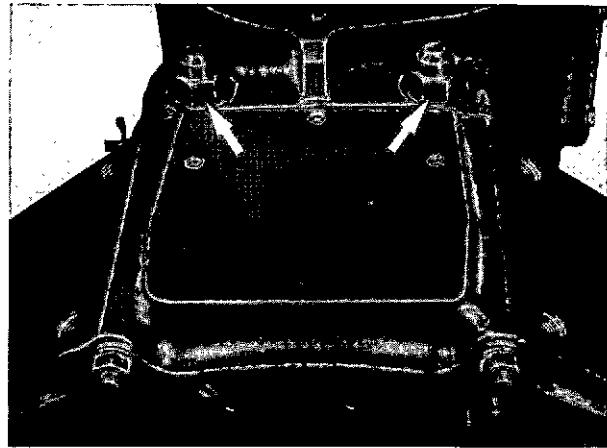


Fig. 4 Rear main bearing capnuts (front identical)

T720031

16. Cylinder heads. Slacken the setbolts and capnuts in tightening sequence (see Section 3). Using slinging attachment GA.13, lift off each head (fig. 3) taking care not to damage the oilway stud. Remove the coolant transfer bobbins, cylinder head joints and their rollpins, and oilway studs.
17. Tappet cover, oil gallery and cam followers.
18. Invert the engine, remove the sump bolts and lift off the sump. To break a sticking sump joint, use jacking bolts in the $\frac{3}{8}$ -inch UNF tappings at each corner. Unlock and slacken the oil pump drive-gear nut. Unbolt and remove the oil gallery and pump. Retain the shims fitted between pump and bearing cap.

19. Barring adaptor, damper and hub from crankshaft nose end. Adaptor and damper are secured by sixteen setbolts. Use spanner GA736 and a 4lb. (1.8kg.) hammer to slacken the hub nut (right-hand thread).
20. Wheelcase cover and gears. Unlock and slacken cam gear setbolts before removing idler gear.
21. Wheelcase backplate. Note positions of fitted bolts and dowels (see Section 12).
22. Clutch, flywheel and flywheel housing. After removing the flywheel setbolts, fit two guide bars GA.256 horizontally opposite to one another. (Do not use guide bars GA.687, which are for fitting the flywheel, or their nylon inserts may be damaged). Remove the timing pointer cover from the 4 o'clock position on the flywheel housing and unscrew the timing pointer, which otherwise will foul the starter ring. Using extractor GA.247, withdraw the flywheel dowels. Slide the flywheel clear of its housing, fit slinging eye GA.16 to a circumferential bolt-hole, and lift the flywheel away.
23. Crankshaft rear seal. Note four locating dowels (two in crankcase, two between seal halves).
24. Turn engine horizontal. Remove big-end bolts, caps and bearings, and carefully withdraw pistons and connecting rods through the cylinder bores. Keep each assembly together.
25. Using extension spanner GA.21, slacken external capnuts of front and rear main bearings (figs. 4 and 5).
26. Invert engine. Slacken and remove main bearing lateral setbolts on both sides of crankcase (fig. 6).
27. Remove main bearing nuts, including external capnuts (fig. 4).
28. Extract main bearing caps, using tool GA.2/M1 (fig. 7) where necessary.
29. Using slinging beam J.47789, lift out the crankshaft (fig. 8).
30. Turn engine vertical and extract cylinder liners using tool GA.629 (fig. 9). Protect liners against damage whilst out of crankcase.
31. Camshaft. Take care not to damage bearing surfaces during withdrawal. Extract rear bearing sealing plug by means of two $\frac{5}{16}$ inch UNF bolts screwed into the tappings provided.

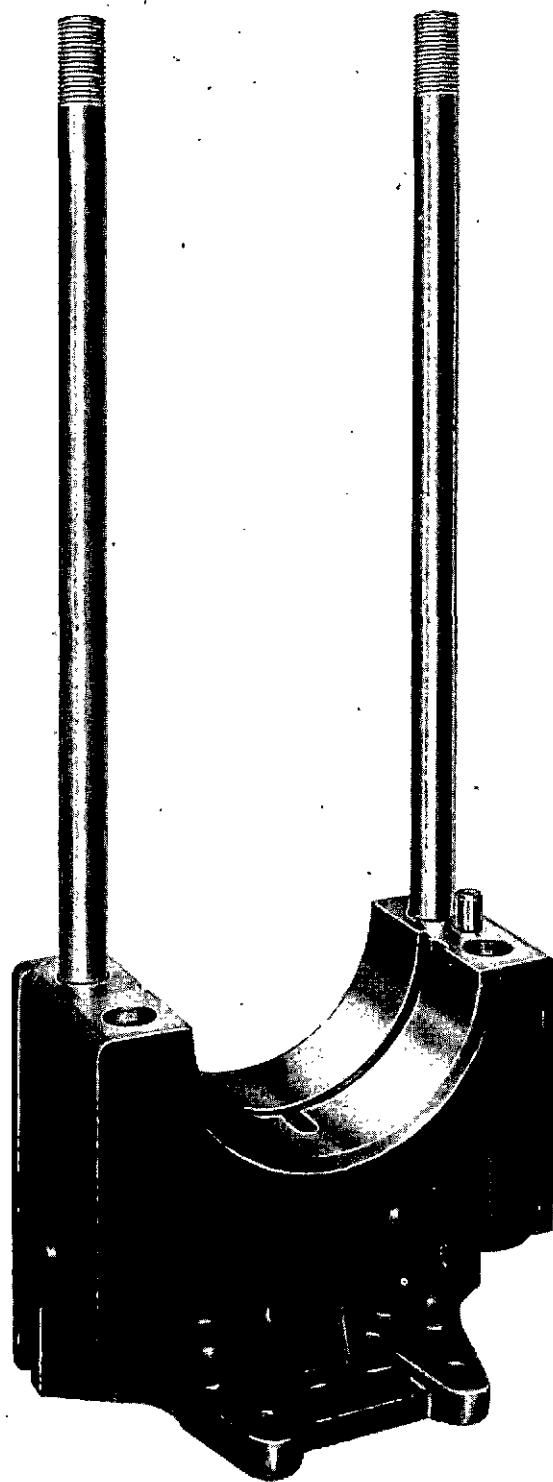


Fig. 5 Front and rear main bearing caps

T720032

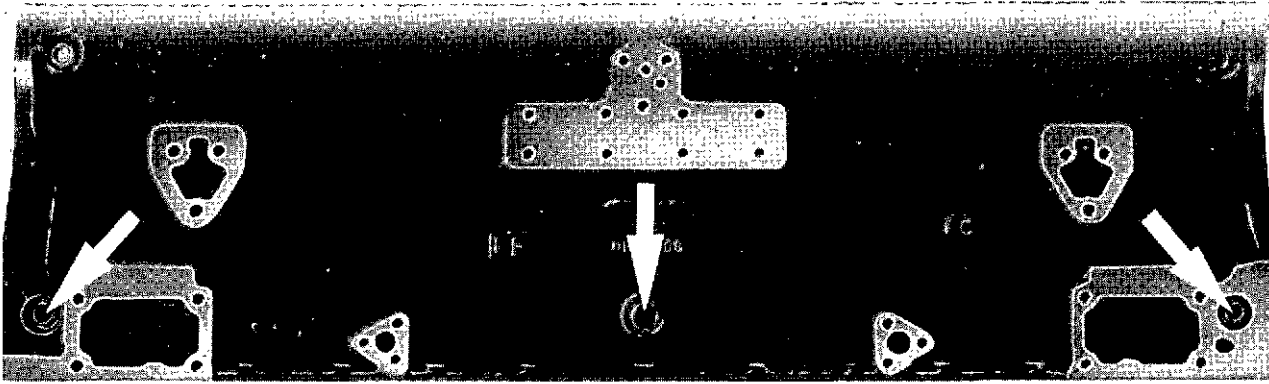


Fig. 6 Main bearing lateral bolts, both sides of crankcase

T720033

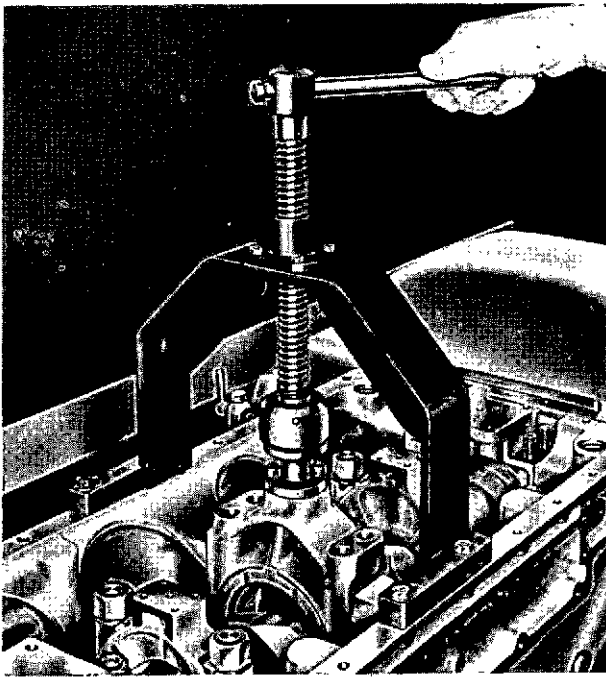


Fig. 7 Extracting main bearing cap

T195

SPECIAL TOOLS

- J.47967 Engine turnover stand
- J.47783 Crankcase lifting tackle
- GA.454 Injector extractor, lever type
- GA.627 Injector extractor, inertia type
- GA.681 Adaptor, GA.627 to injector
- GA.13 Lifting attachment, cylinder head
- GA736 Spanner, crankshaft hub nut
- GA.256 Guide bars, flywheel removal
- GA.247 Extractor, flywheel dowels
- GA.16 Slinging eye, flywheel
- GA.21 Extension spanner, main bearing capnuts
- GA.2/M1 Extractor and inserter, main bearing caps
- GA.629 Extractor and inserter, cylinder liners
- J.47789 Slinging beam, crankshaft

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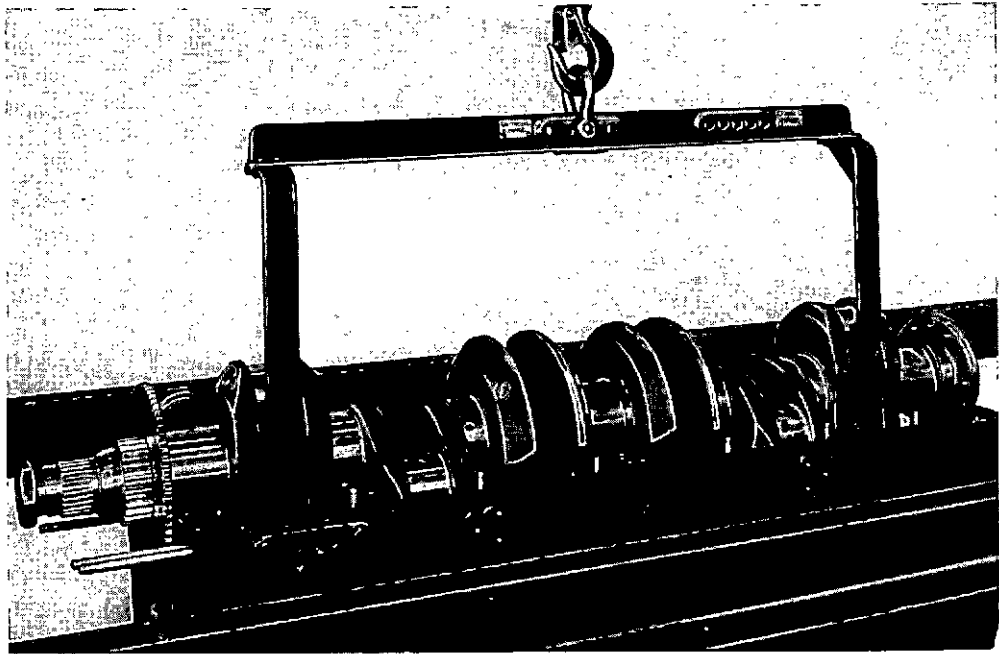


Fig. 8 Lifting crankshaft

T720034

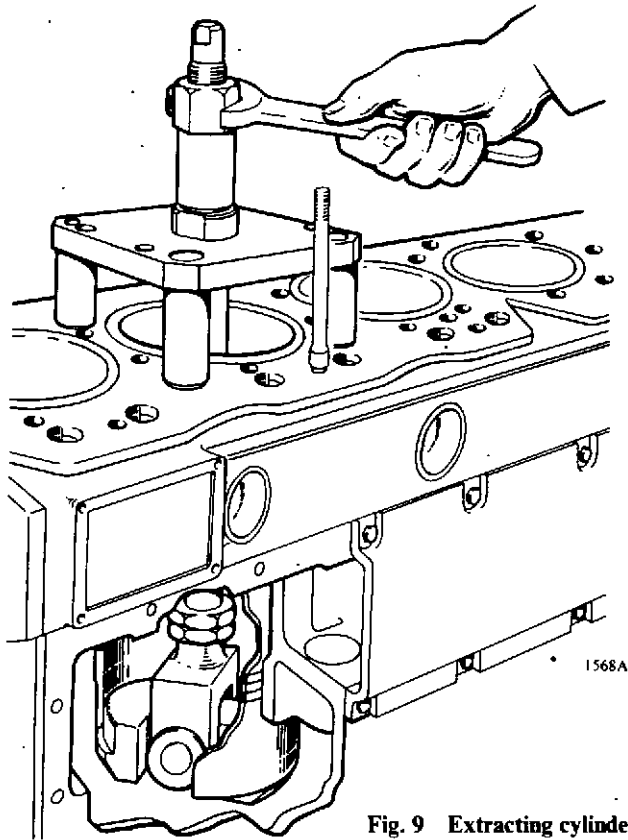


Fig. 9 Extracting cylinder liner

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SECTION 3—ASSEMBLING THE ENGINE

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This Section deals with final erection of the engine from components which have been inspected (and, where applicable, built into sub-assemblies) as described under their appropriate headings.

Attention is drawn to the recommendations made under 'General Information' at the front of this Manual. These are based on good engineering practice and their observance is essential to the production of an efficient, reliable and long-lived unit.

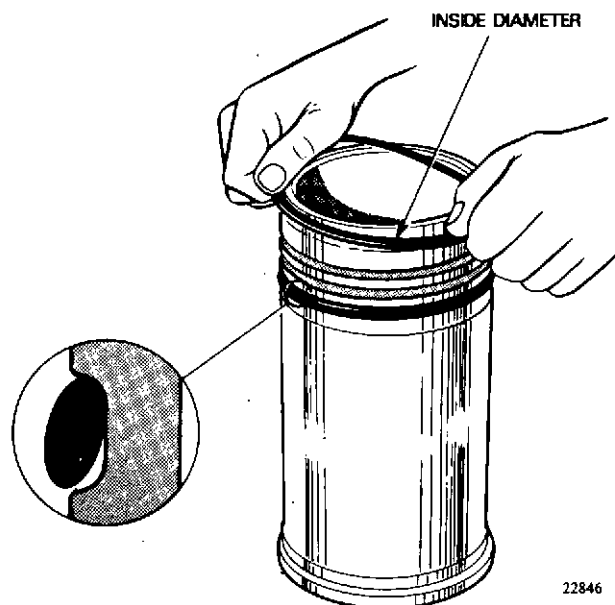
SEQUENCE OF ASSEMBLING

A typical sequence is summarised below and followed by a detailed description of each operation in the same order. As with dismantling, the positioning of certain components (e.g. Turbocharger) to suit an installation may affect the sequence slightly, but this will only occur after the basic engine has been assembled.

- 1-2. Preparing crankcase
3. Cylinder liners to crankcase
4. Crankshaft and main bearings
5. Camshaft to crankcase
6. Wheelcase backplate
7. Camshaft front end
8. Backlash checks
9. Timing wheelcase gears
10. Oilway studs
11. Cam followers, and oil gallery to valve gear
- 12-13. Connecting rods and pistons, as units
14. Cylinder heads and valve gear
15. Adjusting tappet clearances
16. Oil pump and gallery
17. Oil pressure test
18. Crankshaft rear seal
19. Flywheel housing
20. Flywheel
21. Wheelcase cover
22. Sump
23. Crankshaft front end
24. Manifolds and coolant rail
25. Coolant pump
26. Heat exchanger
27. Starter motor
28. Oil filters
29. Fuel filter
30. Injection pump and mounting bracket
31. Injectors
32. Injection and spill pipes
33. Alternator and belts
34. Turbocharger
35. Miscellaneous

METHOD OF ASSEMBLING

1. **Crankcase in turnover stand.** When the core plugs have been fitted, mount the crankcase in the stand using four temporary bearer brackets.
2. **Camshaft rear bearing sealing plug.** Use a new 'O' ring, enter the plug with its tapped holes outwards, and press it flush with the crankcase rear face.



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Fig. 1 Fitting liner sealing rings

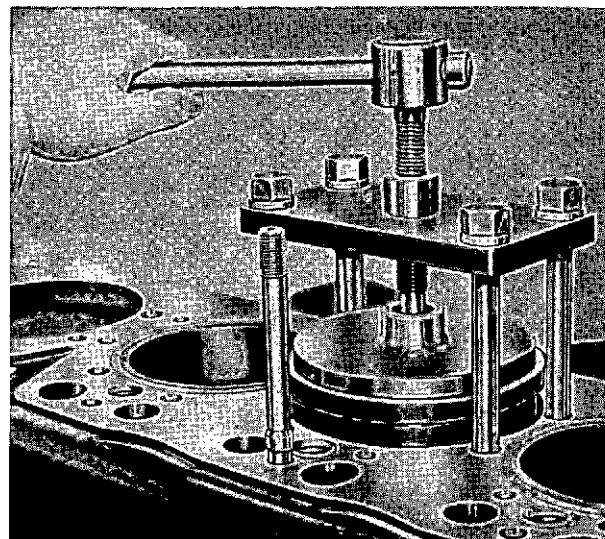
3. **Cylinder liners.** See Section 4 for reconditioning and protrusion checks, noting that a replacement liner must be etched with its position number, as described below, when its protrusion check is completed.

On each liner in turn, apply Linalube — Part No. OE. 45113 (NOT grease) to the skirt and fit new sealing rings as illustrated in fig. 1, ensuring that each ring takes up the position shown and is not twisted. An improved ring OE. 46017, having a blue-and-white paint marking, is now in use. Apply 'Linalube' to the crankcase in the skirt area and insert the liner into its correct numerical position (numbering is from front to rear), aligning the position number etched on the spigot to the large coolant port (fig. 14). Use tool GA. 629 to press the liner fully home (fig. 2). Do NOT drive the liner in, or damage may result.

INVERT THE ENGINE

4. Crankshaft and main bearings

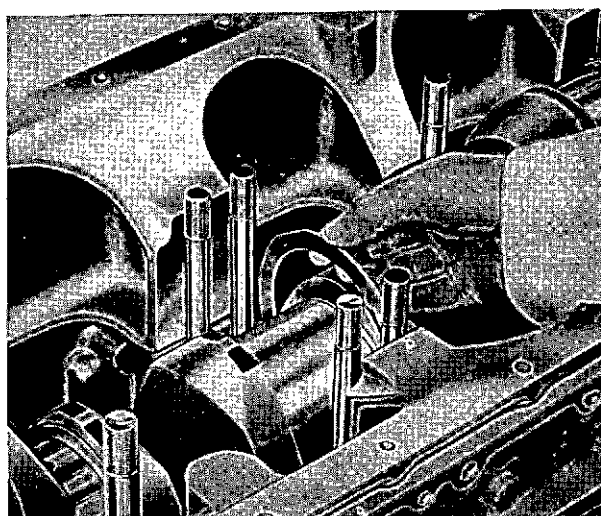
- (a) Check that dowels are in position at front, centre and rear bearing housings. Fit and oil the upper halves of the bearing shells. Sling the crankshaft, complete with its gears and



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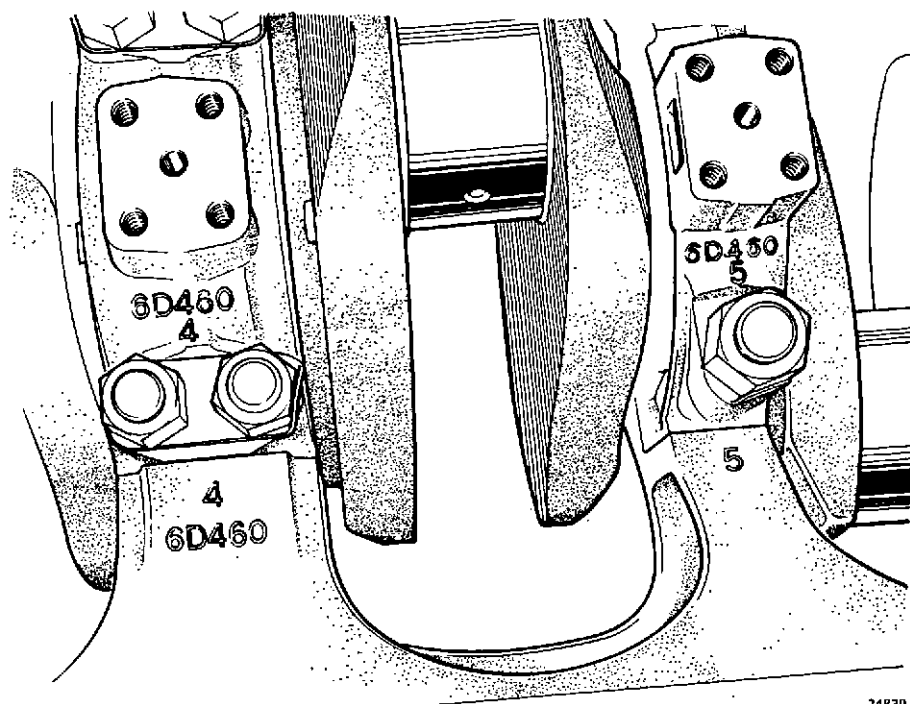
Fig. 2 Pressing in cylinder liner

sealing plugs (see Section 6) and lower it into position. Feed the upper halves of the thrust washers into place on both sides of the centre bearing, with the bronze face of each washer to the crankweb (fig. 3). Assemble the lower half bearing shell and the lower halves of the thrust washers to the centre bearing cap, and fit the cap. Fit the remaining bearing caps and lower half bearings.



T202

Fig. 3 Fitting upper half thrust washer



24839

Fig. 4 Main bearing correlation marks

Notes: (i) The correlation marks on each bearing cap must correspond to the adjacent marks on the crankcase (fig. 4).

(ii) Before fitting the front and rear main bearing caps, check that the oilway blanking plug in each has been fitted, using Loctite '225' and locked by its tabwasher.

Oil the threads of the main bearing studs, and fit the lockplates and nuts, applying a light smear of molybdenum disulphide grease to each nut on the face in contact with the lockplate. Fit also the external capnuts at front and rear. Do not tighten any bearing nuts beyond nipping point at this stage.

(b) Fit and nip the lateral setbolts, each with a plain washer beneath the head, at Nos. 1, 4 and 7 bearing positions on both sides of the crankcase.

(c) Working outwards from the centre, progressively tighten the main bearing nuts to the following torque loadings:

Centre and both end bearings —

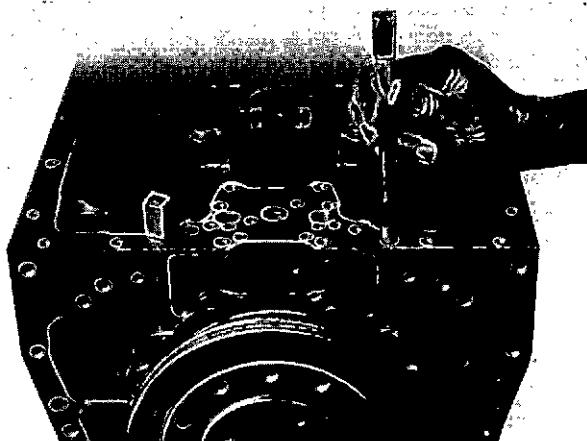
160 lbf.ft. (220 Nm)

Intermediate bearings—

200 lbf.ft. (270 Nm)

Note: When tightening the external capnuts, the extension spanner GA.21 and a torque loading of 140 lbf.ft. (190 Nm) gives an effective loading of 160 lbf.ft. (220 Nm).

(d) Tighten the lateral setbolts to 70 lbf.ft. (95 Nm).



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Fig. 5 Rear main bearing sealing plugs

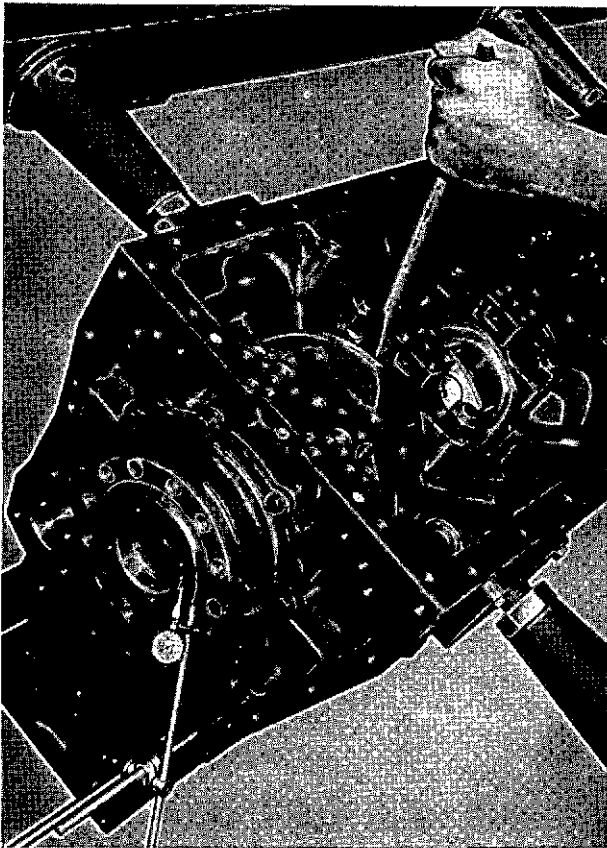


Fig. 6 Measuring crankshaft end float

T720036

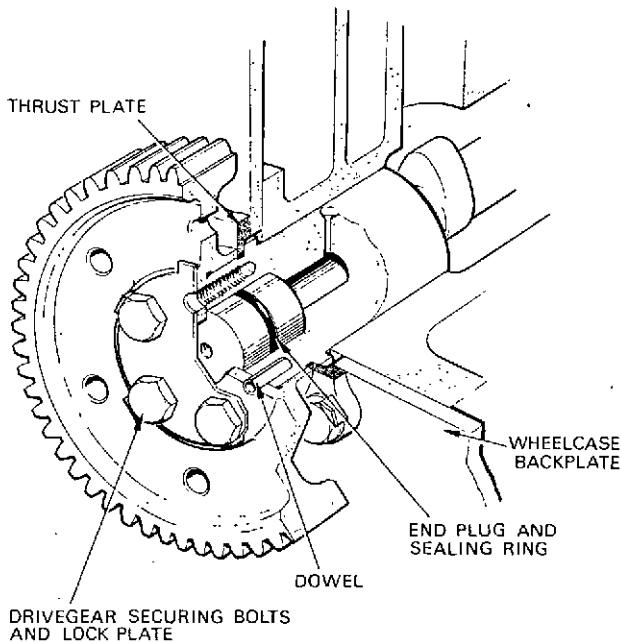


Fig. 7 Camshaft front end assembly

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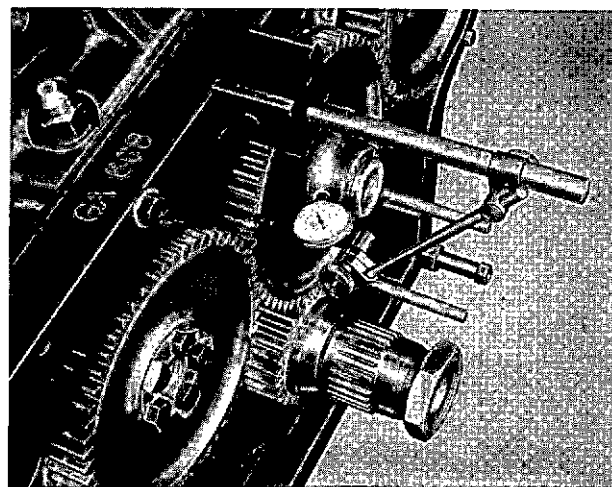


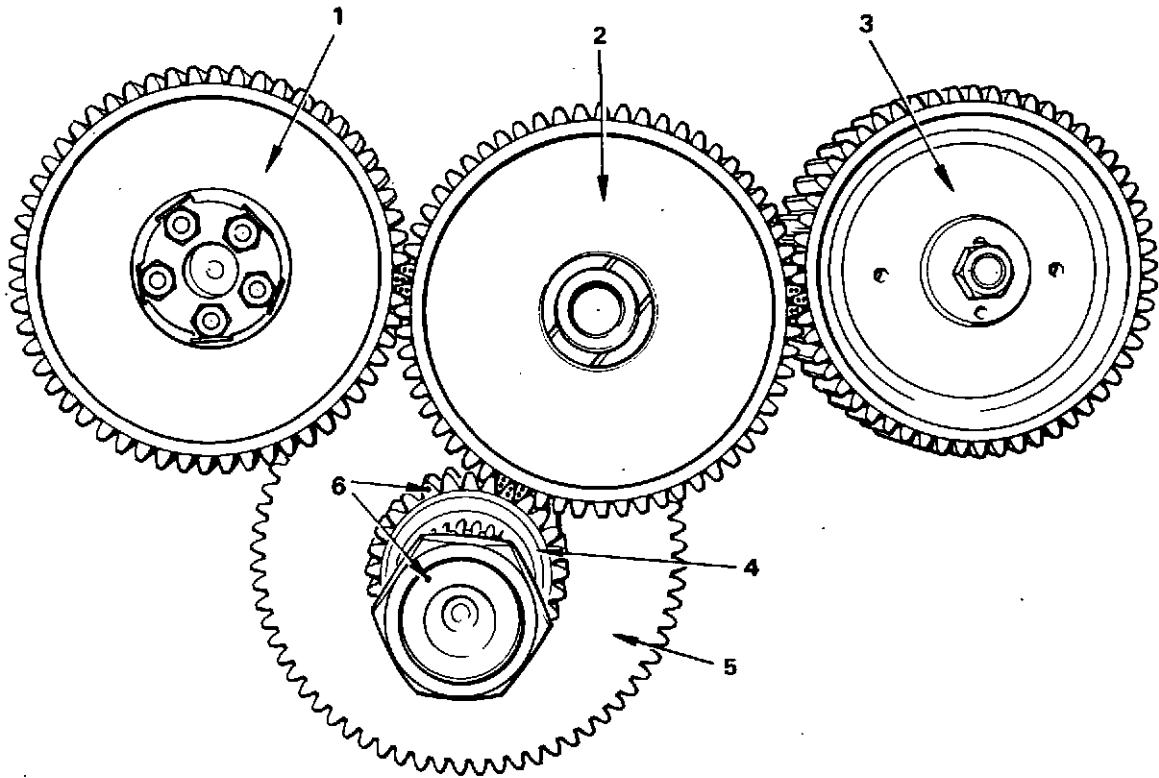
Fig. 8 Measuring idler gear backlash

T720037

- (e) Fit wooden sealing plugs to the rear main bearing cap. Coat each plug with 'Wellseal', drive it fully home (fig. 5), and cut off the surplus flush with the crankcase.
- (f) Check that the crankshaft rotates freely, and measure its end float (fig. 6). Limits are 0.005 to 0.013 inch (0.13 to 0.33 mm).

TURN THE ENGINE UPRIGHT

5. **Camshaft.** Check that the plugs are fitted to each end of the shaft (screwed plug, locked by tab-washer, at rear; aluminium plug and 'O' ring, extractor tapping outward, at front). Oil the bearing surfaces and carefully guide the shaft into position in the crankcase.
6. **Wheelcase backplate.** Fit the two locating dowels (see fig. 10), apply a thin coat of 'Wellseal' to the crankcase front face and attach the joint. Apply 'Wellseal' to the joint and fit the backplate, using temporary bolts and nuts with distance pieces as illustrated to ensure rigidity. Fit the idler gear axle, located by two dowels with circlips, tighten its setbolts and bend up their tabwashers. Refer to Section 12 if a new backplate or axle are to be fitted.
7. **Camshaft front assembly.** Referring to fig. 7, fit the thrust plate, counterbore inwards, centralise it visually around the camshaft, tighten its setbolts to 40 lb.ft. (55Nm) and bend up their



- | | |
|-----------------------|------------------------------------|
| 1 CAMSHAFT DRIVEGEAR | 4 CRANKSHAFT PINION |
| 2 IDLER GEAR | 5 OIL PUMP DRIVEGEAR |
| 3 AUXILIARY DRIVEGEAR | 6 CRANKSHAFT PINION LOCATION MARKS |

Fig. 9 Timing marks, wheelcase gears

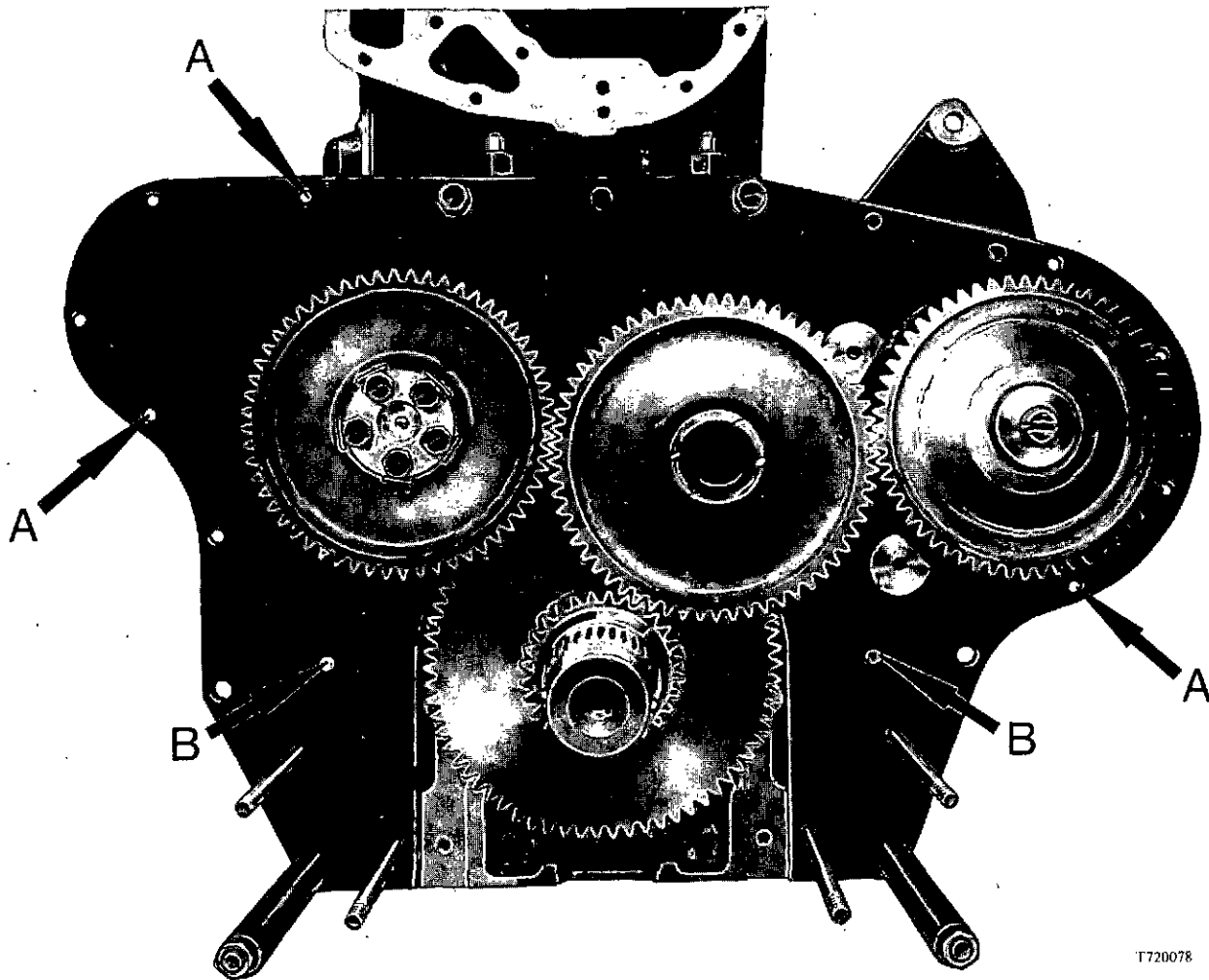
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tabwashers. Assemble the drivegear on its five rollpin dowels, which are offset for correct location, and fit the setbolts and lockplate. Temporarily fit the idler gear to prevent rotation, and tighten the setbolts to 45 lb.ft. (60Nm). Check that the camshaft end float is within the limits of 0.004 to 0.010 inch (0.10 to 0.25mm), and bend up the tabs of the lockplate.

8. **Backlash checks.** Bolt the stiffening frame GA.668 to the wheelcase backplate. Measure the backlash, in each instance at four equidistant points on the idler gear circumference, between the idler gear and each of the three gears with which it meshes (fig. 8). For all these gears, limits

are 0.004 to 0.010 inch (0.10 to 0.25mm). If incorrect backlash cannot be rectified by renewal of worn gears, the idler gear axle must be repositioned as described in Section 12. Remove the stiffening frame GA.668 on satisfactory completion of checks.

9. **Timing of wheelcase gears.** Mesh the idler with the crankshaft pinion, camshaft drivegear and auxiliary drivegear so that the marked teeth are engaged as shown in fig. 9.
10. **Oilway studs.** Ensure that the drillings (arrowed, fig. 11) are clear, and fit the two studs to the crankcase top face.



T720078

A FITTED BOLTS—WHEELCASE LOCATION
B DOWELS—BACKPLATE LOCATION

Fig. 10 Wheelcase and backplate location points

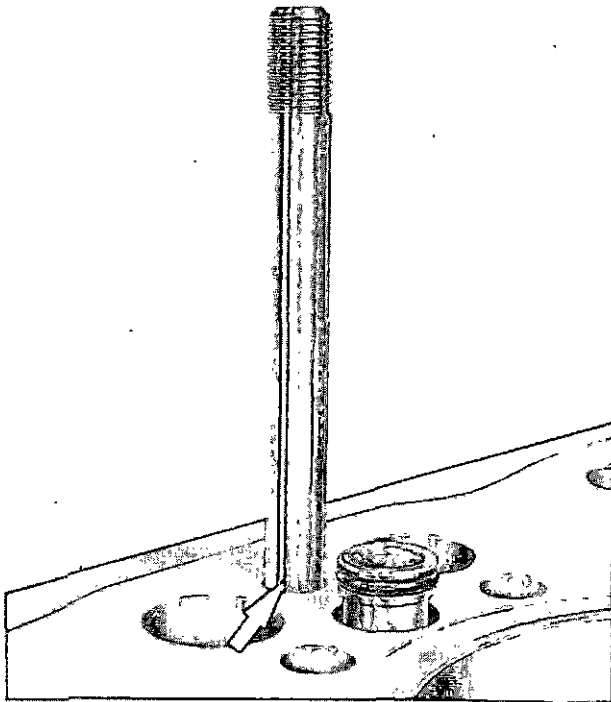


Fig. 11 Cylinder head oilway stud (drilling arrowed) T720039

11. **Cam followers and valve gear oil gallery.** Oil and fit cam followers. Assemble the oil gallery with its longest face inwards (fig. 12) and a spigot washer beneath each bolt head. Fit the baffle plate, with a joint on each side, and the tappet cover. Fit two retaining tools GA.623 (fig. 12) to prevent the cam followers falling out if the engine is inverted prior to fitting cylinder heads.

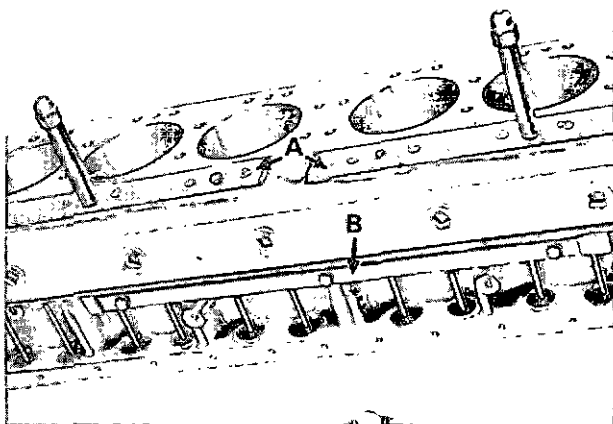


Fig. 12 Cam follower retainers (A) and oil gallery (B) T720040

TURN THE ENGINE HORIZONTAL

12. **Connecting rods and pistons.** With these components assembled together as described in Section 7, oil the pistons, stagger the ring gaps and, using tool GA.12 to compress the rings (fig. 13), enter each assembly into its liner, with the relative position of piston to crankcase as shown in fig. 14. Guide the connecting-rod towards the crankpin, oil the bearings, and assemble the big-ends with the correlation marks aligned. Fit the big-end bolts, oil their threads and tighten the nuts to 160 lbf.ft. (220 Nm) or alternatively until the bolts have stretched 0.008 to 0.011 inch (0.20 to 0.27 mm). No locking is necessary.

Note: On all 'C-RH' build engines the big-end bearings have a circumferential oil groove to supply oil to the piston-cooling jets in the small-end eye. These bearings are NOT interchangeable with ungrooved bearings used on earlier engines which did not have piston cooling jets.

13. **Checking piston height.** With each piston in turn at TDC, measure the clearance of the piston crown below the crankcase top face. A dial gauge kit GA.65 can be supplied to special order. Alternatively, use datum tool GA.693 (or a locally-produced tool made to the dimensions in fig. 15) in conjunction with feeler gauges. Clearance must be between 0.012 and 0.015 inch (0.30 and 0.38 mm) and if necessary this may be obtained by machining the piston top face. Restore the 'FRONT' and cylinder position markings if these are removed by this machining.

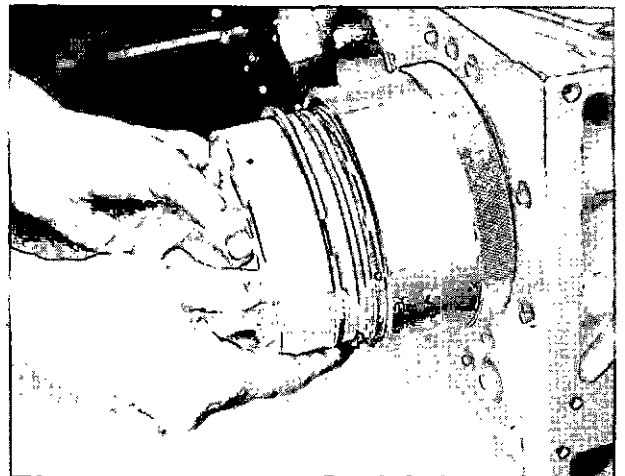


Fig. 13 Fitting piston and connecting rod T720041

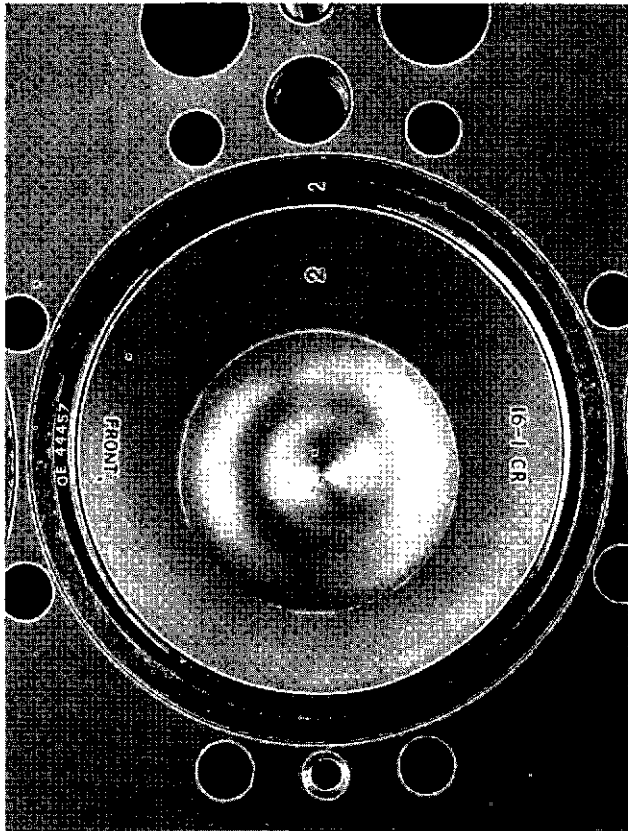


Fig. 14 Correlation of piston and liner to crankcase

T720042

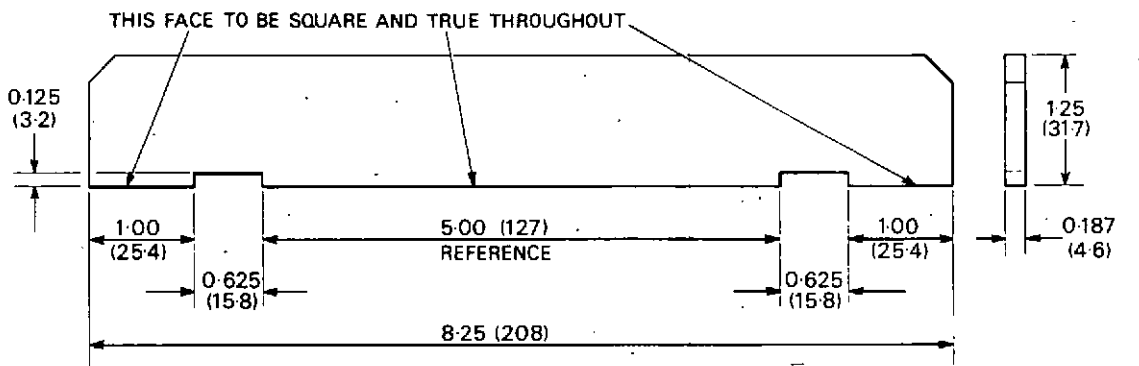
14. **Cylinder heads and valve gear.** Fit the four rollpins which locate the cylinder head gaskets to the crankcase top face. Thoroughly clean all joint faces, but do not remove the anti-corrosive coating from the gaskets. Fit the large coolant bobbins and locate the gaskets, corrugations uppermost, on their dowels. Fit the small bobbins, screw in a guide bar opposite each oilway stud and lower the heads into position.

Assemble a hardened steel washer to each setbolt and oilway stud. Sparingly oil the threads and washers before fitting the bolts and nuts. Do NOT apply oil excessively, since it could enter the blind bolt holes and cause hydraulic pressures, and do NOT drop the bolts into their holes or the threads may be damaged.

Screw in each bolt at least two turns by hand to ensure correct engagement; similarly, fit the oilway stud nuts finger-tight. Gently nip all setbolts and nuts; then align the heads by temporarily fitting the inlet manifold, without joints and nipping its setbolts.

In the sequence shown in fig. 16, tighten down each cylinder head as follows:

- (a) All setbolts and nuts to 50 lbf.ft. (70 Nm).
- (b) All setbolts and nuts to 100 lbf.ft. (140 Nm).
- (c) All setbolts and nuts to 150 lbf.ft. (205 Nm).
- (d) In rising numerical order, all setbolts in black circles to 175 lbf.ft. (240 Nm).



MATERIAL: MILD STEEL

DIMENSIONS: INCHES (MM)

24835

Fig. 15 Datum tool for checking piston height with feeler gauges

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Note: The setbolts and nuts of a newly-fitted cylinder head must be re-torqued to their final loadings, and the tappet clearances checked, after the first 10 to 20 E.S.C. units. This work is to be carried out on complete engines after running-in at the factory.

Assemble the pushrods and valve rocker gear, with a plain steel washer beneath the head of each pedestal setbolt. Before tightening down, ensure that the tappet adjusting screws are slackened to the 'maximum clearance' position. Tighten the pedestal setbolts evenly to 30 lbf.ft. (40Nm).

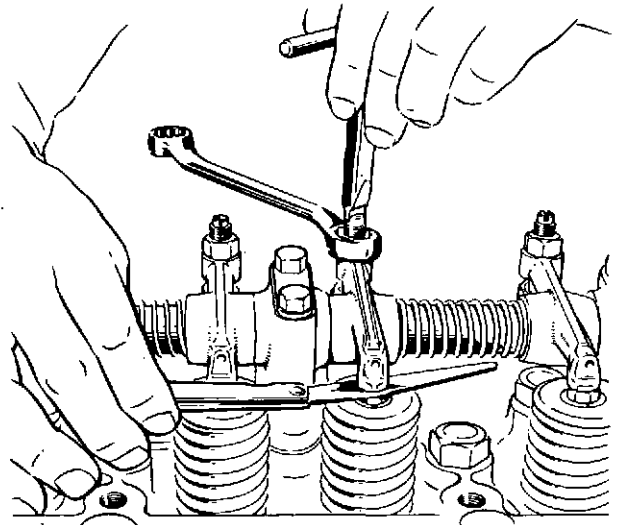
15. **Adjusting tappet clearances.** To facilitate barring over the crankshaft, screw two setbolts into its rear face. Turn the crankshaft anti-clockwise, viewed from the rear, and adjust tappet clearances in the following cylinder sequence. The term 'valves rocking on' means 'inlet valve just opening, exhaust valve just closing'.

Valves rocking on	Adjust tappets on
No. 6	No. 1
No. 3	No. 4
No. 5	No. 2
No. 1	No. 6
No. 4	No. 3
No. 2	No. 5

Adjust the valve tappet clearances as illustrated in fig. 17, to the following dimensions:

- Inlet: 0.015 inch (0.38mm)
- Exhaust: 0.025 inch (0.63mm)

Re-check each clearance after tightening the locknut of the adjusting screw to 30 lbf.ft. (40 Nm). Do not fit the rocker covers permanently until



23375A

Fig. 17 Adjusting tappet clearance

the oil pressure test and injection pump timing have been carried out. Pour oil over the valve gear before finally fitting the covers.

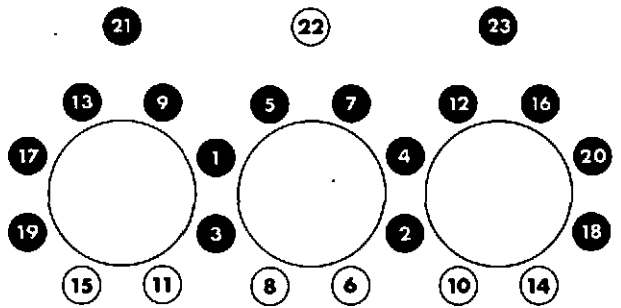
INVERT THE ENGINE

16. **Oil pump and gallery.** These components are fitted separately, pump first. Drivegear backlash is adjusted by shims between pump casing and main bearing cap. The pump is located to the bearing cap by two dowels which pass through the shims.

Using the original shims, fit the dowels and bolt the pump to the bearing cap. Fit the drivegear, tighten its retaining nut to 50 lbf.ft. (70 Nm) and bend up the tabs of the lockwasher.

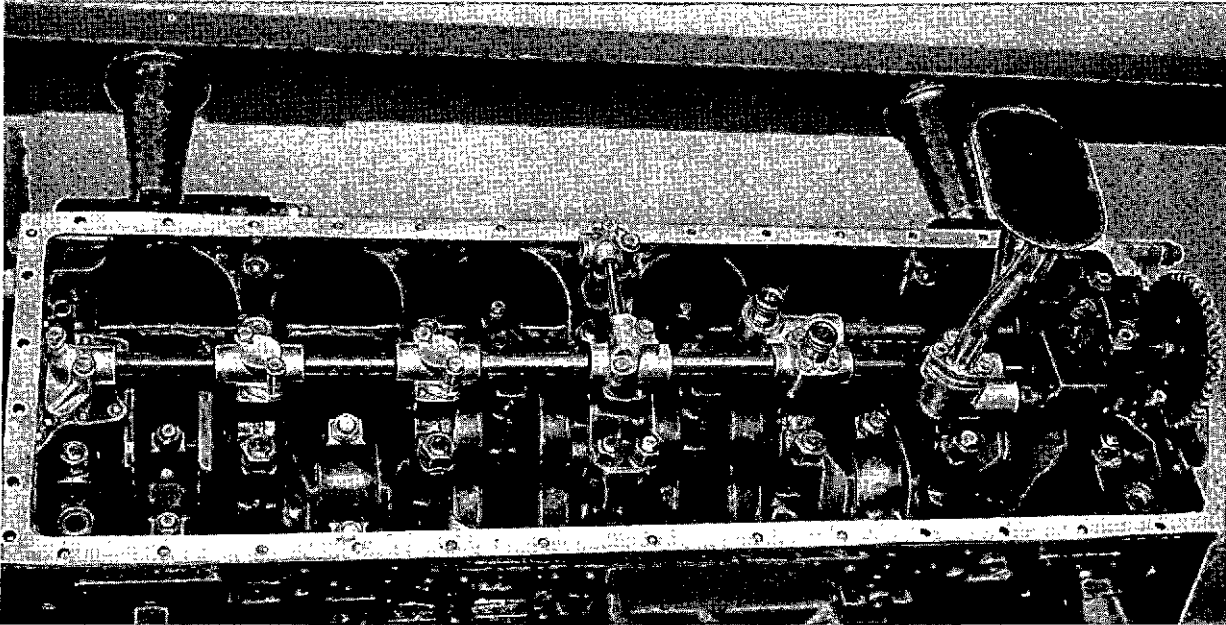
Check drivegear backlash at four equidistant points on the gear *with the engine upright in running position*. Limits are 0.002 to 0.006 inch (0.05 to 0.15mm). Adjust if necessary by varying the shim thickness between pump and bearing cap. Shims are supplied in thickness of 0.008 and 0.012 inch (0.2 and 0.3mm).

Note: If this backlash is measured with the engine *inverted* the reading on a new engine should be between 0.004 and 0.010 inch (0.10 and 0.25mm), due to the crankshaft moving to the opposite limit of its radial clearance in the main bearings.



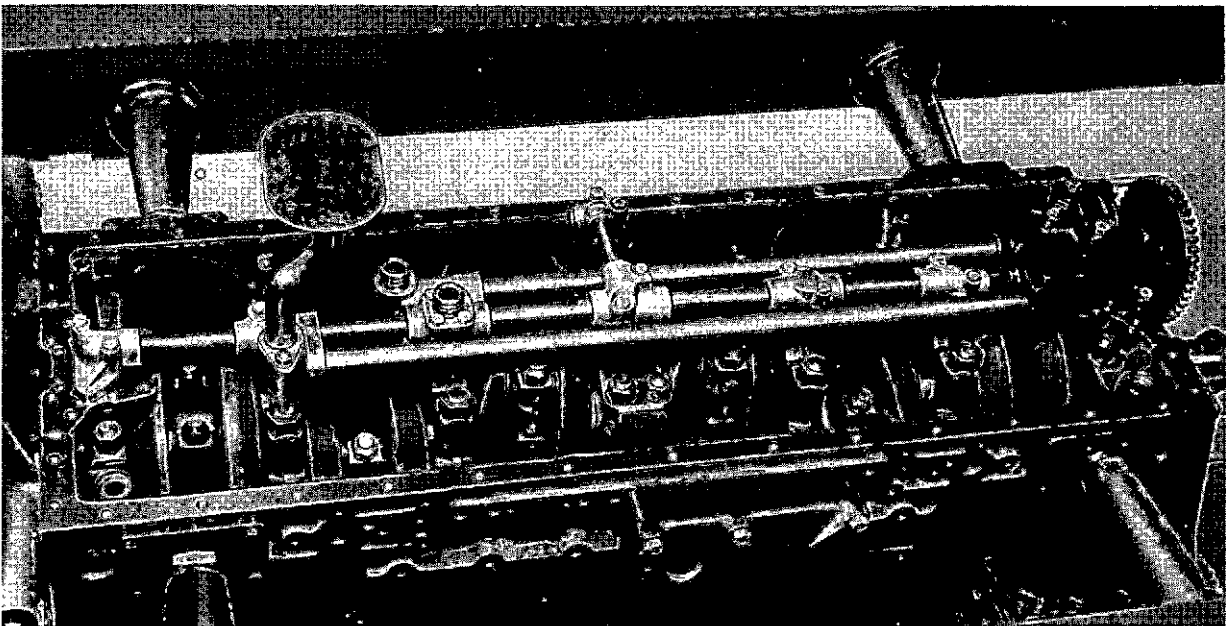
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Fig. 16 Cylinder head tightening sequence



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Fig. 18 Oil gallery, forward pannier sump



T720044

Fig. 19 Oil gallery, rear pannier sump

Fit new 'O' rings to the pump, assemble the gallery (figs. 18 and 19), also using new 'O' rings, and bolt it into position using a new joint washer at each bearing cap. Bend up all locking tabs and finally, screw the drain tube into its taper thread in the rear bearing cap.

17. **Oil pressure test.** This test requires a rig capable of supplying at least 2 gallons (9 litres) of filtered lubricating oil at 40 lbf./sq. inch (276 kN/sq.m).

Bolt a temporary retaining plate over the camshaft rear bearing plug. Fit sealing plug GA.45 to the bore of the idler gear axle (arrowed, fig. 20). With the engine inverted, connect the test rig to the gallery inlet (fig. 20) and admit oil at 40 lbf./sq. inch (276 kN/sq.m) to the system. Check that oil issues from the following points:

1. Oil pump bearings; 2. All main, big-end and small-end bearings; 3. Connecting rod small-end drillings for piston cooling; 4. Camshaft bearings; 5. Valve rocker gear; 6. Outlet connection, for injection pump supply.

Inspect crankpin sealing plugs and oil gallery joints for leakage. Shut off the oil pressure, remove sealing plug GA.45 from the idler gear axle, and check that oil is present in the axle bore. Pour about 1 pint (0.6 litre) of oil into the suction filter, turn the crankshaft in the direction of rotation and check that oil emerges from the outlet bobbin adjacent to the test rig connection.

Note: It is advisable to carry out the pressure test at this stage of engine build (i.e. before the rear main bearing seal is fitted) to avoid any possibility of oil accumulating in the seal due to the crankshaft being stationary. Such an accumulation could render the seal ineffective and possibly set up a siphoning action under running conditions.

18. **Crankshaft rear seal**

(a) *Engines fitted with rear-drop sump*

The seal arrangement consists of a two-piece housing which encloses an Acme thread and slinger ring machined on the crankshaft. The two halves of the housing are dowelled together, the assembly then being located to the crankcase by two dowels with retaining circlips (fig. 21).

To assemble the seal, fit the two dowels and the retaining circlips to the crankcase rear face,

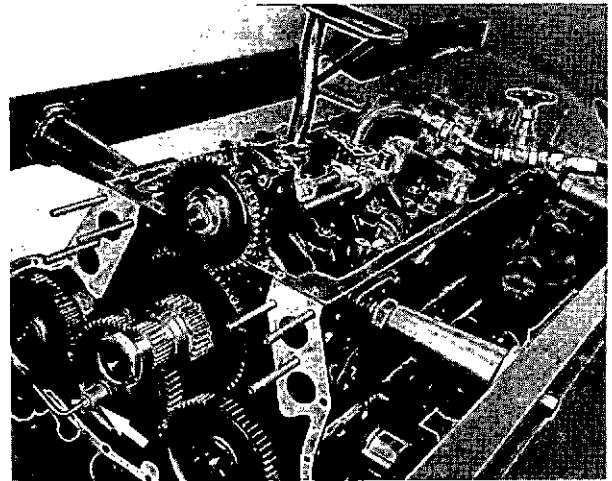


Fig. 20 Lubrication system pressure test

T720045

and affix a new joint washer with a thin smear of 'Wellseal'. Fit the upper half of the seal to the crankcase so that its two dowels are *just* entered. Fit the dowels between the seal halves, apply a thin coat of Loctite '225' to both joint faces of the halves, and bolt them together. Push the seal assembly fully home and bolt it to the crankcase.

(b) *Engines fitted with forward-drop sump.*

This type of seal arrangement consists of a lip type oil seal pressed into a single piece housing (fig. 22).

