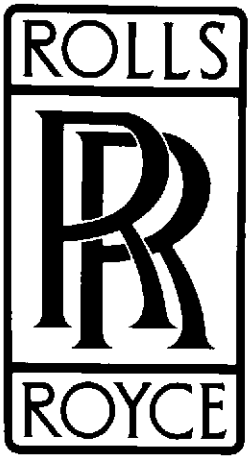


WORKSHOP MANUAL
CV8 ENGINES

T.S.D. Publication 3130

First Issue

July 1982

Printed in England

FRONTISPIECE

1. Engine Service Counter
2. Coolant temperature shutdown switch
3. Crankcase breather connection
4. Spill return to supply tank
5. Fuel from supply tank
6. Turbocharger bearing priming pipe.
7. Starter motor.
8. Sump drain plug
9. Alternator

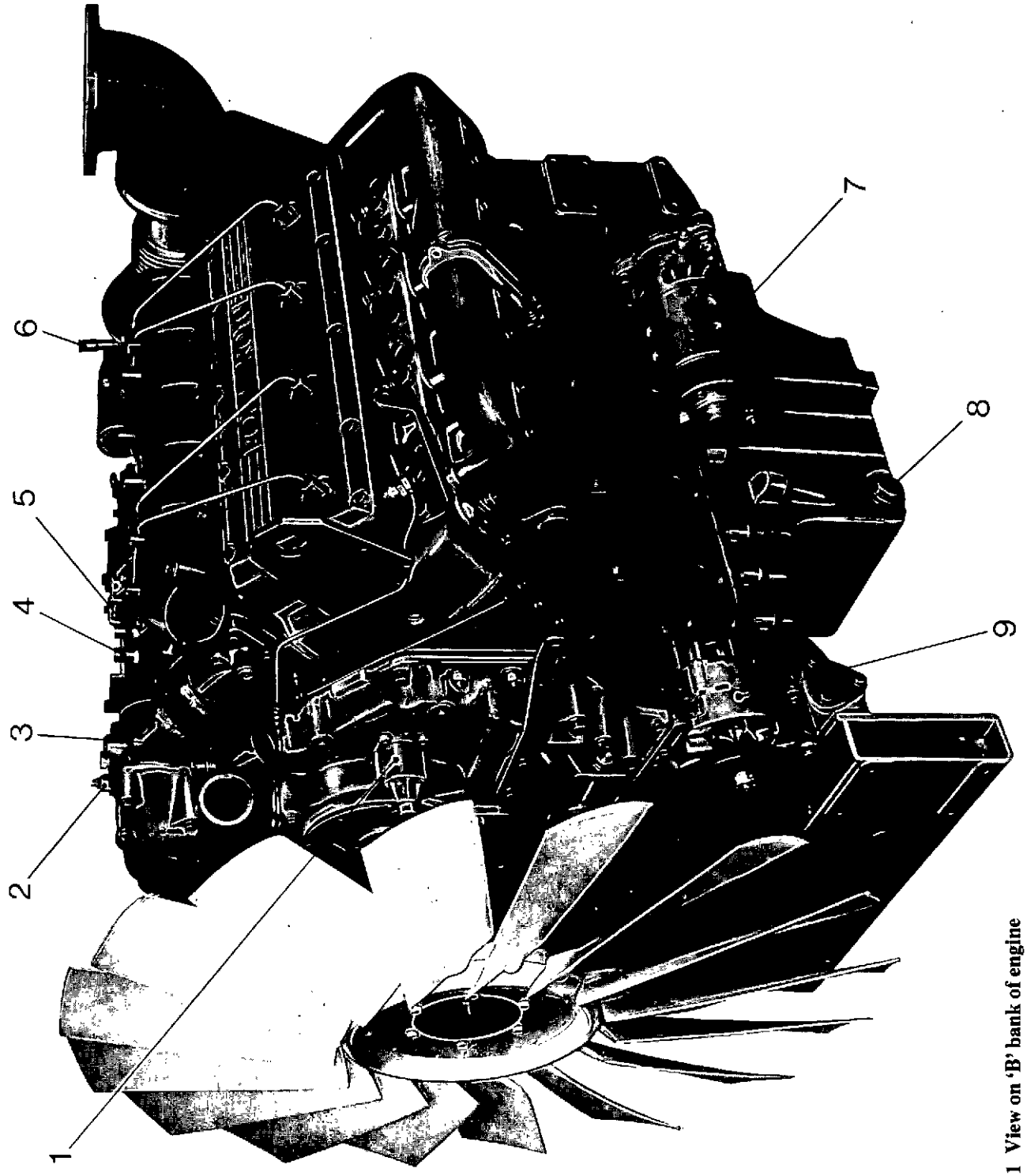


Fig.1 View on 'B' bank of engine

FRONTISPIECE

10. Oil filler
11. Injector gland nut
12. Fuel filter canister
13. Thermostat housing
14. Coolant pump
15. Oil pressure shutdown switch
16. Coolant drain cock
17. Lubricating oil filter canisters
18. Oil-to-coolant heat exchanger
19. Dipstick

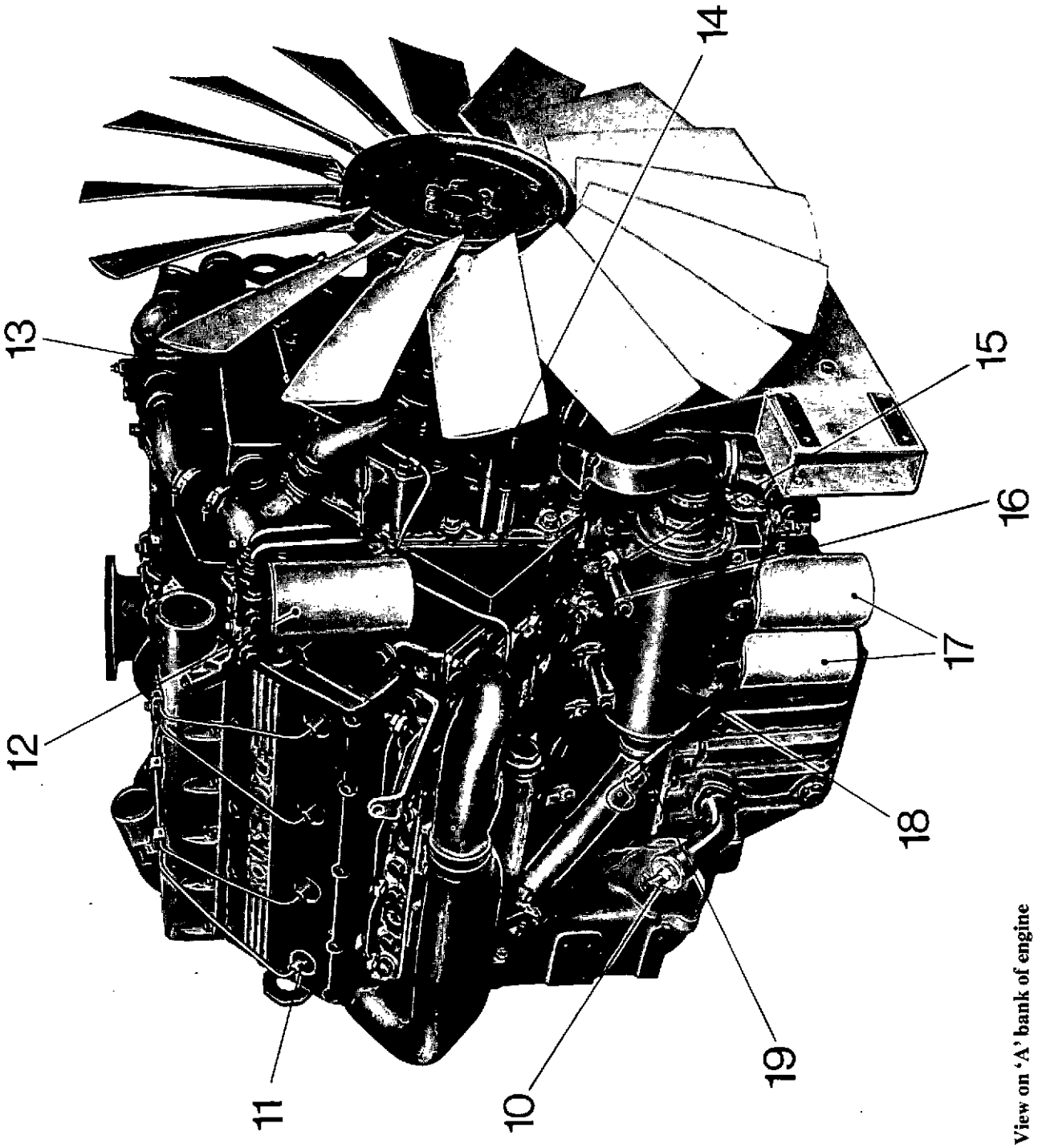


Fig. 2 View on 'A' bank of engine

NOTES TO USERS

Using and maintaining this Manual

The purpose of this Manual is to provide all the information necessary for the complete overhaul of Rolls-Royce CV8 diesel engines.

Due to the many versions of these engines and their varied applications, only those differences which affect basic procedures are mentioned specifically. Consequently, the illustrations and text may not always be identical in every respect to the corresponding arrangement on the engine being overhauled.

The information in this Manual is the latest available at the time of printing but continuing research and development work at Rolls-Royce Motors Limited will, from time to time, make it necessary to amend the text and/or the illustrations in the Manual to keep it up to date.

Service Instructions (C.V.I's) Changes in service techniques are issued as Service Instructions, in leaflet form, and sent in bulk to Dealers and Distributors for onward transmission to Operators.

Service Bulletins (C.V.B's) Engine design changes are issued as Service Bulletins, in leaflet form, and forwarded to Dealers and Distributors.

On receiving a C.V.I. or C.V.B., the user of the Manual should immediately endorse the relevant Section to keep the Manual in line with the latest developments.

Periodically, each Rolls-Royce technical publication is revised to include all relevant information from C.V.I's and C.V. B's distributed since the previous issue of the publication concerned. When this occurs, the revised publication is allocated the next consecutive Issue Number.

Information specifically concerning engines on which production has finally ceased is eventually, after several years, dropped from the Manuals to make room for new material. However, whilst these engines continue in service, it is Rolls-Royce policy to make every effort to maintain copies of this information.

Service

Throughout the world, Dealers and Distributors appointed by Rolls-Royce can provide advice, spare parts and Factory-trained staff. When necessary they can consult the area-based Rolls-Royce engineer or the Service Department of Rolls-Royce Motors, Diesel Division.

Advice and assistance can be more readily provided if enquiries are accompanied by the following:

1. In all cases, (a) the Engine Number, Designation and Build Number as stamped on the crankcase data plate, and (b) the operating units recorded by the Engine Service Counter (E.S.C.).
2. If a proprietary unit (e.g. injection pump, turbocharger) is involved, the details on its data plate and the number of operating units run.
3. Any other information logically connected with the subject, e.g. type of fuel, lubricating oil or coolant used, engine operating conditions, details of servicing history, etc.

To assist in reducing 'down time' to a minimum, Operators are recommended to make use of the established Service Exchange Scheme, details of which are given in this Section.

Instruction

A five day course on servicing and overhaul of CV8 engines is available at the Factory. For details apply to: The Superintendent, Customer Training Centre, Rolls-Royce Motors Limited, Diesel Division, Shrewsbury.

Associated Technical Publications for CV8 engines

T.S.D. 968	Service Reclamation Schemes	T.S.D. 3125	Essential Information for Operators
T.S.D. 3085	Fuel, Oil and Coolant Recommendations	T.S.D. 3128	Service Instructions
T.S.D. 3115	Servicing Manual	T.S.D. 3129	Service Bulletins
T.S.D. 3120	Operator's Guide		

SERVICE EXCHANGE SCHEME

The information in this Manual will assist the Operator in carrying out any work, from minor repairs to complete engine overhaul, on the CV8 range of engines. Occasionally, however personnel, equipment or time may not be available, which could result in delay before the engine returns to service. For this reason, Rolls-Royce Motors Limited have instituted a Service Exchange Scheme so that Dealers and Distributors can speedily supply a 'short engine' or major component, fully reconditioned at the Factory and guaranteed for six months. In certain circumstances, a reconditioned complete engine can be supplied.

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

AIR COMPRESSOR
ALTERNATOR
COOLANT PUMP
CRANKSHAFT
CYLINDER HEAD
FUEL INJECTOR
FUEL INJECTION PUMP (Complete)
FUEL FEED PUMP
LUBRICATING OIL PUMP
STARTER MOTOR
TURBOCHARGER

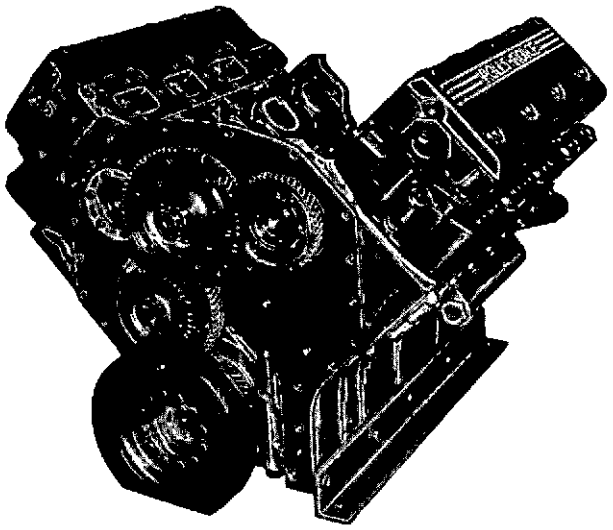


Fig. 1 Short engine, front view.

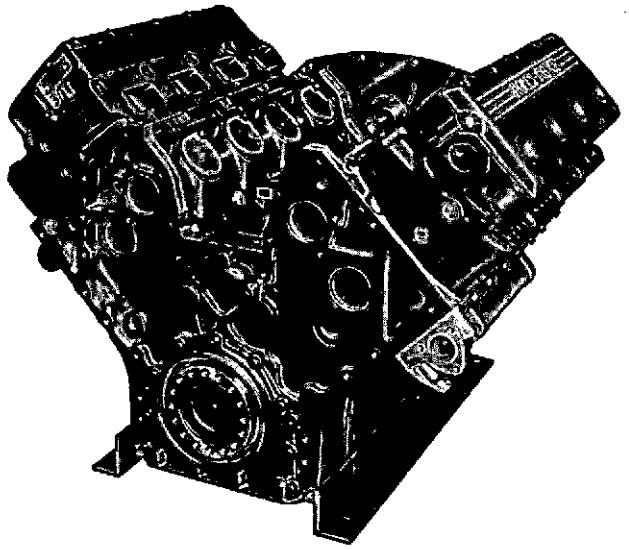


Fig. 2 Short engine, rear view.

CONTENTS

GENERAL INFORMATION

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

Cleanliness

The importance of this cannot be over-emphasised, particularly in respect of the fuel system. The ingress of dirt and foreign matter is a major cause of rapid wear, damage and engine failure.

During dismantling, first clean the vicinity of the component concerned, and ensure that all openings and disconnected pipes are blanked off without delay.

After removal, clean and inspect each component and, if serviceable, protect it against dirt, damage and corrosion until it is refitted. Special care is required with ball and roller bearings; after washing and inspection, they should be dipped in light-bodied oil and wrapped in clean paper.

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

Special tools

These are provided for specific jobs and should be used, where recommended, to save time and prevent damage to parts. Where applicable, a list of relevant tools is given at the end of each Section.

Hose connections

Levering off a hose with a screwdriver causes damage to the adaptor or pipe. Cut through the hose with a sharp knife, and afterwards cut the ends from the adaptor pipe.

When fitting a new hose an approved rubber lubricant may be used as an alternative to glycol, water or French chalk (see Section 1). Never lubricate a hose with oil or grease, which are injurious to rubber.

Gaskets, joints, 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.

'Wellseal" compound is recommended for general use when making joints. As with any liquid jointing, it should be applied thinly to avoid the possibility of oilways and ducts being obstructed by excess compound.

'O' rings should be lightly lubricated to help prevent 'trapping' during assembly.

Locking devices

Used splitpins, lockplates and tabwashers must *never* be refitted. The correct method of fitting locking devices is shown in fig. 1.

All-metal stiffnuts may be re-used provided that thay have not lost their efficiency, i.e. they still offer noticeable resistance to movement against normal spanner leverage. At least one full thread of the bolt or stud should protrude through a stiffnut when it is fully tightened.

Do *not* re-use stiffnuts having nylon or fibre inserts.

If spring washers have become flattened or their locking 'corners' rounded, thus impairing their efficiency, it is recommended that they be renewed.

Oil seals

Pack these with 'Vaseline' before fitting, and be careful not to cut the rubber on sharp edges. Unless otherwise specified, fit the seal with the wiping edge inwards to the bearing.

Torque loadings

These are specified for certain setbolts and nuts where defect or failure could result from incorrect

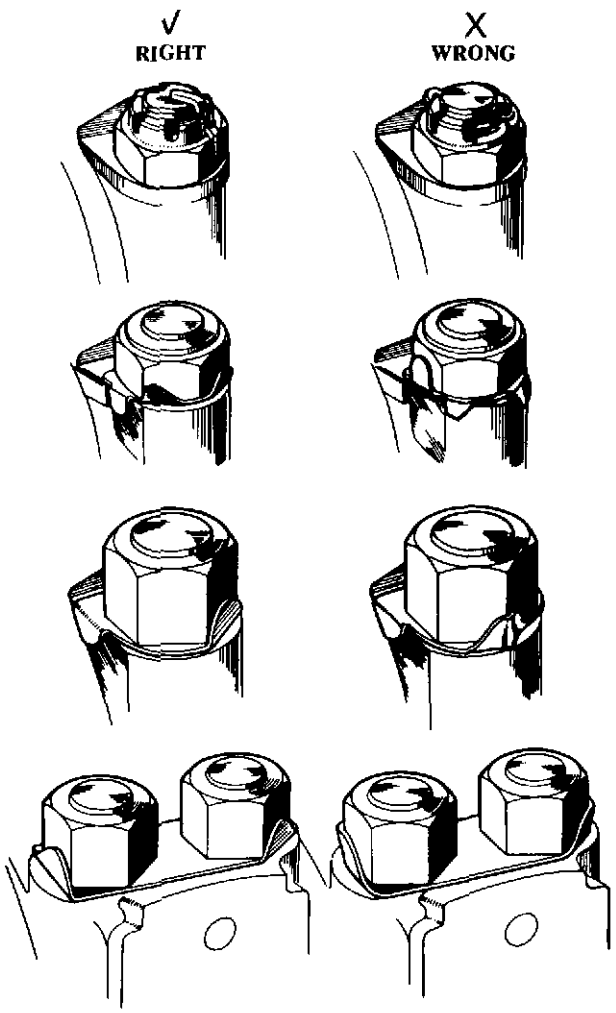


Fig. 1 Right and wrong methods of locking

tightness. For certain joints, such as cylinder head to crankcase, it is also essential that tightening is done evenly, progressively and in the correct order, to the instructions given in the assembly sequence.

Fits and clearances

At the end of each Section dealing with the inspection and assembly of an engine component will be found a table of relevant fits and clearances.

The dimensions given are such that a part falling within the limits is acceptable for a full period of service. Certain parts, worn beyond these limits, may be reclaimed under approved Repair Schemes which are circulated to authorise Dealers and Distributors.

Crack detection

Wherever possible, highly stressed components such as crankshafts, connecting rods, gear wheels and cylinder liners should be tested for cracks at overhaul periods or when they have been subjected to excessive loading or impact.

Ferrous components should be tested on an electro-magnetic rig. Non-magnetic components, such as valves and pistons, may be tested by means of a dye penetrant. A recommended process is Ardrox 996, available from Ardrox Limited, Brentford, Middlesex.

Exchange units

Unserviceable units should be returned complete to the same standard as the replacement unit. All apertures should be blanked off, and joint faces protected. Where necessary, treat the unit internally and externally against corrosion.

Spares

To comply with the terms of the Rolls-Royce Guarantee, and to ensure maximum liability. USE ONLY GENUINE ROLLS-ROYCE PARTS supplied by the Factory or an accredited Dealer. These parts are manufactured to the latest specification and are GUARANTEED for six months.

Customers are WARNED against using non-genuine spares, notably filter elements. Such items may not conform to Rolls-Royce standards; their use may not only invalidate any current Rolls-Royce Guarantee, but seriously reduce engine life and performance.

SECTION 1—DESCRIPTION AND DATA

The Rolls-Royce CV8 is an eight cylinder, pressure-charged, direct injection, liquid cooled, four stroke, compression ignition engine in a 90 degree 'V' configuration.

Engine identification

The engine type, series and build number are printed on a data plate attached to the crankcase.

Proprietary units such as fuel injection pumps, turbochargers and starter motors carry their own data plates.

Bank and cylinder bore identification

Throughout this Manual reference is made to the 'A' bank and 'B' bank sides of the engine. For ease of identification the 'A' bank side is to the left and the 'B' bank side is to the right, when viewed on the front (free) end of the engine.

The cylinder units are numbered from the front to the rear (flywheel) end, A1 to A4 and B1 to B4.

Crankcase

The close-grained high duty iron crankcase is cast as a monobloc unit and dipped in a special compound to seal all non-machined surfaces against contamination.

The five main bearing caps of forged steel are each attached with two setbolts. Lateral security is effected by setbolts screwed into locating pads in the bearing caps, through the crankcase side walls.

The two banks of four cylinders, in a 90 degree included angle 'V' configuration, are in a conventional staggered pattern with 'B' bank leading.

Cylinder bores are machined to accept full length slip fit liners which are of centrifugally cast iron, machined to fine tolerances and pre-finished.

Crankshaft

The chrome molybdenum steel forged crankshaft is nitride hardened on all surfaces except the front and rear faces, the tapped and dowel holes and the oil thrower ring.

The nine bearing surfaces consist of five main journals and four crankpins, each crankpin serving two connecting rods.

A conventional sludge trap is incorporated in the oilway of each crankpin, with an alloy plug in the crankweb to allow access for cleaning.

The rear end face of the crankshaft is drilled and tapped with 16 equally spaced holes to accept the flywheel securing screws. A spring dowel set in the crankshaft end face locates the flywheel on the crankshaft for timing mark alignment.

A 45 toothed helical gear is machined on the front end of the crankshaft to serve as the primary drive for the gear train.

The front end face is drilled and tapped to accommodate 12 equally spaced setbolts which secure the counterbalance and multigroove pulley to the crankshaft, the counterbalance being located by means of a spring dowel.

Main bearings

These are steel-backed, lead-bronze, half bearing shells with a lead indium plated inner surface.

The upper half of each bearing has an oil groove machined centrally around the inner surface connecting with a transfer hole which receives the lubricant supply from the crankcase oilway. A locating tang is pressed out from one end of the shell.

The lower half is similar but with shortened machined grooves. These correspond with the upper half groove for the transfer of lubricating oil to the lower bearing surface.

Thrust washers

Two steel-backed lead-bronze thrust washer halves are carried in machined recesses on either side of the centre main bearing support. Oil from the centre main bearing provides lubrication for the thrust washers, which have grooves machined across the faces to assist oil flow.

The lower halves of the thrust washers are similar but have an integral locating tang on one end.

Connecting rods

These are chrome-molybdenum steel forgings machined to accept steel-backed lead-bronze small end bushes and big-end bearing shells similar in composition to the main bearing shells. The small end is of wedge design to assist pressure loading of the small end bearing and piston.

A hole bored centrally through the column of each rod allows pressurised oil to be directed intermittently from the crank pin to the gudgeon pin and small end bearing.

Markings on each connecting rod assembly give rod to cap correlation, weight and when allocated, the cylinder bore number.

Pistons

Cast from high silicon aluminium alloy with the crown machined to form an open toroidal combustion chamber, each piston carries three compression and one oil control ring in machined grooves. 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 is fully floating and is retained by the conventional circlip method.

Camshafts

Manufactured in a cast iron alloy, the unidentical camshafts have chill-hardened cam noses with precision machined tapers.

The two camshafts each have five bearing journals and are high mounted inside the 'V' of the crankcase. Thrust plates, bolted to the housing, position each shaft axially.

Both shafts, of the same overall length, are identified by the positioning of the cam lobes. Each pair of cam lobes on the 'B' bank camshaft is closer to the drive end than those on the 'A' bank camshaft, to accommodate the off-setting of the cylinder bores.

A flange on the drive end of each camshaft accepts the cam phasing gears, each secured with six setbolts and located by spring steel dowels. Drive is provided by the fuel injection pump compounded drive gear.

Collars machined on each camshaft at the drive-end serve as bearing surfaces for the thrust plates.

The bearings are steel-backed, lead-bronze bushes manufactured with clinch butt joints and are disposed singly in each bank. All bushes are drilled and grooved for lubrication, each bush being fed with pressurised oil via drillings from the auxiliary oil galleries.

Pushrods and tappets

The tappets, made of a cast iron alloy, are fully machined with chill-hardened bases and are treated to provide an oil retaining surface finish. Lubrication is provided from rocker gear spill and from cam lobe splash oil.

The pushrods, manufactured from medium carbon steel bar, have a circular foot forged on the lower end and a cup shape on the upper end. Both ends are induction hardened with the pushrod foot finally machine polished.

The mating end of each rocker adjusting screw is radiused to allow maximum surface contact with the pushrod cup during angular operation.

Cylinder heads

Manufactured from close grained, high duty cast iron, the two cylinder heads, each covering a bank of four cylinders, are machined across the upper and lower faces for a close tolerance fit between each rocker box assembly and cylinder-block top face respectively. Machined joint faces serve to accommodate the induction manifold on the inner and exhaust manifold on the outer side of each cylinder-head casting. Internal coolant passageways are cast around the valve guides and injector pockets.

Valve guides are cast in high quality nickel chrome alloy, ground to a final finish and inserted under pressure into the cylinder head casting.

Valve seat inserts are frozen into position against machined shoulders in the cylinder head casting.

The two inlet valves used for each cylinder are manufactured as steel forgings machined to close tolerances. The valve stems are chrome flashed. The two exhaust valves over each cylinder are manufactured in Nimonic material in two sections, friction welded near the valve heads, with the valve stems chrome flashed.

The valves are secured in a conventional collet, seat and spring arrangement, the exhaust valves being fitted with valve rotators in place of the upper spring

seats. Paired movement of the valves is controlled by a bridge piece, with the adjusting screw and locknut on the outer arm of the bridge. An induction hardened button is inset at the centre of the top face of each bridge piece, connecting with the rocker arm, pushrod and finally the tappet and camshaft.

The rocker arm assemblies for each bank of cylinders are mounted on a main rocker shaft housed in a cast aluminium rocker box. Each rocker box is located by two spring steel dowels protruding from the cylinder head, and secured by ten socket cap screws and eleven setbolts. The setbolts and screws are torque-tightened to a specific figure. An oil resistant gasket is fitted dry between the cylinder head and the rocker box.

Four injectors to each cylinder head are secured by setbolts on socket capscrews and finger clamps. Injector spill is discharged via banjo unions attached to the injector side connections protruding through the rocker box outer walls. Interconnecting pipework carries the spill fuel to the supply tank.

Top covers to each rocker box are manufactured in cast aluminium and are secured with ten setbolts, an oil resistant gasket being fitted between the two faces.

High pressure pipework connects the fuel injection pump with the injector inlet unions protruding through each rocker box cover.

Gear train

The wheelcase, mounted on the front of the engine, houses a train of helical gears with the main drive being provided by the crankshaft front gearing.

A small idler attached to the front main bearing transmits the drive to the oil pump gear. A large compounded idler attached to the crankcase forms the intermediate drive to the coolant pump gear and the fuel injection pump compounded gear, which in turn drives the two cam phasing gears.

On the automotive version of the CV8 engine, an idler driven by the fuel pump compounded gear provides the power take off for a compressor mounted on the back plate. Two auxiliary drive gears are carried in the 'B' bank side of the gear train, one over the cam phasing gear driven by the fuel pump gear and the other beneath the cam phasing gear, driven through an idler by the large compounded idler gear.

The timing gears, positioned across centres, use a machined spot on one tooth locating between two spots on the engaged gear.

The lubricating oil pump idler is secured to its axle with a self locking nut. Other idler gears are secured with hexagon headed setbolts.

Flywheel

The flywheel and starter ring assembly is fitted to the rear end face of the crankshaft. Provision is made for the fitting of a transmission coupling to the flywheel, to suit individual engine applications.

The flywheel housing, bolted directly to the crankcase, supports a flange mounted Butec MS 1A or C.A.V. S 130L electric starter motor, on the lower 'B' bank side.

An Ingersoll Rand air starter is available, dependent upon the engine application.

A timing cover high on the 'A' bank side of the flywheel housing gives access to the flywheel timing marks and pointer.

Fuel system

The Bosch fuel injection pump, mounted on a platform in the centre of the crankcase 'V', is a conventional in-line unit feeding the eight injectors and is driven from the main gear train by a drive shaft with spring plate couplings.

The fuel injection pump camshaft hub is located by a key and secured with a spring washer and nut on the tapered shaft end. An adjustable yolk, bolted to the hub, carries one spring plate coupling assembly.

Viewed from the drive end, the pump camshaft rotates clockwise.

The firing order of the pump elements, numbered from the drive (engine wheelcase) end, is 1,4,3,5,8,7, 6,2 for engines fitted with the 'Paired Throw' crankshaft and 1,3,6,5,4,8,7,2 for engines fitted with the 'Cruciform' crankshaft. The pump firing order is at intervals of 45 degrees, with number one element at spill cut off point (B1 cylinder firing) in each case.

Static timing is stamped on the data plate affixed to the crankcase. High pressure fuel pipes connect each injector to the fuel injection pump in the following sequence viewed from the drive end:

B1, A1, B2, A2, B3, A3, B4, A4

The high pressure pipes are manufactured from 6 mm diameter steel pipe with a 2 mm bore. Zinc plated nuts and collars are incorporated at both ends of each pipe, with the cylinder number stamped on the side of the injector union nuts.

A mechanically operated feed pump delivers fuel from the supply tank(s), via low pressure pipework, to the

injection pump. A pump mounted relief valve allows excess fuel to be returned, with injector spill, back to the supply tank(s).

The low pressure pipework is manufactured in mild steel and incorporates standard low pressure joints of tubing nuts and sleeves.

Cooling system

The gear driven coolant pump consists of a conventional vaned impeller on a shaft, supported by twin ball races in a cast iron housing. The pump is designed to give a coolant flow of 227 litres/minute (50 imp. gallons/minute) at an engine speed of 1500 rpm.

A drilling in the bearing housing allows spill oil from the gear train to lubricate the ball-races, with the excess oil flowing through the front ball race back into the wheelcase. A lip type oil seal and a ceramic face coolant seal are fitted around the pump shaft between the bearing and coolant housings to prevent contamination. A telltale hole, drilled into the pump housing, indicates any leakage past either seal.

Coolant is delivered from the pump discharge directly to the oil-to-coolant heat exchanger situated on the 'A' bank side of the crankcase. From the heat exchanger the coolant is directed to the rear end of the 'A' bank coolant gallery cover where connecting pipework divides the coolant equally between the 'A' and 'B' bank galleries. The coolant then circulates around the cylinders and enters the cylinder heads where it circulates around the injector pockets and valve guides. Bobbin connections in the cylinder head inner walls then direct the flow into passageways in the induction manifolds. Outlets at the front end of each manifold allow the dual flows of coolant to merge at the thermostat housing where, if normal working temperature has not been achieved, the by-pass valve remains open for the coolant to return direct to the pump suction. At normal working temperatures the by-pass valve will be closed and the coolant will be directed through the radiator before passing to the coolant pump suction.

Under normal operating conditions the cooling system will be pressurised to 50 to 70 kN/sq. m. (7 to 10 lbf/sq. inch).

Lubrication system

A conventional wet-sump system is used on CV8 industrial engines. The cast aluminium sump, with an oil drainage well at one end, is reversible to suit the engine application.

Lubricating oil is drawn from the sump by a spur gear type pump and delivered under pressure to the two canister type filters. From the filters the oil passes through the single tube pack type oil-to-coolant heat exchanger, the base of which forms the oil filter header bracket.

The oil then enters a passageway near the front of the 'A' bank side of the crankcase and continues into a gallery running through the 'V'. A transfer casting, bolted to the rear face of the crankcase, allows the oil to enter the main gallery which is bored parallel to the first gallery.

From the main gallery, drillings at the front end direct the oil into auxiliary galleries running the length of the crankcase above the camshafts, whilst smaller drillings direct an oil supply to each main bearing housing.

Drillings from the auxiliary galleries direct oil to the camshafts, valve gear and cylinder liner outer walls.

A fitting with connecting pipework at the rear end of the main oil gallery delivers oil to the turbocharger bearings. Another fitting, adjacent to the oil feed connection, returns oil from the injection pump and governor and the turbocharger to the crankcase.

Drillings from the periphery of the front main bearing housing carry a supply of oil to the idler gear axles in the main gear train.

A hole drilled through the top face of each cylinder block into the relevant auxiliary gallery, allows oil to be delivered through drillings in the cylinder-heads into the central rocker pedestals. From the pedestals the oil is fed through hollow rocker shafts to each rocker arm bush. Drillings in each rocker arm direct a splash feed to the contact faces of the arm.

The pushrod feet and tappets are lubricated by the rocker arm drain oil running down each pushrod, and splash oil from the cam lobes.

Oil filler and dipstick

A steel pipe with an expanding type rubber plug is mounted on the sump for filling and topping up the lubrication system. A smaller bore tube also mounted on the sump houses the spring steel dipstick.

The oil filler pipe and dipstick tube may be mounted on either side of the engine to suit application.

Induction and exhaust systems

Cast iron manifolds direct the exhaust gases through the rotor section of the turbocharger where the waste

energy is used to drive the compressor wheel. This in turn draws air through the air cleaner and delivers it under pressure to the induction manifolds to be distributed to each cylinder as the inlet valves open.

Each exhaust manifold is made in two parts connected by a captive sleeve. The front section is a single bore pipe, the rear section is a double pipe to share the volume of gases leaving the cylinders. The exhaust from each bank of cylinders is led to the rear of the engine where a cross-connecting pipe forms a common discharge to the turbocharger rotor housing.

A bellows unit and flange adaptor bolted to the turbocharger outlet allow the fitting of exhaust pipework and silencers to suit the engine installation.

Where charge cooling is required, the air-to-air type of cooling is normally used. The compressor directs the air through pipework incorporated in the radiator to be fan cooled as is the engine coolant.

The cooled air is then delivered via large bore pipework to the induction manifolds.

Starter motor (Butec or C.A.V.)

A Butec MS1A starter, flange mounted on the 'B' bank side of the flywheel housing, is actuated through a solenoid switch bolted on the motor field ring. An over-running clutch, incorporated in the starter, prevents damage to the armature and starter ring under overload conditions.

The Lucas-C.A.V. S130L starter motor is a flange mounted model and operates through a solenoid switch mounted internally around the armature shaft. An overspeed ratchet device prevents damage to the armature should the starter ring drive the pinion when the engine starts up.

Both types of starter motor operate on a 24 volt circuit.

Alternator

A 30 amp Butec Type A13 or Type A3024 alternator, located on the 'B' bank side of the crankcase, is belt driven from the crankshaft front pulley. The alternator provides a 24 volt charging circuit for the starter batteries.

Engine protection

Pressure and temperature probe type switches are incorporated in the lubrication and cooling systems respectively. If the oil pressure drops below 152 kN/sq. m. (22 lbf/sq. inch) or coolant temperature exceeds 96 deg. C., the respective switch will actuate a shutdown solenoid to prevent serious engine damage.

The shutdown solenoid mounted in the crankcase 'V' is linked directly with the fuel injection pump STOP lever. The solenoid, used in the energised-to-run mode, overrides the governor control to stop the engine when the STOP button is pressed or when one of the engine protection switches detects oil pressure or coolant temperature beyond the permissible limits.

TECHNICAL DATA

TYPE.....Direct injection, liquid cooled, pressure charged four stroke, compression ignition, with charge cooling.

CONFIGURATION .....Eight cylinders in 90 deg. included angle 'V'.

BORE.....135 mm (5.315 inches)

STROKE .....152 mm (5.984 inches)

CUBIC CAPACITY
(Total swept volume) .....17.4 litres (1062 cu. inches)

COMPRESSION RATIO.....13.5 : 1

DIRECTION OF ROTATION .....Anti-clockwise viewed on flywheel

CYLINDER FIRING ORDER
Paired Throw crankshaft A1, B1, A2, B2, B3, A4, B4, A3
Cruciform crankshaft A1, B1, B2, A3, B3, A2, A4, B4

ASPIRATION .....Pressure charged by a single, rear mounted turbocharger

VALVE TAPPET CLEARANCES (Hot or cold)
Inlet .....0.2 mm (0.008 inch)
Exhaust.....0.5 mm (0.020 inch)

INJECTION TIMING .....As stamped on engine data plate

DRY WEIGHT OF BARE ENGINE (approximate) .....1202 kg (2,650 lb)

COOLING SYSTEM

APPROVED COOLANT .....See leaflet TSD. 3085 in rear cover pocket

CAPACITY (approximate) .....91 litres (20 Imp. gallons)

TEMPERATURE (at sea level)
Normal running .....75 deg. C
Maximum intermittent .....95 deg. C

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

COOLANT FLOW RATE .....227 litres / minute (50 Imp. gallons/minute) at 1500 engine rpm

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

RADIATOR .....Cov Rad or Marston 1.5 sq. m. (16 sq. ft.)

SYSTEM CLEANING COMPOUNDS
I.C.I. Limited .....* Lissapol 'N', 1% (10 cc/litre-45cc/Imp. gallon)
Lissapol 'NDB', 2% (20 cc/litre-90 cc/Imp. gallon)

* Lissapol 'N' is available from Rolls-Royce Motors Limited in 5.5 litre (1 Imp. gallon) containers under part number OE 41334.

FUEL SYSTEM

APPROVED FUELS .....See leaflet TSD. 3085 in rear cover pocket

TYPE .....Pressurised supply to injection pump with through flow return to tank

INJECTION PUMP .....Bosch S 3000, 8 element, in line unit

GOVERNOR .....Bosch RQ (V) 2 speed, integral with injection pump Or Ambac Electronic

FEED PUMP .....Bosch FP/KD Camshaft operated

FUEL FEED PRESSURE .....140 to 210 kN/sq. m. (20 to 30 lbf/sq. inch)

FUEL INJECTORS .....Axial feed, low spring type

INJECTOR NOZZLES .....6 hole, 0.33 mm x 0.7 mm long, 150 deg. included angle spray, zero offset

INJECTION PRESSURE.....240 bar (240 atmospheres)

INJECTION TIMING .....As stamped on engine data plate

MAIN FUEL FILTER .....Single, engine mounted, spin-on type expendable canister

PRIMARY FILTER .....Single, Purolator PU 464, wire wound element or Harwood water separator/filter

LUBRICATION SYSTEM

APPROVED LUBRICANTS.....See leaflet TSD. 3085 in rear cover pocket

TYPE.....Wet sump

OIL CAPACITY

Sump .....36.3 litres (8 Imp. gallons) maximum
13.6 litres (3 Imp. gallons) minimum

System total .....41 litres (9.4 Imp. gallons)

OIL PUMP.....Conventional scavenge/pressure, gear type unit driven from main gear train

OIL PRESSURE ..... 346 kN/sq. m. (50 lbf/sq. inch) under normal engine load conditions

*170 kN/sq. m. (25 lbf/sq. inch). Minimum permissible at rated speed

70 kN/sq. m. (10 lbf/sq. inch). Minimum permissible at idling speed. (Automotive)

OIL FLOW RATE .....114 litres/minute (25 Imp. gallons/minute) at 80 deg. C. and 1500 engine rpm

PRESSURE RELIEF VALVE

Type .....Conventional spring and plunger (non-adjustable)

Opening pressure ..... 415 kN/sq. m. (60 lbf/sq. inch)

OIL FILTERS .....Two spin-on type expendable canisters (engine mounted)

MAXIMUM OIL TEMPERATURE .....120 deg. C.

OIL-TO-COOLANT HEAT EXCHANGER .....Serck, shell and tube, baffled and finned

* Important for the protection of turbocharger bearings

INDUCTION SYSTEM

AIR CLEANERS .....Donaldson Cyclopac FHG 12 (2)

TURBOCHARGER .....Holset 4LGK

ELECTRICAL EQUIPMENT

ALTERNATOR..... Butec 24 volt 30 amp, belt driven

STARTER MOTOR .....Butec type MS1A or Lucas C.A.V. S130L

STOP CONTROL .....Lucas C.A.V. solenoid operated. Type 368/9B

WARNING AND SHUTDOWN SWITCHES .....Teddington temperature switch. TYPE DCA/AB/096. 96 deg. C. setting. Teddington pressure switch. Type DCA/BC/152. 152 kN/sq. m. (22 lbf/sq. inch) setting.

LUBRICANTS AND FLUIDS APPROVED FOR USE DURING SERVICING AND OVERHAUL

(Equivalents of alternative manufacture are acceptable)

	Manufacturer	Brand or specification
ALTERNATOR		
Diode cleaning fluid	Applied Chemicals Ltd	Fluid grade 8-23
Diode grease	—	Silicon MS200, MS4, MS5
COOLING SYSTEM		
Hose and 'O' ring lubricant	—	Castor oil
EXHAUST SYSTEM		
Screw thread anti-seize grease	Rocol Ltd Slip Group	Rocol J166 Copaslip
INDUCTION SYSTEM		
Emulsifying solvent	Morris's Shrewsbury	Pavan
JOINTS		
Jointing compound	Wellworthy Ltd	Wellseal
Sealant and thread locking where specified	Douglas Kane Sealants	Loctite 601, 542, Studlock 270, green retaining compound 290.

STARTER MOTOR		
Commutator cleaning fluid	I.C.I. Limited	Genklene 'N'
	Applied Chemicals Limited	Fluid grade 8-23
Lubricator wick oil (Butec)	Various	Mineral oil SAE 5W/20
Lubricator wick oil (C.A.V.)	Shell	Tellus T27 oil
Armature shaft bush (C.A.V.)		Turbo 41 oil
Grease, where specified (C.A.V.)		Aero Shell 16 grease
Insulating adhesive (C.A.V.)	Bostik	Clear adhesive 1437

Detailed information, for the products listed below, will be found on the Manufacturers data sheets.

DYE PENETRANT

Ardrox 996: Ardrox Limited, Brentford, Middlesex.

GENERAL CLEANING AND INHIBITION

Ardrox 667: Ardrox Limited, Brentford, Middlesex.
Maxan 774: Henkel Chemicals Limited, Edgware Road, London.

These products are methylene chloride based and are safe to use on most metals for the removal of carbon build up and for paint stripping. They are harmful to rubber and most plastic materials.

Method of use

The components to be cleaned must be immersed in the cleaning fluid long enough to produce the required standard of cleanliness. After cleaning, the components must be thoroughly rinsed in clean water. In use, maintain a water seal of at least 76 mm (3 inches) above the cleaning fluid to prevent evaporation and the escape of toxic fumes.

Goggles and protective clothing must be worn at all times when using these fluids and the container must be in a well ventilated area.

Do NOT smoke in the vicinity of the cleaning tank.

Duroclean 150 powder: Diversey Limited, Northampton.

This product is an alkali based degreasing compound and is safe to use on brass, copper and ferrous metals. It must not be used on aluminium, lead, tin and zinc.