To assemble the seal arrangement to the engine, press the seal fully home in the housing and fit the two dowels with the retaining circlips into the respective holes on the rear of housing flange. Smear both sides of the joint washer with 'Wellseal' and affix over the dowels on the housing, ensuring that the cut-away on inside diameter of joint washer is in line with the drain trough in the housing. Fit the guide tool GA.800 to the crankshaft flange and wipe the edge of flange with clean dry rag. Slide the housing and seal over the guide tool with the drain trough positioned to the bottom of the crankcase. Press firmly into position on the dowels and secure with the fixing screws. Remove the guide tool GA.800.

CAUTION Care should be taken not to damage the lip seal during handling and fitment. A damaged seal should be discarded and a new seal

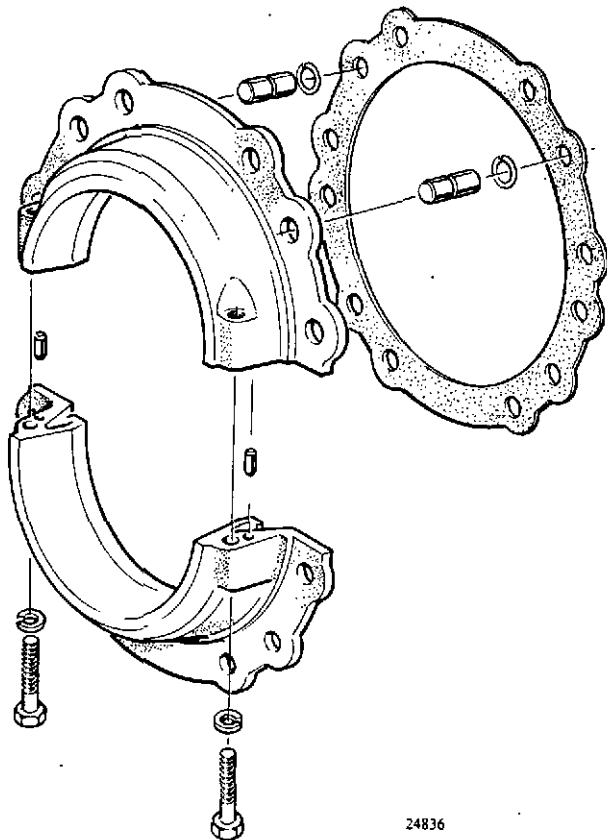


Fig. 21 Crankshaft rear seal—exploded

fitted. Failure to replace a damaged seal can result in oil leakage when the engine is returned to service.

19. **Flywheel housing.** Note: If a tachometer perception head is fitted, remove it until the flywheel is in position.

Ensure that the blanking setbolt and aluminium washer are fitted to the oil hole in the crankcase rear face, opposite the camshaft blanking plug. Mount the flywheel housing on its two dowels, fit the setbolts, tighten them to 45 lbf.ft. (60Nm) and bend up their tabs.

When fitting the two external stiffening brackets, fully tighten them to the flywheel housing before tightening their remaining setbolts.

20. **Flywheel.** One of the three dowel holes is offset (fig. 25). Position this hole at 6 o'clock by setting the crankshaft to No. 1 TDC. Fit two nylon-

faced guide bars GA.687 to the crankshaft rear face. Unscrew the timing pointer. Offer up the flywheel with its timing marks at approximately 4 o'clock, thus aligning the dowel holes, and push it into place along the guide bars. Temporarily secure the flywheel by two setbolts at opposite points, nipped up and then slackened slightly. Grease the three dowels sparingly and fit each one by tapping on the head of a $\frac{1}{8}$ inch UNF bolt temporarily screwed into the extractor hole. Fit the nine retaining bolts and their lockplates, tighten the bolts evenly to 85 to 90 lbf.ft. (115 to 120 Nm) and lock them. Refit the timing pointer.

21. **Wheelcase cover.** Pack a new oil seal with Vaseline and press it, lip inwards, flush with the front face of the cover bore if the crankshaft hub is unworn. If the hub is grooved by the previous seal, press the new seal 0.110 inch (2.8 mm) below the front face; if the hub has two grooves, press the seal fully home.

Note: Kit GA.420 is used for renewing the seal on an installed wheelcase cover. It cannot be used if the cover is detached. See Section 12.

Fit the crankshaft hub rear cone. This can be assembled and removed with the wheelcase cover installed, but fitting at this stage is preferable.

Remove the idler gear axle support plate from the wheelcase cover and clean the joint faces. Oil the gear train and, using a new joint washer, fit the wheelcase cover. The locating of the fitted bolts is shown in fig. 10.

Measure the end float of the idler gear in the following manner:

- (a) Push the gear fully inwards and measure the protrusion of the front face of the gear bearing beyond the support plate joint face.
- (b) Measure the depth of the counterbored thrust face in the support plate.
- (c) Subtract (a) from (b) to obtain the end float. Limits are 0.013 to 0.027 inch (0.33 to 0.68 mm).

Apply 'Wellseal' to the joint faces, and refit the idler axle support plate, with no joint washer.

INVERT THE ENGINE

22. **Sump.** Fit the relief valve assembly and oil gallery pipes (see fig. 23) using new joints and 'O' rings. Coat sump and crankcase joint faces thinly with 'Wellseal', attach a new joint washer and temporarily fit a $\frac{1}{8}$ inch UNF guide pin of suitable length (dependent on sump type) at each corner of the crankcase joint face. Lower the sump into position on the pins, fit the setbolts, each with a plain and spring washer, and tighten them evenly. Tighten the sump drain plug to between 80 and 85 lbf.ft. (110 to 115 Nm) and wire-lock it.

TURN THE ENGINE UPRIGHT

23. **Crankshaft front end.** A typical assembly is illustrated in fig. 24, and consists of the hub (with its cones, retaining nut and lockplate), the pulley/damper unit and barring adaptor. On some applications the barring adaptor is replaced by a starter claw which is an extension of the hub nut.

Thoroughly clean all parts, apply a very thin film of grease to the hub bore splines, oil the hub nut thread and fit the hub, steel cone and hub nut. Tighten the nut to 700 lbf.ft. (950 Nm), either

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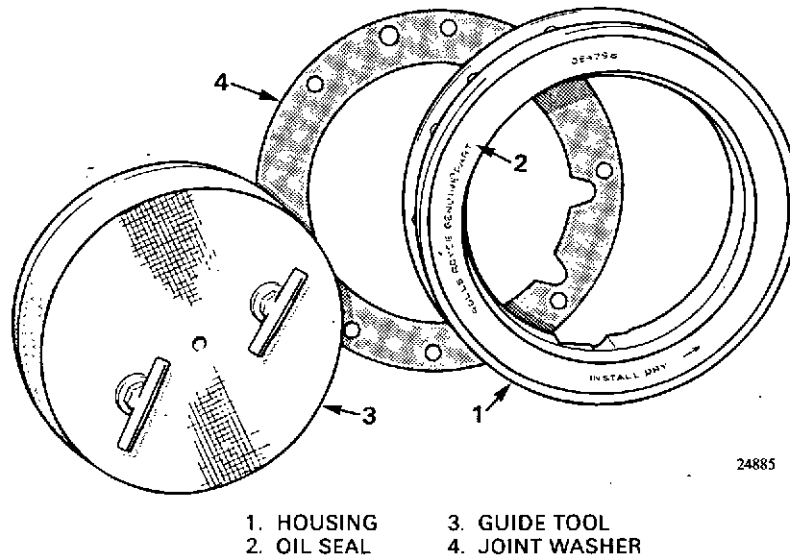


Fig. 22 Crankshaft rear seal

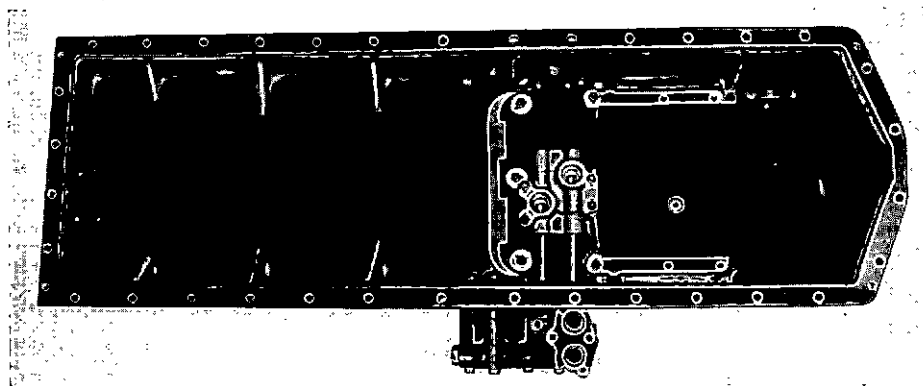


Fig. 23 Interior, forward pannier sump

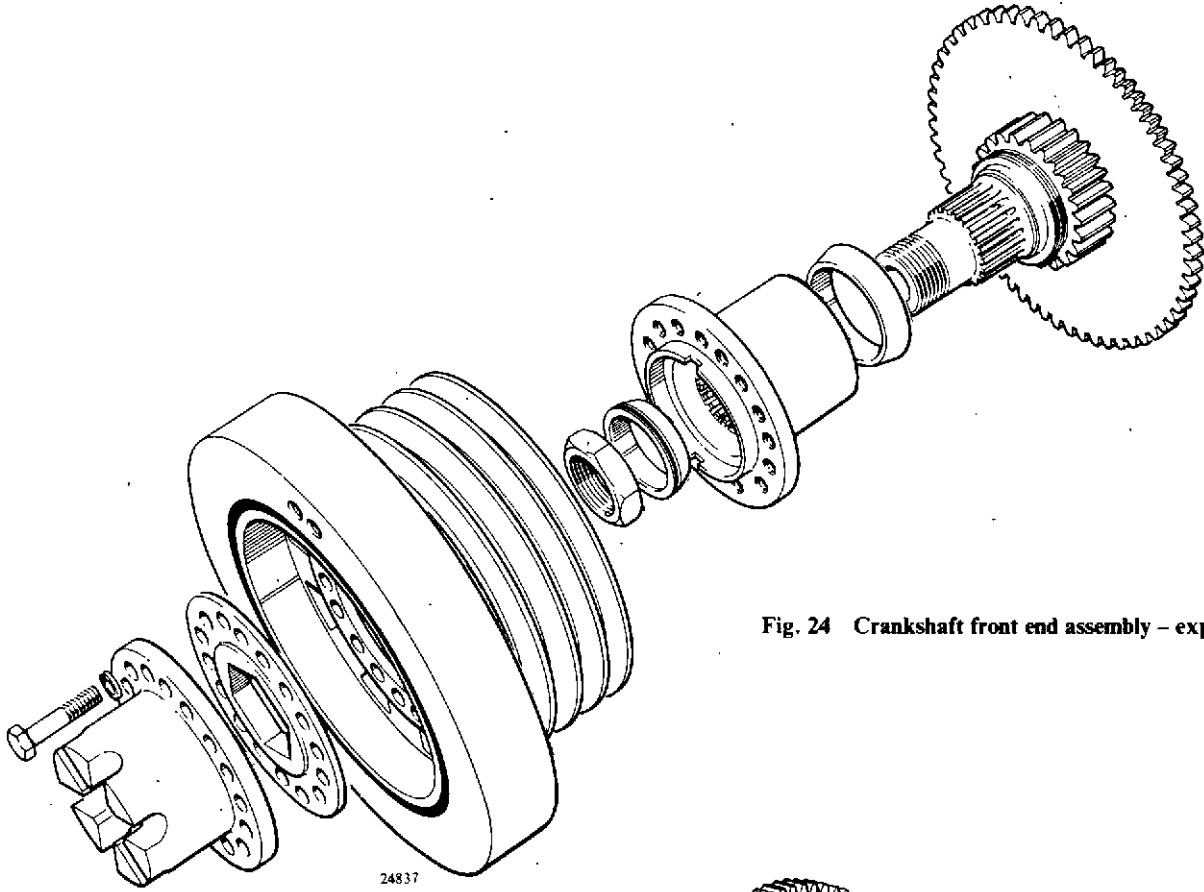
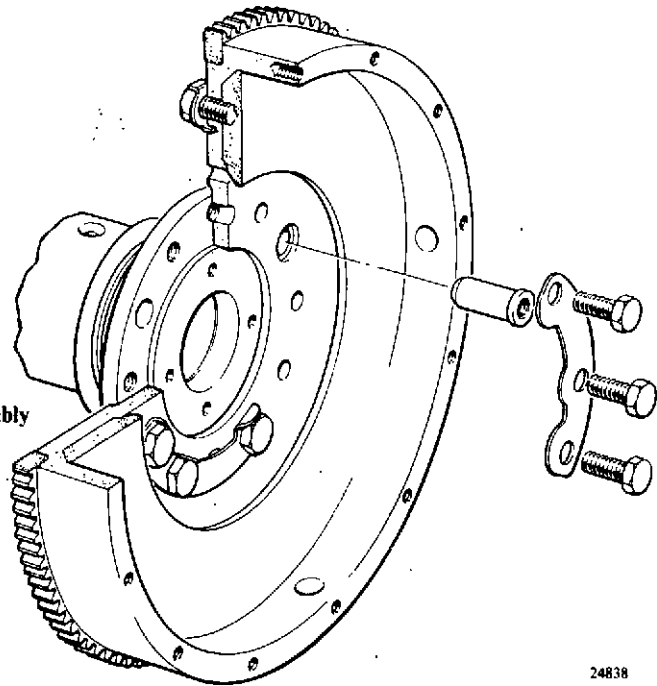


Fig. 24 Crankshaft front end assembly - exploded

24837

Fig. 25 Crankshaft rear end assembly



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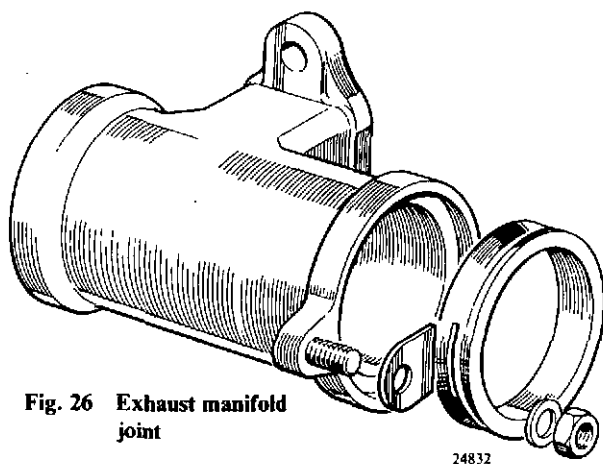


Fig. 26 Exhaust manifold joint

by torque spanner or alternatively by the following method using spanner GA.736 and a 4 lb (1.8 kg) hammer:

- (a) Spanner-tighten the nut as fully as possible *by hand*.
- (b) Hammer-tighten the nut *exactly* one flat further.
- (c) If the crankshaft pinion has been disturbed, slacken the nut and repeat (a) and (b).

Note: Insufficient tightening can result in fretting of splines and cone faces.

Fit pulley/damper unit, lockplate and, if applicable, barring adaptor. These components are all secured to the hub by 16 set-bolts which are tightened to 30 lbf.ft. (40 Nm) and locked by spring washers. If difficulty in fitting the lockplate is experienced the hub nut may be tightened further by the minimum amount necessary, but it must NOT be slackened for this purpose.

24. **Manifolds and coolant rail.** Fit the exhaust manifold, with a light smear of anti-seize compound on the screw threads. Each intersection sealing ring is assembled with its lockplate slot offset towards the lockplate stud boss (fig. 26).

No joints are used between exhaust manifold and cylinder heads.

Fit the inlet manifold, with new joint washers. Assemble the coolant rail, using new 'O' rings, and bolt it into position.

25. **Coolant pump.** Loosely fit the hoses and clips. Screw guide pins into two of the pump bolt tappings in the crankcase. Fit a new joint, using 'Wellseal', and slide the pump along the pins until the coolant rail enters the thermostat hose. Fit the retaining bolts and tighten the hose clips.
26. **Heat exchanger.** Bolt the mounting plate to the crankcase and then secure the heat exchanger to the plate.
27. **Starter motor.** Ensure that the joint faces are clean, and tighten the setbolts firmly.
28. **Oil filters.** Ensure that new elements are fitted and that the filter bowls are primed with oil. Tighten the bowl-securing bolts to 20 lbf.ft. (27 Nm).
29. **Fuel filter.** Fit the filter unit and its mounting bar, together with the extended studs which carry the high-pressure pipe clips.
30. **Injection pump.** Fit the two dowels to the pump mounting and bolt it to the crankcase. Note that the access hole in the mounting is opposite the lateral bolt of the centre main bearing. Assemble the injection pump to its mounting, fitting the four retaining bolts finger-tight. Do NOT connect any rigid pipes to the pump or governor at this stage. Fit the drive coupling arm to the injection pump camshaft and tighten its nut to between 85 and 90 lbf.ft. (115 to 120 Nm). This nut is locked by a flat spring washer.

Note: Ensure by blueing that the tapers of these drive coupling arms have a *minimum* of 80% contact.

Bar over the engine in direction of rotation until No.1 inlet valve closes, and continue turning until the injection timing figure on the engine flywheel, as stamped on the crankcase data plate, is opposite the pointer (fig. 27).

Set the adjustable coupling of the injection pump to mid-point of its range (fig. 28 Item 2). Turn the pump until its timing marks are aligned (fig. 28 Item 3) and fit the coupling yoke and spring packs between pump and drive-shaft. Note that it is important to fit bolts with their heads to the fuel pump, as shown in Fig. 28 Item 1.

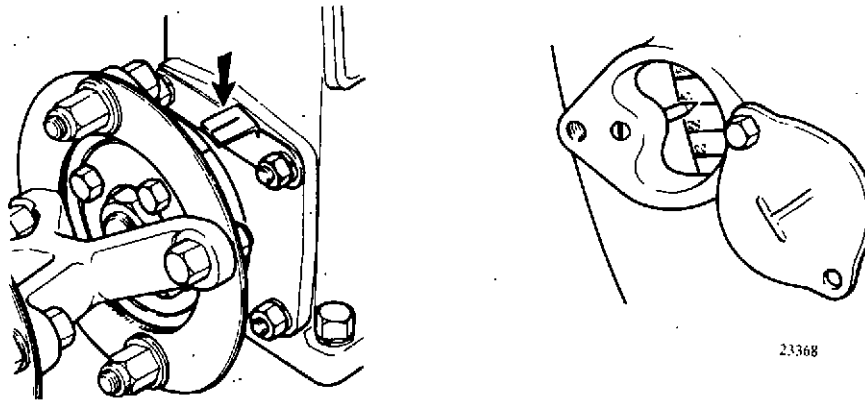


Fig. 27 Injection pump timing

Tighten the stiffnuts until the spring packs are just nipped, then continue tightening progressively, turning the engine during the early stages to enable the drive and pump to take up unstressed positions. Finally, tighten the nuts to 85 lb.ft. (115 Nm) using spanner GA.733.

Evenly tighten the four pump-to-mounting bolts to 30 lb.ft. (40 Nm) and, on completion, check visually that the spring packs are not distorted.

Turn the engine backwards a little to take up the backlash, and then forwards until the engine flywheel timing figure is again aligned with its pointer. Check that the pump timing marks are aligned (fig. 28).

If necessary, slacken the adjustable coupling bolts (fig. 28), align the pump timing marks, nip the bolts and carry out a further check.

Finally, tighten the adjustable coupling bolts and fit the timing pointer cover to the flywheel housing.

Fit the pump lubricating oil supply and drain pipes, and pour $\frac{1}{4}$ pint (0.4 litre) of engine lubricating oil into the pump cambox, via the filler plug on the governor housing.

31. **Injectors.** Ensure that the seatings and injector nozzles are clean, and lightly smear the injector body with coppaslip anti-seize compound. Fit the injectors with new rubber seals OE.48293 and tighten down the retaining setscrews to 8.5 lb.ft. (11 Nm), using spanner OE.3311.

Caution: No joint washer is used between injector nozzle and seating. Any washers supplied with injectors must be removed and discarded. Coppaslip **MUST NOT** be applied around the injector nozzle area.

32. **Injection pipes.** The high-pressure pipes in particular must be treated with great care and not strained or forced into position. When fitting each pipe, blow through it with dry compressed air and ensure that it lies naturally between its unions so that no distortion of pipe or rubber dampers occurs when the gland nuts and securing clips are tightened. **DO NOT OVERTIGHTEN THE GLAND NUTS.**

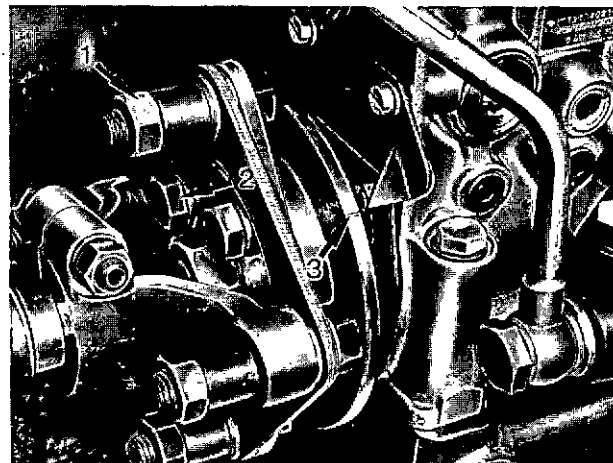


Fig. 28 Adjustable coupling

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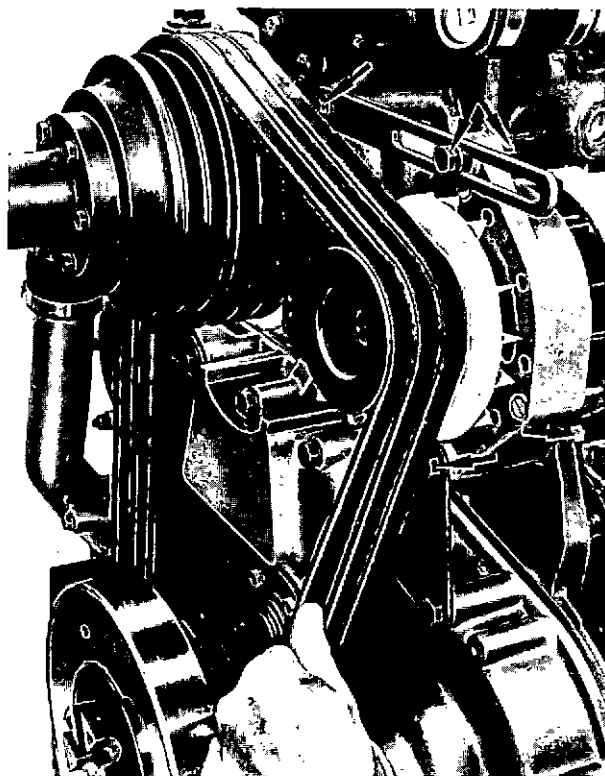


Fig. 29 Belt adjustment

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Use new joint washers at each of the spill pipe banjo connections.

33. Alternator and driving belts.

Fit the alternator and swivel it inwards on its pivot until the belts can be fitted easily by hand. Do not lever belts into position.

To ensure maximum life for belts and the bearings of alternator and coolant pump it is essential that each belt is correctly tensioned and the pulleys are aligned. On a multi-belt drive, all belts must be renewed together.

Adjustment of main belt tension is made by slackening the bolts indicated by arrows in fig. 29 and swivelling the alternator about its pivot. Belts are supplied in sets, all belts in a set being exactly of equal length. Belts from different sets must NOT be mixed, since they will not necessarily be of equal length. These belts must be tensioned so that *on each belt* the deflection at mid-point of the longest run is $\frac{1}{2}$ inch (12mm) under a pressure of 8.5 to 9.5 lb. (3.85 to 4.3 kg).

Alignment of the alternator and coolant pump pulleys is checked, after the belts are tensioned, by placing a straightedge across the front faces of both pulleys and measuring by feeler gauge. Malalignment must not exceed 0.025 inch (0.6mm) and is corrected by spacing washers fitted behind the alternator pulley. Use wrench OE.44083 to hold the pulley whilst slackening its nut, and withdraw the pulley from its parallel shaft using extractor OE.44398. When refitting the pulley, tighten the nut to 40 lbf.ft. (55 Nm).

Checking new belts

New belts should be checked, and adjusted if necessary, after the first 15 minutes running, then weekly for the first four weeks, and thereafter at the intervals specified in the Servicing Schedule.

34. **Turbocharger.** No joint washer is used between exhaust manifold and turbocharger, and it is therefore essential that the contacting faces are clean and flat. Fit new hose connections of the approved reinforced silicone type to the induction side, ensuring that they are properly aligned and firmly clipped.

Apply a light coating of anti-seize compound (see Section 1) to all bolts and nuts before assembling the unit to the engine. If a bellows-type diffuser is fitted ensure that it is properly aligned to avoid distortion which could cause early failure. Before fitting the lubricating oil feed and drain pipes, check them for damage and restrictions.

Prime the turbocharger bearings by pouring $\frac{1}{4}$ pint (0.2 litre) of engine lubricating oil into the filler pipe on the bearing housing.

Note: Although the turbocharger is simple in principle and construction, it is, in fact, a precision-built machine operating at very high speeds. Its performance and life are dependent on correct operation and efficient servicing. During test-running of new and overhauled engines at the Factory a special 'throw-away' filter OE.43712 is fitted at the turbocharger oil inlet flange; this protects the turbocharger bearings against contamination during initial running and is then removed and destroyed. Distributors wishing to adopt this precaution are reminded that (1) the filter **must** be removed before the engine goes into

service and (2) the filter cannot be cleaned and **must** be destroyed on removal to ensure that it is not re-used. See Section 15 'Running-in'.

35. **Miscellaneous.** Make a final check to ensure that all pipes are adequately supported and not liable to chafing. Blank off all orifices.

SPECIAL TOOLS

- | | | | |
|----------|--|---------|--|
| J.47967 | Engine turnover stand | GA.420 | Kit, renewing crankshaft front seal on installed wheelcase, consisting of: |
| J.52673 | Temporary bearer brackets (4 off) | GA.364 | Extractor |
| J.47783 | Crankcase lifting tackle | GA.694 | Inserting tool |
| J.47789 | Slings beam, crankshaft | GA.421 | Box |
| GA.13 | Lifting attachment, cylinder head | GA.623 | Tool, cam follower retaining (2 off) |
| GA.16 | Slings eye, flywheel | GA.12 | Tool, piston ring compressing |
| OE.40897 | Torque spanner, 4 to 25 lbf.ft. | GA.65 | Kit, piston height (special order) |
| DV.1978 | Torque spanner, 20 to 100 lbf.ft. | GA.693 | Datum tool, piston height |
| OE.40898 | Torque spanner, 50 to 250 lbf.ft. | GA.45 | Plug, sealing idler gear axle bore, oil pressure test |
| GA.629 | Insertion/extraction tool, cylinder liners | GA.256 | Guide-bars flywheel removal (2 off) |
| GA.2/M2 | Insertion/extraction tool, main bearing caps | GA.687 | Guide-bars, flywheel fitting (2 off) |
| GA.21 | Extension spanner, main bearing capnuts | GA.736 | Spanner, crankshaft hub nut |
| GA.497 | Tab bender, main bearing nuts | OE.3311 | Spanner, injector flange nuts |
| GA.668 | Stiffening frame, wheelcase backplate | | |

SECTION 4—CRANKCASE AND CYLINDERS

DESCRIPTION

The crankcase comprises the crank chamber and cylinder block, cast as a single unit in high-grade nickel-chrome iron. The crank chamber extends well below the crankshaft centre line to ensure rigidity, and incorporates five transverse webs which carry the centre and intermediate bearings of the crankshaft. Additional stiffness is provided by lateral setbolts at the front, centre and rear main bearing caps (see Section 2 fig. 6).

The crankshaft is carried in seven plain bearings with removable caps, and is located by thrust washers at the centre bearing. The camshaft has seven journals and runs in bearing surfaces machined in the crankcase casting.

Slip-fit wet liners are carried in the cylinder block, which has cast-in webs to control coolant circulation. At the top of each liner is a flange, the underside of which forms a coolant seal with the seat of a counter-bore in the crankcase top face. At its skirt the liner is grooved for three composition sealing rings.

Cam followers of chilled cast iron are carried in machined bores adjacent to the crankcase webs. All oilways are drilled for cleanliness and uniformity, and the crankcase interior surface is sealed to prevent contamination of lubricating oil and coolant by casting residue.

INSPECTION AND TESTING

Remove all blanking plugs and thoroughly clean the crankcase, paying particular attention to oilways. Refit the coolant plugs to the cylinder block, applying Loctite '225' to their threads and using new joint washers:

Pressure test

To test for cracks, fit the blanking-off assembly GA.486, immerse the crankcase in water at 60 deg.C (140 deg.F) for 20 minutes, apply air pressure at 30 lbf./sq. inch (206 kN/sq.m) and examine for leaks.

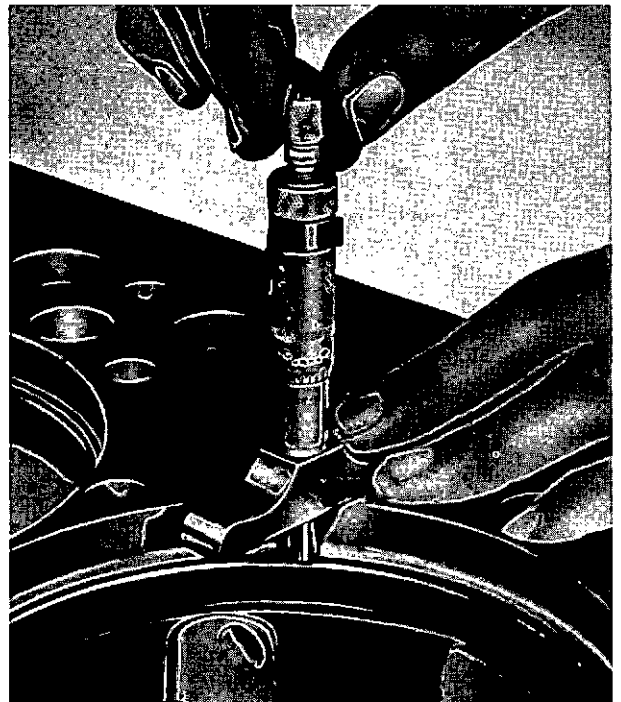


Fig. 1 Measuring depth of liner flange seating. 2876

Top face

Eroded bobbin recesses will necessitate returning the crankcase to the factory for reclamation. Inspect the top face for signs of fretting by the cylinder heads. This face may be reclaimed by machining, subject to the following limitations. See SRS 32 for details:

1. The amount of metal removed should be the minimum necessary to restore the surface, and must not exceed 0.020 inch (0.51 mm), measured from standard. After machining, the appropriate figure is stamped on the top face in an area not covered by the cylinder heads.
2. Clearance of 0.012 to 0.015 inch (0.30 to 0.38 mm.) between crankcase top face and piston crowns at TDC must be maintained, if necessary by machining the pistons. See Section 3, Item 13.
3. Whatever amount is removed from the top face, the depths of bobbin and cylinder liner recesses must be maintained.

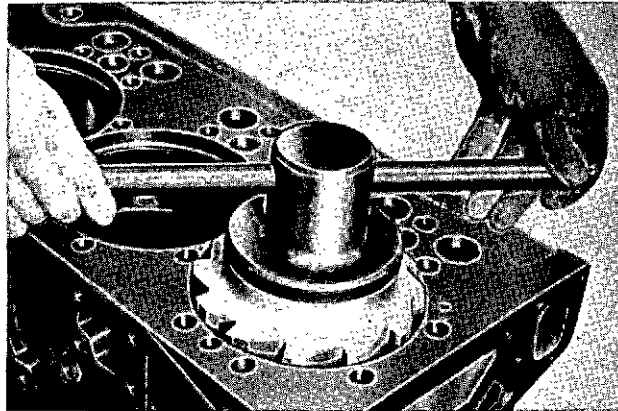


Fig. 2 Cutting liner flange seating 2877

Liner recesses

Inspect each liner flange seating for fretting and, to confirm that the seal is satisfactory, check by 'blueing' that contact between liner flange and seating is 100% of circumference and at least 50% of width.

Measure the depth of each flange seating below the top face at four equidistant points (fig. 1) and record the readings. Use cutter GA. 320 (fig. 2) to reclaim unsatisfactory seatings, or to restore seating depth after machining of the top face.

Reclamation of the flange seating will reduce the protrusion of the cylinder liner above the crankcase top face. To restore this protrusion to its limits of 0.003 to 0.005 inch (0.08 to 0.13 mm.) proceed as follows:

1. If the cylinder liner flange is of standard thickness, a special liner, having a flange 0.005 inch (0.13 mm.) thicker, is available. This liner is identified by a 'V' groove on the flange circumference. Note that when a new liner is fitted, the piston rings should also be renewed.
2. If the protrusion cannot be restored by the above method, the necessary amount must be machined from the crankcase top face (see SRS 32).

Liner lower sealing bores

Inspect the bores in the crankcase for erosion and damage. Instructions for repair, which involves machining the bore and fitting a stainless steel sleeve, are given in SRS 17 (issue 5).

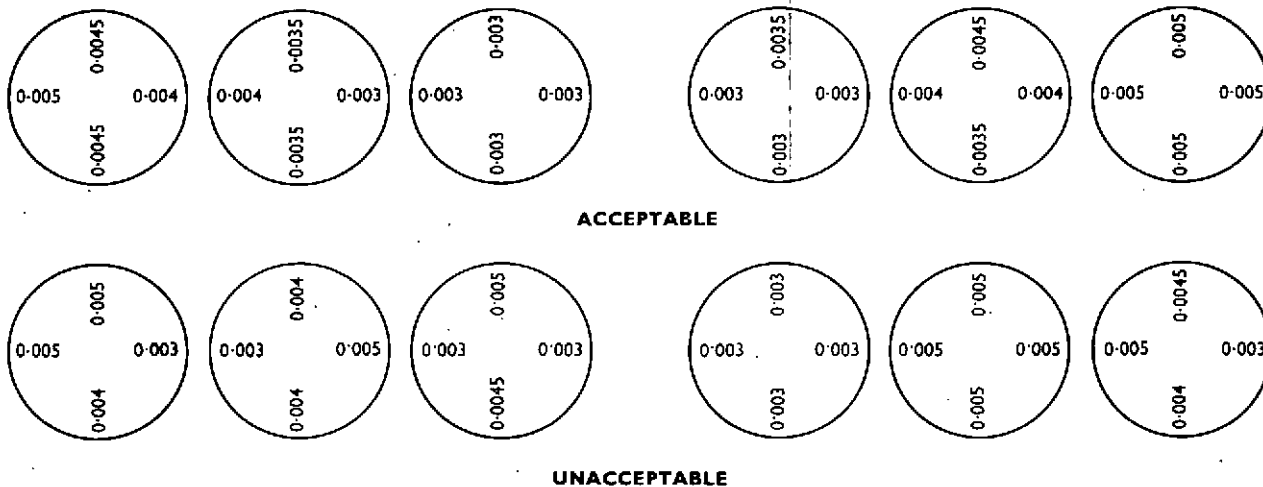


Fig. 3 Acceptable and unacceptable protrusions of cylinder liners

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Cylinder liners

After thorough cleaning, inspect the top flange for fretting and the coolant surfaces for erosion and pitting, particularly in the area of the sealing ring grooves. Inspect and measure the bores. Carry out a crack test. Finally, check that the flange makes satisfactory contact with its seating, as previously described.

Liners have three grooves machined in the skirt to accommodate composition sealing rings. The current part number for the sealing ring is OE 46017 and bears a blue-and-white paint marking for identification.

Cylinder liner protrusion

Carefully fit the liners to the crankcase, *without sealing rings*, and with their etched Position Numbers to the large coolant port (see Section 3. fig. 14). Measure the protrusion of each liner flange above the crankcase top face at four equally spaced points. Limits are 0.003 to 0.005 inch (0.08 to 0.13 mm) and the protrusions must also conform to the following requirements as shown in fig. 3:

1. Maximum variation of 0.001 inch (0.025 mm) between highest and lowest on any one liner flange.
2. Maximum variation of 0.001 inch (0.025 mm) between protrusions at *adjacent* points on flanges of neighbouring liners.

Rectify incorrect protrusions as described under 'Liner recesses' earlier in this Section.

Note: If a new liner is being fitted, etch its Position Number on the flange, opposite the large coolant port (see Section 3. fig. 14), when the protrusion check is satisfactorily completed.

Assembling liner to crankcase

The method of fitting the sealing rings to the liner skirt and finally assembling a liner to the crankcase is illustrated and described in the early stages of Section 3 'ASSEMBLING THE ENGINE'.

Main bearings

Measure the lateral width of the bearing caps and their locations. Assemble them to the crankcase and measure the bearing bores. Refer to SRS 101 for details of reclaiming malaligned bores. See Section 6 for dimensional check of centre bearing and thrust washers.

Cam followers

Inspect the followers for wear and scuffing, and check each in its bore. Slight damage may be stoned out if a follower is otherwise serviceable.

SPECIAL TOOLS

GA 486	Pressure test assembly
GA 320	Cutter, liner flange seating

SERVICE RECLAMATION SCHEMES

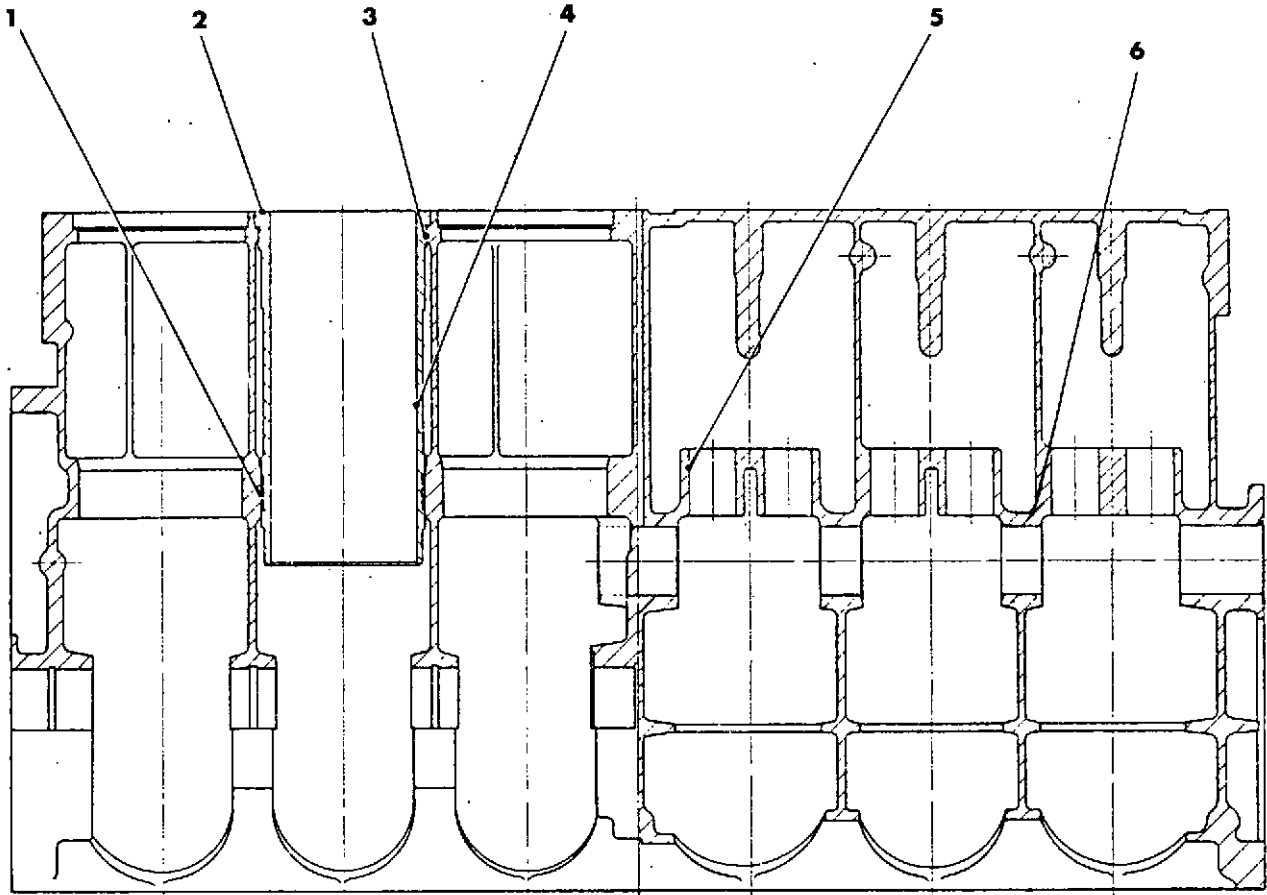
SRS 17 (Issue 5)	Reclamation of liner lower sealing bore in crankcase
SRS 32	Reclamation of crankcase top face
SRS 101	Reclamation of crank journals and crankpins, and reboring of main bearing housings.



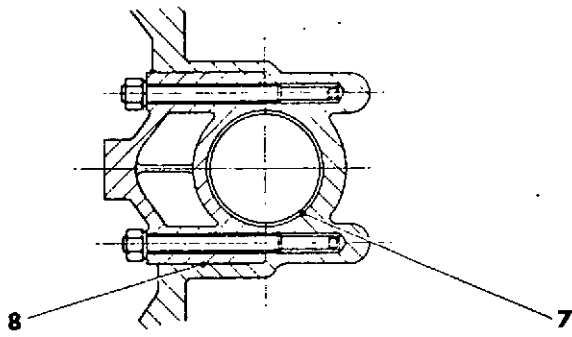
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FITS AND CLEARANCES

CRANKCASE AND CYLINDER LINERS



24882



ROLLS-ROYCE DIESELS

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No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	CYLINDER LINER IN CRANKCASE Liner skirt in crankcase Crankcase—lower bore	5.676 to 5.677	144.17 to 144.20			0.003 to 0.005	0.08 to 0.13			For reclamation of eroded bore, see SRS 17 (Issue 5)
		5.672 to 5.673	144.07 to 144.09							
2	Liner skirt—diameter									See text and SRS 32 for limitations and reclamation details
3	Protrusion of liner above crankcase face Crankcase counterbore—depth	0.495 to 0.496	12.57 to 12.60							See text and SRS 32 for limitations and reclamation details
		0.499 to 0.500	12.68 to 12.70							
4	Liner in crankcase Crankcase—upper bore	5.778 to 5.779	146.76 to 146.78							See also 'Pistons' in Section 7
		5.775 to 5.776	146.68 to 146.71							
4	CYLINDER LINER OUT OF CRANKCASE Liner—bore	5.125 to 5.126	130.17 to 130.20	5.137	130.48					See also 'Pistons' in Section 7

ROLLS-ROYCE DIESELS

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
5	CAM FOLLOWER IN CRANKCASE Crankcase bore	1.625 to	41.27 to			0.002 to	0.05 to			
		1.626	41.30			0.0035	0.09	0.004	0.10	
6	CAM FOLLOWER — dia.	1.6225 to	41.21 to							
		1.623	41.22							
6	CAMSHAFT BEARINGS IN CRANKCASE Crankcase — bore	2.5995 to	66.03 to			Interference	Interference			See Section 5 for fit of camshaft in bearings
		2.6005	66.05			0.0055 to	0.14 to			
6	CAMSHAFT BEARING — dia.	2.603 to	66.12 to			0.0025	0.06			
		2.605	66.17			Interference	Interference			
7	MAIN BEARING HOUSING IN CRANKCASE Bearing housing — bore	4.100 to	104.14 to							See SRS 101 for details of boring oversize
		4.101	104.16							
8	BEARING CAPS IN CRANKCASE Bearing cap location — width	6.625 to	168.27 to			Interference	Interference			
		6.626	168.30			0.0005 to	0.013 to			
8	BEARING CAP — width	6.625 to	168.27 to			0.001	0.025			
		6.6255	168.29			Clearance	Clearance			

SECTION 5—CAMSHAFT

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DESCRIPTION

The camshaft has seven journals and runs in bearing surfaces machined in the parent crankcase metal, without conventional bushes.

It is gear-driven at one-half engine speed, via an idler gear in mesh with the crankshaft pinion, and the gear-wheel teeth are marked to facilitate timing (see Section 3. fig. 9).

The drivegear is located by offset roll-pins and bolted to the front of the camshaft, end float being controlled by a phosphor-bronze thrust plate (see Section 3. fig. 7).

A drilling throughout the length of the camshaft is blanked off at the front by an aluminium plug and 'O' ring, and at the rear by a screwed plug locked by a tabwasher.

Oil under pressure enters the camshaft at its centre journal and emerges from cross-drillings at the remaining journals. The rear journal also has a small longitudinal drilling to prevent pressure build-up in its bearing housing, which is blanked off.

INSPECTION

Remove the end plugs and clean the camshaft bore. The front plug has a $\frac{1}{16}$ inch UNF tapping for extraction purposes. Carry out a crack test on camshaft and drivegear, preferably by an electro-magnetic method.

Inspect the cams, journals and thrust face for wear and damage, measuring the lift of each cam. Slight scoring may be stoned out, provided that the cam profile is unaffected. If wear exceeds the limits quoted at the end of this Section the camshaft must be renewed.

Inspect the drivegear teeth and thrust face for wear and damage. Measure the thickness of the phosphor-bronze thrust plate at its contact area.

When refitting the camshaft end plugs apply Loctite '225' to the thread of the screwed plug, tighten the plug firmly and bend up its tabwasher; fit a new 'O' ring to the aluminium plug, oil it and fit the plug with the extractor tapping outwards.

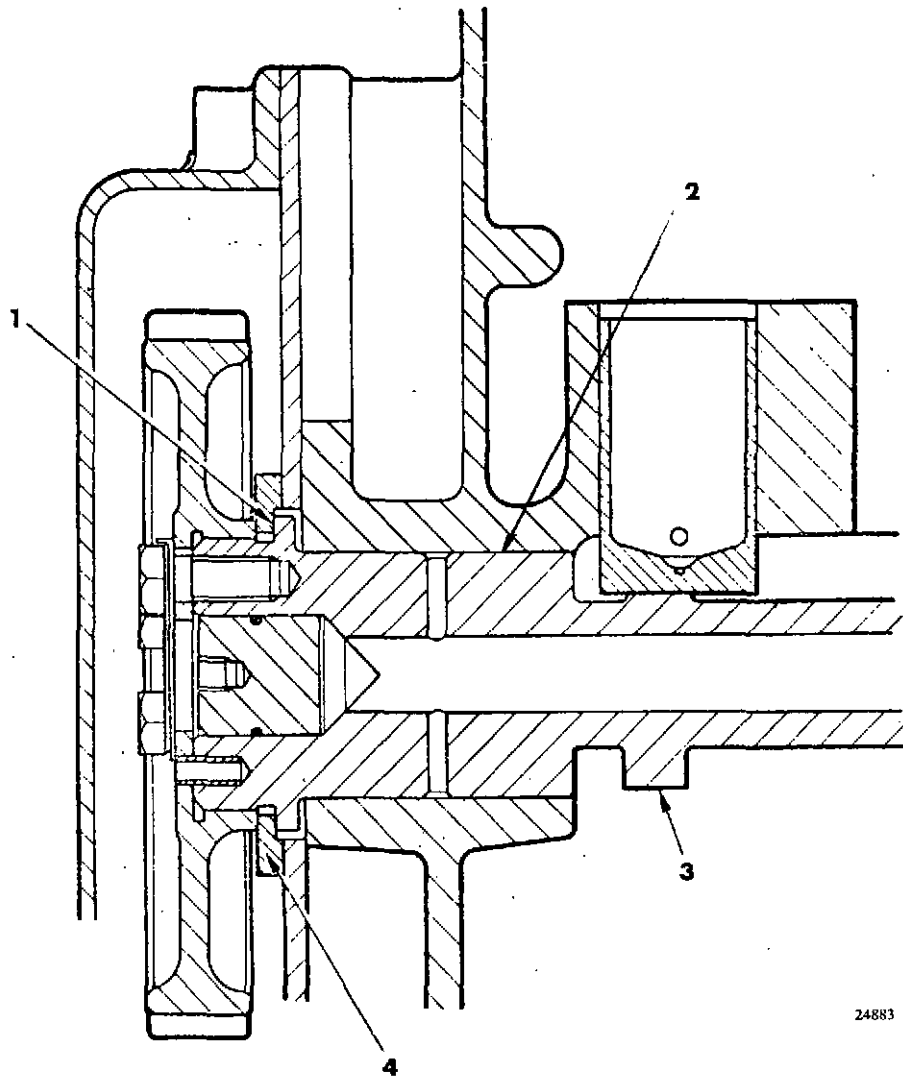
Information concerning cam followers is given in Section 4.



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FITS AND CLEARANCES

CAMSHAFT



24883

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No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	CAMSHAFT & BEARINGS Camshaft end float									
2	Camshaft—diameter	2.5955 to 2.596	65.92 to 66.03			0.004 to 0.010	0.10 to 0.25	0.031	0.79	See Item 4
3	Cam lift—inlet —exhaust	0.388 to 0.390 0.391 to 0.393	9.85 to 9.91 9.93 to 9.98	0.370	9.40					
4	Thrust plate—thickness at contact area	0.193 to 0.196	4.90 to 4.98	0.183	4.65					



SECTION 6—CRANKSHAFT, MAIN BEARINGS, FLYWHEEL

DESCRIPTION

The crankshaft is forged from chrome-molybdenum steel and dynamically balanced. All bearing surfaces are nitride-hardened and lapped to size. The seven main bearings are pressure-fed with oil from a gallery pipe bolted to the bearing caps and, except from the centre bearing, a drilling from each journal conveys oil to an adjacent crankpin which incorporates a sludge-trap with detachable plug.

End float is controlled about the centre bearing by steel-backed lead bronze thrust washers. At the rear of the crankshaft are an oil thrower, a scroll-type seal and a mounting flange for the flywheel. The nose of the crankshaft carries the oil pump drive-gear and the main pinion, and is splined to receive a hub to which the pulley, damper and barring adaptor are bolted. Main bearings are pre-finished steel-backed lead-bronze shells with lead overlay, indium-flashed.

The flywheel is spigot mounted, located by three dowels (one offset) and retained by nine setbolts with

lockplates: their torque-loading, with oiled threads is 85 to 90 lbf.ft. (115 to 120 Nm). A starter gear ring is shrunk on to the forward edge.

DISMANTLING

Screw extractor GA.17 on the pinion thread and withdraw the pinion (fig. 1). Remove the Woodruff keys, and tap the oil pump drivegear forward to detach it from its dowels.

To extract a sludge trap plug (fig. 2), drive it inwards slightly, remove the circlip using levers GA.716 and withdraw the plug by means of its $\frac{5}{16}$ inch UNF tapped hole, using either extractor GA.171 or a long bolt and sliding weight.

CRANKSHAFT AND BEARINGS

Thoroughly clean all components, with particular attention to the crankshaft oilways.

Crankshaft

Carry out a crack test, preferably by an electro-magnetic process, on the shaft, pinion and oil pump drivegear. Inspect the journals and crankpins for scoring, and measure their diameters. Regrinding is permissible in four stages, each of 0.010 inch (0.25 mm.) on diameter. Re-nitriding is necessary at the minus 0.020 inch (0.51 mm.) and minus 0.040 inch (1.02 mm.) stages. See SRS 101 for details of grinding and nitriding operations.

Check the crankshaft for 'bow' with the front and rear journals mounted in 'V' blocks. The permissible bow must be progressive along the length of the shaft.

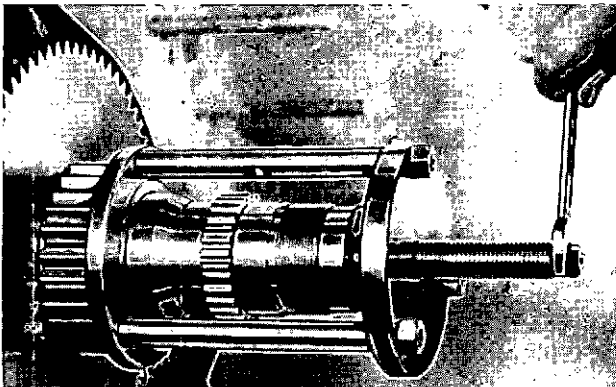


Fig. 1 Withdrawing crankshaft pinion

1704

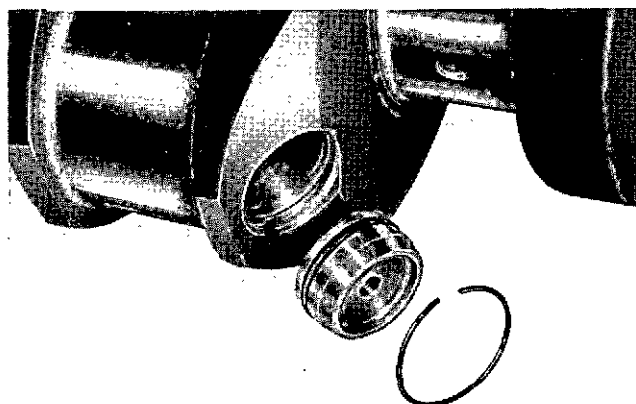


Fig. 2 Crankshaft sludge trap plug T720051

Measure the length of the centre journal and the width of the centre bearing (including thrust washers), and calculate the end float. If beyond limits with new washers, see SRS 8.

Inspect the crankshaft generally for damage to screwthreads, keyways, dowel holes and oil seal scroll. Check the rear flange, the pinion area and the splines for fretting. Inspect the teeth of the pinion and the oil pump drivegear.

Refit the sludge trap plugs, using new 'O' rings. Oil the bores, press each plug into its housing with tool GA 171, fit the circlip and pull the plug back against it. Position the oil pump drivegear on its dowels, insert the Woodruff keys and fit the pinion, *ensuring that its alignment dot coincides with the punch-mark on the crankshaft nose (see Section 3, fig. 9).*

Bearings

Inspect for wear, cracks and embedded foreign matter. It is advisable to renew any bearing if there is the slightest doubt that it will complete a further full period of service.

FLYWHEEL

Inspect the clutch friction face for wear and scores. If the face is integral with the flywheel it may be

reclaimed by grinding up to 0.025 inch (0.63 mm.) from standard, subject to fitting of a new centre plate and satisfactory maintenance of other clutch clearances. Some flywheels have a renewable friction face, secured by eight setbolts, $\frac{7}{16}$ -inch UNC or $\frac{3}{8}$ -inch UNF, according to specification. These setbolts are tightened to 18 lbf.ft. (2.5 kg.m.) and 33 lbf.ft. (4.6 kg.m.) respectively.

Where applicable, check the fit of the pilot shaft bearing in the flywheel bore (see SRS 86 for repair details).

Check bolt and dowel holes for elongation, and examine contact surfaces for fretting. Inspect the teeth of the starter ring for wear and damage.

Renewing starter ring

Drill holes in the ring body at diametrically opposite positions until it is weakened sufficiently to be driven off. Do not attempt to drill through the teeth. Ensure that the new ring and its seating are clean and free from burrs. Heat the ring evenly to 200 deg. C (292 deg. F), fit it to the flywheel and rotate it to ensure correct seating. Allow to cool naturally, and check by feeler gauge that the ring is flush with the shoulder on the flywheel.

SPECIAL TOOLS

GA 17	Extractor, crankshaft pinion
GA 171	Tool, sludge trap plugs
GA 716	Levers, sludge trap plug circlip

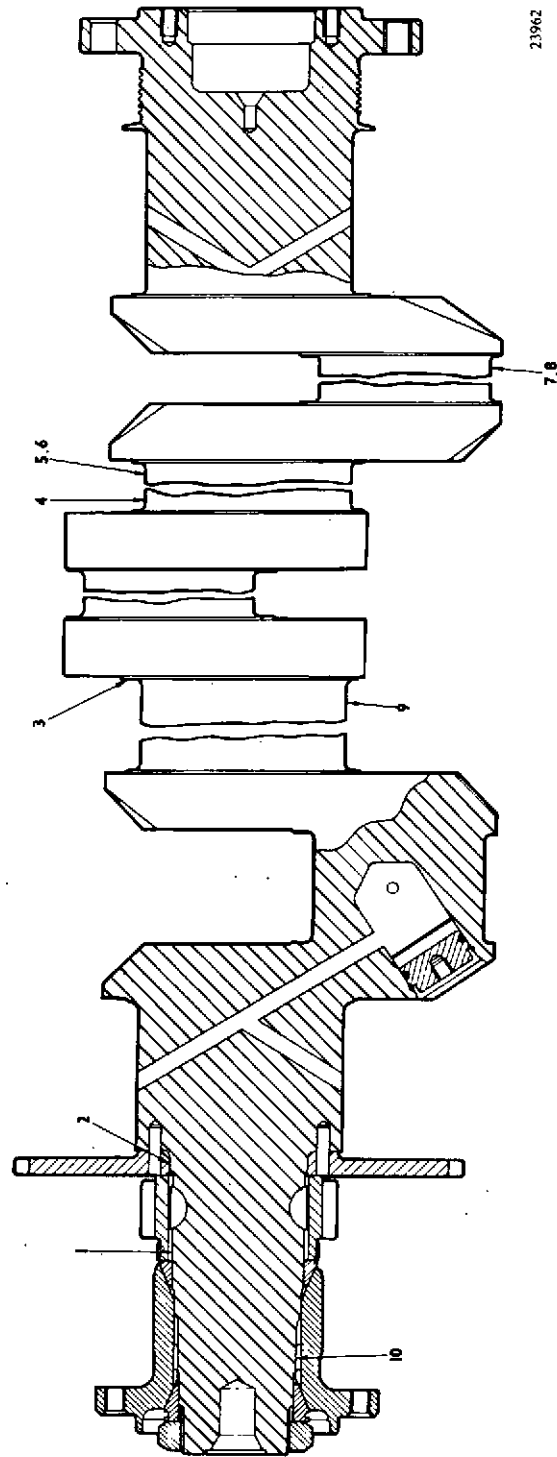
SERVICE RECLAMATION SCHEMES

SRS 8	Reconditioning crankshaft centre bearing thrust faces.
SRS 9	Reclaiming dowel holes in rear flange.
SRS 101	Reclaiming journals and crankpins. Reboring main bearing housings.

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FITS AND CLEARANCES

CRANKSHAFT



23962

ROLLS-ROYCE DIESELS

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No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	CRANKSHAFT PINION ON CRANKSHAFT Pinion—bore Crankshaft—diameter	2.500 to	63.50			0.0005 to	0.013 to			
		2.5005	63.51			0.0015	0.038			
2	OIL PUMP DRIVEGEAR ON CRANKSHAFT Gear—bore Crankshaft—diameter	2.625 to	66.67 to			0.0005 to	0.013 to			
		2.6255	66.69			0.0015	0.038			
3	CRANKSHAFT END FLOAT Centre journal—length Centre bearing—width over thrust washers	3.175 to	80.64 to			0.005 to	0.13 to			See SRS 8
		3.177	80.69			0.013	0.33	0.020	0.51	
4	CRANKSHAFT JOURNALS Diameter	3.8995 to	99.05 to							See SRS 101
		3.900	99.06	3.897	98.98	0.003	0.076			
5	Ovality									
6	Journals in main bearings Running clearance					0.0035 to	0.09 to			
						0.0055	0.14			

ROLLS-ROYCE DIESELS

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
7	CRANKPINS Standard size—diameter	3.249 to 3.2495	82.52 to 82.54	3.2465	82.46					See SRS 101 Total indicator reading 0.020 inch (0.51 mm.) Bow to be progressive throughout crank length
8	Ovality			0.003	0.076					
9	CRANKSHAFT BOW Bow at centre journal when supported by end journals in V-blocks			0.010	0.25					
10	CRANKSHAFT HUB Hub on crankshaft—backlash between splines					0.0005 to 0.0003	0.013 to 0.08	0.006	0.15	

SECTION 7—PISTONS AND CONNECTING RODS

PISTONS

These are of light alloy with a cast-in austenitic iron insert which carries the top ring. The piston crown is machined to form a combustion chamber, the size of which determines the compression ratio. The gudgeon pin is offset 0.062inch (1.6mm) from the vertical centre-line of the piston: it is fully floating and retained by circlips.

The piston assemblies used on 'C-RH' engines are illustrated in fig. 1. Details of their ring packs are as follows:

Turbocharged engines

- Top ring:* OE 46334 Molybdenum inlaid.
- 2nd ring:* OE 40750 Barrel-faced, chrome-plated internal chamfer. See Note.

3rd ring: OE 42524 Plain-faced, internal L recess. See Note.