	Nm	lbf. ft.
FUEL INJECTION PUMP		
Camshaft hub nut	149	110
Mounting setbolts	41	30
Adjustable coupling setbolts	41	30
Delivery valve connectors	80	60
Delivery valve assembly nuts	40	30
Spring plate coupling bolts	120	88
FUEL INJECTORS		
Clamp setbolts	40	30
or Socket capscrews	60	44
Nozzle capnut	81	60
Spill connections	27	20
GEAR TRAIN		
Compound gear setbolts (Using Studlock 270)	40	30
Auxiliary drive gear setbolts (Using Studlock 270)	30	22
Main idler gear axle setbolts	71	52
LUBRICATING OIL PUMP		
Oil pump idler gear axle nut (Nyloc)	80	60
Gear retaining nut	120	88
Casing setbolts	21	15
MAIN BEARING CAPS		
Securing setbolts	488	360
Lateral setbolts	177	130
ROCKER BOXES		
Securing setbolts	41	30
Socket capscrews	35	26
Rocker cover setbolts	21	15
Bridge piece adjusting screw locknut	40	30
Tappet adjusting screw locknut	40	30
SUMP		
Securing setbolts	55	40
Insert for drain plug (Using Loctite 542)	305-340	225-250
Drain plug	110-115	80-85
TURBOCHARGERS		
'V' band clamps: Multi segment	13.5	10
Single segment	18	13
Turbine housing	13.5	10
Note: Tighten multi-segment to 13.5 Nm plus a further 120 deg. Slacken and retorque to 13.5 Nm.		
Other applications: Captive 'T' bolt	17	12.5
Quick release	9	7
WHEELCASE AND BACKPLATE		
Bolts to crankcase	95	70

SECTION 2 — DISMANTLING THE ENGINE

Before dismantling, clean the engine thoroughly and ensure that the cooling and lubricating oil systems are drained completely. Coolant drain cocks are fitted to each side of the cylinder block and a drain plug is fitted beneath the lower end of the coolant pump/radiator pipe.

Most of the lubricating oil can be drained via the two sump plugs. Oil trapped in the heat exchanger may be drained by removing the oil filter canisters*.

Where dismantling involves the removal of proprietary items (e.g. turbocharger), or a sub-assembly, instructions for reducing these units to their component parts are given in the appropriate sections.

To facilitate refitting of the components, the smaller items (e.g. fuel injection pipes, clips, brackets etc.) should be labelled and stored in containers with associated engine parts.

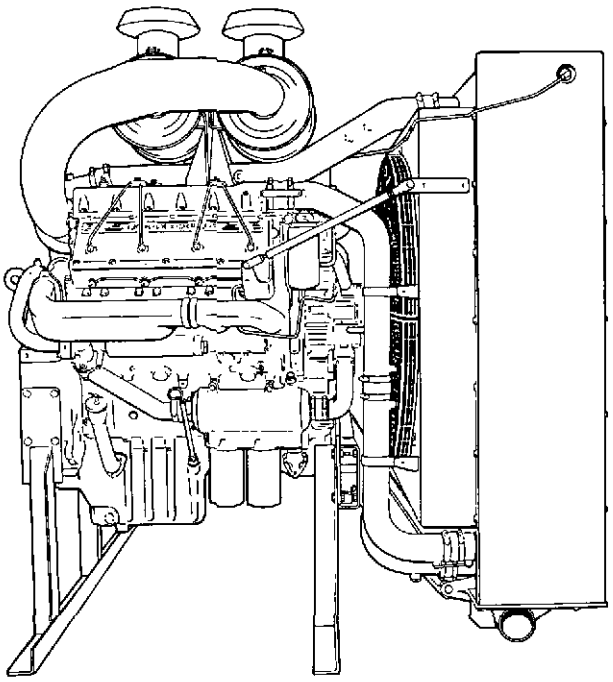


Fig. 1 Engine/radiator assembly on transportation stands.

Prior to the removal of the radiator, the engine may be mounted on simple support stands, as used for transportation (see fig. 1). Once the radiator has been removed, the engine will stand on its sump with appropriate packing beneath the front end.

The following sequence is given as a guide for the convenience of Operators.

Items in this Section marked will necessitate the use of Special Tools, some of which are illustrated in SECTION 3—ASSEMBLING THE ENGINE.*

DISMANTLING SEQUENCE

1. Remove the air ducting between the air cleaners, turbocharger, radiator and induction manifolds.
2. Remove the air cleaners and support brackets.
3. Remove the coolant pipework between the engine and radiator.
4. Remove the crankcase breather pipe.
5. Remove the fan guard.
6. Remove the radiator, stay rods, mounting beam and mounting brackets.
7. Remove the fan.
8. Remove the dipstick tube, oil filler pipe and coolant drain cocks.
9. Remove the oil-to-coolant heat exchanger and associated pipework.
10. Remove the alternator and mounting bracket.

Fit the front and rear engine mounting brackets and secure the engine in the turnover build stand then proceed.

11. Remove the starter motor.
12. Remove the fuel filter, header bracket and associated pipework.
13. Remove the exhaust elbow and bellows unit.

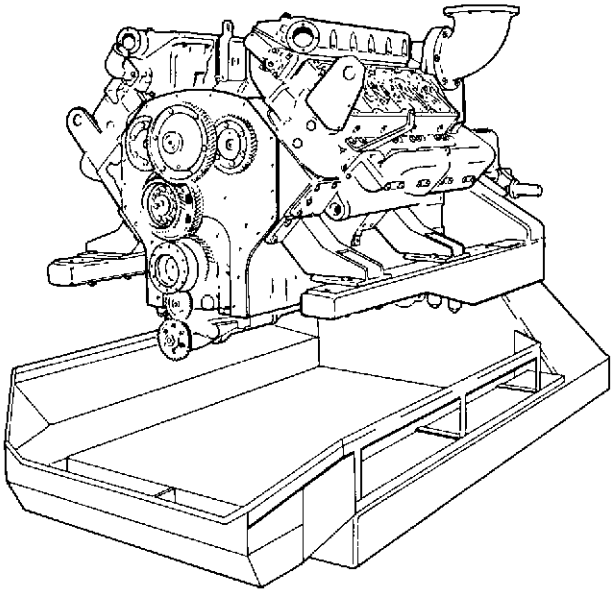


Fig. 2 Engine in Turnover Build Stand VP.5908.

14. Remove the turbocharger, oil pipework and exhaust manifolds.
15. Remove the coolant rail.
16. Remove the front engine mounting.
17. Remove the Engine Service Counter.
18. Release the jockey pulley and remove the fan belts.
19. Remove the crankshaft pulley and counter balance.
20. Remove the fan pulley and jockey pulley.
21. Remove the rocker covers.

*22. Remove the fuel injector clamps and withdraw the injectors. A sticking injector may be freed using the Inertia Extractor, VT. 11692 and Adaptor VT. 17973. Care must be taken to avoid slackening the copper injector sleeve in its housing when using the extractor.

23. Remove the rocker boxes and withdraw the pushrods.

*24. Disconnect the auxiliary drive coupling and remove the fuel injection pump and shut down solenoid.

25. Remove the fuel feed pump.

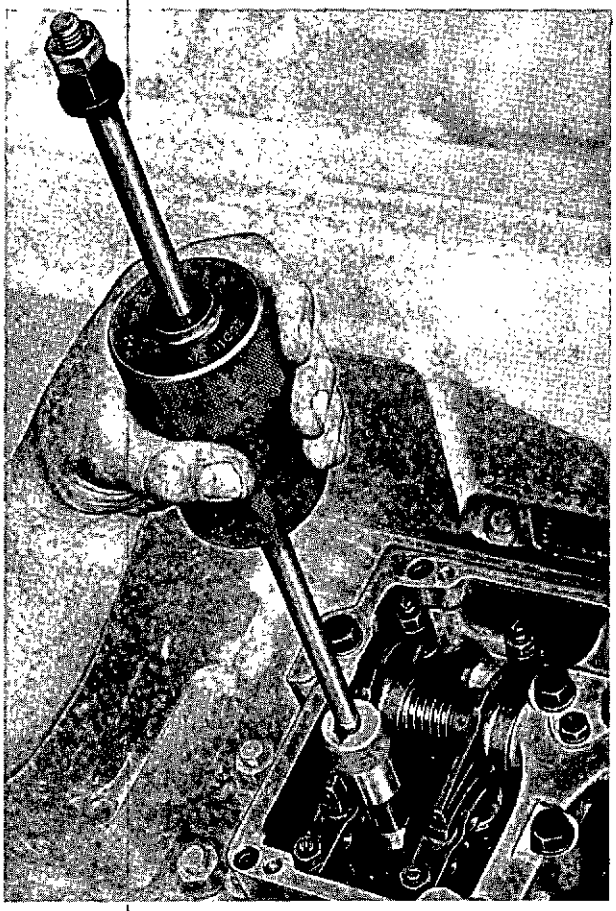


Fig. 3 Removing sticking injector.

26. Remove the coolant pump and associated pipework.
27. Remove the thermostat housing.
28. Remove the induction manifolds and coolant transfer bobbins.
29. Remove the crankcase breather adaptor.
30. Remove the fan adaptor.

*31. Remove the wheelcase.

*32. Remove the flywheel and flywheel housing.

33. Remove the turbocharger mounting duct and heat shield/lifting eye.

*34. Tilt the engine and remove each cylinder head and oil transfer bobbins.

*35. Withdraw the tappets and secure the cylinder liners with the retaining bars.

*36. Remove the auxiliary drive coupling yoke, then remove the auxiliary drive oil seal housing.

37. Remove the idler gears.

38. Remove the camshaft thrust plates and withdraw the camshafts.

*39. Remove the wheelcase back plate.

Turn the engine over until the sump is uppermost.

40. Remove the sump.

41. Remove the oil pump pipework.

42. Remove the oil pump.

43. Remove the baffle plate.

*44. Slacken all the big end bearing bolts and tilt the engine to the required angle; withdraw each piston/connecting rod assembly, using the Guide Pin, VT 14048. Turn the engine until the sump face is again uppermost.

*45. Remove all main bearing caps with bearing shells, and thrust washer bottom halves.

*46. Lift out the crankshaft and bearing shells, and thrust washer top halves.

47. Remove the piston oil jets.

*Turn the crankcase upright and remove from the build stand.

48. Remove the mounting brackets.

49. Remove the oil transfer housing from rear face of crankcase.

50. Remove the coolant gallery covers.

51. Remove the retaining bars and withdraw the cylinder liners.

*52. Remove any suspect cup plugs.

SPECIAL TOOLS

Part Number	Description
VP 5015	Lifting beam, complete engine.
VP 6202	Lifting beam, engine/radiator assembly.
VP 5007	Lifting bracket, cylinder head.
VP 5008	Lifting bar, flywheel.
VP 5014	Lifting plate, flywheel housing.
VP 5641 (2)	Mounting bracket, engine to build stand.
VP 5642 (2)	Mounting bracket, engine to build stand.
VP 5908	Build stand engine.
VP 6815	Lifting plate, crankcase.
VP 7621/1	Lifting bracket, crankshaft (CV 2457).
VP 7621/2	Lifting bracket, crankshaft (CV 7693).
VT 14040 (2)	Guide studs, flywheel to crankshaft.
VT 11496 (2)	Guide studs, main bearing caps.
VT 11671	Inertia extractor, main bearing caps.
VT 11692	Inertia extractor, fuel injectors.
VT 17973	Adaptor, inertia extractor (VT 11692).
VT 14048	Guide pin, connecting rod big end.
VT 12341	Extractor, auxiliary drive yoke.
VT 12918	Wrench, fuel filter canisters.
VT 17416 (2)	Retaining bar, cylinder liners.
VT 17844 (2)	Guide studs, flywheel housing.
VT 17845 (2)	Guide studs, wheelcase.
VT 17877	Barring adaptor, crankshaft.
VT 18038	Wrench, oil filter canisters.

Cup plug servicing kits are available in a range of sizes to suit the bore of the component which houses a particular cup plug. Each kit consists of a tap, an extractor nut and an insertion tool. The following is a list of kits available and the correspondence cup plug sizes:

Kit Number	Cup Plug Size
VT 12859	12 mm
VT 12862	16 mm
VT 12865	20 mm
VT 12868	22 mm
VT 12874	25 mm
VT 12877	32 mm
VT 12883	40 mm
VT 12886	45 mm
VT 12889	50 mm
VT 12892	71.5 mm

SECTION 3 — ASSEMBLING THE ENGINE

Components referred to in this Section include sub-assemblies which have been overhauled as described under their respective headings elsewhere in this Manual.

Instructions concerning assembly procedure, which are given in the General Information section, will do much to ensure long and trouble-free service from the engine if they are carefully followed during engine build.

ASSEMBLY SEQUENCE

1. Fit two Mounting Brackets, VP 5641, and two Mounting Brackets, VP 5642, to the sides of the crankcase and secure each with four slave setbolts.
2. Using five slave setbolts, secure the Lifting Plate, VP 6815, to the fuel injection pump location in the crankcase 'V'. Lift the crankcase into the Turnover Build Stand, VP 5908, with the front (free) end facing outwards. Secure the assembly with eight bolts and nuts and remove the lifting plate.

Crankshaft and main bearings

3. Turn the crankcase until the sump joint face is uppermost and position the upper halves of the main bearing shells. Smear the bearing surfaces liberally with clean engine lubricating oil and using the appropriate lifting bracket, (see the Special Tools list at the end of the Section), lower the prepared crankshaft assembly into position. Ensure that the bearing shells are not dislodged during this operation.
4. Smear the upper halves of the thrust washers with clean engine lubricating oil and feed them into the recesses at each side of the centre main bearing. Ensure that the bronze faces of the washers are toward the crankshaft webs.
5. Fit the lower halves of the main bearing shells into the bearing caps and smear each shell liberally with clean engine lubricating oil.
6. Apply a light smear of grease to the recesses on each side of the centre main bearing cap, fit the lower halves of the thrust washers into their recesses with the bronze faces outwards then fit the bearing cap assembly into the crankcase using Guide Studs, VT 11495. If the cap is a tight fit in its housing, use a soft-faced mallet to tap it into position. Remove the guide studs, fit the securing setbolts, (see Item 8) and align the cap with the crankcase housing. Tighten the setbolts securely and check the crankshaft for axial movement. If it is found that the crankshaft is difficult to move, check that the thrust washers are not being bowed by pressure on the butts. If this is the case, the bowing may be cured by removing the bearing cap and filing the butts of the thrust washers. Refit the thrust washers and bearing cap, and re-check the crankshaft movement.

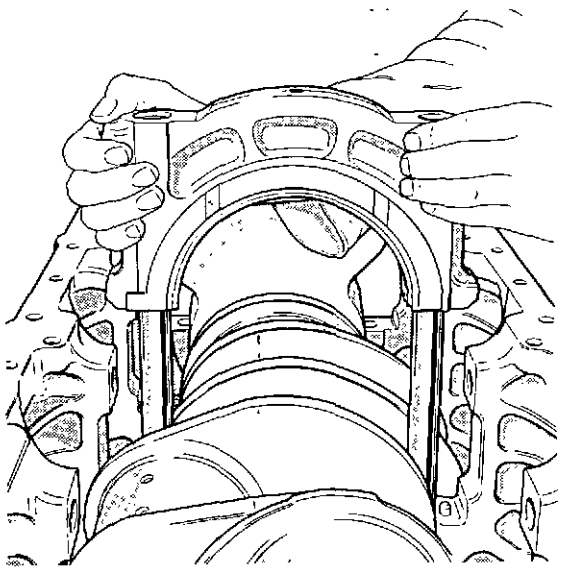


Fig. 1 Fitting centre main bearing cap.

7. Fit the other four main bearing cap assemblies into the crankcase ensuring that the correlation numbers on each cap coincide with the numbers stamped in the crankcase.

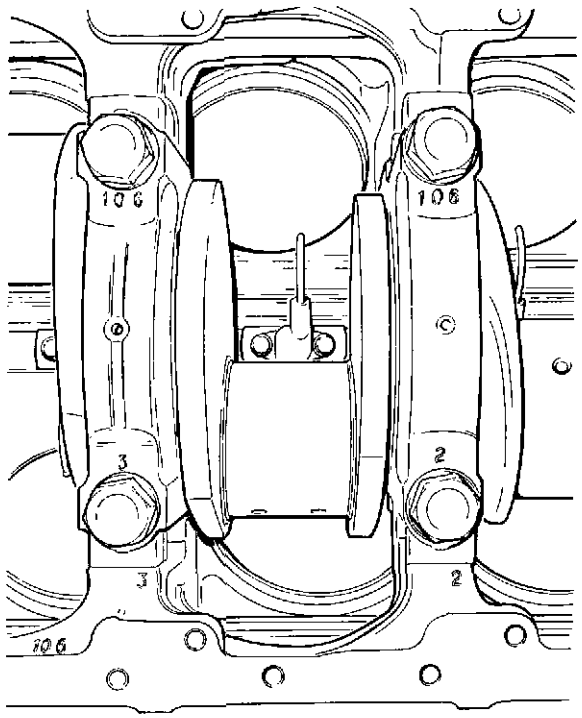


Fig. 2 Main bearing correlation numbers.

8. Oil-wet the underside of the heads and the threads of the main bearing cap and lateral setbolts and run each bolt in finger tight.
   Note: Plain washers must be fitted beneath the head of each lateral set bolt.
9. Ensure that each main bearing cap machined side face is flush with the corresponding face of the crankcase then tighten the main setbolts to a torque loading of 488 Nm (360 lbf. ft.) in the sequence given in Figure 3.
   Note: As each main bearing cap is secured, check the crankshaft for freedom of rotation before tightening the setbolts of the next bearing cap in the sequence.
10. Tighten the lateral setbolts in alphabetical order as shown, to a torque loading of 177 Nm (130 lbf. ft.).
11. Set up a D.T.I. gauge as shown and measure the crankshaft end float by levering the shaft backwards and forwards with a small crowbar or large screwdriver. End float should be between 0.10 mm and 0.30 mm (0.004 and 0.012 inch).

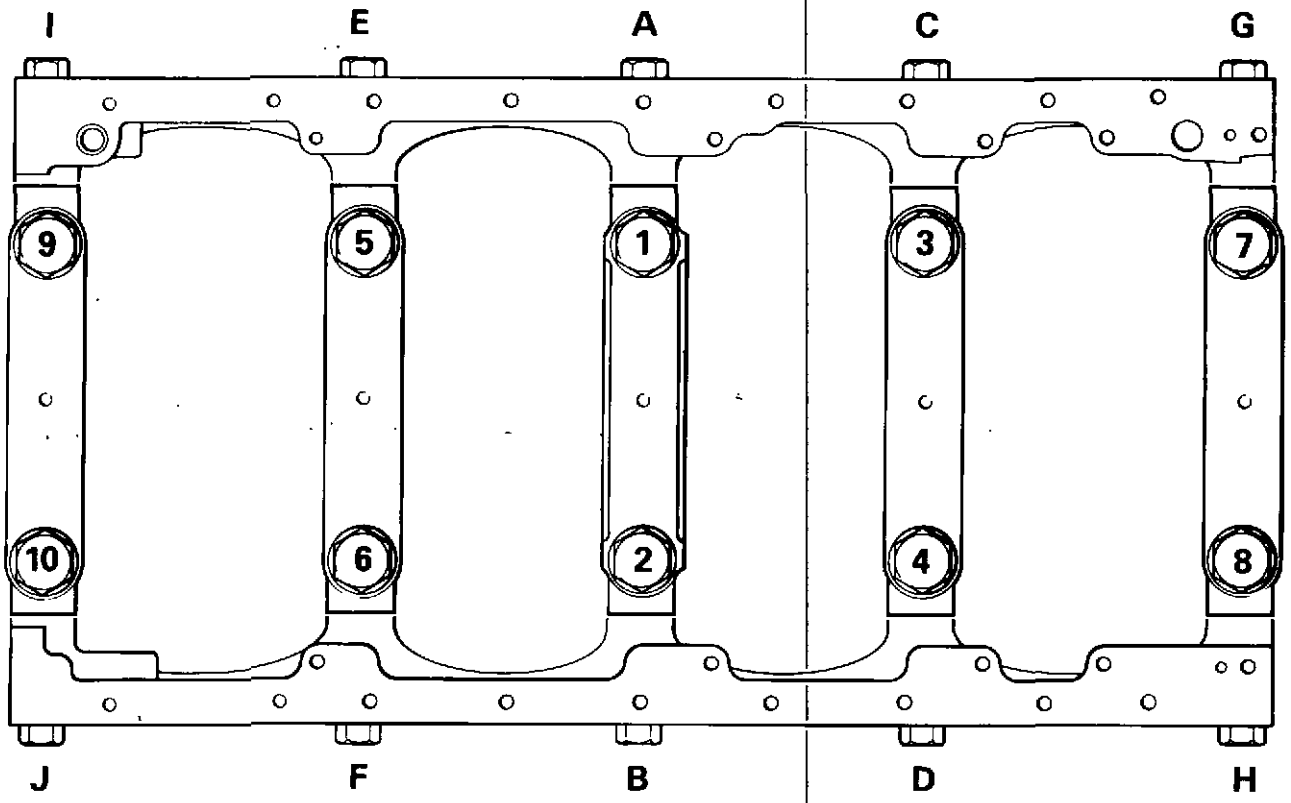


Fig. 3 Main bearing cap bolt tightening sequence.

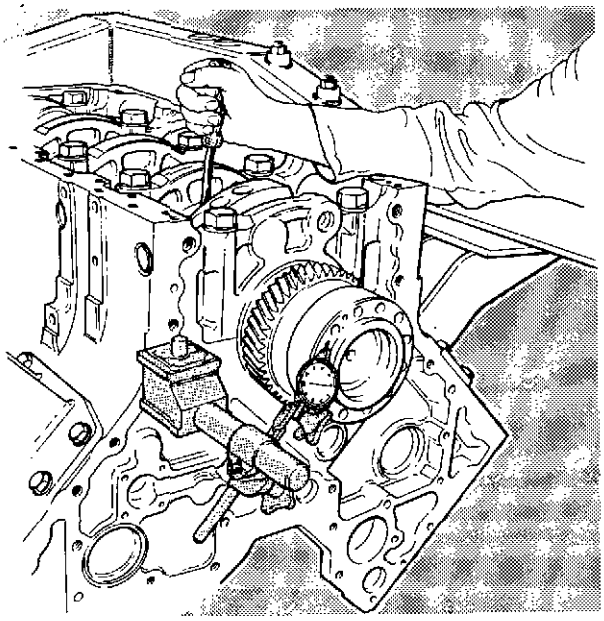


Fig. 4 Measuring crankshaft end float.

Rear oil seal

12. Place the baseplate of the Seal Insertion Tool, VT 17880, on the table of a hand operated press and position the rear oil seal housing on the locating pins. Press the oil seal fully into its housing using the pressure ring. Fit the housing to the rear end face of the crankcase with a jointing gasket and nine setbolts and spring washers. Ensure that the crankcase sump face and lower face of the oil seal housing are correctly aligned before tightening the setbolts. Slip an 'O' ring seal into the machined groove around the periphery of the housing.

Cylinder liners

13. Check the landings of each cylinder liner. Lap in if necessary. (See Section 4—Crankcase and Cylinder Liners).
14. Apply a light coating of 'Wellseal' jointing compound to the shoulder of each liner and insert it into its respective bore. Fit the liner Retaining Bars, VT 17416.
15. Fit the crankshaft Barring Adaptor VT 17877, to the front end of the crankshaft.
16. Turn the crankcase until the 'A' bank is horizontal and rotate the crankshaft until 'A1' crankpin is at B.D.C.

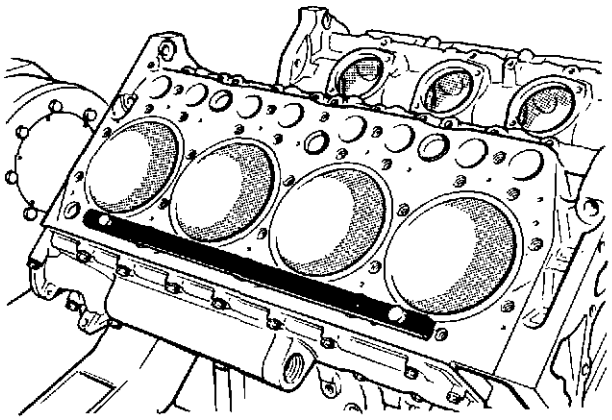


Fig. 5 Liner retaining bar.

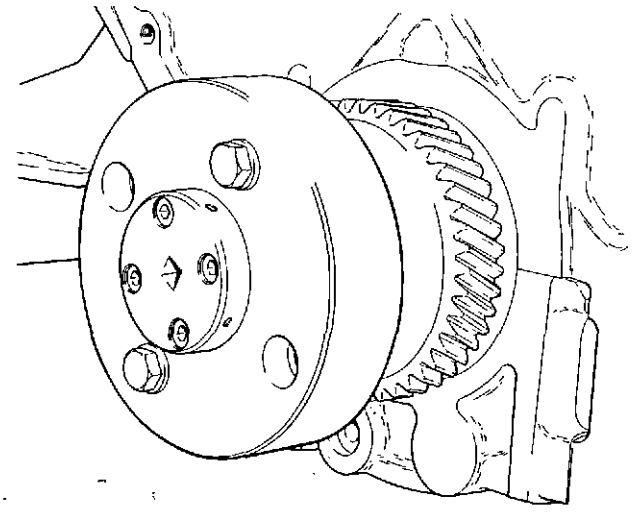


Fig. 6 Crankshaft barring adaptor.

Pistons and connecting rods

17. Screw the Guide Pin, VT 14048, on to a bolt in the 'A1' piston/connecting rod assembly.
18. Ensure that the piston ring gaps are correctly 'staggered', lubricate the piston liberally with clean engine oil and push the piston/connecting rod assembly into the 'A1' cylinder bore using the Piston Ring Sleeve, VT 10714.
19. Oil the big-end bearing and carefully guide the big end on to the crankpin with the chamfered bore of the connecting rod facing the adjacent crank web.

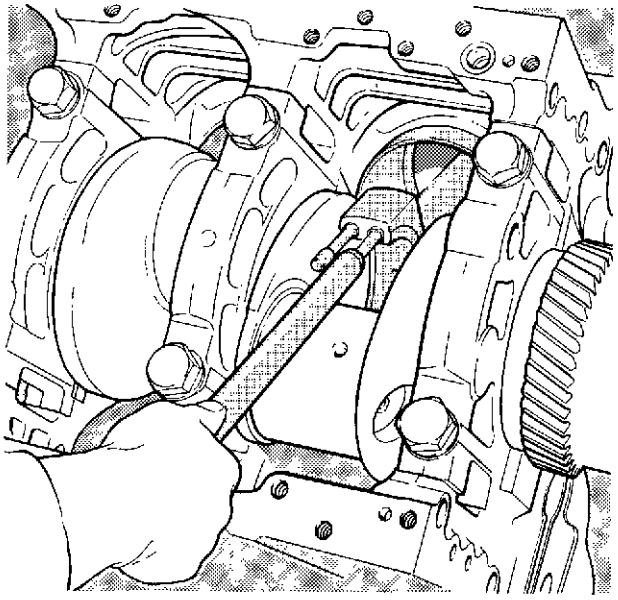


Fig. 7 Connecting rod guide pin.

20. Remove the guide pin, liberally oil the crankpin and fit the bearing cap/shell assembly on the big end securing bolts.
21. Lightly oil the bolt threads before fitting the nuts. Nip each nut before proceeding to the next unit.
22. When all 'A' bank pistons are fitted, check that the oil jets locate correctly in the piston skirt cut-outs as the crankshaft is rotated.
23. Turn the crankcase until 'B' bank is horizontal and rotate the crankshaft until 'B1' crankpin is at B.D.C.
24. Carry out the piston fitting procedure for all 'B' bank cylinders and check oil jet locations.
25. Turn the crankcase so that the sump joint face is uppermost and tighten the big-end bolts in a diagonal pattern to a torque loading of 60 Nm. (42 lbf. ft.). Continually check the crankshaft for freedom of rotation as each unit is tightened.

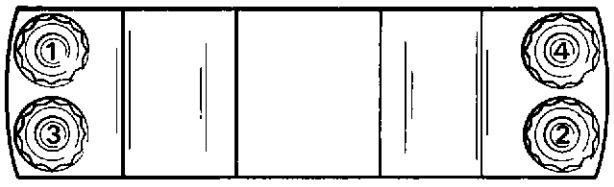


Fig. 8 Big end bolt tightening sequence.

26. Set up a D.T.I. gauge as shown and check the end float of the big ends. The permissible end float is between 0.2 mm and 0.4 mm (0.008 inch and 0.016 inch).

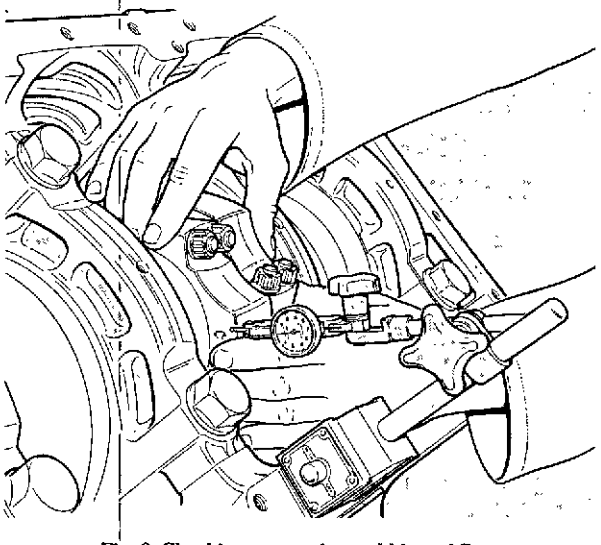


Fig. 9 Checking connecting rod big end float.

27. Rotate the engine until the 'A' bank flame face is horizontal and check the depth of each piston crown at T.D.C. below the cylinder block flame face, using Height Gauge, VT 10715. Permissible clearances are 0.31 mm to 0.38 mm (0.012 inch to 1.015 inch).

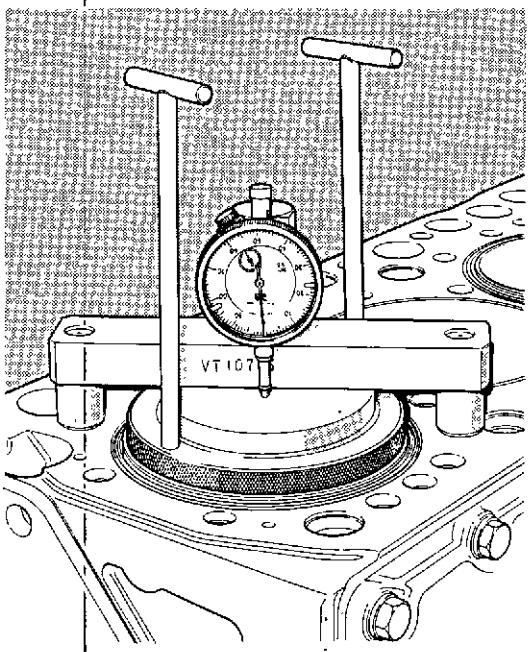


Fig. 10 Checking piston height.

28. Rotate the engine until the 'B' bank flame face is horizontal and check the 'B' bank piston/flame face clearances.

Wheelcase backplate

29. Apply a thin coating of 'Wellseal' to the backplate joint face, position the gasket on the backplate and apply a further coating to the outer face of the gasket.
30. Fit two Guide Studs, VT 17845, in the crankcase/wheelcase bolt holes and position the backplate. Tap in the two locating dowels and secure the backplate with six setbolts and spring washers. Remove the guide studs.

Camshafts

31. Fit the Lead-in Mandrel, VT 17842, to the end of the 'A' bank camshaft, liberally oil the camshaft bushes and feed in the camshaft. Before the camshaft is completely home, engage the thrust plate on the camshaft collar, coat the underside of the counter-sunk screw heads with anti-seize compound and secure the thrust plate to the crankcase. Torque tighten the screws to 70 Nm (50 lbf. ft.).
32. Transfer the lead-in mandrel to the 'B' bank camshaft and fit the camshaft and thrust plate. Remove the lead-in mandrel.
33. Set up a D.T.I. gauge and check the end float of each camshaft. Permissible movement is 0.01 to 0.55 mm (0.004 to 0.022 inch). After checking the end float, fit the two large steel cup plugs into the crankcase camshaft bores, using Insertion Tool, VT 10708.

    Note: Coat the edge of each cup plug with Loctite 542 and insert the plugs so that the lip is *just* below the end face of the crankcase.

Gear train

34. Fit the gear rings to each camshaft flange, tap in the locating dowels and, using Studlock 270 on the threads secure each gear ring with six setbolts and plain washers. Torque tighten the securing setbolts to 40 Nm (30 lbf. ft.).
35. Using Studlock 270 on the threads, assemble the large and small idler gears with 12 setbolts and 1 plain washer. Tap in the locating dowel and torque tighten the setbolts to 40 Nm (30 lbf. ft.), then fit the assembly to the crankcase with two thrust washers, thrust plate and axle, and secure with two setbolts and lockplate. Ensure that the large gear timing marks are correctly aligned with the crankshaft timing mark before torque tightening the setbolts to 71 Nm (52 lbf. ft.). Tab up the lockplate.
36. Fit the oil pump idler gear on to its axle, with the boss extension away from the axle flange. Push the axle securing bolt through the drilling in the front main bearing cap, from the inner side. Fit the axle over the bolt with the idler gear in mesh with the crankshaft gear and run the self-locking nut up to the axle flange. Torque tighten the nut to 80 Nm (60 lbf. ft.).
37. Check the backlash between the gears as follows:

    Set up a magnetic based D.T.I. gauge on the backplate, so that the gauge lever rests upon the side of one of the teeth on the oil pump idler gear. Rotate the idler gear by hand as far as possible in each direction and check the deflection of the D.T.I. needle. The total movement should be between 0.100 and 0.235 mm (0.004 and 0.009 inch).

    Next, set up the D.T.I. gauge to check the backlash of the main idler gear. The deflection should be between 0.100 and 0.239 mm (0.004 and 0.0095 inch).

Auxiliary drive assembly

38. Remove the oil seal housing and woodruff key from the auxiliary drive assembly, preparatory to fitting to the backplate.
39. Turn both camshafts until the timing marks on the gears face in towards the centre of the engine.
40. Fit the auxiliary drive assembly to the backplate with the outer gear timing mark in mesh with the timing marks on the small idler gear and ensuring that the camshaft timing marks are in mesh with the timing marks on the auxiliary drive assembly inner gear. The two 'sight holes' in the outer gear facilitate the lining up of the latter timing marks.

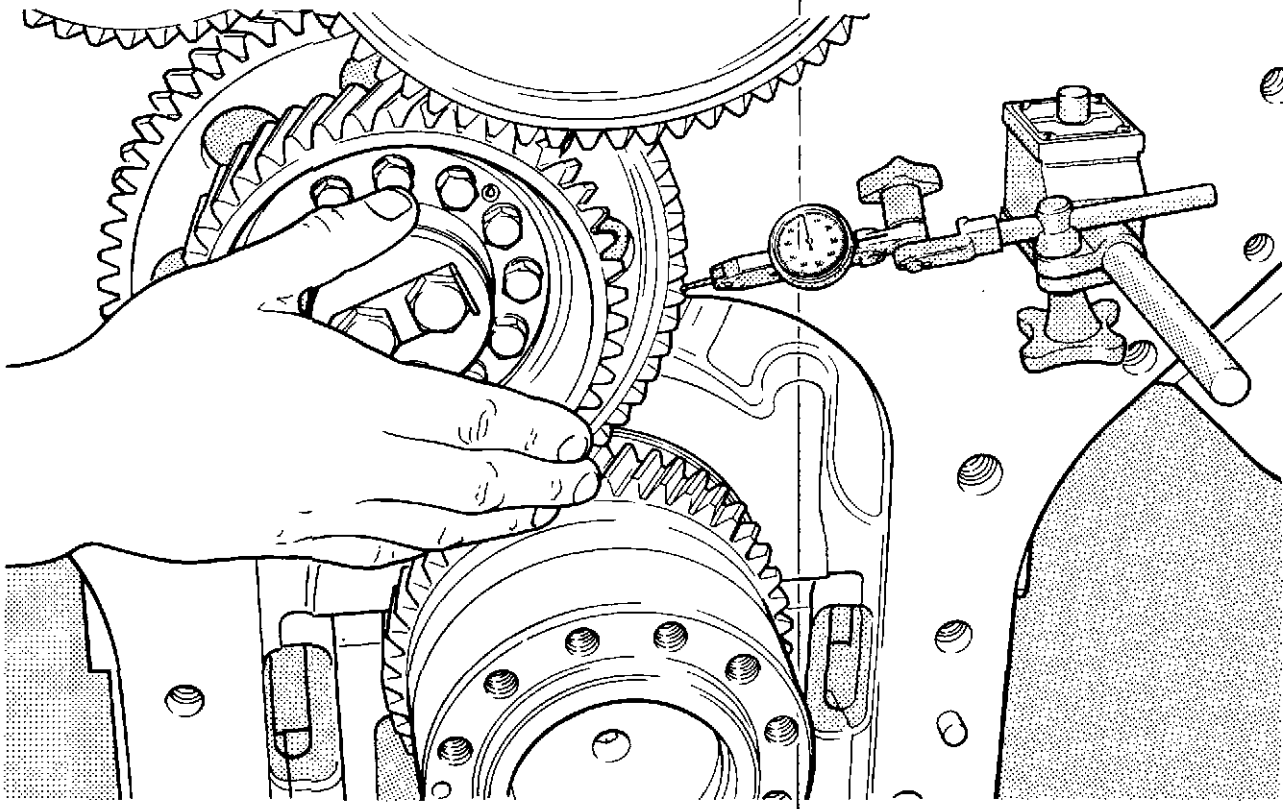


Fig. 11 Checking main idler gear backlash.

Fit the housing of the Alignment Tool, VT 17974, over the studs on the engine side of back plate and secure with the oil seal housing nuts. Enter the sleeve section of the tool into the housing and screw up the sleeve, hand tight, on the auxiliary drive shaft thread. This will hold the gear steady to enable correct backlash readings to be taken between the auxiliary drive gear and the meshing gears, i.e. camshafts and main idler.

Note: When measuring backlash, always ensure that one of the gears is held stationary, otherwise false readings will be obtained.

41. Check the end float of the idler gears as follows:

    Set up the D.T.I. gauge as Item 37 but let the gauge lever rest on the outer face of the gear to be checked; note the total axial movement of the gear. The end float for the main idler gear must be between 0.100 and 0.425 mm (0.004 and 0.017 inch). The end float for the oil pump idler gear must be between 0.150 and 0.300 mm (0.006 and 0.012 inch).

Cylinder heads

42. Turn the engine so that the 'A' bank flame face is horizontal and remove the cylinder liner retaining bars.
43. Liberally oil the tappet bores and fit the tappets.
44. Fit the two cylinder head locating dowels and the oil transfer bobbin, complete with sealing ring, into the cylinder block flame face and position the new cylinder head gasket.
45. Screw two Guide Studs, VT 17843, into the cylinder head bolt holes and carefully lower the cylinder head into position, using the Lifting Bracket, VP 5007.

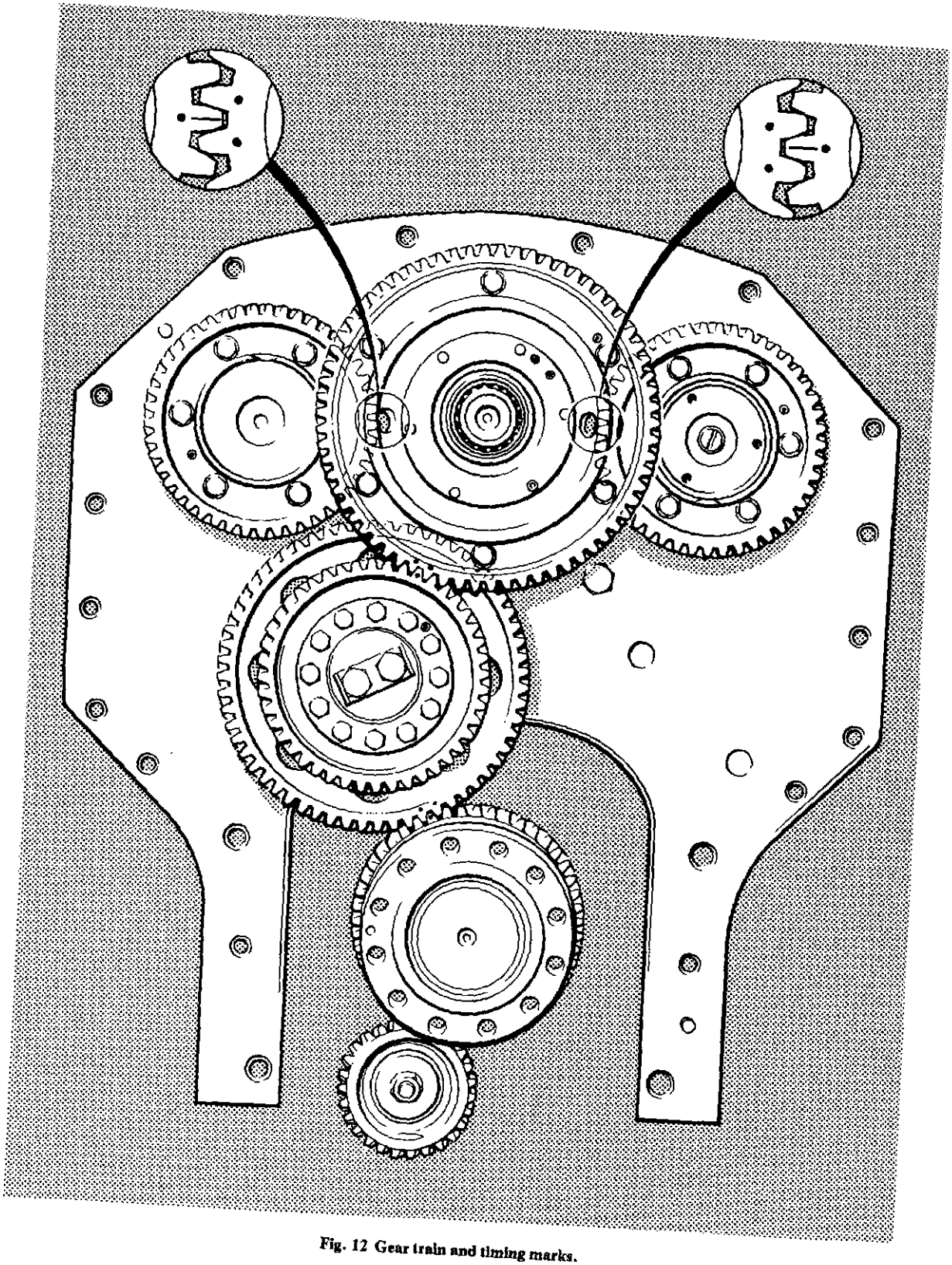


Fig. 12 Gear train and timing marks.

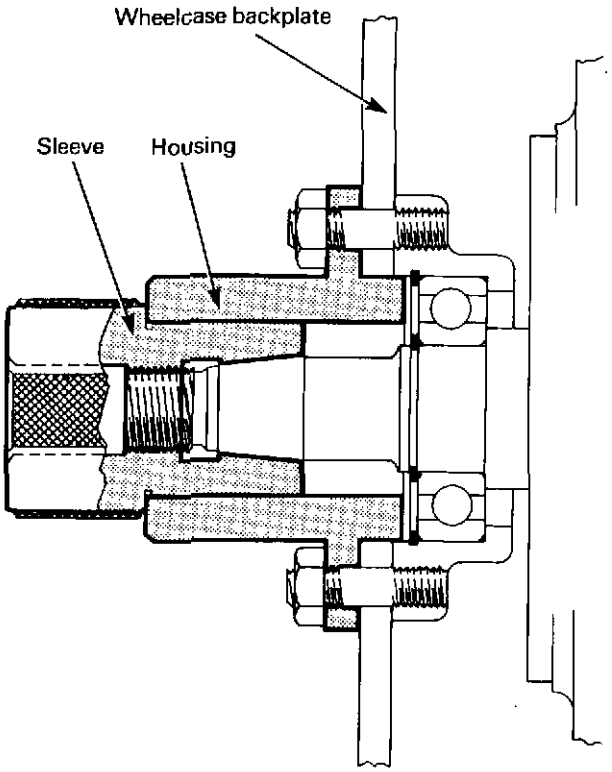


Fig. 13 Alignment tool in position.

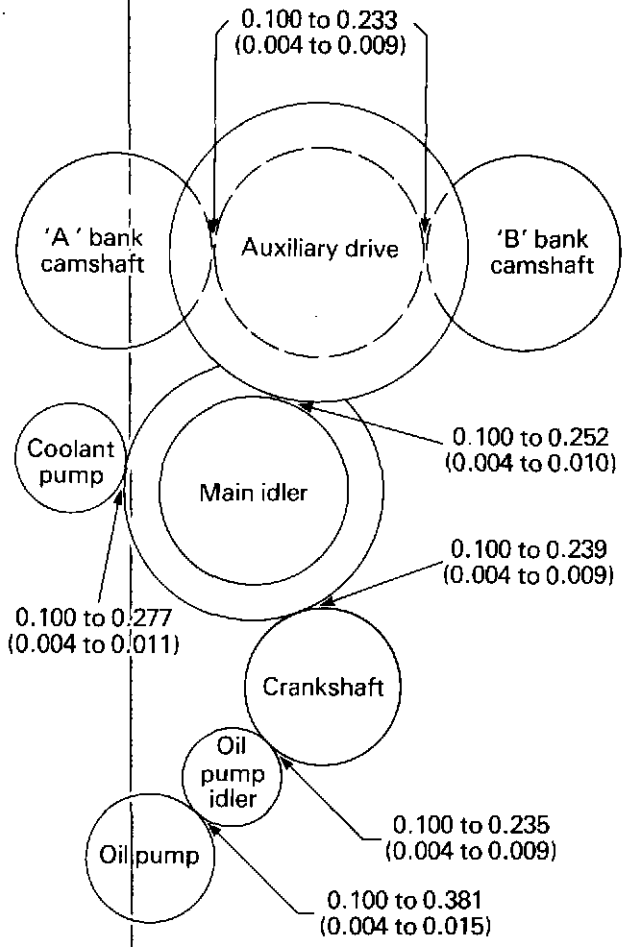


Fig. 14 Gear train backlash readings, Metric [Imperial].

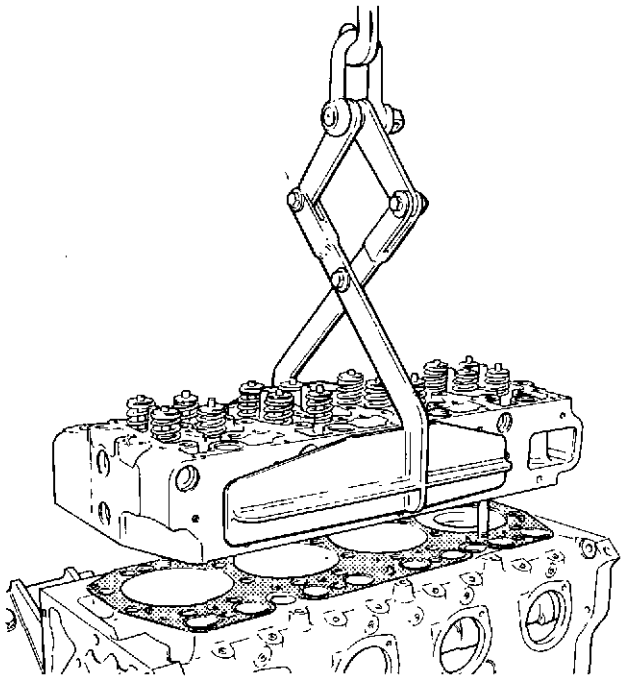
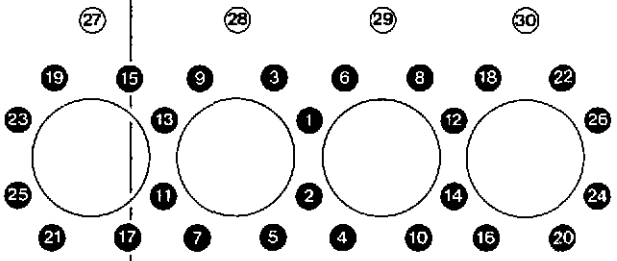


Fig. 15 Fitting cylinder head.



Figures in black circles.....240 Nm. (175 lbf./ft.)
Figures in white circles.....175 Nm. (130 lbf./ft.)
plus 1/6 turn

Fig. 16 Cylinder head bolt torque tightening sequence.

46. Remove the lifting bracket and guide studs and lightly oil the cylinder head bolt threads. Fit all the bolts and washers complete with lifting eye, radiator stay bracket and exhaust bellows support bracket.
47. Following the correct sequence, tighten the cylinder head bolts in steps of 50 Nm (38 lbf. ft.), until the final torque figure is achieved.
48. Fit new 'O' ring seals around the four alloy blanking plugs. Lubricate the rings with castor oil and press the plugs into the access holes in the induction ports.
49. Turn the engine so that the 'B' bank flame face is horizontal and fit the cylinder head using the same procedure as that used on 'A' bank, then turn the engine upright to its normal position. If new cylinder heads have been fitted, stamp the bank letter on each head for future reference.
50. Fit the heat shield/lifting eye to the rear end face of the crankcase with one setbolt and spring washer. Ensure that all the bolt holes are aligned with those in the crankcase before tightening the setbolt.
51. Fit the turbocharger mounting duct to the heat shield, over the three studs protruding through the crankcase; fit the setbolt, with a spring washer, and fit nuts and spring washers to each stud. Tighten each nut and bolt securely.

Flywheel and housing

52. Screw two Guide Studs, VT 17844, into the crankcase/flywheel housing bolt holes and, using the Lifting Beam, VP 5014, position the flywheel housing over the guide studs. Secure the housing to the crankcase with ten setbolts and spring washers and two bolts, nuts and spring washers. Remove the guide studs and fit the two remaining setbolts and spring washers. Torque tighten each bolt to 95 Nm (70 lbf. ft.).
53. Check that the spring dowel is fitted in the crankshaft rear end flange and using the Lifting Bar, VP 5008, position the flywheel on the crankshaft.
54. Fit the clamping ring and secure the flywheel with 16 socket head capscrews. Torque tighten the capscrews to 315 Nm (232 lbf. ft.).
55. Screw the timing pointer into the flywheel housing and using new gaskets and spring washers, fit the blanking covers each with two setbolts. Fit the plug complete with new joint washer.

    At this stage, the coolant gallery covers may be fitted, using new jointing gaskets, followed by the coolant rail and hose connection heat shield.

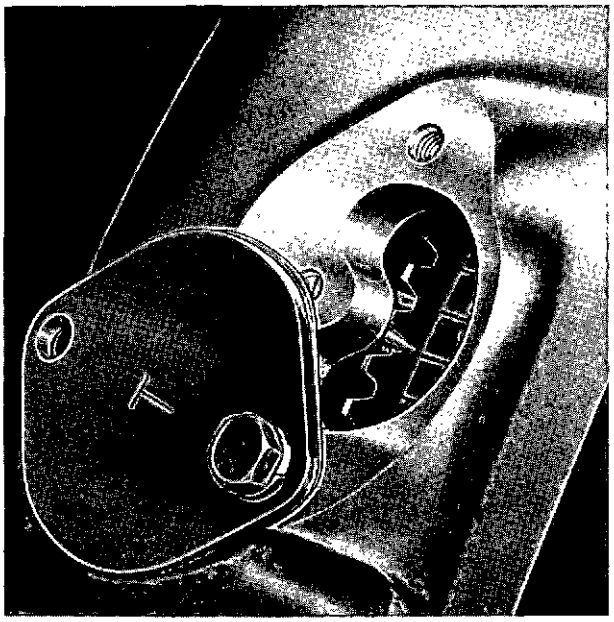


Fig. 17 Flywheel timing pointer.

Valve gear

56. Insert the 16 pushrods through the cylinder head apertures and check that the 4 rocker box locating spring dowels are in place.
57. Liberally oil the valve bridge guides, bridge pieces and pushrods and position the rocker box gaskets over the locating dowels in the cylinder head top face.
58. Ensure that the rocker adjusting screws are all slackened right back, then fit the rocker box assemblies on to their respective cylinder heads.
59. Fit the rocker box securing setbolts with plain and spring washers, and fit the socket head capscrews. Tighten the setbolts and capscrews. evenly and progressively to the following torque loadings.

    Setbolts .....41 Nm (30 lbf. ft.)

    Capscrews .....35 Nm (26 lbf. ft.)

The following sequence, specified in Items 60 to 65 inclusive, applies to engines fitted with the Cruciform crankshaft, CV 7693. For engines fitted with the Paired Throw crankshaft, CV 2457, the correct sequence will be found in the table given below.

60. Rotate the crankshaft until the piston in the 'B3' cylinder is at T.D.C. on its compression stroke with the valves on 'A1' 'rocking', i.e. exhaust valves just closing, inlet valves just opening.

61. Slacken the locknuts on the 'B3' bridge piece adjusting screws and turn each screw back until it is clear of its valve stem. In turn, press down firmly on the centre of each bridge piece and turn the adjusting screw until it is felt to *just* touch the valve stem tip. Turn the screw a further 60 deg. (1/6 turn) and tighten the locknut to a torque loading of 40 Nm (30 lbf. ft.).

Caution: It is important that no side load is placed on the valve stems when tightening the adjusting screw locknuts.

Note: The bridge piece setting may be carried out during cylinder head overhaul, before fitting the rockers, if preferred.

62. Using a set of feeler gauges, set the clearance between the inlet valves rocker adjusting screw and valve bridge button to 0.2 mm (0.008 inch) and tighten the locknut to 40 Nm (30 lbf. ft.).

63. Set the clearance between the exhaust valves rocker adjusting screw and bridge button to 0.5 mm (0.020 inch), and torque tighten the locknut as for the inlet valves.

Note: Re-check the inlet and exhaust valve clearances after torque tightening the locknuts before proceeding to the next unit.

64. Rotate the crankshaft through 90 deg. in the normal direction of rotation. This will bring the 'A2' piston to T.D.C. on its compression stroke with 'B1' valves 'rocking'. Set the valve bridge as described in Item 62, if not previously adjusted.

65. Set the 'A2' tappet clearances as described in Items 63/64 and proceed in 90 deg. steps until all units have been adjusted.

Note: See the tappet setting sequence given at bottom of page.

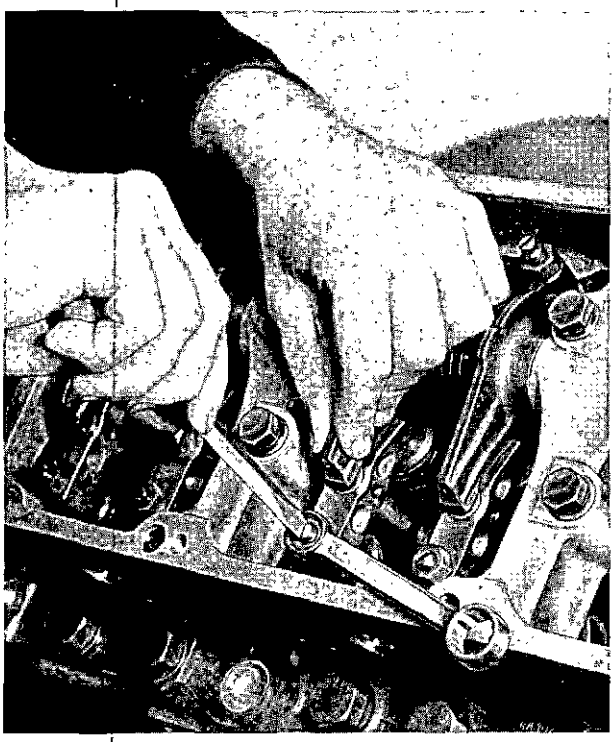


Fig. 18 Setting valve bridge pieces.

Crankshaft CV 7693		Crankshaft CV 2457	
Valves rocking on	Set clearance on	Valves rocking on	Set clearance on
A1	B3	A1	B3
B1	A2	B1	A4
B2	A4	A2	B4
A3	B4	B2	A3
B3	A1	B3	A1
A2	B1	A4	B1
A4	B2	B4	A2
B4	A3	A3	B2

Fig. 19 Tappet setting sequence

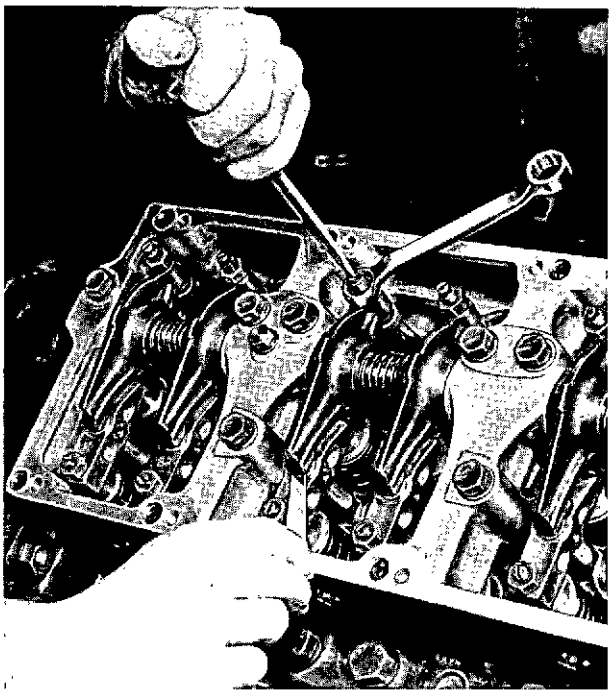


Fig. 20 Setting valve tappet clearance.

Oil test

When the engine has reached this stage it is advisable to apply an oil test to ensure that the moving parts are adequately lubricated, and to check that oil seals are not leaking. An oil circuit Test Trolley VP 4000 is available for this purpose.

66. Fit the oil test union to the turbocharger oil feed aperture in the crankcase 'V' and connect the oil pipe from the test trolley. Switch on the electric pump.
67. Check for a good flow of oil from any of the fixed oil jets and a liberal supply from the main bearings, connecting rod big and small end bearings, all idler gear axles, the rocker arm bushes and a flow from the rocker arm drillings to supply the push rods and valve gear.
68. Check that there is no leakage from any of the crankshaft cup and sludge plugs, and the cup plugs and blanking plugs in the auxiliary oil galleries.
67. Switch off the test pump, disconnect the oil pressure pipe and remove the pipe union from the crankcase 'V'.
70. Temporarily fit the rocker box covers to protect the valve gear.

Wheelcase

If, during overhaul, the two studs to the right of the 'B' bank camshaft bore have been removed from the crankcase end face, they must be replaced before fitting the wheelcase.

71. Coat the threads with 'Loctite 542' and screw in the two securing studs.
72. Apply a coating of 'Wellseal' to both sides of the wheelcase joint gasket and position the gasket on the backplate.
73. Using two Guide Studs, VT 17845, assemble the wheelcase to the backplate and secure with setbolts and nuts, with plain and spring washers. Torque tighten the nuts and setbolts to 95 Nm (70 lbf. ft.).

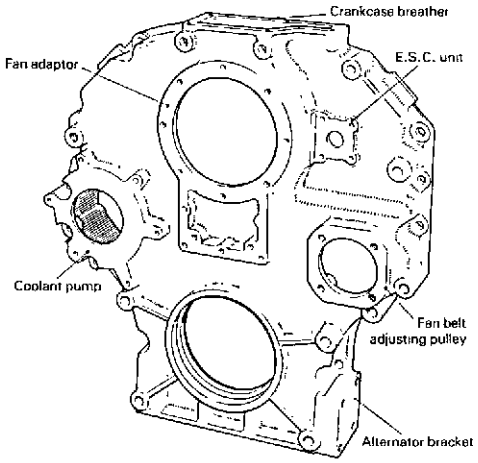


Fig. 21a Wheelcase, CV 8095 with parts locations.

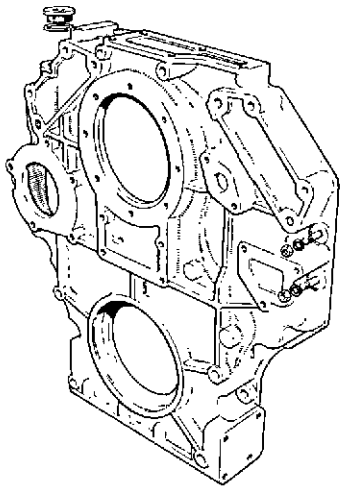


Fig. 21b Wheelcase, CV 2680.

74. Coat the fan adaptor gasket with 'Wellseal' and fit the assembly to the wheelcase. Secure the assembly with setbolts and spring washers.

75. Apply a coating of 'Wellseal' to each side of the breather connection gaskets. Fit a gasket, baffle plate, the second gasket and finally the breather connection to the aperture in the wheelcase top face. Secure the connection with five setbolts, plain and spring washers.

76. Remove the auxiliary drive alignment tool and turn the crankshaft backwards and forwards, sufficient to note the full axial movement of the auxiliary drive shaft. Set the shaft at approximately mid-point of its travel and fit the oil seal housing, complete with a full laminated shim pack, over the studs on the engine side of the back plate. Nip up the six securing nuts. Set up a D.T.I. gauge in the crankcase 'V' with the indicator lever resting on the end of the auxiliary drive shaft. Rock the crankshaft backwards and forwards and note the D.T.I. readings. The correct end float for the auxiliary drive shaft assembly is 0.08 to 0.12 mm (0.003 to 0.005 inch). Remove layers from the laminated shim and check the axial movement of the assembly until the correct reading is achieved. Finally secure the oil seal housing and shims with the six nuts and Dowty washers and refit the woodruff key.

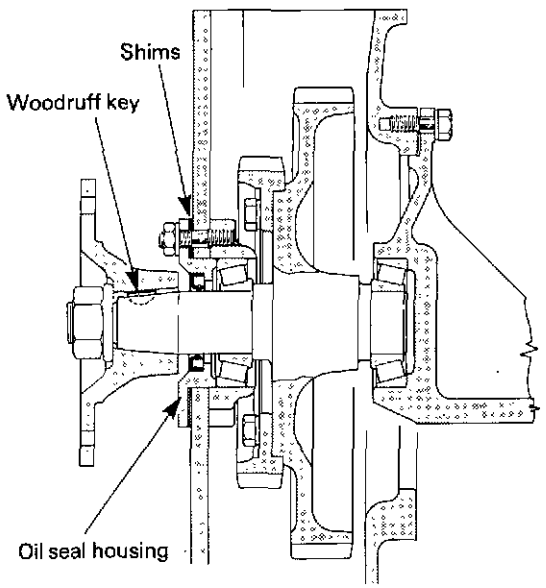


Fig. 22 Auxiliary drive assembly.

Coolant pump

77. Remove the suction cover from the coolant pump assembly and using a dry gasket, temporarily secure the pump to the wheelcase with two or three setbolts and plain washers.

78. Set up a D.T.I. gauge with the lever against one of the coolant pump impellor blades at a point 44 to 45 mm radially from the centre of the shaft. Turn the impellor by hand to the limit of its movement in both directions and check the backlash reading on the gauge. The total reading should be between 0.100 and 0.277 mm (0.004 and 0.011 inch).

79. Remove the coolant pump, coat the gasket with 'Wellseal' and refit the pump to the wheelcase complete with the suction cover. Secure with setbolts, plain and spring washers.

80. Fit the by-pass suction connection to the pump cover flange with a joint gasket and, dependent upon the type of coolant pump used, secure the connection with three setbolts with plain and spring washers or three bolts and nuts with plain and spring washers. Slide a hose connection and two hose clips over the free end of the by-pass suction connection.

Oil pump and sump

Turn the engine over so that the sump face is uppermost

81. Fit the oil baffle plate to the crankcase and secure with four setbolts and spring washers.

82. Fit two locating dowels into the crankcase sump face and secure the oil pump assembly in position with three setbolts and spring washers.

83. Fit the oil pump drive gear with a locking washer and retaining nut. Torque tighten the nut to 120 Nm (88 lbf. ft.), and tab up the washer. Check the gear backlash. See figure 14.

84. Fit the rubber 'O' rings to each end of the oil suction pipe, smear the rings with castor oil and insert one end of the pipe into the oil pump casing.

85. Fit the suction connection to the free end of the suction pipe and secure with two setbolts and spring washers.

86. Fit new 'O' rings to the suction bobbin, lubricate with castor oil, and insert the bobbin in the aperture in the suction connection.

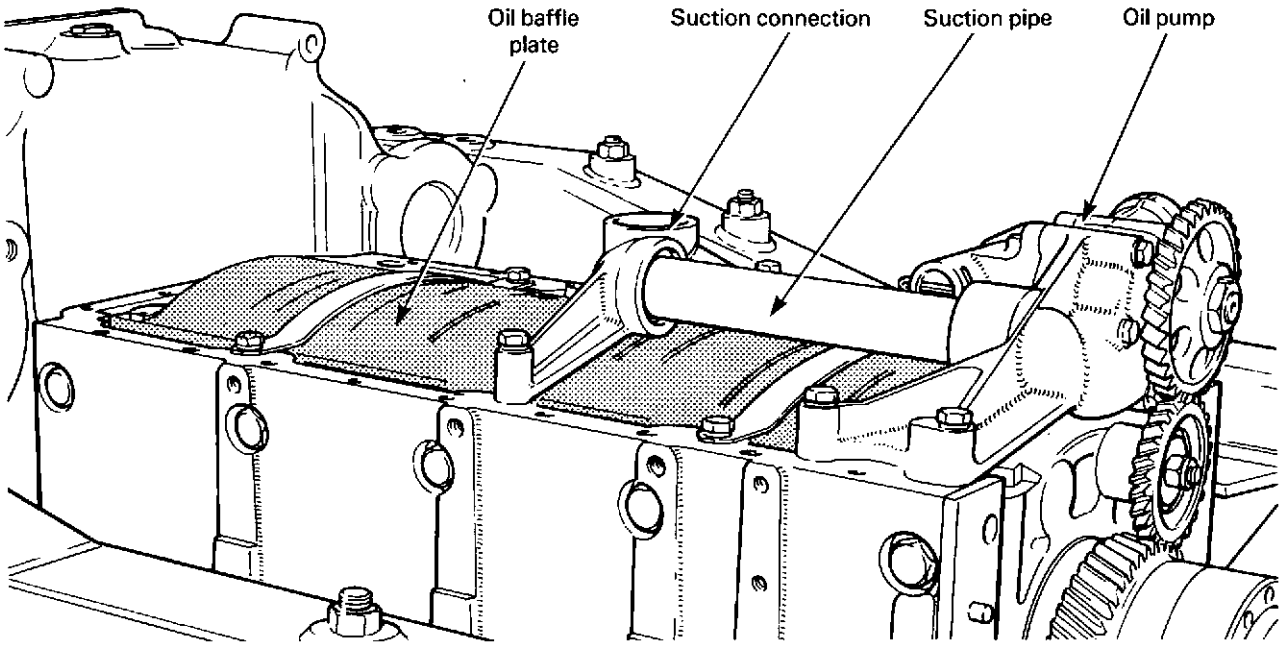


Fig. 23 Oil pump and baffle plate.

87. Apply 'Wellseal' to both sides of the sump joint gasket and position it on the crankcase sump face, then fit two Guide Studs VT 10723 into the setbolt holes.

88. Lower the sump assembly on to the crankcase, remove the two guide studs and fit the 28 setbolts with spring washers. Torque tighten the setbolts to 55 Nm (40 lbf. ft.).

Induction manifolds

Turn the engine to its normal operating position.

89. Fit new 'O' rings to the eight coolant bobbins, lubricate with castor oil and insert the bobbins into the cylinder head apertures.

90. Fit the two induction manifold gaskets to the cylinder head inner machined faces and secure the two lower sections of the induction manifolds to their respective cylinder heads with 24 setbolts and spring washers.

91. Fit the upper sections of the induction manifolds to the lower sections with joint gaskets and 28 setbolts with plain and spring washers.

92. Fit the two blanking plates, with gaskets, to the rear end of the manifold lower sections using setbolts and spring washers.

93. Fit the two elbow connections, with gaskets, to the front end of the lower manifold sections and secure each elbow with four setbolts, plain and spring washers.

94. Slide a hose connection and two hose clips on to each elbow. Fit the thermostat connecting pipe to the 'A' bank elbow and position the hose and hose clips over the joint. Slide a hose connection and two hose clips over the free end of the pipe.

Thermostat

95. Fit the thermostat assembly on to the engine breather and secure with four setbolts and spring washers; slide the hose connections over the elbow and connecting pipe joints and align and tighten the six hose clips.

96. Slide a hose connection and two hose clips over the thermostat by-pass outlet and fit the connecting pipe between the thermostat and coolant pump connection. Position the two hoses and align and tighten the four hose clips.

Exhaust manifolds

97. Using the Stud Box, VT 11685, insert the 16 studs in each cylinder head exhaust manifold joint face.

98. Using the Stud Box, VT 11684 screw in the six lockplate securing studs at the exhaust manifold coupling positions.

99. Fit the sealing rings and sealing pipes, complete with lockplate, into their respective duct or manifold bores; fit plain washers and nuts to each stud and tighten securely.

100. With the front and rear sections of the manifolds closed up as single units, offer each assembly up to its cylinder head joint face. Ensure that each sealing ring and sealing pipe is housed correctly at each end, fit 16 plain washers and nuts to the manifold retaining studs and tighten securely.

Fuel feed pump

Turn the crankshaft until the fuel feed pump drive cams on the 'A' bank camshaft are in a 'neutral' position, prior to fitting the pump and its adaptor.

101. Fit the fuel feed pump adaptor complete with new 'O' ring, to the crankcase. Ensure that the pump securing bolt holes in the adaptor are so positioned that the pump may be mounted in its correct operating position, (see illustration). Secure the adaptor with two setbolts and spring washers.

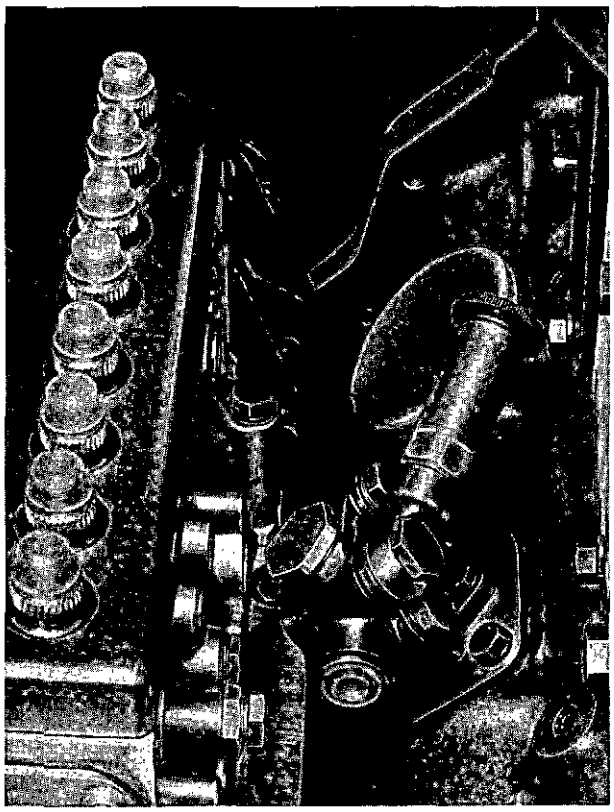


Fig. 24 Fuel feed pump.

102. Fit the fuel feed pump, complete with gasket, to the adaptor and secure with three setbolts and spring washers.

Shutdown solenoid

103. Fit the sandwich plate to the shutdown solenoid with one bolt nut and spring washer and position the assembly on its mounting bracket. insert three setbolts with spring washers and secure to the bracket with the control rod facing towards the rear of the engine.

Note: On engines having the solenoid attached to the induction manifold, no sandwich plate is fitted between the solenoid and mounting bracket.

Fuel injection pump mounting

104. Tap the two locating dowels into the fuel injection pump mounting plate and secure the plate in the crankcase 'V' using five setbolts and new spring washers.

Auxiliary drive coupling

Remove the 'B' bank cylinder head rocker cover and turn the crankshaft, in the normal direction of rotation, until 'B1' piston is at T.D.C. on its compression stroke. At this point the woodruff key fitted in the auxiliary drive shaft will be facing upwards.

105. Assemble the coupling drive flange with one pack of six spring drive plates, two bolts, two long reach nuts and four washers, as shown in the illustration. Torque tighten the nuts to 120 Nm (88 lbf. ft.).

106. Ensure that the woodruff key is firmly set in the auxiliary drive shaft and fit the spring drive assembly on to the shaft. Screw the retaining nut on to the shaft with the plain washer and torque tighten to 200 Nm (149 lbf. ft.).

Note: The above torque figure applies to nuts with 18 mm diam. threads. For shafts fitted with the 22 mm nut the torque loading must be 300 Nm (221 lbf. ft.).

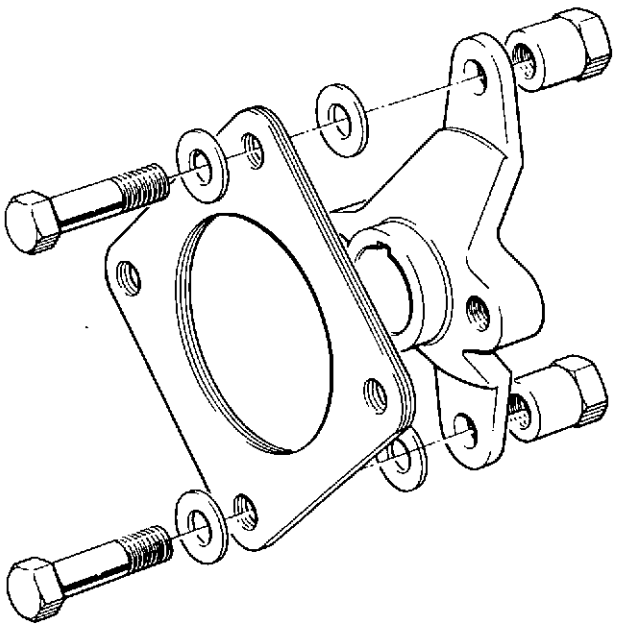


Fig. 25 Auxiliary coupling drive flange.

To assist in setting the fuel injection timing, it is recommended that a mark be made on the top edge of the coupling flange corresponding to the position of the woodruff key. If the crankshaft is inadvertently turned before the fuel injection pump is fitted, the 'B1' piston will be in the correct position for setting the fuel injection timing when the marked arm of the flange is uppermost.

107. Check that the operating lever has been fitted to the fuel injection pump speed control lever, situated on the 'A' bank side of the governor housing, then slacken the four securing bolts on the pump drive hub and remove the drive flange and clamping plate.

108. Assemble the adjustable coupling plate with the pack of six spring drive plates, the two short securing bolts, four washers and long reach nuts as shown in figure 26. Torque tighten the nuts to 120 Nm (88 lbf. ft.). Push the long coupling bolts through the spring plate bolt holes with a plain washer beneath each bolt head.

109. Using a spanner on the pump hub nut, turn the hub until the timing mark is opposite the pointer and fit the spring plate assembly to the pump with the clamping plate and four setbolts with spring washers. Do not tighten the clamping bolts at this stage.

110. Fit two washers over the long coupling bolts, slide on the coupling yoke, ensuring that the cross connecting arm is away from the pump hub, then fit two more washers on to the protruding ends of the coupling bolts.

Fuel injection pump

111. Lift the pump into the engine 'V' and slide it forward on its mounting plate until the two long coupling bolts pass through the bolt holes in the spring plate drive coupling. Fit two more washers and run the two nuts on to the bolts. Do not tighten the nuts.

112. Fit the four setbolts into the fuel injection

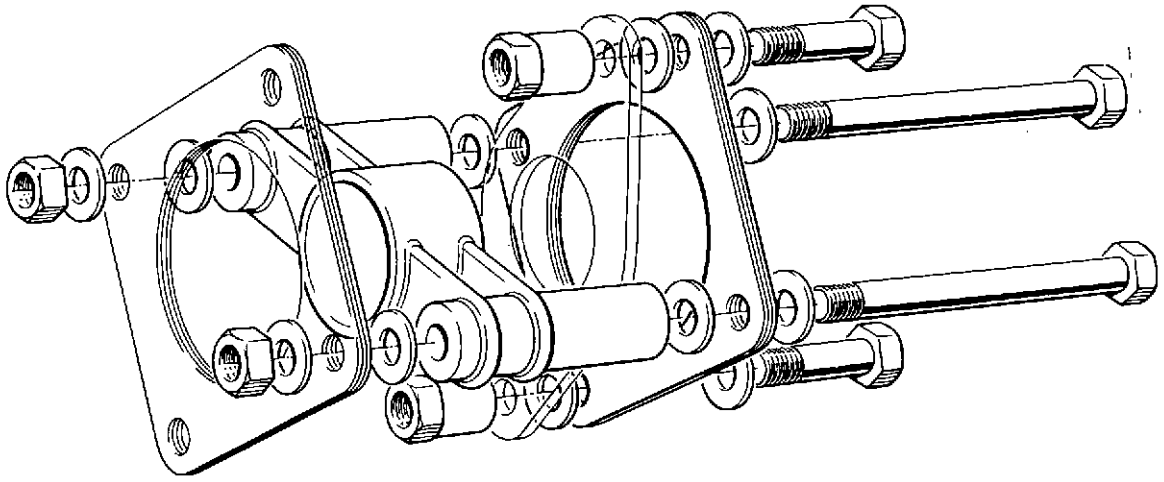


Fig. 26 Auxiliary drive coupling assembly.

pump housing, with plain and spring washers, and secure the pump to its mounting plate. Torque tighten each setbolt to 41 Nm (30 lbf. ft.).

113. Torque tighten the long coupling bolts and nuts in the drive coupling to 120 Nm (88 lbf. ft.).

Injection pump timing

114. Remove the timing pointer cover from the flywheel housing, check the engine data plate for the correct timing and turn the crankshaft until the timing marks are aligned, figure 17.

115. Check that the 'B1' cylinder valves are closed, with the 'B1' piston at T.D.C. on compression stroke.

116. Turn the fuel injection pump hub by hand until the timing mark overshoots the fixed pointer, then carefully turn the hub back until the marks are aligned. Tighten the four clamping setbolts securely.

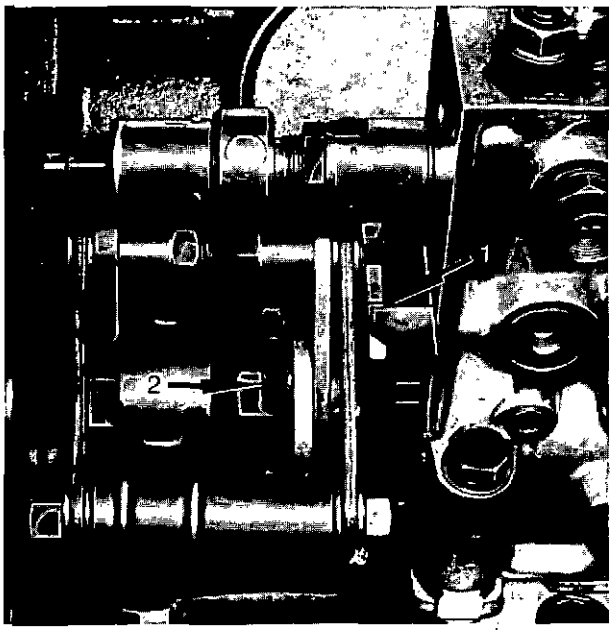


Fig. 27 Injection pump timing marks.
1. Timing marks. 2. Clamping setbolts.

Turn the crankshaft back approximately one quarter of a revolution then forward again until the flywheel timing marks are correctly aligned. Check the alignment of the fuel injection pump timing marks and readjust if necessary, then refit the flywheel timing pointer cover and remove the barring ring from the crankshaft front end.

Governor controls

117. Remove the rubber cover from the terminal block at the end of the shutdown solenoid so that the switch gear is exposed and screw the control rod into the ball joint coupling on the stop control lever. Leave the control rod locknuts slack to allow for adjustments.

118. Operate the unit manually and check that the switch opens when the plunger is pressed fully home. By exerting more pressure on the plunger, a further movement of 0.5 to 0.8 mm (0.02 to 0.03 inch) should be obtainable as the spring in the spherical joint is compressed.
If necessary, adjust the length of the control rod to achieve the above requirements then tighten both locknuts commencing with the locknut at the plunger end of the rod. Re-check the movement after tightening the locknuts.

Caution: Incorrect adjustment of the control rod can cause damage to the governor linkage or may prevent the isolation of the solenoid pull-in coil, resulting in an overheated unit and failure of the windings.

119. Assemble the speed control rod and support bracket as in the illustration. Run the locknut well up the lower threaded end of the rod and screw the rod into the ball joint connection on the governor speed control lever. Position the bracket over the bolt holes in the top of the 'A' bank induction manifold and secure with two setbolts and spring washers.

Fuel injectors

120. Remove the 'A' bank rocker cover and check all the copper injector sleeves on each bank for cleanliness.

121. Unscrew the spill connection from each injector in turn and ensure that new copper sealing washers and outer rubber seals have been fitted.

122. Slide the injector body into its sleeve and screw in the spill connection through the wall of the rocker box.

123. Fit the injector clamp and socket capscrew. Torque tighten the capscrew to 60 Nm (44 lbf. ft.) then torque tighten the spill connection to 27 Nm (20 lbf. ft.).

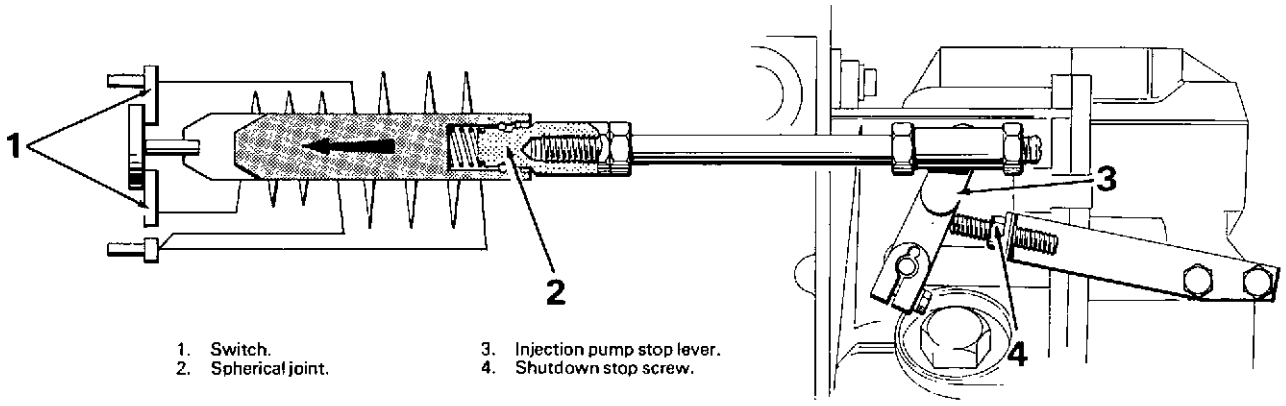


Fig. 28 Solenoid stop control linkage.

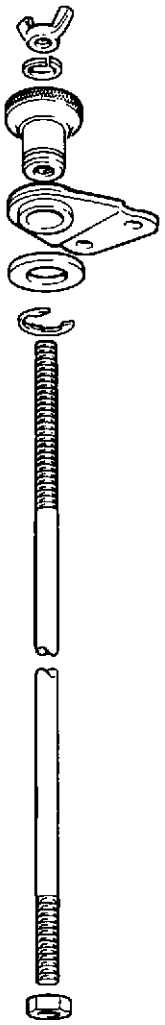


Fig. 29 Speed control linkage.

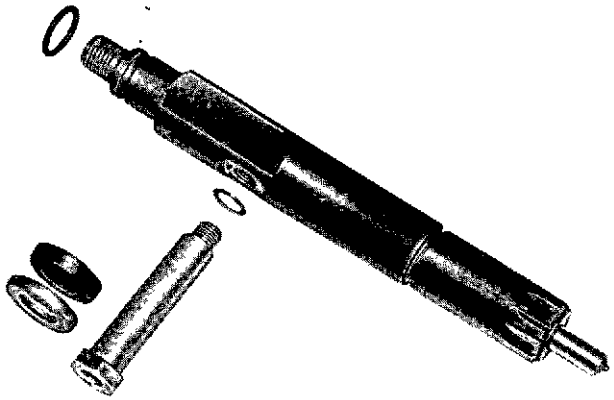


Fig. 30 Bosch fuel injector assembly.

When all the fuel injectors are fitted, remove the dust caps from the high pressure inlet connections and check that each injector is fitted with new rocker cover 'O' ring seals.

124. Lightly oil the 'O' ring seals and fit the rocker covers to each rocker box with new gaskets. Do NOT apply jointing compound to the gaskets. Fit the ten securing setbolts with plain and spring washers and torque tighten to 21 Nm (15 lbf. ft.). Refit the injector dust caps.

Alternator

125. Fit the alternator mounting bracket to the wheelcase and secure with four setbolts and spring washers.

126. Fit the adjusting arm to the wheelcase and lightly secure with the long pivot/setbolt and spring washer.

127. Position the alternator in the mounting bracket and fit the alternator pivot bolt through the bracket and alternator housing. Fit the nut with plain and spring washers.

128. Position the adjusting arm so that the adjusting bolt can be fitted through the slot and the bolt hole in the lug on the alternator housing. See Figure 32.

Note: A plain washer must be fitted between the bolt head and adjusting arm, and a spring washer and nut behind the lug. Do NOT tighten any bolts at this stage.

Pulleys and drive belts

129. Fit the inertia ring to the front end of the crankshaft and tap in the spring dowel, then fit the crankshaft pulley up to the inertia ring and screw in the twelve securing setbolts with spring washers. Torque tighten the setbolts to 95 Nm (70 lbf. ft.).

130. Fit the belt tensioner pulley and bracket assembly to the wheelcase with a new gasket and nip up the securing setbolts. Check the pulley for alignment with the crankshaft pulley by placing a straightedge across the end of the belt tensioner pulley. Add shims, between the bracket back plate and the joint gasket, to give the necessary alignment. When the pulley is correctly aligned secure the assembly to the wheelcase with four setbolts and spring washers.

Note: On engines fitted with Wheelcase, CV2680, a Distance Piece, CV5325, must be fitted behind the outer edge of the bracket assembly as a support for the large diameter setbolt.

On all engines, the upper two setbolts of the bracket assembly are used to secure a smaller bracket which supports the engine breather pipe.

131. Fit the fan drive pulley to the adaptor assembly and nip up the six securing setbolts. Check the pulley alignment with the crankshaft drive pulley and add shims between the adaptor assembly coupling flange and the inner face of the fan pulley, to give the necessary alignment. When the correct alignment is achieved secure the fan pulley to the adaptor with the six setbolts and spring washers.

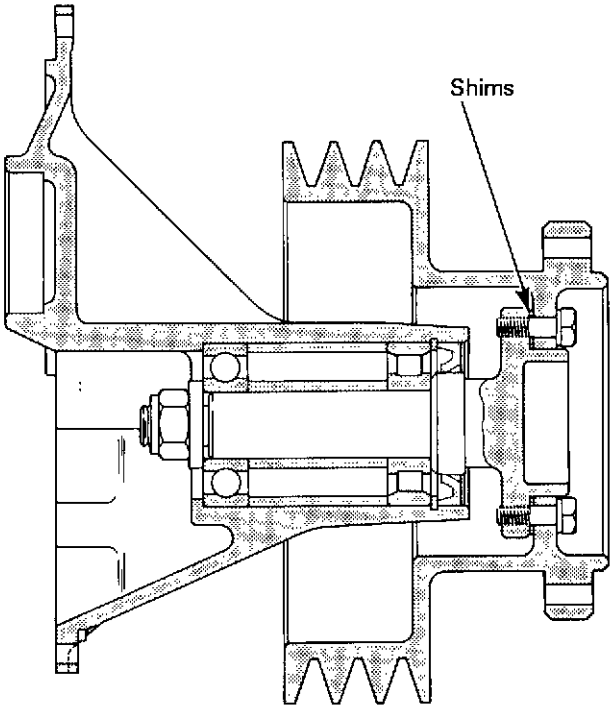


Fig. 31 Fan adaptor and drive pulley.

132. Fit the front mounting and secure to the engine with six setbolts and spring washers.

133. Place the two alternator drive belts over the crankshaft drive and alternator pulleys. Adjust the belt tension by swivelling the alternator about its pivot bolt until the deflection at mid-point of each belt is 12 mm (0.5 inch) under a pressure of 3 to 4 kgf. (7 to 8 lbf.). When the correct tension is achieved, tighten the two adjusting arm bolts and the alternator pivot bolt securely.

Note: On engines fitted with the Butec A3024 alternator, only one drive belt is required.