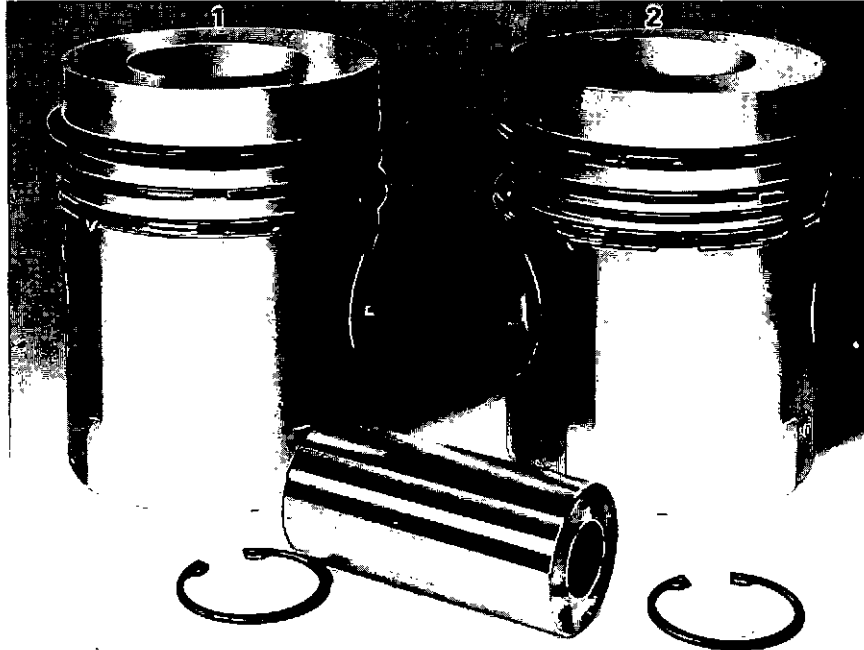
Oil control ring: OE 39127 Chrome-plated rails. 150 lbf./sq. inch backing spring (coded yellow).

Normally-aspirated engines

- Top ring:* OE 48279 Molybdenum inlaid
- 2nd ring:* OE 40750 Barrel-faced, chrome-plated, internal chamfer. See Note.
- Oil control ring:* OE 39127 Chrome-plated rails. 150 lbf./sq. inch backing spring (coded yellow).

Note: Rings OE 40750 and OE 42524 are fitted with their internal chamfer or recess towards the piston crown and are etched TOP or UP on the uppermost face.

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1 NORMALLY ASPIRATED ENGINES
2 TURBOCHARGED ENGINES

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Fig. 1 Piston assemblies

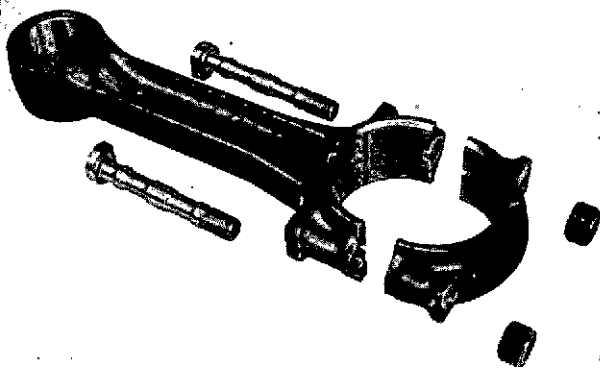


Fig. 2 Connecting rod assembly

T720053

CONNECTING RODS

These are steel forgings, drilled longitudinally for pressure lubrication of the small-end (fig. 2). Two $\frac{3}{64}$ -inch (1.2 mm.) drillings in the small-end eye direct oil jets to the ring belt area within the piston for cooling purposes. To maintain this oil supply the big-end bearing bore has a circumferential oil groove.

The big-end bearings are steel-backed lead-bronze shells with lead overlay, indium-flashed. The small-end has twin steel-backed lead-bronze bushes pressed in from either side to leave an oilway gap between them.

Each rod and its cap are stamped with correlation marks (fig. 3) and, on factory-built engines, the cylinder number. All rods are stamped with the letter of their weight group, as described later. Rod and cap are secured together by two bolts and nuts, no locking device being used. The big-end will pass through the cylinder bore.

At manufacture, all rods are weighed and classified in groups of 4 oz. (113 grammes) range, each group having an identifying letter which is stamped on the rod (fig. 3). All rods in a factory-built engine or 'short engine' are of the same weight group, and if individual rods are changed on an engine in service the order for replacements should specify the weight group letter. If the correct rod is not available, one of the nearest group may be fitted.

- The weight groups are as follows:
- A 7lb. 10oz. to 7lb. 14oz. (3.46 kg. to 3.57 kg.)
 - B Above A to 8lb. 2oz. (3.68 kg.)
 - C Above B to 8lb. 6oz. (3.80 kg.)
 - D Above C to 8lb. 10oz. (3.91 kg.)
 - E Above D to 8lb. 14oz. (4.02 kg.)
 - F Above E to 9lb. 2oz. (4.14 kg.)

Caution: Before fitting a replacement rod, ensure that it has the correct oilway drillings as described, and that these drillings are clear.

DISMANTLING

Using 'Seeger' pliers, remove the gudgeon pin circlips. Heat the piston in oil or water and push out the gudgeon pin sufficiently to release the connecting rod. Remove the piston rings, using pliers GA 612 and locating ring GA 617 (fig. 4). Ensure that gudgeon pin and rings are identified with their piston.

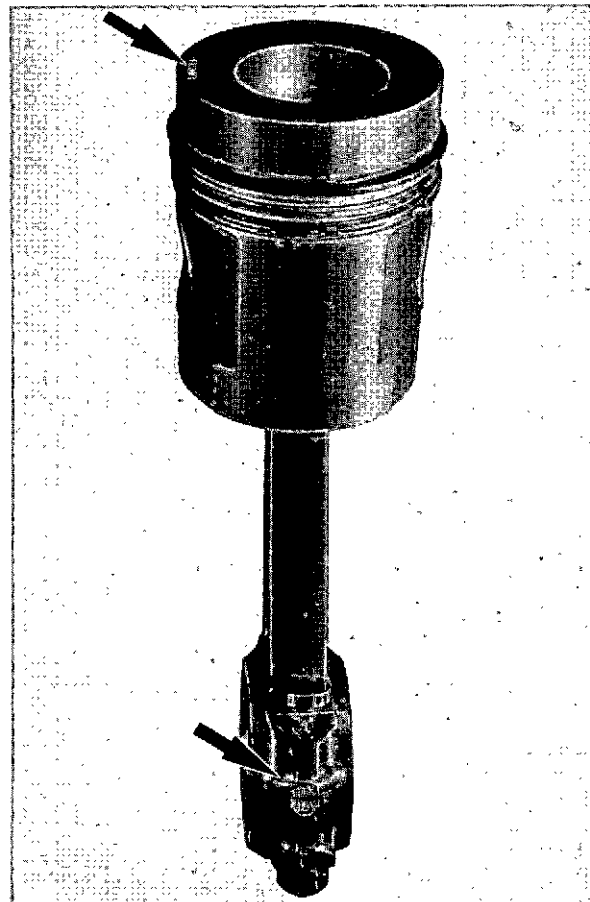


Fig. 3 Correlation marks

T720054



Fig. 4 Using piston ring tools GA 612 and GA 617

T720055

INSPECTION

Pistons and rings

De-carbonise the piston, preferably by soaking in a proprietary solvent such as "Ardrox 691".

Inspect the piston for scores and wear, and ensure that ring grooves are not worn beyond limits, checking if necessary with new rings.

Crack-test the gudgeon pin and check its fit in the piston. It should be a hand push-fit at 20 deg.C (68 deg.F).

Inspect the piston rings for scores, wear and signs of leakage. Discard the top ring if the molybdenum inlay has large pores or voids or is breaking up, comparing the surface if necessary with that of a new ring. Inspect the spring behind the oil control ring for wear. Should this spring be unserviceable the ring and spring must be renewed together. A spring giving a radial pressure of 150 lbf./sq. inch is identified, when new, by a yellow paint marking.

Check the gap of each ring in a new liner or in an unworn portion of its own cylinder. Discard any ring having a gap in excess of limits.

Notes: (a) If a new liner is fitted, the piston rings should also be renewed.

(b) When a new ring, particularly one having a chrome-plated rubbing face, is fitted in a used liner, the 'glaze' of the cylinder bore must be broken by lapping or light honing.

Connecting rods and bearings

Carry out an electro-magnetic crack test on rod, end cap and bolts. Inspect the bolts for signs of stretch and damage, and renew any found defective.

Check the small-end bearings for wear. If renewal is necessary, the pre-finished double bushes must be coated with zinc-based grease and drawn in, one from each side, flush with the rod eye faces, using tool GA 285/1M. The annular space between them forms an oil-way at least 0.1 inch (2.5 mm) wide, in-line with the oil drillings. Procedure for fitting new bushes is as illustrated in fig. 6 and 7, using tool GA 285/1M (fig. 5). Refer to O.E.B. 384 for further details.

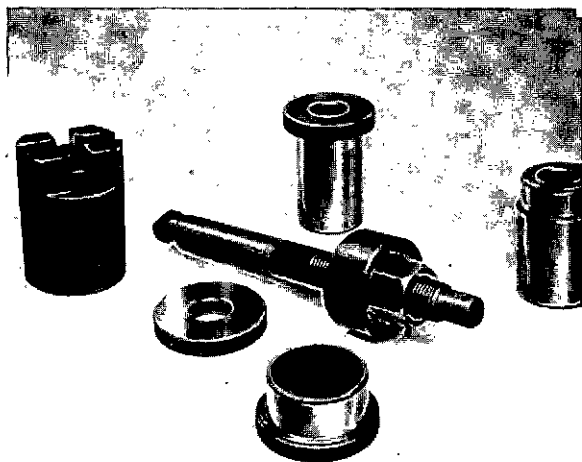


Fig. 5 Small end bush renewal tool GA 285/1M

T720077

Check alignment of big and small ends in two planes. *Do not* attempt to correct a bent or twisted rod.

Carefully inspect the big-end bearings for cracks, scores, wear and embedded foreign matter. Renew them if there is the slightest doubt that they will complete a full period of service. Ensure that replacement bearings are of the correct type, i.e. that they have a circumferential oil groove in the bore.

ASSEMBLING

Fit the piston rings, using pliers GA 612 and locating ring GA 617 (fig. 4). Ensure that non reversible rings are the right way up, and that the correct backing spring is fitted behind the oil control ring, as previously described.

Oil the small-end bush, heat the piston by immersion in hot water and assemble the piston to the connecting rod so that the FRONT marking on the piston crown and the identification stampings on the big-end are in the relationship shown by the arrows in fig. 3.

Fit the circlips, ensuring that they are properly seated by rotating them in their grooves.

See Section 3 for details concerning fitting of the assembly to the engine and checking the piston height. Note that the piston and rod assembly is fitted to the engine with the connecting rod correlation marks *away from* the camshaft, i.e. on the left-hand side of the engine, viewed from the rear.

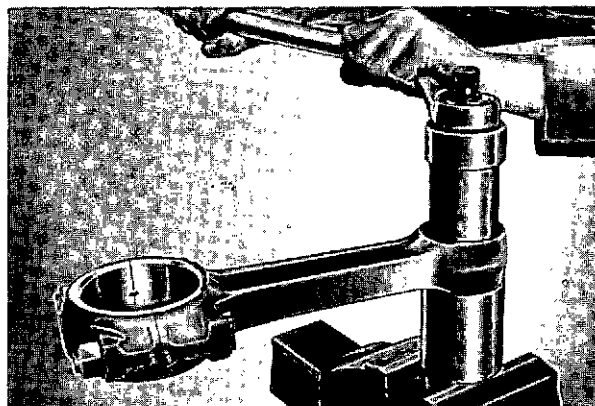


Fig. 6 Removing small end bush

T1744

SPECIAL TOOLS

- GA 285/M1 Tool, renewing double small-end bush
- GA 612 Pliers, piston ring
- GA 617 Locating ring for GA 612

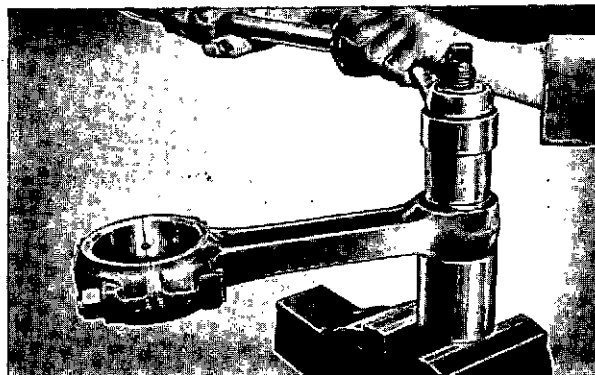


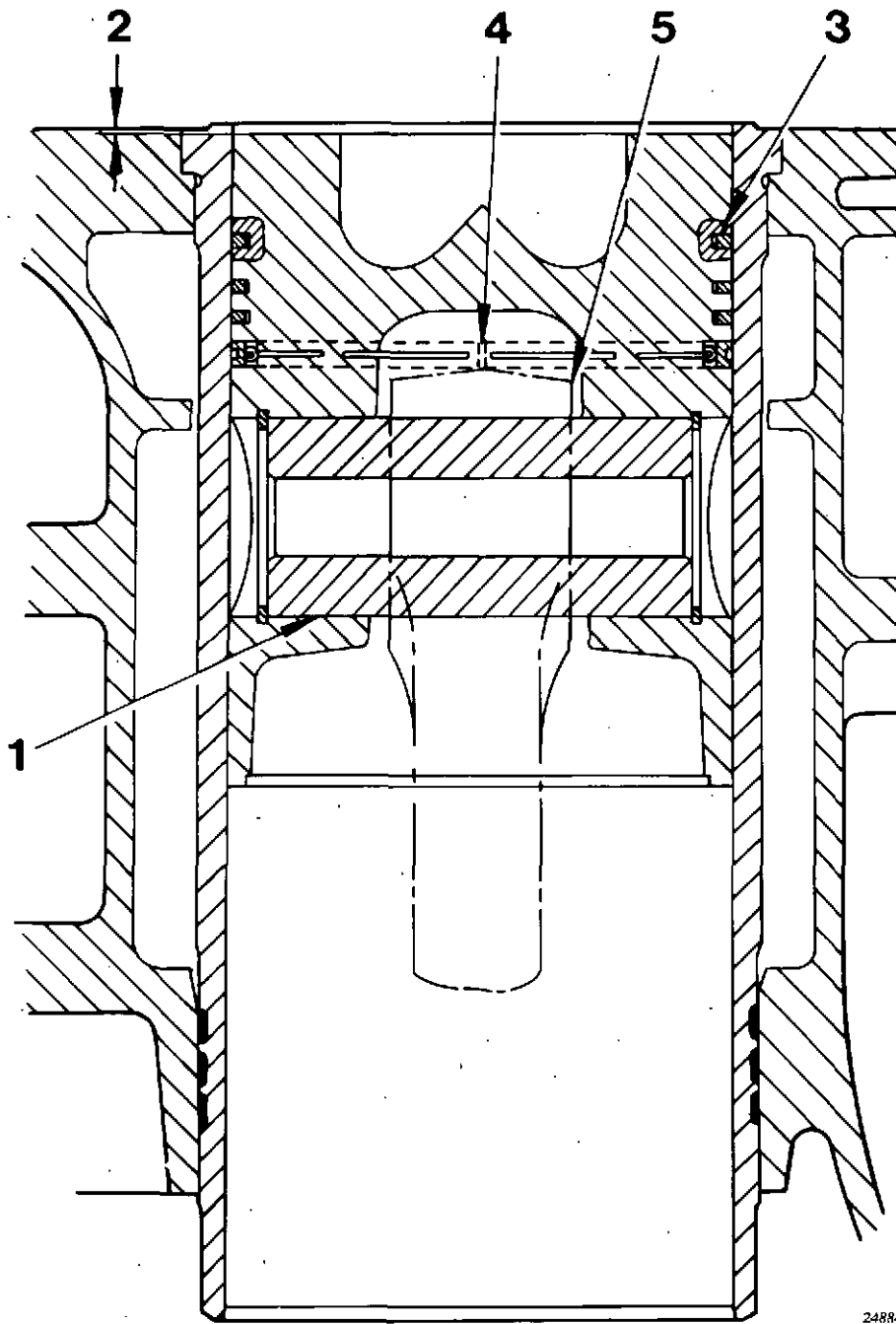
Fig. 7 Fitting small end bush

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FITS AND CLEARANCES

PISTONS AND RINGS



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ROLLS-ROYCE DIESELS

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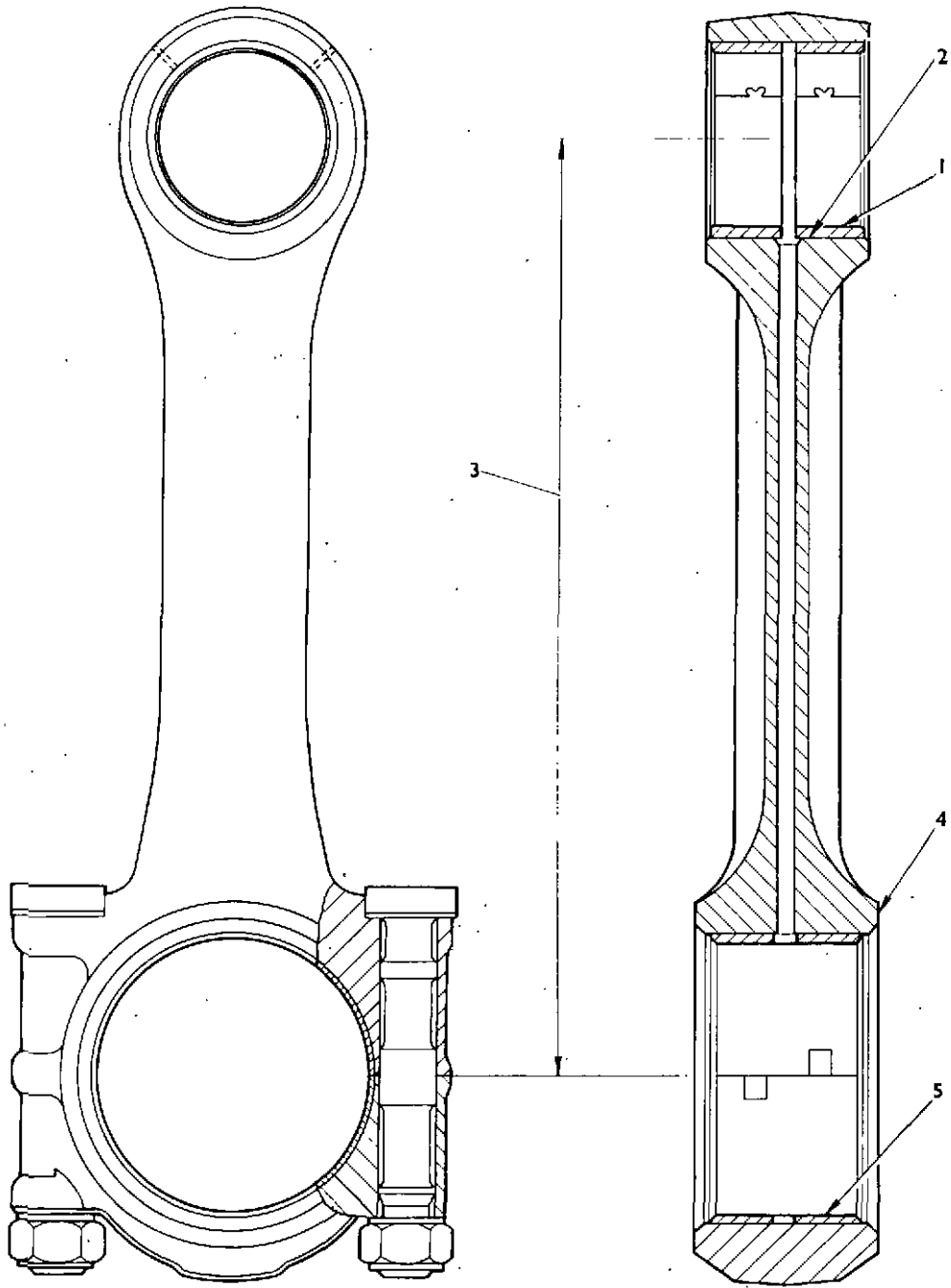
No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	GUDGEON PIN IN PISTON Piston—bore Gudgeon pin—diameter	2-000 to 2-0002	50-800 to 50-806			0-012 to 0-015	0-30 to 0-38			To be a hand push fit at 20 deg. C (68 deg. F)
2	PISTON CROWN CLEARANCE AT T.D.C. Crown of piston below crankcase top face									Maintain clearance by machining piston crown as necessary
3	PISTON RINGS Side clearance in groove Top ring 2nd ring 3rd ring (4-ring piston) Oil control ring					0-003 to 0-005 0-002 to 0-0035 0-002 to 0-004 0-002 to 0-0035	0-08 to 0-13 0-05 to 0-09 0-05 to 0-10 0-05 to 0-09	0-010 0-006 0-006 0-006	0-25 0-15 0-15 0-15	Ring OE 46334 Ring OE 40750 Ring OE 42524 Ring OE 39127
4	Ring gap in new liner Top ring 2nd ring 3rd ring (4-ring piston) Oil control ring					0-026 to 0-034 0-017 to 0-027 0-017 to 0-027 0-017 to 0-032	0-66 to 0-86 0-43 to 0-68 0-43 to 0-68 0-43 to 0-81	0-060 0-060 0-060 0-040	1-52 1-52 1-52 1-01	Ring OE 46334 Ring OE 40750 Ring OE 42524 Ring OE 39127
5	CONNECTING ROD IN PISTON Side clearance					0-150 to 0-165	3-81 to 4-19			

ROLLS-ROYCE DIESELS

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FITS AND CLEARANCES

CONNECTING RODS



24848 A

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	SMALL-END Gudgeon pin in bush Bush—bore Gudgeon pin—diameter	2.0015 to 2.002	50.84 to 50.85			0.0012 to 0.002	0.032 to 0.051	0.0025	0.063	
2	Bush in small-end Small-end—bore Bush—diameter	2.250 to 2.2505	57.150 to 57.163			Interference 0.0035 to 0.0015	0.089 to 0.038			
3	ERRORS IN ALIGNMENT Errors in alignment between big and small ends per inch of mandrel Parallelism	2.252 to 2.2535	57.200 to 57.239					0.001	0.025	
4	BIG END End float					0.003 to 0.008	0.08 to 0.20	0.012	0.30	
5	Running clearance					0.0025 to 0.004	0.06 to 0.10			

ROLLS-ROYCE DIESELS



SECTION 8 — CYLINDER HEADS AND VALVE GEAR

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DESCRIPTION

All 'C-RH' engines have two identical cast-iron cylinder heads, each secured to the crankcase top face by 22 setbolts and one drilled stud by which pressure oil is conveyed to the valve rocker gear.

Each cylinder is served by one inlet and one exhaust valve, operating in renewable cast-iron guides in the cylinder head and actuated by rocker arms and pushrods from a low-mounted camshaft. On engines assembled before Build Line number 63037 both inlet and exhaust valves are Stellite-faced with chrome-flashed stems and a face angle of 30 degrees. The exhaust valve stem is sodium-filled and Stellite-tipped; the inlet valve has a solid stem and flame-hardened tip.

Engines after Build Line number 63037 are fitted with exhaust valves (Part No. OE 47586) in Nimonic material and have solid stems; inlet valves are the same for all engines.

Both valves have double springs, retained by conventional split collets with a rubber sealing ring. A valve rotator is fitted beneath the exhaust valve springs and a distance piece of equivalent thickness beneath the inlet valve springs. When new, the springs are identified by a red paint stripe.

The upper end of each exhaust valve guide is machined to carry an oil seal, which provides more effective control of valve stem lubrication.

Renewable valve seat inserts of chrome-iron are shrunk into the cylinder head and a swirl crescent is machined in the cylinder head flame face, adjacent to each inlet valve seat.

Rolled-in exhaust valve inserts were introduced from Build Line No. 60951 onwards.

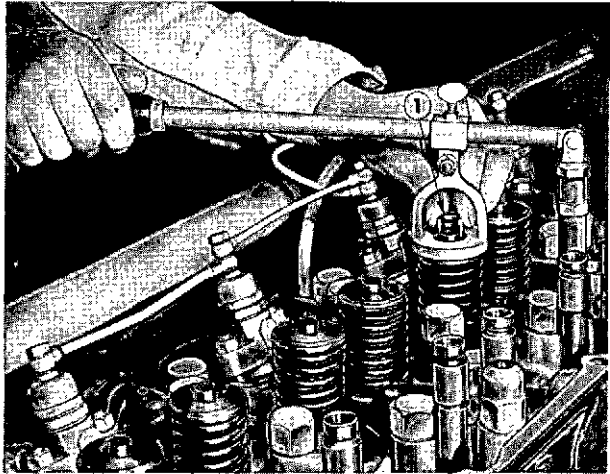
The valve rocker assembly is carried on pedestal brackets bolted to platforms within the head casting. It is lubricated from the main oil system under reduced pressure due to restrictor drillings in the oilway studs (Section 3 Fig. 11). Oil from the gallery in the tappet chest passes upwards through drillings in the crankcase to the two oilway studs, emerges from the restrictor drillings into the annular space between each stud and the cylinder head, and then flows through a cross-drilling to the centre rocker pedestal, where it enters the hollow rocker shaft. Each rocker arm is drilled to supply oil from its pivot bearing to the valve stem tip and pushrod cup.

Injectors are carried in renewable sleeves rolled into the cylinder head. No joint washer is fitted between injector and sleeve seating, the seating face being recut as necessary when injectors are changed.

VALVE SPRING RENEWAL (INSTALLED HEAD)

If necessary, valve springs and rotators may be renewed without removing a cylinder head, as follows:

1. Remove the appropriate rocker cover and turn the engine forward until the inlet valve of the cylinder concerned *just* commences to open. The piston will then be near TDC.
2. Slacken the tappet screws of this cylinder; then remove the rocker assembly.
3. Screw tool GA.25 into an adjacent bolt hole (fig. 1). Ensuring that no components can fall down the pushrod holes, compress the springs and extract the collets. Release the springs and remove the retainer, and rubber 'O' ring. Withdraw the springs and fit new valve stem seals.



1 SPLIT COLLET

TS1125

Fig. 1 Valve spring compressing tool

4. Assemble the springs and retainer, compress them and slide a new 'O' ring over the valve stem. Fit the collets and release the springs; check that the 'O' ring is correctly positioned.
5. Refit the rocker assembly, tightening the pedestal setbolts evenly to 30 lbf.ft. (40 Nm).
6. Reset the tappet clearances of all valves in the head and refit the rocker cover.

DISMANTLING AND CLEANING

To protect the flame face, stand the head on suitable wood packing. On each valve in turn, compress the springs using tool GA.25 (fig. 1) and remove the collets, spring retainer, springs and rotator or distance piece. Withdraw the valves and keep each assembly together, identified with their position in the engine.

Decarbonise the head and valves by soaking in a proprietary solvent such as 'Ardrox 691'.

CAUTION: Do not use solvent on valve springs, as this may damage their surface finish.

Finally, wash all components in paraffin, paying particular attention to oilways, and dry off with compressed air.

CYLINDER HEAD CASTING

Fit locally-made blanks to the coolant apertures and carry out a pressure test at 30 lbf./sq. inch (210 kN/sq.m) with the head immersed in water at 60 deg. C (140 deg. F). Note any leaks from cracks, core plugs or injector sleeves.

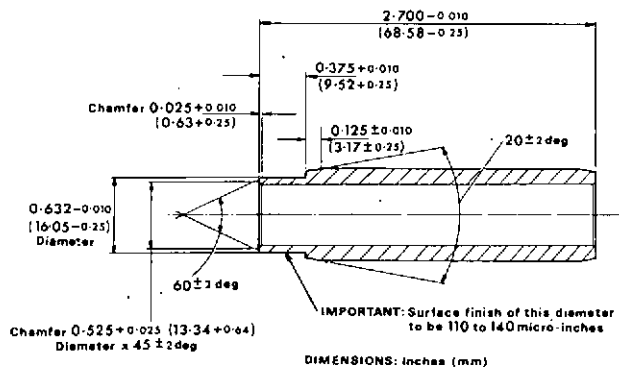
Inspect the flame face for fretting or other damage. If necessary it may be reclaimed by surface grinding to a maximum of three stages, each of 0.005 inch (0.13 mm.). See S.R.S. 6 for details.

VALVE GUIDES

Check the fit of each valve in its guide and, if the clearance exceeds the limit in the Schedule at the end of this Section, retest using a new valve.

If the clearance is still excessive renew the guide, using Kit GA.698 as follows.

Note: Replacement exhaust guides should be of the modified type which carry a valve stem seal OE.45920 on the upper end. If necessary, earlier guides held as spares may be machined to the dimensions shown in fig. 2.



24873

Fig. 2 Modifying exhaust guide for seal

Working from the flame face, drive out the old guide using drift GA.462. Prepare the new guide by freezing in liquid air or, if this is not available, by coating it with graphited machine oil. Using tool GA.640, press the new guide into position until the tool contacts the flame face; this ensures the correct protrusion above the top face as shown in fig. 3. Inlet guides and unmodified exhaust guides are symmetrical and may be inserted either end first; modified exhaust guides must be fitted by inserting the machined end.

Using reamer GA.474, operated by hand, finish the guide bore and check with plug gauge GG.1. Finally, recut the valve seat at 30 degrees.

VALVE STEM SEALS

As mentioned earlier under 'DESCRIPTION' these are now fitted to the *exhaust* valve guides to control valve stem lubrication, the guides being modified to carry the seals. It should be noted that the valve rotator cannot be removed or fitted when the seal is in position. To remove a seal, lever it carefully upwards: it cannot be re-used and must be discarded. To fit a new seal, assemble it to tool GA.718, insert the tool into the guide (fig. 17) and carefully tap the seal into place until it reaches the shoulder on the guide. Check that the seal is not cracked or distorted and, when fitting the valve, ensure that its stem is oiled.

VALVE SEAT INSERTS

Examine all inserts for pitting, cracks and valve bedding. The seat face may be restored by cutting or grinding at 30 degrees, removing the minimum amount of metal necessary.

For this purpose the cutting tool GA.607 is recommended and is supplied with full instructions for use. Alternatively, a proprietary grinding machine may be used.

After reconditioning the valve and its seat, fit the valve and measure the clearance of the valve head below the flame face of the cylinder head. Limits are given in the Schedule at the end of this Section. If clearance is beyond the limit, retest using a new valve. Should this not bring the clearance within limits, the insert must be renewed.

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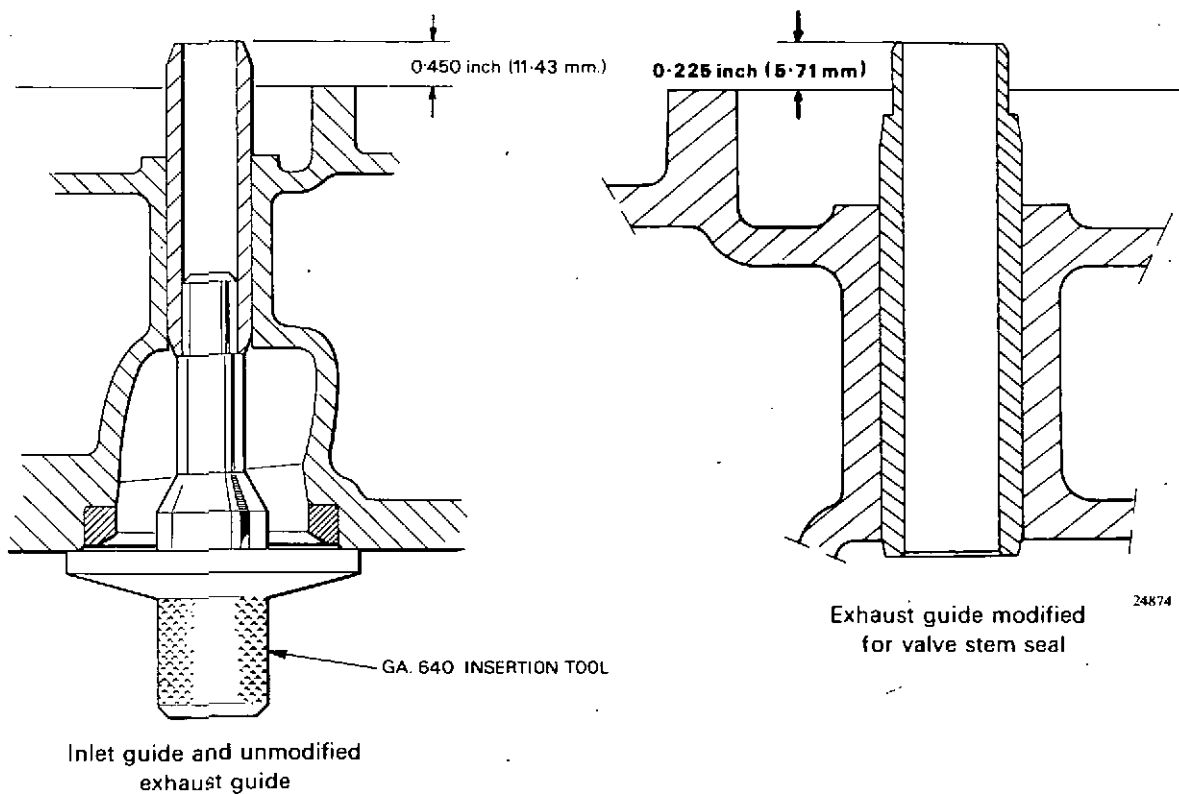


Fig. 3 Position of valve guides

Removing an insert

Engines prior to Build No. 60951

The recommended method is to machine two $\frac{3}{8}$ -inch (9.5 mm) holes close together in the insert weakening it so that it may be fractured and withdrawn. For this purpose a cutter assembly GA.691 and its guide GA.690 are available (fig. 4). The guide has two shrunk-in bushes spaced for use with 2.44-inch (62 mm) diameter and 2.289-inch (58.1 mm) diameter inserts respectively; the size is stamped on each bush. Ensure that the correct size is used when proceeding with this operation.

Engines from Build No.60951 onwards

(Rolled-in inserts)

Use GA 804 cutter with GA 805 arbor, turning by hand in a clockwise direction, to remove the rolled-over material retaining the six exhaust valve inserts.

When this exercise has been completed proceed with the directions given for the earlier engines.

GA 691 cutter is adjustable for depth relative to its stop face, and is locked in position by two Allen screws.

CAUTION: It is essential to set the cutter so that there is no possibility of machining through the insert and into the cylinder head; a safety margin of at least 0.020 inch (0.5 mm) should be allowed.

Calculating the setting of the cutter edge beneath its stop face involves adding together the following three dimensions and subtracting the safety margin:

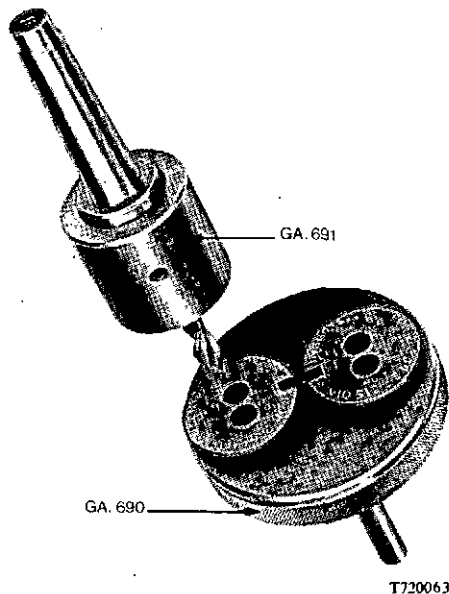


Fig. 4 Valve seat removal tools

(i) Thickness of cutter guide bush in tool GA.690. This is 1.0 inch (25.4 mm.).

(ii) Depth of insert beneath flame face. Due to possible reclamation of flame face, and differences in insert thickness, this dimension may vary and must be measured by depth gauge.

(iii) Thickness of insert. Minimum dimensions are:
Inlet: 0.308 inch (7.8 mm.)
Exhaust: 0.243 inch (6.17 mm.)

Note: The exhaust insert thickness quoted here is that of OE.43479, which may be identified by a V groove concentric with the valve seat. Its predecessor OE.42294 was 0.020 inch (0.5 mm.) thicker and had no groove.

Example calculation for cutter setting:

	<i>inches</i>	<i>(mm.)</i>
(i) Cutter guide bush.....	1.000	(25.40)
(ii) Insert below flame face*	0.129	(3.28)
(iii) Thickness, inlet insert.....	0.308	(7.82)
	<hr/>	<hr/>
	1.437	(36.50)
Subtract safety margin.....	0.020	(0.50)
	<hr/>	<hr/>
Set cutter edge to.....	1.417	(36.00)

* Measured for each insert

To remove an insert, assemble cutter guide GA.690 to it and clamp both GA.690 and cylinder head securely to the machine table. Set the cutter of tool GA.691 to the required depth, as explained, and lock it by means of the two Allen screws. Using a cutting speed of 350 to 400 rpm, and fine feed with ample cutting oil, machine two holes in the insert, locating the guide by a short length of $\frac{3}{8}$ -inch (9.5 mm.) rod in the first hole whilst machining the second. Remove the tools from the cylinder head, insert a length of $\frac{3}{8}$ -inch (9.5 mm.) rod in one of the holes, fracture the insert and remove it. Clean the counterbore and inspect it for burrs and damage.

Fitting a new insert (non rolled-in type)

Replacement inserts are available either to standard diameter or 0.002 inch (0.05 mm.) oversize. If an oversize insert is to be fitted the counterbore in the cylinder head must be machined to maintain the interference fit specified in the Schedule at the end of this Section.

The inserting tool GA.682 (fig. 5) consists of two threaded drawing-in assemblies for inlet and exhaust inserts respectively. A sleeve GA.142 is used with

each assembly if no valve guides are fitted. When fitting an exhaust insert or an unmasked inlet insert, either assembly is used by itself. If a masked insert is to be fitted (normally-aspirated engines) the masking must be positioned as shown in fig. 6; this is achieved by using both assemblies of tool GA.682 together, as shown in fig. 5. The exhaust insert must be fully home, with its inserting assembly left in position; the inlet insert is then fitted to its assembly tool so that the masking is located in the cutaway, and is drawn into place, which is only possible if the flats machined on the assembly tools are together as illustrated, thus ensuring correct positioning of the masking.

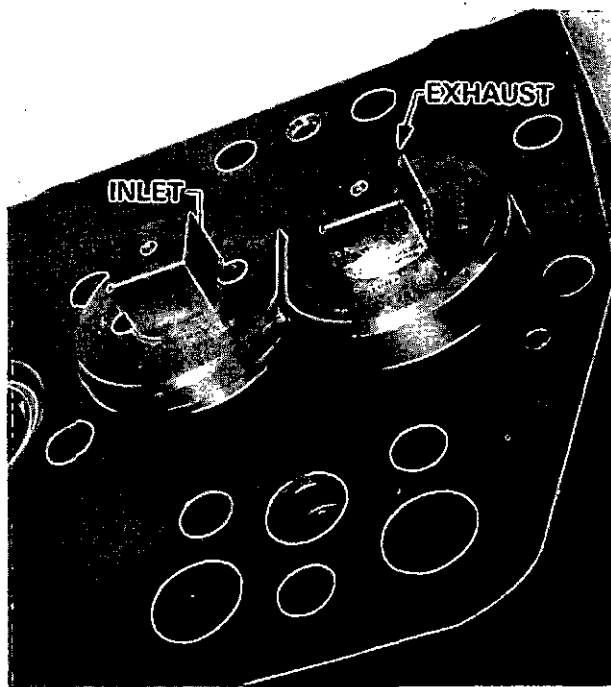


Fig. 5 Valve seat inserting tools, as used for masked insert

For preference, an insert should be frozen in liquid air immediately before insertion. If this is not available the cylinder head must be heated in boiling water for half-an-hour and the insert drawn into place as quickly as possible. Check by feeler gauge that the insert is fully home. If applicable, fit the valve guide as previously described. Finally, cut or grind the valve seat at 30 degrees, assemble the valve and measure the clearance between valve head and flame face.

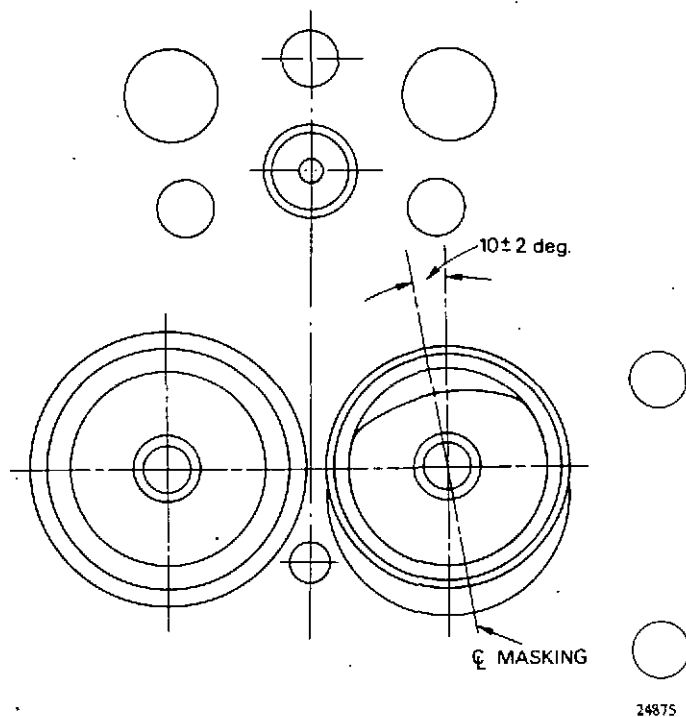


Fig. 6 Alignment of masked inlet seat insert

Fitting a new insert (rolled-in type)

Replacements for this type of insert are available either to standard diameter (OE 46959) or 0.002 inch oversize (OE 46960) and have a chamfer on each outer edge.

To fit a new insert as a replacement for one of similar type proceed as follows:

1. Assemble the new insert in the cylinder head in the manner described previously for the non rolled-in type.
- * 2. Position GA 803 'rolling tool' into the valve guide. Whilst maintaining steady downwards pressure, turn clockwise at a speed of 100 rpm until the stop on the tool is reached. Lubricate between the rollers and cylinder head surface during this operation with S.A.E. 30 grade oil.

To modify a cylinder head and enable a rolled-in type insert to be fitted as a replacement for a non rolled-in type proceed as follows:

1. Fit the new insert as in (1) above.
2. Locate GA 802 'counter-bore cutter' in the valve guide and whilst applying downward pressure

turn slowly in a clockwise direction until the cutting ceases. This will provide a suitable surface for the rolling-in process.

3. Proceed with the rolling-in process as in (2)* previous.

VALVES

After thorough cleaning, use a powerful magnifying glass to inspect the valves for cracks, pitting or other damage to the heads. Inspect the stems, collet grooves and tips for wear. On apparently serviceable or reclaimable valves, test the heads for cracks using a dye-penetrant process such as 'Ardrox 996' which is obtainable, with instructions for use, from Ardrox Limited, Commerce Road, Brentford, Middlesex.

Check heads of exhaust valves for 'dishing' by straightedge and feeler gauge. Scrap the valve if the clearance under the straightedge exceeds 0.015 inch (0.38mm.).

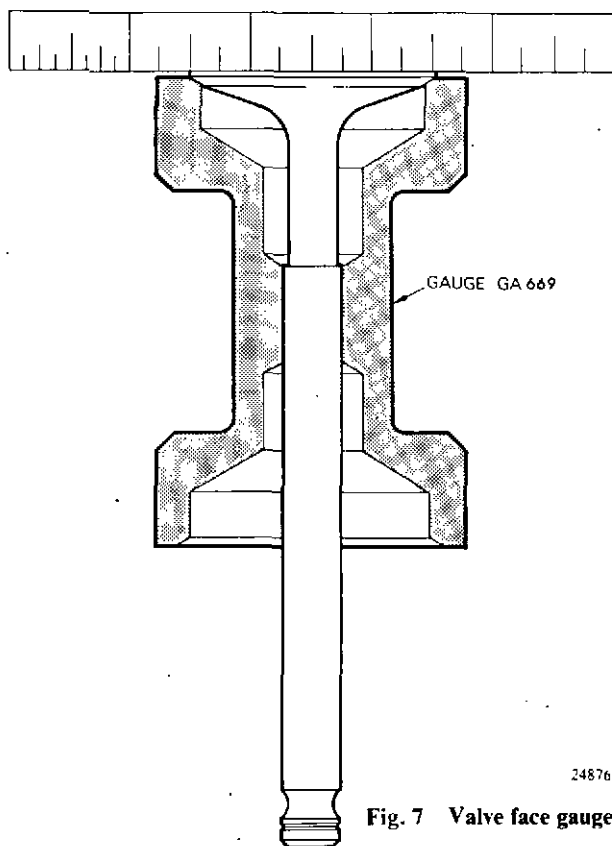


Fig. 7 Valve face gauge

Reclaim pitted or worn valve faces by grinding at 30 degrees, removing the minimum amount of material necessary to restore the face. Use gauge GA.669 which accepts an exhaust valve at one end and an inlet valve at the other, (fig. 7) to check whether sufficient material remains. Scrap any valve if its head comes below the top face of the gauge, as measured by the straight-edge.

WARNING: Sodium filled exhaust valves (fig. 8) must be broken down before being sent as scrap. This is done by dry-grinding the stem at mid-point until the sodium is just exposed, and immediately immersing the valve in a tank containing at least 20 gallons (90 litres) of water. As the sodium dissolves, hydrogen is given off and the water becomes a caustic solution: adequate precautions against fire and personal injury are therefore necessary.

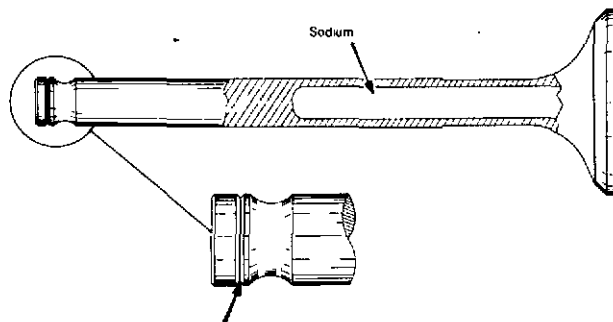


Fig. 8 Identification groove, sodium-filled valve

Exhaust valves in Nimonic material have the part number OE.47586 stamped close to the collet recess.

Identification by stamping or pop-marking is NOT recommended, since these indentations can form the starting-place for cracks which may eventually cause valve head failure.

Assemble each valve to its guide and check for seating, lapping-in if necessary. Finally, measure the distance of the valve head below the flame face of the cylinder head. This must be within the limits given under 'Fits and Clearances' at the end of this Section. Insufficient clearance is rectified by recutting the valve seat. Excessive clearance may be rectified by fitting a new valve or, if this is inadequate, by renewing the insert.

VALVE ROTATORS (ROTOCOIL)

Inspect for cracks and other damage, and check that the inner and outer components will rotate freely, relative to one another. If the wear pattern on the valve stem tip indicates that the valve has not rotated, change the rotator even though superficially it may appear serviceable. Note that when valve stem seals are fitted they must be renewed if rotators are removed.

INJECTOR SLEEVES

Engines prior to Build Line No. 60951

Recondition the sleeves using kit GA.702, which consists of reamer GA.304 for cleaning the nozzle bore and cutter GA.299 for refacing the nozzle seating (fig. 10). Do not remove more metal than is necessary to restore the seating face. The maximum depth of the seating face, measured from the flange face on the cylinder head, is 3.54 inches (90 mm).

A sleeve which has been recut beyond the limit, or has been damaged, or is leaking from the rolled joint and cannot be rectified by use of the roller expanders GA.688 and GA.689, may be renewed as described below. For this purpose a service sleeve OE 42770 and tool kit GA.700 are available.

1. Using the tap GA.671, cut a thread in the sleeve bore (fig. 11) to a minimum depth of one inch (25 mm.).
2. Screw the extractor GA.672 into this thread and withdraw the sleeve (fig. 12). Considerable effort is required to shear the rolled-out diameter of the sleeve.
3. Clean out the bore and groove in the cylinder head. Insert the service sleeve OE 42770 and press it in by hand as far as possible. Locate tool GA.306 in the sleeve bore and also on the injector studs, securing it by the two nuts. Tighten the centre screw of the tool to press the sleeve fully home (fig. 13). The top of the sleeve will then be slightly below the cylinder head face.
4. Fully retract the tapered spindle of the lower roller expander GA.688, grease the rollers and insert the assembly into the sleeve bore. Rotate the spindle clockwise until the lower portion of the sleeve is sealed in the cylinder head bore.

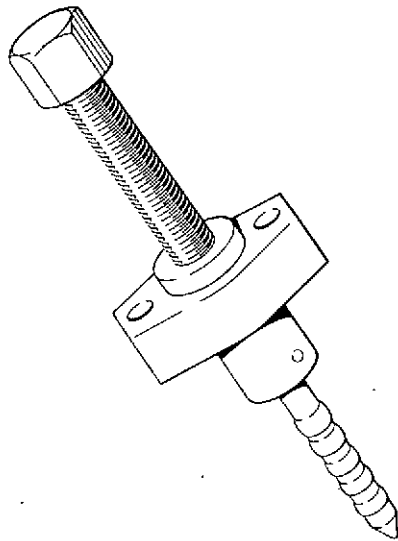
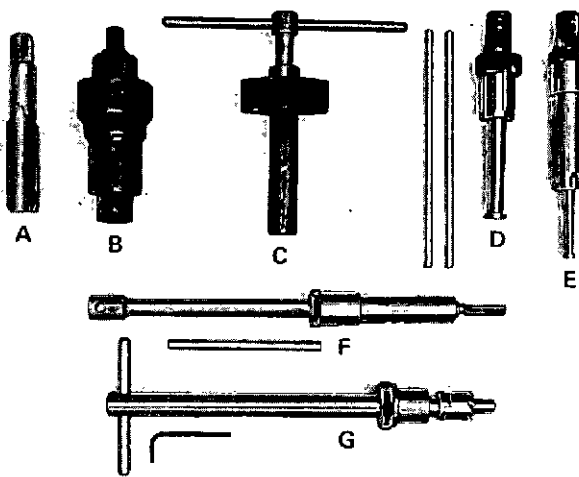


Fig. 9 Ballising Tool 24886

VALVE SPRINGS

Check each one for wear, corrosion and distortion. Measure the free length and the length under load, as applicable, to the instructions given in 'Fits and Clearances' at the end of this Section. Scrap any spring which is not entirely satisfactory.



- | | |
|----------------------|-----------------------|
| A. Tap for extractor | E. Expander, lower |
| B. Extractor | F. Nozzle bore reamer |
| C. Inserting tool | G. Seating cutter |
| D. Expander, upper | |

Fig. 10 Injector sleeve tools

T720065

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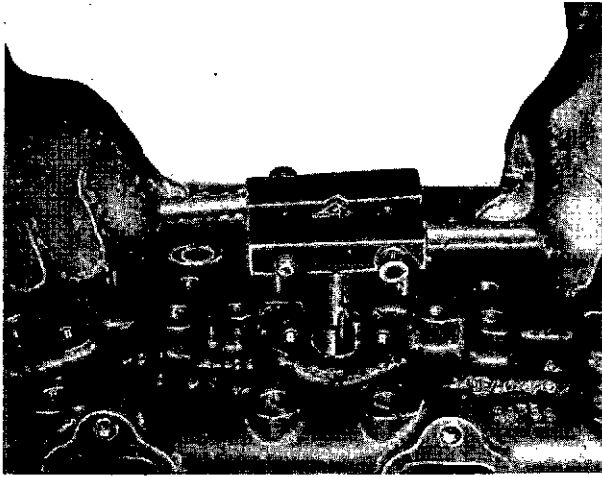


Fig. 11 Tapping the old sleeve

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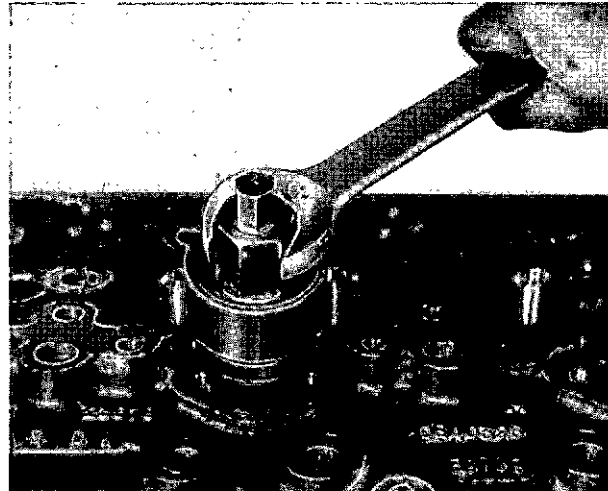


Fig. 12 Extracting the old sleeve

T720067

Disengage the tool by turning the spindle anti-clockwise. Repeat for the top portion of the sleeve, using the upper roller expander GA.689 (fig. 14).

5. Using the reamer GA.304, ream the nozzle bore to 0.378 inch (9.6mm.) diameter.
6. Reface the lower seating, using cutter GA.299 (fig. 15) well lubricated with cutting oil. Remove the minimum amount of metal required to obtain full seating, and take care to avoid 'chatter'.
7. Clean thoroughly, and if possible carry out a pressure test at 30 lbf./sq. inch (210 kN/sq.m) air pressure with the cylinder head submerged in water at 60 deg.C (140 deg.F.).

Engines from Build Line No. 60951 onwards.

Cylinder heads on these engines are fitted with 'ballised' injector sleeves which may be reconditioned using the cleaning and renewal kit GA.722. The maximum permitted depth of the seating face measured from the flange face on the cylinder head, after recutting the seating, is 3.54 inches (90 mm). If this depth is exceeded, or if the sleeve is damaged or leaking, a replacement sleeve OE 47012 must be fitted as follows:

1. Tap thread in the sleeve bore, screw in the extractor and withdraw the sleeve.

2. Clean out the bore in the cylinder head and press in the service sleeve OE 47012 as far as possible by hand.
3. Smear the lower end of the 'ballising tool' GA.720/M1 (fig. 9) with grease and fit the tool in the injector sleeve, using the injector retaining setscrews. Tighten down the centre screw thus forcing the end of the spindle through the lower end of the sleeve and sealing the sleeve in the cylinder head bore.

CAUTION: If carrying out this operation with the cylinder head in position on the engine always ensure that the piston of the cylinder being worked on is at B.D.C.

4. Grease the rollers of the expander tool GA.689 and insert the assembly into the upper portion of the injector sleeve bore. Rotate the spindle clockwise until the sleeve is sealed in the cylinder head bore. Disengage the tool by turning the spindle anti-clockwise.
5. Using the reamer GA.726 ream out the nozzle bore in the injector sleeve.
6. Reface the lower seating using cutter GA.299 with pilot GA.725, well lubricated with cutting oil. Remove only the minimum of metal necessary to obtain a full seating, and take care to avoid 'chatter'.

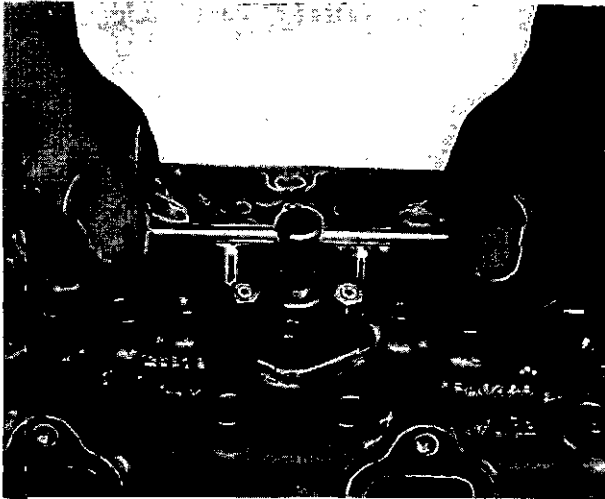


Fig. 13 Pressing in the new sleeve

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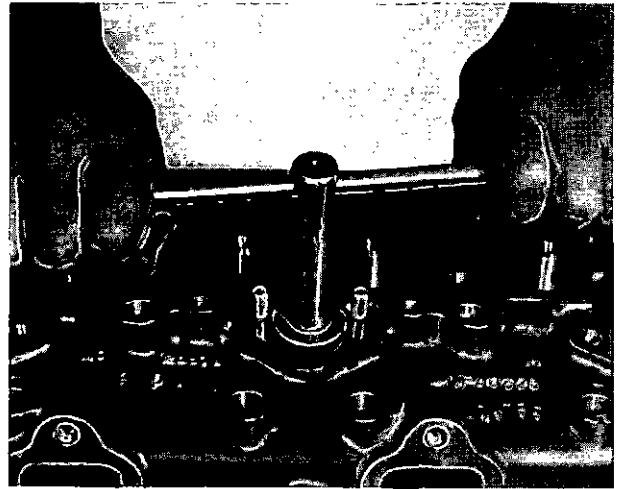


Fig. 15 Cutting injector seating

T720070

7. Clean thoroughly, and if possible carry out a pressure test at 30 lbf./sq. inch (210 kN/sq. m) air pressure with the cylinder head submerged in water at 60 deg.C (140 deg.F).

VALVE ROCKER ASSEMBLY

Remove the circlips from the rocker shaft, and the setbolt from the centre pedestal, and dismantle the assembly (fig. 16.). Unscrew the blanking plugs from the shaft. Thoroughly clean all parts, with particular attention to the oilway drillings. Refit the plugs.



Fig. 14 Rolling in the new sleeve

T720069

Inspect all components for wear and damage. Remove any slight ridges on rocker pads by careful stoning. Renew worn rocker bushes as necessary, ensuring that the oil holes are correctly aligned. These bushes are pre-finished and do not require machining.

Reassemble the rockers, commencing by fitting the centre pedestal and engaging its locating setbolt with the recess in the rocker shaft (both arrowed, fig 16). Note that the shaft oilway drillings are then on the underside. Tighten and lock the centre pedestal setbolt and assemble the remaining components, finally securing them with new circlips. No locating setbolts are fitted to the tappings in the two outer pedestals.

PUSHRODS

Examine the hardened ends for wear and damage, and check each rod for bowing. Maximum run-out, measured over the full length of the rod, is 0.025 inch (0.63 mm.).

CORE PLUGS

These are brass cups, driven into position, and are of three sizes. The kit for renewing a plug consists of a tap for cutting a screw-thread in the inner circumference of the old plug, an extractor which engages in this thread, and a drift for inserting the new plug. After removing the old plug, clean out the centre bore and, if desired apply a thin coat of sealing compound to the new plug before driving it home.

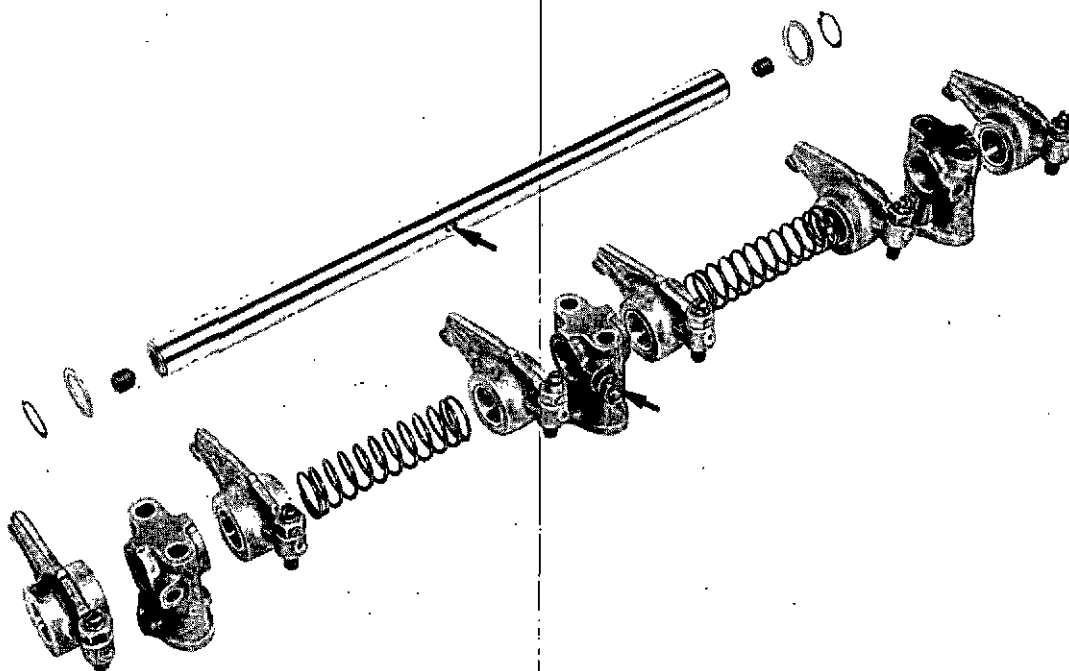


Fig. 16 Valve rocker assembly—exploded

ASSEMBLING THE VALVES

Fit a rotator to each exhaust guide and a distance piece to each inlet guide. As described under 'Valve stem seals', and illustrated in fig. 17, fit a new seal to each exhaust guide. Fit the valves, ensuring that their stems are oiled before insertion. Assemble a pair of springs and a retainer to each valve. In turn, compress the springs with tool GA.25 (fig. 1) and slide a rubber 'O' ring over the valve stem so that when the collets are fitted and the springs are released the rubber sealing ring is trapped inside the retainer.