134. Move the fan belt tensioner pulley to its 'slack' position, i.e. in towards the centre line of the engine, by slackening the large locknut and turning the adjusting bolt accordingly. Fit the three fan belts over the crankshaft, tensioner and fan drive pulleys and turn the adjusting bolt until the deflection at the arrow, shown in

figure 34 for each belt is 20 mm (0.75 inch) under a pressure of 3 to 4 kgf. (7 to 8 lbf.). When the correct tension is achieved, tighten the large locknut securely.

Engine Service Counter

135. Position the Engine Service Counter (E.S.C.) tang in the slot in the drive adaptor at the front end of the 'B' bank camshaft. Fit the four clamps, with setbolts and spring washers and turn the E.S.C. unit until the window is in the desired viewing position before tightening the setbolts.

Note: On engines fitted with Wheelcase CV 2680, only two setbolts are used to secure the E.S.C. unit.

Turbocharger

Check that the exhaust manifold turbocharger mounting flange is clean and undamaged and examine the corresponding joint face of the turbocharger. As this is a metal to metal joint, any dirt or damage could cause leakage of exhaust gases.

136. Fit the turbocharger on to its mounting and secure with four nuts and plain washers.

The exhaust gas outlet from the turbocharger may be one of two types of fitting. The flat face type is fitted with six studs to accept a normal flange connection; the recessed face type without studs accepts a spigot connection which is secured with a 'V' hand clamp. Fitting instructions for each type are given below.

137. Ensure that the joint faces are clean and undamaged and proceed as follows.

(a) **Spigot type**

Pass the bellows of the diffuser through the circular cut out in the support bracket and enter the spigot into the recessed turbocharger exhaust outlet. Line up the large flange bolt holes with those in the bracket and loosely fit the six securing bolts through the bracket and joint flange to position the bellows unit. Slide a 'V' band clamp around the periphery of the spigot joint and lightly nip up the clamp nut.

Fit the special corrugated steel gasket over the protruding coupling bolts and position the exhaust elbow on the bracket end of the

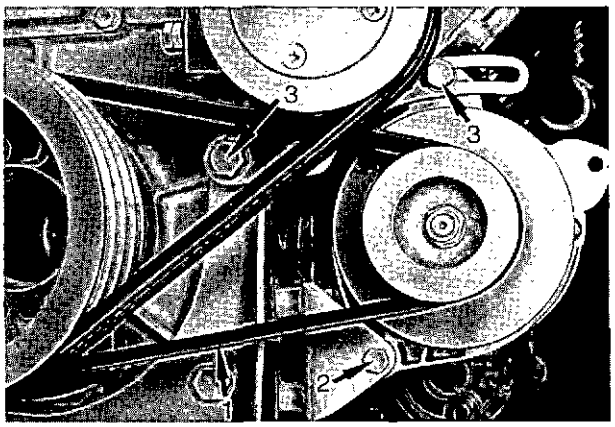


Fig. 32 Alternator belt adjustment.
1. Deflection test point. 2. Pivot bolt. 3. Adjusting arm bolts.

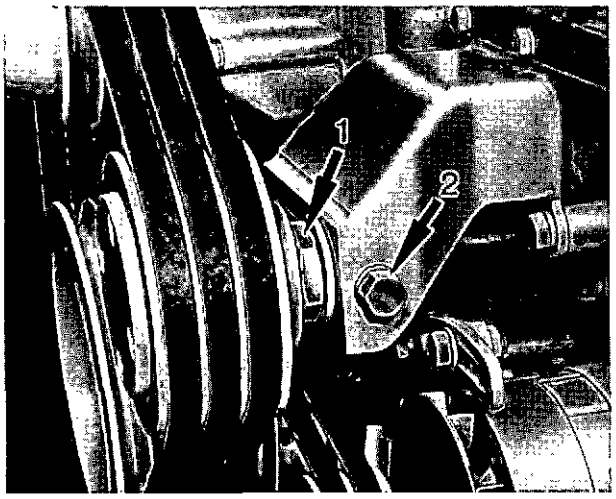


Fig. 33 Fan belt adjustment.
1. Locknut. 2. Adjusting bolt.

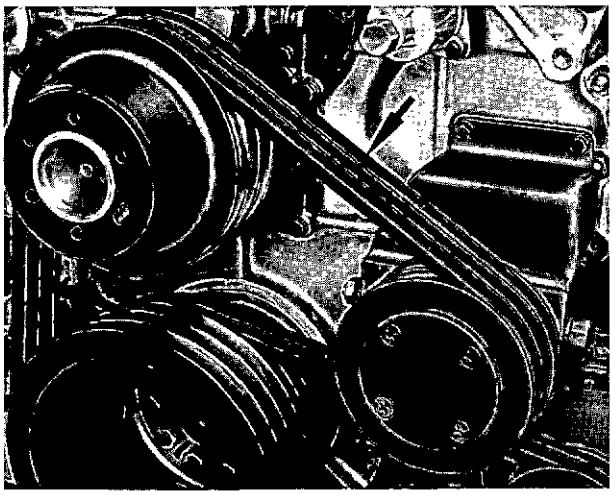


Fig. 34 Fan belt deflection test point.

bellows unit. Screw on six nuts with spring washers and tighten securely.
Torque tighten the 'V' band clamp nut as follows:
On multi-segment clamps, tighten the nut to 13.5 Nm (10 lbf. ft.) then turn the nut a further 120° and, without disturbing the connection, slacken the nut two or three turns and re-tighten to the original loading i.e. 13.5 Nm.
On single segment clamps tighten the clamp nut to 18 Nm (13 lbf. ft.). There is no necessity to slacken and retighten the nut. Blank off the open end of the elbow.

(b) **Flange type**
Fit a special corrugated steel gasket over the six studs in the turbocharger exhaust outlet joint face. Pass the bellows unit through the support bracket aperture and locate over the six studs. Loosely fit the securing bolts through the bolt holes in the bracket and outer bellows unit flange. Screw six nuts with plain washers on to the studs at the inner end of the bellows unit and tighten securely. Fit the larger corrugated steel gasket over the protruding bolts at the bracket end of the unit, position the exhaust elbow over the bolts, screw on six nuts with spring washers and tighten securely. Blank off the open end of the elbow.

Fuel filter

138. Fit the fuel filter bracket to the front of the 'A' bank rocker box and secure with two setbolts with plain and spring washers.

139. Fit a new rubber sealing ring around the adaptor union on the underside of the bracket.

140. Fit a new fuel filter canister to the bracket as follows:
Check that the canister is fitted with the outer rubber seal and ensure that the contact faces of the canister and filter bracket are clean. Screw the canister on to the adaptor union until the rubber sealing rings *just* contact their joint faces. Tighten the canister further, by hand, a MAXIMUM of three quarters of a turn. DO NOT overtighten.

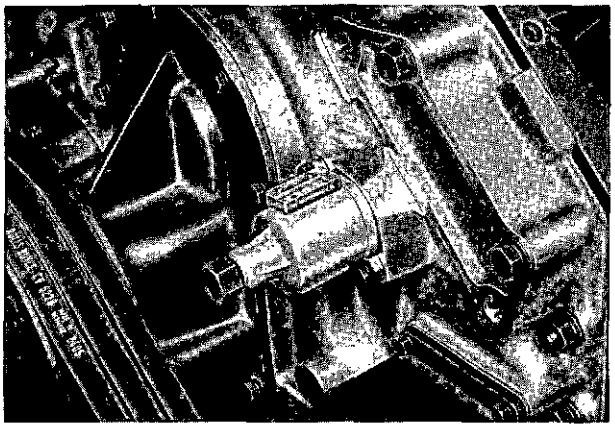


Fig. 35 Engine Service Counter.

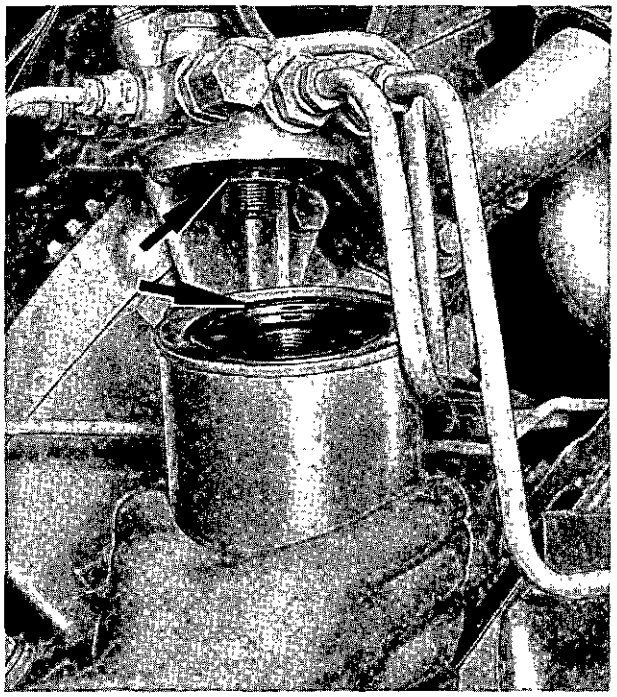


Fig. 36 Fuel filter canister sealing rings.

Starter motor

141. Fit the starter motor to the flywheel housing and secure with three setbolts and spring washers.

Oil-to-coolant heat exchanger

142. Prepare the three bobbin connectors for the oil-to-coolant heat exchanger, by fitting four 'O' ring seals to each of the two smaller bobbins

and two 'O' ring seals to the large bobbin. Lubricate each bobbin with castor oil and fit the bobbins in to their pockets. The large bobbin should be pressed into the lubricating oil pump pressure outlet through the sump side wall. Push one small bobbin into the opening leading into the top of the heat exchanger-to-sump elbow connection.

Note: On some engines, the large bobbin is flanged at one end to enable it to be secured to the sump wall with the three elbow securing setbolts. In such cases, only one 'O' ring seal is necessary around the inner end of the bobbin and a jointing gasket must be fitted between the flange and the sump wall.

143. Fit the oil-to-coolant heat exchanger to the crankcase with the gallery bobbin located in the heat exchanger oil outlet. Secure the heat exchanger with four setbolts with plain and spring washers.

144. Lightly coat one side of the elbow connection gasket with 'Wellseal' jointing compound and position the gasket on the sump around the oil pump outlet, with the 'Wellseal' acting as an adhesive.

145. Fit the bobbin/elbow assembly into the aperture beneath the front end of the heat exchanger and secure to the sump wall with three setbolts with plain and spring washers.

146. Slide a hose connection over the heat exchanger coolant inlet with two hose clips, fit the coolant pump discharge connection into the hose and insert a gasket between the pump casing and the flange of the connection. Secure the connection with two setbolts, two bolts and nuts and plain and spring washers. Finally tighten the hose clips securely.

147. Slide a hose connection over the heat exchanger coolant outlet with two hose clips. Fit the end of the connecting pipe into the hose, with the flanged end positioned against the 'A' bank coolant gallery inlet connection. Insert a gasket between the flange and the coolant gallery connection and secure with two setbolts and one bolt and nut with plain and spring washers. Finally tighten the two hose clips securely.

Lubricating oil filters

148. Check that the oil filter contact faces, beneath the oil-to-coolant heat exchanger, are clean and fit two new filter canisters complete with sealing rings. DO NOT tighten the canisters at this stage.

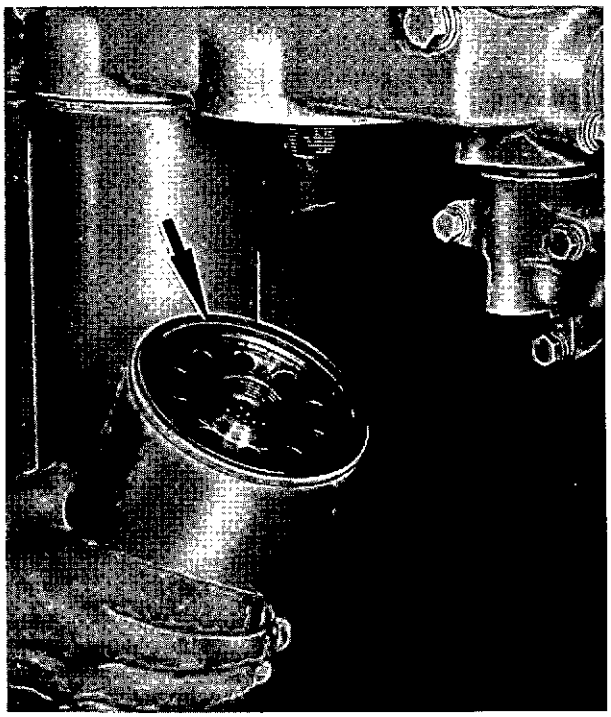


Fig. 37 Oil filter canister sealing ring.

Using the Lifting Beam, VP 5015, support the engine on a suitable crane or hoist; release the engine from the build stand and remove the mounting brackets. Fit transportation feet to the engine front mounting and to the flywheel housing and set the engine down on the workshop floor or work surface.

If transportation stands are not available, the engine may be stood on its sump with suitable packing supporting the front mounting bracket.

Low pressure fuel pipes

149. Fit the oil feed pipe between the discharge adaptor, situated mid-way along the inner wall of the 'B' bank cylinder block, and the fuel injection pump oil inlet adaptor.

150. Fit the fuel injection pump spill pipe to the low pressure relief valve, on the 'B' bank side of the injection pump casing, with the banjo bolt and

two copper sealing washers. Do not tighten any pipe connections until the pipe run is completely coupled.

Fit the down pipe from the fuel interface connection, complete with reducing connector and 'T' piece, and couple up to the pump spill pipe. Add the short connecting pipe and fit the second 'T' piece.

Remove each injector spill connection sealing plug and fit the spill pipe assemblies, with new copper sealing rings, on each side of the banjo unions. Loosely screw in the eight banjo bolts.

Fit the two spill connecting pipes from the second 'T' piece to the injector spill pipe assemblies by removing the banjo bolts from the 'A1' and 'B1' injector spill connections, and passing the banjo bolts through the double banjo unions with a third copper sealing washer beneath each bolt head.

Remove the two appropriate wheelcase securing setbolts and fit two pipe clips, with 'neoprene' inserts, around the 'T' piece-to-'A' bank spill pipe. Screw in the two setbolts with the clip flanges against the wheelcase beneath the plain and spring washers.

Tighten up all connections on the pipe run.

151. Fit the pipe support plate to the front end of the fuel injection pump and secure with two setbolts and spring washers.

152. Fit the fuel suction pipe from the rear end of the fuel feed pump to the union on the interface bracket, with new copper sealing washers on each side of the banjo connection. Align the pipe with the support plate and fit the distance piece between the plate and the neoprene type pipe clip. Secure the clip with a bolt, nut and spring washer. Tighten the banjo bolt and the union connections.

Remove the setbolts with plain and spring washers from the two lower lugs nearest the front end, on the inner side of the 'A' bank induction manifold.

153. Position the fuel feed pump-to-filter header bracket pipe, with new copper sealing washers each side of the feed pump banjo union. Locate the pipe clip, with neoprene insert, over the front lug bolt hole and tighten the pipe connections.

154. Fit the filter header bracket-to-injection pump pipe, locating the two pipe clips, with neoprene inserts, over the two manifold bolt holes and tighten the pipe connections.

155. Re-fit the two manifold securing setbolts with the plain and spring washers and tighten securely.

Turbocharger oil pipes

156. Slip a hose connection and two hose clips on to the lower end of the turbocharger oil drain pipe. Secure the flanged end with gasket, to the turbocharger oil outlet, using two setbolts and spring washers. Position the hose over the crankcase oil drain adaptor and tighten the pipe clips.

157. Remove the dust cap from the turbocharger oil inlet opening and fit the temporary filter into the aperture with the gasket holes aligned. Fit the oil feed pipe/priming stand pipe assembly to the turbocharger and secure with two setbolts and spring washers at the turbocharger end and the standard pipe union at the crankcase adaptor end.

Caution: The temporary filter must be removed and discarded after the engine has undergone its initial running-in period and a normal jointing gasket fitted in its place.

Injection pump oil drain

158. Fit the fuel injection pump oil drain pipe into the crankcase dual adaptor. Align the banjo connection end with the outlet adaptor in the end of the governor casing; fit the banjo bolt with new copper sealing washers on each side of the banjo union. Tighten each connection.

159. Slip a hose connection over the end of the coolant crossover pipe, complete with two pipe clips, and position the pipe over the flywheel housing. Align the flange with the 'A' bank gallery connection, fit the joint gasket and secure with three bolts, nuts and spring washers. Slide the hose over the 'B' bank gallery connection and tighten the two hose-clips. Finally secure the steadying bracket to the flywheel housing with a setbolt and spring washer.

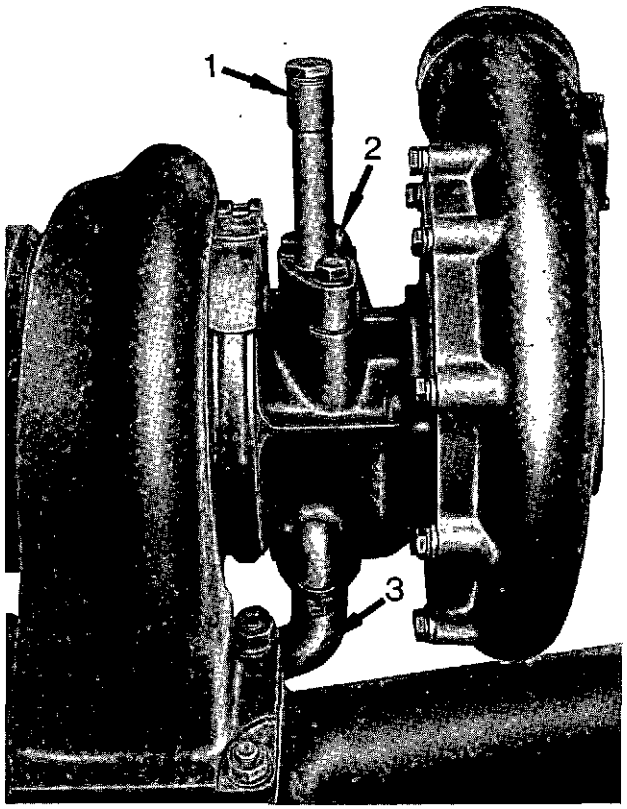


Fig. 38a Holset turbocharger.

1. Primary stand pipe. 2. Oil feed pipe. 3. Oil drain pipe.

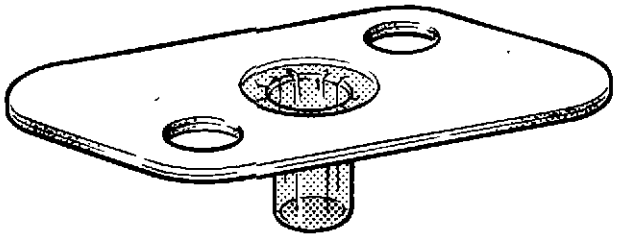


Fig. 38b Turbocharger temporary oil filter.

High pressure fuel pipes

Remove the dust caps from the injector and fuel injection pump high pressure connections and unscrew the shroud setbolts securing the fuel interface bracket to the 'B' bank induction manifold.

160. Loosely fit the injector feed pipes shown in the illustration. Ensure that each pipe is aligned correctly, press the rubber shroud inserts over each pipe, then position the shrouds over the inserts. Tighten the pipe unions taking care not to strain or twist the pipes. Finally, secure the shrouds to the induction manifolds with setbolts and new spring washers.

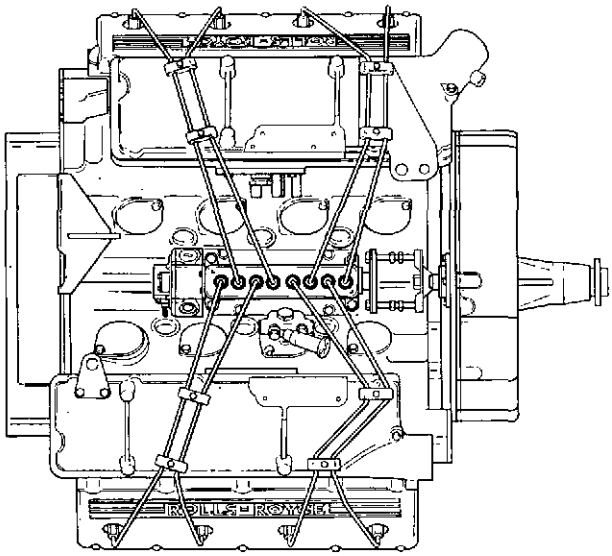


Fig. 39 Injector feed pipe runs.

Oil filler and dipstick

161. Fit the oil filter pipe to the sump with a new gasket and secure with three setbolts and spring washers.

162. Fit the dipstick tube to the tube adaptor in the sump wall and secure with the nut and olive. Place the dipstick in the tube.

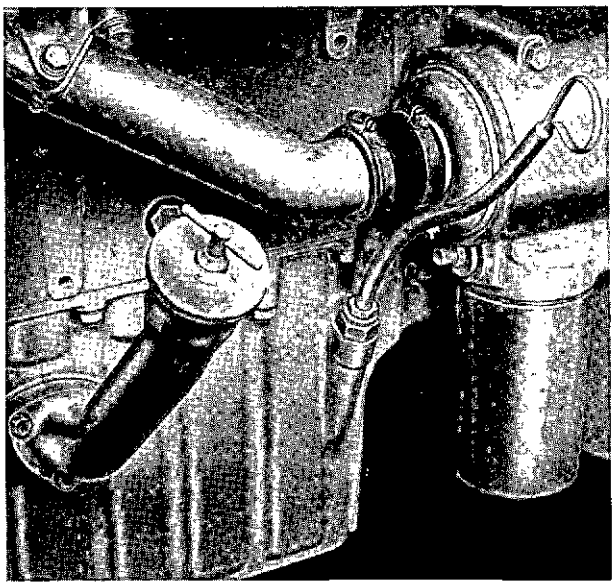


Fig. 40 Oil filler pipe and dipstick location.

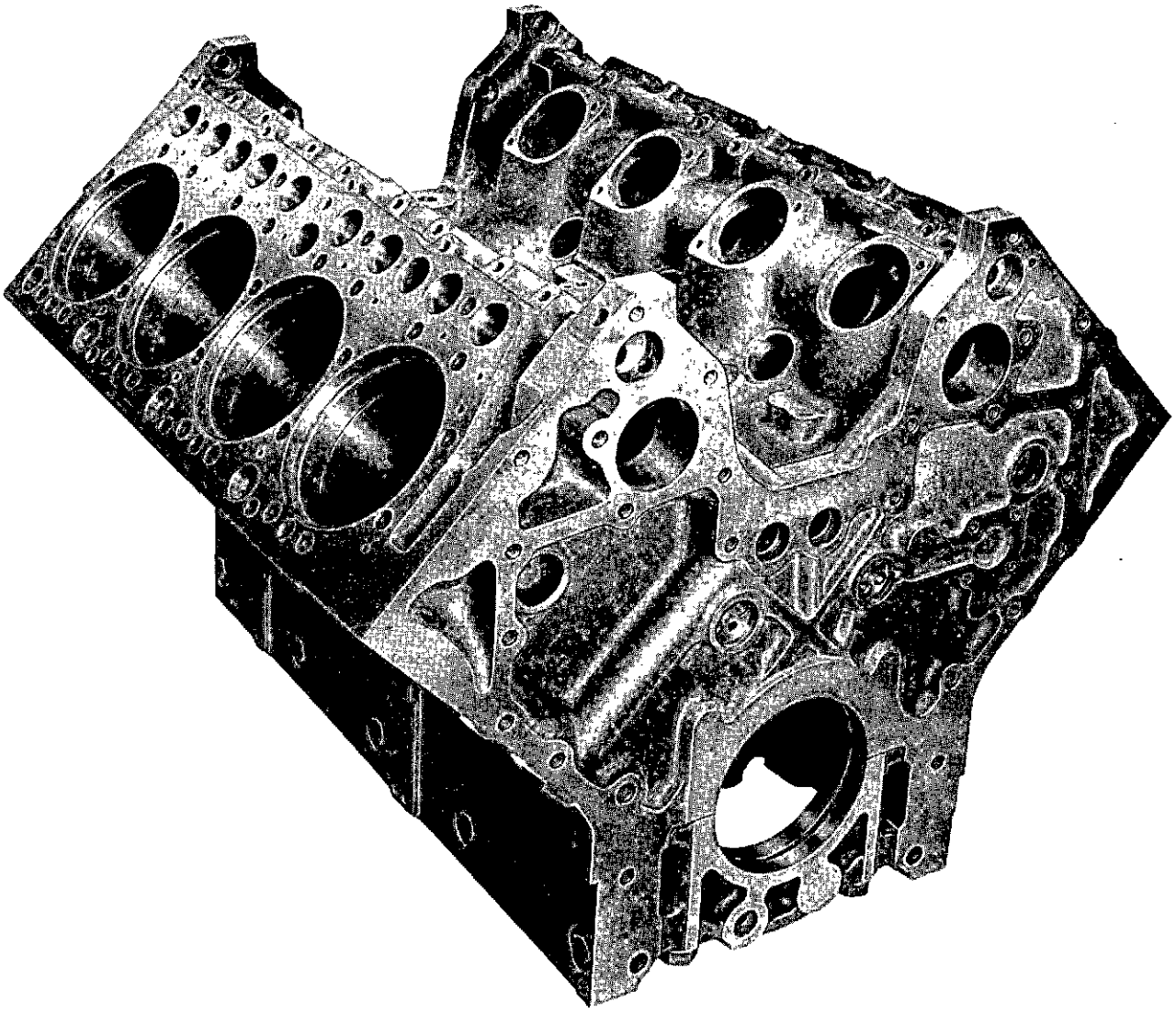


Fig. 1 Crankcase, front end view

SECTION 4—CRANKCASE AND CYLINDER LINERS

DESCRIPTION

The close grained, high duty iron crankcase is cast as a monobloc unit and dipped in a special compound to seal all non-machined faces against contamination.

The cylinder block, which forms the upper part of the crankcase, consists of two banks of four cylinders in a 90 deg. included angle 'V' configuration. The cylinder bores, arranged in a conventional staggered pattern, are machined to accept full length, slip-fit, dry liners.

Five crankshaft main bearing assemblies are secured by forged steel bearing caps, each with two bolt fixings. Two lateral securing bolts, passing through the crankcase wall into each main bearing cap, give added rigidity to the assembly.

All oilways are drilled for cleanliness and uniformity.

The eight slip-fit dry liners are flanged at the upper ends and are retained in their respective crankcase bores by the two cylinder heads. Each liner is manufactured from high quality, centrifugally cast iron, differentially hardened and pre-finished, with a fine honed oil retaining surface in the piston bore.

CRANKCASE

Cleaning and inspection

After the engine has been stripped down to the bare crankcase, carefully check all cup plugs for signs of leakage as advised in Section 2—Dismantling the engine. Remove any suspect plugs with the appropriate plug extractor and remove any traces of sealing compound from the plug bores.

Unscrew all the oilway blanking plugs and thoroughly clean out the oilways and coolant cavities, using a proprietary brand of solvent. For this purpose, Rolls-Royce recommend the use of 'Ardrox' dichloromethane based solvent and 'Diverspray' 30' inhibiting spray cleaner. These products are safe to use on all ferrous and non-ferrous metals, but it is important that the directions for use, as given at the end of Section 1—Data, should be followed.

When the crankcase is clean, check all machined faces for signs of wear or damage, particularly the liner flange seating. If any fretting has occured, the surface may be restored by following the instructions given in S.R.S. 131. Similarly, any damage to the crankshaft bearing bores may be rectified by following the instructions given in S.R.S. 130.

Coat any new cup plugs and the oilway screwed plugs with 'Loctite' 542 and fit them into their locations, as appropriate.

CYLINDER LINERS

Cleaning and inspection

Remove any carbon build up by soaking the liner in 'Ardrox' solvent. (See Section 1—Data). Inspect the top flange for any signs of damage or fretting. If necessary, refer to S.R.S. 131 for detailed instructions.

Check each liner seating by 'blueing' the underside of the liner flange before fitting the liner into its respective bore. Using light pressure, partially rotate the liner backwards and forwards in the crankcase and check the marking left on the crankcase shoulder. The contact must show a full bedding around the circumference and at least 50 per cent across the landing width.

If the contact area on the shoulder does not meet the above requirements, the liner flange must be bedded to the shoulder using a fine grade of lapping compound. A Lapping Tool, VT 12230, is available to facilitate lapping and/or checking the bedding area.

Note: Do not lap in any liner more than is absolutely necessary to restore the seating face, as liner protrusion may be adversely affected.
The crankcase bore and cylinder liner must be scrupulously cleaned after lapping, to ensure that no harmful lapping compound enters the lubrication system via the sump.

Cylinder liner protrusion

Check the crankcase top face for cleanliness and ensure that the Protrusion Gauge, VT 14041, is clean.

Position the gauge over the liner to be measured and place the D.T.I. support stand on the gauge plate, with the D.T.I. button extension resting on the crankcase top face. Zero the D.T.I. needle and carefully re-position the support stand so that the button extension rests on the top landing of the cylinder liner. Note the reading on the D.T.I. Repeat this operation for each of the 16 positions on both cylinder banks. (See illustration).

Note: If protrusion checking is to be carried out when the crankcase is in its normal upright position, the protrusion gauge plate may be secured by inserting two of the cylinder head bolts through the holes in the plate.

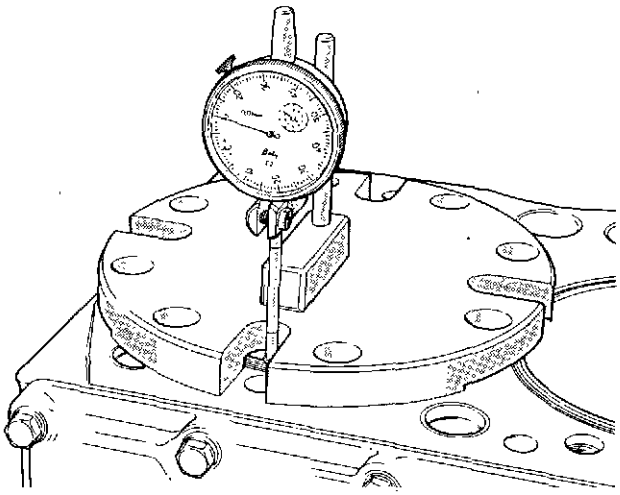


Fig. 2 Liner protrusion gauge

Important:

1. The protrusion for each liner must be between 0.076 mm and 0.127 mm (0.003 inch and 0.005 inch).
2. Variation in protrusion around the circumference of any liner must not exceed 0.025 mm (0.001 inch).
3. The difference in protrusion between the adjacent points of any two liners must not exceed 0.025 mm (0.001 inch).

Cylinder liner fitting

When fitting replacement liners, it is advisable to etch the correlation numbers on the lower section of the liner skirt.

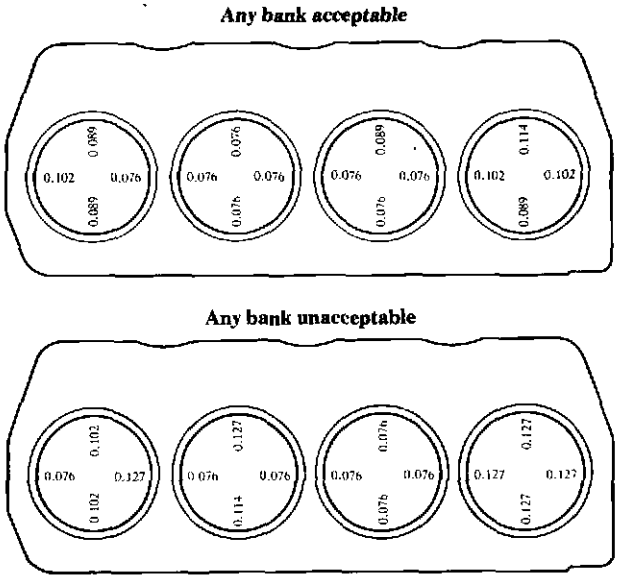


Fig. 3 Acceptable and unacceptable protrusions

After checking protrusions during engine build, a light coating of Wellseal jointing compound should be applied to the underside of each liner flange, immediately before the final fitting.

CAMSHAFT BEARINGS

The camshaft bearings, disposed singly in each camshaft bore, are steel-backed, lead-bronze rolled bushes with clinch-butt joints.

The bearings will not normally require any special treatment, other than ensuring that they are cleaned thoroughly during overall.

Damaged or worn bearings may be removed and new bearings fitted using the Insertion/extraction Tool, VT 20174, instructions for the use of which will be included in the kit.

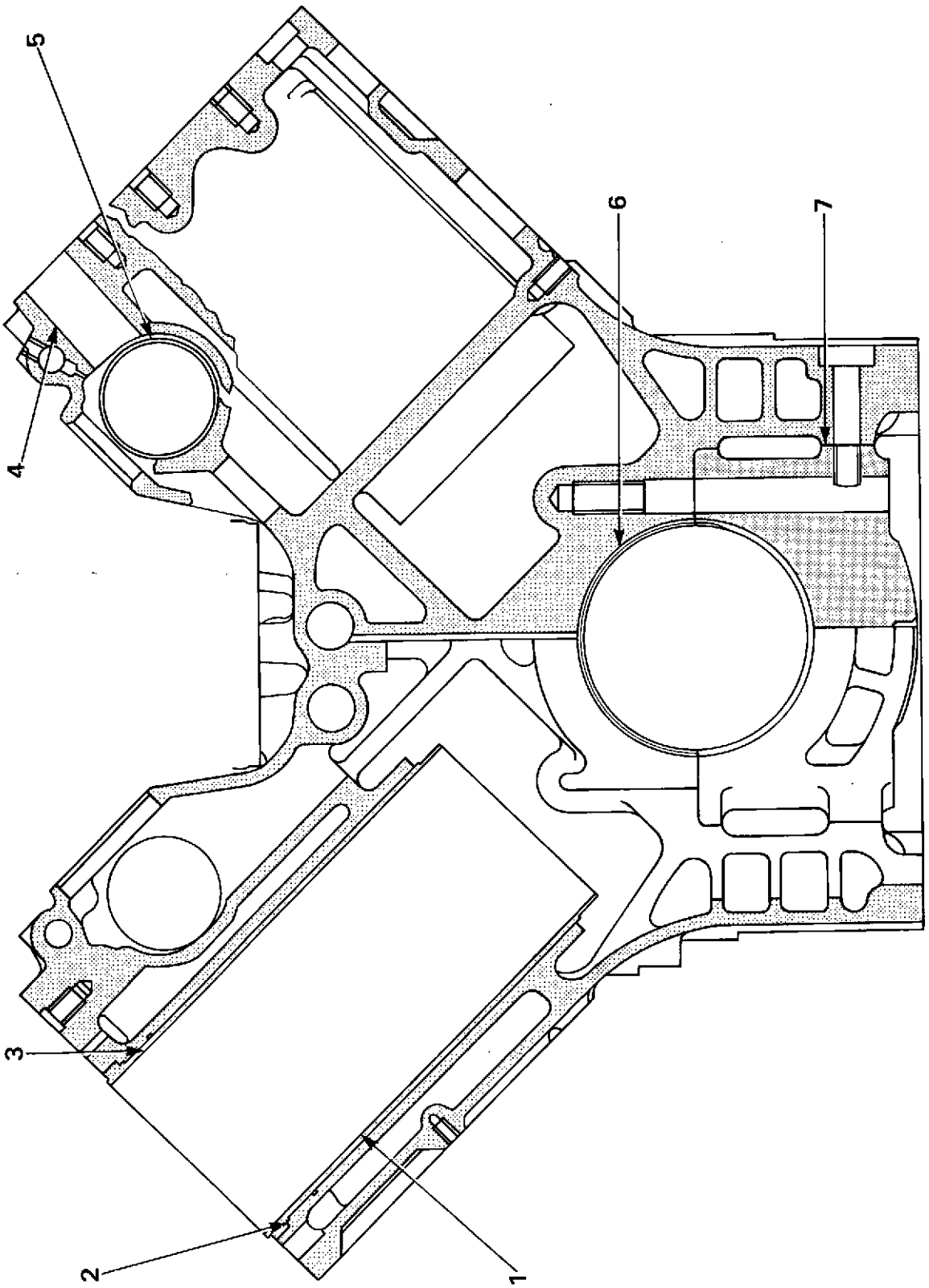
SPECIAL TOOLS

Part No.	Description
VP 6815	Lifting plate, crankcase
VT 12230	Lapping tool, cylinder liners
VT 14041	Protrusion gauge, cylinder liners
VT 20174	Insertion/extraction tool, camshaft bearings

SERVICE RECLAMATION SCHEMES

S.R.S. 130	Reclamation main bearing bores
S.R.S. 131	Reclamation liner flange seating

FITS AND CLEARANCES
CRANKCASE AND CYLINDER LINERS


5
6
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2
1

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		mm	inch	mm	inch	mm	inch	mm	inch	
	CYLINDER LINERS IN CRANKCASE									
1	Crankcase bore	140.488 to 140.513	5.531 to 5.532			0.013 to 0.064	0.0005 to 0.0025			
	Liner skirt diameter	140.449 to 140.475	5.5295 to 5.5305							
2	Liner protrusion Crankcase counterbore depth (Nominal)	11.900 to 11.930	0.468 to 0.469			Proud 0.076 to 0.127	0.003 to 0.005			Liners must be fitted selectively to obtain the correct protrusion parameters.
	Liner flange depth (Nominal)	12.000 to 12.025	0.472 to 0.473							
3	CYLINDER LINERS OUT OF CRANKCASE Liner bore	135.000 to 135.025	5.315 to 5.316	135.306	5.327					
4	TAPPETS IN CRANKCASE Crankcase bore	36.000 to 36.025	1.417 to 1.418			0.025 to 0.066	0.001 to 0.0025	0.075	0.003	
	Tappet diameter	35.959 to 35.975	1.4155 to 1.416							
5	CAMSHAFT BEARINGS IN CRANKCASE Crankcase bore	71.500 to 71.530	2.815 to 2.816			Interference 0.060 to 0.140	0.002 to 0.005			
	Camshaft bearing diameter	71.590 to 71.640	2.818 to 2.820							
6	MAIN BEARING HOUSING IN CRANKCASE Bearing housing bore	149.000 to 149.100	5.866 to 5.870							
7	BEARING CAPS IN CRANKCASE Bearing cap location width	236.000 to 236.025	9.2913 to 9.292			Interference up to 0.013	0.0005			
	Bearing cap width	236.000 to 236.013	9.2913 to 9.2918							

SECTION 5—CAMSHAFTS AND BEARINGS

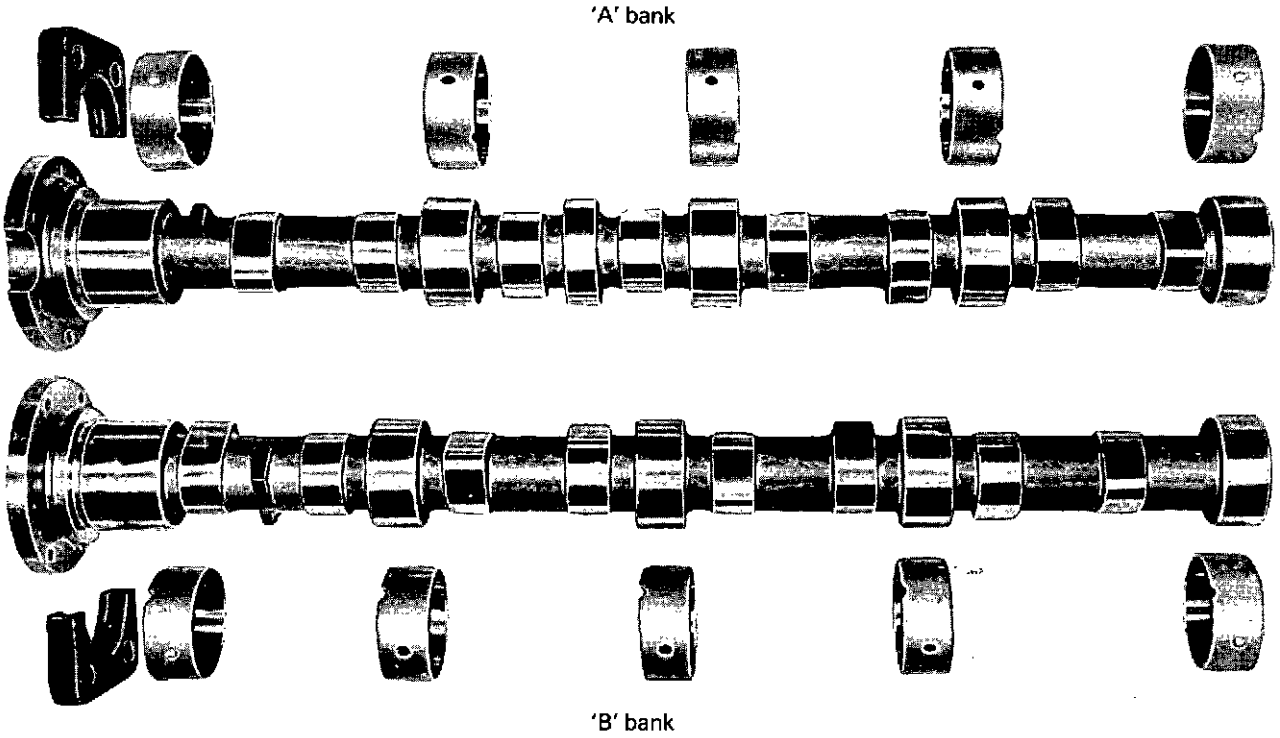


Fig. 1 Camshafts and bearings

DESCRIPTION

The two unidentical camshafts are carried in steel-backed, lead-bronze bushes, high mounted in the crankcase 'V', and driven at half engine speed from the main gear train. End float control is effected by two thrust plates, bolted to the front end of the crankcase, locating on collars machined near the front end of each shaft. The cam drive gears are secured to the camshafts each with six setbolts and one locating dowel. Timing marks on each gear ensure correct positioning with the auxiliary drive gear.

Each bearing is drilled for the supply of oil to each camshaft journal, from the appropriate auxiliary oil gallery. Small bore drillings from each gallery provide a continuous supply of oil to each cam lobe.

Removal of camshafts

If it is intended to remove one or both camshafts with the engine in its normal operating position, the radiator and numerous other components must first be removed, and provision must be made for supporting the engine beneath the front end of the sump. The recommended dismantling sequence is as follows:

1. Drain the cooling system completely.
2. Shut off the fuel supply at the tank and remove the fuel filter.
3. Remove the air cleaner duct, air cleaners and support brackets.
4. Remove the turbocharger-to-radiator duct.
5. Disconnect and remove all coolant pipework

between the thermostat, induction manifolds, coolant pump and radiator, and remove the small bore vent pipe which is clipped to the radiator top casing.

6. Remove the fan and belt guards.
7. Release the radiator stays and remove the radiator.
8. Remove the fan.
9. If fitted, remove the inertia ring from the crankshaft front end, (cruciform crankshafts only).
10. Slacken the tensioner pulley and alternator adjusting bar and remove all the driving belts.
11. Remove the tensioner pulley and the E.S.C.
12. Remove the alternator and adjusting bar.
13. Remove the engine breather pipe and fuel injector spill cross connection.
14. Remove the fan adaptor and pulley assembly.
15. Remove the crankshaft pulley and damper.
16. Remove the connecting pipe between the coolant pump and the oil-to-coolant heat exchanger.
17. Remove the coolant pump.
18. Remove the thermostat housing assembly.

Before proceeding, fit suitable packing beneath the front end of the engine sump.

Note: The packing must be carefully measured to ensure that the engine weight is equally shared by the rear engine supports and the temporary packing.

19. Remove the front engine mounting and radiator support.
20. Remove the wheelcase.

If it is intended to remove one camshaft only, some of the following instructions will refer to the bank in question.

21. Remove the exhaust manifold as necessary.
22. Remove the high pressure, low pressure and fuel spill pipework where applicable.
23. Remove the fuel filter header bracket. ('A' bank only).
24. Disconnect the speed control. ('A' bank only).
25. Disconnect and remove the stop solenoid, complete with its mounting plate. ('B' bank only).
26. Remove the fuel feed pump and access plate. ('A' bank only).
27. Remove the exhaust elbow. ('B' bank only).
28. Remove the induction manifold as necessary.
29. Remove the appropriate rocker box and withdraw the pushrods.
30. Remove the cylinder head and withdraw the tappets.
31. Disconnect the fuel pump drive and remove the auxiliary drive gear assembly.
32. Remove the gear ring from the end of the camshaft, as necessary.
33. Measure and record the end float of the camshaft.
34. Unscrew the thrust plate securing screws and remove the thrust plate.
35. Remove the access plates from the crankcase 'V' as necessary.
36. Carefully guide the camshaft out of the bearings.