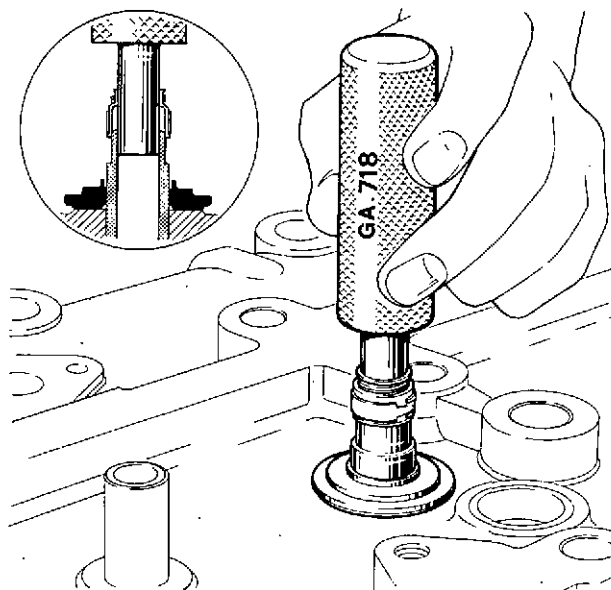


Fig. 17 Fitting seal to exhaust valve guide

24K79

SPECIAL TOOLS

GA.13	Lifting attachment, cylinder head	GA.725	Pilot
GA.25	Tool, compressing valve spring	GA.726	Reamer
GA.718	Fitting tool, exhaust valve stem seal	GA.727	Tool box
GA.698	Kit, valve guide renewal, comprising:	GA.700	Kit, injector sleeve renewal, comprising:
GA.462	Extractor	GA.671	Tap, extractor thread
GA.640	Insertion tool	GA.672	Extractor
GA.474	Reamer	GA.306	Insertion tool
GG1	Plug gauge	GA.688	Expander lower
GA.699	Box	GA.689	Expander upper
		GA.701	Box
GA.607	Tool, cutting valve seats	GA.385	Kit, core plug renewal, comprising:
GA.607/1	Replacement cutter for GA.607	GA.382	Tap
GA.669	Gauge, valve face	GA.377/M1	Extractor
		GA.387	Insertion tool
GA.691	Cutter assembly, removing valve seats		} $\frac{9}{16}$ - inch plug OE.21386
GA.690	Guide for GA.691	GA.383	Tap
GA.682	Insertion tool, valve seats	GA.378/M1	Extractor
GA.142	Sleeves (2) for GA.682, if no guides	GA.388	Insertion tool
			} 1-inch plug OE.21387
*GA.702	Kit, 'low spring' injector sleeve servicing comprising:	GA.384	Tap
GA.299	Cutter, injector seating	GA.379/M1	Extractor
GA.675/M1	Holder for GA.299	GA.389	Insertion tool
GA.721	Pilot for GA.675/M1		} $1\frac{3}{8}$ - inch plug OE.22354
GA.304	Reamer, nozzle hole	GA.386	Box
GA.674	Holder for GA.304	GA.802	Counter bore cutter
GA.619	Allen key	GA.803	Rolling tool
GA.703	Box	GA.804	Hand cutter
GA.722	Kit, cleaning and renewal, comprising:	GA.805	Arbor (for GA.804)
GA.299	Cutter		
GA.306	Insertion tool		
GA.619	Allen key		
GA.671	Hand tap		
GA.672	Extractor		
GA.674	Reamer holder		
GA.675/M1	Cutter holder		
GA.689	Expander		
GA.720/M1	Ballising tool		

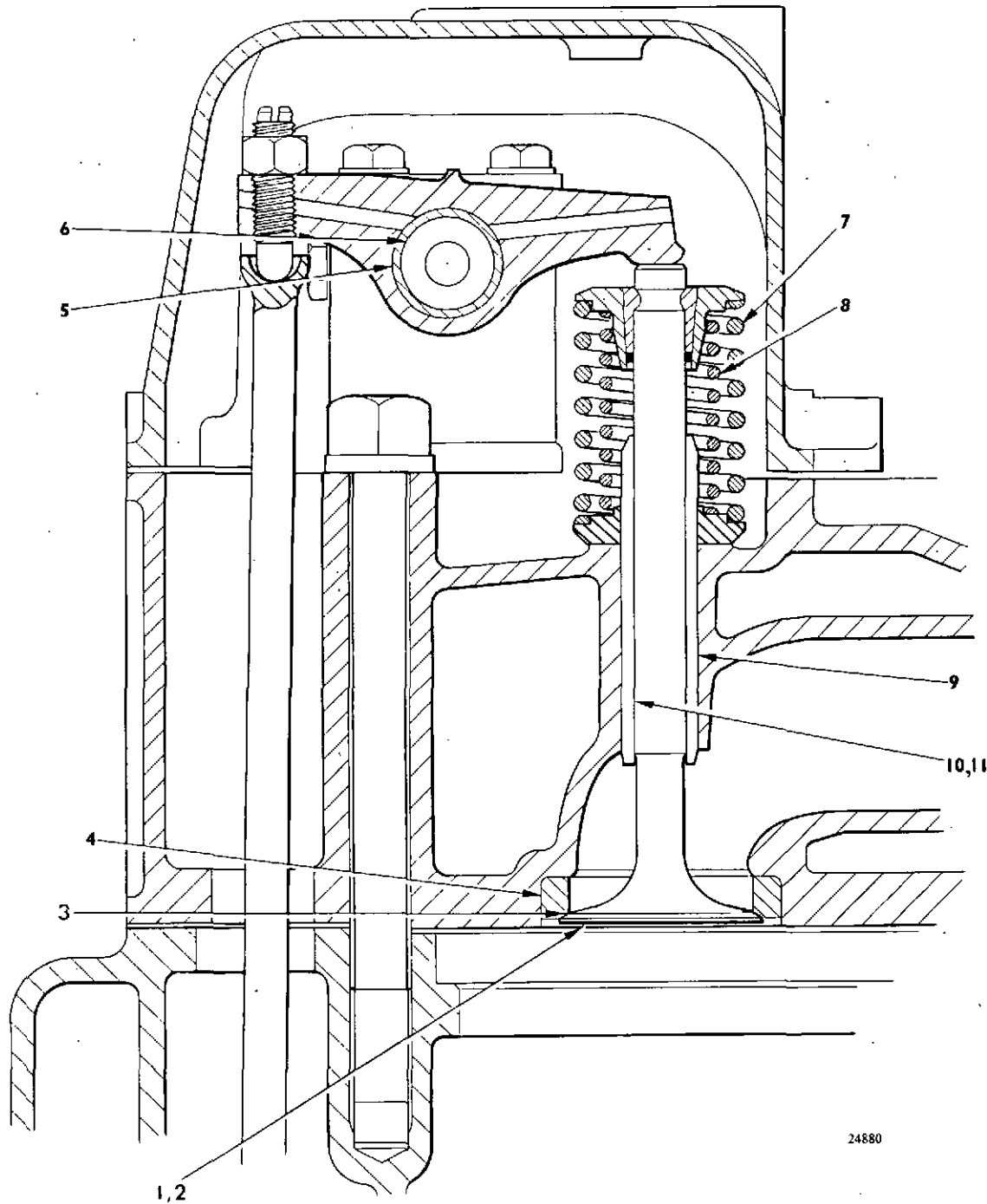
SERVICE RECLAMATION SCHEMES

SRS6 Reclaiming cylinder head flame face

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FITS AND CLEARANCES

CYLINDER HEADS AND VALVE GEAR



24880

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	VALVE CLEARANCE BELOW FLAME FACE Normally aspirated engines Inlet					0.025 to	0.63 to	0.054	1.37	Masked insert
						0.042	1.07			
2	Turbocharged engines Inlet					0.090 to	2.29 to	0.119	3.02	
						0.107	2.72			
3	VALVE SEAT INSERTS Angle of valve seat	30 deg.				0.025 to	0.63 to	0.054	1.37	
						0.042	1.07			
4	Inserts in cylinder head Cylinder head—bore *Insert—diameter	2.286 to 2.287 2.289 to 2.290				0.090 to	2.29 to	0.119	3.02	
						0.107	2.72			
5	ROCKER GEAR Bush in rocker arm Rocker arm—bore	1.0312 to 1.0317 1.034 to 1.035				Interference	Interference	0.002 to 0.004	0.05 to 0.10	
						26.19 to 26.21 26.26 26.29	0.0022 to 0.0037			
6	Rocker arm on shaft Bush—bore	0.8745 to 0.875				0.001 to	0.02 to	0.005	0.13	
						0.002	0.05			
	Shaft—dia.	22.17 to 22.18								

* Diameter of standard items. Inserts 0.002 in. (0.05 mm.) oversize are available and cylinder head bore must be machined to maintain correct fit.

ROLLS-ROYCE DIESELS

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
7	VALVE SPRINGS Outer (new) Free length (nominal) Minimum length under 76 ± 4 lb. (34 ± 1.8 kg.) load	3.07	77.97							For both springs, maximum lean is 0.06 inch (1.5 mm.) when stood on either end.
		2.025	51.43	2.025	51.43					
8	Outer (used) Minimum length under 68.5 lb. (31 kg.) load Inner (new) Free length (nominal) Minimum length under 40 ± 2.5 lb. (18.1 ± 1.1 kg.) load	2.89	73.40							
		1.86	47.24	1.86	47.24					
9	VALVE GUIDES Cylinder head—bore Valve guide—dia.	0.750 to 0.7505	19.05 to 19.06							Interference 0.0005 to 0.013 0.0005 to 0.013
		0.751 to 0.7515	19.07 to 19.08							
10	VALVES IN GUIDES Inlet valve—dia. Valve guide—bore	0.498 to 0.4985	12.65 to 12.66							Max. bellng at lower end of bore: 0.020 in. (0.51 mm.) on diameter
		0.500 to 0.5005	12.70 to 12.71			0.0015 to 0.0025	0.038 to 0.063	0.006	0.15	
11	Exhaust valve—dia. Valve guide—bore	0.4955 to 0.496	12.58 to 12.59							Max. bellng at lower end of bore: 0.040 in. (1.02 mm.) on diameter
		0.500 to 0.5005	12.70 to 12.71			0.004 to 0.005	0.10 to 0.13	0.010	0.25	

SECTION 9 — COOLING SYSTEM

DESCRIPTION

The system illustrated in fig. 1 applies to 'C-RH' engines currently in production.

Coolant leaving the radiator is drawn through an oil-to-coolant heat exchanger by a belt-driven centrifugal pump and delivered to the inlet gallery of the cylinder block through a port in the pump back-plate. After circulating around the cylinder liners the coolant passes through transfer bobbins into the cylinder heads where it flows round the valves and injectors.

On leaving the heads the coolant passes through a gallery pipe to the thermostat housing mounted above the coolant pump. If working temperature has not been reached, the thermostat valves are shut and the coolant is by-passed back to the pump for recirculation through the engine. At working temperature, the coolant passes through the thermostat to enter the bottom of the 'two-pass' radiator. The coolant then flows up and down the radiator and is cooled before returning to the engine.

The engine is fitted with a drain cock on the left-hand side of the cylinder block, forward of the flywheel housing (see Frontispiece). This cock is open when turned anti-clockwise to its full extent. On some installations a drain cock is also fitted at the rear of the heat exchanger.

COOLANT

For information on recommended coolant, refer to leaflet TSD 3085 which is carried in a pocket in the

rear cover of this Manual. Instructions for maintenance of the system in service are given in the Engine Servicing Manual, TSD 3126.

COOLANT PUMP

The coolant pump is mounted on the crankcase and is illustrated in cross-section in fig. 2. The following information concerns dismantling, inspection and assembly with reference to the item numbers on Fig. 2.

Dismantling

Remove the backplate (18) and withdraw the rotor from the shaft. It is a press fit and two $\frac{1}{8}$ inch UNF tappings are provided for use with extractor GA.7. Unscrew the setbolts securing the bearing housing (5) to the pump casing (8) and separate them. Unlock and unscrew the rotor shaft nut and remove its tabwasher and keywasher.

Press the rotor shaft (1) out of the bearing housing (5); this will bring the roller bearing inner race, the distance piece (6) and the outer seal (2) with it. Remove the circlip (3), press out the ball bearing (7) and the roller bearing outer race (4).

Inspection

Inspect the rotor shaft (1) for wear, especially at the seal rubbing areas. Clean all grease from the bearings and examine them for wear. The ball bearing controls the end float of the shaft, which should not exceed 0.005 inch (0.13 mm). Examine the rotor for erosion, corrosion and damage.

KEY TO FIG. 1—TYPICAL COOLING SYSTEM,

- 1. Oil-to-coolant heat exchanger
- 2. Coolant inlet gallery
- 3. Coolant outlet gallery
- 4. Thermostat housing
- 5. Coolant outlet to radiator
- 6. Thermostat
- 7. To thermostat from outlet gallery
- 8. Thermostat by-pass to pump
- 9. Pump to inlet gallery
- 10. To pump from heat exchanger
- 11. Engine drain cocks
- 12. Radiator drain plug

- A General view of system
- B = Flow through thermostat and pump
- C = Diagrammatic circuit
- D = Flow through cylinder block and head, from front

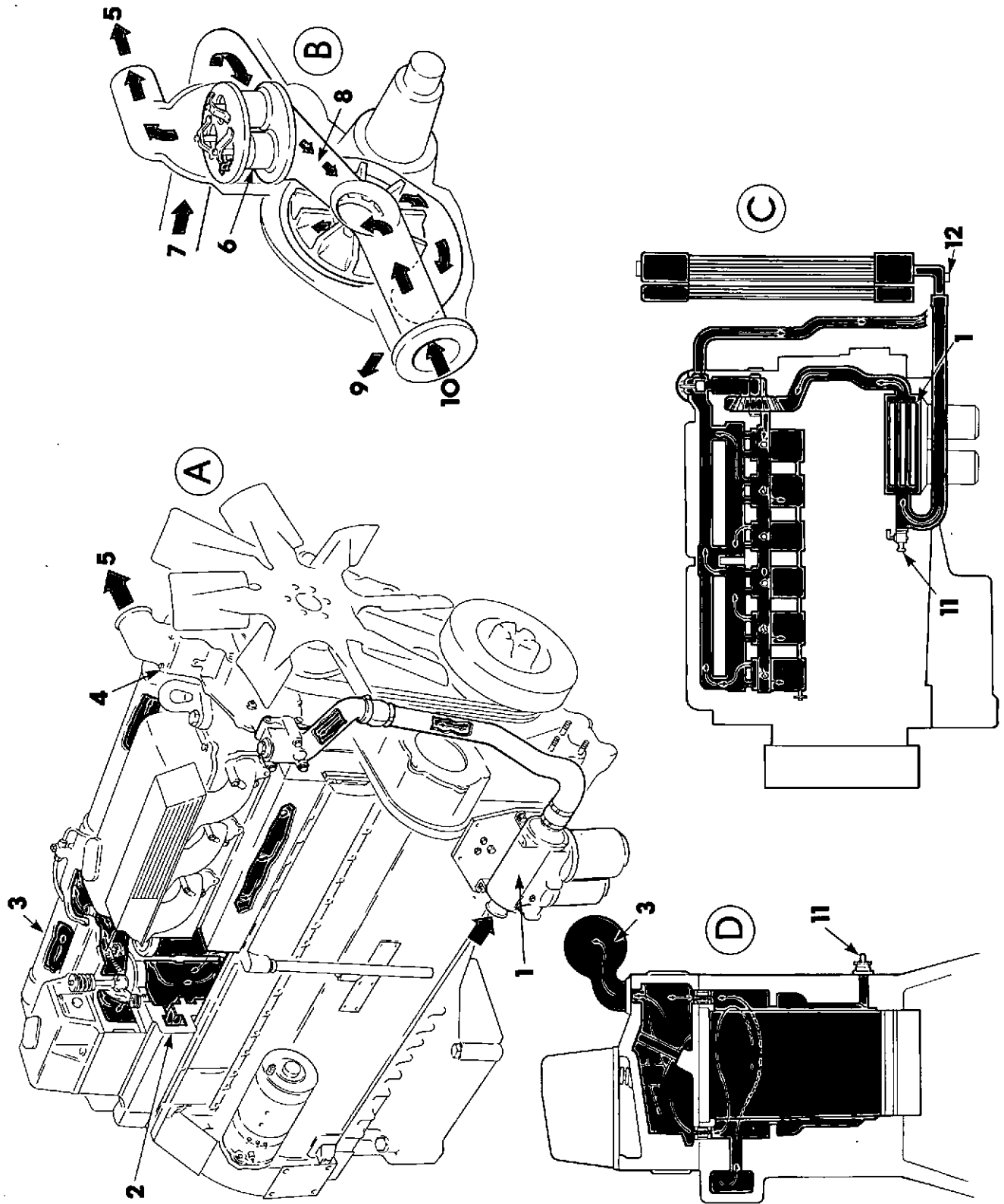
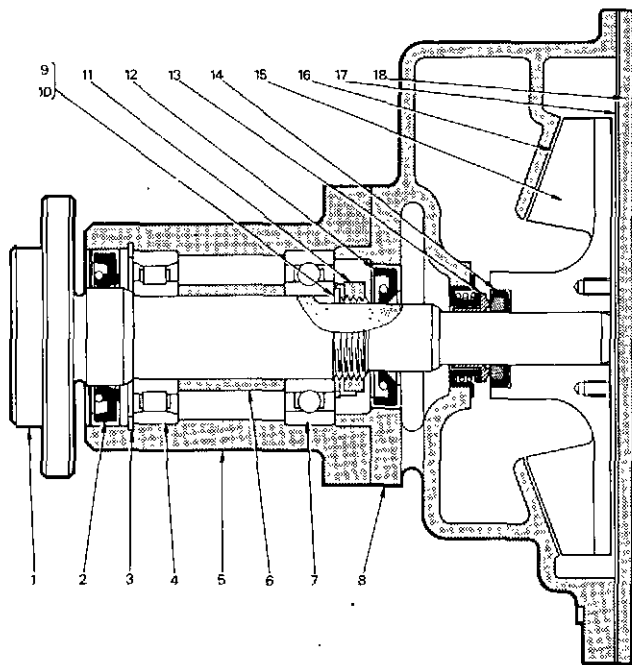


Fig. 1 Cooling system



- | | | |
|-------------------|----------------|------------------------|
| 1 ROTOR SHAFT | 7 BALL BEARING | 13 GLAND SEAL UNIT |
| 2 OUTER SEAL | 8 PUMP CASING | 14 CERAMIC COUNTERFACE |
| 3 CIRCLIP | 9 LOCKWASHER | 15 ROTOR |
| 4 ROLLER BEARING | 10 TABWASHER | 16 RUNNING CLEARANCE |
| 5 BEARING HOUSING | 11 LOCKNUT | 17 JOINT GASKET |
| 6 DISTANCE PIECE | 12 INNER SEAL | 18 BACKPLATE |

24869

Fig. 2 Coolant pump

If the gland seal unit and ceramic counterface (13/14) are not in good condition, and in particular if their rubbing faces are even slightly worn or damaged, they should both be renewed together. Both units are rubber-mounted and renewal is by simple substitution, no special tools or sealant being necessary.

If possible, the inner and outer lipseals should be discarded and new items fitted as a matter of routine. In any case, they must be renewed if their condition is at all doubtful.

Assembling

Press the outer race of roller bearing (4) into the bearing housing (5) and fit the circlip (3). Fit the outer lipseal (2); with its lip facing outwards, and press it $\frac{1}{8}$ inch (3.2mm) below the face of the bearing housing. In this position the seal is at mid-point of bore depth; if necessary it may be left flush with the face, or pressed fully home, to avoid a groove worn in the shaft by a previous seal.

Insert the rotor shaft (1) and fit the roller bearing and distance piece (6). Half-fill the bearing housing with Shell Retinax 'A' or equivalent grease. Do not overfill. Fit the ball race (7), followed by keywasher, tabwasher and nut. After tightening the nut, check

the shaft for free rotation before bending up the locking tabs.

Press the inner lipseal into the pump casing (8), so that the lip faces forward (fig. 2) and the seal casing is flush with the rear face. Bolt the bearing housing to the pump casing.

Ensure the rotor shaft and rotor bore are free from grease, and that the seal faces are perfectly clean, and press the rotor into position, flush with the end of the shaft. Check that the rotor does not foul the casing when turned. Before finally fitting the backplate (18) measure the rotor vane running clearance as indicated in fig. 2.

This clearance should be between 0.034 and 0.070 inch (0.86 and 1.78 mm).

THERMOSTAT

A triple-element wax-type Western Thomson thermostat is carried in a housing bolted to the top face of the coolant pump casting (fig. 3). The thermostat is located in its housing by a roll-pin which engages with a recess in the rim and ensures that each element is directly above a by-pass port. As the valves open the ports are shut off by the elements and the coolant is directed to the radiator. The

opening temperature of each valve is stamped on its element, the leading valve commencing to open at a slightly lower temperature than the other two.

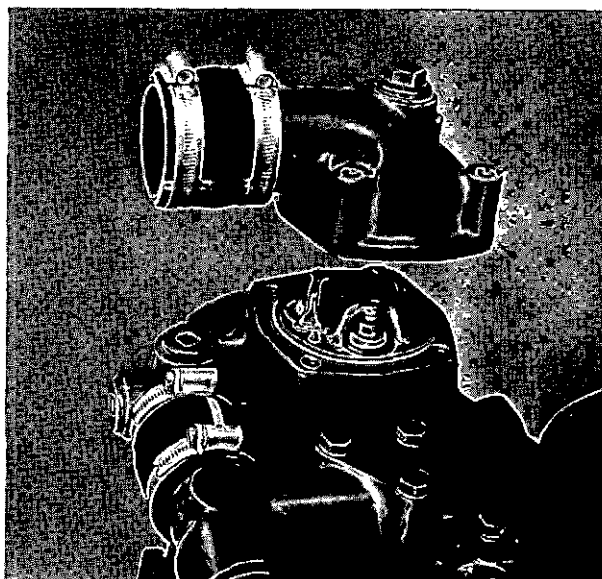


Fig. 3 Thermostat in housing

T720024

A thermostat (fig. 4) with a vent hole pin and stainless steel valves and straps is fitted; the operating check data is as follows:

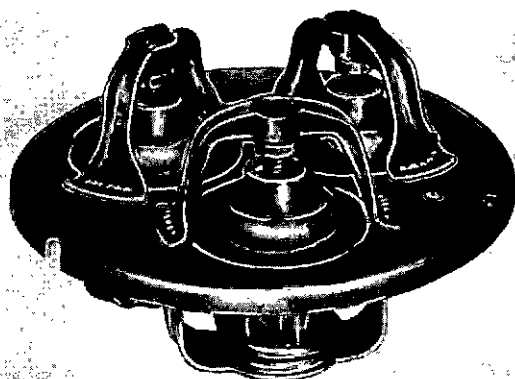


Fig. 4 Thermostat unit

T720064

To remove the thermostat, dismantle the thermostat housing cover, which is secured by four setbolts (fig. 3). After cleaning, inspect the unit for distortion, cracks and damage.

The thermostat requires no routine servicing and must be renewed if it becomes defective. Should one or more of the valves be sticking, this may often be rectified by applying a little silicone grease to the valve spindles and operating the valves by hand to work the grease into the glands.

Note: Silicone grease should be applied as above to the valve spindles of a replacement thermostat, or a thermostat fitted to an engine which is to stand with the coolant system drained. A suitable grease is Valve Seal 'A', manufactured by Midland Silicones Limited, 63 Temple Row, Birmingham 2.

Checking operating temperatures

1. Mark the strap of the leading valve and place the thermostat, right way up, in a container filled with water to the level of the valve platform. Position an accurate thermometer as close as possible to the valves.
2. Heat the water, and note the temperature at which the leading valve opens sufficiently to admit a 0.002 inch (0.05 mm) feeler gauge.
3. Continue heating and, in similar fashion, note the opening temperature of the two trailing valves.
4. Continue heating and note the temperature at which each valve is fully open, i.e. when it ceases to move after opening approximately $\frac{3}{8}$ -inch (9 mm).
5. Compare the readings with the following limits:

Leading valve opens:	77 to 81 deg.C (171 to 179 deg.F)
Trailing valves open:	81 to 85 deg.C (179 to 185 deg.F)
All valves fully open:	93 to 97 deg.C (199 to 207 deg.F)

Checking operating speeds

1. With all valves fully closed, immerse the thermostat, right way up, in boiling water to the level of the valve platform and note the time after immersion at which each valve opens sufficiently to admit a 0.002 inch (0.05 mm) feeler gauge.
2. Maintain the water at boiling point and note the time from immersion at which all valves are fully open.

3. Remove the thermostat and plunge it into cold water. Note the time taken for all valves to close fully.
4. Compare the readings with the following limits:
 - Leading valve commences opening: Within 15 secs
 - Trailing valves commence opening: Within 20 secs
 - All valves fully open: Within 60 secs
 - All valves closed in cold water: 4 to 8 secs

Emergency action, unserviceable thermostat

If a replacement thermostat is not available it will be necessary, *as a temporary measure only*, to jack the

valves fully open and run the engine with the radiator partly blanked off. *In no circumstances should the engine be run without a thermostat, since the by-pass ports would then be permanently open, causing overheating.*

OIL-TO-COOLANT HEAT EXCHANGER

Description and instructions for overhauling this component are given in Section 11, 'LUBRICATION SYSTEM'.

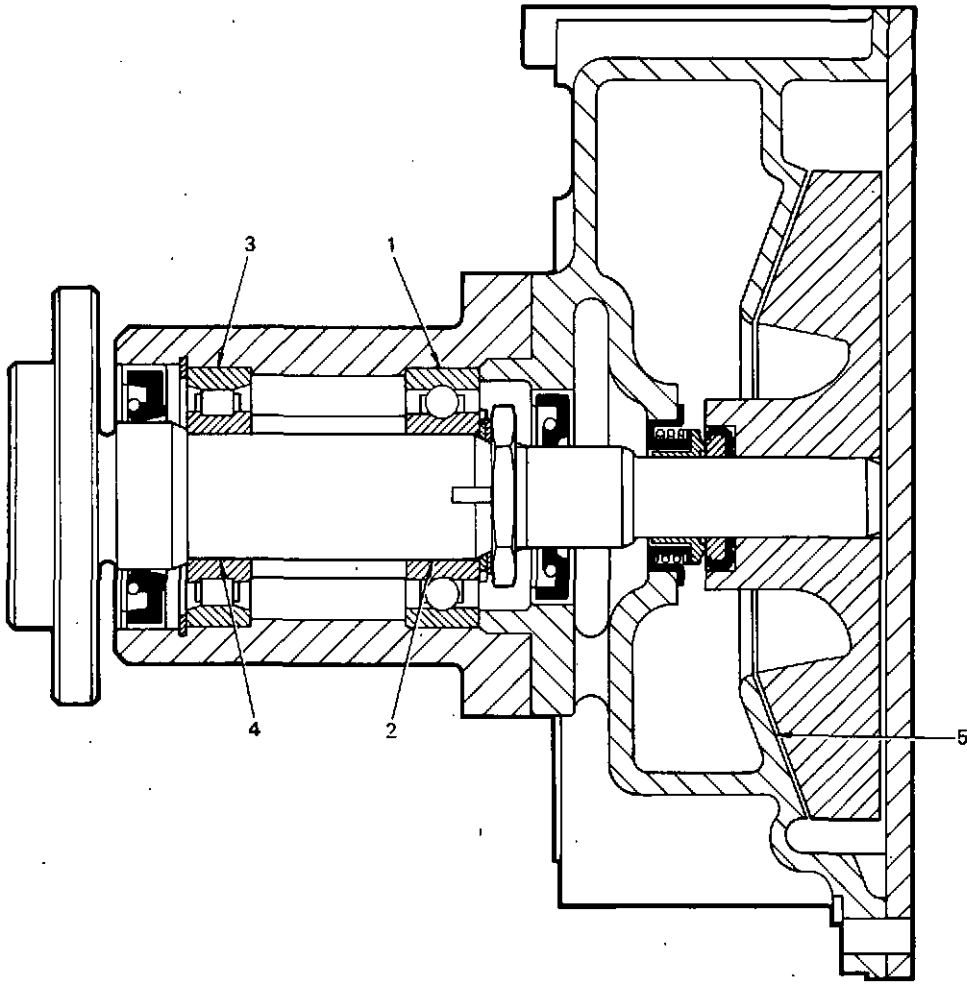
SPECIAL TOOLS

GA.7 Extractor, pump rotor.

Printed in Great Britain

FITS AND CLEARANCES

COOLANT PUMP



24871

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	ROTOR SHAFT BALL BEARING Bearing in housing Housing—bore Bearing—dia.	2.4407 to	61.99 to							Renew bearing if endfloat exceeds 0.005 in. (0.13 mm)
		2.4412	62.01			Interference 0.0002 to 0.0007	0.005 to 0.019 clearance			
2	Bearing on shaft Bearing—bore Shaft—dia.	1.1807 to	29.99 to							
		1.1813	30.00			Interference 0.0004 to 0.00025	0.010 to 0.006 clearance			
3	ROTOR SHAFT ROLLER BEARING Bearing in housing Housing—bore Bearing—dia.	2.4407 to	61.99 to							
		2.4412	62.01			Interference 0.0002 to 0.0008	0.005 to 0.020 clearance			
4	Bearing on shaft Bearing—bore Shaft—dia.	1.1806 to	29.99 to							
		1.1811	30.00			Interference 0.0005 to 0.00025	0.013 to 0.006 clearance			
5	ROTOR CLEARANCE Clearance between rotor and casing or adaptor									
						0.034 to 0.070	0.86 to 1.78			

ROLLS-ROYCE DIESELS



SECTION 10—FUEL SYSTEM

Repair and overhaul work on injectors, pumps and governors should only be undertaken by suitably trained and equipped personnel, working in conditions which conform to a high standard of order and cleanliness. If these requirements cannot be met, the faulty or life-expired unit should be exchanged for one which has been reconditioned and tested at the factory.

PART 1—INJECTORS

Description

Each injector is of the 'low spring' type and consists of a closed type 'S' size nozzle, carried in a holder. The nozzle is made up of a valve and a body which are lapped together to form a replaceable unit. At the nozzle tip are radially-drilled spray holes, four on normally-aspirated engines and five on turbocharged engines. The nozzle holder contains a spring-loaded spindle, which holds the nozzle valve on its seat, and an adjusting screw for setting the spring pressure.

On all 'C-RH' engines the injector operating pressure is 220 atmospheres. Injectors currently fitted to production engines and supplied as spares are of

the 'controlled flow' type on which the nozzle spray holes are produced to closer limits than previously. Their Rolls-Royce Part Numbers are as follows:

OD.17534: Normally aspirated engines

OD.17532: Turbocharged engines

Dismantling

Place the injector, nozzle downwards, in holding plate OD.17162 and remove the capnut to expose the adjusting screw. Unscrew the adjusting screw and remove the shim, spring and spindle.

CAUTION: Until this has been done the nozzle capnut must *not* be unscrewed, or the injector will be damaged.

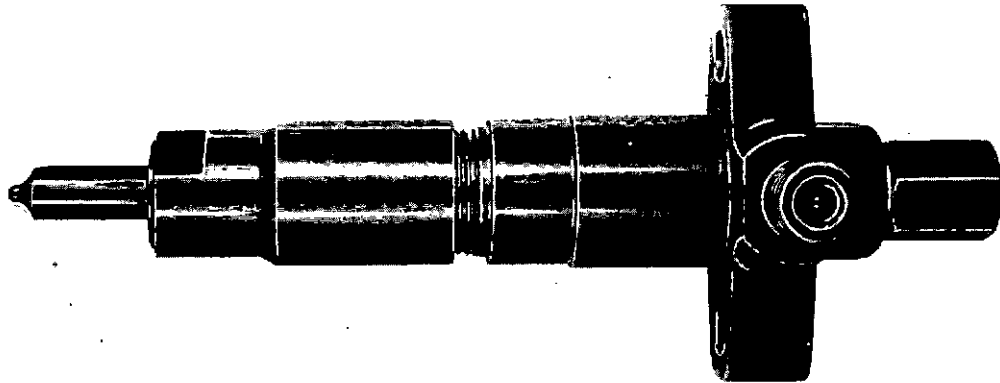


Fig. 1 Injector

T720056

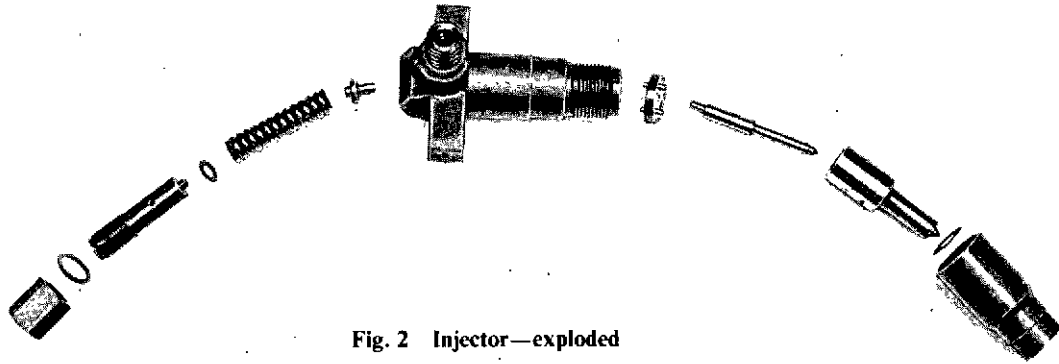


Fig. 2 Injector—exploded

T720057

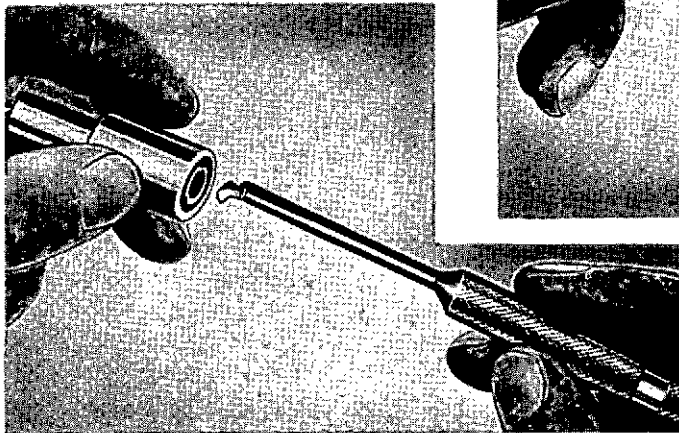
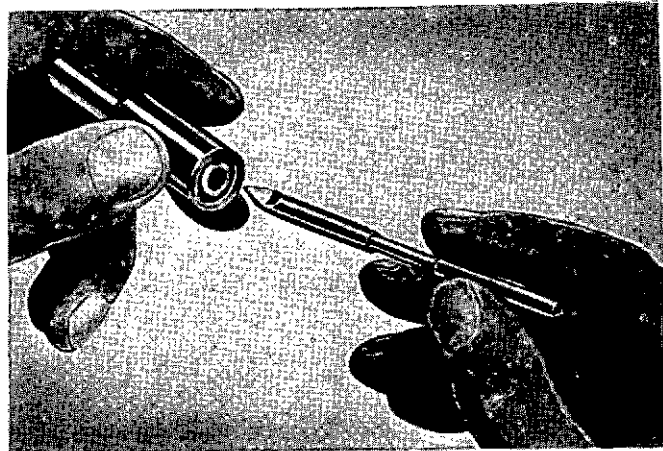
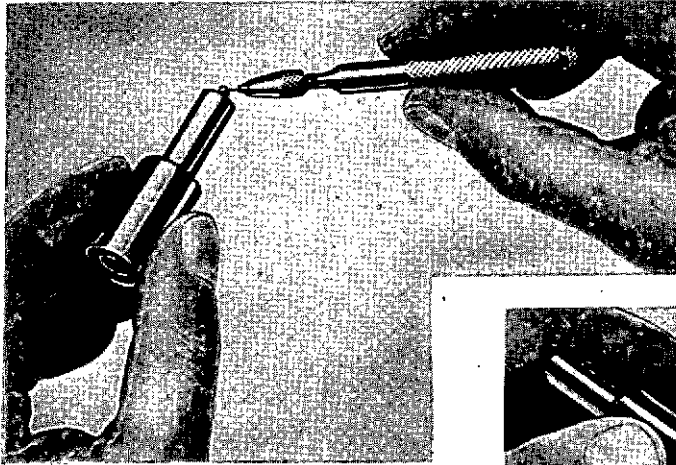


Fig. 3 Cleaning the nozzle

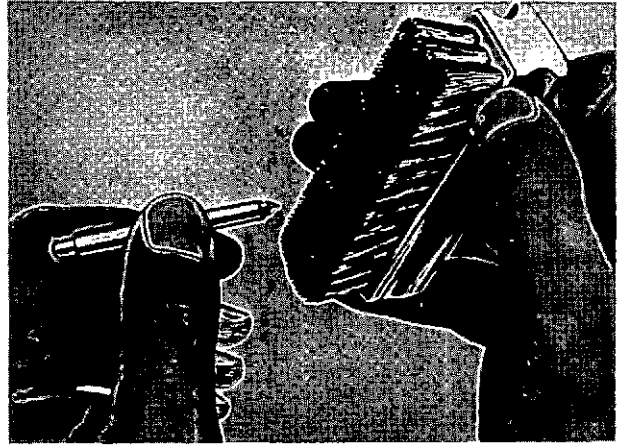
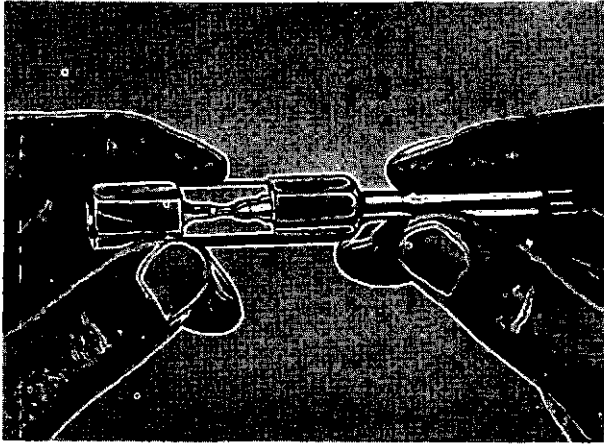


Fig. 4 Cleaning the nozzle valve

T720058

Reverse the injector in the holding plate and, using adaptor OD.13101, unscrew the nozzle capnut. Remove the nozzle and valve, and ensure that they remain together. Note that a 'skid washer' OD.14995 should be fitted beneath the nozzle shoulder (fig. 2). Remove the transfer block.

Cleaning

Wash the holder and its associated components in paraffin or fuel oil, and dry off with compressed air. Soak the nozzle assembly in a carbon solvent such as 'Ardrox' 690 or 1618, obtainable from Ardrex Limited, Commerce Road, Brentford, Middlesex.

Do *not* use a powered wire wheel to clean nozzle parts.

Remove any remaining carbon from the nozzle and valve by means of the tools in cleaning kit KRP.1089 as illustrated in figs. 3 and 4 (see also 'Use of cleaning wires').

Inspection

Check that the valve slides freely in the nozzle and is not scored or worn. If the valve face or nozzle tip are discoloured due to overheating, both components must be renewed.

DO NOT attempt to lap the valve to its seat, since their angles are not identical.

Inspect the pressure faces between holder, transfer block and nozzle for scratches and damage which would cause leakage under high pressure. Examine the spring and spindle for damage, distortion and corrosion.

Use of cleaning wires

Nozzle spray holes have nominal diameters of 0.355 mm. on normally aspirated engines and 0.36 mm. on turbocharged engines. It is important that all carbon is removed from their bores and cleaning wires are available in sizes to cover the manufacturing limits to which the holes are drilled. These wires are of D-section and are measured in millimetres across the full diameter.

Fit the wire to its holder so that not more than $\frac{1}{16}$ -inch (1.5 mm.) protrudes from the chuck. A greater protrusion increases the risk of wire breakage, and it is extremely difficult to remove a broken wire from a spray hole. Insert the wire with a twisting, scraping action until it has cleared the hole.

After every spray hole has been cleaned in this manner soak the nozzle again in solvent, as previously described under 'Cleaning', to dissolve any carbon remaining in the bores. Then assemble the nozzle to flushing tool OD.5178, attach it to setting outfit OD.16849, and flush through in reverse-flow direction to dislodge any loose fragments.

Assembling

Assemble the valve to its nozzle whilst both are immersed in clean test oil.

Fit the 'skid washer' OD.14995 to the nozzle shoulder (fig. 2) and the transfer block to the holder, ensuring that they are aligned as in fig. 5.

Engage the nozzle with the dowels on the transfer block and fit the nozzle capnut, hand-tight.

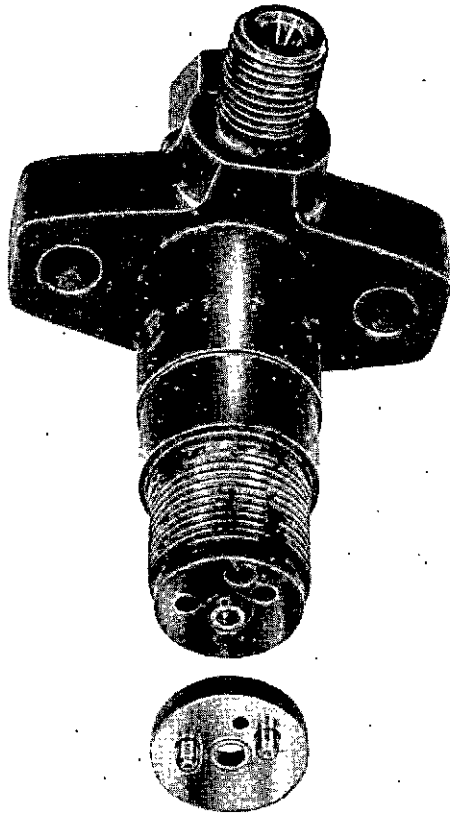


Fig. 5 Alignment of transfer block

T720059

Place the injector, nozzle upwards, in holding plate OD.17162 and use torque spanner adaptor OD.13101 to tighten the nozzle capnut to 50 lbf.ft. (68 Nm).

Invert the injector in the holding plate and fit the spindle, spring and shim. Screw the adjusting screw to its approximate setting, and temporarily fit the washer and capnut.

Setting and testing

This is carried out in three stages, using the nozzle setting outfit OD.16849. Only Shell Calibration Fluid, Esso TSD Oil 815 or Castrol Calibrating Oil 8327 should be used.

WARNING: When testing an injector, the nozzle must be turned away from the operator, since the spray has sufficient force to penetrate the human skin.

1. Pressure setting

Close the pressure gauge valve, and operate the pump smartly to expel air. Open the valve $\frac{1}{4}$ -turn, operate the pump slowly, and note the pressure gauge reading at which the needle 'flicks', indicating nozzle valve opening. Turn the adjusting screw as necessary to give an opening pressure between 225 and 230 atmospheres, to allow for settling down in service. Fit and tighten the capnut, taking care not to disturb the setting of the adjusting screw.

Dry the nozzle tip, pump up the pressure to 210 atmospheres, and maintain it for 10 seconds. The nozzle should remain dry; slight dampness is acceptable but there must be no droplets.

2. Back-leakage check

Pump up a pressure of 160 to 165 atmospheres. Allow the pressure to fall naturally to 150 atmospheres, and then note the time taken to continue falling from this point to 100 atmospheres.

The time should not be less than six seconds and, in the absence of other leaks, a shorter time indicates excessive leakage past the lapped portion of the nozzle valve.

Before rejecting a nozzle assembly ensure that leakage is not due to dirt on the pressure faces and, in the event of an unusually high number of rejections, check that the fault does not lie within the test rig.

Note: Do not attempt to rectify leakage by over-tightening the nozzle capnut.

3. Atomisation check

Close the pressure gauge valve, pump up the pressure until the nozzle commences to spray, and continue to pump at about three strokes every two seconds. Check that all sprays are of equal size and fully atomised, and that after spraying the nozzle is dry.

Storage

Following satisfactory completion of the tests, wipe the injectors dry, fit their protective caps and store them in a clean warm place until required for use.

Note that new rubber sealing rings OE.43694 beneath the injector flanges will be required on assembly to the engine.

SPECIAL TOOLS

Rolls-Royce Part No.	C.A.V. Part No.	Description
OD.17162	7244-61	Injector holding plate
OD.16849	7144-644E	Nozzle setting outfit
OD.5178	7044-137	Nozzle flushing tool
OD.13101	7144-879	Spanner adaptor, nozzle capnut
KRP.1089	7244-10	Nozzle cleaning kit*

*Containing the following tools for Rolls-Royce injectors:

OD.5167	7044-68	Wire brush
OD.12504	7044-124	Nozzle body seating scraper
OD.12505	7044-69A	Scraper holder
OD.12506	7044-69E	Cavity scraper, 1-2 mm. dia.
OD.17243	7044-69G	Cavity scraper, 1-8 mm. dia. (radiused end)
OD.5169	7044-71	Body groove scraper
OD.5170	7044-72	Nozzle valve seat cleaner
OD.5180	7044-120	Cleaning wire holder

Cleaning wires (supplied separately from kits, in tubes of 10):

OD.13157	7244-6G	Cleaning wire, 0.34 mm. diameter (4-hole nozzle, normally aspirated engines)
OD.13158	7244-6H	Cleaning wire, 0.36 mm. diameter (5-hole nozzle, turbocharged engines)



PART 2—INJECTION PUMP, TYPE 'PE'

Note: Although some illustrations in the following text depict a 6-element 'Left-hand' pump, the operations and essential details apply equally to the 'Right-hand' unit.

DISMANTLING

1. It is important to provide adequate storage trays, those for paired or associated assemblies such as pumping elements and tappets being divided into numbered compartments to enable each assembly to be kept together.
2. Thoroughly clean the unit, and drain the lubricating oil by removing the feed pump and governor access cap.
3. Mount the pump on a suitable rig, such as the swivel vice 0 681 240 048 shown in fig. 6. Remove the rear cover and dismantle the governor as described under 'DISMANTLING' in Part 3.
4. Invert the pump and remove the bottom plate.
5. Referring to fig. 7, remove the six tappet access screws from the pump casing. In turn, bring each tappet to TDC and fit a holder 1 681 115 12F to lift and retain the tappet clear of the cam lobe. To do this, proceed as follows, dependent on the pump stroke:

On 12 and 13 mm bore pumps screw in the element and guide sleeve by hand and then finally tighten one turn using a spanner. Then fit the cap-screw by hand until the element reaches the tappet and use an Allen key to turn it half-a-turn further. Do *not* exceed this, or the element may foul the cam.

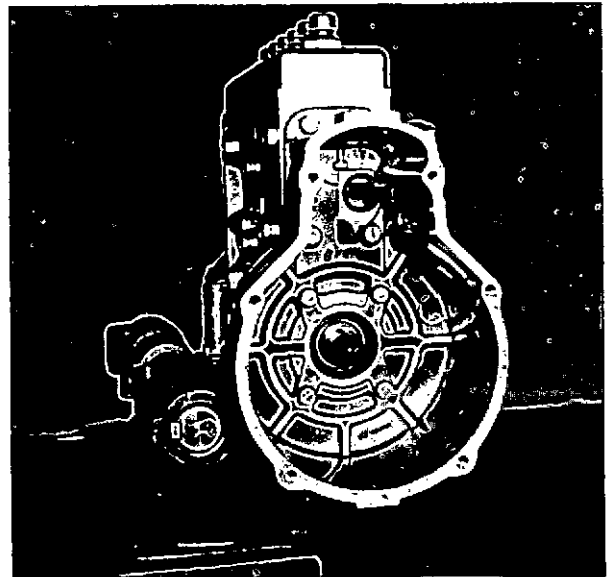


Fig. 6 Pump on swivel vice

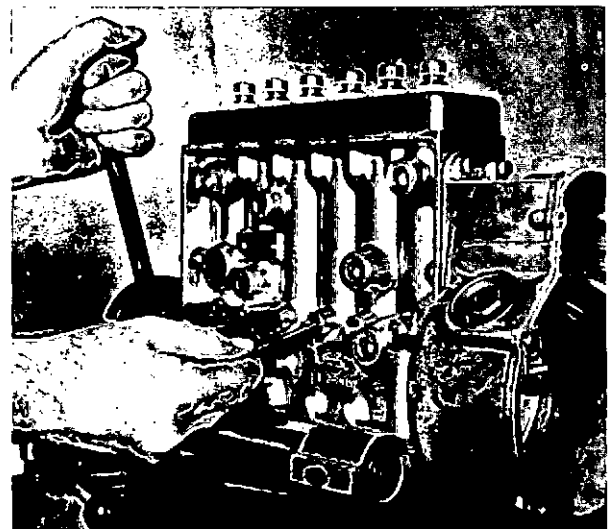


Fig. 7 Fitting tappet holders

6. Invert the pump and remove the camshaft centre bearing, which is retained by two socket screws (fig. 8).
7. Turn the pump upright and remove the screws securing the drive end bearing plate. Referring to fig. 9, fit supporting bracket 1 682 329 011 and withdraw the bearing plate by using a claw extractor engaged in the recesses provided. The supporting bracket is necessary to avoid transferring load to the opposite end bearing via the camshaft. Remove the 'O' ring and shims from the end plate recess.
8. Withdraw the camshaft (fig. 10).
9. Remove the governor housing and adjusting plate from the opposite end (fig. 11).
10. Invert the pump, fit element spring compressing tool 1 688 110 027, together with pivot bar 1 683 001 003 and, on each tappet in turn, push the roller down, remove the tappet holder and unload the plunger spring (fig. 12).
11. Withdraw the roller tappets (fig. 13), use a wire hook to lift out the spring plate and pump plungers (fig. 14) and take out the plunger springs (fig. 15). Place each assembly in the appropriate compartment of its storage tray.
12. Set the control rack to mid-position and remove the control sleeves and upper spring plates (fig. 16).
13. Unscrew the smoke stop or excess fuel device assembly, together with its adaptor, from the drive end.
14. Using pin spanner 1 687 950 075, unscrew the threaded bush (fig. 17) and pull out the control rack and its dowel pin. Remove the control rack guide at the drive end by means of a wire hook and then use a long drift to tap out the guide at the governor end.
15. Turn pump upright and remove the top cover. Unscrew the nuts securing the delivery valves and remove their washers. Extract the delivery valves, using tool 1 688 110 026 (fig. 18), ensuring that each assembly is stored in the same compartment as its associated components removed in Operation 11. Remove any packings which may have remained in the housing (fig. 19).

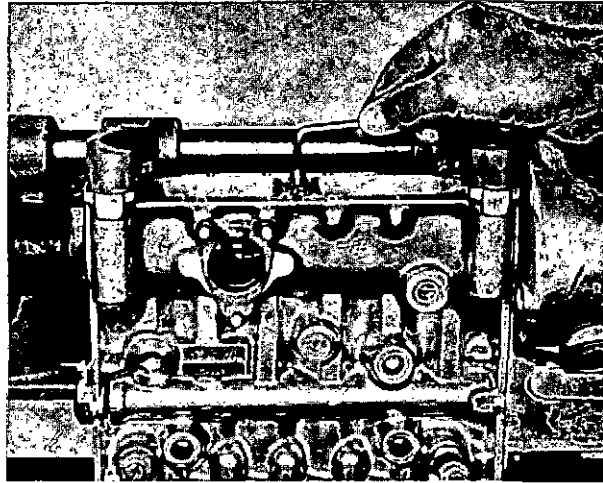


Fig. 8 Removing centre bearing

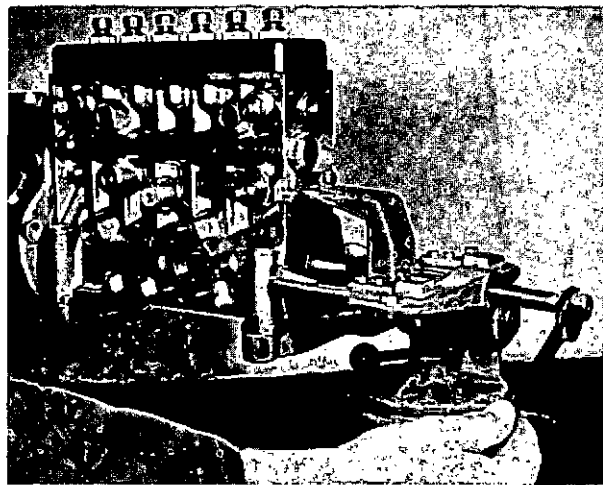


Fig. 9 Withdrawing drive end bearing plate

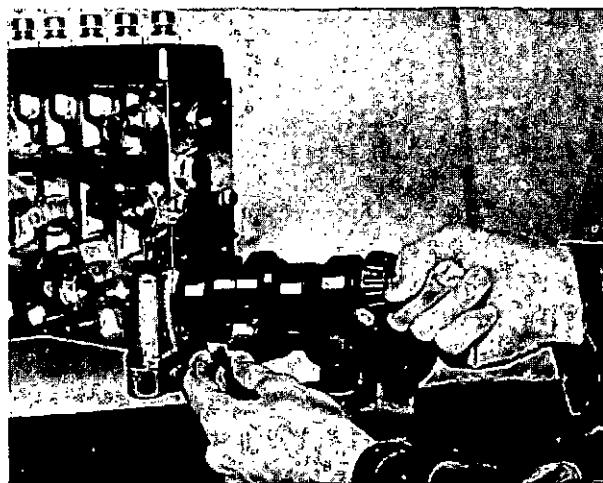


Fig. 10 Removing camshaft

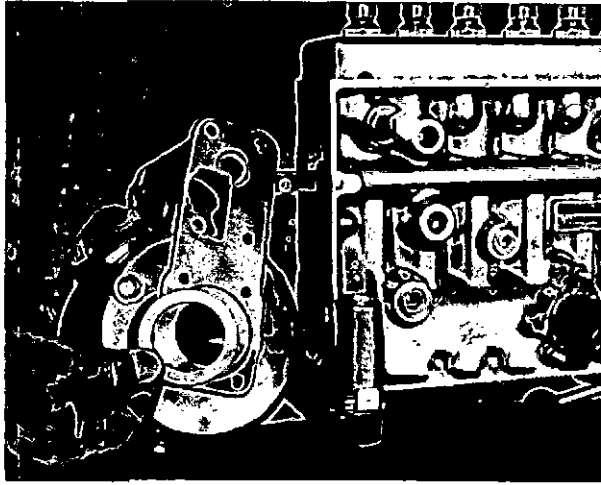


Fig. 11 Removing governor casing and adjusting plate

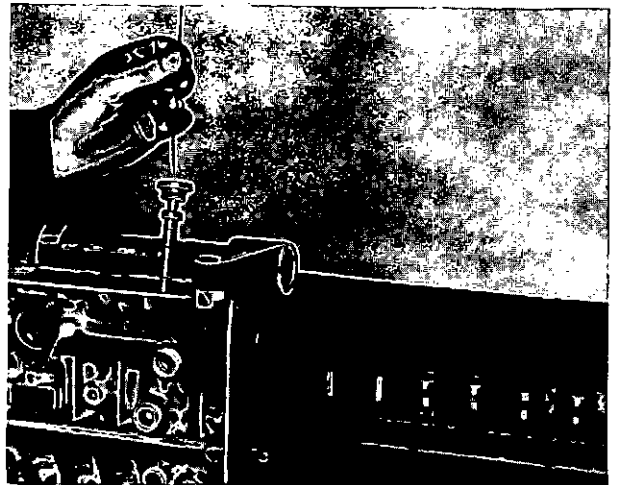


Fig. 14 Withdrawing plunger and lower spring plate

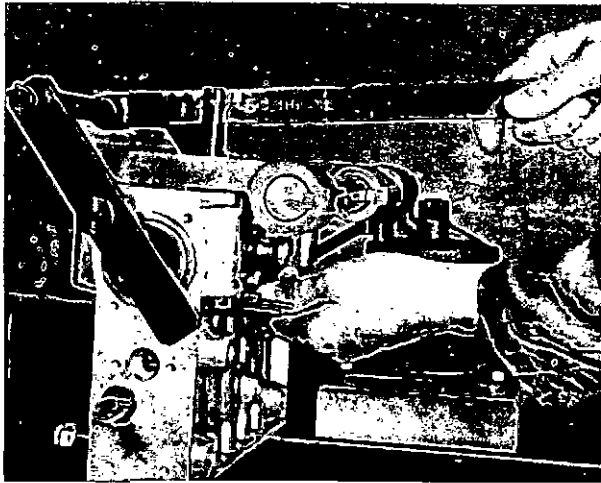


Fig. 12 Unloading plunger springs

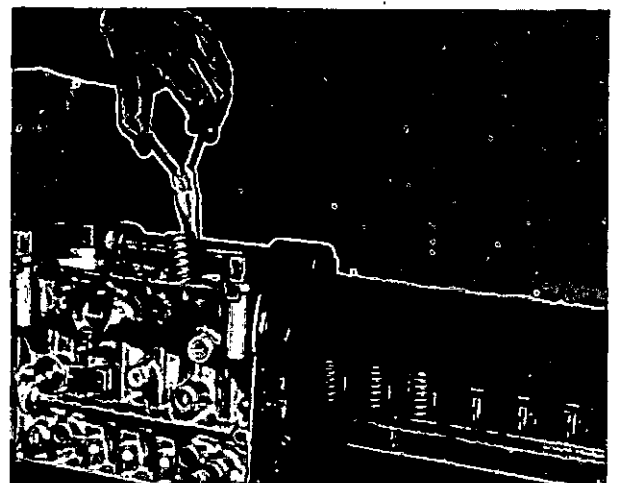


Fig. 15 Extracting plunger springs

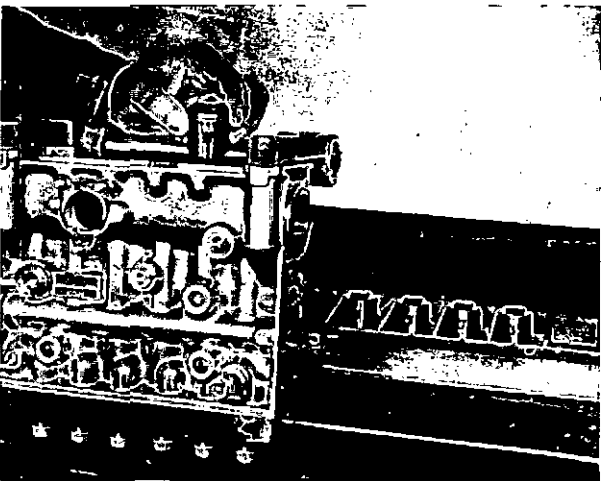


Fig. 13 Removing tappets

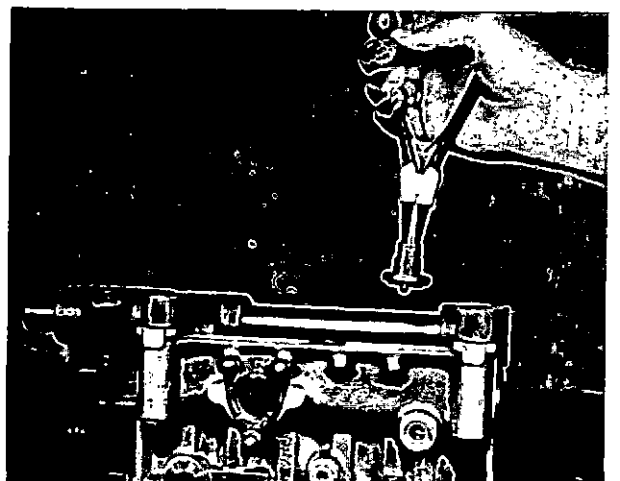


Fig. 16 Removing control sleeves and upper spring plates

16. Remove the circlip, baffle sleeve and 'O' ring from pump barrel. Remove 'O' ring, nylon ring and phasing shims from delivery valve flanged bush. Using mounting device 1 682 310 031 and ring spanner 1 687 950 525 (fig. 20) unscrew the connector from the flanged bush and remove the spring, delivery valve and washers.

CLEANING AND INSPECTION

Remove and discard all seals, joints and 'O' rings. Clean all parts in petrol or paraffin, using a soft brush, and dry them with a compressed air jet. Do NOT use cloth or rag for this purpose. Ensure that paired or associated components remain together.

Element plungers and their barrels must not be deeply scored, and the plunger helices should have clean sharp edges. If a plunger or barrel are unserviceable both components must be replaced by a mated assembly. Similarly, the delivery valve collar should not be deeply grooved and its face and seating must be unworn; these items must also be renewed as an assembly even if only one is unserviceable. When reconditioning a pump after prolonged service it is advisable to renew all pumping element and delivery valve assemblies as a matter of routine, thereby simplifying adjustment on the test rig and ensuring long-term reliability.

Inspect all other components for wear and damage, replacing them where necessary. Pay particular attention to cam lobes, tappet rollers, bearings and the ball notches in the control rack.

ASSEMBLING

1. Check camshaft projection as follows:
 - (a) Remove bearing outer race at governor end (fig. 21). Then press it in again until it protrudes 0.118 inch (0.3 mm), as shown by dimension 'a' in fig. 22.
 - (b) Place the adjusting plate on the outer race, fit the joint washer and governor housing and lightly tighten the securing screws. Then press the assembly fully home (fig. 23) fully tighten the securing screws.
 - (c) Insert the camshaft, complete with front and rear bearings but without centre bearing. Fit drive end bearing plate with same shims as found during dismantling, but omitting the 'O' ring, and tighten the retaining screws

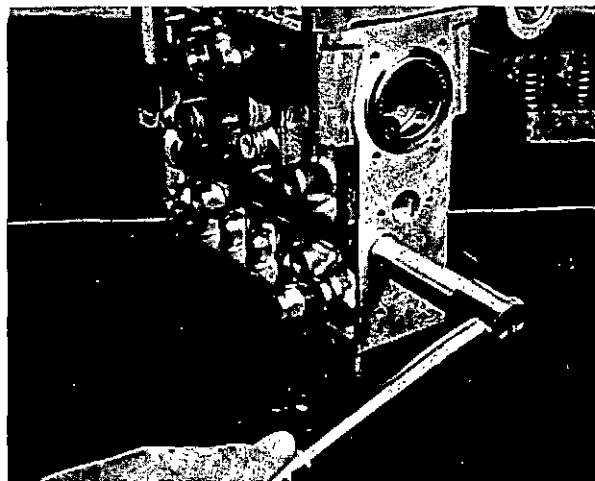


Fig. 17 Unscrewing threaded bush

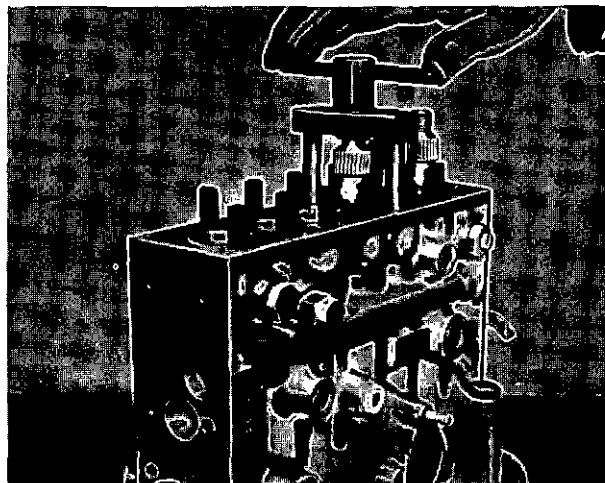


Fig. 18 Extracting delivery valve

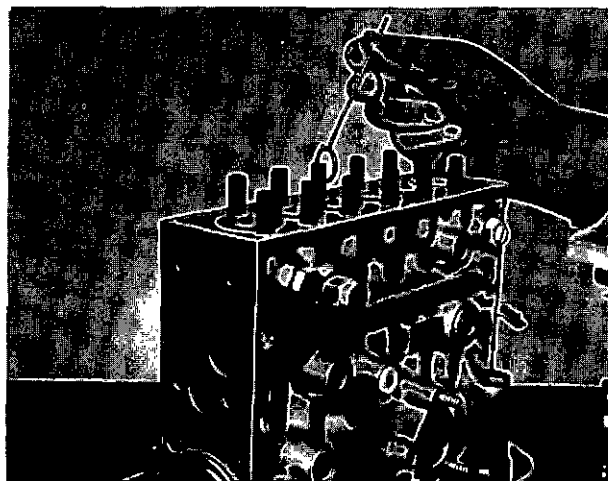


Fig. 19 Removing packings from housing

firmly. Press measuring bar 1 682 310 018 on to the camshaft taper and measure the clearance between bar and pump housing (fig. 24). Limits are 0.512 to 0.551 inch (13 to 14 mm.). If *below* limits, fit an appropriately thicker adjusting plate at the governor end and press the outer race further in, as in (b) above. If *above* limits, repeat (a) and (b), using an appropriately thinner adjusting plate.

- (d) When the projection is correct, remove the governor housing, adjusting plate and camshaft.

2. Assemble the barrel/delivery valve assemblies as follows:

- (a) Using mounting device 1 682 310 031 clamped in a vice, refer to fig. 25 and fit flange bushing (1); then insert pump barrel (2) so that the notch on its collar engages with the peg inside the flange bushing (the barrel must drop into position under its own weight). Assemble delivery valve (3), joint (4), spring (5) and washer (6). Fit 'O' ring (7) to connector (8) and screw the latter into the flange bushing (1). Finally, torque - tighten the connector to between 51 and 58 lbf.ft. (69 to 79 Nm) using socket 1 687 950 062 (fig. 26).
- (b) Refer to fig. 27 and slide washer (4) on to pump barrel (8) until it abuts against flange bushing (9); then assemble baffle sleeve (3), with its offset radial drillings away from flange bushing (9), and fit circlip (2). Finally fit Viton ring (1) to the lower groove of the pump barrel.

Note: Do not confuse this Viton ring with the rubber 'O' ring of similar size fitted to the pump casing bore. Distinguishing features are that the Viton ring is greyish in colour and slightly harder to compress. Fig. 28 shows the rubber ring 'a' and Viton ring 'b' under equal radial pressures.

Again referring to fig. 27, the 'O' ring (5), nylon ring (6) and phasing shims (7) are not fitted until the barrel/delivery valve unit is assembled to the pump housing (Operations 4 and 5).

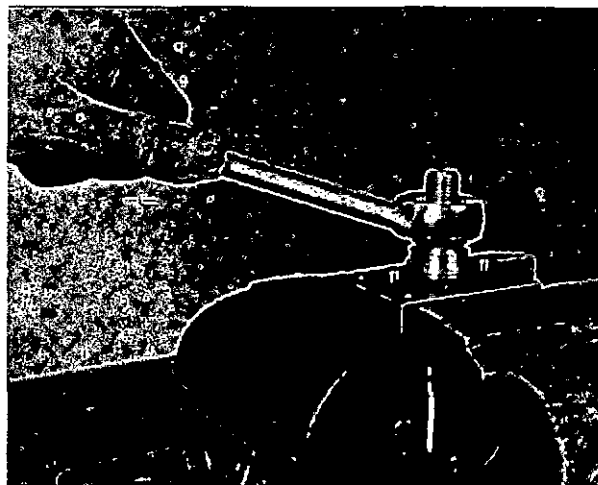


Fig. 20 Dismantling barrel/delivery valve assembly

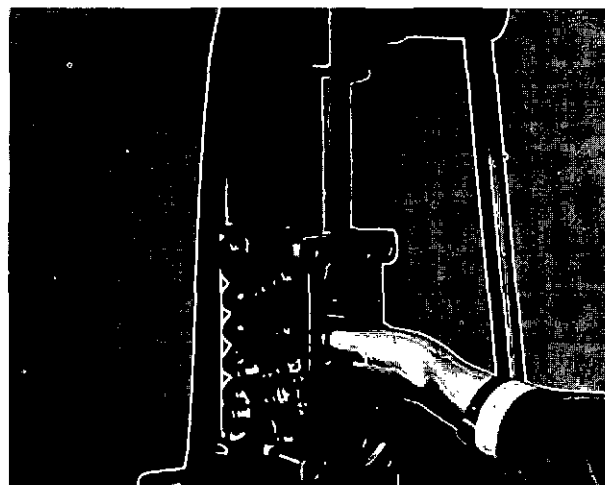


Fig. 21 Removing outer race from governor end

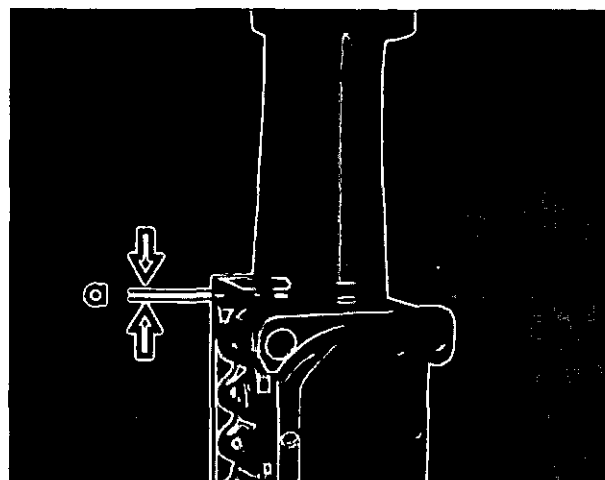


Fig. 22 Re-positioning outer race (first operation)

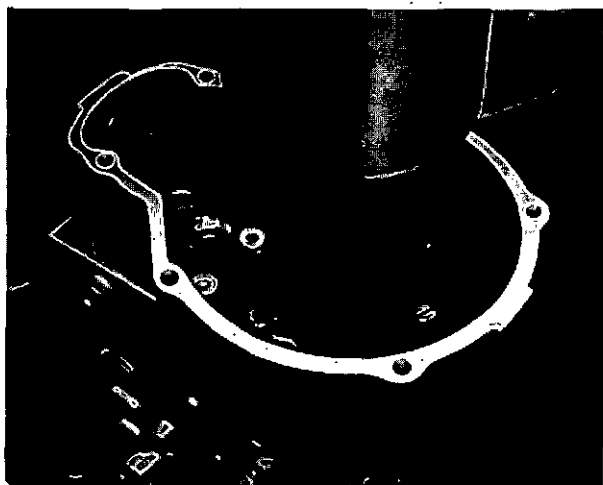


Fig. 23 Re-positioning outer race (second operation)

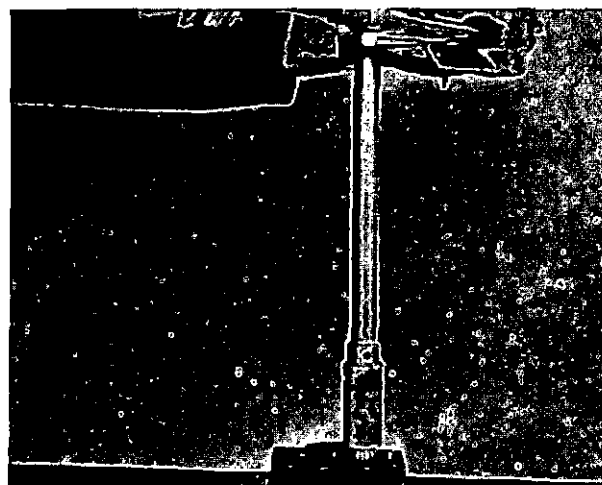


Fig. 26 Tightening connector

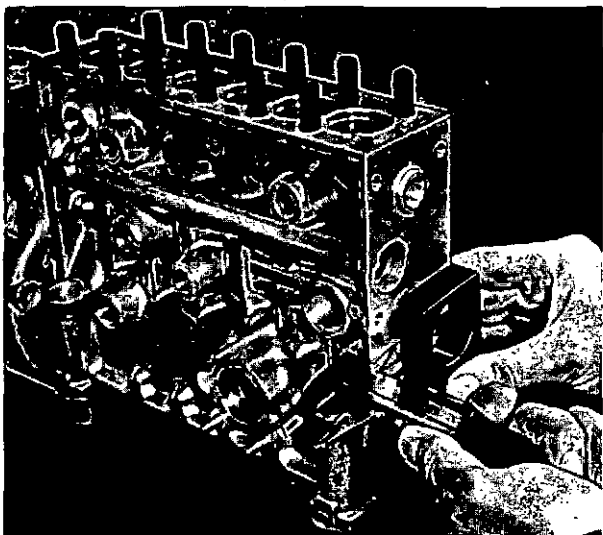


Fig. 24 Measuring camshaft position

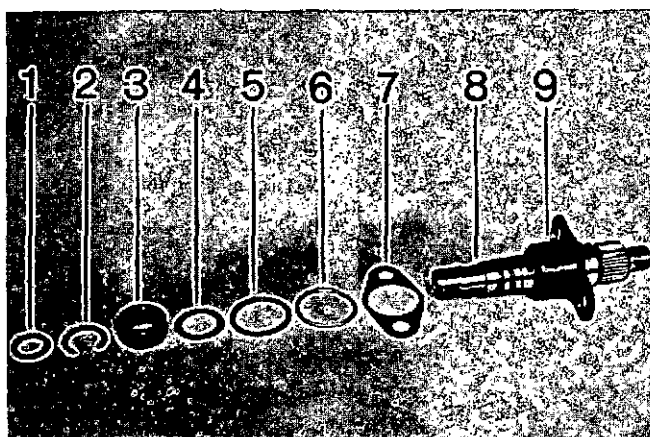


Fig. 27 Mounting components - barrel to pump casing

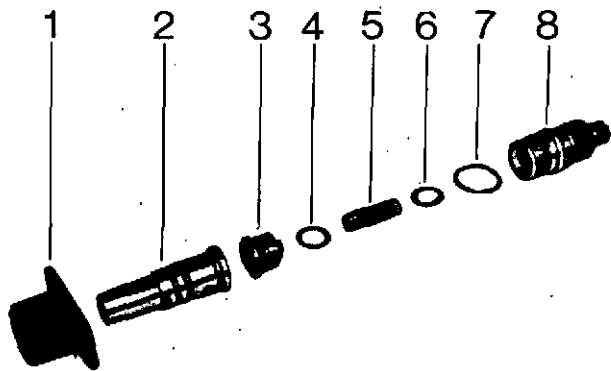


Fig. 25 Barrel delivery valve assembly - exploded

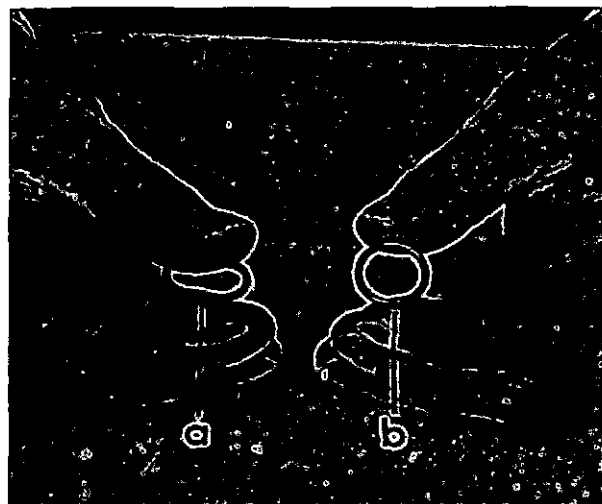


Fig. 28 Comparing rubber ring 'a' with Viton ring 'b'

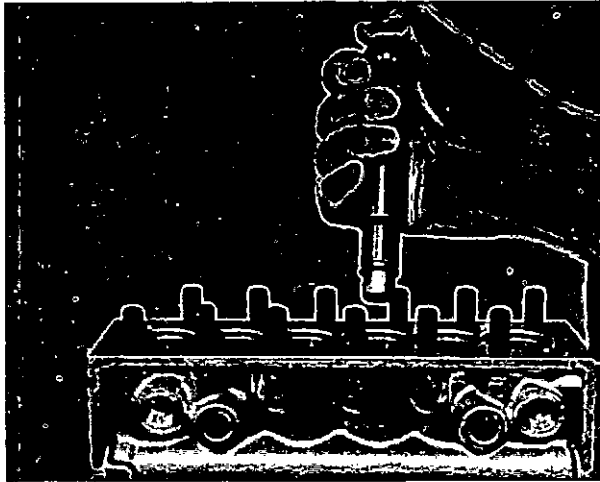


Fig. 29 Fitting rubber 'O' ring

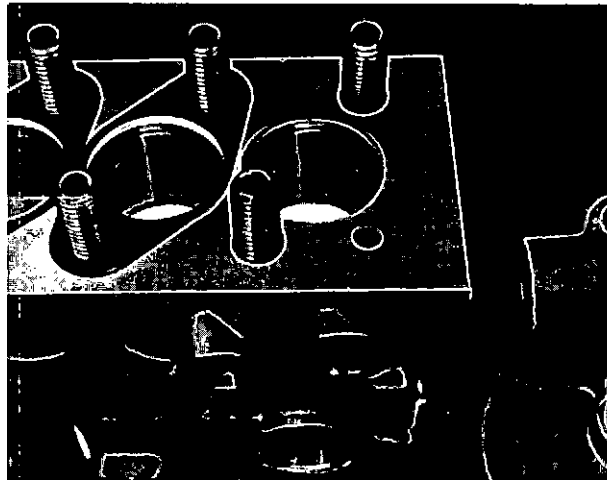


Fig. 30 Fitting 'O' rings, nylon rings and phasing shims



Fig. 31 Inserting barrel delivery valve assembly

3. Using tool 1 688 110 028, fit a rubber 'O' ring, see NOTE in 2 (b), to each bore (fig. 29). Depress tool plunger, fit a greased ring, enter tool fully into bore and release plunger.
4. Fit a greased 'O' ring, nylon ring and shim (fig. 27, Items 5, 6, and 7) to each port (fig. 30). NOTE: On pumps with numbers prefixed '626' and later the nylon ring is superseded by a steel ring permanently pressed on the flange bushing (fig. 25, Item 1), the port recesses are deeper, and protruding two-piece shims are used.
5. Insert the barrel/delivery valve assemblies, each with the drilling for the flange bushing peg (arrowed, fig. 31) towards the pump rack. Ease the units into place by gentle downward pressure and rocking, using ring spanner 1 687 950 525 (fig. 32). Fit the plain washers, spring washers and nuts, finger-tight; position each assembly with its securing studs at mid-point of the adjusting slots and tighten the nuts evenly to between 29 and 32 lbf.ft. (39 and 44 Nm).
6. Invert the pump, dip the plungers in clean fuel oil and fit them to their respective barrels, using pliers 0 681 340 003. Secure them by screwing six retaining pins (locally made from mild steel to the dimensions in fig. 33) into the tappet holder holes. Remove the pump from its mounting rig, connect an air-line to the fuel inlet gallery and blank off the spill connection. Immerse the pump, upside down, in fuel oil and admit air at 35 lbf./sq. inch (241 kN/sq.m) to the inlet gallery (fig. 34). There must be *no leakage* from the casting or pump barrels; this is *most important*, since any internal leakage (e.g. from damaged seals) can result in fuel oil entering the engine lubrication system via the injection pump. Small white bubbles at the plungers and delivery pipe connections may be disregarded.
7. Remove the pump from the test tank and re-mount it on the rig. Invert it and remove the retaining pins and plungers fitted for the pressure test.
8. Enter the control rack, with its guide block and travel limiting pin, from the governor end (fig. 35), aligning the vertical guide with the edge of the pump housing as shown.

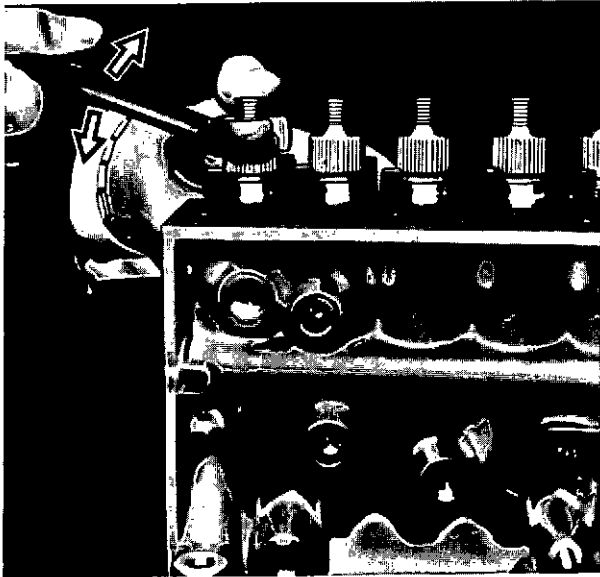


Fig. 32 Easing assembly into place

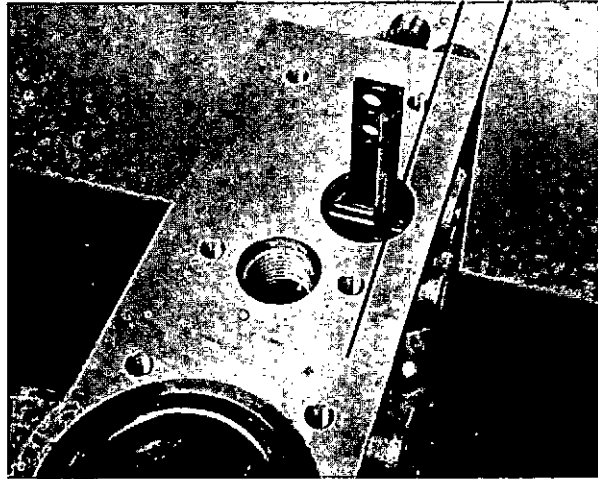


Fig. 35 Alignment of control rack

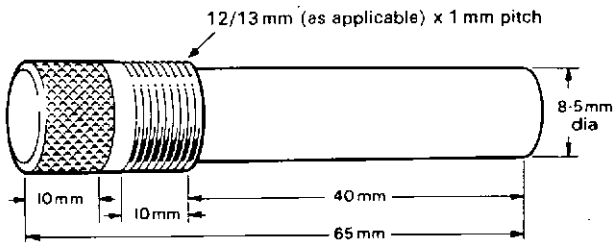


Fig. 33 Plunger retaining pin for pressure test

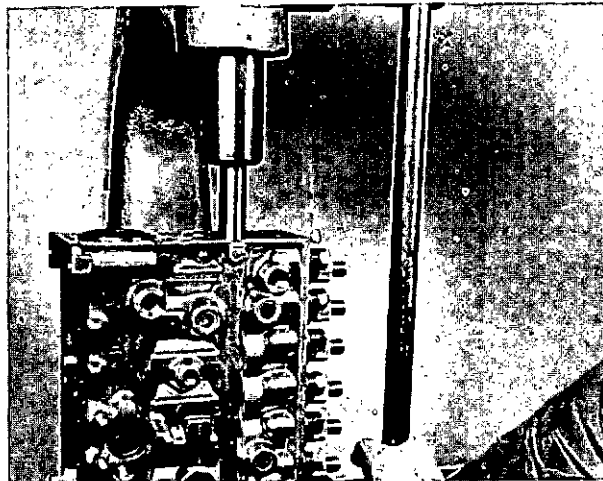


Fig. 36 Pressing in guide block

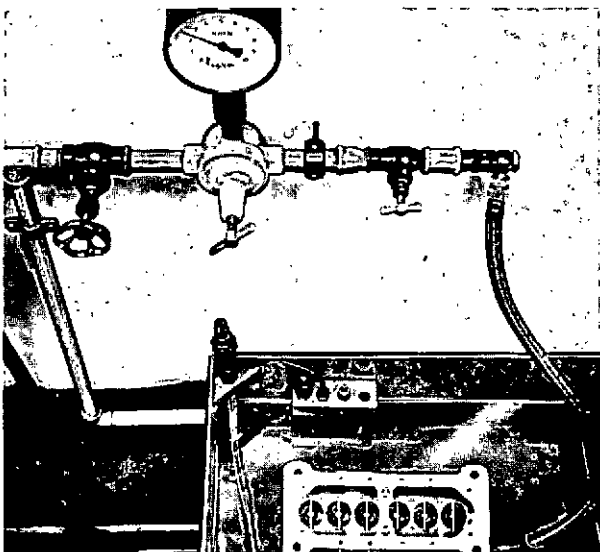


Fig. 34 Pressure test

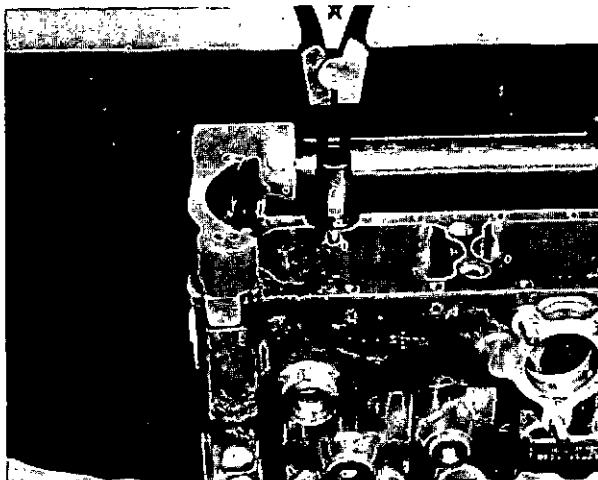


Fig. 37 Fitting control sleeves

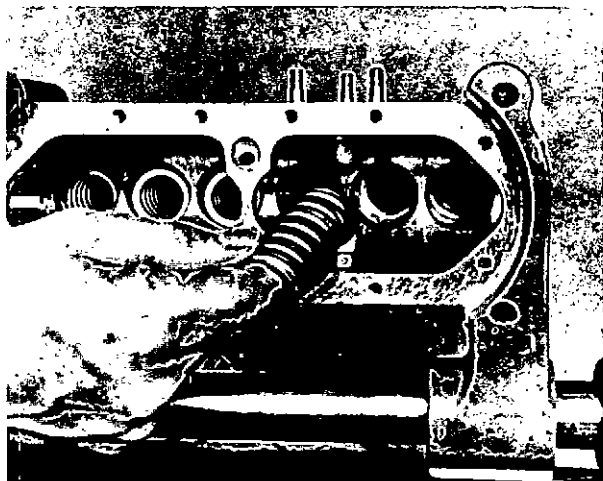


Fig. 38 Inserting upper plate and plunger spring

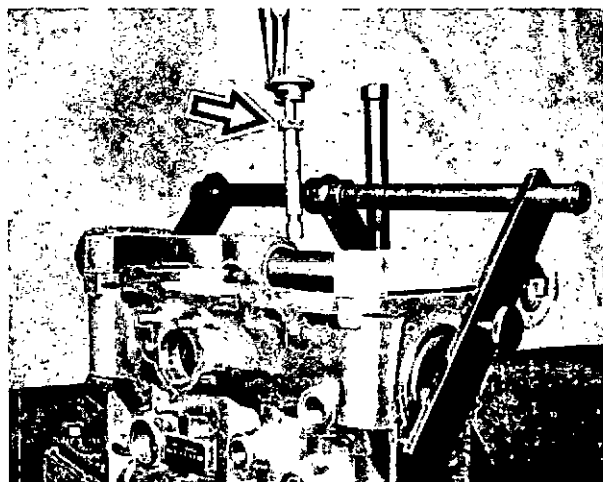


Fig. 39 Fitting plunger and lower plate

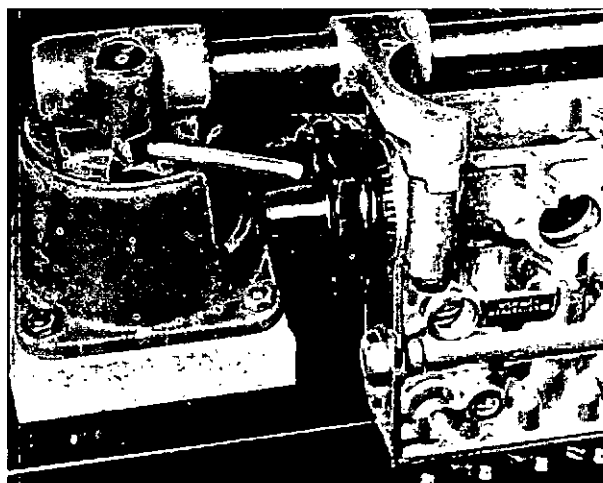


Fig. 40 Assembling drive end bearing

9. Use a suitable tube to press the guide block fully home (fig. 36), taking care that it does not become tilted. Secure it by screwing in the threaded bush to a torque loading of 22 to 29 lbf. ft. (30 to 39 Nm), using pin spanner 1 687 950 075.
10. Assemble the guide block at the drive end of the control rack (in this instance no pressure is necessary) and retain it by fitting the blanking plug.
11. Set the control rack to mid-position (i.e. with control sleeve notches in line with tappet guides) and fit the control sleeves (fig. 37), ensuring that in each case the driving ball is engaged with the rack notch. Check that the rack has free and full movement.
12. Insert the upper spring plates and plunger springs (fig. 38).
13. Fit spring compressing tool 1 688 110 027 and pivot bar 1 683 001 003 to the pump housing. On each element in turn:
 - (a) Fit the lower spring plate to its plunger and insert the assembly into its barrel (see fig. 39) with the line on the plunger towards the rack, as indicated by the arrow.
 - (b) Assemble the tappet, compress its spring and use holder 1 681 115 12F to retain it until the camshaft has been fitted. Screw the holder element and guide sleeve, without the capscrew, fully into the access tapping. Then fit the capscrew, tightening it until the tappet roller is 2.527 inches (64.2 mm) from the lower joint face of the pump casing.
14. Fit the governor housing and joint washer, together with the appropriate adjusting plate as determined in Operation 1. Enter the camshaft from the drive end and fit the new centre bearing tightening its two socket screws to between 5

and 6.5 lbf.ft. (8 to 9 Nm). Assemble the drive end bearing plate with shims, but omitting the 'O' ring (fig. 40).

15. Measure the camshaft end float by using tool 0 681 440 013, screwed on to the drivenut thread, and dial gauge 1 687 233 011, as shown in fig. 41. Limits are 0.0008 to 0.0024 inch (0.02 to 0.06 mm.). Adjust if necessary by varying the shims beneath the bearing plate. Fit the 'O' ring when finally assembling the bearing plate.
16. Using a new joint gasket, fit the base cover plate.
17. Turn the pump upright. In turn, bring each tappet to TDC and unscrew the tappet holder 1 681 115 12F (fig. 42). When all tappet holders are removed, fit the blanking screws to the tappet access holes.
18. Fit the feed pump. Assemble the governor as described in Part 3, prime the unit with engine lubricating oil, and carry out Test Procedure as described in Part 5.

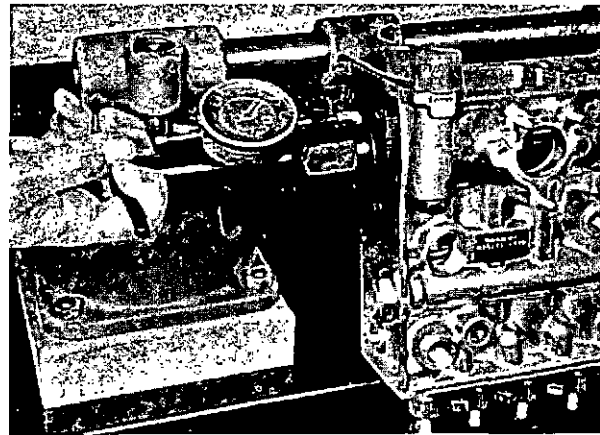


Fig. 41 Checking camshaft end float

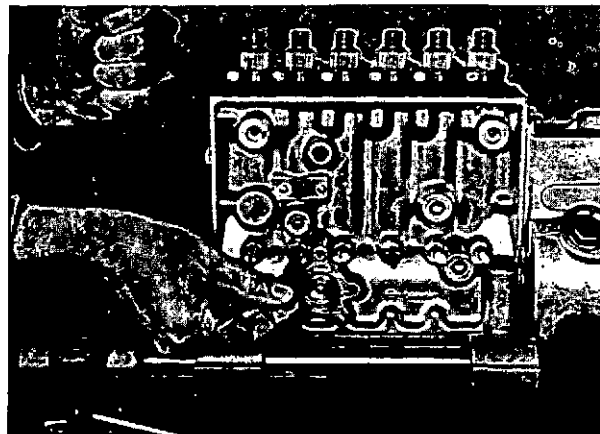


Fig. 42 Removing tappet holders

SPECIAL TOOLS — BOSCH 'PE' PUMP

Bosch Part No.	Description
0 681 240 048	Swivel vice
1 682 310 031	Mounting device, element
1 687 950 062	Spanner, socket, delivery valve connector.
1 688 110 026	Extractor, element
1 680 363 001	*Extractor, governor flyweights
1 687 950 525	Spanner, open ring, delivery valve connector
1 681 115 12F	Tappet holder (one per element)
1 687 950 064	*Spanner, governor nut
1 688 110 027	Compressing tool, element springs, 6-element pumps
1 683 001 003	Pivot bar
1 682 310 018	Measuring bar, camshaft position
1 688 110 028	Inserting tool, 'O' rings in pump bores
1 687 950 075	Spanner, pin, threaded bush
0 681 340 003	Pliers, plunger inserting
1 682 329 011	Bracket, camshaft bearing plate extractor
1 688 130 019	Measuring tool, camshaft end float, less dial gauge
1 687 233 011	† Dial gauge for 1 688 130 019

*Also listed in 'SPECIAL TOOLS, BOSCH RQV GOVERNOR,' Part 3 of this Section

† Also listed in 'Special tools, Test Procedure,' Part 5 of this Section

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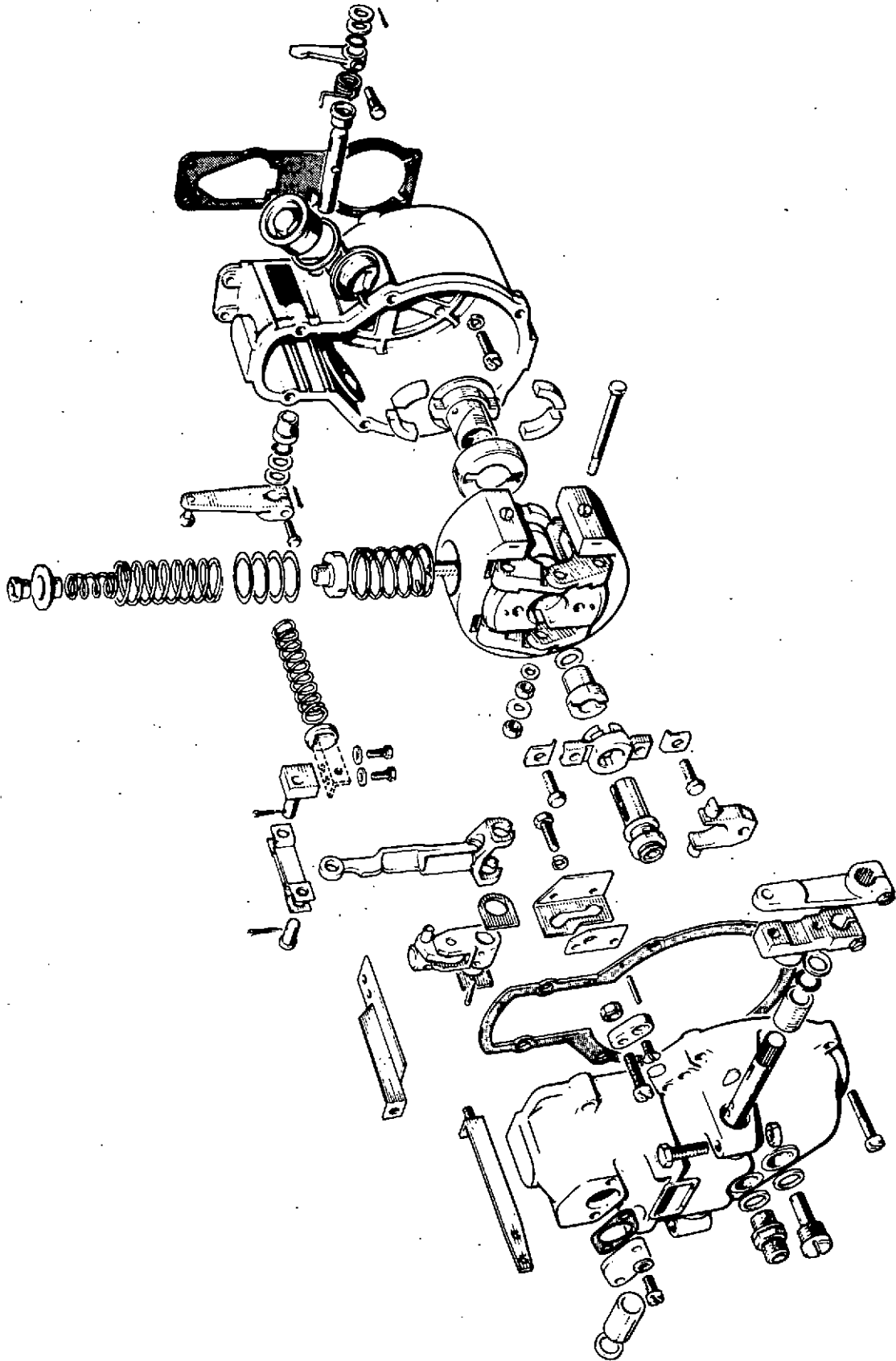


Fig. 43 Typical governor

PART 3 — GOVERNOR, TYPE RQV

As explained and illustrated early in Part 2, the governor is best dismantled when it and the injection pump have been drained of lubricating oil (by removing the feed pump and filler plug) and mounted on a suitable rig, such as the swivel vice 0 681 240 048 shown in fig. 6.

DISMANTLING

1. Unscrew the guide pin (fig. 44, Item 'B') from the rear cover. This pin is assembled with sealing compound and its removal requires an adequate and well-fitting screwdriver.

Remove the six retaining setscrews and carefully tap the rear cover with a soft mallet to break the joint. Position the control arm vertically and withdraw the cover after raising it to disengage the sliding block (arrowed, fig. 45) from the floating lever (fig. 46, Item 'B').

2. Again referring to fig. 46, remove link pin 'A' and tie the link fork out of the way. Pull back the slider 'E' with the floating lever 'B', turn lever 'B' clear of the rack extension, swing it back 90 degrees and lift it away, together with the slider. Unlock and unscrew the nuts 'C' from the coupling bolt and remove the bolt. The adjusting pin 'F' can then be withdrawn from the governor hub. Unscrew the two bolts 'D' and remove the guide bush.
3. Clamp the camshaft at its drive end and, using spanner 1 687 950 064, remove the flyweight assembly retaining nut and, if applicable, end float adjusting washer. Use extractor 1 680 363 001 (fig. 47) to withdraw the flyweight assembly from the taper on the pump camshaft.

INSPECTION AND REPAIR

Wash all parts in paraffin and dry off with a compressed air jet. Discard used joints, splitpins and tabwashers.

Inspect each component for wear and damage, renewing where necessary. If required, instructions for reclaiming certain parts (e.g. flyweights) may be obtained from the Manufacturer, but in general it is

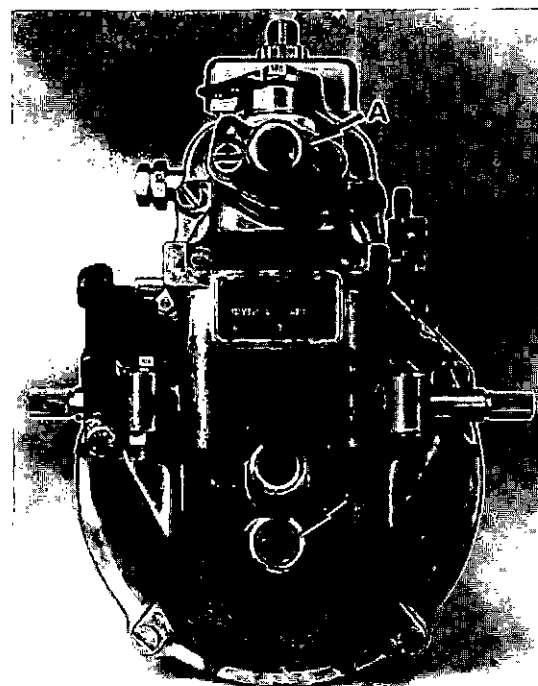


Fig. 44 Rear cover, showing rack access 'A' guide pin 'B'

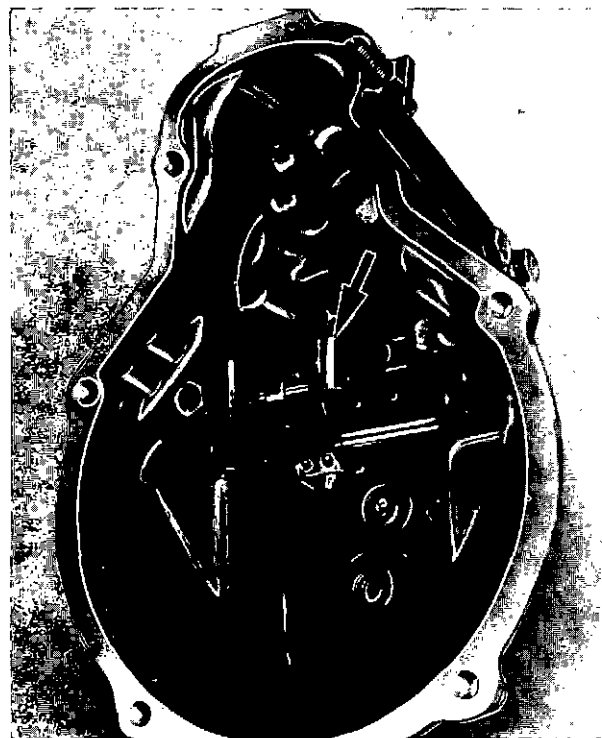


Fig. 45 Rear cover interior; sliding block arrowed

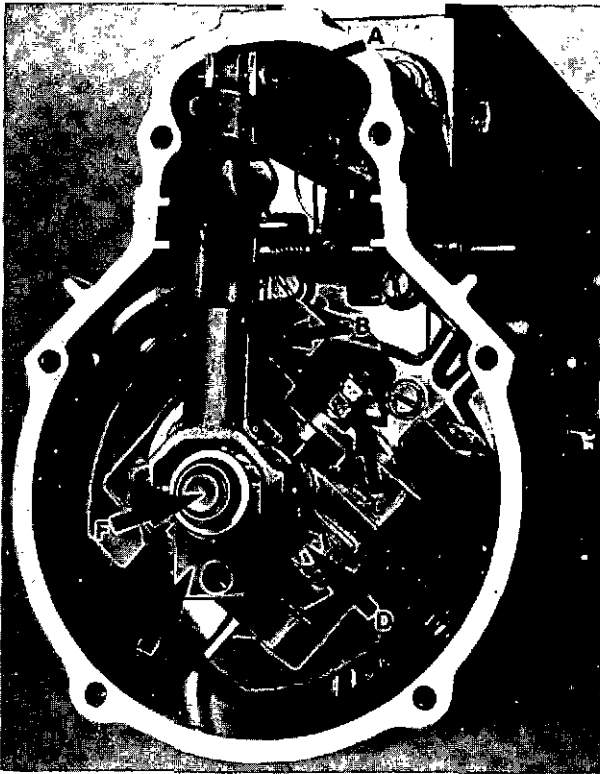


Fig. 46 Governor with rear cover removed

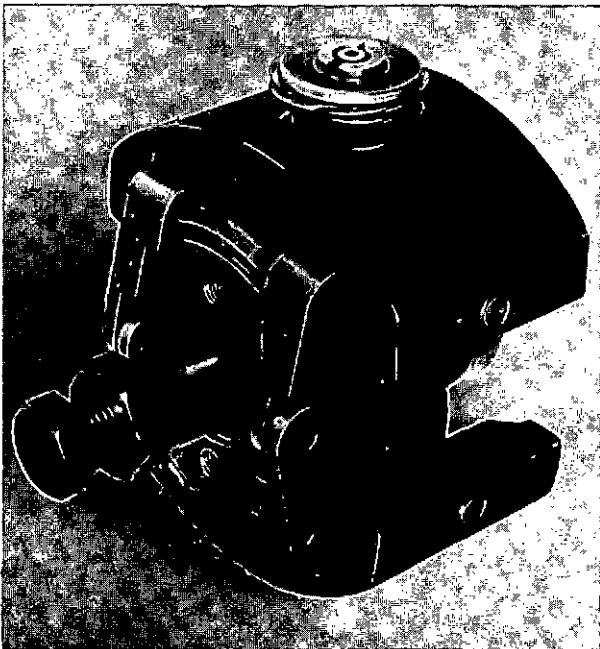


Fig. 47 Flyweight unit and extractor

recommended that if examination reveals excessive damage or accumulative wear the complete flyweight assembly be renewed. In addition to the rotating parts, closely inspect the linkwork, pins and guide slots for excessive clearances or damage, renewing components if defects are other than superficial (e.g. small burrs which can be stoned off) since these will tend to cause erratic governing.

Renewing flyweight assembly

If a new flyweight assembly is to be fitted its end float when mounted on the camshaft must first be checked and adjusted if necessary. For this purpose there must be no rubber blocks in the hub coupling.

Clamp the camshaft drive end, assemble the flyweight to its taper, fit the adjusting washer and retaining nut and tighten the nut to 36 lb. ft. (5 kg. m.). Check that, with the camshaft held stationary, the flyweight assembly can be rotated between the rubber block stops and has an end float of between 0.002 and 0.004 inch (0.05 and 0.1 mm.). Adjust, if necessary, by varying the thickness of the washer beneath the retaining nut. On completion of this check, remove the flyweight assembly from the camshaft and fit the rubber blocks to the hub as described below.

Renewing rubber blocks in hub

The four rubber blocks of the cushion drive in the flyweight hub may be renewed by levering the coupling out of the articulation piece (fig. 48).

Lightly lubricate the new blocks, and enter them whilst refitting the coupling (fig. 49). Take great care to avoid cutting or otherwise damaging the rubber. Finally, tap or press the coupling fully home in the articulation piece.

Renewing flyweight springs

Remove both sets of springs by unscrewing their retaining nuts with spanner 1 687 950 000. Note any shims beneath them. If replacement springs are to be fitted, refer to the Parts Book to ensure that they are of the correct type for the governor specification. When replacing springs, screw their retaining nut to the basic setting shown in fig. 50 ensuring that this is identical on both spring assemblies.

Note: Springs may be changed on an installed governor via the oil filler orifice, as shown in fig. 51. A special tool 1 683 455 000, which engages with the filler cap thread, is available for this purpose.

Adjusting pin

This pin (fig. 52) connects the flyweight coupling bolt to the slider in the governor hub. Check that its spring and bearing surfaces are serviceable. The setting of the pin should not be disturbed unnecessarily but if adjustment is unavoidable it should be carried out as described later, under 'ASSEMBLING' and also in Part 5, Stage 'B'.

ASSEMBLING

1. Ensure that the tapers of the camshaft and governor hub are clean and undamaged. Although a keyway may be machined in the camshaft taper, no key is used. Assemble the flyweight unit to the camshaft and fit the adjusting washer and retaining nut. Clamp the drive end of the camshaft and tighten the retaining nut to 36 lbf.ft. (49 Nm) using spanner 1 687 950 064. After tightening, check by moving the flyweight assembly about the camshaft that the cushion drive in its hub is free to operate.
2. Fit the guide bush, tighten its securing bolts (fig. 46, Item 'D') and bend up their locking tabs. A sectioned view of the governor assembled to this stage is shown in fig. 53.
3. Check that the internal spring of the adjusting pin (fig. 52) has no end play and yet is not compressed. Adjust, if necessary, by turning the castellated carrier bolt relative to the eyed bearing bolt at the opposite end. Finally, set the bearing bolt 2 mm. below the end face of the adjusting bush, as shown, and assemble the adjusting pin to the guide bush bore, securing it by temporarily fitting the coupling bolt (fig. 54), which passes through the eye of the bearing bolt.
4. Pull the adjusting pin rearwards sufficiently to draw the flyweights inwards, but without exerting excessive load on the internal spring of the pin. In this position the measuring gauge 1 682 329 038 should fit snugly into the slider recess of the adjusting pin (figs. 52 and 55). Adjust, if necessary, by means of the bearing bolt in the adjusting pin, as shown in fig. 54.
5. Assemble the coupling bolt so that it has end float of 0.040 to 0.080 inch (1 to 2 mm.), tighten its two nuts together and bend their lockwasher over one flat of each. Mount the slider and floating lever and fit the link pin, together with its splitpin (fig. 56).

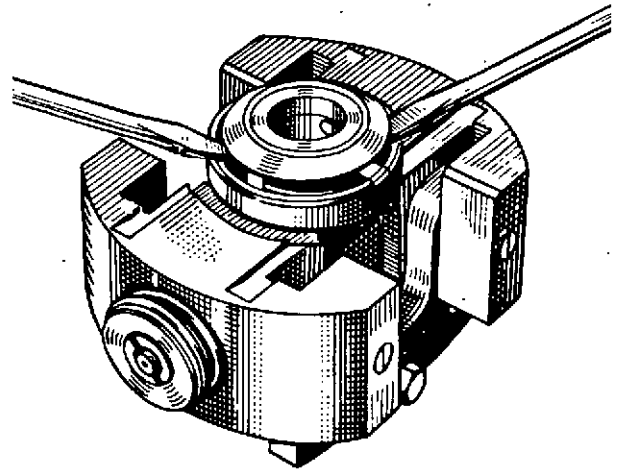


Fig. 48 Removing coupling and rubber blocks

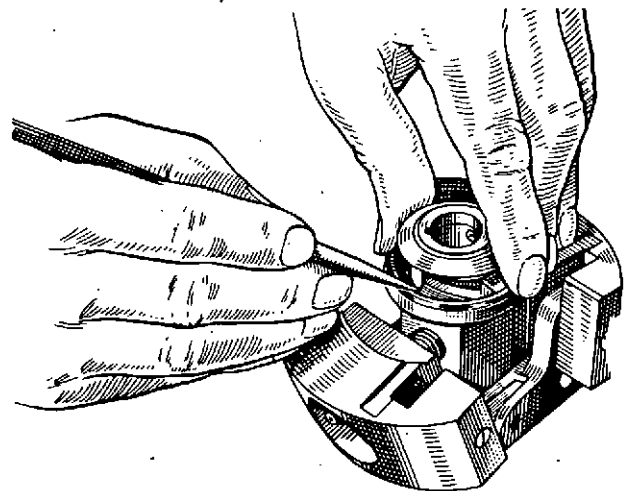


Fig. 49 Fitting coupling and rubber blocks

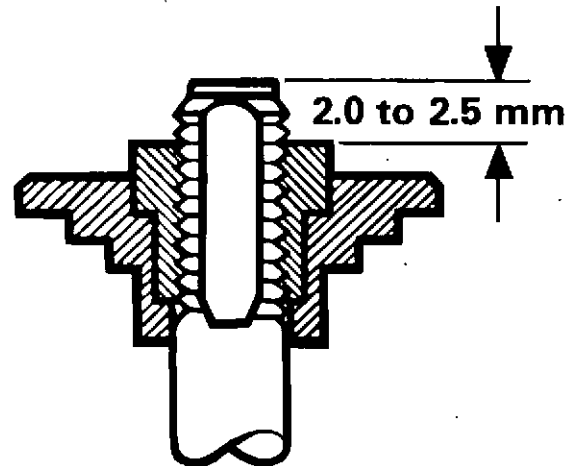


Fig. 50 Flyweight spring basic setting

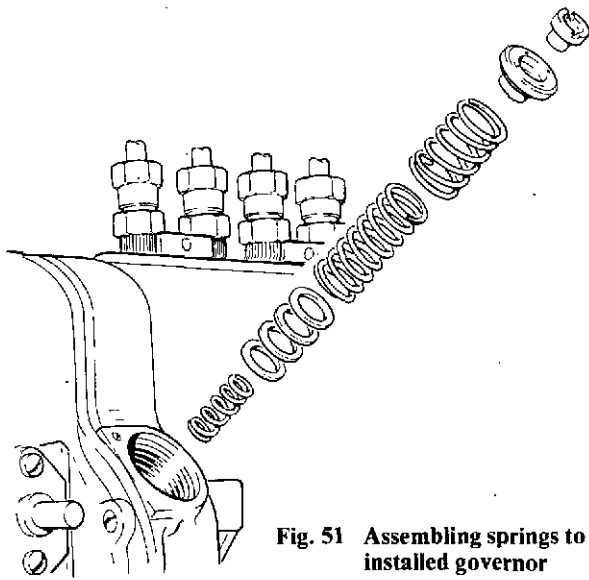


Fig. 51 Assembling springs to installed governor

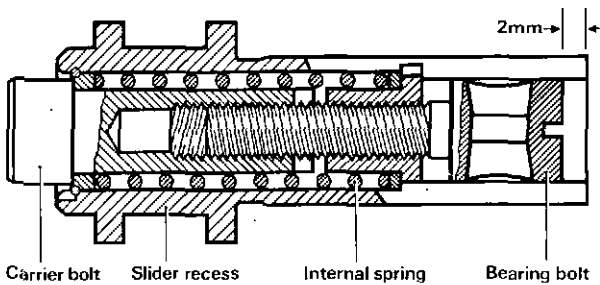


Fig. 52 Adjusting pin - sectioned

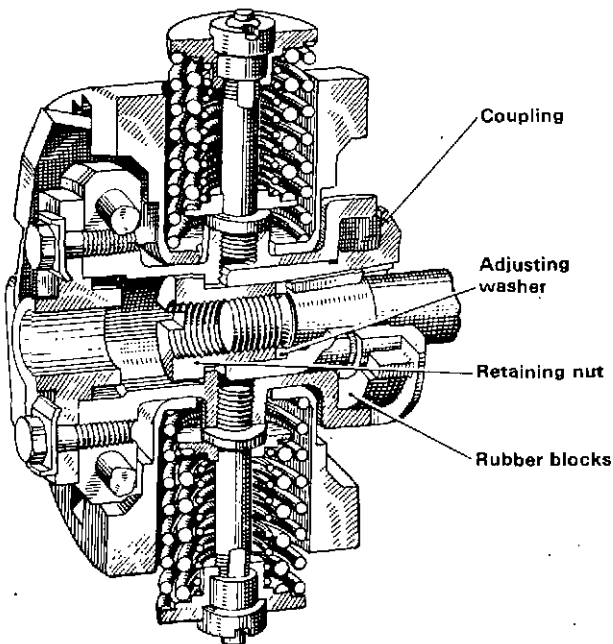


Fig. 53 Flyweight assembly - sectioned

6. Invert the governor rear cover and set the control lever to MAX. FUEL so that the pilot pin is at the bottom of the 'S' curve. Place a new gasket on the joint face and measure the distance between the gasket and the pilot pin, as in fig. 57. this dimension, to the *centre* of the pin, should be 0.965 inch (24.5 mm.). Using the depth gauge as illustrated, *deduct* from its reading the thickness of the measuring bar and *add* 0.118 inch (3mm.), which is half the diameter of the pilot pin. Adjust, if necessary, by means of shims beneath the 'S' curve plate.
7. Fit the feed pump and prime the injection pump with adequate engine lubricating oil for test running.
8. Final fitting of the governor rear cover is carried out during Stage 'B' of the Test Procedure (see Part 5). Concerning this, the following instructions are particularly important:
 - (a) Apply a non-setting compound to both sides of the joint gasket.
 - (b) Ensure that the sliding block is positioned with its long section uppermost (fig. 45) when it enters the slotted recess in the floating lever (fig. 46, Item 'B').
 - (c) Seal the guide pin thread with Loctite 241.

SPECIAL TOOLS — BOSCH RQV GOVERNOR

Bosch Part No.	Description
1 687 950 064	*Spanner, governor nut
1 680 363 001	*Extractor, governor flyweights
1 682 329 038	Measuring device, sliding sleeve position
1 683 455 000	Compressing tool, governor springs
1 687 950 000	Spanner, adjusting governor springs

*Also listed in 'SPECIAL TOOLS, 'PE' PUMP', Part of this Section

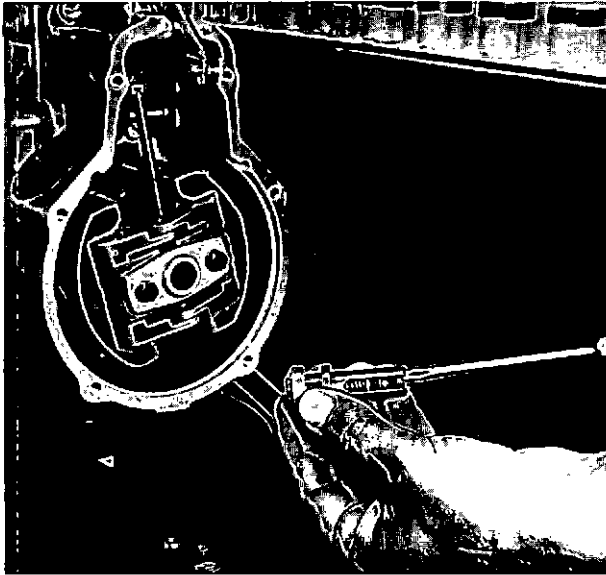


Fig. 54 Adjusting pin and coupling bolt

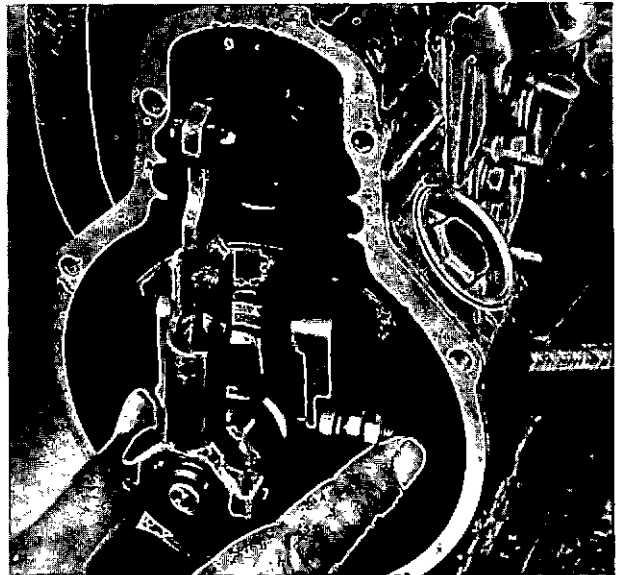


Fig. 56 Coupling bolt, floating lever and slider



Fig. 55 Gauge for checking sliding sleeve position

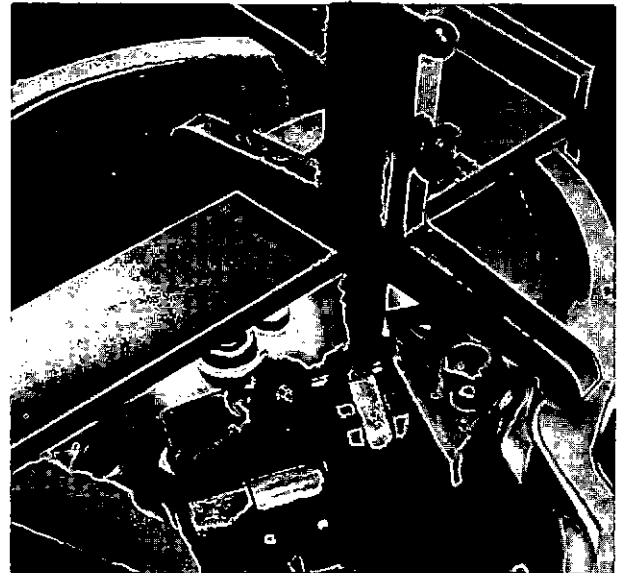


Fig. 57 Checking position of 'S' plate



PART 4 — FEED PUMP, TYPE FP/KD 22P

DESCRIPTION

This pump (fig. 58) is of the spring-loaded plunger type, mounted on the injection pump and operated by a double eccentric on the camshaft. Four spring-loaded nylon valves, two inlet and two delivery, are carried in the pump body. A hand-operated plunger pump for priming purposes is mounted above one of the inlet valves; the plunger must be lightly screwed down against its sealing washer when not in use to prevent leakage of fuel.