INSPECTION

Thoroughly clean the camshaft, then subject the shaft to a crack test preferably by the electro-magnetic method.

Inspect the cams and journals for wear and damage. Slight score marks may be removed with an oil stone, provided that the cam profile is unaffected. Excessively worn camshafts must be renewed.

Crack test the gear ring and inspect the teeth for wear and damage.

Check the thrust plate for wear and damage and renew the plate if the end float, before removal, exceeds 0.55 mm (0.022 inch).

Inspect the tappets for wear and damage and check the clearance of each tappet in its housing. (See Section 4. FITS AND CLEARANCES).

CAMSHAFT BEARINGS

As stated in Section 4—CRANKCASE AND CYLINDER LINERS, the camshaft bearings will not normally require any special treatment other than thorough cleaning. Renewal of any damaged bearings will normally be carried out when the crankcase has been stripped to the bare state as described in Section 2.

Inspect each bearing for wear and damage especially score marks caused during camshaft withdrawal. Clean up any slight marks and check the camshaft running clearances. Renew any bearing which exceeds the limits given at the end of the Section. A combined insertion/extraction tool is available for this purpose, instructions for the use of which, are included in the kit.

CAMSHAFTS—FITTING

Check that the bearing oilways are clean and free of restrictions. Oil the bearings and carefully guide the camshaft into position in the crankcase. Before the camshaft is fully home, prepare the thrust plate by coating the contact faces of the groove with anti-scuffing compound such as 'Molyslip' and coat the countersunk faces of the securing screws with anti-seize compound such as Rocol' J166.

Slip the thrust plate into position around the camshaft collar and secure it to the crankcase with the two countersunk setscrews. Torque tighten the screws to 70 Nm (52 lbf. ft.).

Check that the camshaft rotates freely and measure the end float. Limits on new assemblies are 0.100 mm to 0.550 mm (0.004 inch to 0.021 inch).

Fit the drive gear ring to the camshaft flange and tap in the locating dowel. Coat the thread of the six setbolts with 'Studlock' 270, fit the bolts, with plain washers, and torque tighten to 40 Nm (30 lbf. ft.).

Inspect the auxiliary drive oil seal for serviceability and fit the assembly to the backplate, ensuring that the timing marks on the camshaft gears, main idler gear and auxiliary drive gear are correctly in mesh. See Section 3 for details.

Connect the fuel pump drive coupling, ensuring that the timing marks are correctly positioned, (see Section 3), and tighten the yoke nuts and the spring drive coupling nuts to the correct torque figure, (see Date Section).

Refit the rest of the engine components in the reverse order to the dismantling sequence, renewing all gaskets and checking the fits and clearances where applicable.

SPECIAL TOOLS

As required for engine assembly/dismantling. See relevant Sections.

FITS AND CLEARANCES
CAMSHAFTS AND BEARINGS

SECTION 6—CRANKSHAFT, MAIN BEARINGS AND FLYWHEEL

Description

A five bearing, chrome molybdenum, forged steel crankshaft is fitted to the CV8 engine. The crankshaft may be one of two designs namely, Paired Throw or Cruciform. The type of shaft fitted to a particular engine may be ascertained by the number stamped or cast on to the front crank web. If, for any reason, the crankshaft has to be renewed, it is important to order the correct Part Number, as Cruciform and Paired Throw crankshafts are not interchangeable unless the camshafts and fuel injection pump are renewed also.

The main bearings are steel backed, lead bronze half shell type with lead indium flashing on the running faces. Lubrication for the bearing surfaces is provided from the main oil gallery drillings.

Thrust washers, located on either side of the centre main bearing housing, control the crankshaft end float.

The flywheel, secured to the crankshaft rear end face with 16 socket capscrews, is located by means of a single dowel. Timing marks on the flywheel periphery can be observed through an aperture in the flywheel housing. A starter gear ring is shrunk on to the front edge of the flywheel.

Removal

Details given below are, in general, a reversal of parts of the sequence given in Section 3—ASSEMBLING THE ENGINE.

1. Drain the lubrication and cooling systems completely and remove the fuel and lubricating oil filter canisters.
2. Disconnect and remove the oil-to-coolant heat exchanger and the starter motor.
3. Fit the transportation feet or other suitable engine supports and remove the radiator and associated pipework, followed by the fan, drive belts and crankshaft front end attachments. Fit the barring device to the crankshaft front end.
4. Remove the wheelcase.
5. Remove the air cleaners and ducting.
6. Using the Lifting Beam, VP 5015, lift the engine, remove the transportation feet and fit the engine into a turnover build stand.
7. Remove the timing cover from the flywheel housing and unscrew the timing pointer.

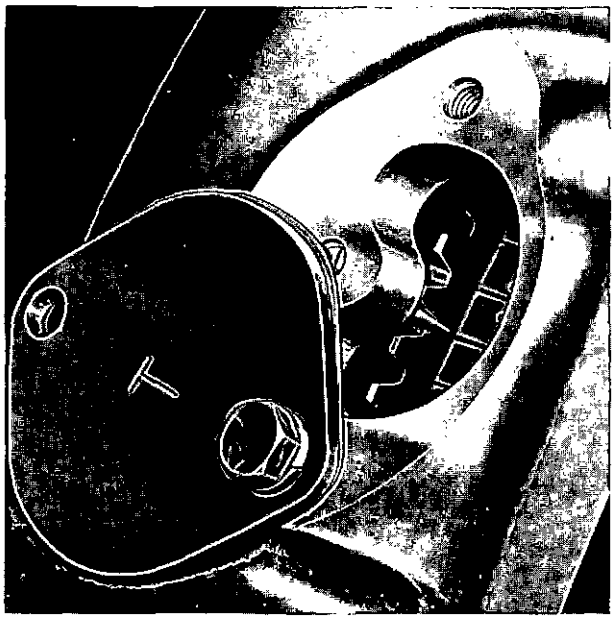


Fig. 1 Flywheel timing pointer.

8. Using the guide studs and lifting bar, remove the flywheel and clamping ring.
9. Using the guide studs and lifting beam, remove the flywheel housing, followed by the oil seal housing.
10. Turn the engine over and remove the sump followed by the oil pump assembly and baffle plate.
11. Remove the oil pump idler gear and axle from the front main bearing cap.

Turn the engine in the build stand, to a suitable angle to enable the connecting rod big end bearings to be removed.

12. Remove the nuts from the connecting rod big end bolts, lift off the bearing cap and remove the lower bearing shell. Using the guide pin, gently push the piston/connecting rod assembly clear of the crankshaft and lift out the upper bearing shell.

    Caution: Do not push the piston/connecting rod assembly far enough to make contact between the piston crown and the valve heads.

    When the crankshaft is turned to gain access to each big end bearing, great care must be taken to ensure that the crankpins do not foul the bolts of previously removed bearings.

13. Remove the ten lateral setbolts and washers from the crankcase side walls.

14. In turn, remove the setbolts from each main bearing cap and, using the guide studs and extractor remove the cap. Lift out the lower bearing shell from each cap. Remove the thrust washers with the centre main bearing cap.

When all the main bearing caps have been removed, lift out the crankshaft, using the appropriate lifting bracket, and remove the upper bearing shells.

CRANKSHAFT

Dismantling and cleaning

Screw the extractor into the tapped hole in each sludge plug, press the plug inwards and release the spring retaining ring. Withdraw each plug and clean the components in a non-caustic cleaning solution.

Wash out the crankshaft oilways and sludge traps with paraffin and blow through with compressed air.

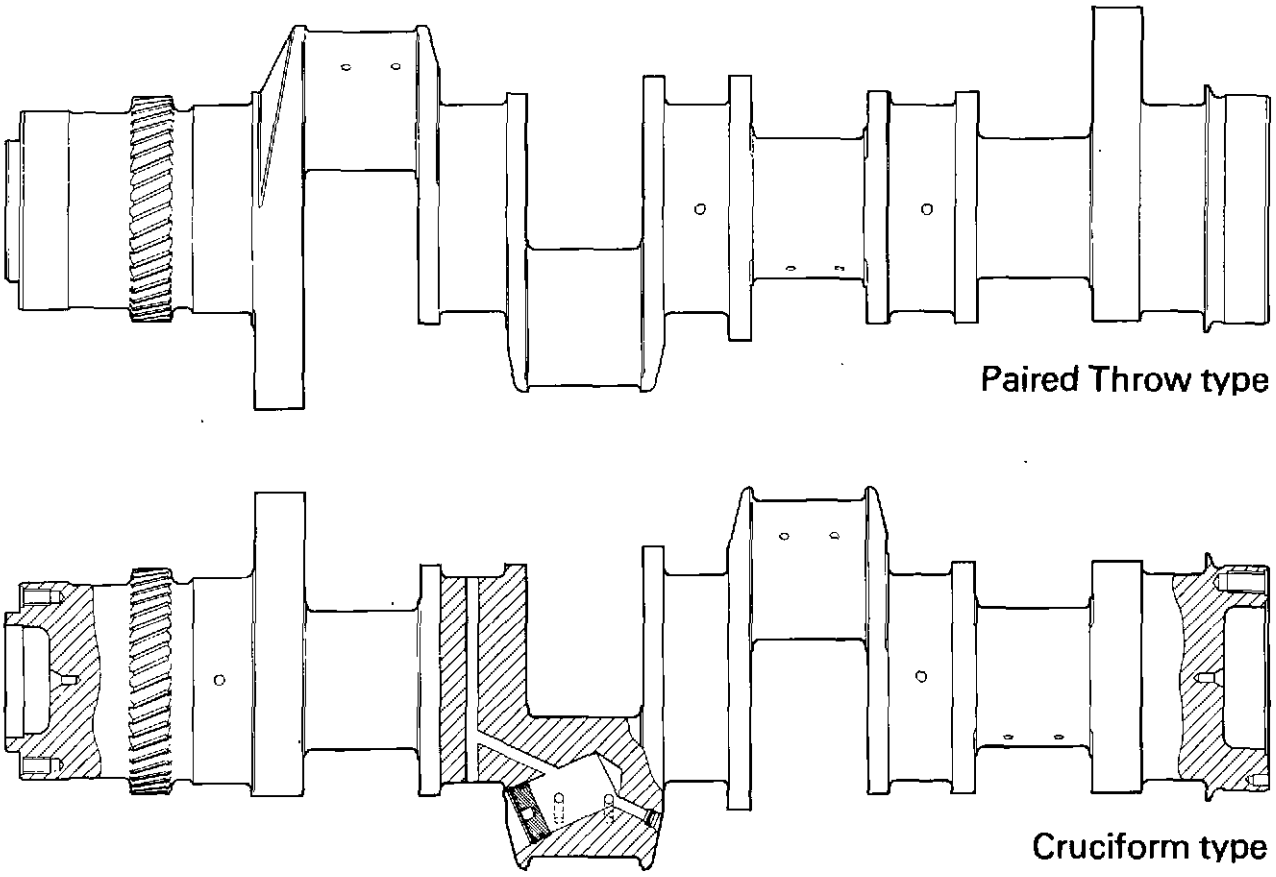


Fig. 2 Crankshaft

Ensure that the crankshaft is thoroughly cleaned then subject it to a crack test, preferably by the electro-magnetic method.

Inspection
Examine the main journals and crankpins for wear and score marks and check for ovality. Check the two thrust faces for score marks. For reclamation of damaged or worn journals and crankpins, see S.R.S. 121 Issue 2.

Support the shaft at each end, by means of 'V' blocks beneath the front and rear main journals. Measure the amount of 'bow' at the centre main journal. The permissible bow must be progressive, along the length of the shaft.

Check the front and rear end faces for damage and check for score marks on the balance weight and flywheel circumferential locations.

Providing that the shaft is serviceable, slight scoring on the journals, crankpins, thrust faces and end locations may be polished out using a very fine grade of oil stone.

MAIN BEARINGS

Inspection
Check the bearing shells for wear, cracks and embedded foreign material. Renew any bearing shells in sets, if there is the slightest doubt that the bearing will not complete a further full period of service.

Thrust washers
Check the thickness of the thrust washers. Nominal new dimensions are: 2.93 to 3.0 mm (0.116 to 0.118 inch). If excessive wear is apparent on the thrust faces, when checked in conjunction with the crankshaft end float, new thrust washers must be fitted.

FLYWHEEL

Inspection
Check the bolt and dowel holes for elongation and examine the contact face for signs of fretting.

Check the teeth of the starter ring for wear and damage. If excessively worn or damaged, the ring should be renewed as follows:

1. Place the flywheel assembly horizontally on a drill table and drill holes through the ring body in diametrically opposite positions, until the ring is weakened sufficiently to be driven off. Do not attempt to drill holes through the flame hardened teeth. Take care not to damage the flywheel during any of the preceeding operations.
2. Check the flywheel and the new starter ring for burrs. Ensure that both components are clean.
3. Heat the ring evenly to 200 deg. C., fit the ring on to the flywheel location and rotate it to ensure correct seating.

   Important: Ensure that the chamfered edge of the teeth face away from the flywheel.
4. Allow the ring to cool naturally, then check by feeler gauge that the ring is tight against the shoulder of the flywheel.

ASSEMBLY

Fit new 'O' ring seals to each of the sludge plugs. Coat each plug and housing with clean engine oil and using the extraction/insertion tool, push each plug into the crankshaft housing. Insert the spring retaining ring then pull the plug back against it.

Fit the main bearings as described in Section 3—ASSEMBLING THE ENGINE, and carefully lower the shaft into position.

Caution: Extra care must be taken when fitting the crankshaft if the piston/connecting rod assemblies and gear train have not previously been removed.

Ensure that the big end bolts do not foul the crankpins and that the crankshaft gear timing marks are correctly positioned, relative to the main idler gear.

Fit the thrust washers and main bearing caps as described in Section 3, and check the crankshaft end float.

Refit the previously removed components, using new gaskets, oil seals and washers where advised in the relevant Sections of the Manual.

SECTION 7—PISTONS AND CONNECTING RODS

DESCRIPTION

Pistons

The pistons, cast from high silicon aluminium alloy, have open toroidal combustion chambers machined into their crowns.

Three compression rings and one oil control ring are carried in machined grooves around each piston wall, the top ring being carried in an austenitic iron insert to reduce wear. All the rings are fitted above the gudgeon pin.

The ring type and position is as follows:

Top ring—Inlaid molybdenum surface

Second ring—Chrome plated

Third ring—Ferrox treated surface

Bottom ring—Composite chrome plated oil control

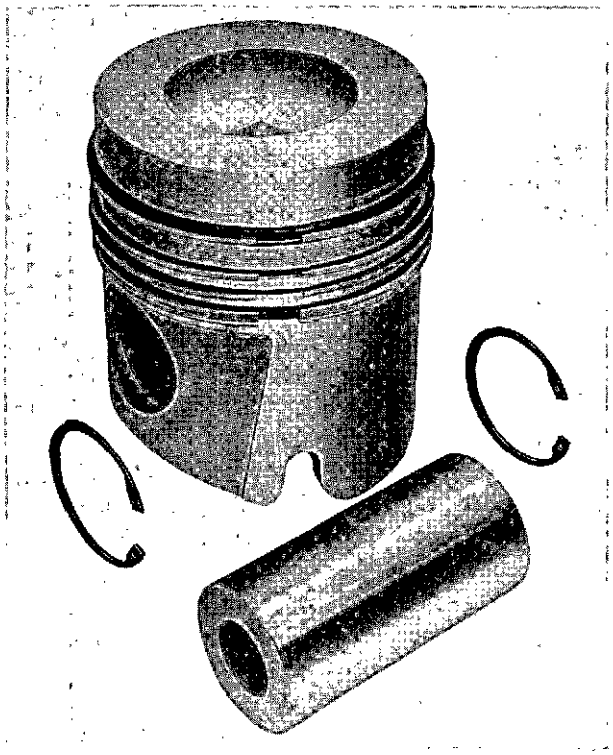


Fig. 1 Piston assembly

Each piston is tin plated on all surfaces apart from the gudgeon pin bore.

The fully floating gudgeon pin is retained by circlips carried in machine grooves in the gudgeon pin bore.

Connecting rods

The connecting rods are chrome-molybdenum steel forgings with pressed in steel backed, lead-bronze small end bushes. The big end bearings are of conventional design in that renewable steel-backed, lead-bronze half shells are used. The shells, as with the main bearings, have lead indium flashed running faces.

Positioning of the bearing shells is provided by machined grooves in the steel shells locating on shoulders around the centre of each big end bolt.

A hole bored centrally through the column of each rod allows pressurised oil to be directed, intermittently, from the crankpin to the small end bush.

Markings on each connecting rod assembly provide rod to cap correlation and cylinder bore number.

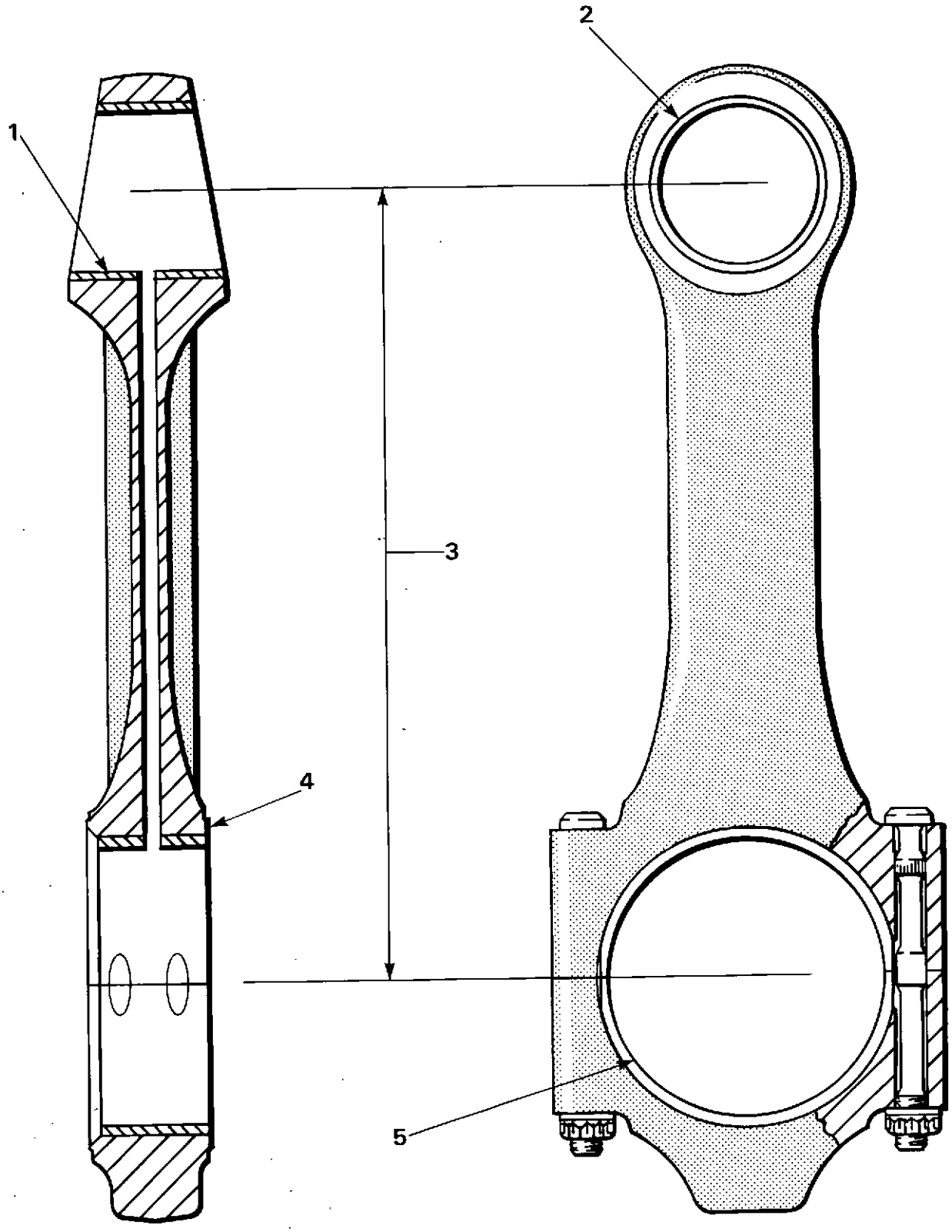
Each connecting rod, complete with small end bush and big end bolts and nuts, is weighed during manufacture and stamped with a group letter. All rods having the same group letter fall within a weight range of 0.980N (0.22 lbf). If for any reason a connecting rod has to be renewed, it is important that the replacement rod should be of the same group as the original.

Weight groups are as follows:

Y—40.697N to 41.678N (9.149 lbf to 9.369 lbf)
Z—41.678N to 42.659N (9.369 lbf to 9.590 lbf)
A—42.659N to 43.639N (9.590 lbf to 9.810 lbf)
B—43.639N to 44.620N (9.810 lbf to 10.031 lbf)
C—44.620N to 45.600N (10.031 lbf to 10.251 lbf)
D—45.600N to 46.581N (10.251 lbf to 10.472 lbf)
E—46.581N to 47.562N (10.472 lbf to 10.692 lbf)

PISTON AND CONNECTING ROD REMOVAL

1. Drain the coolant to a level below the outer edge of the cylinder head.
2. Drain the lubricating oil from the sump.


1
2
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5

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		mm	inch	mm	inch	mm	inch	mm	inch	
	SMALL-END									
1	Gudgeon pin in bush									Bush bored to size after being pressed into position.
	Bush bore	55.035 to 55.050	2.1667 to 2.1673			0.035 to 0.055	0.0014 to 0.0022	0.067	0.0026	
	Gudgeon pin diameter	54.995 to 55.00	2.1651 to 2.1653							
2	Bush in small-end									
	Small-end bore	60.00 to 60.03	2.3622 to 2.3633			Interference 0.042 to 0.097	0.0017 to 0.0038			
	Bush diameter	60.072 to 60.097	2.365 to 2.366							
3	ERRORS IN ALIGNMENT									
	Errors in alignment between big and small-ends per 25.4 mm (1.0 inch) of mandrel									
	Parallelism			0.025	0.001					
	BIG-END									
4	Side clearance					0.20 to 0.40	0.008 to 0.016	0.558	0.022	Total end float for each pair of big-ends between the crank webs.
5	Running clearance					0.026 to 0.088	0.001 to 0.003			Check that crankpin is within limits of ovality.

SECTION 8—CYLINDER HEADS AND VALVE GEAR

DESCRIPTION

The two cylinder heads, each covering a bank of four cylinders, are manufactured from close grained, high duty, cast iron and machined on the upper and lower faces for a close tolerance fit between the rocker box assemblies and cylinder block top faces respectively. Machined joint faces serve to accommodate the induction manifold on the inner, and exhaust manifold on the outer side of each cylinder head casting. Internal coolant passageways are cast into each head around the valve guides and fuel injector sleeves.

The 16 valve guides carried in each cylinder head are cast in high quality nickel chrome alloy, ground to finished size and inserted under pressure into the cylinder head casting. The inlet valve guides are distinguishable by the tapered outer diameter at the lower end.

The high quality, iron alloy, valve seat inserts are frozen into position against machined shoulders in the cylinder head flame face; the lip of each exhaust insert recess is then rolled for added security.

The fuel injectors are housed in renewable copper sleeves which are positioned in the cylinder head pockets, then expanded top and bottom to form coolant seals. The injectors are carried in their respective sleeves without joint washers, the seating face of each sleeve being re-cut as necessary when the injectors are changed.

The valve rocker gear is carried in two alluminium alloy 'rocker boxes', one for each cylinder head, and secured to their respective heads with setbolts and socket cap screws. Lubrication is provided from the auxiliary oil galleries via restrictor bobbins between each cylinder head and crankcase top face and then through drillings in each head and rocker box to the rocker shafts. From the rocker shafts, drillings direct the oil to each rocker arm bush and through the rocker arms to the push rod and valve bridge contact faces.

CYLINDER HEAD REMOVAL

The cooling system must be drained to a level beneath the outer edge of the cylinder head flame face. Failure to do so can cause contamination of the sump oil.

A number of engine components must first be removed to enable the cylinder head to be lifted clear of the engine. A brief inspection of the engine will give a general idea of the amount of work necessary.

The dismantling sequence is as follows:

1. Disconnect the air ducting between the turbocharger and air cleaners; remove the air cleaners and support brackets.
2. Remove the fuel injector high pressure feed pipes as necessary.
3. Remove the injector spill pipework as far as the 'T' piece connection.
4. Remove the upper section of the radiator-to-induction manifold ducting where appropriate.
5. Release the thermostat-to-induction manifold hose connection.
6. Ensure that the radiator is adequately supported, then remove the appropriate stay rod.
7. Remove the exhaust manifold, complete with the two turbocharger connections on 'A' bank or the single connection on 'B' bank.
8. Disconnect the governor speed control, ('A' bank only).
9. Disconnect the turbocharger-to-radiator duct support, ('A' bank only).
10. Remove the low pressure fuel pipework between the fuel feed pump and filter header bracket, and between the filter header bracket and fuel injection pump, ('A' bank only).
11. Remove the fuel filter and header bracket, ('A' bank only).
12. Remove the exhaust elbow and turbocharger bellows unit, ('B' bank only).
13. Disconnect the fuel delivery and spill return pipes at the fuel interface unions, ('B' bank only).

14. Remove the shutdown solenoid, if mounted on the induction manifold inner wall, ('B' bank only).
15. Remove the induction manifold.
16. Remove the rocker cover.
17. Unscrew the spill connections and remove the fuel injectors.
18. Remove the rocker box and lift off the eight valve bridge pieces. Withdraw the eight pushrods.

After removal of the above components, the four alloy blanking plugs must be withdrawn from the top of the induction ports to gain access to the concealed cylinder head securing bolts.

If the engine has been placed in a build stand to remove the cylinder head, the engine should be turned to bring the cylinder head into the horizontal position.

Remove the 26 long and four short securing setbolts and fit the two Guide Studs, VT 17843, into the cylinder head bolt holes on diagonally opposite sides of the cylinder head. Fit the Lifting Bracket, VP 5007, into the manifold ports and lift the cylinder head clear of the engine. Place the cylinder head on a soft topped work bench to protect the flame face from damage.

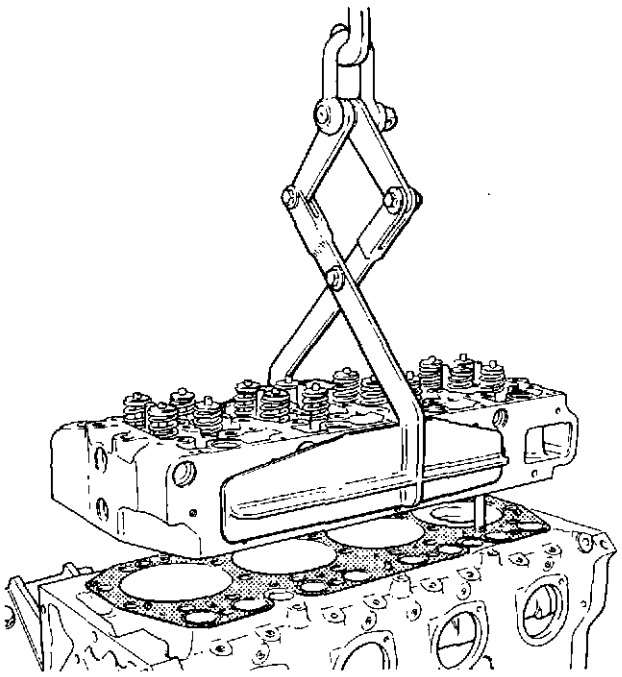


Fig. 1 Cylinder head lifting bracket VP 5007

If the engine is in its normal operating position, the cylinder head must be lifted using the Lifting Bracket, VP 7692. This allows the head to be lifted at an angle of 45 degrees from the horizontal.

Warning: To avoid any possibility of the cylinder head falling from the crankcase, the guide studs must be fitted before all the cylinder head securing bolts are removed.

Lift the oil restrictor bobbin from its location in the crankcase top face and place it in safekeeping for re-use.

Remove and discard the metal cylinder head gasket.

CYLINDER HEAD DISMANTLING AND CLEANING

Check all cup plugs for signs of coolant leaks. Any suspect plugs may be removed using the appropriate servicing kit. See SECTION 2—DISMANTLING THE ENGINE.

With the cylinder head resting, flame face down, on the work bench:

1. Screw the adaptor of the Valve Spring Compressor, VT 14037, into a suitable rocker box securing bolt hole.

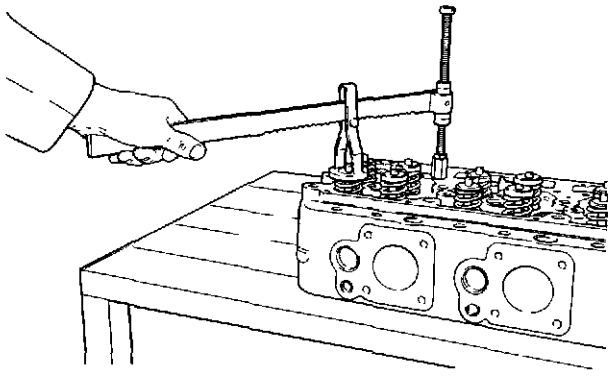


Fig. 2 Valve spring compressing tool VT 14037

2. Screw the compressor tool stud into the adaptor, finger tight, and nip up the locknut.
3. Position the arm at a convenient height on the stud, using the two knurled locknuts.
4. Position the stirrup on the arm, directly over one of the valve assemblies.
5. Compress the valve spring and lift out the collets followed by the upper spring seat or rotator, the spring and the lower spring seat.

6. Re-position the compressor tool, as necessary, until all the valve spring assemblies have been removed.

Clean all the components, using an emulsifying solvent, to Rolls-Royce recommendations. (See Data Section). Heavy carbon deposits on most components may be removed by soaking in a solution of 'MAXAN' or 'Ardrox 667'.

Caution: Valve springs must not be subjected to the 'Maxan' or Ardrox' cleaning process, as the surface finish may be adversely affected.

CYLINDER HEAD CASTING

If any leaking cup plugs were removed, prior to cleaning the cylinder head, they must be renewed before pressure testing.

Lightly coat the new plugs with 'Loctite 542' and insert them into the cylinder head casting, using the appropriate servicing kit.

Fit locally made blanks to the coolant apertures and connect an air supply to the coolant galleries. The air pressure must be 207 kN/sq. m. (30 lbf/sq. inch).

Immerse the cylinder head in a tank of water at 60 deg. C. and check for any bubbles from around all the cup plugs and injector sleeves. Renew any plugs or sleeves which are not air-tight.

Inspect the flame face for signs of fretting or other damage. If necessary, the face may be reclaimed by surface grinding, in four stages, to a maximum of 0.51 mm (0.020 inch). Etch details of any grinding carried out, on an area of the flame face not covered by the cylinder head gasket.

VALVE GUIDES

Check the clearance of each valve stem in its guide. This should be within the limits given at the end of the Section under 'FITS AND CLEARANCES'. If the clearance is excessive, re-check using a new valve. If the clearance is still excessive, a new valve guide must be fitted.

Renewal

Using the Valve Guide Kits, VT 12784 for exhaust valve guides or VT 12790 for inlet valve guides, proceed as follows:

1. Press out the old guide using the appropriate extractor.

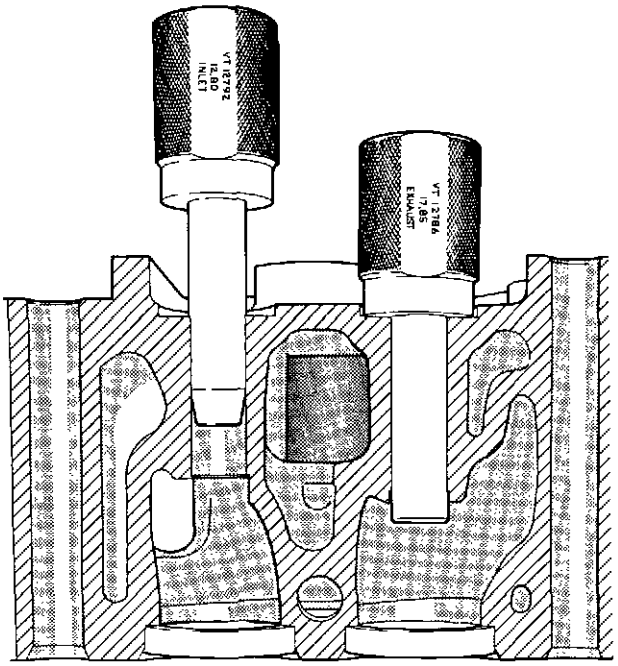


Fig. 3 Valve guide insertion tools

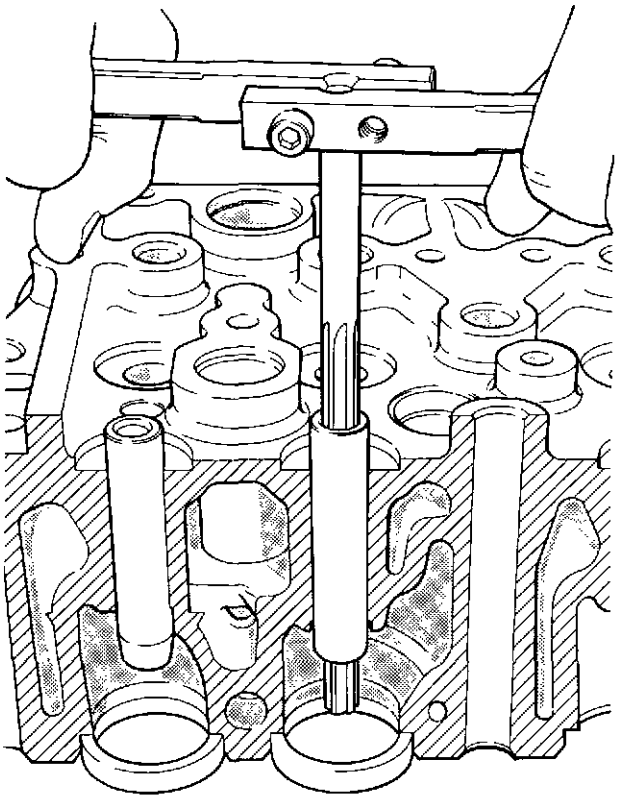


Fig. 4 Reaming valve guides

2. Prepare the new guide by lightly coating it with light machine oil and entering it into the cylinder head bore, taper end downwards for inlet valve guides or radiused end down for the exhaust valve guides.
3. Place the appropriate insertion tool over the top of the guide and, using a hand press, press the guide into position until the insertion tool contacts the valve spring seat landing. This will give the correct protrusions of 12.8 mm (0.50 inch) for inlet valve guides or 17.85 mm (0.70 inch) for exhaust valve guides.
4. Ream the new valve guide and check the bore with the appropriate plug gauge.

When new valve guides have been fitted, the associated valve seat insert must be re-cut using the Kit, VT 14049, to ensure concentricity.

VALVE SEAT INSERTS

Inspect all the inserts for pitting, cracks and valve bedding. The seating face may be restored by lapping in or, in severe cases, by cutting the face at the correct angle i.e. 45 deg. for exhaust valves and either 30 deg. or 45 deg. for the inlet valves as appropriate. The Servicing Kit, VT 14049, is available for this purpose.

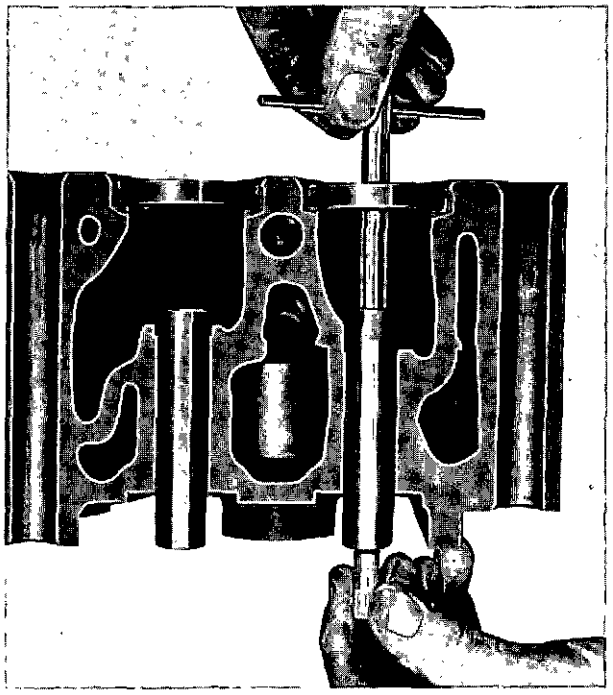


Fig. 5a Fitting cutter guide

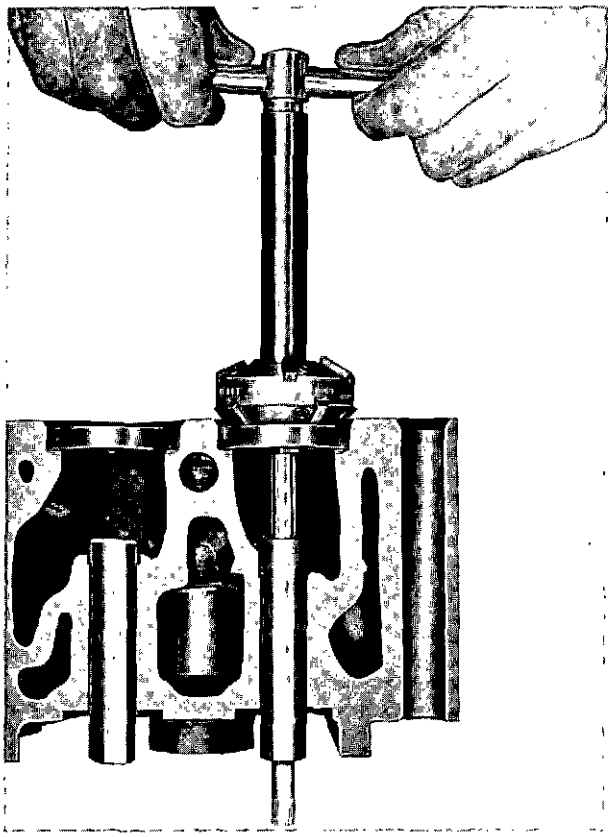


Fig. 5b Cutting valve seat insert

Note: When restoring a seating face, it is important that only the minimum amount of metal is removed.

After reconditioning the seat insert and its valve (see 'VALVES', this Section), fit the valve into the guide and check the clearance of the valve head below the cylinder head flame face. If the clearance is beyond the limits, given at the end of this Section, re-check using a new valve. If the clearance is still beyond the permissible limits, a new valve seat insert must be fitted.

Removing an insert

Before an exhaust valve set insert can be removed, the rolled over edge of the cylinder head casting must be cut away. A Hand Cutter, VT 13768, and Arbor, VT 13713, are available for this purpose. (See illustration).

For the removing and fitting of valve seat inserts, a Renewal Kit, VT 12799, is available.

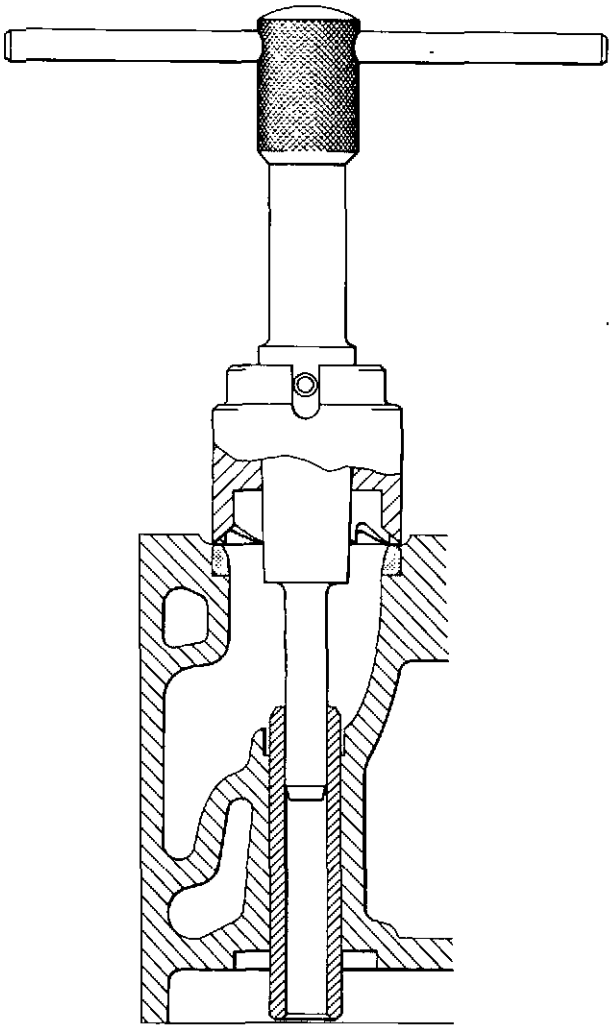


Fig. 6 Cutting tool and arbor

Important: Before attempting to remove any valve seat inserts, the cylinder head must be checked to see if reclamation of the flame face has been carried out. If the flame face has been machined, the insert cutter assembly must be adjusted accordingly by inserting the appropriate sized feeler gauge between the end of the cutter and the setting gauge, before locking the stop collar. This will ensure that the cutter does not break through the insert and damage the cylinder head insert shoulder.

Assuming that the relevant valve guide is in position and is not excessively worn in the bore, proceed as follows:

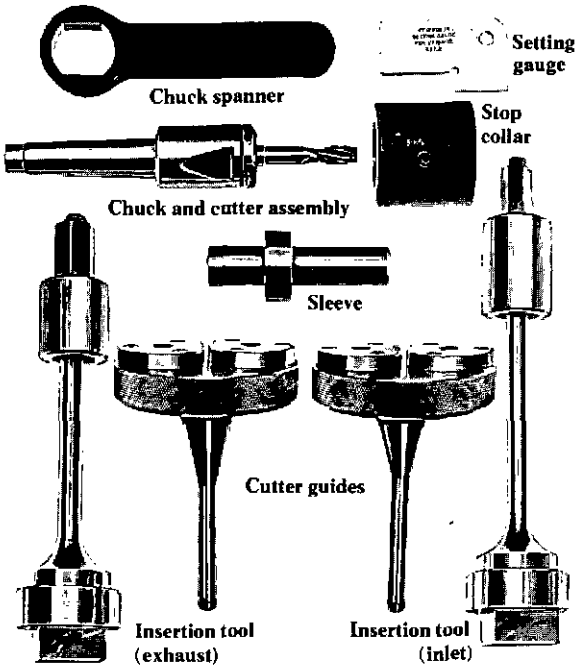


Fig. 7 Insert renewal kit VT 12799

1. Secure the cylinder head, flame face up, on the table of a milling machine.
2. Fit the taper shank chuck to the machine and lock in the cutting tool.
3. Slide the stop collar over the chuck, with the grub screw aligned with the flat location on the side of the chuck.
4. Using the setting gauge, position the stop collar accurately and tighten the grub screw.
5. Fit the appropriate bushed, cutter guide into the valve guide and cut into the valve seat insert until the stop collar contacts the upper face of the bush.
6. Repeat this operation, using the second bush, to give two holes radially opposite to each other in the valve seat insert.

It should then be possible to break out the damaged insert by inserting a steel rod in the cutter holes and levering slightly.

If the valve guide is worn, it must be renewed or removed before cutting the valve seat insert.