DISMANTLING AND INSPECTION

Before removing the feed pump from the injection pump, slacken the priming pump casing, the blanking plugs above the remaining three valves and the plug retaining the plunger spring. Remove the priming pump and dismantle the four valves and their springs. Unscrew the plunger and spindle. Remove the circlip retaining the tappet assembly and withdraw the unit.

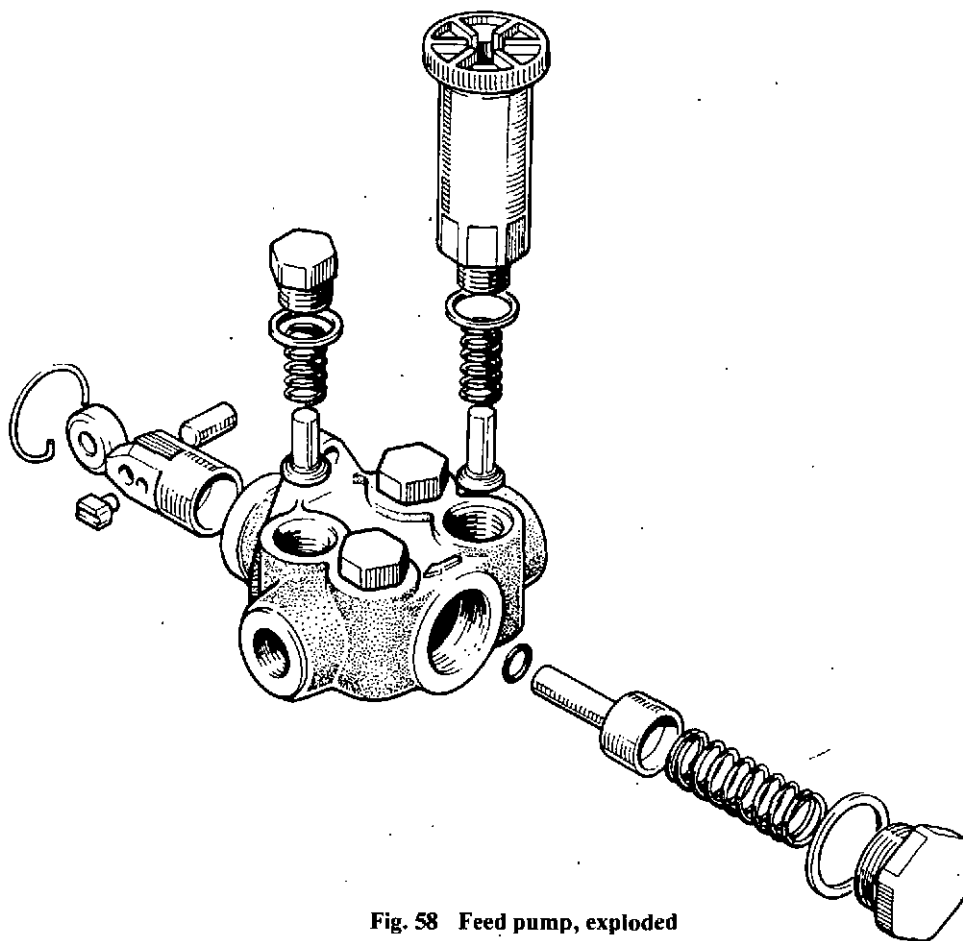


Fig. 58 Feed pump, exploded

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Check that the valves are seating correctly and that their springs are in good condition.

Inspect the plunger and its spindle for wear and scores. NOTE: These two components are matched by the Manufacturer and identified by a colour code; replacements should be to the same standard. Check also that their spring is in good condition.

Examine the plunger and tappet bores in the housing for scores and wear. Renew the 'O' ring if its condition is at all doubtful. Dismantle the tappet assembly and inspect its components for wear and damage, renewing them as necessary.

Check the action of the hand priming pump. This cannot be dismantled and must be replaced as a unit if unserviceable.

ASSEMBLING

Ensure that all parts are thoroughly clean and lightly oiled. Assemble the pump in the reverse of dismantling sequence, using new joint washers. If possible, carry out a leakage test by blanking off the outlet connection and applying air pressure at 28 lbf./sq. inch (193 kN/sq.m) to the inlet connection with the pump immersed in fuel oil. Check for air bubbles, operating the plunger to ensure that there is no leakage from the tappet bore.

Check pump output during testing of the injection pump. The low-pressure relief valve is carried in the bolt securing the spill pipe banjo to the injection pump gallery and opens at 15 to 22 lbf./sq. inch (104 to 152 kN/sq.m); feed pump output pressure at operating speed should easily exceed this. If required, particulars of further tests involving special apparatus are available from the Manufacturer.

PART 5 — TEST PROCEDURE

EQUIPMENT SPECIFICATION

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Bosch Part No.	Description
—	Test Bench, Bosch 385
1681 443 022	*Test injector, 175 ats., 12 mm and 13mm bore pumps (1 per element)
1680 750 060	*HP pipe, 12 mm and 13 mm bore pumps (1 per element)
1686 430 007	*Drive coupling
1417 413 025	*Overflow valve
1688 130 085	Measuring rig, plunger lift, less dial gauge
1687 233 011	† Dial gauge for 1688 130 085
1688 130 030	Measuring rig, rack travel, less dial gauge
1687 233 015	Dial gauge for 1688 130 030
1687 950 525	† Spanner, open ring, delivery valve
0681 440 006	Setting rig, control lever position
1688 130 095	Measuring rig, sliding sleeve travel

* If a Hartridge 1100 Test Bench is used these items are replaced by the following, and the Bosch FP/KD feed pump, together with its pressure relief valve on the injection pump, are included in the circuit.

Rolls-Royce Part No.	CAV/Hartridge Part No.	No. off	Description
—	7244-108	Set of 6	Test injectors, 175 ats., 12 and 13 mm. bore pumps
OD 18514	—	1 per element	HP pipe, 8 x 3 x 760 mm., 12 and 13 mm. bore pumps
OD 18526	AFB 27	4	Holding-down bolt
OD 18527	FP164	4	Banjo union
OD 18528	Banjo union		
OD 18529	AT 16/24/8	3	Banjo bolt, 14 x 1.5 mm
OD 18530	ALP 104	4	Pipe, flexible
OD 17531	FP 383	1	Drive coupling, 25 mm. taper
—	—	8	Washer, copper, 14 mm.

† Also listed in 'SPECIAL TOOLS, BOSCH PE PUMP' (see Part 2)

Test Oils

Bosch: 01 61 v 11	Shell (Overseas): Calibration Fluid B
Esso: Calibration Fluid 1L 1838	Shell (UK): Calibration Fluid C

TEST SEQUENCE

Testing is done with the pump mounted on the test bench, using the equipment specified. The Test Schedule appropriate to the engine application, as listed at the end of this Part, is then carried out in the following three-stage sequence:

- A Pump pre-stroke setting, phasing and calibrating
- B Governor setting
- C Final setting of pump/governor assembly

**STAGE 'A' — PRE-STROKE SETTING
PHASING AND CALIBRATING**

NOTE: The operations in this Stage are carried out with the governor rear cover removed.

1. Pre-stroke setting

This involves setting the plunger lift to port closure on No. 1 element, as follows:

- (i) Remove the LP relief valve assembly and fit a blanking plug similar to that at the other end of the inlet gallery.
- (ii) Unscrew the access plug to No. 1 tappet (see fig. 59, Item 'A') and turn the camshaft until No. 1 tappet is approximately at BDC.
- (iii) Referring to fig. 60, fit measuring rig 1 688 130 085 to the access plug tapping, ensuring that the probe rests on the upper edge of No. 1 tappet, as in the inset. Assemble dial gauge 1 687 233 011 to the rig and set it to zero.

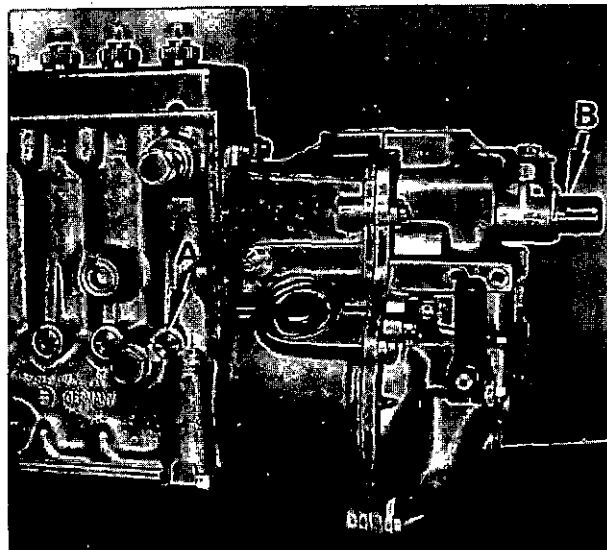


Fig. 59 Tappet access plug 'A'. Rack stop locknut 'B'

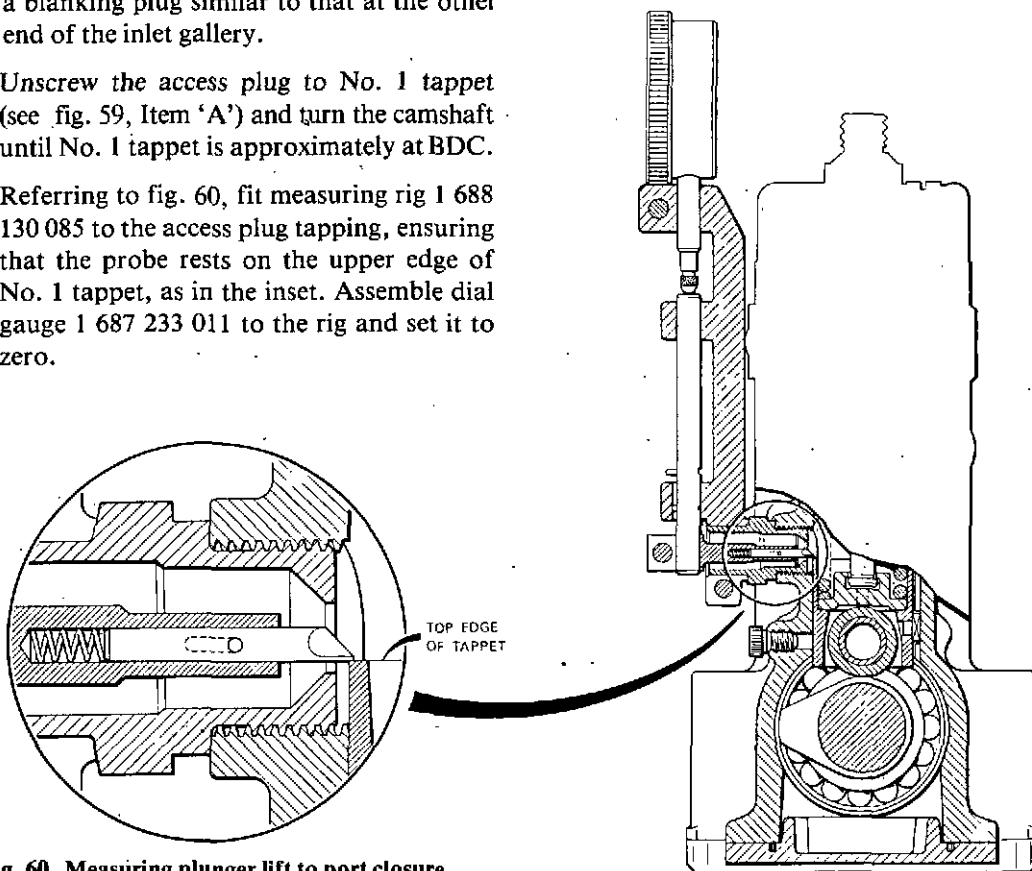


Fig. 60 Measuring plunger lift to port closure

- (iv) Switch on the feed pump of the test bench. Open the leak-off screw on No. 1 test injector and increase feed pressure until oil emerges from it.
- (v) Turn the pump camshaft manually in direction of rotation (clockwise, viewed from drive end) until oil *just* ceases to flow from the leak-off. The dial gauge reading at this point should be within the limits specified against 'Plunger lift to port closure' in Stage 'A' of the Test Schedule. Adjust, if necessary, by means of the phasing shims beneath the barrel/delivery valve assembly (fig. 61), reducing shim thickness to rectify late closure, and vice versa. Pumps with serial numbers prefixed '626' and later have two-piece shims which can be changed without removing the barrel/delivery valve assembly. Variation of shim thickness affects the dial reading by a corresponding amount. When correct, leave camshaft at No. 1 port closure and set the pointer of the graduated disc on the pump drive to a convenient figure, noting this for reference during phasing.
- (vi) Remove measuring rig 1 688 130 085, together with its gauge, and refit the blanking plug (fig. 59, Item 'A').

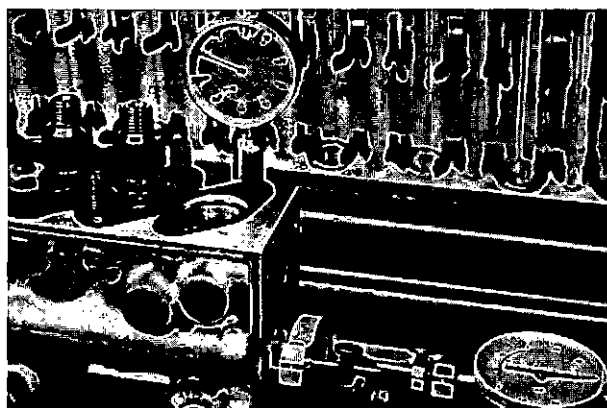


Fig. 61 Adjusting thickness of phasing shims

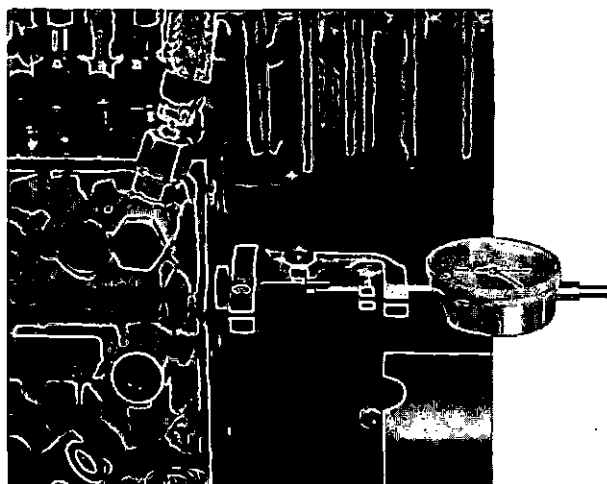


Fig. 62 Measuring rack travel

2. Phasing

Turning the camshaft in direction of rotation, check the port closures of the remaining elements in sequence order (viz: 4, 2, 6, 3, 5, in multiples of 60 degrees), using No. 1 as a datum in each case. Correct any element found beyond limits (± 0.5 deg.) by means of its phasing shims as described earlier. Note that if barrel/delivery valve assemblies are disturbed they should be reset at mid-slot position when their securing nuts are tightened after phasing, thus providing calibration adjustment in either direction.

3. Calibrating

- (i) Remove the blanking plug fitted to the LP relief valve tapping for pre-stroke setting and substitute overflow valve 1 417 413 025, connecting its outlet pipe to the test bench oil return system. Set test oil supply pressure to 221bf./sq. inch (152kN/sq.m).

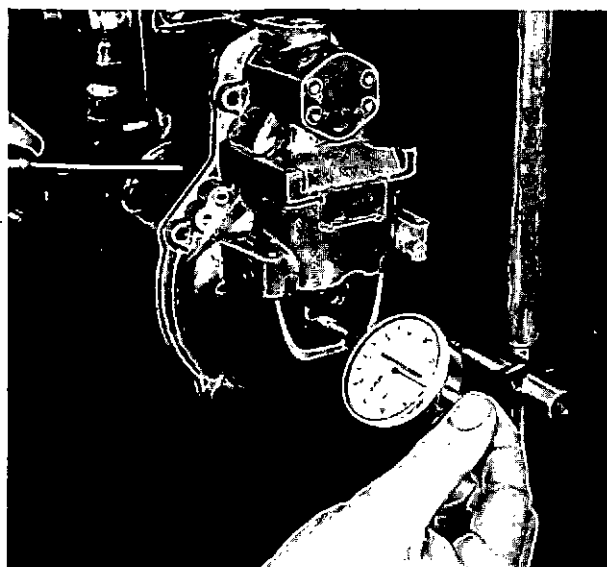


Fig. 63 Measuring sliding sleeve travel

- (ii) Remove the excess fuel device (or smoke stop, as applicable) and fit the rack travel measuring rig 1 688 130 030, together with its dial gauge 1 687 233 015, as shown in fig. 62. With the control rack in the STOP position, zero the dial gauge and tighten the clamping screws. Ensure that the rack can travel its full range of approximately 21 mm.
- (iii) Referring to Stage 'A' of the appropriate Test Schedule, run the pump at 600 r.p.m. and measure the rack travel and the delivery from each element. These should conform to the figures in heavy type at the head of Columns 2 and 3 of the Table under 'Calibrating'. The spread should not exceed the figure quoted in Column 4. Correct errors on individual elements as necessary by rotating their flange bushings within the limits of the adjusting slots, using open ring spanner 1 687 950 525. On completion, tighten the flange bushing nuts to between 29 and 32 lbf.ft. (39 and 44 Nm). Carry out the remaining tests in the Table in Stage 'A'. In each case the delivery from every element should conform to the limits quoted, and failure to do so indicates a faulty element which should be renewed.

STAGE 'B' — GOVERNOR SETTING

1. Setting sliding sleeve travel

Note: The sliding sleeve consists of the slider and the adjusting pin, as an assembly (Items 'E' and 'F' respectively in fig. 46).

- (i) For protection, a cutaway rear cover should be fitted whilst this operation is carried out. Mount the measuring rig 1 688 130 095, attaching the magnetic base of the dial gauge to the slider. With the pump stationary, pre-load the gauge approximately 20 mm; at the same time take up any play in the governor mechanism by lightly pulling on the gauge spindle as shown.
 - (ii) Referring to Stage 'B' of the appropriate Test Schedule, carry out test running as specified in Columns 10 and 11 of the Table, working to the upper limit where possible. Make corrections by equal adjustment of the flyweight spring retaining nuts; a difference of one notch between them is permissible. Turning the nuts clockwise reduces sleeve travel, and vice versa.
 - (iii) Fit the permanent rear cover. Refer to Part 3 'GOVERNOR', under 'Assembling'. Item 8, for details of this operation.
- ### 2. Checking run-out characteristics
- (i) Remove the speed control lever, reverse it and refit it in the same relative position.
 - (ii) Attach the setting rig 0 681 440 006 as shown in fig. 64. Note that the rack travel measuring rig used in Stage 'A' is still fitted.
 - (iii) Referring to Stage 'B' of the appropriate Test Schedule, set the control lever to the basic angle specified in Col. 1 of the Table. Run the pump at the speed specified at the top of Col. 2, measure the rack travel and compare it with the limits at the top of Col. 3. If correction is necessary, use the following three methods in sequence order until successful:
 - (a) Vary the basic settings of the control lever within the limits of ± 3 degrees.
 - (b) Alter the setting of the adjusting pin (figs. 52 and 54). Turning the bearing bolt one half-turn clockwise reduces rack travel approximately 2.25 mm., and vice versa.
 - (c) Vary the thickness of the shims beneath the (S) plate (fig. 57). Reducing shim thickness by 0.15 mm. reduces rack travel approximately 1 mm., and vice versa.
 - (iv) Leave the control lever set as at the completion of (iii) above and carry out the subsequent tests in Cols. 2 and 3.
 - (v) Carry out similar tests as detailed in Cols. 4 to 6 and 7 to 9 respectively. For each of these tests, correction may be made by varying the basic setting of the control lever within the limits of ± 3 degrees to bring rack travel within limits.

STAGE 'C' — FINAL SETTING

1. Setting MAX. FUEL stop

- (i) Remove the rack travel measuring rig 1 688 130 095, together with its dial gauge, and fit the excess fuel device or smoke stop, as applicable.
- (ii) Referring to Stage 'C' of the appropriate Test Schedule, run the pump at the speed quoted in the first column of the Table and measure the fuel delivery from each element. Compare the results with the fuelling figure shown on the Rolls-Royce data plate affixed to the side of the governor. Adjust, if necessary, by altering the setting of the rack stop. Referring to fig. 59, remove the cover 'B', slacken locknut and screw the stop clockwise to reduce fuelling, or vice versa as required.
- (iii) On completion, tighten the locknut and refit the cover.

2. Governor break-away

- (i) Remove the speed control lever (reversed during Stage 'B') and refit it in its normal position.
- (ii) Remove the rack access plate on the governor rear face (fig. 44, Item 'A') and mount a dial gauge with its button resting on the rack extension. If necessary a bolt may be fitted to the tapping in the extension to facilitate this. Pre-load and zero the gauge.
- (iii) Set the control lever on the MAX. FUEL stop (fig. 65, Item 'B'). Referring to the Table in Stage 'C' of the appropriate Test Schedule, run the pump and note the speed at which the rack commences to move, as indicated by the dial gauge. This speed should be between the two quoted in Col. 3. If the speed recorded is incorrect, extract the lead seal, (fig. 65, Item 'A'), remove the cover screw beneath it and adjust the MAX. SPEED stop 'B' as necessary. Screw the stop clockwise to increase speed, and vice

versa. On completion, tighten the stop locknut, refit its cover, and replace the rack access plate.

3. Excess fuel

Referring to Stage 'C' of the appropriate Test Schedule, depress the EXCESS FUEL lever, run the pump at the speed specified in the Table and check that fuel delivery is within the limits quoted.

4. Idling

Adjust the stop (fig. 61, Item 'C') to give fuelling of 2 ccs. per 100 strokes at 325 r.p.m. Final adjustment is made on the engines at installation.

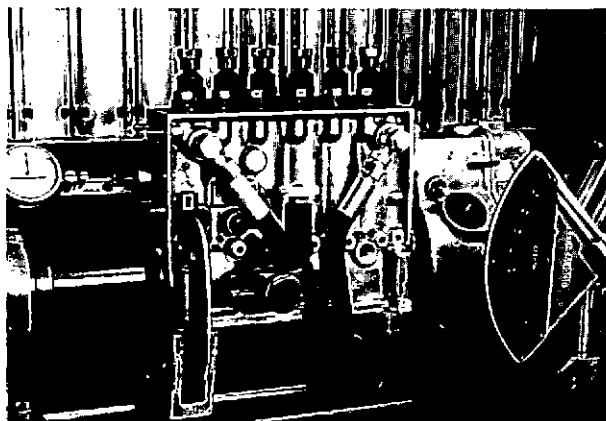


Fig. 64 Checking governor run-out



Fig. 65 Control lever stops and seal

TEST SCHEDULE

Engine specification: Rolls-Royce C6 200G
Injection pump: PE6P 120A 320RS 3042
Injection pressure: 175 ats

Governor: RQV 350/650-750 PA 386R
Test oil temperature: 40 deg. C (140 deg. F)
Feed pressure: 22 lbf./sq. inch (152 kN/sq.m).

A. Fuel Injection Pump Settings

Port closing at prestroke — 3.40 to 3.50 mm (from BDC)

Rotational speed rev/min	Control rod travel mm	Fuel delivery 'cm'/100 strokes	Difference 'cm'/100 strokes
720	14.3	32.1 to 32.5	0.5 (0.8)
	+0.1		
350	4.3 to 4.5	1.6 to 2.0	0.4 (0.7)

B Governor Settings

Upper rated speed			Intermediate rated speed			Lower rated speed		
Degree of deflection of control lever	rev/min Control rod travel mm	Control rod travel mm rev/min	Degree of deflection of control lever	rev/min	Control rod travel mm	Degree of deflection of control lever	rev/min	Control rod travel mm
ca. 68	730 900	15, 2—17, 8 0—1	ca. 38	675-685 715-745	13,8 4,0	ca.12	100	4, 3-4, 5
ca. 65	13,8 4,0	750-755 775-785					350	
						645-705=2,0		

C. Settings for Fuel Injection Pump with Fitted Governor

Full load delivery		Rotational speed	Fuel delivery characteristics		Starting fuel delivery	
Control rod stop	Test oil temp 40°C (104F)	limitation	High idle speed		idle switching point	
rev/min	cm/1000 strokes	rev/min	rev/min	cm/1000 strokes	rev/min	cm/1000 strokes
720	321,0-325,0 (318,0-328,0)	750-755			100	17-18 mm RW
					350	16-20

PART 6 — AMBAC GOVERNING

DESCRIPTION

The modular designed Ambac governor is offered as an alternative on all 'C-RH' engines.

The system consists of a magnetic pickup, electronic control unit, a frequency trim potentiometer, and an electromagnetic actuator. The actuator and pickup are engine mounted with the other accessories located in a suitable position. A fast system response is obtainable over a broad range and the various elements of the system are easily replaced if necessary.

ASSEMBLING (Fig. 66 and Fig. 67)

The following sequence must be strictly adhered to when the unit is being assembled to the fuel pump.

1. Secure the bellows (3) to the outside ring at the pump rack using the clamp (4).
2. With holding screws (5) and lock washers secure the rack connector link (14) in position.
3. Fit the other side of bellows (3) to the rack connecting link (14) and secure with clamp (4).
4. Remove loose cover (11) and gasket (10).

5. Fit 'O' ring (6) to the housing.
6. Back off the spacer adjusting screws (7).
7. Place the gasket (1) in position and secure the governor unit to the pump using mounting screws (9 and 15) together with lockwashers (8 and 2). Hexagon headed screws to be finger tight only at this stage.
8. Remove one hexagon screw (9) and bring adjusting spacer (7) against the surface in pump cover. Refit hexagon screw and torque to 80 to 97 lbf.in. (9 to 11 Nm). Repeat this operation with the remaining hexagon screw.
9. Check the tightness of all four mounting screws to a torque loading of 80 to 97 lbf.in. (9 to 11 Nm).
10. Position the rod and bearing (12) to allow armature travel of 1 to 4 mm when the rack is fully in towards pump.
11. Assemble spring (20) and bracket in position and secure with screw (17) and locknut (18) to the rack connecting link (14) and rod end bearing (12). Bracket must be free on spring retaining pin.
12. Hold the stop lever (16) against stop in housing with the rack in the extreme position towards pump. Turn the adjusting screw until it makes contact with the lever (16) and then back off screw approximately one full turn.
13. Fit cover (11) and gasket (10) to the housing.
14. The top two cover securing screws have provision for a lock-wiring seal.

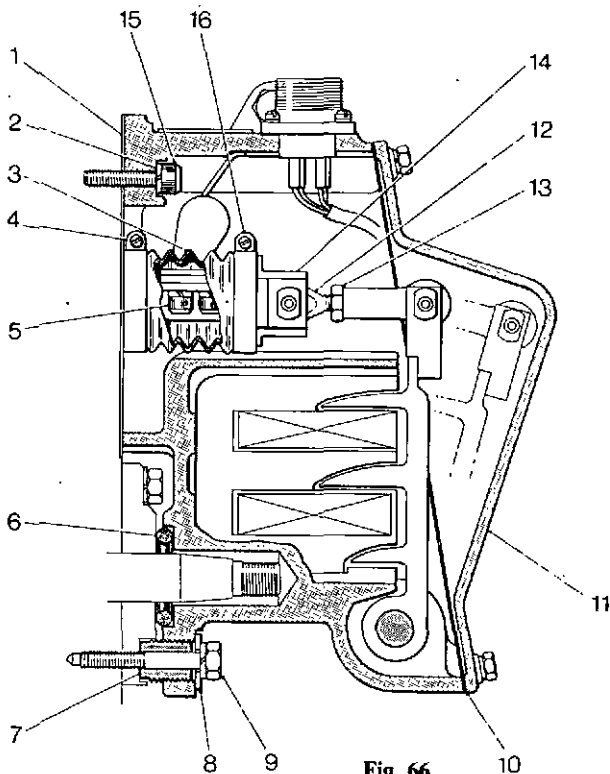


Fig. 66

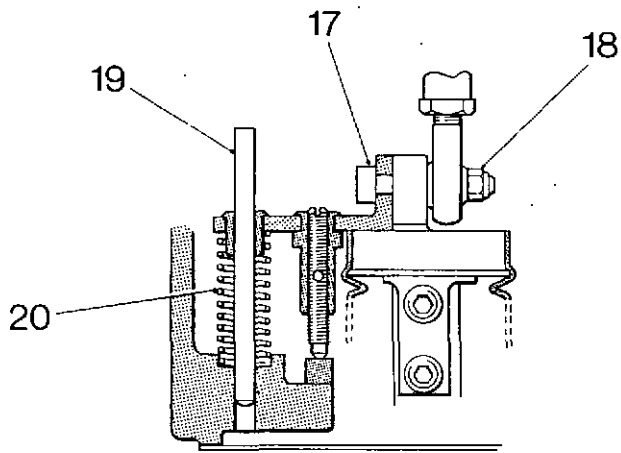


Fig. 67

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ELECTRIC FAULT DIAGNOSIS

If the governor does not operate, measuring, in sequence, voltage between the various control unit terminals and ground (Terminals F, G, H and T are ground) will indicate the possible fault. Should all 5 Voltage tests indicate normal valves, the defect must be in the actuator or in the wiring to the actuator.

TERMINALS	NORMAL VALUE	PROBABLE CAUSE OF NON-NORMAL READING
S	1.0 volt AC-RMS minimum while cranking.	<ol style="list-style-type: none"> 1. Defective magnetic pick up. 2. Gap too large between pickup and gear teeth. 3. Improper or defective wiring to the pickup.
K	10.1 ± .20 volts DC while energized (Internal regulated D.C. D.C. supply).	<ol style="list-style-type: none"> 1. D.C. power not connected or low battery voltage. 2. Frequency trim potentiometer shorted, ground or mis-wired. 3. Wiring error. 4. Defective control unit.
L	<p>Above 5.1 volts D.C. while cranking. (Inverse speed error signal).</p> <p>Above 5.1 volts is under speed signal. Below 5.1 volts is over speed signal.</p> <p>On speed will indicate a steady 5.1 volts.</p>	<ol style="list-style-type: none"> 1. Frequency adjust set too low. Turn clockwise. 2. Defective control unit.
N	8.5 to 9.5 volts D.C. while cranking. (Proportional actuator voltage).	<ol style="list-style-type: none"> 1. Defective control unit. 2. Battery voltage may be too low while cranking.
B	2.5 volts D.C. maximum while cranking. (Transistor voltage).	<ol style="list-style-type: none"> 1. Output transistor open (defective control unit). 2. *Defective actuator 3. Error in wiring to actuator.

Continued

FURTHER FAULT TESTS

SYMPTOM	TEST	PROBABLE TROUBLE
Engine overspeeds	Determine voltage on terminal "L". Should be less than 5.1 volts D.C.	<ol style="list-style-type: none"> 1. Frequency set too high. Turn frequency adjust counter-clockwise. 2. Defective control unit.
Engine overspeeds	Measure the voltage across the insulated nut located on the side of the control unit. Should be more than 2.5 volts D.C.	<ol style="list-style-type: none"> 1. Output transistor shorted (Defective control unit). 2. Wiring to actuator incorrect.
Rack does not move	Measure battery voltage at the battery while cranking. Must be 8.0 volts D.C. minimum.	<ol style="list-style-type: none"> 1. Insufficient battery voltage. Put a momentary connection from terminal "B" on the control unit to negative ground while cranking (Terminal "G" is ground). 2. Replace with battery of higher amp hour rating.
Rack does not move	Ground the insulated nut located on the side of the control unit. Rack should move to full open position.	<ol style="list-style-type: none"> 1. Wiring to actuator or battery incorrect. 2. Actuator or linkage bound. 3. *Defective actuator.

***DEFECTIVE ACTUATOR**

Should the coils of the actuator become open or shorted, replace the actuator. If the coils are not open or shorted, the wiring or connectors are defective.

TEST PROCEDURE FOR ROBERT BOSCH FUEL PUMP FITTED WITH AMBAC INTEGRAL ACTUATOR AGB 250 A1

Fit fuel pump to test rig in normal manner, with cam box primed with oil and oil holes blanked off.

Connect a 12 or 24 D.C. power supply (as available) to the actuator, as shown on fig. 68 (a) or (b). With voltage supplied the pump should deliver full fuel when driven, and the standard pump calibration checks can be undertaken; refer to standard test procedure.

On completion of calibration tests, the power supply should be disconnected with the pump still being driven at rated speed. Fuel delivery should cease immediately the power is disconnected.

The pump should return to full fuel delivery when voltage is re-applied to the actuator, and should cease immediately when the stop lever is moved by hand to the stop position.

If any governor malfunctions are indicated by the above tests, they must be rectified before returning the pump to the engine.

If NO D.C. POWER SUPPLY IS AVAILABLE, the governor operation cannot be checked. The pump operation can be checked by the following procedure:

Remove actuator end cover. Push armature (and rack) fully over to the full fuel position, i.e. fully into the pump body. Hold firmly in this position with a strong spring or length of rubber (a used engine wet liner seal ring is ideal).

With the rack held firmly in this position, the fuel pump rig checks can be performed, as laid down in the standard test procedure.

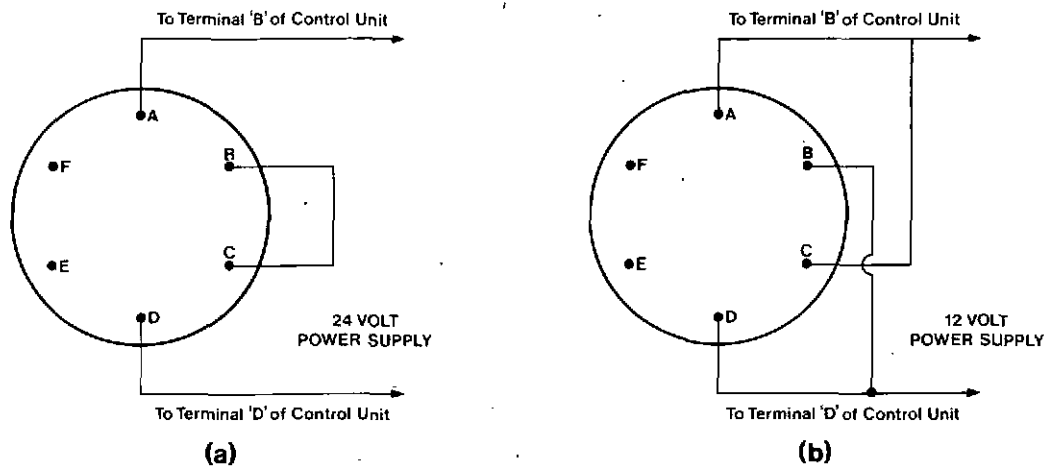


Fig. 68

SECTION 11—LUBRICATION SYSTEM

DESCRIPTION

The system illustrated in figs. 1 and 2 is diagrammatically correct for 'C-RH' engines, but certain components may be differently situated to suit individual installations, e.g. the sump pannier and relief valve may be at front or rear, and the position of filler cap and dipstick will vary.

Engines fitted with rear-drop sump

Approximately 6.5 gallons (29.5 litres) of engine oil is carried in the cast aluminium sump which has a steel insert screwed, sealed and pinned into the pannier base. The insert carries a hexagonal drain plug which is tightened to between 80 and 85 lbf.ft (110 to 115 Nm) and wire locked to it. Maximum and minimum oil levels are indicated by two lines on the dipstick, the difference being approximately 2.5 gallons (11.3 litres).

Engines fitted with forward-drop sump

The forward-drop sump is similar in make-up to the rear-drop sump but has a smaller oil carrying capacity of approximately 5.5 gallons (25 litres). Maximum and minimum oil levels are marked on the dipstick, the difference between marks being approximately 1.5 gallons (6.8 litres).

A spur-gear pump mounted on the front main bearing cap and gear-driven from the front of the crankshaft, draws oil through a filter in the sump pannier and circulates it under pressure throughout the system. After circulation the oil returns to the sump by gravity, external drain pipes being provided for the turbocharger (if fitted) and the injection pump/governor assembly.

On leaving the pump the oil passes through gallery pipes to a spring-loaded relief valve, carried in a casting bolted to the exterior of the sump. This valve controls pressure at 50 to 70 lbf./sq. inch (345 to 483 kN/sq.m) and returns surplus oil to the sump. The oil then enters the heat exchanger at its rear end and passes six times over the tube pack before leaving at the front and entering the parallel-flow filters.

Two by-pass valves, one above each filter bowl, are carried in the filter header to prevent oil starvation if the filters become choked. A tapping for the turbo-charger supply is taken from the rear of the header, on the 'clean' side of the filters.

On leaving the filter header the oil returns to the relief valve casting, where a tapping is taken for the pressure gauge, and then enters a gallery supplying each main bearing. The crankshaft is drilled for big-end lubrication, each crankpin embodying a sludge trap with detachable plug. The big-end bearings are grooved to provide a continuous flow of oil through the drilled connecting rods to the small-end bearings; two drillings in the small-end eyes supply jets of cooling oil to the undercrown areas of the piston.

Oil from the centre main bearing passes through a drilling to the camshaft centre bearing, where it enters the hollow camshaft and emerges from a drilling at each journal. A cross-drilling at the front of the crankcase carries oil from the camshaft front bearing to the idler gear axle and to an external connection for the injection pump oil supply.

A drilling upwards from the camshaft centre bearing into the tappet chest is connected to a gallery which supplies oil, through further drillings in the cylinder block, to an oilway stud passing through each cylinder head. This oil, at reduced pressure due to a restrictor drilling in the stud (see Section 3, fig. 11), enters the hollow rocker shafts to lubricate the rocker bearings and passes through drillings in the rocker arms to the pushrod ends and valve tips. (See Section 8 CYLINDER HEADS).

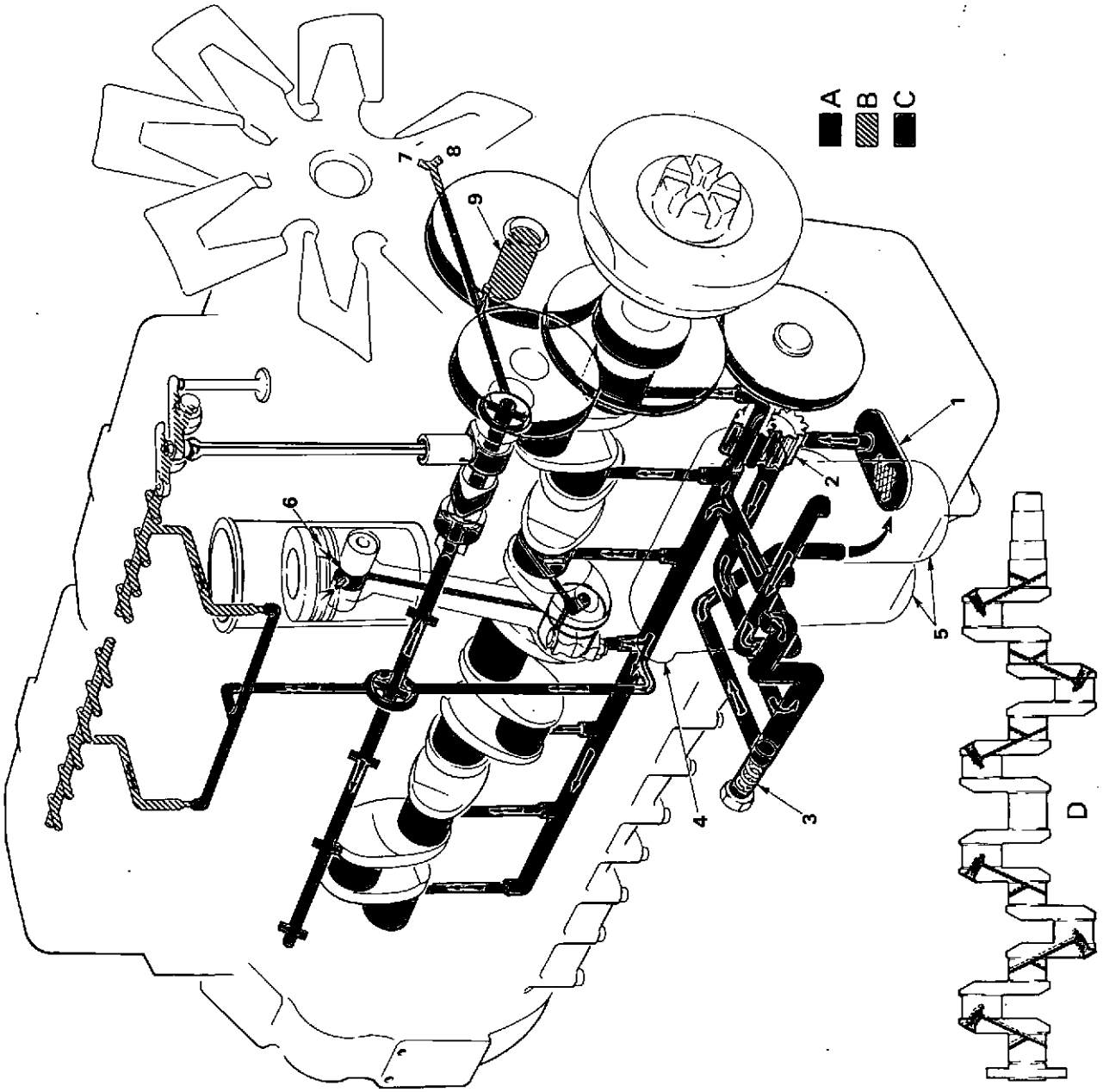
LUBRICATING OIL

Use only a lubricating oil to the grade and viscosity approved by Rolls-Royce for the engine (see leaflet T.S.D. 3085 in the pocket at the back of this Manual). Change the oil and service the filters in accordance with the Servicing Schedule given in the Servicing Manual T.S.D. 3126, Operator's Guide T.S.D. 3124 and Wall Chart T.S.D. 3133.

**KEY TO FIG. 1—LUBRICATION SYSTEM—OIL FLOW THROUGH
MAIN ENGINE**

- | | |
|----------------------------------|--------------|
| 1. Suction filter | |
| 2. Pressure pump | |
| 3. Oil pressure relief valve | |
| 4. Oil-to-coolant heat exchanger | } See fig. 2 |
| 5. Parallel-flow main filters | |
| 6. Piston cooling jets | |
| 7. Supply to air compressor | |
| 8. Supply to injection pump | |
| 9. Idler gear axle | |
-
- | |
|---|
| A — High pressure system |
| B — Restricted flow system |
| C — Suction, spill and splash lubrication |
| D — Crankshaft oilways |

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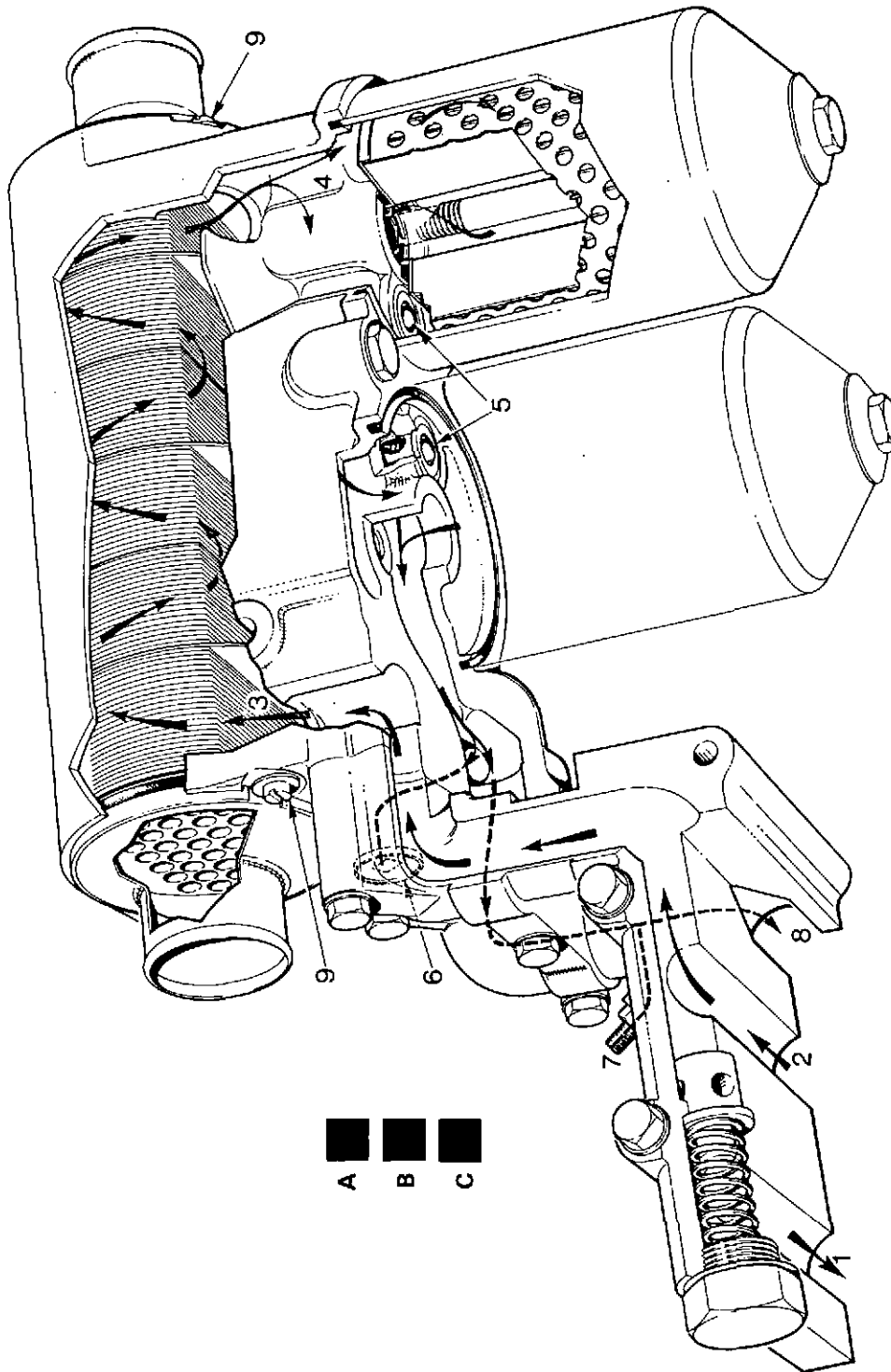
Fig. 1 Lubrication system—oil flow through main engine

KEY TO FIG. 2—LUBRICATION SYSTEM—OIL FLOW THROUGH RELIEF

VALVE, HEAT EXCHANGER AND FILTERS

1. Relief valve spill to sump
2. Oil supply from pump
3. Oil inlet to heat exchanger
4. Oil exit to filter header
5. Filter by-pass valves
6. Turbocharger supply (if applicable)
7. Pressure gauge connection
8. Delivery to main bearings
9. Tube pack locating screws

- A — Unfiltered oil from pump
B — Relief valve spill to sump
C — Filtered oil to engine



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Fig. 2 Lubrication system—oil flow through relief valve, heat exchanger and filters

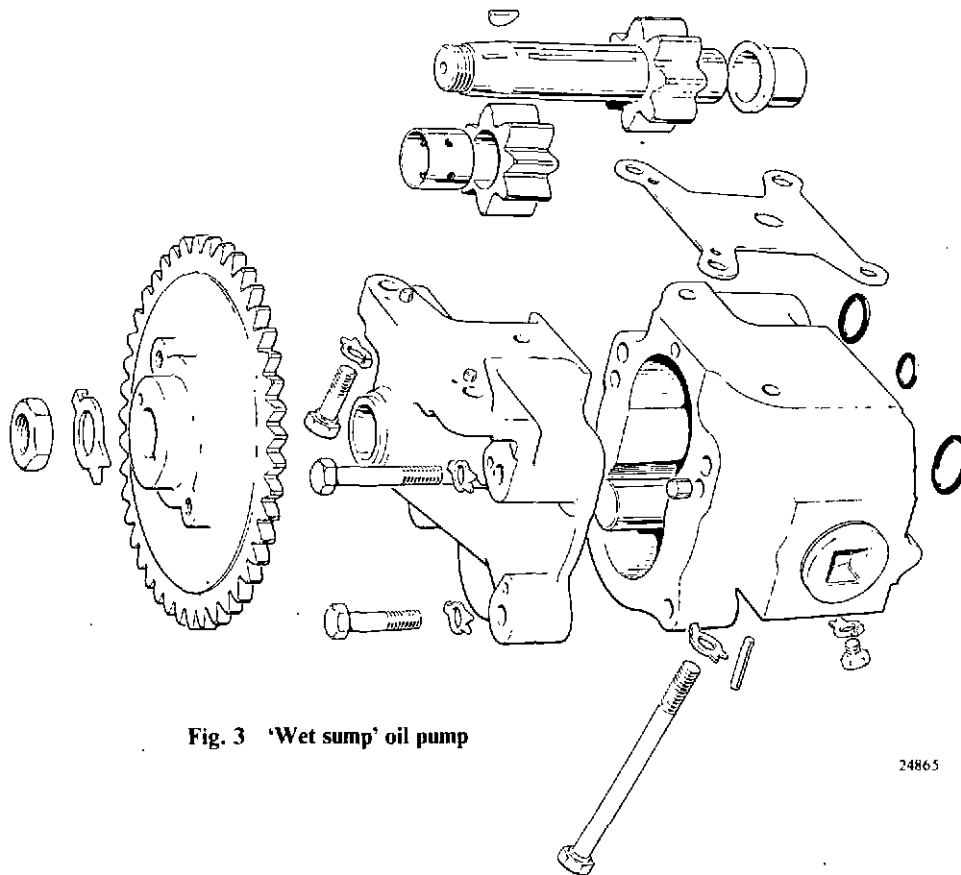


Fig. 3 'Wet sump' oil pump

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OIL PUMP

Dismantling

Unlock and unscrew the pinion nut, and withdraw the pinion, using extractor GA.7. Remove the pump casing setbolts and dismantle the unit (fig. 3), keeping mated components together.

Inspection

Thoroughly clean all components. Inspect casings, gears and bearings for wear and damage. Remove any small burrs by careful stoning, and polish out any slight scoring. If possible, carry out a crack test on the gears and pinion.

Scoring or wear on the inner face of the front cover may be removed by machining a maximum of 0.010 inch (0.25 mm.) from the surface, taking care to keep the face square with the bearing bore. Any other unserviceability of the casing halves or the driven gear spindle will involve renewal of the pump casing.

Check the diametral clearance and end float of the gears in the casing, and the fit of the spindles in their bearings.

Assembling

Oil the parts and assemble the pump as shown in fig. 3, ensuring that the casing joint faces are perfectly clean and dry; no jointing compound is used. Before fully tightening the casing setbolts, check by straight-edge that the pump-mounting faces are aligned with one another. After tightening, check that the drive-shaft can be turned easily by hand. The pump drivegear is fitted after the pump has been assembled to the engine, so that its securing nut may be tightened to 50 lbf.ft. (70 Nm). Note that the pump is dowelled to the front main bearing cap and that drivegear backlash is adjustable by shims (see Section 3. Item 16).

Provided that the fits and clearances of pump components conform to the limits quoted in the Schedule at the end of this Section, the performance of the pump will be adequate and no rig test is necessary.

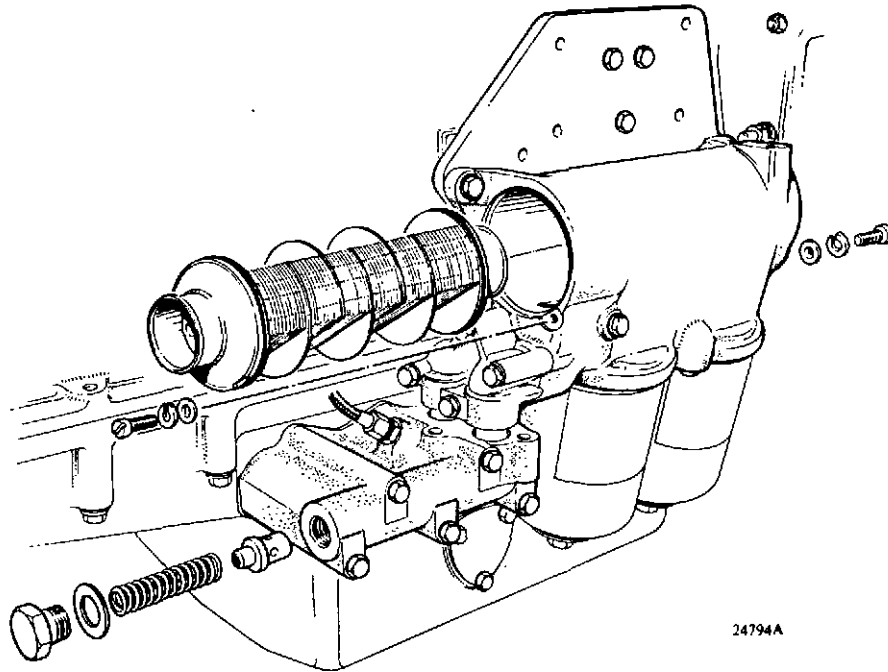


Fig. 4 Relief valve and heat exchanger—exploded

OIL PRESSURE RELIEF VALVE

The valve assembly (fig. 4) is bolted to the sump panner at front or rear of the engine, dependent on installation requirements. It consists of a non-adjustable spring-loaded plunger in a casting which is directly connected to the pressure pump outlet. Pressure in excess of approximately 60 lbf./sq. inch (414 kN/sq.m) causes the plunger to move against its spring, uncovering ports by which surplus oil is returned to the sump.

Dismantling

Unscrew the capnut and withdraw the spring. Extract the plunger from its bore, using tool GA.14 or a 2BA bolt screwed into the tapping in the plunger stem. The latest plunger has no tapping and may be withdrawn by means of a piece of close-fitting rubber or plastic tubing forced over the stem.

Inspection

Examine the plunger and its bore in the casting, and reject them if deeply scored. Check that the plunger slides freely without being loose in the bore. Slight burrs may be stoned out.

Two types of plunger may be encountered, the earlier type having a small conical seating above the cylindrical body; on the later type this seating is deleted and the new version of this type has no extractor tapping, as previously described. All plungers are fully interchangeable.

Inspect the spring for wear and distortion. A new spring conforms to the following requirements:

Free length: 2.54 inches (64.6 mm.)

Length under 26 lb. (12 kg.) load: 1.65 ins. (42 mm.)

Reassembling

When reassembling the unit, fit a new aluminium washer, 0.036 inch (0.9 mm.) thick, under the spring capnut, otherwise the setting of the valve will be altered.

OIL-TO-COOLANT HEAT EXCHANGER

The unit (figs. 2 and 4) consists of a finned tube pack in a housing which also forms the oil filter header. Coolant from the radiator outlet passes through the tube bores, and lubricating oil at controlled pressure from the pump enters through a port at the rear of the housing and flows over the exterior of the pack.

Baffle plates on the tube pack direct the oil six times across the tubes before it enters the oil filter header via a port at the forward end.

On most engines the tube pack is reversible in the housing, the exception being where a hose connection is at an angle to suit a particular installation. Location of the baffle plates to the inlet and outlet ports is ensured by a 2BA screw and washers engaged in a machined recess at each end. A rubber 'O' ring in a groove at each end of the tube pack forms an oil seal within the housing bore.

Dismantling and cleaning

1. Drain the coolant, disconnect the coolant hoses and lubricating oil pipes from the unit, unscrew the four setbolts which secure the unit to its mounting plate and lift it away. Remove the filter bowls.
2. Unscrew the 2BA screw from each end of the housing and push the tube pack forward so that the front 'O' ring can be removed. Then withdraw the pack rearward (fig. 4). Do NOT attempt to push an 'O' ring through the housing, since it could foul an oilway port and cause the pack to become jammed.

Note: If pressure is necessary to move the pack, it must not be applied to the sheet metal ends. Use a medium-soft wooden dolly of round section, applying the end-grain to the ends of the tubes. After using this method, always check that the tube bores are clear and undamaged.

3. Wash the tube pack in paraffin, taking care not to damage the fins, blow through the tubes with compressed air, and wash the pack in hot water.
4. Hard deposits in the tube bores may be loosened by soaking the pack in a solution of 1 part inhibited hydrochloric acid to 3 parts of fresh water. When frothing ceases, immerse the pack in a solution of washing soda (sodium carbonate) in hot water, 1 lb. to 5 gallons (0.5 kg. to 25 litres). Finally, blow through the tube bores with an air jet and wash the pack in hot fresh water.

Inspecting and reassembling

1. Inspect the pack for corrosion, cracks and damage, and if possible make a pressure test by

applying air at 30lb./sq. inch (210 kN/sq.m) to the tube bores with the pack immersed in water at 176°F (80°C).

2. Assemble the tube pack to its housing in the following sequence to avoid damaging the 'O' rings by contact with the edges of the housing ports. *See Note in Operation 2 under 'Dismantling and Cleaning' concerning use of pressure on the tube pack.*
 - (a) Ensure that the housing bore is perfectly clean and free from burrs. Apply a light smear of rubber grease or engine oil to the bore at both ends.
 - (b) Insert the tube pack, without 'O' rings, at the rear of the housing, and align the machined recesses for the locating screws. Push the pack into the housing until the 'O' ring groove just emerges at the front.
 - (c) Fit the front 'O' ring, lightly lubricated, and carefully pull the tube pack backwards until the rear 'O' ring groove is just exposed.
 - (d) Fit the rear 'O' ring, lightly lubricated, and push the pack into its correct position in the housing. Check that the tube bores are clear and undamaged.
 - (e) Fit a locating screw, with spring and plain washer, at each end of the housing. Refit the filter bowls, with new elements.
3. Refit the unit to the engine in the reverse sequence of Operation 1 under 'Dismantling and cleaning', using new hoses and joints.

MAIN FILTERS AND BY-PASS VALVES

Two filters, in parallel, are mounted on a header incorporated in the oil-to-coolant heat exchanger, which is bolted to a plate on the right-hand side of the crankcase at sump level.

Each filter bowl (fig. 5) houses an expendable element and is secured to the header by a central fixing bolt. A by-pass valve is carried in the header above each filter.

Filter servicing

Remove the bowls by unscrewing their central bolts. Discard the elements and clean the bowl components. Fit new elements and joint rings, fill the bowls with clean engine oil and reassemble them to the header, tightening the central bolts to 20lb. ft. (27 Nm).

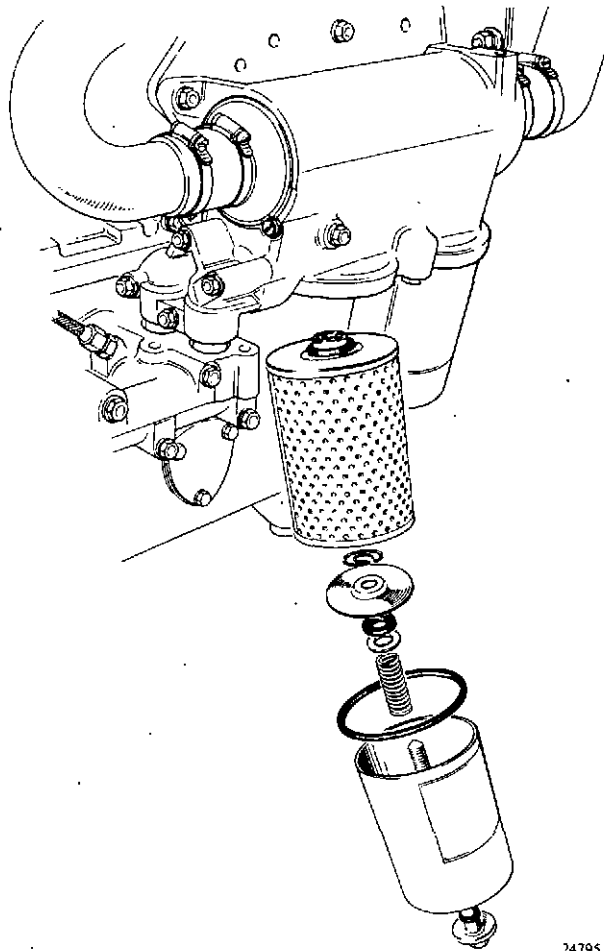


Fig. 5 Oil filters—one assembly exploded

WARNING: Use *only* genuine Rolls-Royce elements, which are guaranteed to conform to Rolls-Royce Specification. These elements are clearly marked “ROLLS-ROYCE GENUINE OIL FILTER REPLACEMENT”, followed by the Rolls-Royce Part Number, and each is sealed in a plastic bag. The use of other elements, which do not conform to Rolls-Royce Specification, will involve risking engine damage and may also invalidate the Rolls-Royce Guarantee.