To remove a valve seat insert when the valve guide is not fitted proceed as follows:

1. Push the Sleeve, VT 12805, into the cylinder head valve guide bore before turning the head over.

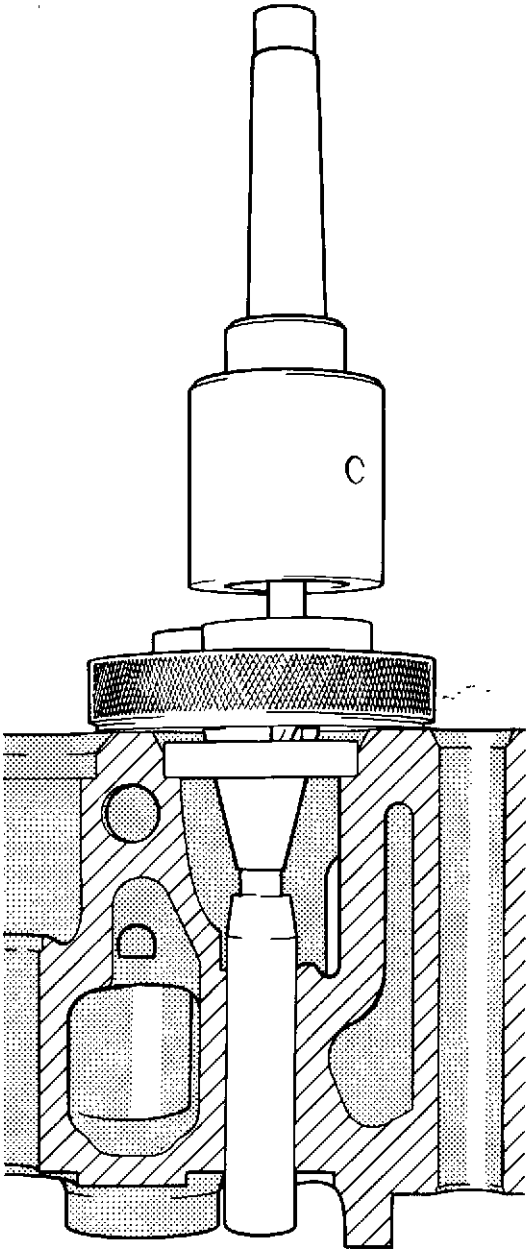


Fig. 8 Valve seat insert cutting

2. Rest the cylinder head on two parallel support bars on the table of the milling machine, ensuring that the lower end of the sleeve is clear of the table before clamping the cylinder head.
3. Remove the valve seat insert as previously descibed, using the inlet insert bushed guide, VT 12800, for both exhaust or inlet valve seat inserts.

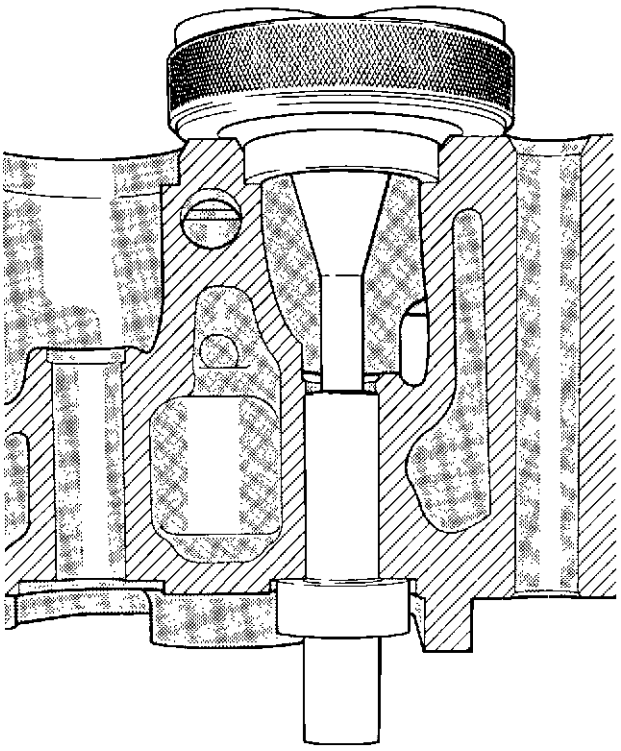


Fig. 9 Insert cutter guide in sleeve

Fitting new inserts

Valve seat inserts are available in two sizes, standard and service, the service insert being 0.05 mm (0.002 inch) larger on the outer diameter. If a service insert is to be fitted, the cylinder head recess wall must be machined prior to fitting, to maintain the correct interference fit as given in 'FITS AND CLEARANCES' at the end of the Section.

Before renewing inlet valve seat inserts, see note under 'VALVES', this Section.

Ideally, the replacement insert should be frozen in liquid air immediately before fitting. If this is not possible, the cylinder head must be heated in boiling water for 30 minutes and the insert drawn in as quickly as possible.

Two valve seat Insertion Tools VT 12903 and VT 12804, are included in the renewal kit. As with the cutter guides, these tools require the valve guides to be in position or the sleeve, VT 12805, pushed into the cylinder head valve guide bore. Both inlet and exhaust valve seat inserts must be positioned using the inlet insertion tool when the Sleeve, VT 12805, is being used.

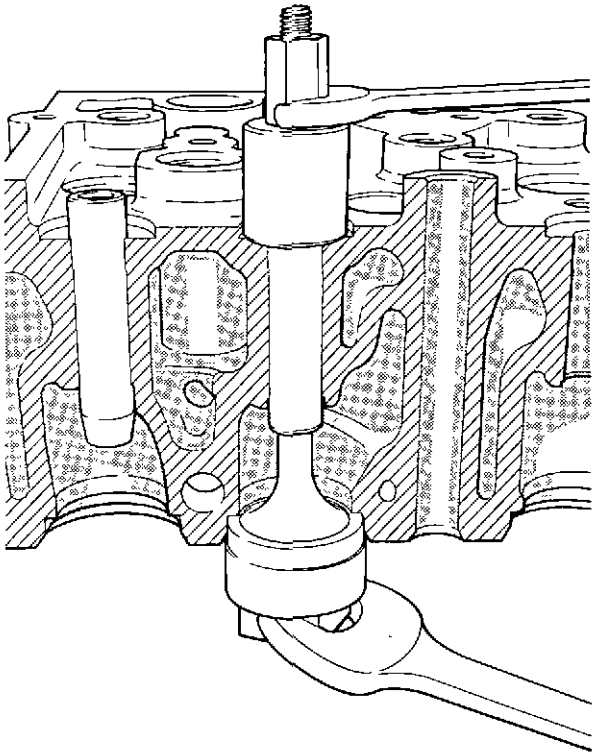


Fig. 10 Fitting insert with valve guide in position

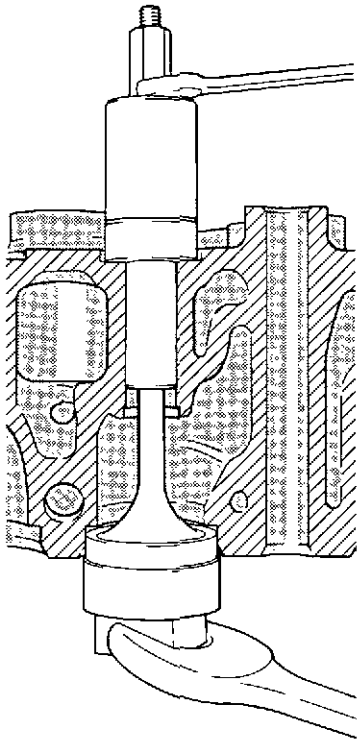


Fig. 11 Fitting insert using sleeve

Check by feeler gauge that the insert is fully home.

After renewing an exhaust valve seat insert, the cylinder head casting must be rolled around the circumference of the insert. If the insert has been fitted using the Sleeve, VT 12805, the valve guide must first be pressed into its bore, (see 'VALVE GUIDES', this Section), before the insert can be rolled in.

The rolling in procedure is as follows:

1. Position the Rolling Tool, VT 18340, in the Setting Ring, VT 18341, and set the rollers as follows:
   (a) Slacken the securing screws on each roller holder, and the locknut on each stop screw.
   (b) Using the appropriate feeler gauges, adjust each roller holder in turn so that the clearance between the roller and the setting ring is 0.50 mm (0.020 inch). Tighten each securing screw and stop screw locknut.
   Note: Ensure that the head of the stop screw is backed against the tool housing when setting the clearance.
   (c) Re-check each roller clearance and reset any roller holder, if necessary, before using the tool on the cylinder head.
2. Coat the rollers and the counterbore in the cylinder head with clean engine oil. Locate the rolling tool in the valve guide and rotate slowly, applying sufficient pressure to 'spread' the cylinder head material into the valve seat insert chamfer. When the tool housing face contacts the stop plate, the insert is fully rolled in and the tool should be removed.

If applicable, fit new inlet valve guides as previously described.

Cut or grind the valve seat inserts at the correct angle, i.e. 30 deg. or 45 deg. dependent on the type in use. Lap in the valves and check with blue marking that the valves are seating around the full circumference of the contact faces.

Finally assemble the valves to the cylinder head and, using a straight-edge and feeler gauge, check the clearance between each valve head and the cylinder head flame face. If the clearance is beyond the permissible limits, a new valve must be fitted.

VALVES

After thoroughly cleaning, carefully inspect each valve

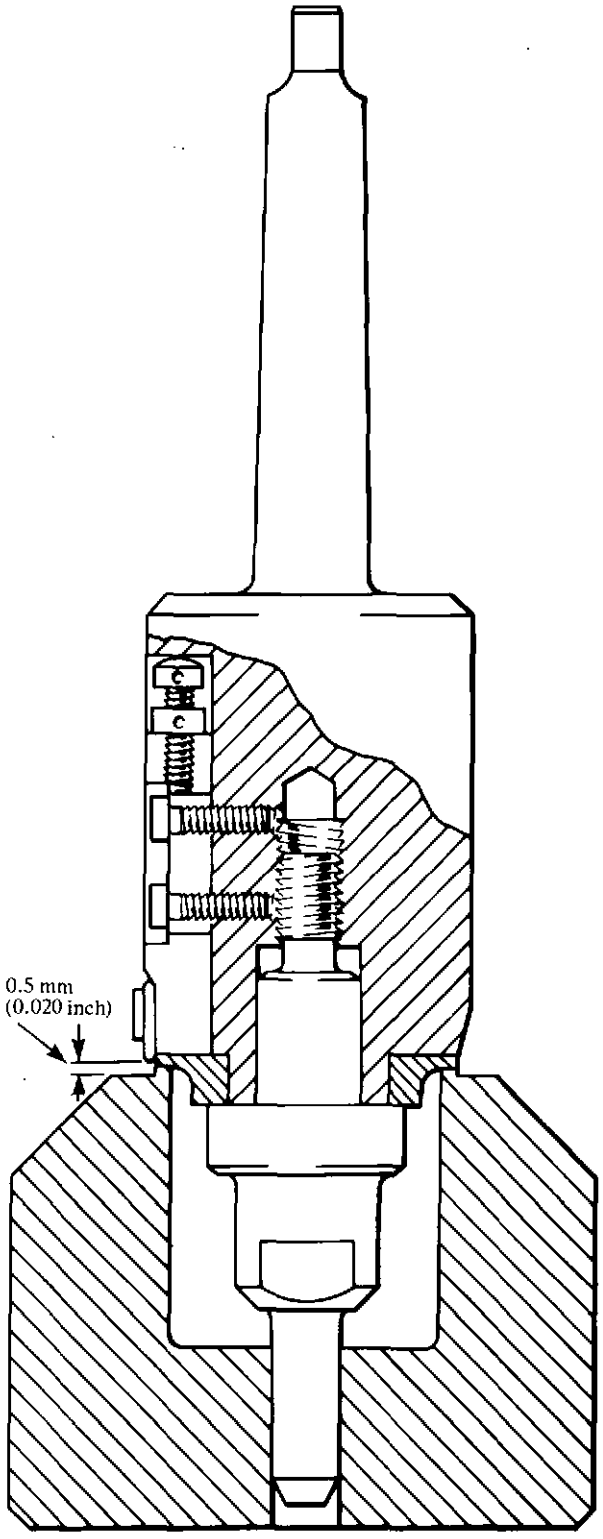


Fig. 12 Rolling in tool in setting ring

for cracks, pitting or other damage to the head. Check the valve stems, collet grooves and tips for wear. On apparently serviceable valves, test the heads for cracks using a dye penetrant process such as 'Ardrox 996'. See Data Section for details.

Check the valve for 'dishing' by means of a straight-edge and feeler gauge. Scrap any valve if the clearance exceeds 0.13 mm (0.005 inch).

Assemble each valve to the cylinder head and check the seating, lapping in the valve if necessary.

Finally check the clearance between the valve head and clearance head flame face. If it is more than the permissible clearance given at the end of this Section, re-check using a new valve. If there is still too much clearance, a new valve seat insert must be fitted. Insufficient clearance can be rectified by cutting the seating face of the insert, as previously described.

If any new valves are fitted, their cylinder number and position should be etched near the top of the stem. Valves must not be stamped or pop marked as this may initiate cracking of the valve stem.

Note: If severe bedding or wear is experienced on the earlier type 45 deg. inlet valves and valve seat inserts, it is recommended that the valves and seat inserts be replaced by the later 30 deg. versions. These components must be renewed in sets.

VALVE SPRINGS

Thoroughly clean the valve springs and check for wear, corrosion and distortion. Measure the free length and length under load as specified in 'FITS AND CLEARANCES' at the end of the Section. Scrap any spring which is unsatisfactory.

If one spring on any pair of valves is faulty or damaged, both springs on the pair of valves must be renewed. Old and new springs mixed on any pair of valves can cause wear to the valve bridge and guide.

Check any new springs, to ensure that they are correct for the engine, by noting the green identification mark on the spring coils.

VALVE ROTATORS

Check the rotators for cracks and other damage and ensure that the parts rotate freely, relative to each other.

Inspect the valve stem tips. If the wear pattern indicates that the valve has not been rotating, the

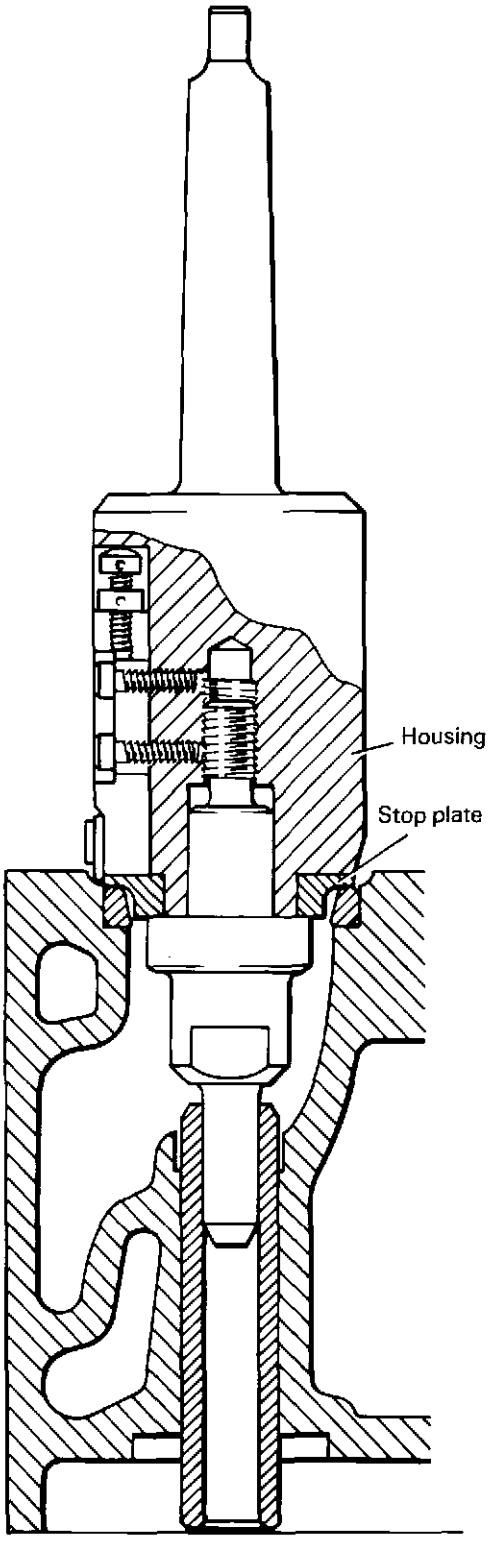


Fig. 13 Rolling in tool

rotator for that particular valve must be renewed even if it appears to be serviceable.

Note: Rotators are fitted in place of the upper spring seats on exhaust valves only.

VALVE BRIDGES AND BRIDGE GUIDES

Inspect the valve bridges and adjusting screws for wear. Check the bridge bores using a new bridge guide as a gauge, and check the bridge guides using a new valve bridge. Renew any compartments which show excessive slackness.

Using the Renewal Kit VT 12796, withdraw any worn valve bridge guide and clean out its cylinder head bore.

Lightly coat any new bridge guides with machine oil, and insert them into their bores using a hand press. To obtain the correct protrusion, each guide must be pressed into its bore until the top face is flush with the top face of the insertion sleeve.

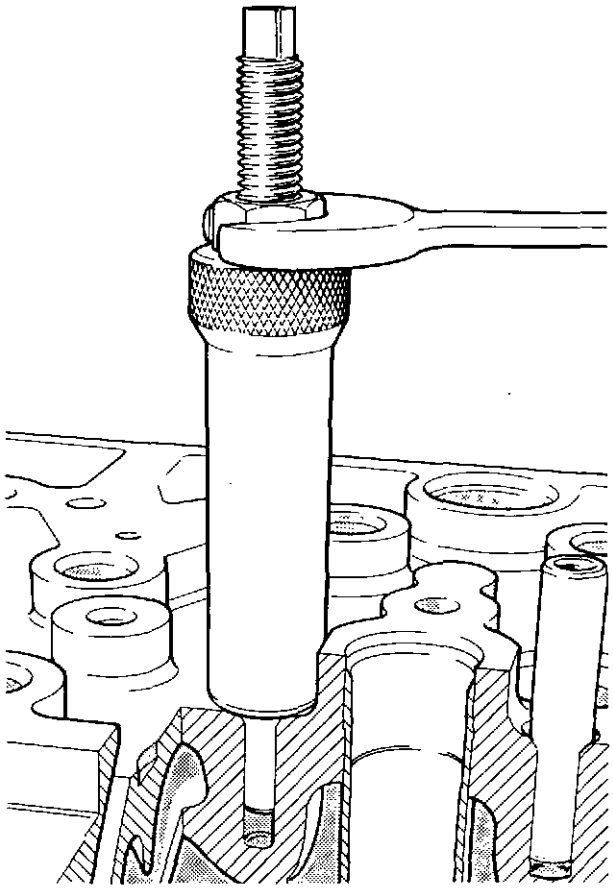


Fig. 14 Withdrawing valve bridge guide

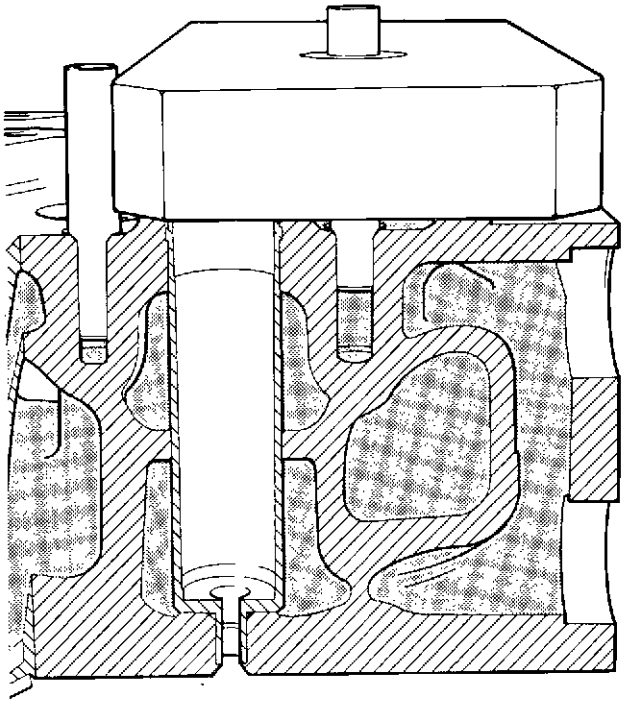


Fig. 15 Valve bridge guide insertion sleeve

PUSHRODS

Examine the ends of each pushrod for wear and damage and check each rod for 'bowing'. Any pushrod having a runout of more than 0.2 mm (0.008 inch) over its total length must be renewed.

INJECTOR SLEEVES

Reconditioning injector sleeves

Using the seating face cutter and nozzle reamer from the Service Kit, VT 12772, remove any build up of carbon or injector seating face damage.

Important: When using the seating face cutter, remove the minimum amount of metal necessary to restore the seating face. The maximum permissible depth of the seating measured from the cylinder head top face is 104.25 mm (4.104 inches).

Renewing injector sleeves

Any injector sleeve which has been re-cut beyond the limit, or has been damaged, or is leaking from the expanded joints and cannot be rectified by further expansion of the sleeve ends, must be renewed as described below.

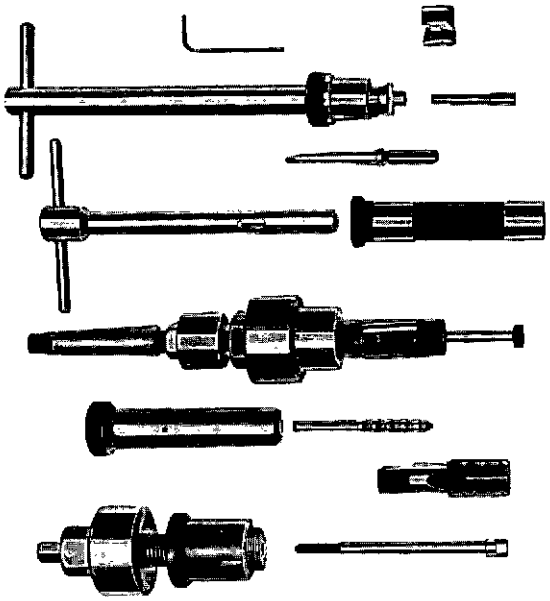


Fig. 16 Injector sleeve service kit VT 12772

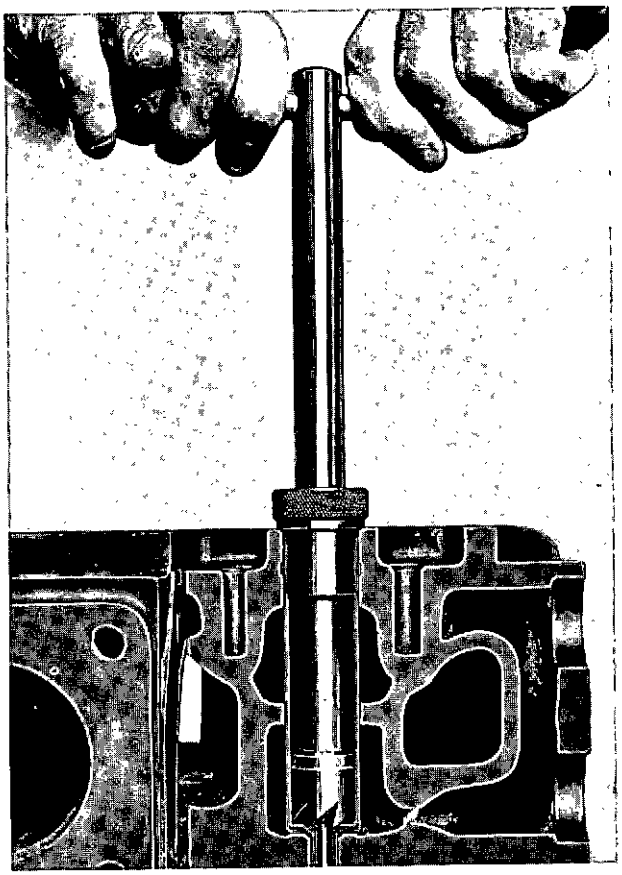


Fig. 17 Seating face cutter

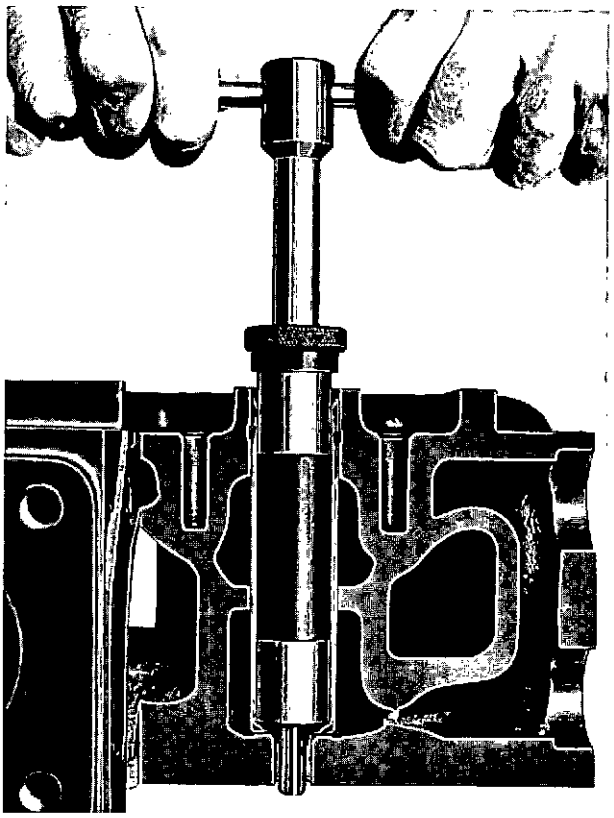


Fig. 18 Nozzle reamer

1. Using the Tap, VT 11103, cut a thread in the sleeve to a depth of at least 25 mm (one inch).

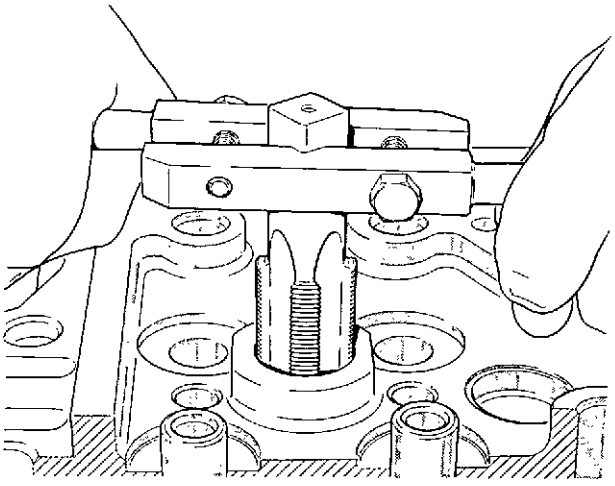


Fig. 19 Tapping injector sleeve

2. Run the nut of the Extractor, VT 11102, to the top of its thread, and run the screw fully into the injector sleeve tapping.

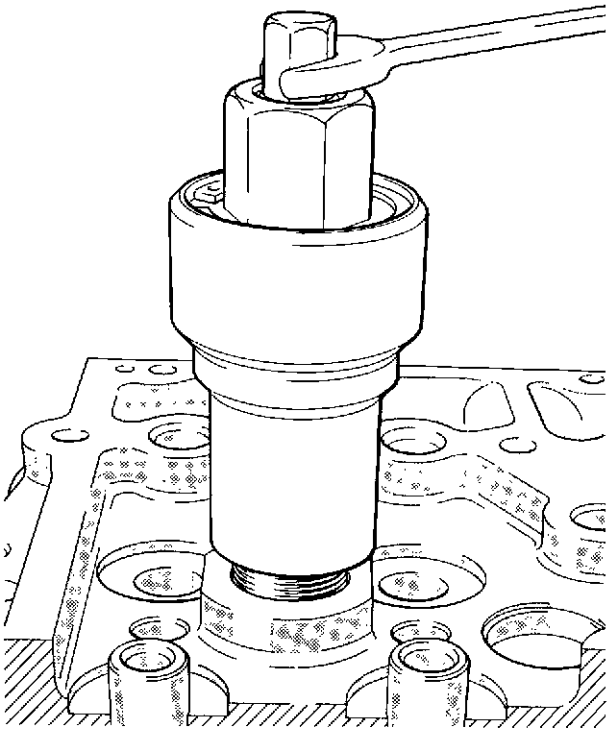


Fig. 20 Fitting extractor VT 11102

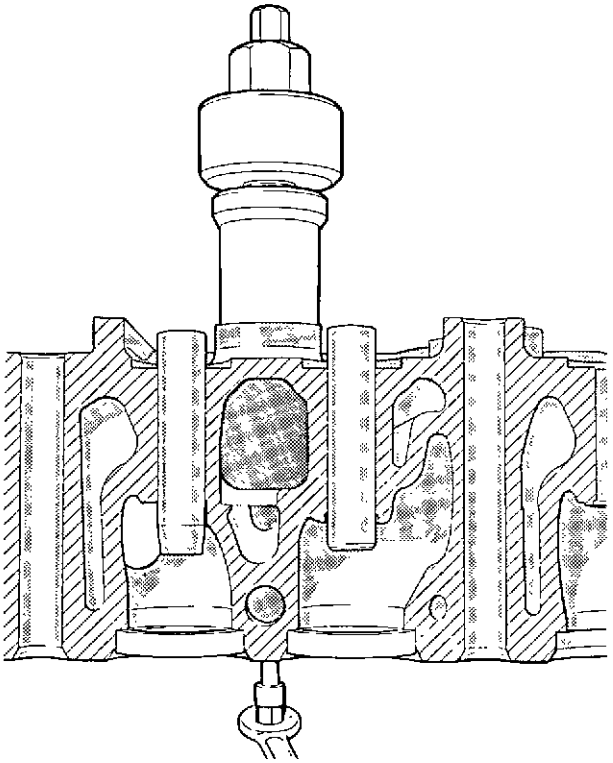


Fig. 21 Fitting stud in extractor

3. Screw the stud in through the injector nozzle until the shoulder of the stud contacts the lower face of the nozzle.
4. Tighten the nut down against the thrust face/ housing assembly and draw out the injector sleeve.

   Note: Considerable effort will be required to shear the rolled out diameter of the sleeve.

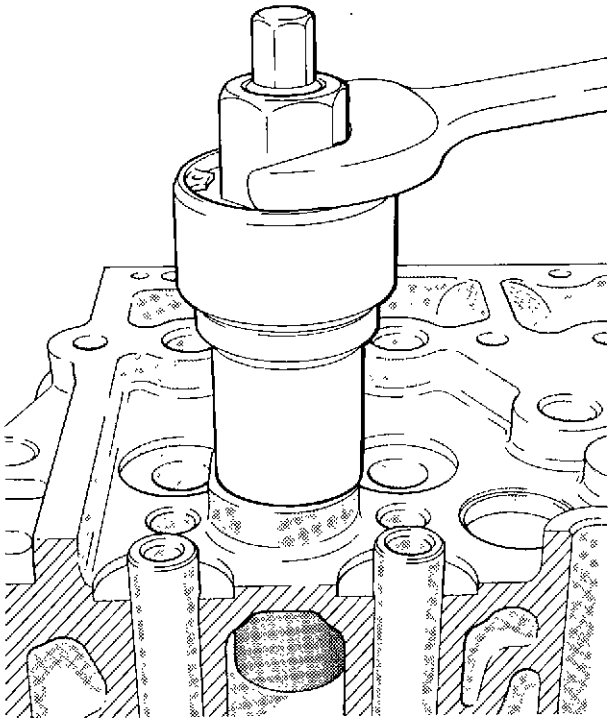


Fig. 22 Withdrawing injector sleeve

5. Clean out the cylinder head bores and sleeve expansion groove, and fit the service sleeve into the pocket.

   Note: Ensure that the new sleeve is fully home before the next operation is carried out.
6. Rest the cylinder head, flame face down, on parallel supports on the bed plate of a hand press. Ensure that the supports are deep enough to allow the Expander Tool, VT 10601, to clear the bed plate.
7. Smear the 'Ballizing' section of the tool with grease and slide the tool into the injector sleeve as shown in the illustration. Slowly press the tool down until the pilot reaches the injector seating face. Remove the 'Ballizing' section of the tool from beneath the cylinder head flame face. The pilot section may be withdrawn from the top.

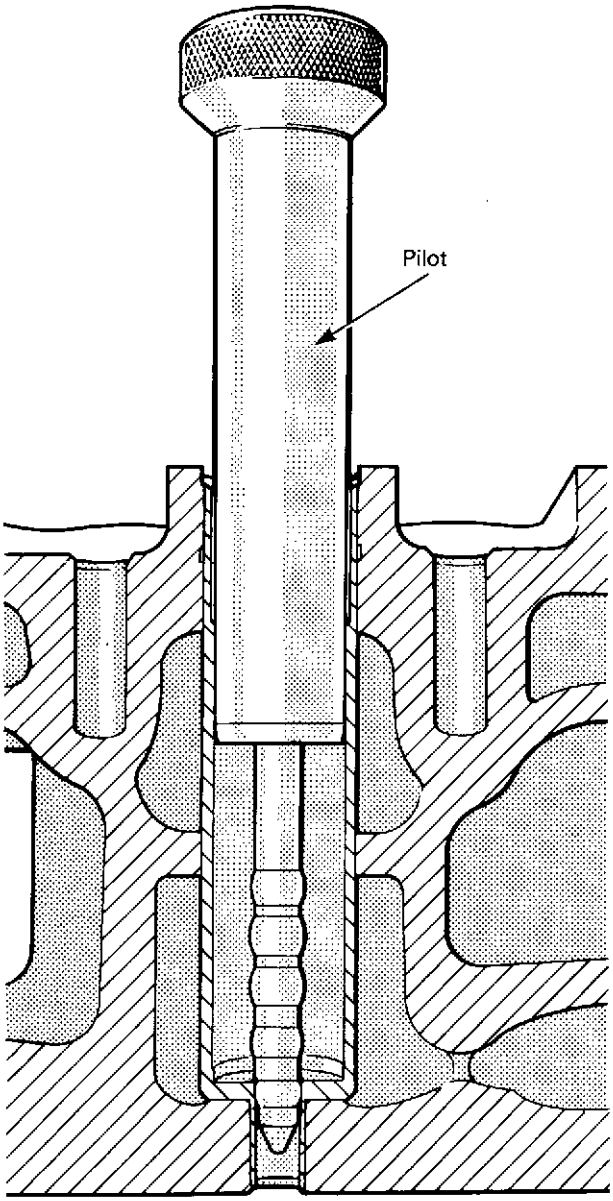


Fig. 23 Expender tool VT 10601

When the injector nozzle has been expanded, the top of the sleeve must then be rolled out using the Expander Tool, VT 10619.

8. Measure the depth of the injector sleeve counterbore from the cylinder head top face and adjust the depth of the rollers, as shown, until the lower end of the rollers fit into the shoulder of the counterbore. Lock the adjusting nut by tightening the grub screw against the flat machined in the adjusting sleeve thread.

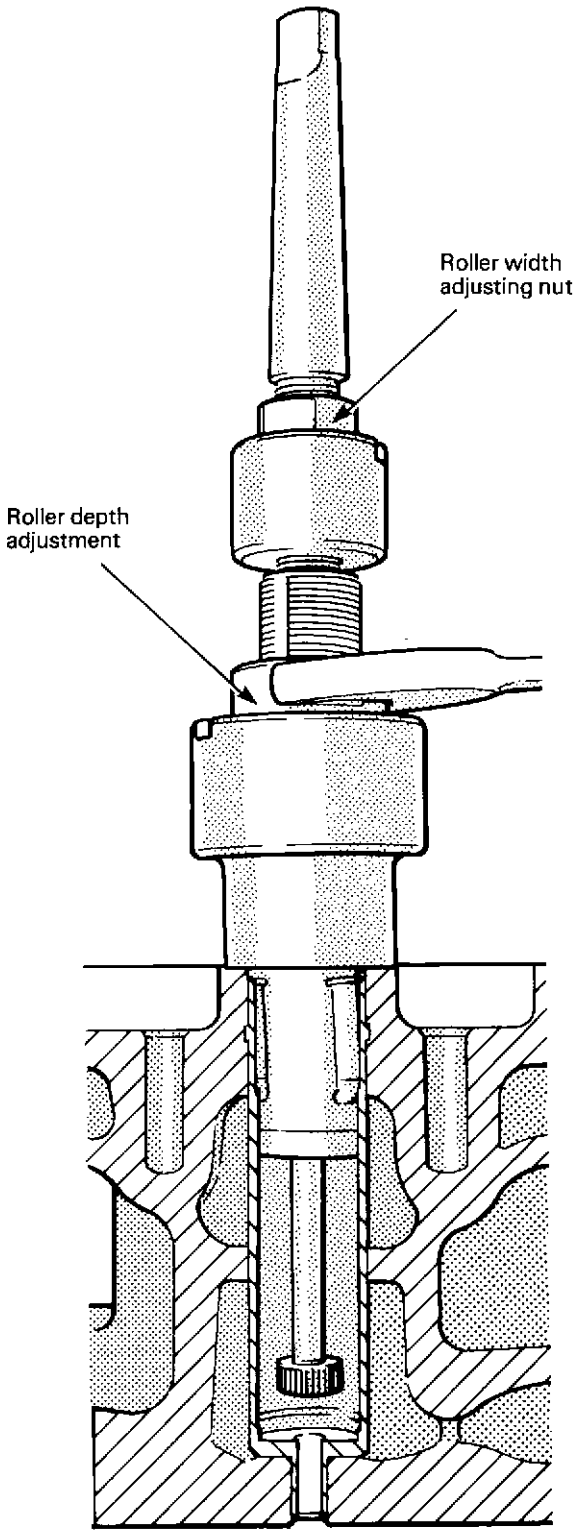


Fig. 24 Expender tool VT 10619

9. Adjust the roller width, using the tapered shaft adjusting nut, until the rollers are pressing firmly against the wall of the injector sleeve. Lock the nut to the shaft by tightening the grub screw against the flat in the shaft thread.
10. Turn the tool at slow speed for three or four revolutions, then re-adjust the roller width as instructed in Item 9.
11. Continue to turn and adjust the rollers in stages until the injector sleeve is rolled out sufficiently to show a band of different coloured metal, where the cylinder head groove encircles the injector sleeve.

Once the final roller width has been ascertained, the tool may be used to expand other replacement sleeves without further adjustment to the depth and width settings.

When rolling out a sleeve with a pre-set expander tool, the tool must be turned slowly under steady pressure until the depth stop contacts the cylinder head top face.

CYLINDER HEAD ASSEMBLING

Oil the valve stems, fit each valve into its guide, then place the lower spring seat, spring and spring retainer or valve rotator, as applicable, over the valve stem.

Compress the spring assembly and fit the collets into the valve stem locating groove. Release the valve spring compressor carefully, then proceed to the next assembly.

When all the valve assemblies are in place, fit the valve bridge pieces on to the bridge guides and set the adjustment as detailed in Section 3.

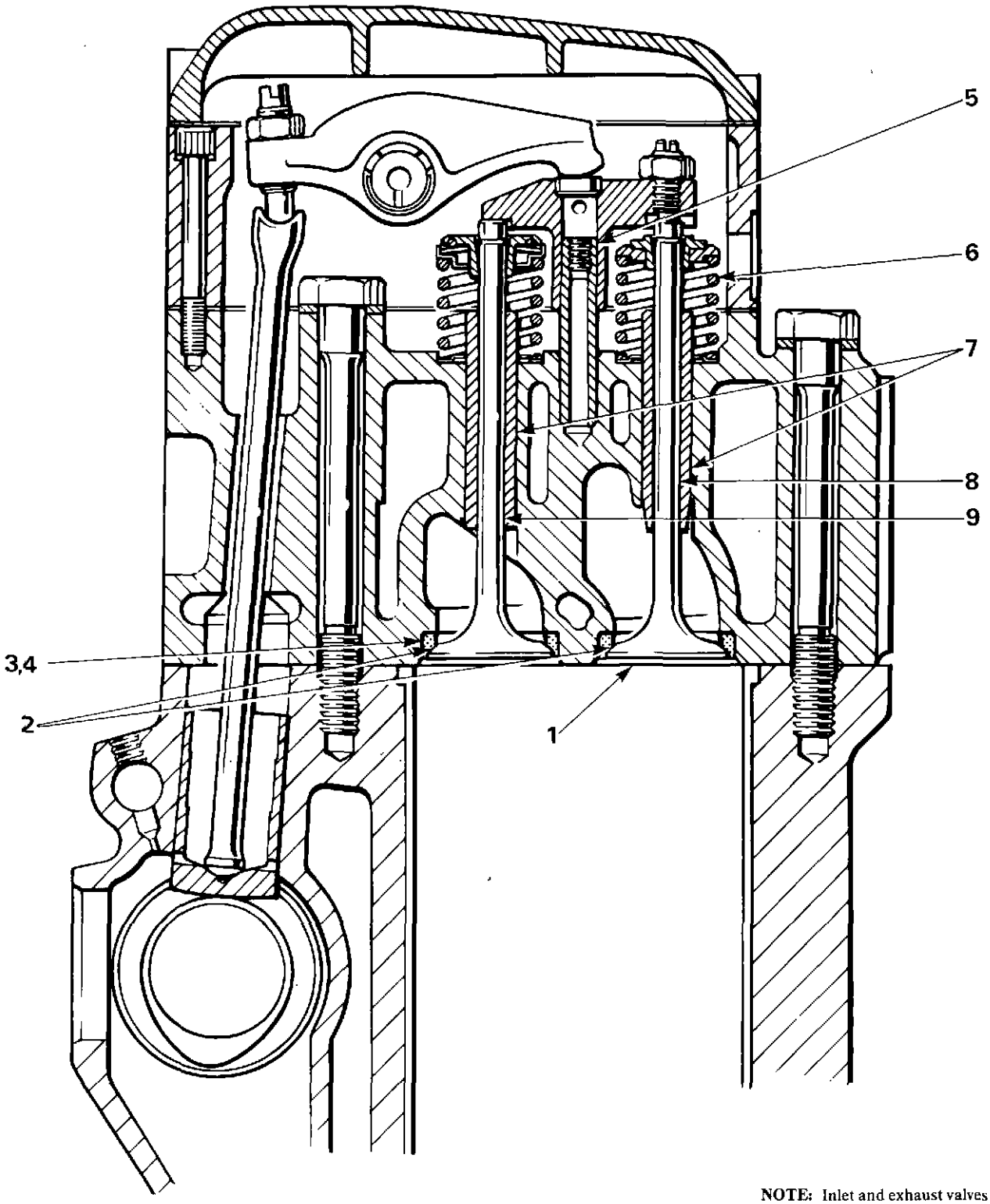
CYLINDER HEAD FITTING

Check the joint faces for cleanliness and ensure that the locating dowels in the crankcase top face are serviceable.

Fit the oil transfer bobbin, with new sealing ring, into its recess and place a new cylinder head gasket on the crankcase top face; fit two guide studs into diagonally opposite cylinder head bolt holes.

Lower the cylinder head on to the crankcase and fit the cylinder head bolts as detailed in Section 3—Items 46 to 49.

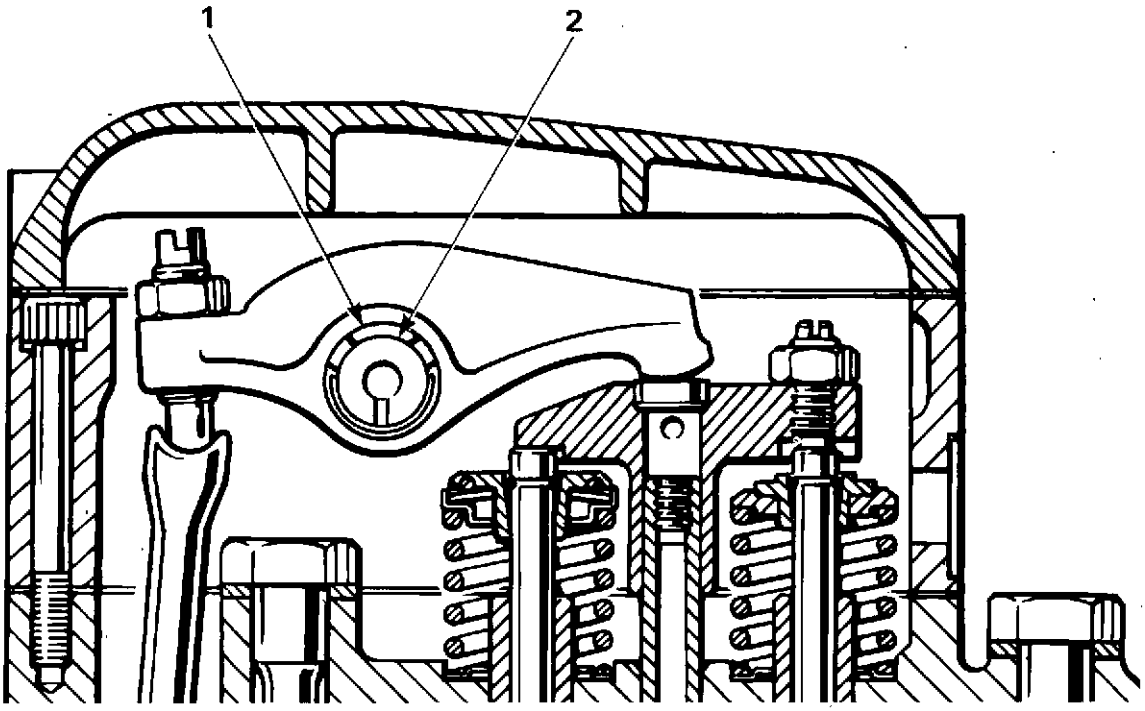
Note: To avoid damage to the threads, the bolts should be placed in the bolt holes, and not dropped in.