By-pass valves

The two spring-loaded ball valves are non-adjustable sealed units, peened into their housings in the header (see fig. 2). No servicing is required. Either valve will open when its filter element becomes choked to the extent that the pressure drop across it exceeds 15 lbf./sq. inch (103 kN/sq.m) and in these circumstances prevents oil starvation by allowing unfiltered oil to pass to the engine.

OIL GALLERIES

Instructions and illustrations concerning the oil galleries in crankcase and sump, and details for carrying out a pressure test of the lubrication system, are given in Section 3 “Assembling the engine”.

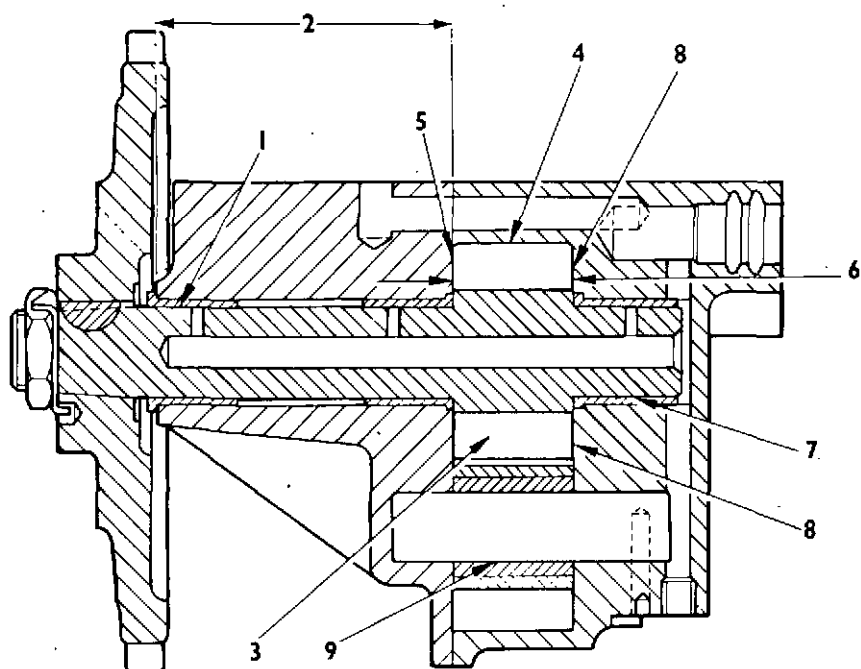
SPECIAL TOOLS

- GA.7 Extractor, oil pump drivegear.
- GA.14 Extractor, relief valve plunger.

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FITS AND CLEARANCES

OIL PUMP—WET SUMP



24866

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	DRIVING GEARSHAFT IN FRONT COVER Gearshaft in bush Bush—bore	0.875 to	22.22 to			0.0015 to	0.038 to	0.005	0.13	
		0.8755	22.24			0.0025	0.063			
2	SCORING ON FRONT COVER Thickness of cover	0.873 to	22.17 to							
		0.8735	22.19							
3	DRIVING AND DRIVEN GEARS Backlash	2.890 to	73.41 to	2.880	73.15					Relap minus 0.010 in. (0.25 mm.) max.
		2.900	73.66							
4	Diametral clearance					0.004 to	0.10 to	0.015	0.38	
						0.010	0.25			
5	End float					0.010 to	0.26 to	0.015	0.38	
						0.012	0.31			
6	Gear thickness	1.1945 to	30.34 to			0.005 to	0.13 to	0.008	0.20	
		1.195	30.35			0.0065	0.16			
7	DRIVING GEARSHAFT IN REAR CASING Gearshaft in bush Bush—bore	0.875 to	22.22 to			0.0015 to	0.04 to	0.005	0.13	
		0.8755	22.24			0.0025	0.06			
	Gearshaft—dia.	0.873 to	22.17 to							
		0.8735	22.19							

Continued

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
8	REAR CASING INNER FACE Scoring									Scoring must not exceed 0.0015 in. (0.04 mm.) deep and 0.010 in. (0.25 mm.) wide
9	DRIVEN GEAR ON SHAFT Shaft in bush Bush—bore Shaft—dia.	0.6562 to 0.6567	16.67 to 16.68			0.0007 to 0.0015	0.019 to 0.038	0.005	0.127	

SECTION 12—WHEELCASE AND GEARS

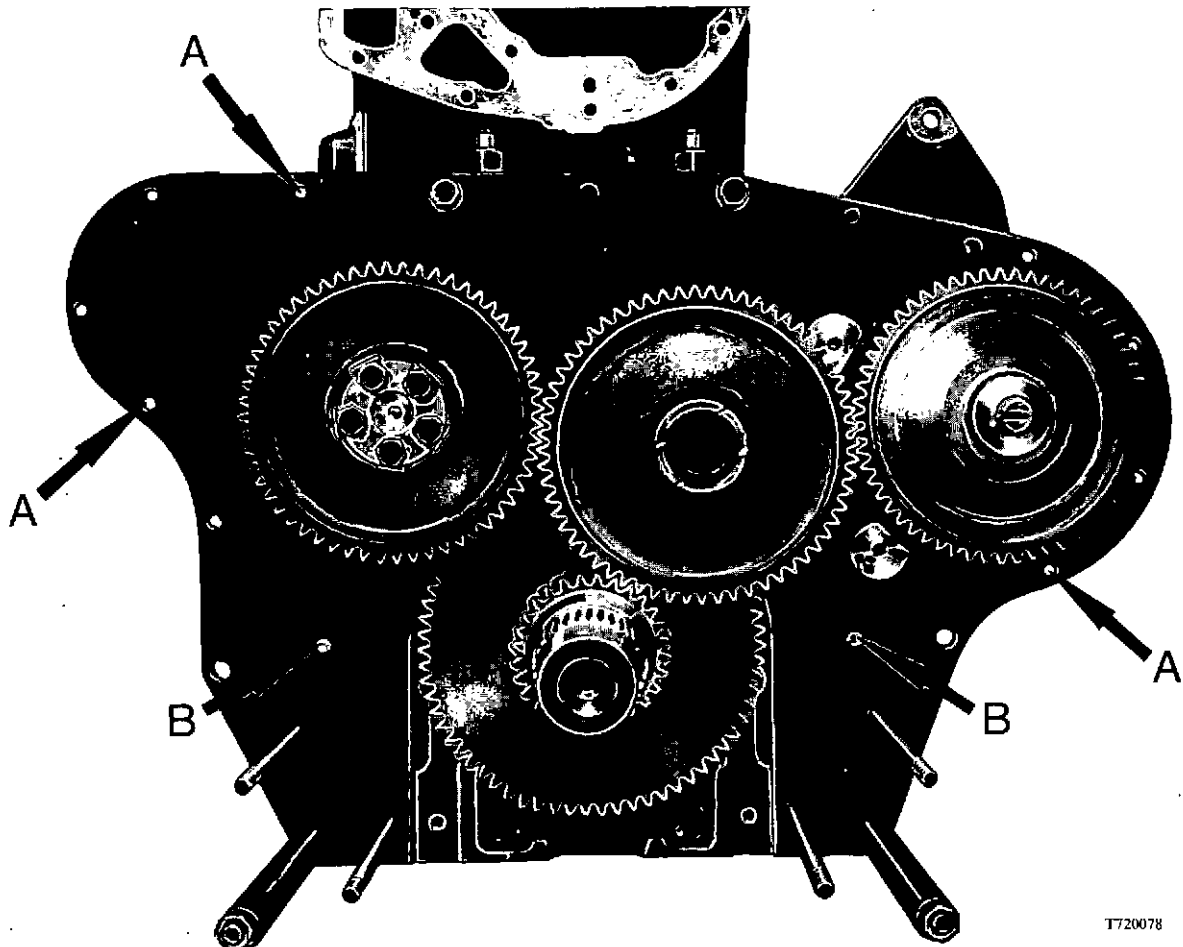
DESCRIPTION

The wheelcase assembly is mounted at the front of the engine. It consists of a train of spur gears, driven from the crankshaft pinion and enclosed between a steel backplate and an aluminium cover which carries the crankshaft front oil seal and the idler gear axle support plate. For information on assembling, backlash and endfloat checks, and timing, see Section 3.

The backplate is dowelled to the crankcase; the idler gear axle is dowelled to the backplate. To ensure centralization of the crankshaft front oil seal and idler axle support, the wheelcase cover is located to the backplate by fitted bolts (fig. 1).

A pinion, keyed to the crankshaft nose, drives the camshaft and auxiliary drivegears at half engine speed via an idler gear. A large gearwheel, dowelled to the

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**A FITTED BOLTS—WHEELCASE LOCATION
B DOWELS—BACKPLATE LOCATION**

Fig. 1 Wheelcase and backplate location points

crankshaft behind the pinion, drives the oil pump which is bolted to No. 1 main bearing cap.

Backlash of the gear train, except the oil pump drive, is set during engine build by adjusting the position of the idler gear axle before reaming its dowel holes. Renewal of backplate or axle, which are supplied with undersize dowel holes, will involve repositioning, as described later in this Section; it does not necessarily apply when gears alone are renewed.

Oil pump drivegear backlash is adjusted by shims between pump and No. 1 main bearing cap. See Section 3 under 'Oil pump and gallery' for details.

DISMANTLING

Wheelcase cover

(a) Dismantling from removed engine.

1. Remove the alternator, complete with support bracket and driving belts.

Unscrew the 16 setbolts from the crankshaft hub and remove the barring adaptor, lockplate, damper and pulley. Using spanner OE.44022 and a 4 lb. (1.8 kg.) hammer, unscrew the hub nut (right-hand thread) and withdraw the hub.

3. Remove the sump, if necessary using a $\frac{3}{8}$ inch UNF jacking bolt at each corner to break the joint.
4. Unscrew the nuts and bolts retaining the cover and front mountings, and lift the cover away.

(b) Dismantling from installed engine

1. Remove the alternator bracket and belts, and dismantle the crankshaft hub as described above.
2. Remove the idler axle support plate from the front face of the wheelcase cover.
3. Unscrew the four setbolts securing the front of the sump to the wheelcase cover.
4. Support the engine beneath the sump. Remove the front mountings; unscrew and withdraw their six retaining studs which pass through the wheelcase cover.

5. Remove the remaining bolts securing the cover, carefully separate the joints between the cover, sump and backplate, raise the cover slightly and lift it away.

Gear train

If the camshaft and auxiliary drivegears are to be removed, leave the idler gear in position whilst slackening their retaining bolts and nut. The camshaft drivegear may be tapped off its dowel when the setbolts are removed; see Section 3, fig. 7 for details. To withdraw the auxiliary drivegear, use extractor OE.44409. Details concerning the crankshaft pinion and oil pump drivegear are given in Section 6.

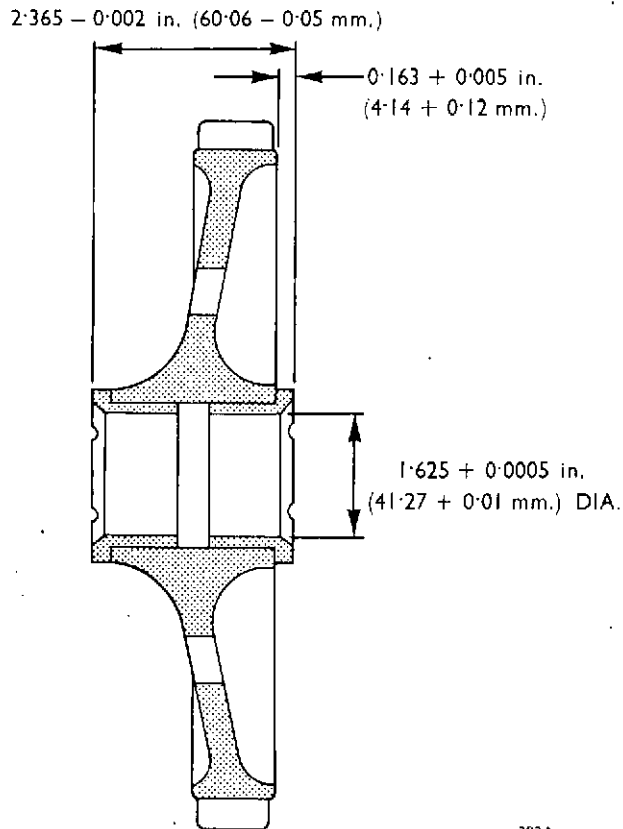


Fig. 2 Dimensions—idler gear bushes

302A

INSPECTION AND REPAIR

Examine all gears for worn or damaged teeth. Wear of the tooth profile is acceptable provided that backlash is within limits and no pitting is evident. Wherever

possible, crack test all gears, using an electro-magnetic method if available.

Examine the wheelcase cover for cracks and damage. Renew the crankshaft front seal, even if apparently serviceable.

Inspect the idler gear bushes and axle for wear. Renew, if necessary, as described later.

Renewing crankshaft front seal

If the wheelcase cover is removed from the engine the seal may be renewed without the use of special tools, as described under 'Wheelcase cover' in Section 3.

For renewing the seal without removing the wheelcase cover from the engine a kit GA.420 is available. Since they locate on the crankshaft nose these tools cannot be used on a dismantled wheelcase.

Remove the crankshaft damper and front hub as described earlier under 'DISMANTLING'. Use extractor GA.364 to withdraw the old seal and tool GA.694 to insert the replacement, lip inwards and lightly packed with Vaseline. Reassemble the front hub and damper as described under 'Crankshaft front end' in Section 3.

Renewing idler gear bushes

Drift out the old bushes. Replacement bushes are supplied with a machining allowance in the bore and whenever possible should be shrunk into position.

Set up the gear on a lathe faceplate so that the finished bore of the bushes will be concentric with the teeth, and machine the bore. Finally, machine the thrust faces of the bushes to ensure correct endfloat. Dimensions are given in fig. 2.

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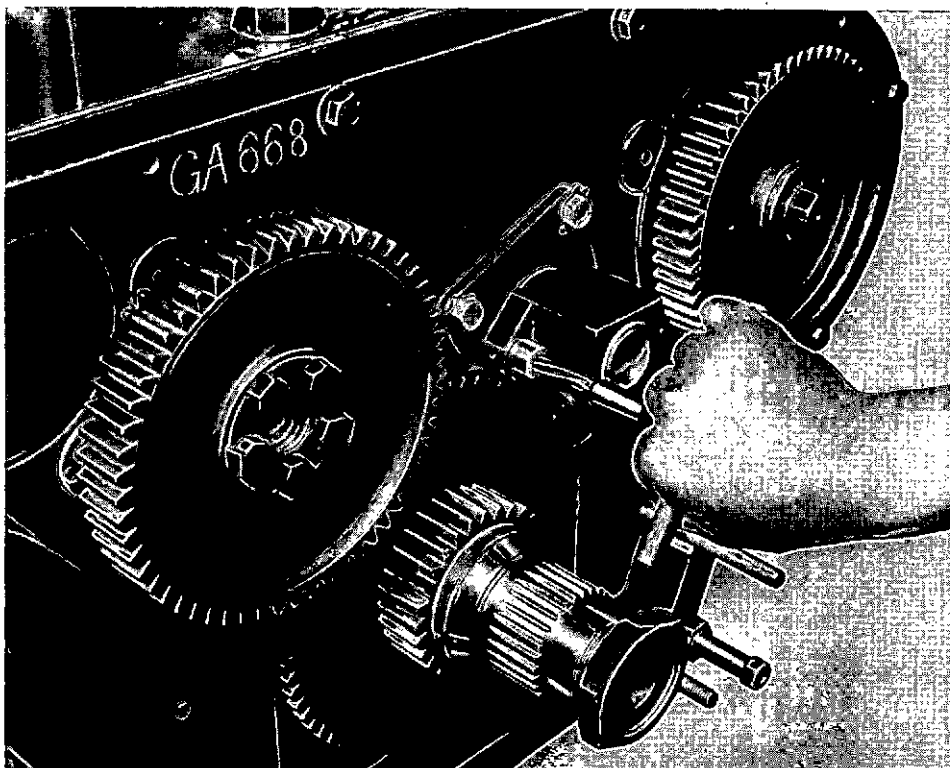


Fig. 3 Reaming dowel holes—idler gear axle

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Repositioning idler gear axle

Backlash throughout the gear train is determined by the position of the idler gear axle, which is located to the backplate by two dowels. If the axle or backplate, or both, have been renewed the axle location must be re-established, the dowel holes of new components having a reaming allowance for the purpose.

The work is carried out in the following manner, after the camshaft and drivegears have been fitted as described in Sect. 3, Items 7 and 8.

1. With the engine in running position, fit the backplate stiffening frame GA.668 (fig. 3).
2. Fit the idler gear axle, without dowels, and nip its setbolts. Slide the idler gear into position and, at four equidistant points on its circumference, measure the backlash between idler gear and crankshaft pinion, camshaft drivegear and auxiliary drivegear (see Section 3, fig. 8). Tap the idler gear hub to move the axle as necessary until each backlash is between 0.004 and 0.010 inch (0.10 and 0.25 mm.) and as equal as possible to the others.
3. Taking care not to disturb the axle, remove the idler gear and tighten the axle setbolts. Ream the dowel holes as follows, using jig GA.338 and reaming kit GA.470 (fig. 3).
4. Fit reaming jig GA.338 to the axle, with $\frac{19}{64}$ inch locating pin GA.339 in one dowel hole. Using $\frac{5}{16}$ inch reamer GA.258, ream the other hole.
5. Fit locating pin GA.340 in the reamed hole, remove pin GA.339, and ream its hole to $\frac{5}{16}$ inch. If both axle and backplate are new, remove the axle, clean out all swarf and continue assembling as described in Section 3 from 'Wheelcase backplate' (Item 6) onwards, using $\frac{5}{16}$ inch dowels OE.5111 and new circlips OE.2296.

6. If either axle or backplate are not new, ream the dowel holes oversize as necessary, in similar manner. Reamers and locating pins are supplied in two increments of $\frac{1}{64}$ inch; see list at end of this Section. When oversize dowels OE.36495 ($\frac{21}{64}$ inch) or OE.39790 ($\frac{11}{16}$ inch) are to be fitted, open out their circlip counterbores in the idler gear axle, using recessing tool GA.106. The same circlip, OE.2296, is used on all three sizes of dowel.

ASSEMBLING

Instructions are given in Sect. 3 under 'Wheelcase cover' and 'Crankshaft front end'. (Items 21 and 23).

SPECIAL TOOLS

- | | |
|----------|---|
| OE.44022 | Spanner, crankshaft hub nut |
| OE.44409 | Extractor, auxiliary drivegear |
| GA.668 | Stiffening frame, wheelcase backplate |
| GA.338 | Jig, idler axle dowel reaming |
| GA.470 | Kit, reaming idler axle dowels, comprising: |
| GA.258 | Reamer, $\frac{5}{16}$ inch (standard) |
| GA.104 | Reamer, $\frac{21}{64}$ inch (1st oversize) |
| GA.105 | Reamer, $\frac{11}{16}$ inch (2nd oversize) |
| GA.106 | Recessing tool: dowel circlip counter-bore |
| GA.339 | Locating pin, $\frac{19}{64}$ inch |
| GA.340 | Locating pin, $\frac{5}{16}$ inch |
| GA.341 | Locating pin, $\frac{21}{64}$ inch |
| GA.342 | Locating pin, $\frac{11}{16}$ inch |
| GA.420 | Kit, renewing crankshaft front seal on assembled wheelcase, comprising: |
| GA.364 | Extractor |
| GA.694 | Inserting tool |
| GA.421 | Box |

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FITS AND CLEARANCES

WHEELCASE GEARS

ROLLS-ROYCE DIESELS

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No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		in.	mm.	in.	mm.	in.	mm.	in.	mm.	
1	IDLER GEAR BACKLASH Backlash between idler gear and: Crankshaft pinion } Auxiliary drivegear } Camshaft drivegear }					0.004 to 0.010	0.10 to 0.25	0.012	0.30	Measured, in each instance, with idler gear in four equally-spaced positions
2	IDLER GEAR AND AXLE Idler gear end float					0.013 to 0.027	0.33 to 0.68	0.045	1.14	
3	Bushes in idler gear Gear - bore	1.8125 to 1.813	46.04 to 46.05				Interference			
	Bushes - diameter	1.8155 to 1.816	46.11 to 46.13				0.0035 to 0.0025			
4	Idler gear on axle Bushes - bore	1.625 to 1.6255	41.27 to 41.29				0.09 to 0.06		0.10	
	Axle - diameter	1.6235 to 1.624	41.24 to 41.25				0.001 to 0.002	0.004		



SECTION 13—TURBOCHARGER, HOLSET

MODEL 4LGK

The turbocharger is a turbine-driven compressor which utilises the waste energy of the exhaust gases to increase the mass airflow to the cylinders. Turbine and compressor are carried at opposite ends of a shaft which rotates in fully-floating bearings lubricated by pressure oil from the filter header. The oil returns to the sump via a large-bore pipe.

Full information concerning operating precautions, routine maintenance, bearing checks and compressor cleaning, is given in the Engine Servicing Manual T.S.D. 3126.

Operators are strongly advised to make use of the Rolls-Royce Service Exchange Scheme when a turbocharger is due for overhaul.

REMOVAL

1. Disconnect the air intake piping to the turbocharger at the compressor inlet and the air cleaners. Remove the piping.
2. Break the hose connections of the air delivery pipes at the manifold duct and at the turbocharger. Remove the pipe and blank off the duct opening.
3. If applicable take the weight of the diffuser whilst disconnecting it.
4. Disconnect the oil feed pipe at the turbocharger bearing housing and at the header bracket of the engine oil filters; remove the pipe.
5. Release and remove the oil drain pipe.
6. Remove the nuts securing the turbocharger to the exhaust manifold and lift the turbocharger from the engine.

Information necessary for complete overhaul is given in the Manufacturer's publication issued by the Holset Engineering Company Limited, Turnbridge, Huddersfield, for each model.

REFITTING

Refitting the turbocharger is the reverse of dismantling but it is advised that the following points be noted:

1. When fitting the turbocharger to the engine, check that the induction and exhaust systems are free from dirt and loose articles.
2. Ensure that all joints are properly made, using new hoses of correct material, and check that the oil supply and drain pipes are clear and undamaged.
3. Make certain that the compressor inlet and outlet piping is not producing strain on the compressor cover.
4. Before starting the engine, prime the turbocharger bearings by pouring one-third pint (0.2 litre) of engine oil into the filler pipe on the bearing housing.

PRECAUTIONS AFTER OVERHAUL

Before a new or overhauled engine equipped with a Holset 4LGK turbocharger is run at Rolls-Royce an expendable filter OE.43712 is fitted to the turbocharger oil inlet flange; this protects the turbocharger bearings during initial running and is then removed and destroyed. Dealers and Operators wishing to adopt this precaution are reminded that (1) the filter *must* be removed before the engine goes into service and (2) the filter cannot be cleaned and *must* be destroyed on removal to prevent re-use.

ROLLS-ROYCE DIESELS



**SECTION 14—ELECTRICAL EQUIPMENT
PART 1—STARTER MOTOR
C.A.V. S130L**

DESCRIPTION

The S130L starter is a 24-volt unit of co-axial construction incorporating a two-stage solenoid switch unit mounted internally around the armature shaft. It is splash and dust proof and oil sealed at the drive end.

Pinion engagement occurs at reduced power thereby avoiding heavy engagement shock and excessive wear of the pinion and flywheel ring gear. Full power is applied when the pinion is fully engaged and locked in position to prevent premature ejection.

OPERATION

The battery supply is connected to the main terminals and when the solenoid is energised the pinion assembly moves forward to its first position. The armature rotates under reduced power and when the pinion has almost reached the fully engaged position the second stage contacts close and full battery power is applied. When the pinion sleeve is in the fully forward position it becomes locked.

The pinion speed is rapidly increased by the engine flywheel when the engine starts. A ratchet device now operates and allows the pinion to rotate at a faster rate than the armature until both are at the same speed, when the ratchet ceases to operate. Should the engine start to drive the armature at a speed in excess of the permitted maximum an overspeed device will operate to return the pinion to its retracted position.

DISMANTLING

Commutator end shield (fig. 1 and fig. 2)

Secure the starter horizontally by the yoke in a soft jawed vice with the large terminal at the commutator end in the 12 o'clock position.

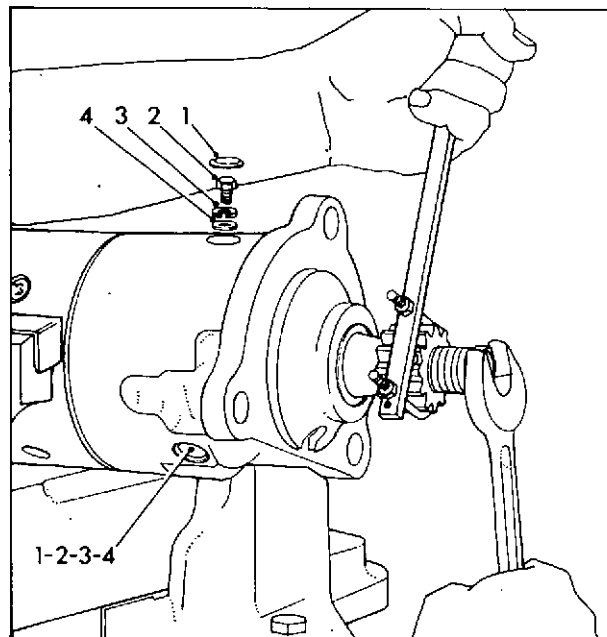


Fig. 1 Loosening pinion stop nut

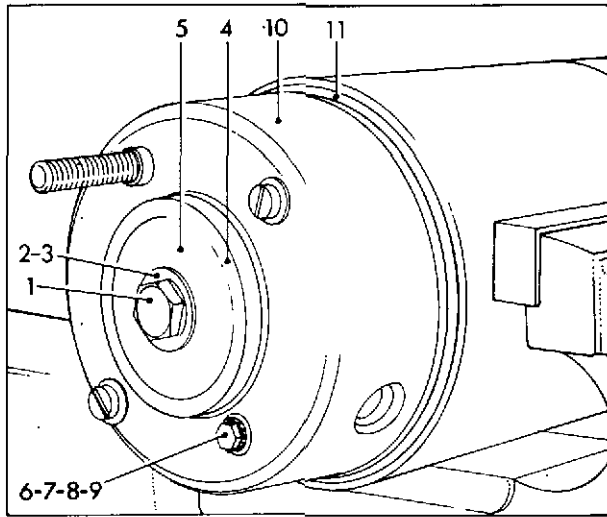


Fig. 2 Removing commutator end shield

Hold the pinion using a suitable tool and unscrew the stop nut two or three turns only. This nut has a left-hand thread. Remove the two core plugs (1) from the drive end shield using a sharp pointed instrument. Unscrew the field terminal screws (2) and remove them together with the spring (3) and plain (4) washers.

Unscrew the commutator end terminal nut and remove the washers, seal and insulating bush.

Remove the commutator end shield cover, through bolts and lift off the cover.

Hold the pinion as previously described and remove the commutator end bolt (1) fig. 2 together with thrust washer (2) and shims (3). Note the number of shims fitted to the drive end shield and retain them for use when re-assembling.

Remove oiler sealing ring (4) and felt washer (5).

Remove screw (6) together with washer (7) washer (8) and bush (9). Remove commutator end shield (10) and retain shims for use when assembling.

Brushgear (fig. 3)

Lift each brush spring (1) fig. 3 in turn and remove the brush (2) from holder. Remove the screws (3) and

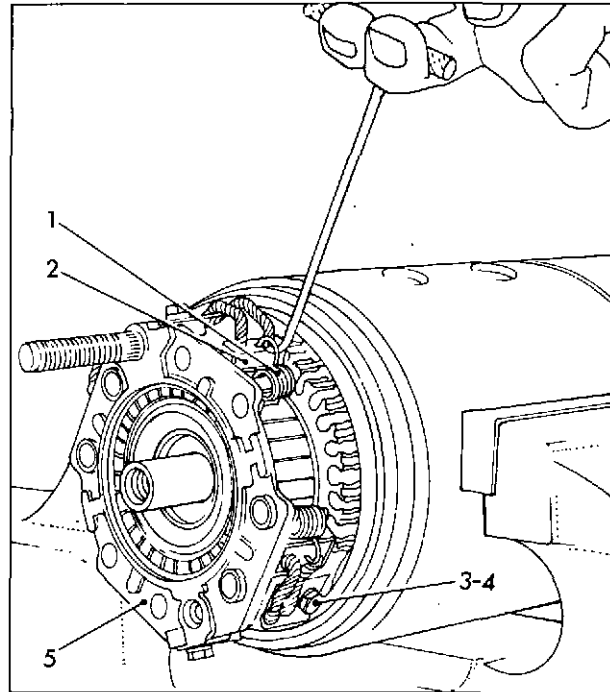


Fig. 3 Removing brushgear

spring washers (4) connecting leads and field coil connectors to brush boxes. Complete brushgear assembly can now be removed.

Drive end shield and pinion sleeve (fig. 4 and fig. 5)

Tap the drive end shield (1) fig. 4 away from the yoke, using a soft hammer, and withdraw it complete with armature. Support the unit as shown to avoid damaging the windings and commutator.

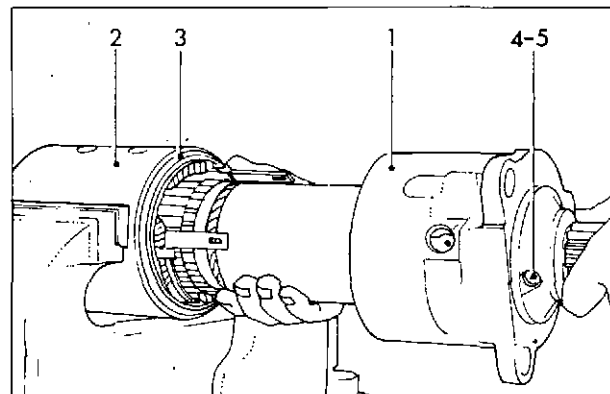


Fig. 4 Removing drive end shield

Remove and discard sealing ring (3).

Using a suitable tool remove oiler core plug (4) and spring.

Discard the plug.

Remove the yoke from vice.

Clamp the armature horizontally in a soft jawed vice and remove pinion stop nut, thrust washer and return spring. Release the ball lock mechanism by pushing the end shield towards the armature and unscrewing the pinion sleeve along the helix until it disengages.

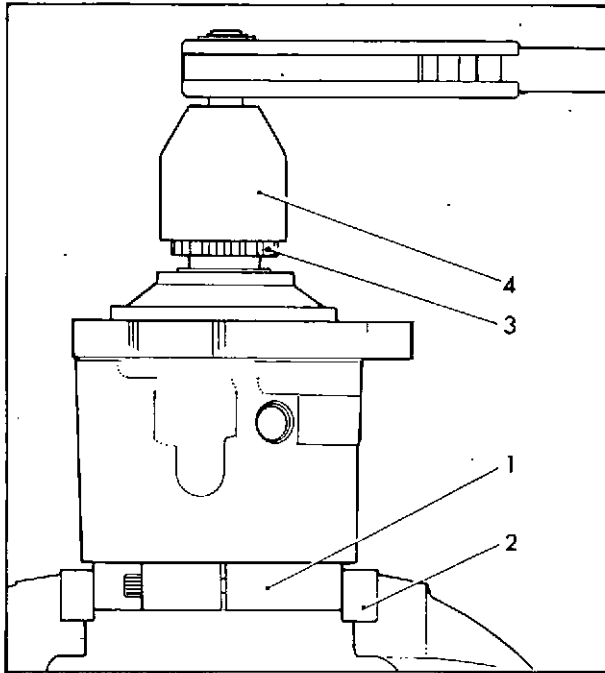


Fig. 5 Removing pinion sleeve

Slide the pinion sleeve together with the drive end shield off the armature shaft. Retain the eight 0.197 ins (5mm) steel balls. Place C.A.V. Tool No. 6244-50 over the trip plate boss and tighten the clamp screw to secure in position. Invert the complete assembly and clamp the tool (1) fig. 5 in the vice (2).

Unscrew the pinion (3) two or three turns using the correct size C.A.V. pinion socket tool.

Release the assembly from the vice and remove tool 6244-50. Unscrew and remove the trip plate together with the lock collar spring and lock collar.

Remove the pinion sleeve from the drive end shield.

Solenoid switch unit (fig. 6 and fig. 7)

Remove screw (1), spring washer (2) and plain washer (3) connecting flexible lead from the resistor to moving contact of switch.

Unscrew nuts (4) from solenoid terminals and remove spring washers (5), plain washers (6), insulating bushes (7) and rubber sealing rings (8). Withdraw solenoid terminals inwards until they are clear of the resistor plate (10).

Remove the resistor (11) and leatheroid insulator (12) from the drive end shield.

Remove main terminal screw (13), spring washer (14), plain washer (15) and two 'Posidrive' screws (16) with spring washers (17).

Withdraw switch assembly (18) from drive end shield and lift out the plunger return spring.

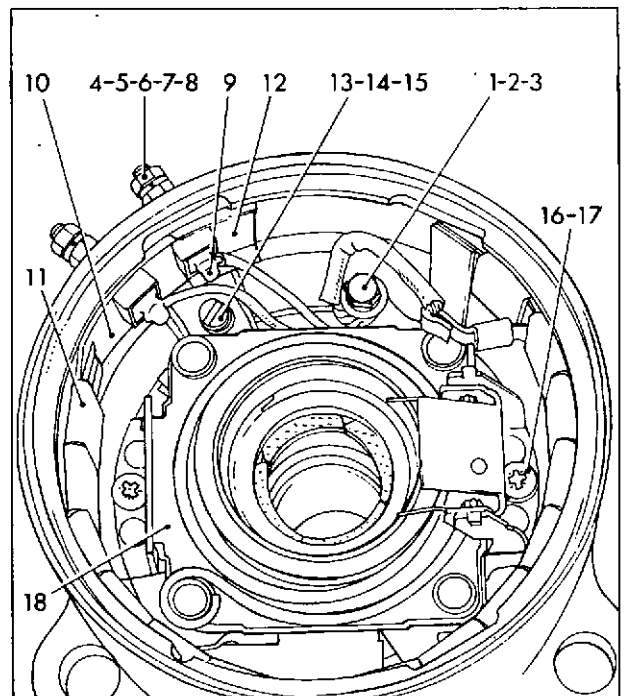


Fig. 6 Removing solenoid switch unit

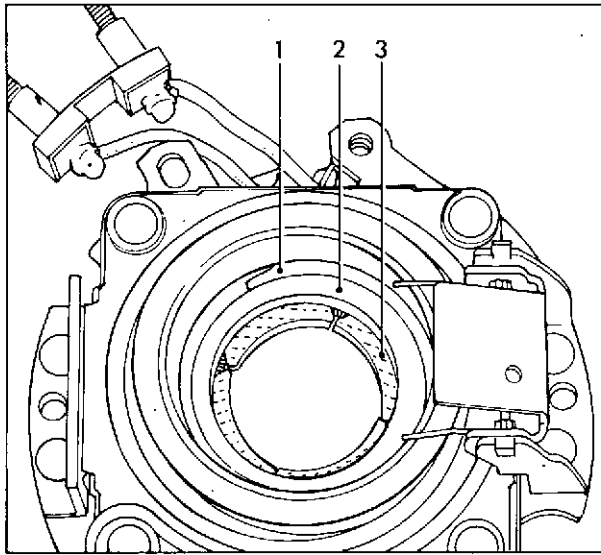


Fig. 7 Removing solenoid plunger segments

Remove 'Spiroflex' circlip (1) fig. 7 by levering the end inwards and 'winding' it out of its groove.

Remove retaining washer (2) and lift out the four segments (3) together with the garter spring.

To remove the main terminal from the drive end shield unscrew and remove the two nuts, spring washers, plain washers, seal locator, insulating washer and sealing washer.

Lift out the terminal assembly from inside the end shield.

Armature (fig. 8 and fig. 9)

Lightly clamp the shaft vertically in a soft jawed vice with the commutator uppermost as shown in fig. 8.

Remove recoil housing (1) from inside commutator sleeve (2). Two holes (3) in the wall of the housing permit the use of two hooked instruments if it is tight in the sleeve.

Slide the two annular keys (4) outwards from the groove in the shaft.

The armature can now be removed from the shaft, using a twisting movement.

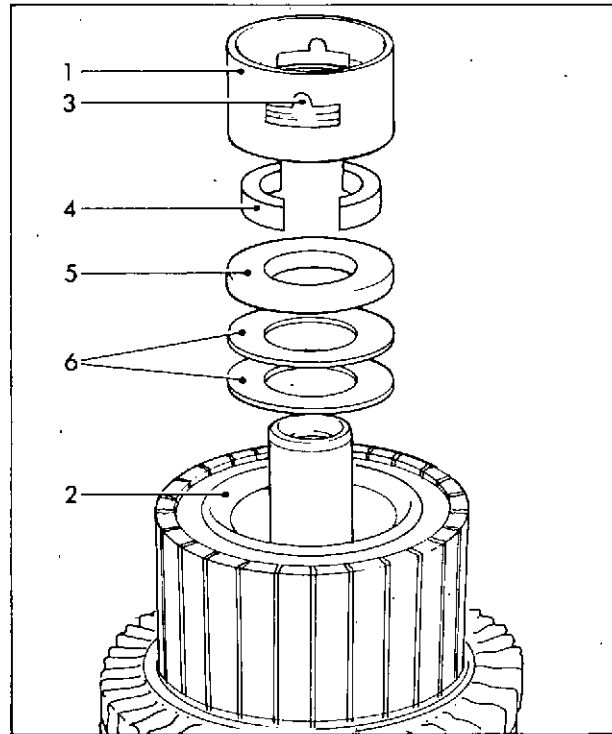


Fig. 8 Removing armature shaft

Remove the two annular keys, thrust washer (5) and shims (6) from the commutator sleeve together with the thrust washer from the shaft. Retain shims

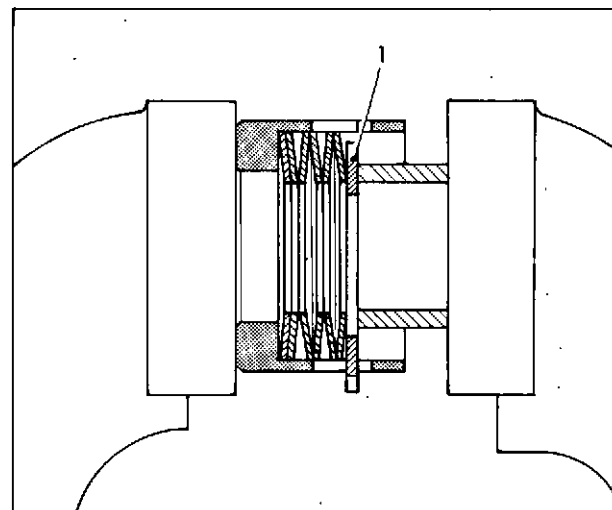


Fig. 9 Dismantling recoil unit

and thrust washers for use on assembly, and remove the shaft from the vice. To dismantle the recoil unit, compress the 'Belleville' washers slightly in a vice using a suitable piece of tubing or rod as shown in fig. 9.

Tap the lock plate (1) sideways until the tongue on one side is clear of the groove in the wall. Release the pressure and lift out the lock plate and 'Belleville' washers.

INSPECTION AND REPAIR

Armature

Examine the windings visually for damage and ensure the bindings are secure and in good condition.

Remove all dust with dry compressed air before testing the windings for continuity, shorted turns, and insulation, with a 'Growler' armature testing machine.

Measure the internal diameter of both bushes. The maximum permissible bore size is 0.790 in (20.075 mm) for the drive end bush and 0.635 in (16.118 mm) for the commutator end bush. If the internal diameter of either bush is greater than these limits, it must be renewed.

Remove the ratchet assembly from inside the armature and examine for wear; renew parts as necessary.

C.A.V. Tool Nos. 6244-31, 6244-32, 6244-33, 6244-36 and 6244-37 are necessary for the removal and refitting of bushes.

The commutator end bush can now be removed using a suitable extractor. Alternatively, it can be removed by driving it out from the commutator end with a sharp pointed implement.

Note: On later machines the hole in the commutator sleeve is increased in diameter to allow the bush to be removed with tool No. 6244-33.

Place the guide tool No. 6244-36 on the fitting pin tool No. 6244-37 and position the new commutator

end bush on the end spigot of the pin. Place the assembly into the armature so that the commutator end bush is just entered into its housing and the guide is in position against the shoulders of the splines. Apply pressure to the end of the pin to press the commutator end bush fully home.

Lightly smear the ratchet components with Aero Shell 16 grease, then assemble them into the armature in the following order: thrust washer (1) fig. 10, armature sleeve ratchet (2), thrust ring (3), helix sleeve ratchet (4), spring (5) and washer (6).

Position the new drive end bush on fitting pin tool No. 6244-31 and insert the pin into the armature so that the end spigot enters the commutator end bush. Apply pressure to the end of the pin until the drive end bush is fully home. The pressure required will be between 3 to 6 tonf (3,000 and 6,000 kgf).

Examine carefully the complete armature shaft for signs of wear or damage, with particular attention to the ratchet and pinion helices and the shoulder of the annular groove for the steel locking balls.

The commutator can be cleaned with a very fine grade of glass paper. Emery or carborundum paper must NOT be used. If the commutator surface is pitted or grooved it may be set up in a lathe and skimmed to a very fine finish.

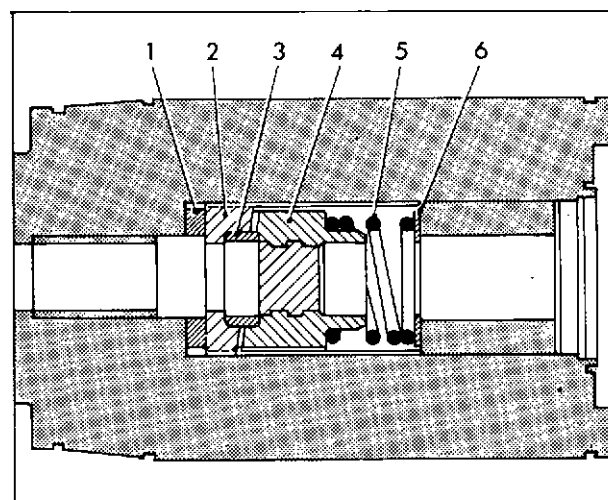


Fig. 10 Assembling ratchet mechanism

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Note: The commutator must be concentric with the armature bearings to within ± 0.002 in (0.05 mm) and may be machined to a minimum diameter of 2.319 in (58.90 mm).

The full width of the commutator segment insulators should be undercut to a minimum depth of 0.040 in (1 mm).

Brushgear

Remove all dust with dry compressed air and inspect visually for signs of wear or damage.

Test the insulation between positive and negative brush boxes using a suitable test instrument; a reading of 1 Megohm should be obtained.

Brushes should be renewed if damaged or less than 0.39 in (10 mm) in length.

New brushes should be bedded in until 80% of the contact area conforms to commutator curvature.

Drive end shield and pinion sleeve.

Lever out and discard the bearing bush oil seal.

Visually inspect the drive end shield casting for cracks or damage to the sealing ring recess, mounting flange or threads.

Check the bearing for wear and if the internal diameter exceeds 1.264 in (32.10 mm) the bearing must be renewed as follows:

Remove the oiler sealing plug and spring and extract the old bearing with tool No. 6244-41. Discard the felt wick. Position a new felt wick in line with the oiler hole and insert the felt retaining collar tool No. 6244-42 into the bore of the drive end shield to retain the wick while the new bush is being fitted.

Blank out the rectangular cut-out in the new bush to prevent swarf getting on the felt wick and press the bush into position in the drive-end shield.

After fitting the bush must be fine bored to the correct internal diameter of $1.260 + 0.001$ in ($32 + 0.03$ mm).

Remove the blanking from the hole in the bush and press in a new oil seal with the lips facing outwards as shown in fig. 11.

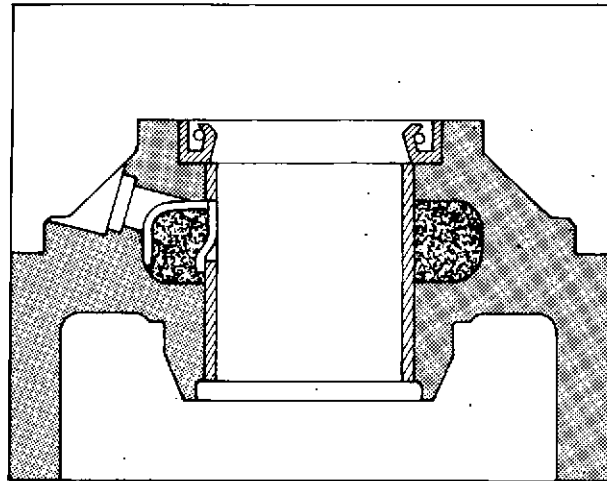


Fig. 11 Drive end oil seal

Note: If a new end shield assembly is being fitted, the leatheroid pad must be removed from the bearing bush before the starter is assembled.

Examine the bearing surfaces of the pinion sleeve for signs of excessive wear or damage. The oil seal in the bore of the sleeve should be renewed when a complete overhaul is being undertaken.

Extract the old seal from the threaded end of the sleeve using a hooked implement. The new seal should be inserted into the bore from the same end and eased into its groove using a round ended tool that will not damage the seal lip.

When correctly installed, the seal lip must be facing towards the pinion teeth as shown in fig. 12.

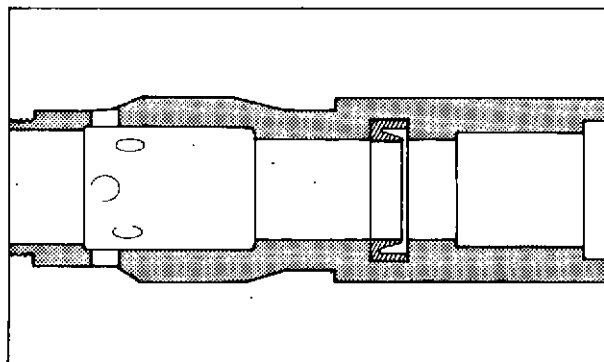


Fig. 12 Pinion sleeve oil seal

If the pinion teeth show signs of damage or excessive wear, the complete pinion sleeve must be renewed. The new pinion sleeve complete with oil seal is available as an assembly.

Solenoid switch unit

Inspect the complete unit for damage and excessive wear with particular attention to the insulation of coil and leads. Ensure insulating bushes are undamaged and the rivets are tight. Check coil continuity using a suitable test instrument or, alternatively, a low voltage battery and lamp wired in series. Test the coil insulation with a 100 volt 'Megger' or similar insulation tester. A reading of 1 megohm should be obtained between coil leads and plunger sleeve.

Should the coil prove faulty the complete solenoid and switch assembly must be renewed.

To check that the switch is operating correctly, stand the plunger return spring on the bench and place the solenoid switch unit over it, coil downwards, as shown in fig. 13. Apply downward pressure to the top of the plunger (1) and check that the first stage contacts (2) close.

Maintain the pressure and depress the trigger (3); the second stage contacts (4) should now snap together. Hold the coil (5) firmly against the bench and release the downward pressure on the plunger.

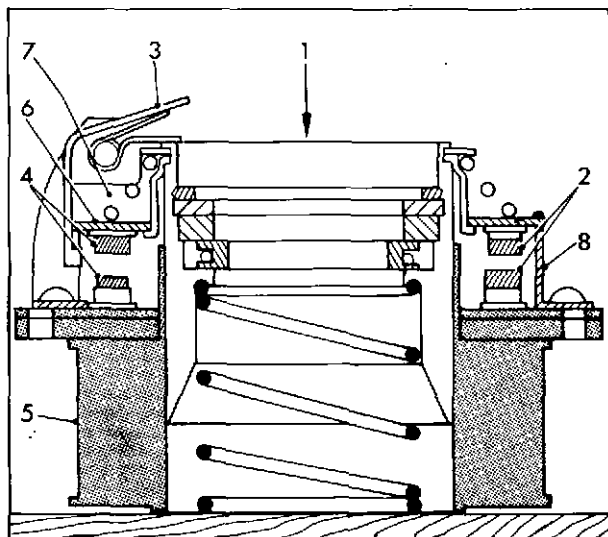


Fig. 13 Checking switch unit operation

The moving contact plate (6) should be moved upwards by the plunger return spring so that it locates behind the step on the trigger.

Check the condition of both sets of contacts and if necessary clean surfaces with very fine carborundum paper and wipe over with white spirit.

Note: If contacts are excessively burnt or pitted they must be renewed as follows:

Spring the two arms of the trigger guide (7) apart and remove the trigger complete with spring and spindle.

Remove the four rivets retaining the contact stop (8) and remove the contact stop and trigger guide. The moving contact and plunger assembly can now be removed followed by the 'fixed contact' plate.

Remove the four rivets (1) fig. 14 holding the 'moving contact' assembly together and this allows the contact (2) and insulator (3) to be removed from the latch plate (4).

When fitting the new moving contact, first assemble the 'insulator' and 'moving contact' to the latch plate ensuring that the 'second stage contact' (5) is adjacent to one of the two lips (6) on the latch plate as shown.

Re-assemble with new rivets as illustrated in fig. 14, ensuring that the long insulating bush (7) is passed through the spring eye and is in the shown position.

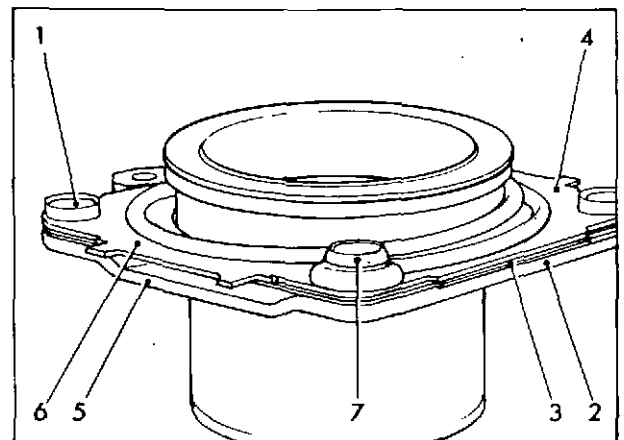


Fig. 14 Renewing switch moving contract

During the assembly of the complete switch unit, place the 'fixed contact plate' onto the coil ensuring the angled slot locates over the raised moulded part of the coil bobbin cheek. Smear the outside diameter of the plunger and the bore of the coil tube with Aero Shell 16 grease.

Place the plunger into the tube ensuring that the 'moving contacts' align correctly with their fixed counterparts. Insert two rivets through the trigger guide, moving contact plate and fixed contact plate; rest the rivet heads on a suitable support and punch over end of rivet.

Secure the contact stop in position with two rivets.

Position the trigger assembly so that the spring ends rest on top of the plunger and then spring it into position between the guide arms. Ensure that the ends of the spindle enter correctly into the two holes.

Check the operation of the complete unit as previously described. Examine the four segments for wear or damage and, if necessary, renew as a complete assembly.

Field coils (fig. 15)

Remove all traces of brush dust with dry compressed air. Inspect the coil insulation and insulating-strip for signs of damage. Test the insulation with a 100 volt 'Megger' or similar test instrument. A reading of 1 Megohm should be obtained between each field coil connection and the yoke. If it is necessary to remove the field coil assembly, proceed as follows with reference to fig. 15.

Note the position of both long field coil connectors (1) in relation to the dowel pin (2) at the drive end of the yoke. Unscrew and remove the eight screws (3) securing the pole shoes (4) to the yoke. The field coils (5) and pole shoes can now be removed together with both leatheroid strips (6). When replacing the field coils into the yoke ensure that the long connectors are in the correct position relative to the dowel pin.

Place each pole shoe in its correct position with the stamped number on the end towards the drive end of the yoke. When viewed from the drive end the first pole shoe past the dowel should be number 3 followed by numbers 4, 1 and 2.

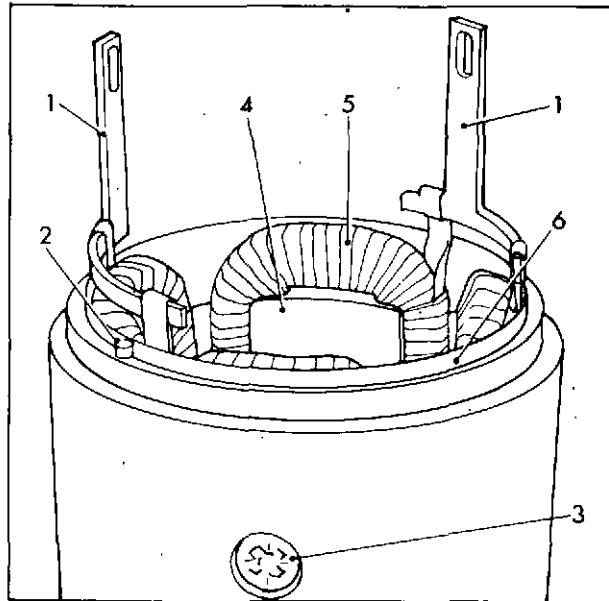


Fig. 15 Dismantling field coils

Secure each pole shoe with two screws, finger tight only. Place two leatheroid strips under the field coils ensuring they are correctly positioned and then tighten all eight pole shoe screws fully.

Commutator end shield (fig. 16)

Ensure the bearing is tight in the housing. If the bore of the bearing (1) exceeds 0.633 in (16.087 mm) the bearing must be renewed.

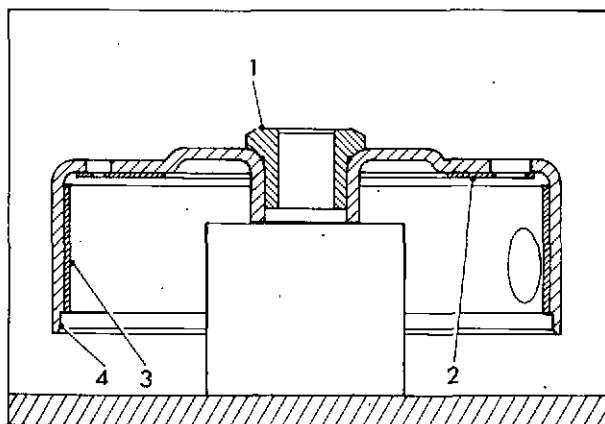


Fig. 16 Commutator end shield bearing

Inspect the insulating plate (2) and strip (3) for damage and renew if necessary, securing into position with 'Bostik' clear adhesive No. 1437. Ensure that the holes in the strip and plate align with the holes in the end shield and that the insulating strip does not protrude into the spigot recess (4).

ASSEMBLY

It is recommended that all sealing devices and locking washers are renewed during assembly.

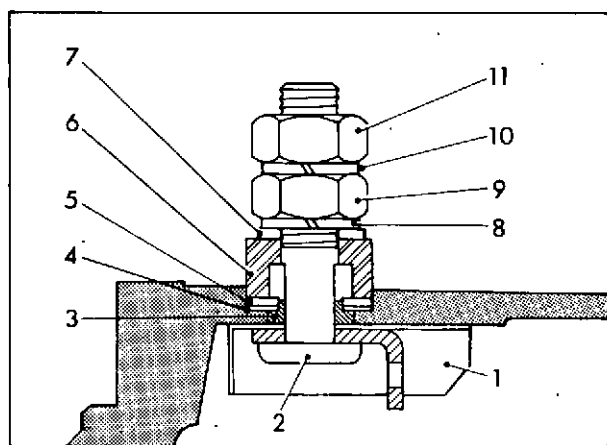


Fig. 17 Drive end terminal assembly

Solenoid switch unit (fig. 17)

Place the moulded insulator (1) over the terminal (2) as shown and place sealing washer (3) in position. Pass the terminal through the hole in the drive end shield which has the large counterbore on the outside. Assemble the items 4-7 inclusive in position and secure with spring washer (8) and nut (9); tighten nut to a torque loading of 9 to 10 lbf.ft (12.2 to 13.6 Nm). Place spring washer (10) in position and screw on nut (11) finger tight.

Ensure that the segments and inside of the plunger are clean and free from oil or grease.

Assemble the four segments (2) fig. 18 inside the spring (1) and position them in the solenoid plunger. Fit the retaining washer (3) over the segments ensuring that the projections on the underside engage between the segments and that the slot locates over the tongue

in the wall of the plunger recess. Insert the 'Spirolox' circlip (4) into the groove in the plunger bore and lightly smear the trigger spring (5) and spindle (6) with Aero Shell 16 grease.

Smear the solenoid plunger return spring with Aero Shell 16 grease and place it in the drive end shield. Insert switch assembly into the shield with the 'fixed contact' connecting arm in line with the main terminal. Fit retaining screws (1) fig. 19 with spring washers (2) and tighten screw to a torque value of 18 to 20 lbf.in (2.03 to 2.26 Nm). Insert screw (3) together with washers (4) and (5) and tighten to torque value of 18 to 20 lbf.in (2.03 to 2.26 Nm). Fit leatheroid insulator (6) in resistor groove and assemble resistor (7) into position in the drive end shield.

Fit the insulator (8) over the terminals (9) and insert terminals through the resistor plate (10), leatheroid insulator and drive end shield. Fit sealing ring (11), insulating bush (12), plain washer (13), spring washers (14) and nuts (15) to each terminal. Tighten to torque value of 18 to 20 lbf.in (2.03 to 2.26 Nm).

Secure resistor flexible lead to switch with screw (16), spring washer (17) and plain washer (18) and tighten to torque value of 15 to 18 lbf.in (1.69 to 2.03 Nm).

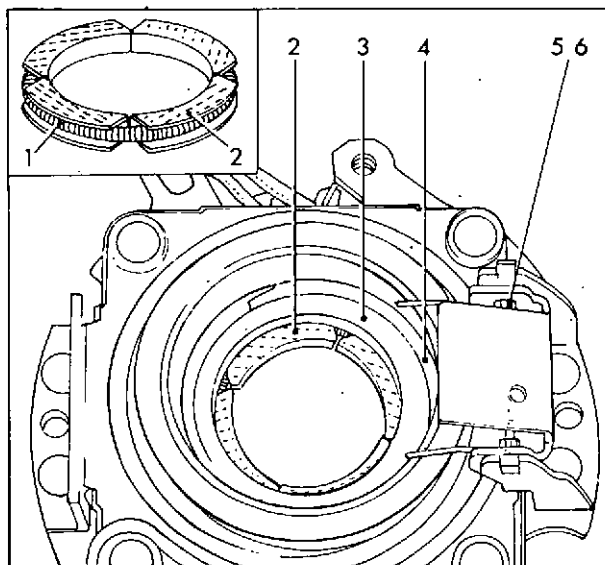


Fig. 18 Assembling solenoid plunger segments

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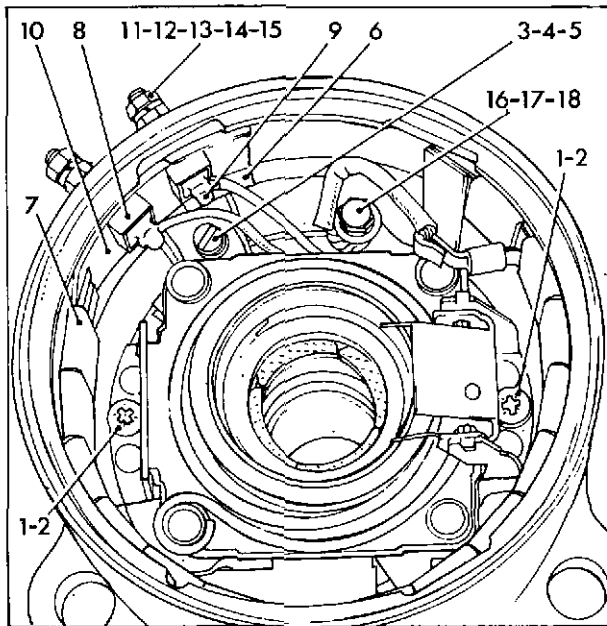


Fig. 19 Replacing solenoid switch unit

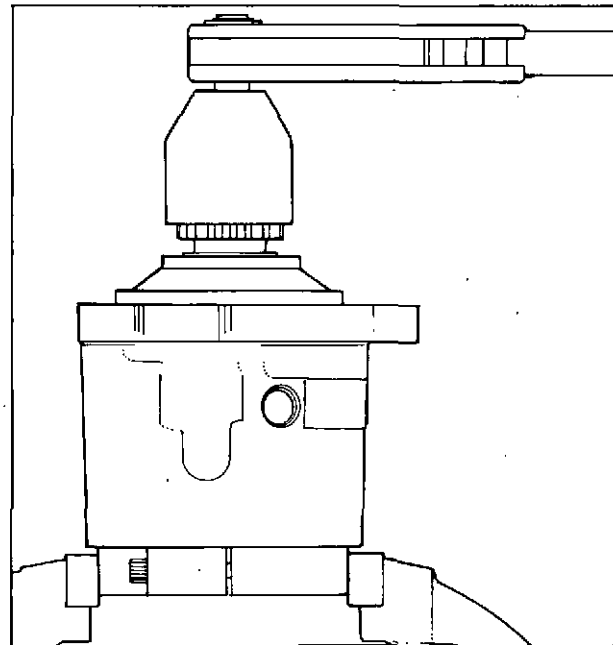


Fig. 21 Tightening trip plate

Pinion sleeve

Check that the leatheroid pad has been removed from the drive end shield bush.