NOTE: Inlet and exhaust valves are shown under one valve bridge for convenience.

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		mm	inch	mm	inch	mm	inch	mm	inch	
	VALVE IN SEATING									
1	Clearance below flame face					1.000	0.0393			
	Inlet valves					to	to			
						1.320	0.0519			
						1.003	0.0395			
	Exhaust valves					to	to			
						1.383	0.0544			
	VALVE SEAT INSERTS									
2	Angle of valve seat									
	inlet	30 deg.								Later engines
	inlet	45 deg.								Early engines
	exhaust	45 deg.								
	Inserts in cylinder head									
		48.00	1.889			Interference				
3	Cylinder head bore	to	to			0.038	0.0015			
		48.016	1.890			to	to			
		48.054	1.8919			0.065	0.0025			
4	*Insert diameter	to	to							
		48.065	1.8923							
	VALVE BRIDGES ON VALVE BRIDGE GUIDES									
		12.755	0.5021							
5	Valve bridge bore	to	to			0.016	0.0006			
		12.780	0.5031			to	to	0.10	0.004	
		12.728	0.5011			0.052	0.002			
	Valve bridge guide diameter	to	to							
		12.739	0.5015							
	VALVE SPRINGS									
6	Free length (Nominal)	47.066	1.853	44.713	1.760					
	Load when compressed to 26.87 mm (1.058 inch)	0.5071 kN to 0.5605 kN	114 lbf. to 126 lbf.							
	VALVE GUIDES									
	Valve guides in cylinder head									
		18.00	0.7086			Interference				
7	Cylinder head bore	to	to			0.008	0.0003	Interference		
		18.02	0.7094			to	to	0.008	0.0003	
		18.028	0.7097			0.041	0.0016			
	Valve guide diameter	to	to							
		18.041	0.7102							

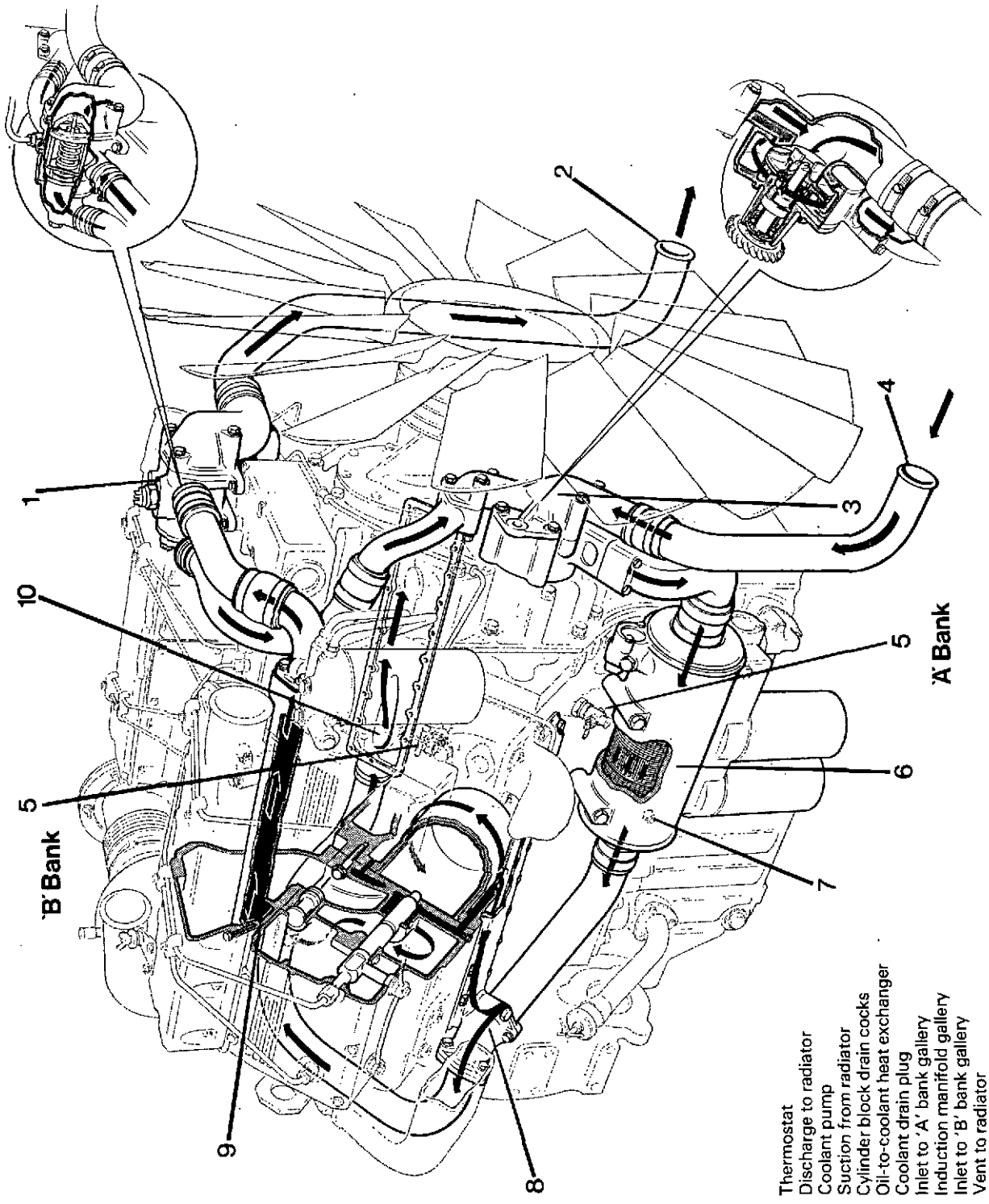
* Standard items. Replacement inserts 0.05 mm (0.002 inch) oversize, are available.


1
2

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		mm	inch	mm	inch	mm	inch	mm	inch	
	ROCKER ARMS									
	Bushes in rocker arms	26.193	1.0312							
	Rocker arm bore	to	to			Interference				
		26.224	1.0324			0.040	0.0015			
1						to	to			
		26.264	1.034			0.096	0.0037			
	Bush diameter	to	to							
		26.289	1.035							
	Rocker arms on shaft	22.212	0.8745							
	Bush bore	to	to							
		22.225	0.875			0.026	0.0011			
2						to	to	0.13	0.005	
		22.174	0.8729			0.051	0.0021			
	Shaft diameter	to	to							
		22.186	0.8734							

SECTION 10—COOLING SYSTEM

TYPICAL COOLING SYSTEM — SCHEMATIC



1. Thermostat
2. Discharge to radiator
3. Coolant pump
4. Suction from radiator
5. Cylinder block drain cocks
6. Oil-to-coolant heat exchanger
7. Coolant drain plug
8. Inlet to 'A' bank gallery
9. Induction manifold gallery
10. Inlet to 'B' bank gallery
11. Vent to radiator

SECTION 10—COOLING SYSTEM

Description

Coolant is drawn from the base of the vertical two pass radiator by the pump and delivered to the oil-to-coolant heat exchanger situated on the 'A' bank side of the crankcase.

From the heat exchanger the coolant passes through pipework to the rear of the 'A' bank coolant gallery where a branch in the pipework divides the flow, passing half to the 'A' bank coolant gallery. The remainder is routed through external pipework around the rear of the crankcase to the 'B' bank coolant gallery.

From the galleries, coolant is directed around the cylinders, and then in to the cylinder heads.

In the cylinder heads the coolant circulates around the injector pockets, valve guides and seats, then through bobbin type connectors in the cylinder head inner walls into galleries in the induction manifolds. Outlets at the front end of each manifold, and connecting pipework, direct the flows from both banks to the thermostat housing where the two flows merge.

If the coolant has not reached normal working temperature the thermostat valve(s) will be closed and the flow of coolant will be directed, via the by-pass port, to the coolant pump suction.

At normal working temperatures the thermostat valve(s) will be open, the by-pass port closed and the flow of coolant will be directed through external pipework to the base of the radiator.

Under normal operating conditions the cooling system will be pressurised at 50 to 70 kN/sq. m (7 to 10 lbf/sq. inch), this pressure being maintained by a pressure/vacuum relief valve incorporated in the

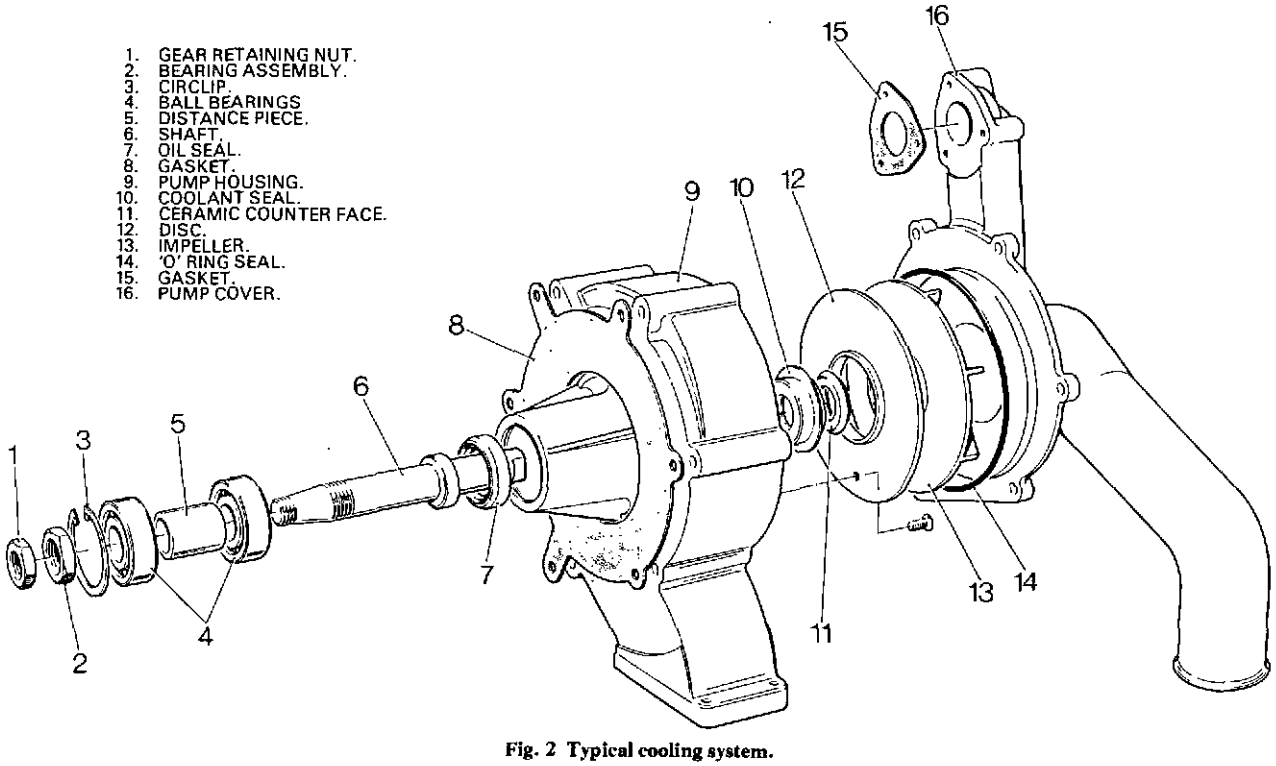


Fig. 2 Typical cooling system.

radiator filler cap.

To drain the system, drain cocks are fitted to each side of the cylinder block and drain plugs are screwed into the base of the radiator, the oil-to-coolant heat exchanger and at the lower end of the thermostat-to-radiator and coolant pump-to-radiator pipework.

COOLANT PUMP

Description

This is a conventional centrifugal pump, driven from the main gear train.

The impeller is a press fit on one end of the pump shaft, A helical cut gear is mounted on a taper at the drive end of the shaft and secured by a nut. The whole of the rotating assembly is supported on two ball races.

Lubrication of the bearings is by splash feed from the gear train via drillings connecting the bearing housing with the wheelcase. Sealing of the bearing housing is by lip type seal. The coolant seal is of the ceramic face type.

A 'tell tale' hole, drilled in the base, of the pump casing, indicates if either seal is leaking.

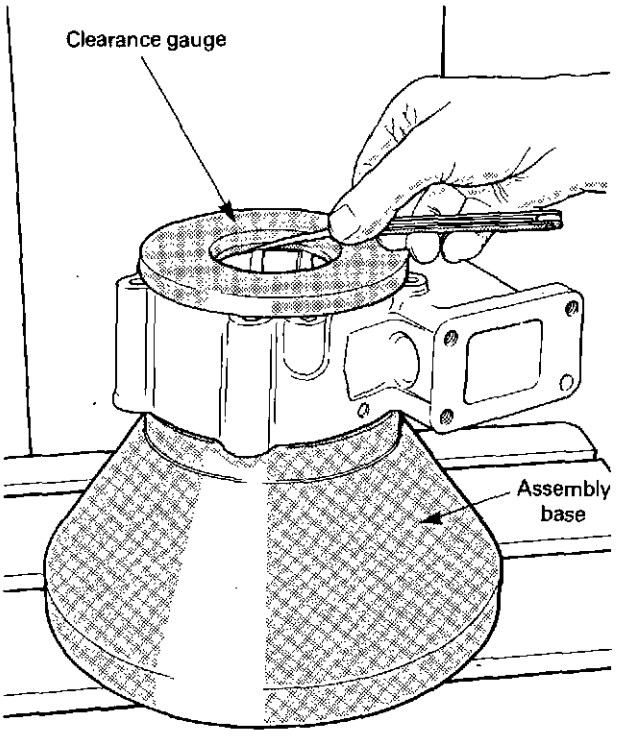


Fig. 3 Checking impeller clearance.

Removal

Before removing the coolant pump from the engine, index mark the position of the front casing relative to the pump body.

1. Drain the cooling system completely.
2. Disconnect the hose coupling the pump inlet to the base of the radiator.
3. Remove the four setbolts securing the heat exchanger pipe flange to the pump outlet, pull the flange away from the pump.
4. Remove the three setbolts securing the by-pass pipe flange to the pump, pull the flange away from the pump.
5. Remove the six setbolts securing the pump to the wheelcase and lift the pump away from the engine.

Note: It may prove necessary to release the fan belt tension to provide access to some of the pump mounting bolts.

Inspection

Carefully clean off any dirt from the impeller, pump casing and drive gear. Spin the rotor assembly and check for sounds of rubbing and for excess play in the bearings. Measure the rotor assembly end float.

Remove any traces of gasket material from the pump casing flange and wheelcase contact face. Fit the pump as detailed in Section 3, and check the gear backlash. Renew the drive gear if the backlash is beyond the permissible limits.

Check the clearance between the impeller vanes and the pump cover. On new pumps, the running clearance is between 1.0 and 1.9 mm (0.039 and 0.075 inch).

Fitting the pump

When fitting the coolant pump, renew the 'O' ring seal on the front cover and use a new jointing gasket, lightly coated with Wellseal jointing compound, between the pump and wheelcase.

Pump overhaul

During engine operation, the coolant pump normally runs trouble free, between engine overhauls. If a malfunction does occur, Rolls-Royce recommend that the Customer takes advantage of the Service Exchange Scheme to renew the unit.

For those Customers wishing to renew components in their own workshops, a series of special tools is available for the purpose, see end of Section.

THERMOSTAT

Description

Early engines are fitted with a single element, wax capsule type, Western Thomson thermostat, Part Number CV 301. Later models are fitted with a triple element wax capsule type Western Thomson thermostat, Part No. OE 43404. These units are not interchangeable and in the event of thermostat failure, it is important that the correct Part Number is noted when ordering replacement units.

CV 301 thermostat

The thermostat is factory set to operate at a predetermined temperature and must NOT be adjusted by Operators.

In operation, the main flow valve of the thermostat begins to open when the coolant temperature reaches 68 to 73 deg. C. and the by-pass valve begins to close a corresponding amount. The normal working travel of the main flow valve is 12.7 mm (0.5 inch) which is achieved at a temperature of 78 to 83 deg. C. When this temperature is reached, the by-pass valve is fully closed ensuring that the full flow of coolant passes through the radiator. At higher temperatures the main flow valve will open to a maximum of 23.8 mm (0.937 inch), the extra travel being taken up by compression of the by-pass valve spring.

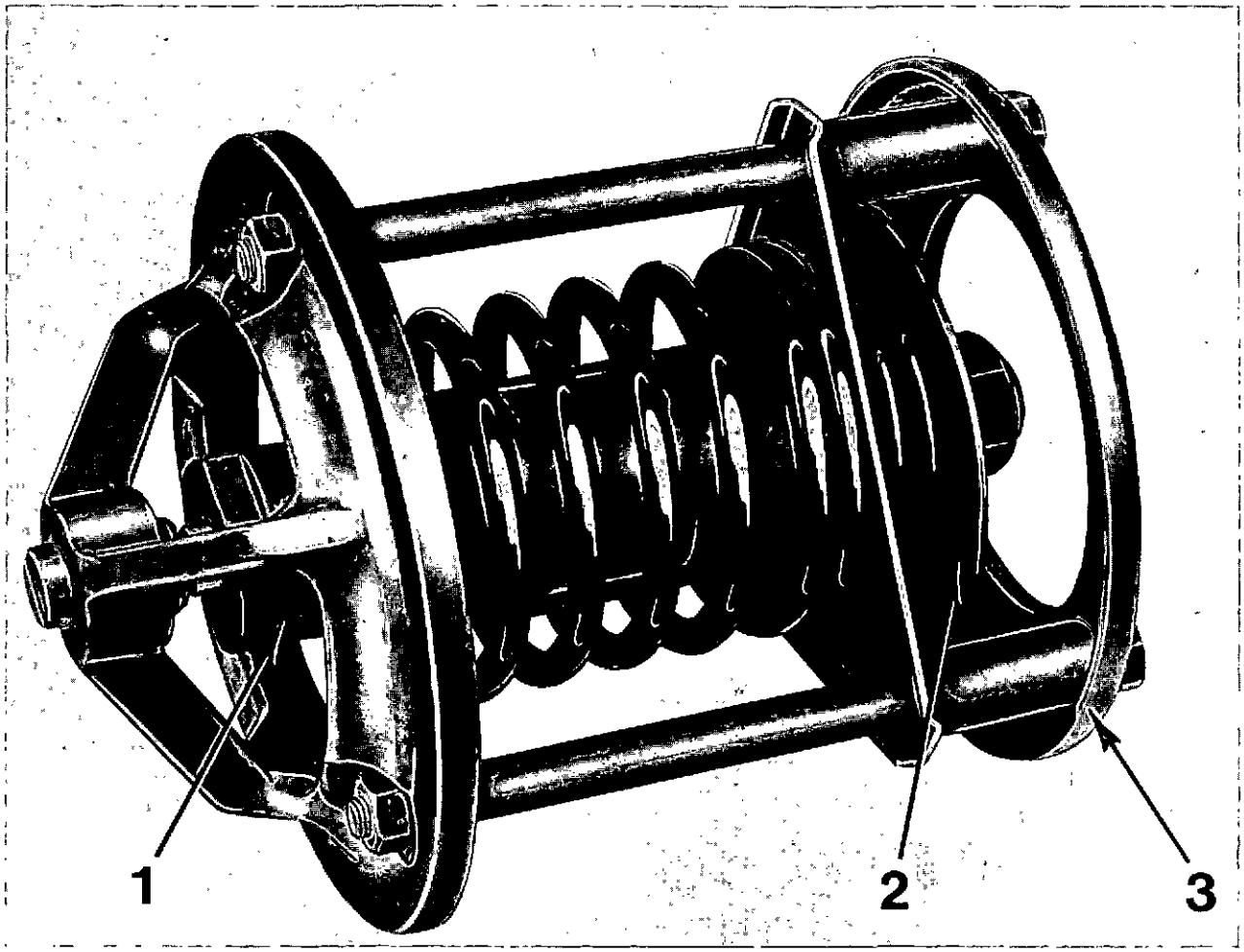


Fig. 4 Thermostat CV 301.

1. Main flow valve opening 2. By-pass valve 3. By-pass valve seat

Inspection

To check the operating characteristics of a thermostat, drain the coolant to below the level of the thermostat housing, release the discharge hose connection, remove the housing cover and withdraw the thermostat unit.

Thoroughly clean the thermostat using a bristle brush and mild detergent. Check for distortion, cracks, damage and sticking valves. A sticking valve may often be remedied by applying silicone grease to the spindle and operating the valve manually to work the grease into the gland. If the thermostat is apparently serviceable, carry out the following tests:

Place the unit in a tank containing water at a constant 20 deg. C. for 5 minutes, then plunge the unit into a tank of water at a constant 100 deg. C. Note the time taken for the valve to open sufficiently to admit a 0.05 mm (0.002 inch) feeler gauge; this should be between 30 and 40 seconds. Note the time taken for the valve to open 12.7 mm (0.5 inch); this should be between 90 and 120 seconds. Finally plunge the unit into a tank containing water at 20 deg. C. and note the time taken for the valve to close completely; this should be between 25 and 35 seconds.

The thermostat is extremely reliable, so incorrect operating characteristics indicate a loss of wax. In such cases the unit must be renewed.

Check the condition of the discharge hose connection and renew if necessary. Refit the housing using a new gasket lightly coated with jointing compound and top up the system with the approved coolant mixture.

Emergency action

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 over-heating.

OE 43404 thermostat

The triple element thermostat is located in its housing by a rollpin which ensures that each element is directly above its by-pass port. As each valve opens, the corresponding port closes thus directing the coolant flow to the radiator.

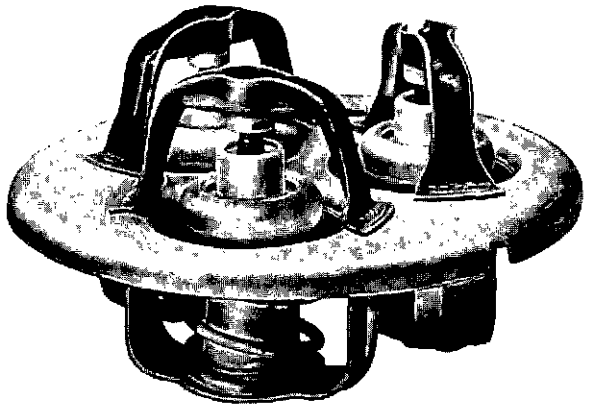


Fig. 5 Thermostat OE 43404.

The opening temperatures differ slightly between the leading valve and the two trailing valves. A nominal operating temperature figure, in degrees C. is stamped on the base of each element.

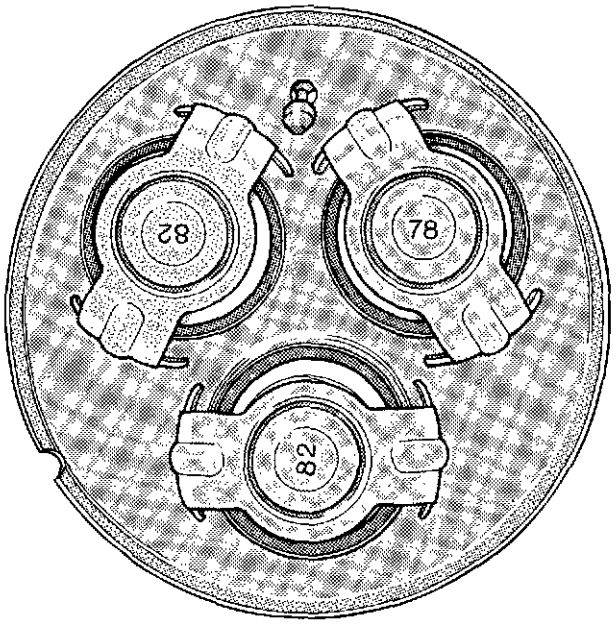


Fig. 6 Operating temperature figures.

Inspection

To remove the thermostat, drain the coolant to an adequate level, disconnect the top hose, remove the housing cover and withdraw the thermostat.

Thoroughly clean the thermostat using a mild

detergent and a small bristle brush, (ideally an old tooth brush). Check for distortion, cracks and sticking valves. Sticking valves may often be freed by applying silicone grease to the spindles and operating the valves manually to work the grease into the glands. If the thermostat appears serviceable, carry out the following tests:

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 cooling system drained. MS.4 silicone grease, manufactured by Ambersil Limited of Basingstoke, Hants, is recommended for this purpose.

Checking operating temperature

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 0.05 mm (0.002 inch) 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 9.5 mm (0.375 inch).
5. Compare the readings with the following limits:

Leading valve opens	:	77 to 81 deg. C.
Trailing valves open	:	81 to 85 deg. C.
All valves fully open	:	93 to 97 deg. C.

Checking operating speed

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 0.05 mm (0.002 inch) 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.

Incorrect operating characteristics indicate a loss of wax. In such cases, a replacement thermostat must be fitted.

Emergency action

As with thermostat CV 301, the valves may be jacked fully open and the radiator partly blanked off as a temporary measure. Do NOT run the engine with the thermostat removed.

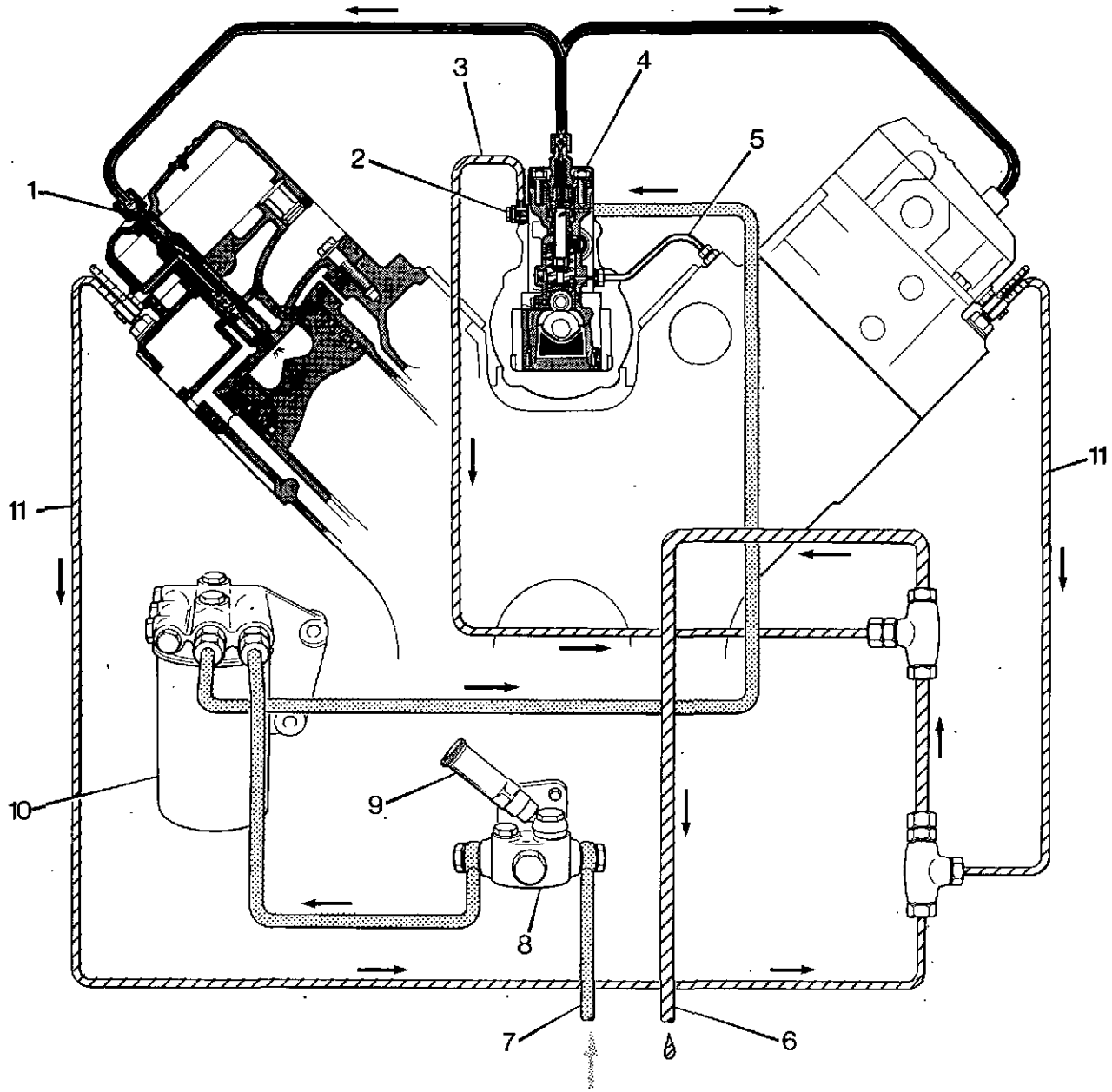
OIL-TO-COOLANT HEAT EXCHANGER

See Section 12, 'Lubrication System'.

SPECIAL TOOLS

Part No.	Description	
VT 18066	Assembly base, coolant pump.	
VT 18083	Insertion tool, volute disc.	
VT 18084	Insertion tool, oil seal.	
VT 18085	Insertion tool, gland seal.	
VT 18087	Insertion tool, impeller.	
VT 18265	Insertion tool, ball bearing.	
VT 18264	Stepped base, bearings to shaft fitting.	
VT 16671	Holding device.	
VT 18266	Gauge, impeller clearance.	
VT 12896	Extractor, oil and coolant seals.	
VT 18357	Holding, fixture	Impeller removal.
VT 18327	Pressing drift	
VT 18326	Spacer ring	

TYPICAL FUEL SYSTEM — SCHEMATIC



1. Fuel injector
2. Low pressure relief valve
3. Excess fuel return
4. Fuel injection pump
5. Lubricating oil supply
6. Spill return to supply tank
7. Suction from supply tank
8. Fuel feed pump
9. Hand priming plunger
10. Main filter canister
11. Injector spill return

■ - High pressure fuel
▨ - Low pressure fuel
▨ - Spill return to tank
■ - Lubricating oil

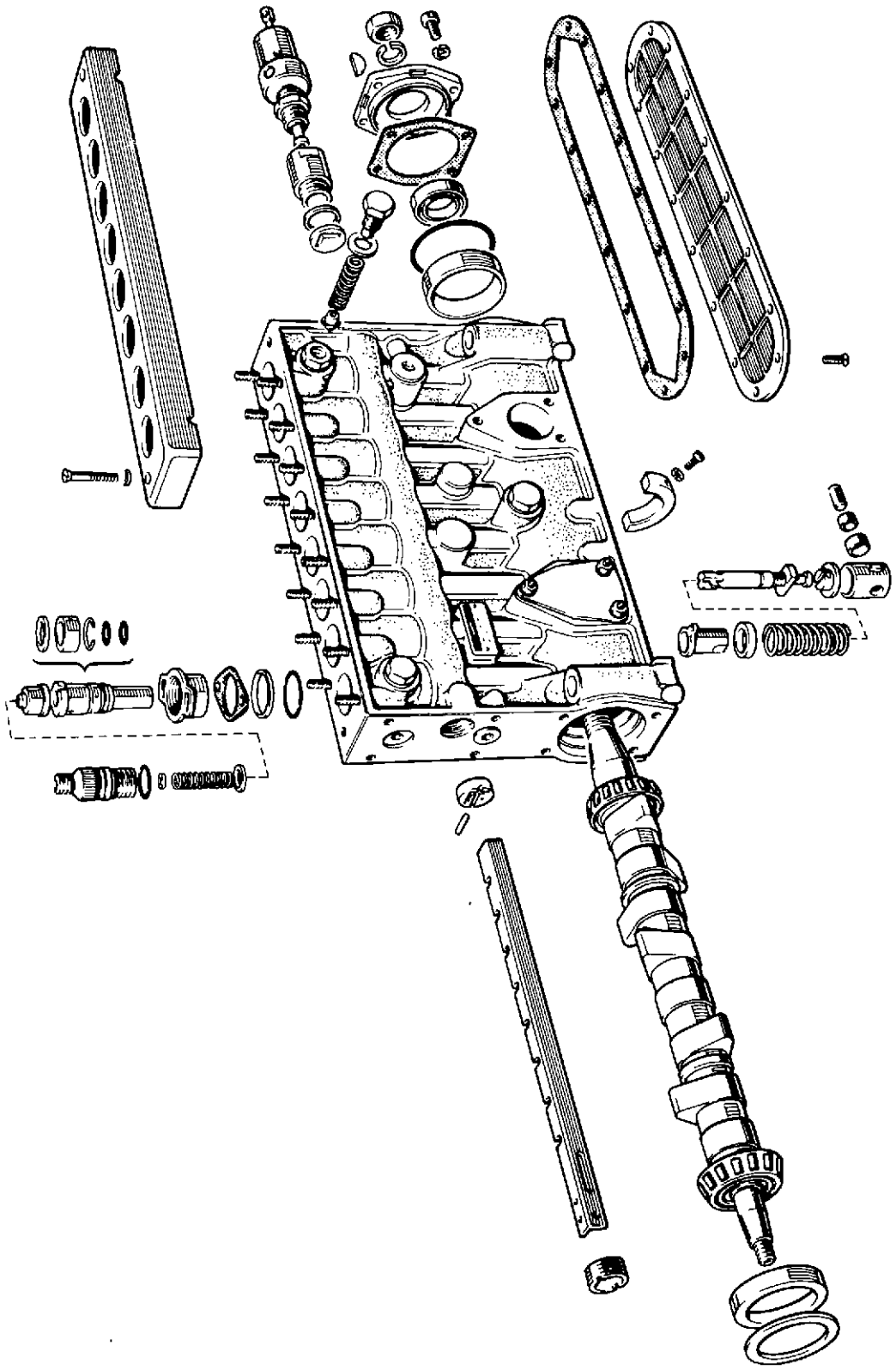


Fig. 1 Injection pump - exploded.

SECTION 11 — FUEL SYSTEM — BOSCH 'PE' PUMP AND ACCESSORIES

PART 1 — INJECTION PUMP, TYPE 'PE'

NOTE: Although some illustrations in the following text depict a 6-element pump, the operations and essential details apply equally to the 8-element 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. 2. Remove the rear cover and dismantle the governor as described under 'DISMANTLING' in Part 2.
4. Invert the pump and remove the bottom plate.
5. Referring to fig. 3, remove the eight 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 mm and 13 mm bore pumps, screw in the element and guide sleeve by hand and then finally tighten one turn using a spanner. Fit the capscrew by hand until the element reaches the tappet and then use an Allen key to tighten it half-a-turn further. Do NOT exceed this or the element may foul the cam.
6. Invert the pump and remove the camshaft centre bearing, which is retained by two socket screws (fig. 4).
7. Turn the pump upright and remove the screws securing the drive end bearing plate. Referring to fig. 5, fit supporting bracket 1 682 329 011 and withdraw the bearing plate by using a claw

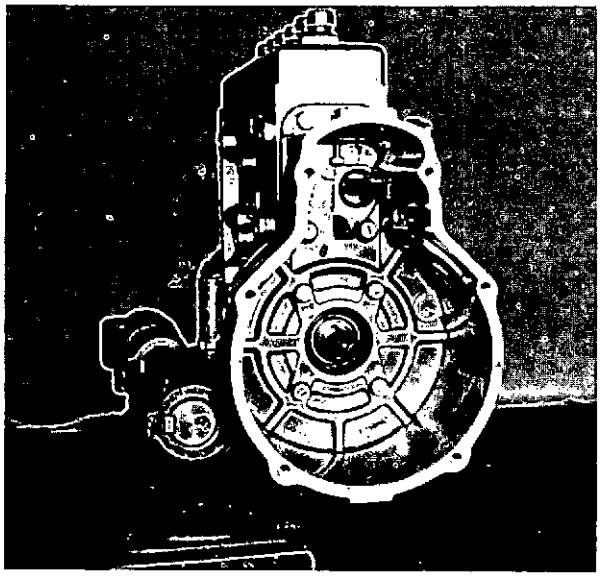


Fig. 2 Pump on swivel vice.

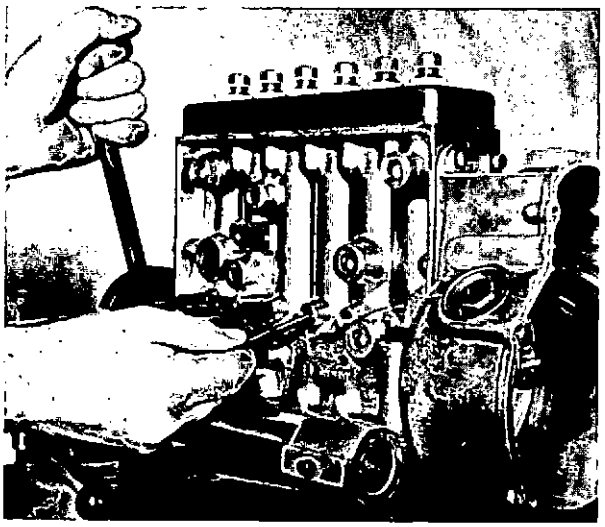


Fig. 3 Fitting tappet holders.

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. 6).

9. Remove the governor housing and adjusting plate from the opposite end (fig. 7).

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. 8).

11. Withdraw the roller tappets (fig. 9), use a wire hook to lift out the spring plate and pump plungers (fig. 10) and take out the plunger springs (fig. 11). 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. 12).

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. 13) 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. 14), 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. 15).

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. 16) unscrew the connector from the flanged bush and remove the spring, delivery valve and washers.

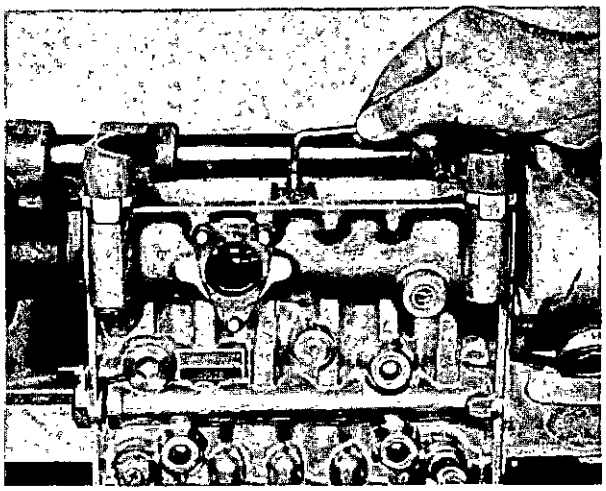


Fig. 4 Removing centre bearing.

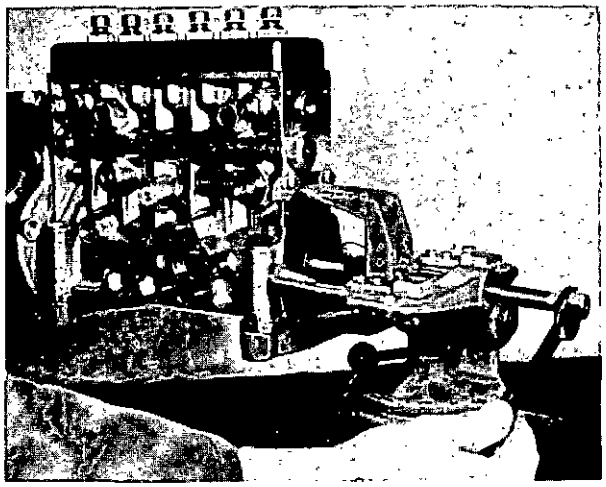


Fig. 5 Withdrawing drive end bearing plate.

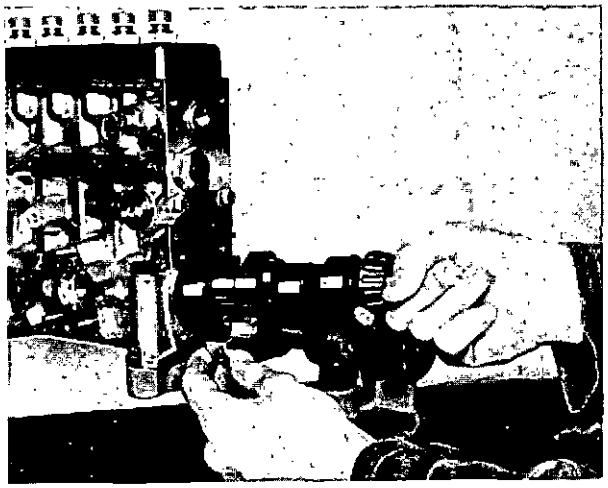


Fig. 6 Removing camshaft.

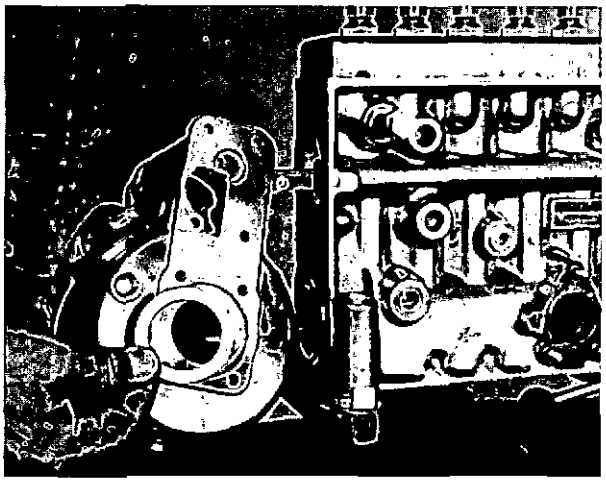


Fig. 7 Removing governor casing and adjusting plate.

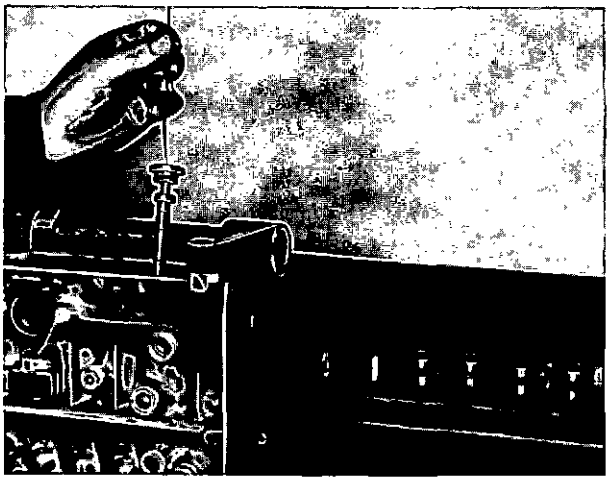


Fig. 10 Withdrawing plunger and lower spring plate.

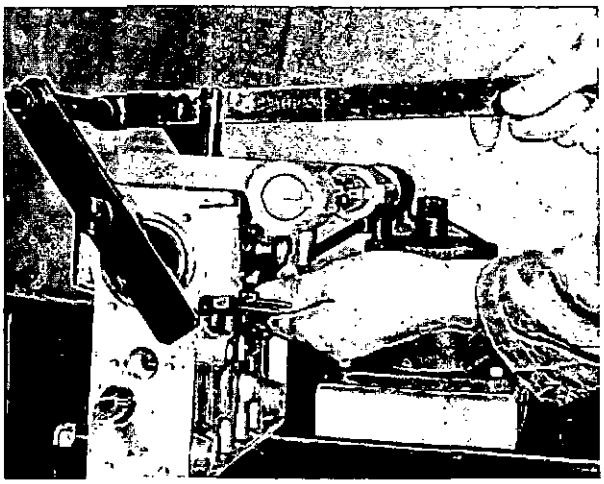


Fig. 8 Unloading plunger springs.