Fit split collar tool No. 6244-43 into the drive end seal and lubricate bearing bore and pinion sleeve with Tellus T27 oil before inserting pinion sleeve into the end shield bearing. Remove the split collar when the sleeve is nearly home and guide sleeve carefully through the four segments.

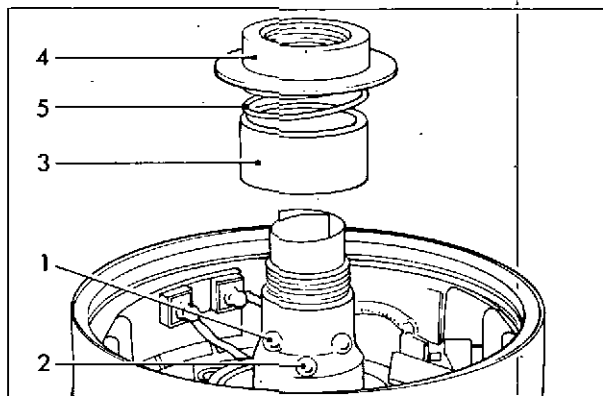


Fig. 20 Assembling pinion sleeve

Grip the pinion teeth firmly in a soft jawed vice so that the threaded end is uppermost as shown in fig. 20.

Form a piece of stiff paper into a tube and insert it into the pinion sleeve bore to prevent the balls from falling inside.

Smear the locking balls (1) and overspeed balls (2) with Aero Shell 16 grease and insert them in the positions shown. Place locking collar (3) in position over the balls.

Degrease the threads of the pinion sleeve and trip plate (4) and then smear both threads with 'Loctite' green retaining compound No. 290.

Place spring (5) in position and screw on the trip plate finger tight.

Secure tool No. 6244-50 over the trip plate boss and clamp the assembly in vice as shown in fig. 21. Using the correct pinion socket, tighten the pinion to a torque value of 40 to 50 lbf.ft (54.2 to 67.8 Nm).

Armature shaft

Lightly smear the 'Belleville' washers (1) fig. 22 with Aero Shell 16 grease and assemble them into the recoil housing (2) as illustrated.

Insert one side of lock washer (3) in the slot in recoil housing and compress the 'Belleville' washers, as shown in fig. 22, until the lock washer can be engaged in the other slot. Clamp the armature shaft vertically in the vice with the threaded end downwards.

Smear the short shaft helix and thrust washer with Aero Shell 16 grease and place the washer on the shaft. Fit the armature to the shaft with a twisting movement to enable the shaft helix to engage with the helix in the ratchet sleeve.

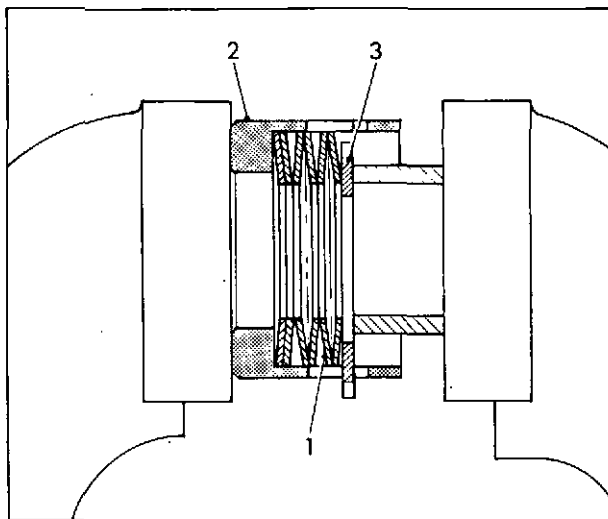


Fig. 22 Assembling recoil unit

Smear the original shims (1) fig. 23 and thrust washer (2) and insert in correct order into commutator sleeve (3). Ensure that the shaft is fully home by applying slight downward pressure and fit keys (4) into the annular groove of the shaft.

Check shaft end float while sufficient pressure is applied to the shaft to overcome the reaction of the ratchet spring. The end float should be between 0.002 and 0.014 in (0.05 and 0.35 mm) and may be adjusted by the addition or subtraction of shims. Use the least number of shims possible and ensure that the thickest shim is next to the keys.

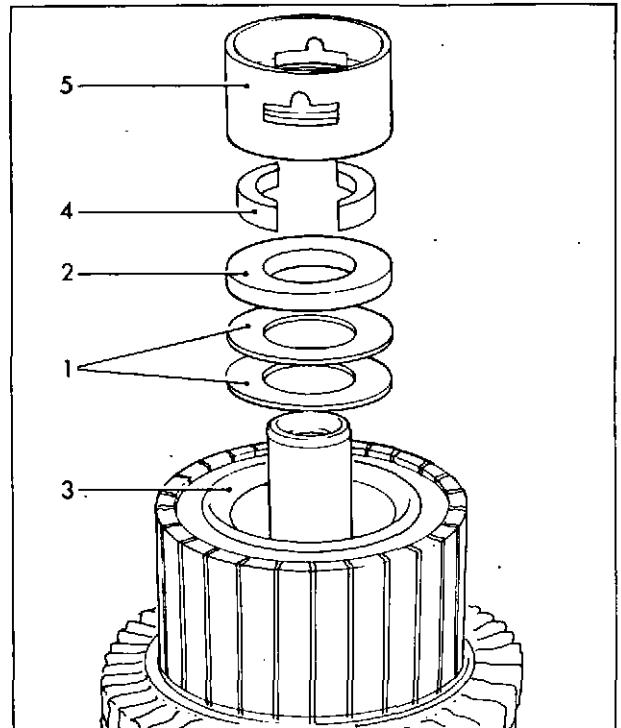


Fig. 23 Replacing armature shaft

Fit the assembled recoil unit (5) into the armature sleeve ensuring that the bore in the lower part locates over the two keys.

Check operating of the ratchet mechanism by turning the armature which should only rotate in one direction.

Remove the armature assembly from the vice.

Drive end shield

Lightly smear helix and bearing surfaces of the armature shaft with Aero Shell 16 grease and clamp the unit horizontally in a soft jawed vice.

Pull the pinion (1) fig. 24 fully out of the drive end shield and retain it in this position.

Slide the pinion and drive end shield onto the armature shaft and release the pull on the pinion.

Remove the paper tube from the pinion before the end shield is fully in position.

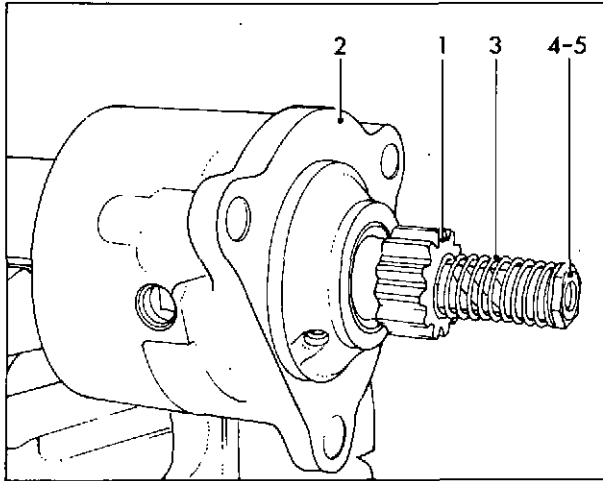


Fig. 24 Assembling drive end shield

Fit the pinion return spring (3) thrust washer (4) and secure with pinion stop nut (5), finger tight only; remove armature from the vice.

Oil the bearing wick with Tellus T27 oil and fit oiler spring and new core plug.

Armature and brushgear

Secure yoke in vice as shown in fig. 25 and place a new sealing ring (1) in position. Insert the armature (3) while taking care to avoid damage to the windings or commutator. Ensure that the dowel in the end of yoke engages with the hole in the drive end shield (4). If necessary tap the shield into position with a soft faced mallet.

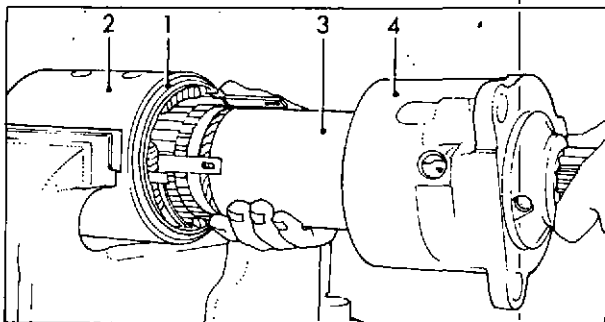


Fig. 25 Replacing armature into yoke

Assemble the brushgear assembly onto the commutator end of the yoke with the large terminal post (1) fig. 26 in line with the register pip on the yoke end.

Fit screw (2) with spring washer (3) through each positive brush lead tag (4) and screw through brushgear into the brushgear assembly. Do not fully tighten the screw.

Insert brushes into holders and secure the remaining two unattached leads with screws (5) and spring washers (6), tightening to a torque value of 15 to 18 lbf.in (1.69 to 2.03 Nm).

Smear the original shims (7) with Aero Shell 16 grease and replace them in the recoil housing, thickest shim last.

Renew sealing ring (8).

Check brush spring tensions with a gauge as shown. Indicated pressure when the spring starts to leave the brush should read 5.25 to 5.50 lbf (2.38 to 2.49 kgf).

Commutator end shield

Ensure that both the insulating plate and strip are in position inside the commutator end shield.

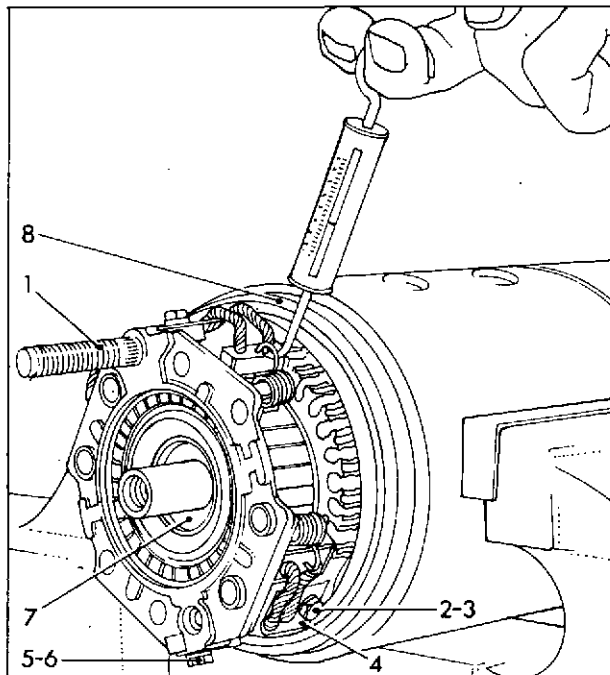


Fig. 26 Replacing brushgear

Smear the bush and the end of the armature shaft With 'Turbo 41' oil.

Assemble the end shield (1) fig. 27 onto the yoke, ensuring that it is correctly located and the brush leads are not trapped.

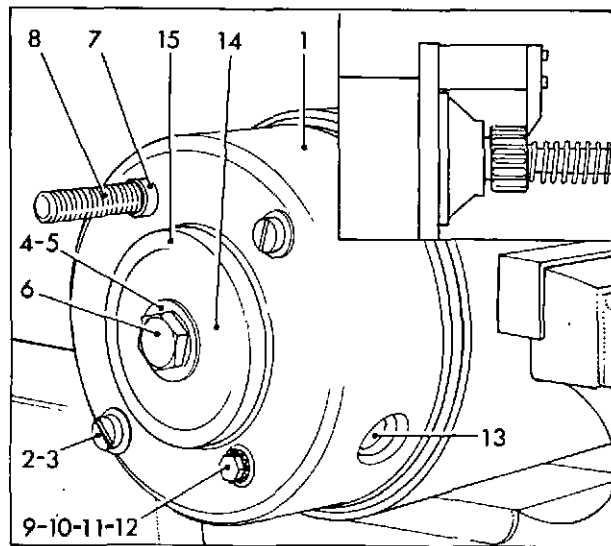


Fig. 27 Replacing commutator end shield

Insert both through bolts (2) with sealing washers (3) and tighten to torque value of 9.5 to 10 lbf.ft (12.9 to 13.6 Nm).

Check the pinion to flange clearance, using gauge tool No. 5693-222, by holding the gauge firmly against the flange as shown in inset on fig. 27. With the pinion loaded slightly inwards the arm of the gauge should just clear the face of the pinion. To adjust this clearance add or subtract shims as necessary between the recoil housing and the end shield boss. Shims of varying thickness are available. Assemble shims (4) thrust washer (5) and bolt (6) and tighten the bolt to a torque value of 25 to 30 lbf.ft (34.0 to 40.7 Nm) while holding the pinion with tool No. 6244-39. Add or subtract shims as necessary to obtain a clearance of 0.004 to 0.012 in (0.1 to 0.3 mm) between thrust washer and the shims.

Hold the pinion and tighten the pinion stop nut to a torque value of 40 to 50 lbf.ft (54.2 to 67.8 Nm).

Slide bush (7) over return terminal (8) and press fully home.

Fit insulating bush (9), plain washer (10) shakeproof washer (11) and screw (12); tighten screw to torque value of 15 to 18 lbf.in (1.69 to 2.03 Nm). Pull on the return terminal (8) and tighten brush screws (13) through the access holes in the commutator end shield to a torque value of 15 to 18 lbf.in (1.69 to 2.03 Nm).

Remove both through bolts and fit felt washer (14) and seal (15). Place the commutator end shield cover (1) fig. 28 in position, refit both through bolts (2) with sealing washers (3) and tighten to torque value of 9.5 to 10 lbf.ft (12.9 to 13.6 Nm).

Fit the thin sealing washer (4), rubber seal (5), seal locator (6), plain washer (7), spring washer (8) and nut (9) on the return terminal; tighten to torque value of 9 to 10 lbf.ft (12.2 to 13.6 Nm). Add a second spring washer and nut to the terminal and screw up finger tight.

Insert the two field coil connecting screws, spring washers and plain washers through the holes in the drive end shield and tighten to torque value of 15 to 18 lbf.in (1.69 to 2.03 Nm).

Fit new core plug to each hole using tool No. 6244-45.

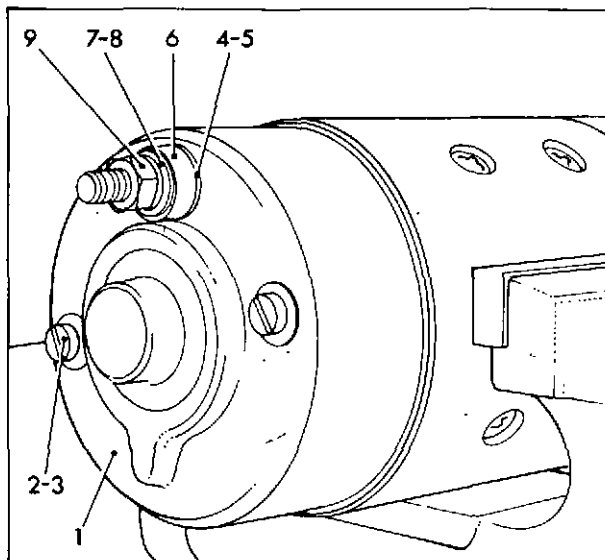


Fig. 28 Replacing commutator end shield cover

TESTING

Check that the pinion will rotate freely when turned by hand and will return easily to its original position when pulled partly outwards and then released.

Note: This check must be carried out before any power supply is connected to the main terminals. Failure to heed this warning could result in serious injury.

Light running test

Secure starter motor in a suitable position. Energise the solenoid with 24 volts and then connect a 24 volt battery supply to the main terminals for a maximum

of five seconds. The pinion should rotate slowly and smoothly with no undue noise or vibration. Disconnect the battery supply from the main terminals. Apply 24 volt to the solenoid terminals and pull the pinion forward into the locked position. Connect the main terminals to the 24 volt supply. In this position the pinion should rotate smoothly at a greater speed than previously

Disconnect the supply to the main terminals; the pinion should now return to its de-energised position and stop rotating.

Further details of testing may be obtained through an official C.A.V. agent.

PART 2—STARTER MOTOR**C.A.V. SP6A24**

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DESCRIPTION

This is a 24-volt axial starter, actuated by an integral solenoid-operated two-stage switch.

Engagement between the pinion and flywheel is effected by a forward and rotational movement of the armature assembly, before the starter develops full torque.

An overload clutch, fitted between the armature and the pinion, has a slipping torque which is approximately twice the lock torque of the starter but less than the shear strength of the pinion teeth.

Referring to fig. 29, when the starter switch is operated the first stage contacts on the solenoid switch (18) close, and a small current passes through the auxiliary field windings, causing the armature to rotate slowly. Simultaneously, the armature assembly (35) is drawn towards the driving end by the magnetic field set up in the windings, and the pinion (39) meshes with the flywheel teeth.

As the armature nears the end of its travel the tripping disc (30) operates the trigger (19) on the solenoid switch, causing the second stage contacts to close and complete the circuit to the main series winding. The starter then exerts its full torque on the engine, and the overload clutch (36) will come into operation should the load be excessive.

When the starter button is released the armature is returned to the disengaged position by the coil spring on the armature plunger (32).

The auxiliary windings are arranged to hold the pinion in mesh until the starter button is released.

MAINTENANCE

In service the following periodic inspections of the starter should be made. Lubrication should not normally be necessary unless the starter is in use without overhaul for longer than three years.

Check the mounting bolts for tightness and the cables and their connections for security and damage.

Ensure that the bushes are free to slide in their holders, and check the tension of the brush springs. The pressure at the point of contact should be 32 to 40 oz. (0.91 to 1.13 kg.) and a reading of less than the lower limit indicates worn brushes. New brushes must be fitted as a set, and bedded to the commutator before the starter is used.

Inspect the insulation of the brush leads and ensure that they do not foul other components.

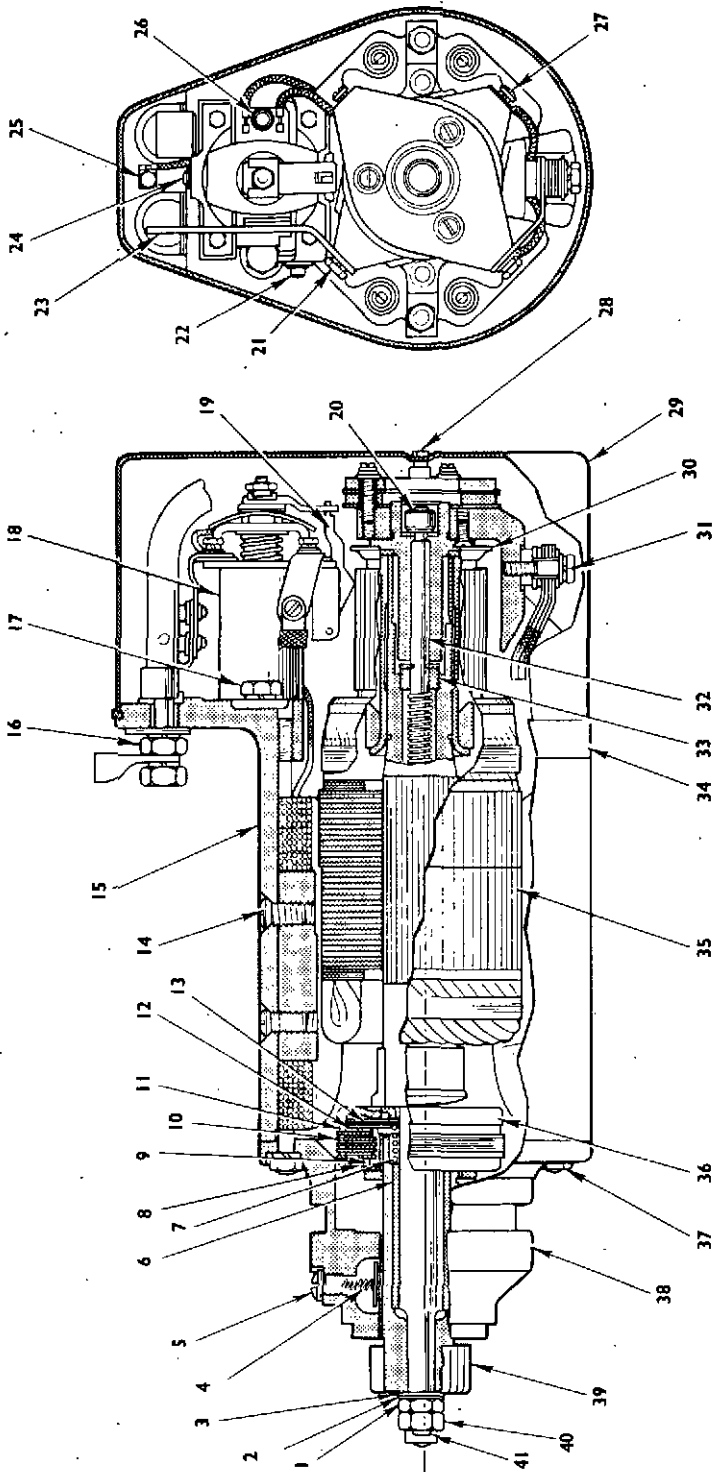
The surface of the commutator should be smooth and clean. A dark brown discoloration is normal and may be ignored. If necessary, any particles of dust should be removed by means of an air jet, and the commutator cleaned by holding a dry cloth against it whilst the armature is turned by hand. If the commutator is badly worn it must be removed and trued up in a lathe, as described under 'Inspection and Repair'.

REMOVAL AND DISMANTLING

Disconnect the leads at the motor terminals, remove the three setbolts from the starter flange and withdraw the starter motor.

Remove the commutator cover (29).

Unscrew the brush lead screws, lift the brush springs and remove the brushes from their holders. Removal



- | | | |
|----------------------|----------------------------|---------------------------|
| 1. NUT | 21. SCREW | 32. ARMATURE PLUNGER |
| 2. WASHER | 22. SCREWS | 33. PLUNGER RETAINING NUT |
| 3. SHIM | 23. NEGATIVE CONNECTOR | 34. COMMUTATOR END SHIELD |
| 4. LUBRICATOR SPRING | 24. SCREWS | 35. ARMATURE ASSEMBLY |
| 5. LUBRICATOR PLUG | 25. SOLENOID COIL TERMINAL | 36. OVERLOAD CLUTCH |
| 6. SHIM | 26. SCREWS | OUTER RACE |
| 7. PINION SPRING | 27. BRUSH LEAD SCREWS | 37. FIXING BOLTS |
| 8. CLUTCH INNER RACE | 28. NUTS | 38. DRIVE END SHIELD |
| 9. CLUTCH SPRINGS | 29. COMMUTATOR COVER | 39. PINION |
| 10. CLUTCH PLATES | 30. TRIPPING DISC | 40. NUTS |
| | 31. SCREW | 41. SPLIT PIN |

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Fig. 29 C.A.V. starter motor

of the brush lead screws also frees the auxiliary field connections to the brushgear.

Mark the leads to the brushgear and solenoid switch for ease of identification when assembling.

Remove the nut (20) from the armature plunger, using C.A.V. tool 5693/45.

Unscrew the main fixing bolts (37). Tap the drive end shield (38) away from the yoke (15), using a hide mallet, and withdraw the shield complete with armature (35).

Hold the armature in a soft-jawed vice and remove the lubricating plug (5) and spring (4) from the drive end shield.

Remove the split pin (41), nuts (40) and (1), and washers (2) and (3), and withdraw the pinion (39) and drive end shield from the shaft.

Remove the pinion spring (7).

Collect the clutch inner race (8), clutch plates (10), shims (11), back plate (12) and pressure plates (13) from the clutch assembly. Identify the clutch plates so that they may be reassembled in their original positions.

Withdraw the shim (6) and, if fitted, the rubber sealing ring from the pinion bore.

Using C.A.V. tool 5693/103, unscrew the armature plunger retaining nut (33) and withdraw the plunger (32) from the armature.

Remove the screws (22), (24) and (26) securing the positive terminal collector, main field coil ends and auxiliary field connections to the solenoid switch.

Remove the screw (31) holding the main field connections to the connection at the bottom of the commutator end shield, and carefully tap the end shield away from the yoke, using a hide mallet.

Disconnect the solenoid coil leads.

Unscrew the negative terminal nut (16) and the screw (21) securing the negative connector to the brushgear, and remove the negative connector.

Unscrew the solenoid screws (17) and remove the solenoid switch.

INSPECTION AND REPAIR

Commutator

Inspect the surface for wear, scores, and uneven discoloration. If these conditions are not severe,

restore the surface by the use of very fine glasspaper (NOT emery cloth or carborundum paper). Use an air jet to remove all traces of abrasive.

Where this treatment would be inadequate, set up the armature in a lathe and skim the commutator, taking care that the surface is concentric with the bearings. Make the finest cut necessary to clean up the surface, using a very sharp tool.

After skimming the commutator, undercut the insulation between the segments to a depth of 0.032 in. (0.8 mm.) using a proprietary tool or ground-down hacksaw blade.

Finally, set up the armature in a lathe and take a fine finishing cut, using a diamond tool. Remove all traces of dust by means of compressed air.

Armature windings

Armature windings may be tested for continuity and short circuits by means of a 'growler'.

If it is necessary to renew the armature, transfer the clutch outer race (36) to the new item. Use C.A.V. tool 5693/61 to press the race from the unserviceable armature. To fit the race to the new armature, insert C.A.V. tool 5693/94 into the armature bore so that the press bears on the tool and not on the end of the commutator.

Field windings

Test the windings for short circuits to earth by means of mains test probes in series with a lamp on the live side. Apply one probe to the yoke and the other to the end of each winding in turn. If the lamp does not light, the insulation is intact.

Make an open circuit test by connecting an ohmmeter across each winding in turn. No reading indicates that the winding is faulty.

Test each winding for internal short circuits by means of a low-reading ohmmeter.

To renew unserviceable coils, unscrew the pole fixing screws (14) and withdraw the poles and windings, noting the position of the windings to facilitate reassembly.

Fit the new windings to the poles and assemble them to the yoke so that the number on each pole corresponds with that on the yoke, and the step machined on each pole is towards the commutator end.

Warm the assembly in an oven and tighten the pole-screws with a proprietary pole-screw driver. Check by feeler gauge that there is no clearance between the mating surfaces of poles and yoke.

Bearings

Insert the pinion into its bearing in the drive end shield, fit the commutator end of the armature to the bearing pin in its end shield and check both bearings for excessive side-play.

A worn bearing pin at the commutator end, or a worn drive end bearing, will necessitate replacement of the respective end shield assembly, since renewal of these bearings entails the use of equipment not normally available.

Brushgear

Check the insulation between the following points, using mains test probes and lamp. The lamp should not light if the insulation is sound:

- (a) Between positive and negative brush holders.
- (b) Between positive brush holder and the frame.
- (c) Between negative brush holder and the frame.

Clutch

Unless facilities are available for testing the slipping torque, it is inadvisable to renew individual components, and a replacement assembly should be obtained if the clutch is unserviceable.

Instructions for adjusting the slipping torque are given under 'Assembling'.

Pinion

Examine the teeth for wear and damage. If a replacement pinion is to be fitted ensure that it has the same number of teeth and is of the same material as the old component.

ASSEMBLING

Grip the armature in a soft-jawed vice, grease the spring and thrust washer on the armature plunger (32), insert the plunger into the armature and tighten the retaining nut using C.A.V. tool 5693/45.

Insert the pressure plates (13), back ring (12) and shims (11) into the clutch outer race (36). Grease the clutch springs (9) and fit them, large end first, into their holes in the inner race (8).

Lightly grease the clutch plates (10) and, commencing with a steel plate fit alternate steel and bronze plates to the splines of the inner race. Assemble the inner race to the outer race.

Grease the pinion spring (7) and fit it to the armature shaft.

Grease the bore of the pinion (39), insert the rubber sealing ring, where fitted, and shim (6) and fit the pinion to the drive-end shield (38), rotating the pinion in the direction of its thread to avoid damaging the lubricating pad.

Assemble the pinion and drive-end shield to the armature shaft. Push the pinion forward and engage it with the internal thread of the clutch inner race. Hold it in this position and fit the shim (3), washer (2) and nut (1). Ensure that the shim is located over the shoulder of the shaft, and tighten the nut. Check that the pinion has a small amount of end float in the armature shaft.

CLUTCH ADJUSTMENT

To adjust the slipping torque of the clutch secure the armature in the clamp bracket 5693/62, and fit the torque bar 5693/147 to the pinion so that the torque is applied against normal starter rotation.

Adjust the clutch, by means of the shims (11) between the clutch plates (10) and the back plate (12), until it will support a weight of between 36.6lb. (16.6kg.) and 42.7lb. (19.4kg.) at the end of the torque bar. This will give a slipping torque of between 120 lbf.ft. (163 Nm) and 140 lbf.ft. (190 Nm).

Shims are supplied in 0.004in. (0.1mm.) and 0.006in. (0.15mm.) thickness, and adding shims will increase the slipping torque.

Slip the clutch ten times and then re-adjust it until it will support a weight of between 30.5lb. (13.8kg.) and 36.6lb. (16.6kg.) at the end of the torque bar. This will give a slipping torque of between 100 lbf.ft. (136 Nm) and 120 lbf.ft. (163 Nm).

Fit, tighten and lock the castellated nut (40).

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Pour approximately 12c.c. of oil into the filler hole in the drive end shield. When this has been absorbed by the pad replace the spring (4) and plug (5) and wipe off any surplus.

Fit the solenoid switch (18) to the commutator end shield, using the screws (17).

Assemble the negative connector (23) to the commutator-end shield, and fit the nuts (16) and screw (21).

Reconnect the solenoid winding leads.

Fit the commutator-end shield to the yoke, ensuring that the dowel is engaged.

Replace the screws (22) (24) and (26) securing the main field coil ends, positive terminal connector and auxiliary field connections to the solenoid switch.

Replace the screws and insulating pieces (31) holding the main field connections to the connector at the bottom of the commutator-end shield.

Assemble the armature and drive-end shield to the yoke, and fit and tighten the fixing bolts (37).

Ensure that the armature is free to rotate.

Fit and tighten the washers and nut (20) to the armature plunger.

Replace the bushes, ensuring that each returns to its original position. New brushes must be bedded in to the commutator.

Connect the brush leads and auxiliary field leads to the brushgear.

Referring to fig. 29 and fig. 30, check the relationship of the trigger (19) and tripping disc (30) by pulling the armature forward until the trigger is raised to its highest extent by the tripping disc. There should then be an adequate clearance ('X') between the shoulder on the trigger and the bottom of the slot in the catch plate.

TESTING

To test the engagement mechanism, insert a strip of insulating material between the second stage contacts of the solenoid, connect the starter to a battery, and press the starter button. The first stage contacts should close, causing the pinion to rotate in the normal direction and move forward approximately 1 inch (25.4mm.).

Do not keep the starter button depressed for longer than necessary, otherwise the auxiliary windings may overheat.

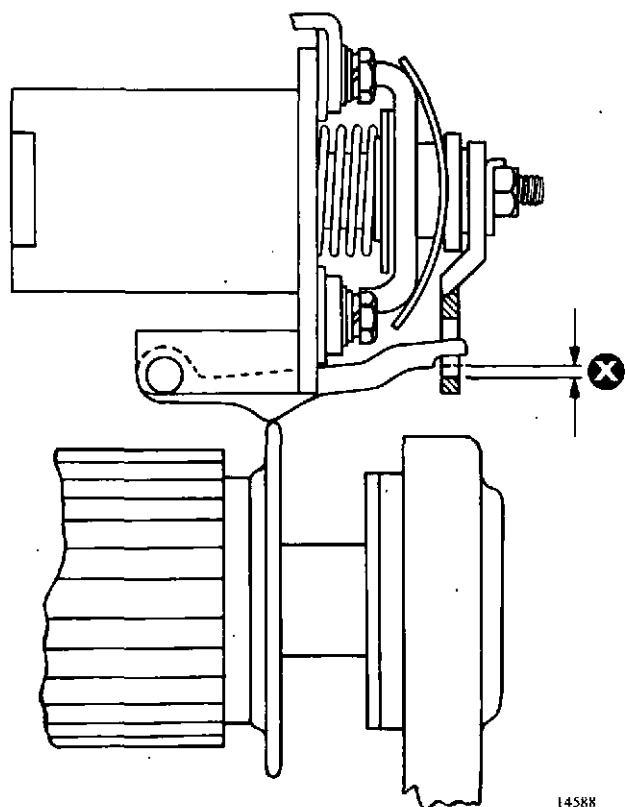


Fig. 30 C.A.V. solenoid trigger

LUBRICATION

For the drive-end bearing a good quality oil is recommended. Use S.A.E. 10W/30W in temperate climates or 5W/20W in sub-zero climates.

For other points, such as the clutch plates and springs, use Shell Nerita grease, BP Energrease or Shell Retinax H.

SPECIAL TOOLS

Rolls-Royce No.	C.A.V. No.	Description
OD.6725	5693/45	Key for plunger nut
OD.13085	5693/61	Extractor, clutch outer race
OD.13086	5693/62	Clamp bracket and shims for adjusting clutch
OD.13087	5693/94	Dolly, clutch housing
OD.13088	5693/103	Key, plunger stop
OD.13089	5693/147	Torque bar for adjusting clutch

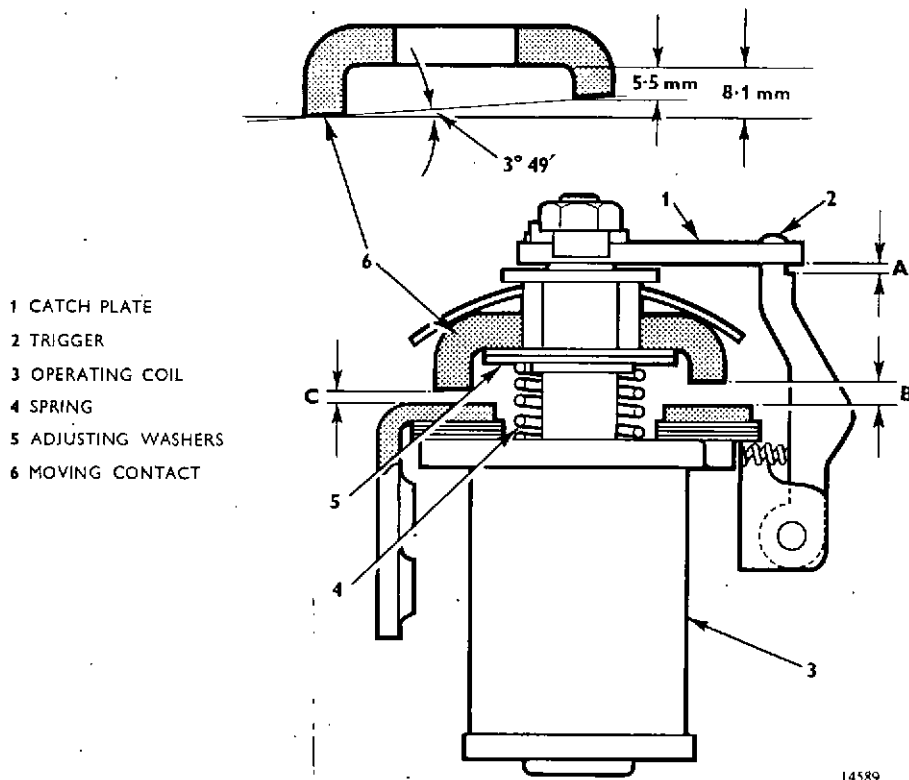


Fig. 31 C.A.V. solenoid switch

SOLENOID SWITCH—C.A.V. BBNG

This is a two-stage unit consisting of an operating coil assembly and two pairs of contacts, and is mounted on the end flange of the starter housing.

Referring to fig. 31, when the starter button is pressed, the solenoid operating coil (3) is energised, drawing in the solenoid plunger until the catchplate (1) rests on the trigger (2) and the first-stage contacts are closed.

As the armature travels forward, engaging the pinion with the engine flywheel, the tripping disc lifts the trigger, allowing the plunger to move fully home and close the second-stage contacts.

The switch will remain in this position until the starter button is released, when the coil spring (4) will return the plunger and moving contact to their original position.

Dismantling and inspection

Remove the nut and tabwasher, catchplate (1), contact guide and leaf spring, and withdraw the moving contact (6).

The contact points may be cleaned with spirit or very fine carborundum paper. If badly burned or pitted they may be refaced in a lathe, but not more than 0.020 in. (0.5 mm.) may be removed.

The faces of the moving contact are inclined at an angle of 3 deg. 49 minutes, and this angle must be maintained when refacing.

The fixed contacts are finished squarely and must be refaced whilst in position on the switch. New fixed contacts are supplied unmachined and must be similarly faced in position.

In the absence of machining facilities, or if the solenoid windings are defective, the switch must be replaced.

If the catchplate and trigger are worn they should be renewed.

Assembling

Apply petroleum jelly sparingly at the junction of the solenoid plunger and the switch body, and also where the leaf spring bears on the moving contact.

Assemble the components in the reverse order of dismantling, but do not lock the securing nut at this stage.

Referring to fig. 31, check contact gaps B and C. Limits are:

Gap B: 0.132 to 0.148 inch (3.4 to 3.8 mm.)

Gap C: 0.354 to 0.433 inch (9.0 to 11.0 mm.)

Adjust if necessary by washers (5) which are supplied in varying thicknesses.

Similarly, check gap A between catchplate and trigger shoulder. Limits are 0.076 to 0.084 inch (1.9 to 2.1 mm.).

Finally, lock the securing nut.

Testing

Measure the force required to overcome the return spring, applied at the tip of the plunger. Limits are 4 lb. 11 oz. to 5 lb. 5 oz. (2.250 kg. to 2.350 kg.).

Measure the force required to overcome both the return spring and the contact spring, applied at the tip of the plunger. Limits are 25 lb. to 29 lb. (11.34 kg. to 13.15 kg.).

Measure the force required to overcome the trigger spring, applied at the peak of the tripping face with the switch in the OFF position. Limits are 7.5 oz. to 10.5 oz. (0.20 kg. to 0.30 kg.).

Ensure that both contacts close when a potential of 15 volts is applied to the solenoid winding.

PART 3—ALTERNATOR

C.A.V. AC5R

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DESCRIPTION

The AC5R alternator has a built-in regulator fixed to the slip ring end shield. The regulator has solid state circuits throughout with the transistors, diodes and resistors mounted on a printed circuit board contained within a special moulding to provide maximum protection. The regulator requires no adjustment during service and is a non-repairable item which must be renewed if found to be faulty.

DISMANTLING

Before dismantling the unit thoroughly clean the alternator using a cloth or brush dipped in kerosene or a suitable cleaning fluid.

It is necessary before commencing dismantling or repairs on the alternator to determine whether the alternator or the regulator is at fault. This may be achieved by the following procedure:

1. Remove the alternator end cover and disconnect the lead from the 'F' terminal on the alternator brush box.
2. Connect a lead from the 'F' terminal on the brush box to the - connection on the alternator.
3. Wire the + and IND connections on the alternator with a lamp and switch as shown in fig. 32. Check the lamp and switch before test. With the switch closed the lamp will light if the regulator is faulty, and will not light if the alternator is faulty.

WARNING: Do not remove any connections while the alternator is running.

Regulator

1. Alternator end cover already removed for fault finding.
2. Mark up the regulator leads and relevant connections, and disconnect leads.

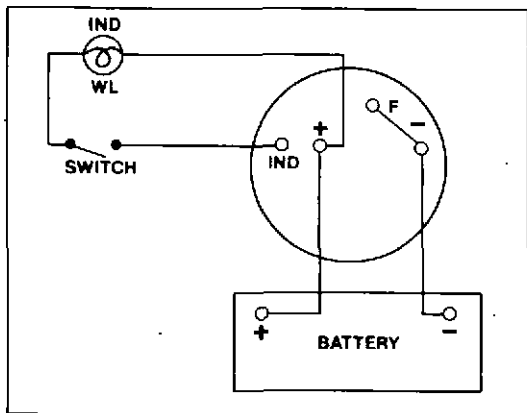


Fig. 32 Test circuit

24887

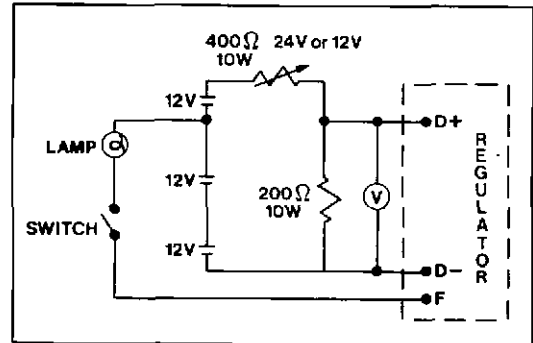


Fig. 33 Regulator test circuit

24888

- Remove lower left hand retaining pillar together with the washers and withdraw the regulator from the slip ring end shield.

In order to dismantle, assemble or test the alternator only, follow the instructions as detailed for the AC5/24 alternator.

INSPECTION AND RENEWAL

Regulator

Thoroughly clean the regulator and Lucar connections and examine visually for signs of cracking or other damage. A new regulator must be fitted if any damage is observed.

Testing. Wire the regulator to the warning lamp, on/off switch, voltmeter, variable resistance and a 36 volt supply, as shown in fig. 33 and proceed with the following tests.

- Close the switch. If the lamp does not light the regulator is faulty and *must* be replaced.
- With the switch closed and the lamp lit, increase the voltage across D+ and D- to 28.5 volts. If the light remains lit the regulator is faulty and *must* be replaced.

Assembly. Position the regulator on the slip ring end shield with the wiring leads on the inner side and line up the locating holes. Secure in position with the pillars and tighten to 15 to 20 lbf.in (1.7 to 2.3 Nm) torque value. Ensure that all connections are in the same positions as noted when dismantling. Secure the end cover in position with screws and washers and tighten to 12 to 15 lbf.in (1.4 to 1.7 Nm).

When checking the alternator output ensure that the battery is not in a fully charged condition, thus preventing the voltage regulator tapering off the alternator output and the following figures being achieved.

Type of Alternator	Cutting-in Speed rpm	Current output at 2000 rpm	Current output at 3000 rpm	Current output at 4000 rpm
24V	1250 at 28 volts	16.5 Amps	25.5 Amps	29 Amps

Variations from the stated output is permissible, but failure to reach within 10% of the stated figure indicates a faulty regulator.

PART 4—ALTERNATOR

C.A.V. AC5/24

DESCRIPTION

Alternator

The alternator is a 3-phase star-connected machine of the revolving field and stationary armature type, self-limiting in current output.

Rectification is by six silicon diodes, mounted in heat sinks in the slip ring end shield and connected in a 3-phase bridge circuit between stator and output terminals. To prevent the battery discharging through the field coil when the alternator is stationary, three auxiliary diodes are used in conjunction with three of the main diodes to form a second rectifier bridge.

The rotor is carried in sealed ball bearings housed in the end shields, a fan at the driving end directing cooling air through the alternator. The two brushes are housed in a moulded box, mounted on the slip ring end shield.

Alternator limitations are as follows:

Cut-in speed (alternator rpm)	1125
Max. output (hot) at 27.5 volts	31 amps
Max. speed (alternator rpm)	10,000

Voltage regulator (Control board)

The Type 440 regulator is fully transistorised. It is sealed and cannot be serviced, adjusted or repaired. Three terminals, marked 'HI', 'MED' and 'LO', are provided to permit a change of setting to suit varying operating conditions.

DISMANTLING

1. Remove the baffle or cowl from the slip ring end shield, disconnect the brush leads and remove brush assembly.
2. Unscrew pulley nut and withdraw pulley and fan.
3. Mark both end shields and the stator to ensure correct alignment on assembling.
4. Remove the three through-bolts and carefully withdraw the drive end shield.
5. Place the stator, slip ring end shield uppermost, on a bench and unsolder the three stator phase leads from the heat sink terminal tags. Do NOT remove the tags from the heat sinks. Separate

the slip ring end shield from the stator, and extract the 'O' ring from the end shield bearing housing.

6. Support the drive end shield and carefully press out the rotor.

INSPECTION

1. Clean rotor shaft and stator, using a cloth moistened with white spirit. Blow off dirt and carbon dust from all parts.
2. Check slip rings for concentricity and wear. Correct by skimming if necessary, but do not reduce their diameter below 1.136 inches (28.85 mm.).
3. Inspect the brushes, and renew them if their length is less than $\frac{5}{16}$ inch (7.9 mm.).
4. Check bearings for wear and renew if necessary.

ELECTRICAL TESTS

Rotor

Test the insulation between each slip ring and the rotor shaft. Minimum acceptable resistance is 10 megohms.

Measure the resistance between slip rings. Limits are 9.4 to 9.8 ohms.

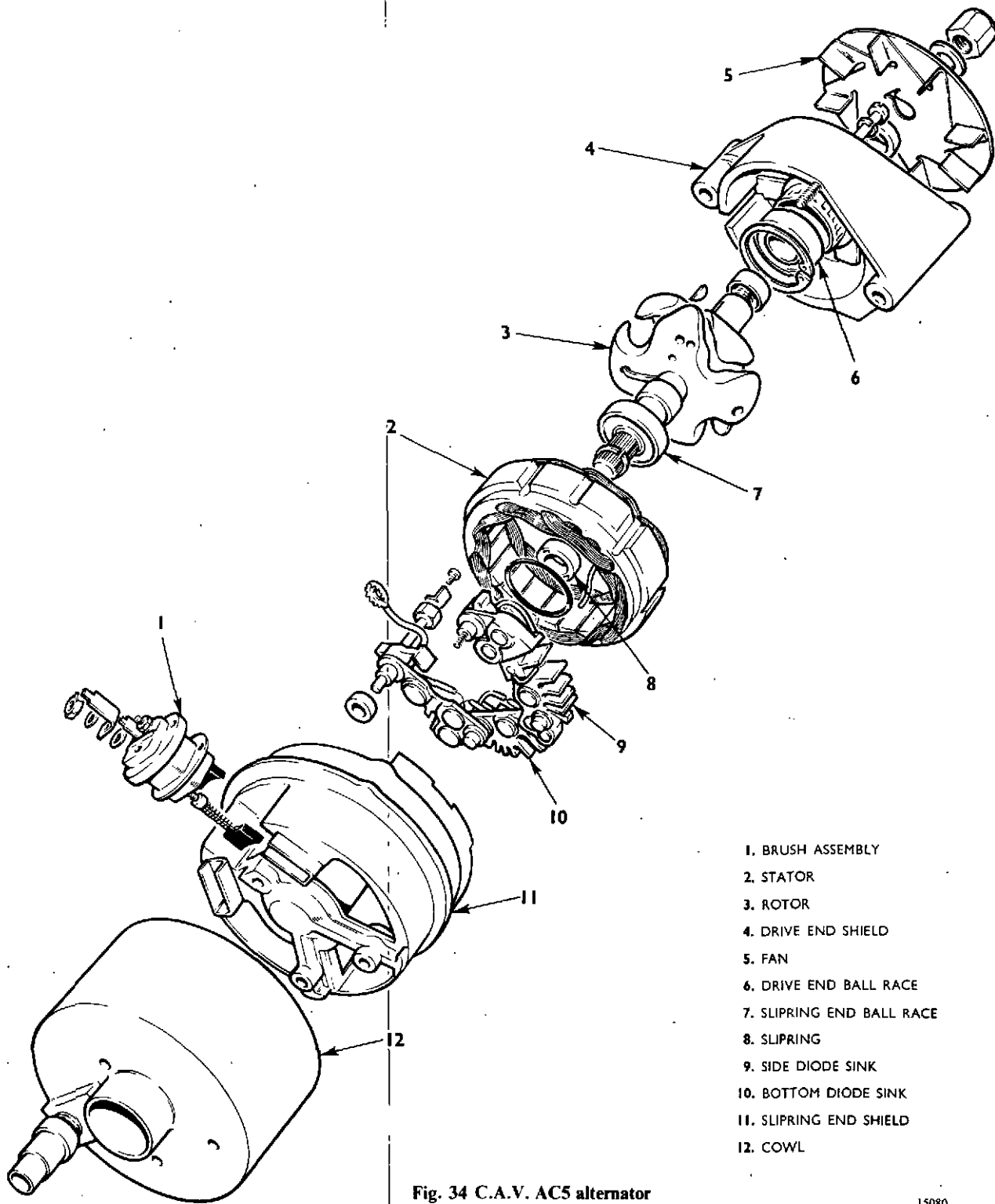
Stator

Test the insulation between stator frame and any terminal tag. Minimum acceptable resistance is 10 megohms.

Connect the stator leads, in pairs, to a 20 amp DC supply and check that the voltage drop in each case is 8.4 volts.

Diodes

Connect a test probe, in series with a 48-watt 24-volt lamp, to the positive terminal of a 24-volt DC supply. Connect another test probe to the negative terminal. Carry out the tests listed in the following table. Faulty diodes must be renewed, together with their heat sinks.



- 1. BRUSH ASSEMBLY
- 2. STATOR
- 3. ROTOR
- 4. DRIVE END SHIELD
- 5. FAN
- 6. DRIVE END BALL RACE
- 7. SLIPRING END BALL RACE
- 8. SLIPRING
- 9. SIDE DIODE SINK
- 10. BOTTOM DIODE SINK
- 11. SLIPRING END SHIELD
- 12. COWL

Fig. 34 C.A.V. AC5 alternator

15080

Test	Test lead conn. (+)	Test lead conn. (-)	Diode under test	Result if serviceable
1	Each heat sink in turn	D+	Positive	Lamp lights
2	D+	Each heat sink in turn	Positive	No light
3	D-	Each heat sink in turn	Negative	Lamp lights
4	Each heat sink in turn	D-	Negative	No light
5	Each heat sink in turn	A	Auxiliary	Lamp lights
6	A	Each heat sink in turn	Auxiliary	No light

ASSEMBLING

1. Position the stator with phase leads uppermost and carefully lower the slip ring end shield on to it, aligning the locating marks made on dismantling. Solder the stator phase leads to the heat sink tags.
2. Assemble the spacer to the rotor shaft, and press the rotor into its bearing in the drive end shield.
3. Fit the slip ring end shield/stator assembly squarely to the drive end shield/rotor assembly, aligning the locating marks as before. Fit the three securing bolts, with 'Loctite' grade A on their threads, and tighten them evenly to 45 lbf.in. (5.1 Nm) whilst carefully tapping the assemblies together.
4. Fit the brushes to their box and assemble the brushgear to the slip ring end shield, using a new joint gasket.

5. Refit the baffle or cowl to the slip ring end shield.
6. Fit the fan, with spacer if applicable. Assemble the Woodruff key (together with any spacing washers fitted for pulley alignment), fit the pulley and tighten its nut to 40 lbf.ft. (54 Nm). To retain the pulley whilst tightening the nut, use strap wrench GA.481.

BENCH TEST

The following equipment is required:
 Variable speed drive, up to 10,000 rpm
 24-volt battery
 Variable load, up to 60 amps
 Control board, Type 440
 0-50 moving coil DC voltmeter
 0-100 moving coil DC ammeter
 110-volt non-destructive flash tester or megohm meter.

1. Test for earths, using the flash meter or megohm meter as follows and taking care always to keep one probe on the frame. Minimum insulation resistance 10 megohms:
 - (a) D+ and earth
 - (b) D- and earth
 - (c) 'A' terminal and earth.
2. Assemble the alternator to its drive and make all connections to battery and control board, with a 24-volt, 2-watt lamp in series with a switch in the circuit. Connect the ammeter in the positive line. The variable resistance, with switch in series, is connected across the battery.
3. Close the switch in series with the warning lamp. The lamp should light.
4. Start the drive and increase speed until warning lamp goes out, indicating alternator charging. This should occur below 1500 rpm.
5. Reduce speed to 1125 rpm and measure voltage between WL and + on control board. This should be between 24 and 28 volts.
6. (a) Connect voltmeter between B+ and B-. Apply 20 to 30 amp load to battery and, with alternator running at 3200 rpm, check that ammeter reading is 28 to 31 at a voltage of 26 to 27.
 - (b) Increase speed to 10,000 rpm and check that ammeter reads 30 to 35 at voltage of 26 to 27.
 - (c) Adjust battery load as necessary. Run alternator at 10,000 rpm for one minute.
7. Reduce speed to 3000 rpm and switch off loads across battery. Voltage should rise to between 26 and 28 and then remain constant, whilst the current reading should fall appreciably. At 15 amps the voltage reading from the MED terminal should be between 27.25 and 27.75 volts; the readings from HI and LO terminals are one volt on either side of this.

SECTION 15—RUNNING-IN AND STORAGE

RUNNING-IN

Every new or reconditioned engine supplied by Rolls-Royce is run-in before leaving the factory and requires no special treatment when put into service, except that the user is recommended to follow the operating instructions given in the Engine Servicing Manual T.S.D. 3126—Chapter 2.

When a 'Short Engine' has been built up and installed, or when a partial overhaul has involved replacement of cylinder liners and piston rings, the user is advised to carry out the following simple 'running-in' sequence before subjecting it to full load:

Note: Before running-in the engine refer to Section 13 for details concerning precautions adopted by Rolls-Royce Motors Ltd. to protect turbocharger bearings during running-in at the factory.

Prior to commencing the appropriate schedule:

- (a) Prepare the engine for running and start up as described in the Servicing Manual T.S.D. 3126, Chapter 2.
- (b) Start the engine, run it at 800 rpm and check that the correct oil pressure is registered steadily on the gauge. Inspect all systems for leaks. Shut down engine and, if necessary, top up the coolant and lubricating oil systems.
- (c) Start up the engine and run-in according to the details given in the appropriate following table:

Engines rated at 1500 rpm

RPM	Load	Duration (minutes)
1000	Minimum	5
1200	Minimum	5
1200	25%	5
1200	50%	5
1500	50%	5
1500	75%	5
1500	100%	10

Engines rated at 1800 rpm

RPM	Load	Duration (minutes)
1000	Minimum	5
1200	Minimum	5
1200	25%	5
1500	25%	5
1500	50%	5
1800	50%	5
1800	75%	5
1800	100%	5

Engines rated at 2100 rpm

RPM	Load	Duration (minutes)
1000	Minimum	5
1500	Minimum	5
1500	25%	5
1800	25%	5
1800	50%	5
2100	50%	5
2100	75%	5
2100	100%	5

Engines in constant speed installations

- (d) These engines are generally connected to their driven equipment by a flexible coupling, and at certain critical speeds the assembly may have torsional characteristics detrimental to its various components.

For this reason it is preferable for an engine to be run-in on a test bed, using the appropriate 'variable speed' schedule previously described, before being installed.

If this is not practicable the engine must necessarily be run-in under working conditions, i.e. at rated speed whilst coupled to its driven equipment, as follows:

RPM	Load	Duration (minutes)
Rated speed	50%	30
Rated speed	75%	60
Rated speed	100%	15

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Checking oil consumption

Where practicable the following check schedule which is suitable for all applications, should be carried out. If this is not possible, the engine should be put to its normal use after running-in and a careful record of oil added kept over a reasonable period of running time (e.g. 100 hours), each dipstick reading and topping-up being made under identical conditions; i.e. engine stationary or running, hot or cold, whichever applies, consistently on each occasion.

Consumption check schedule

1. On completion of running-in, stop the engine. Inspect for leaks, particularly from the lubrication system, and rectify as necessary. Check the oil and coolant levels and top up as required.
2. Run the engine under minimum load for 5 minutes at 1000 rpm (variable-speed engines) or rated speed (constant-speed engines). Shut down and allow the engine to stand for 5 minutes.
3. Remove the sump plug and drain the oil into clean containers, of known weight, for exactly 15 minutes. Alternatively, if the sump can only be emptied by evacuation pump, continue pumping until no more oil is passed. (See Section 1 'Engine Data', for sump capacities).
4. Weigh the oil in the containers and return it to the sump.
5. Re-start the engine and run it at rated speed under 75% load for exactly 2 hours; at the end of this period:
 - (a) On variable speed engines, remove the load and reduce speed to 1000 rpm for 5 minutes.
 - (b) On constant-speed installations, remove the load and continue running at rated speed for 5 minutes.
 - (c) Following (a) or (b), as applicable, shut down and allow the engine to stand for 5 minutes.
6. Drain the oil into the same containers in exactly the same manner as previously (item 3), weigh it in the containers and return it to the sump. Calculate the weight of oil used and convert to pints or litres

as necessary. One Imperial gallon of lubricating oil weighs approximately 8.95lb, one litre weighs approximately 0.897 kg.

Acceptable maximum oil consumption figures are:

Normally aspirated engines

0.60 pints (0.342 litres) per hour.

Turbocharged engines

0.90 pints (0.511 litres) per hour.

STORAGE

Short term

Up to seven days: No treatment is necessary.

Up to one month: Run the engine each week until working temperature is reached. If the engine cannot be run, turn the crankshaft for at least three revolutions.

Long term (maximum 12 months)

If it is necessary to store an engine for a period of 1 month to 12 months the following inhibiting process must be followed:

1. Drain the engine lubricating oil from the sump whilst the engine is warm; remove and drain the oil filter bowls.
2. Refill the filter bowls with PX4 rust preventative (obtainable from Croda Chemicals Ltd., Goole, North Humberside) and refit to engine. Fill sump to normal level with PX4.
3. Run the engine until the normal operating temperature is reached; connect engine fuel feed to a supply of PX4.
4. Run the engine at 1000rpm on minimum load for between 5 and 10 minutes. Stop the engine. Remove the injectors and immerse them in PX4.
5. Remove the rocker covers, set fuel stop to 'NO FUEL', and remove the turbocharger outlet duct, where applicable.
6. Motor the engine over using the starter and simultaneously spray PX4 into the inlet manifold until vapour emerges from each injector orifice. Spray the valve gear, insides of rocker covers and turbocharger outlet duct with PX4 and refit.

7. Spray 40ccs of PX4 through the injector orifice into each cylinder (using a suitable 'self-metering' spray gun), and refit the injectors.

CAUTION: The engine must not be rotated after this operation and must carry a prominent notice to this effect.

8. Drain the cooling system. Fit a standpipe to the coolant inlet and fill the system with a mixture of inhibited ethylene glycol/water until the solution issues from the outlet duct above the thermostat housing. The mixture must contain between 50% and 90% inhibited ethylene by volume. The system must now be allowed to stand for 15 minutes and then be thoroughly drained.

9. Drain the PX4 from the sump and attach a 'NO OIL' notice to the oil filler cap.

10. Brush coat all unpainted areas of the fuel pump, starter motor, alternator, flywheel and external control linkage, where fitted, with PX28 Wax Film (obtainable from Croda Chemicals Ltd.).

11. Spray the interior of the air cleaner with PX4 and seal off with mouldable wrap secured with tape.

12. Remove fan belts and wrap them in waxed paper. Pack them in a large polythene bag and secure them to the engine.

13. Seal off all orifices with mouldable wrapping paper, or plastic caps secured with adhesive tape.

For engines in storage for over 12 months, the above procedure should be carried out at 12 monthly intervals.

ROLLS-ROYCE MOTORS LIMITED

DIESEL DIVISION

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