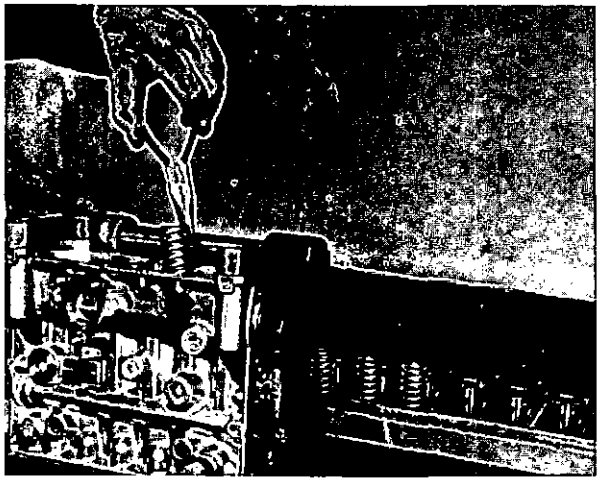


Fig.11 Extracting plunger springs.

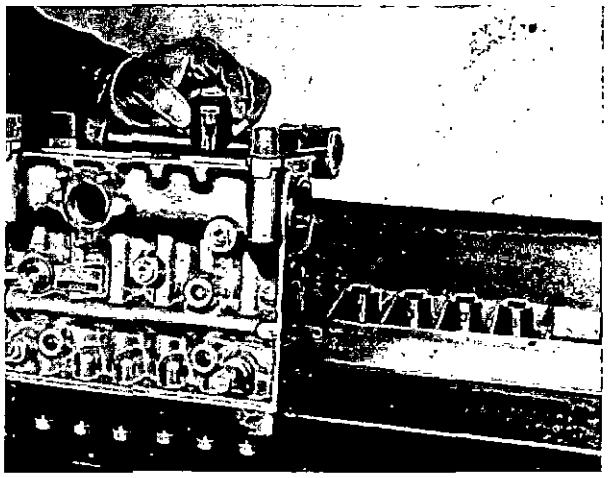


Fig. 9 Removing tappets.

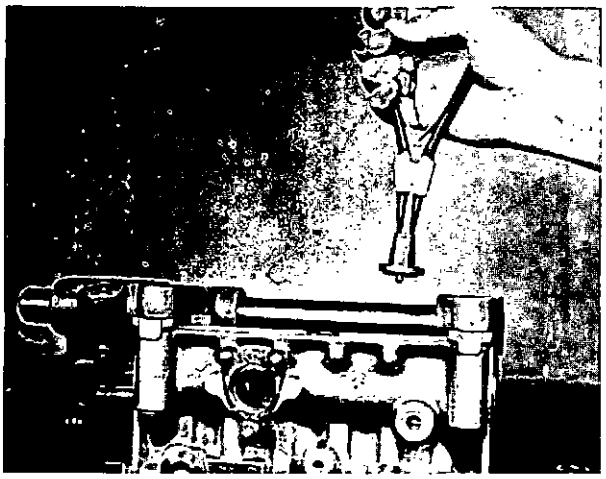


Fig. 12 Removing control sleeves and upper spring plates.

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. 17). Then press it in again until it protrudes 3 mm (0.118 inch), as shown by dimension 'a' in fig. 18.
   (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. 19) and 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 firmly. Press measuring bar 1 682 310 018 on to the camshaft taper and measure the clearance between bar and pump housing (fig. 20). Limits are 13 to 14 mm (0.512 to 0.551 inch). If below limits, fit an appropriately thicker adjusting plate at the governor end and press the

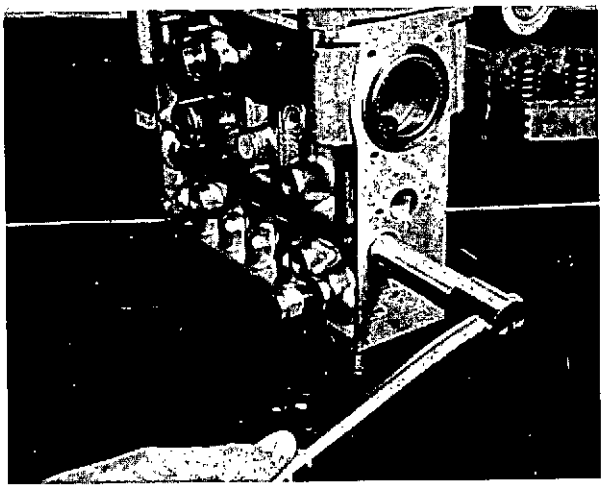


Fig. 13 Unscrewing threaded bush.

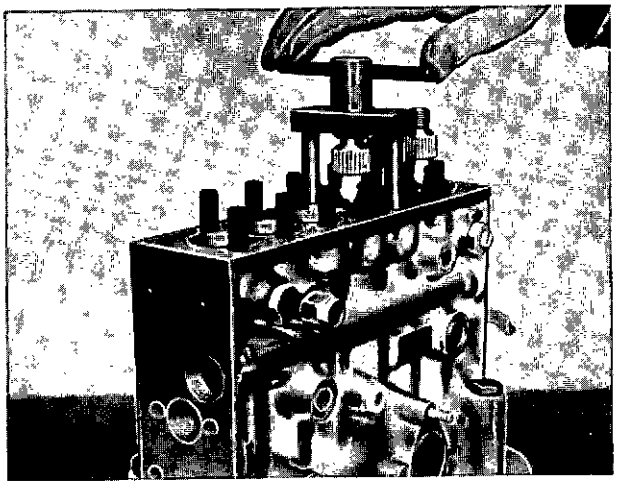


Fig. 14 Extracting delivery valve.

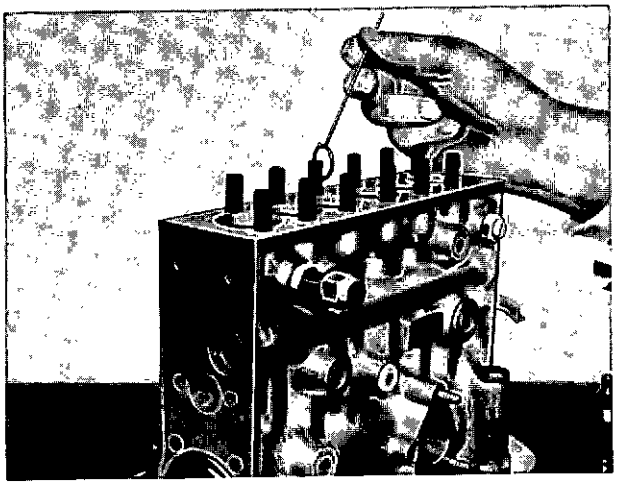


Fig. 15 Removing packings from housing.

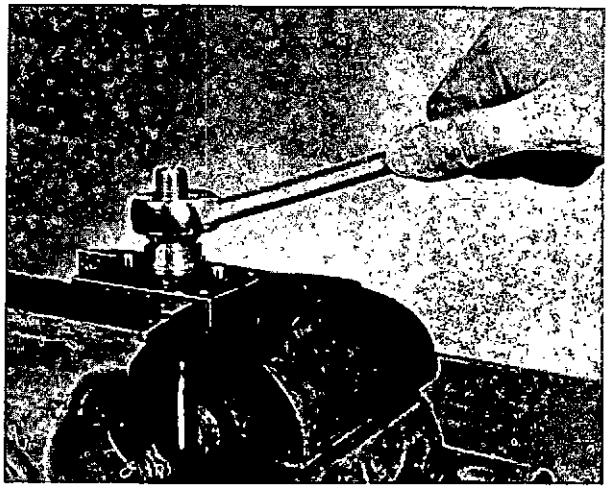


Fig. 16 Dismantling barrel/delivery valve assembly.

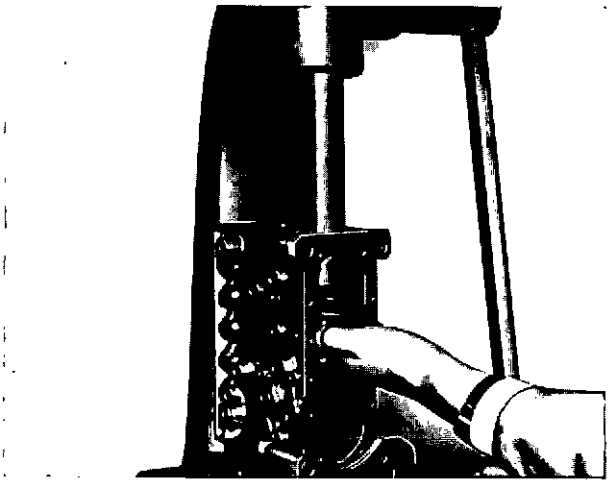


Fig. 17 Removing outer race from governor end.

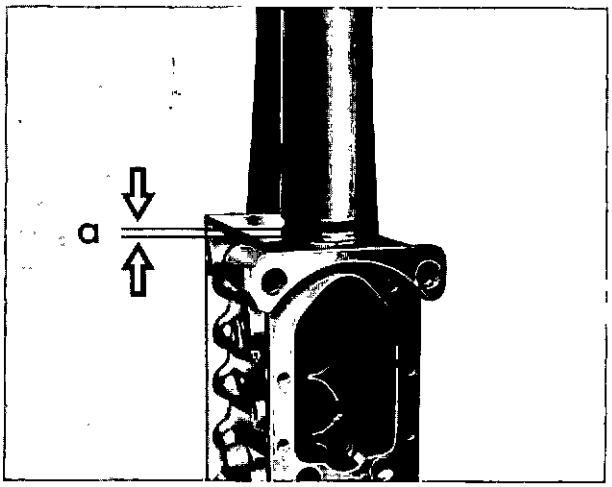


Fig. 18 Re-positioning outer race (first operation).

outer race further in, as in (b), page 6. 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. 21 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 69 and 70 Nm (51 and 58 lbf. ft.) using socket 1 687 950 062 (fig. 22).

(b) Refer to fig. 23 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. 24 shows the rubber ring 'a' and Viton ring 'b' under equal radial pressures.

Again referring to fig. 23, the 'O' ring (5), nylon ring (6) and phasing shim (7) are not fittted until the barrel/delivery valve unit is assembled to the pump housing (Operations 4 and 5).

3. Using tool 1 688 110 028, fit a rubber 'O' ring, see **Note** in 2 (b), to each bore (fig. 25). 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. 23, Items 5, 6 and 7) to each port (fig. 26). **Note:** On pumps with numbers prefixed '626' and later the nylon ring is superseded by a steel

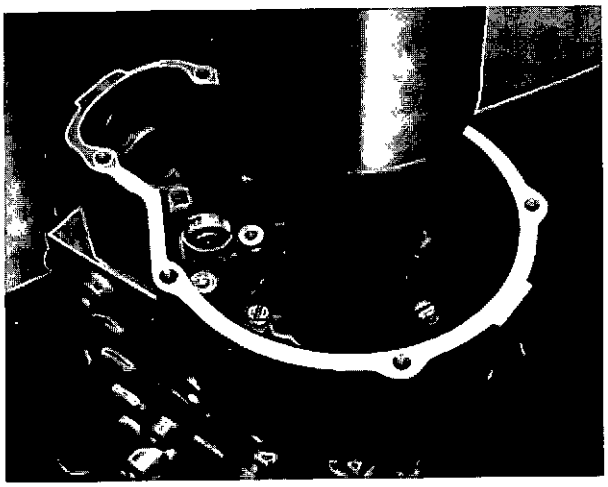


Fig. 19 Re-positioning outer race (second operation).

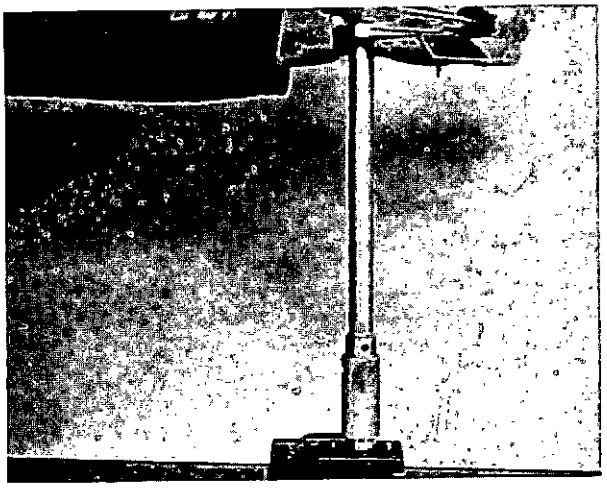


Fig. 22 Tightening connector.

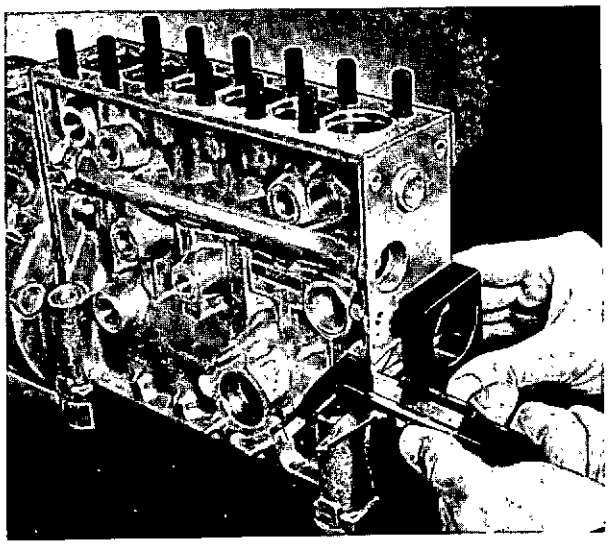


Fig. 20 Measuring camshaft position.

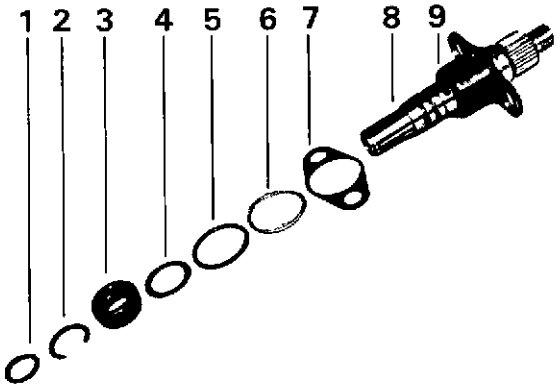


Fig. 23 Mounting components - barrel to pump casing.

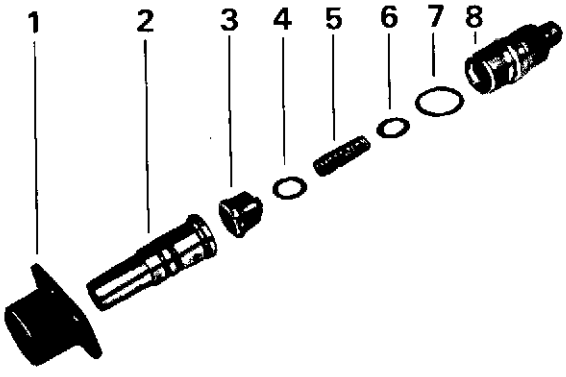


Fig. 21 Barrel/delivery valve assembly - exploded.

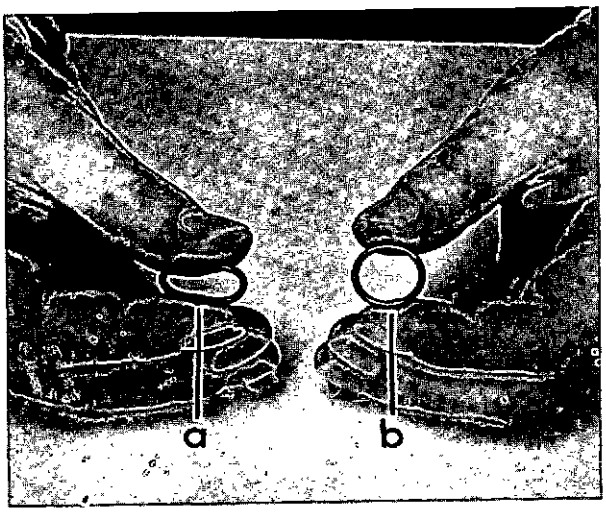


Fig. 24 Comparing rubber ring 'a' with Viton ring 'b'.

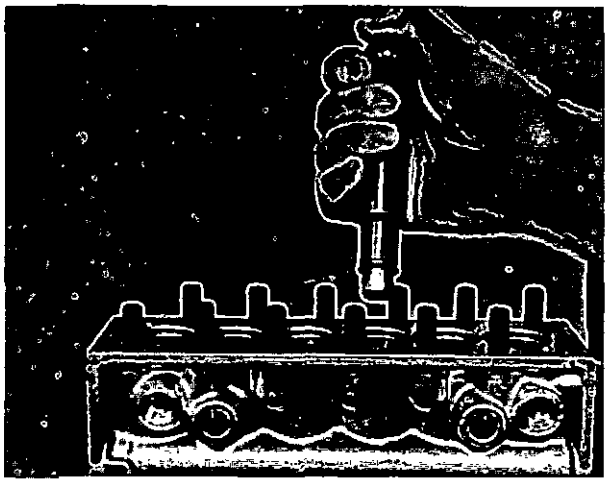


Fig. 25 Fitting rubber 'O' ring.

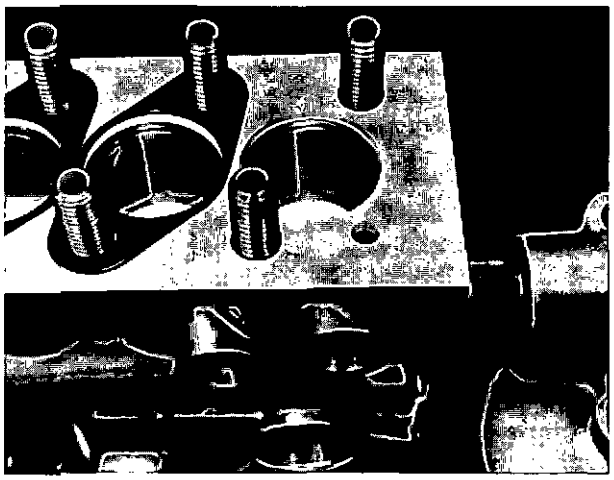


Fig. 26 Fitting 'O' rings, nylon rings and phasing shims.

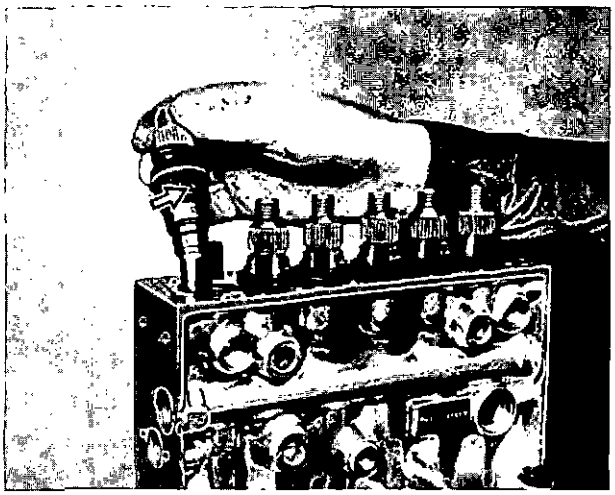


Fig. 27 Inserting barrel/delivery valve assembly.

ring permanently pressed on the flange bushing (fig. 21, 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. 27) towards the pump rack. Ease the units into place by gentle downward pressure and rocking, using ring spanner 1 687 950 525 (fig. 28). 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 39 and 44 Nm (29 and 32 lbf. ft.).

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 eight retaining pins (locally made from mild steel to the dimensions in fig. 29) 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 242 kN/sq. m (35 lbf./sq. inch) to the inlet gallery (fig. 30). 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. 31), aligning the vertical guide with the edge of the pump housing as shown.

9. Use a suitable tube to press the guide block fully home (fig. 32), taking care that it does not become tilted. Secure it by screwing in the threaded bush to a torque loading 30 to 39 Nm (22 to 29 lbf. ft.), using pin spanner 1 687 950075.

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 excess fuel device or smoke stop, as applicable.

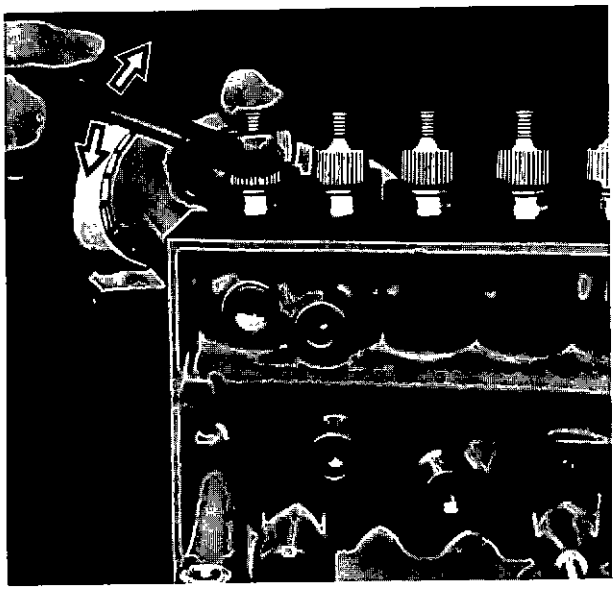


Fig. 28 Easing assembly into place.

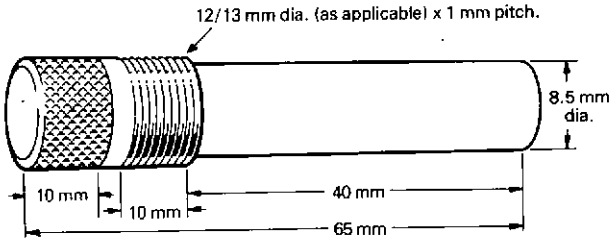


Fig. 29 Plunger retaining pin for pressure test.

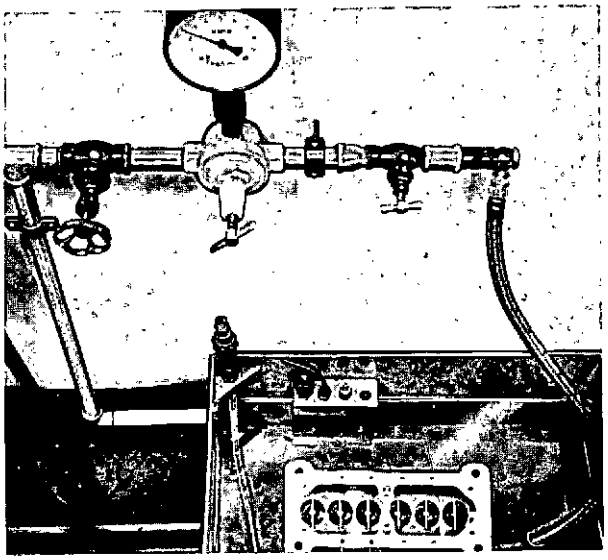


Fig. 30 Pressure test.

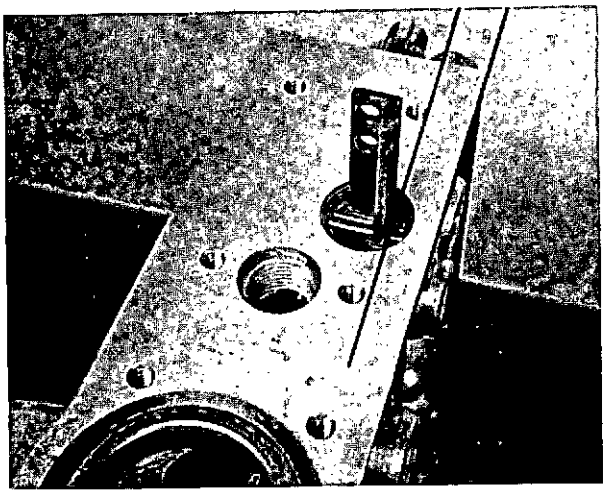


Fig. 31 Alignement of control rack.

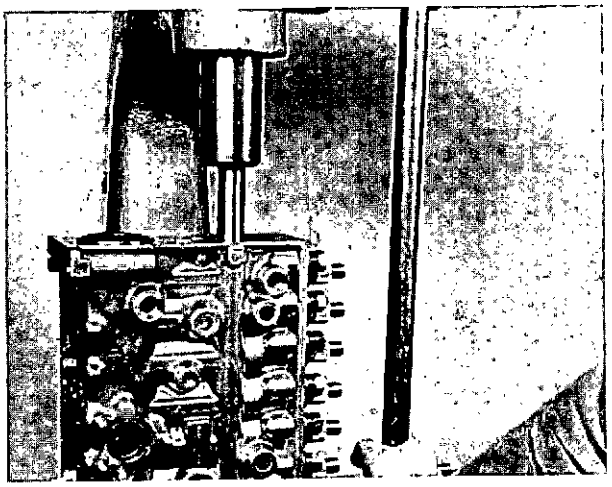


Fig. 32 Pressing in guide block.

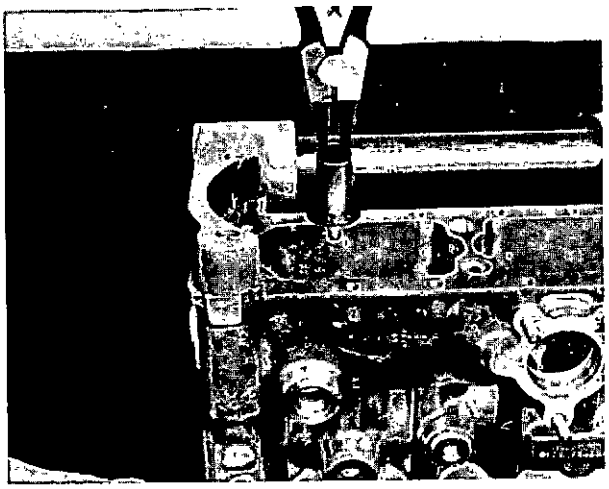


Fig. 33 Fitting control sleeves.

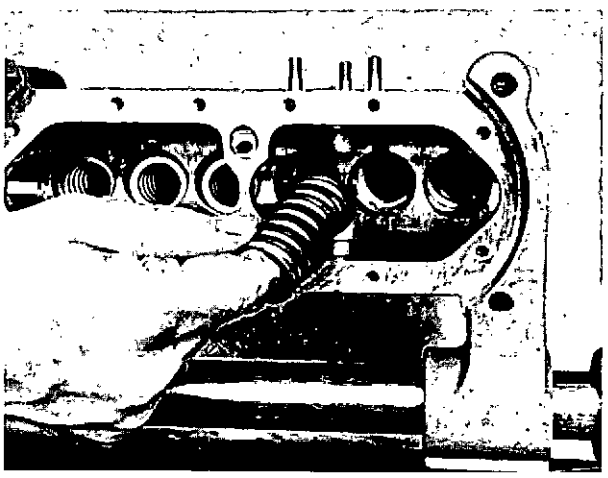


Fig. 34 Inserting upper plate and plunger spring.

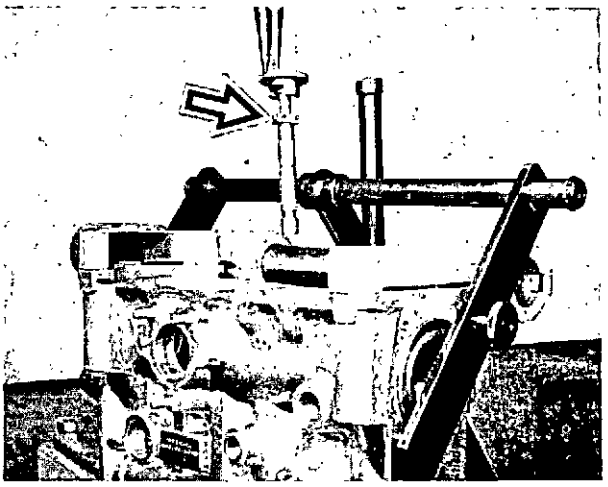


Fig. 35 Fitting plunger and lower plate.

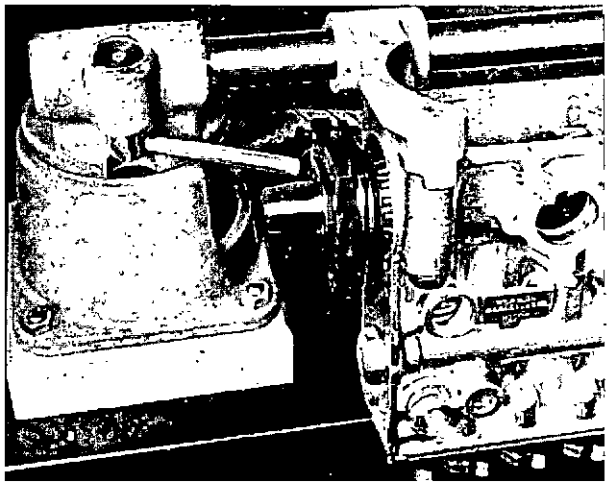


Fig. 36 Assembling drive end bearing.

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. 33), 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. 34).
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. 35) 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 element and guide sleeve, without the capscrew, fully into the access tapping. Then fit the capscrew, tightening it until the tappet roller is 64.2 mm (2.527 inches) 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 centre bearing tightening its two socket screws to between 8 and 9 Nm (5 to 6.5 lbf. ft.). Assemble the drive end bearing plate with shims, but omitting the 'O' ring (fig. 36).
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. 37. Limits are 0.02 to 0.06 mm (0.008 to 0.024 inch). 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. 38). 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 2, prime the unit with engine lubricating oil, and carry out Test Procedure as described in Part 4.

PART 2 — GOVERNOR, TYPE RQV

As explained and illustrated early in Part 1, the governor is best dismantled when it and the injection pump have been drained of lubricating oil (by removing the filler plug) and mounted on a suitable rig, such as the swivel vice 0 681 240 048 shown in fig. 2.

DISMANTLING

1. Unscrew the guide pin (fig. 40, 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. 41) from the floating lever (fig. 42, Item 'B').

2. Again referring to fig. 42, 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. 43) 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,

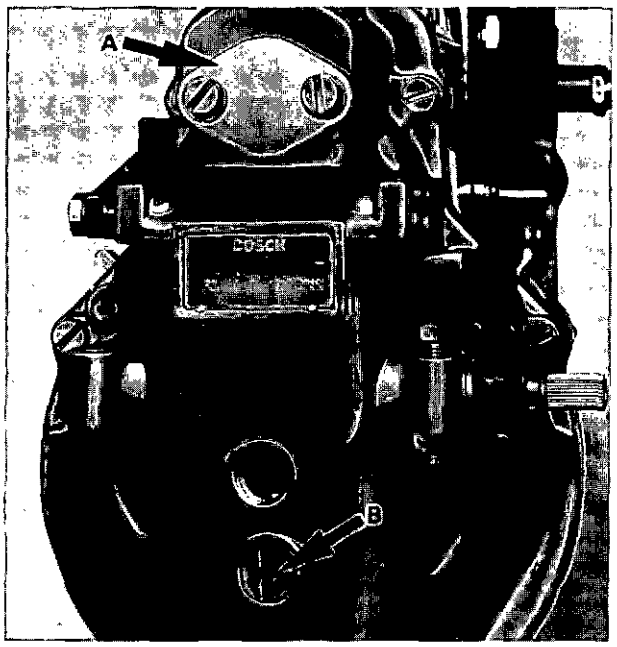


Fig. 40 Rear cover showing rack access 'A'; guide pin 'B'.

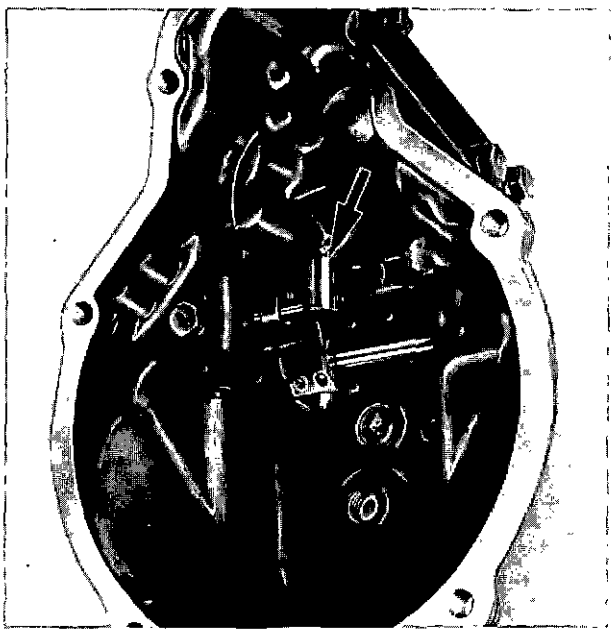


Fig. 41 Rear cover interior; sliding block arrowed.

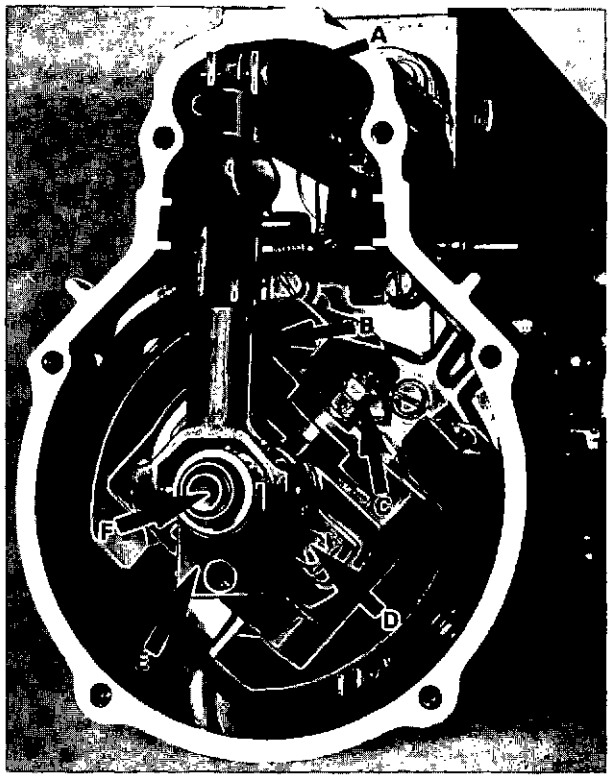


Fig. 42 Governor with rear cover removed.

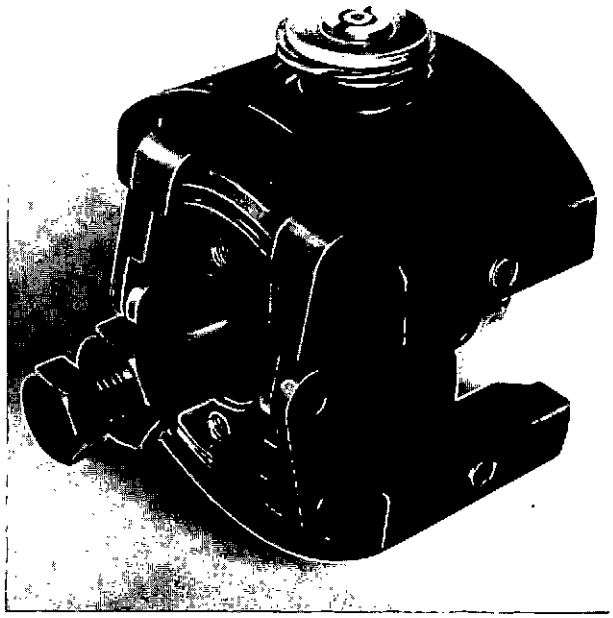


Fig. 43 Flyweight unit and extractor.

renewing where necessary. If required, instructions for reclaiming certain parts (e.g. flyweights) may be obtained from the Manufacturer, but in general it is 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 nut and tighten the nut to 49 Nm (36 lbf. ft.). 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 0.05 and 0.1 mm (0.002 and 0.004 inch). Adjust if necessary, by varying the thickness of the washer beneath the retaining nut. On completion of this check, remove the flyweight assembly 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. 44).

Lightly lubricate the new blocks, and enter them whilst refitting the coupling (fig. 45). 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. 46, 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. 47. A special tool 1 683 455 000, which engages with the filler cap thread, is available for this purpose.

Adjusting pin

This pin (fig. 48) 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 4, 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 40 Nm (36 lbf. ft.), using spanner 1 687 950 064. After tightening, check that the cushion drive is free to operate by moving the flyweight assembly about the camshaft.
2. Fit the guide bush, tighten its securing bolts (fig. 42, Item 'D') and bend up their locking tabs. A sectioned view of the governor assembled to this stage is shown in fig. 49.
3. Check that the internal spring of the adjusting pin (fig. 48) 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. 50), 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 smugly into the slider recess of the adjusting pin (figs. 48 and 51). Adjust, if necessary, by means of the bearing bolt in the adjusting pin, as shown in fig. 50.

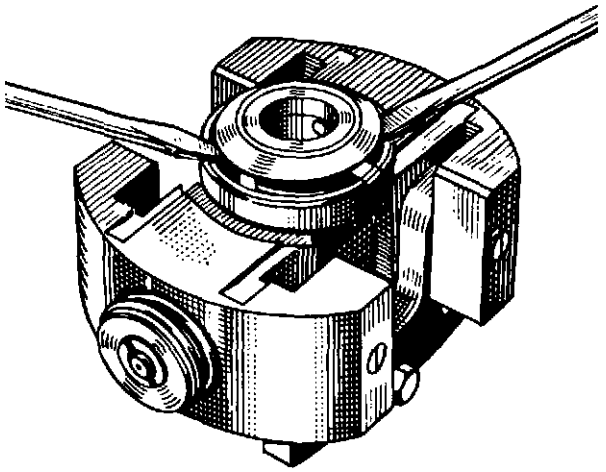


Fig. 44 Removing coupling and rubber blocks.

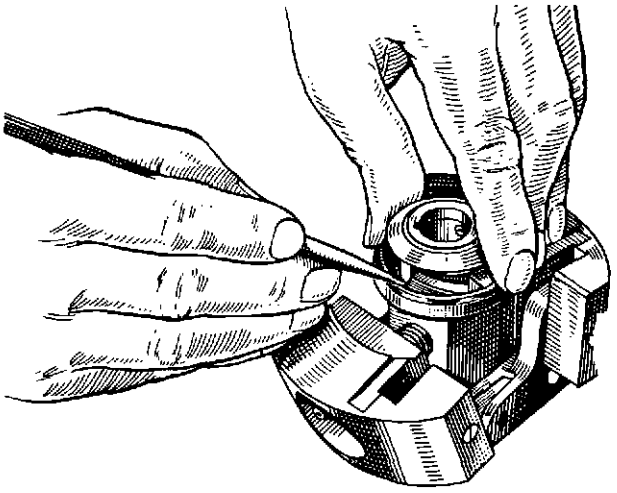


Fig. 45 Fitting coupling and rubber blocks.

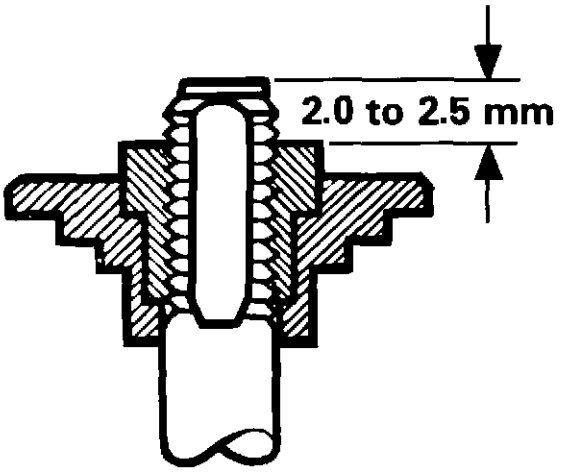


Fig. 46 Flyweight spring basic setting.

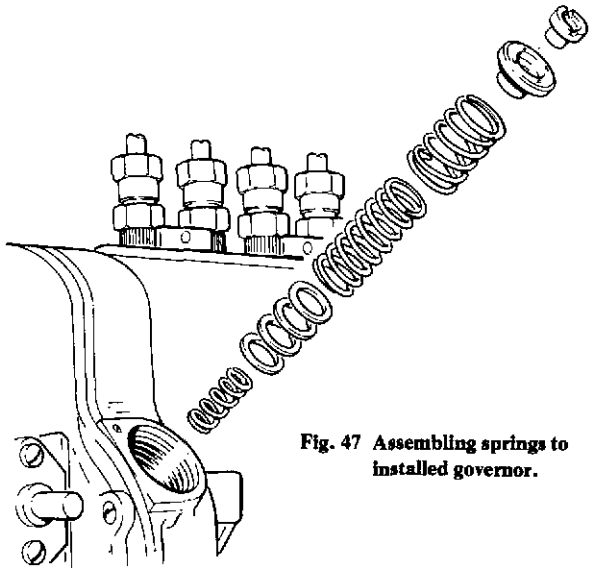


Fig. 47 Assembling springs to installed governor.

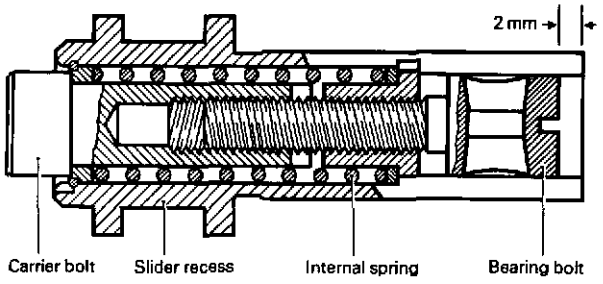


Fig. 48 Adjusting pin - sectioned.

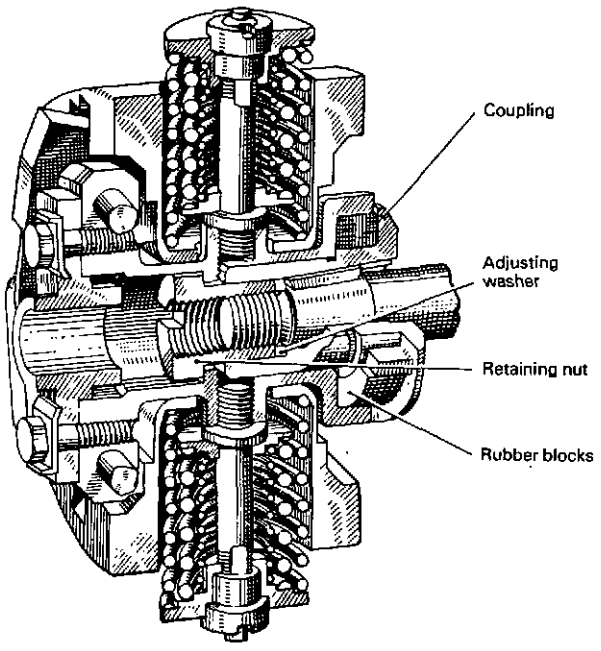


Fig. 49 Flyweight assembly - sectioned.

5. Assemble the coupling bolt so that it has an end float of 1 to 2 mm (0.040 to 0.080 inch), 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. 52).
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. 53. This should be 24.5 mm (0.965 inch). Using the depth gauge as illustrated, deduct from its reading the thickness of the measuring bar and add 3 mm (0.118 inch), 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 4). 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. 41) when it enters the slotted recess in the floating lever (fig. 42, 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 1 of this Section.

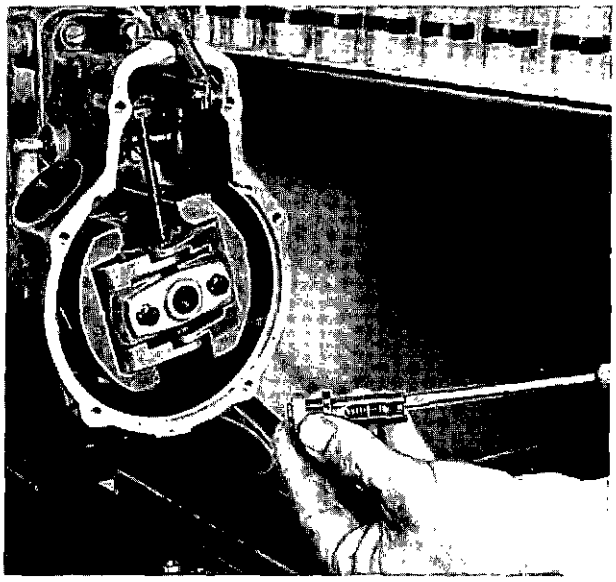


Fig. 50 Adjusting pin and coupling bolt.

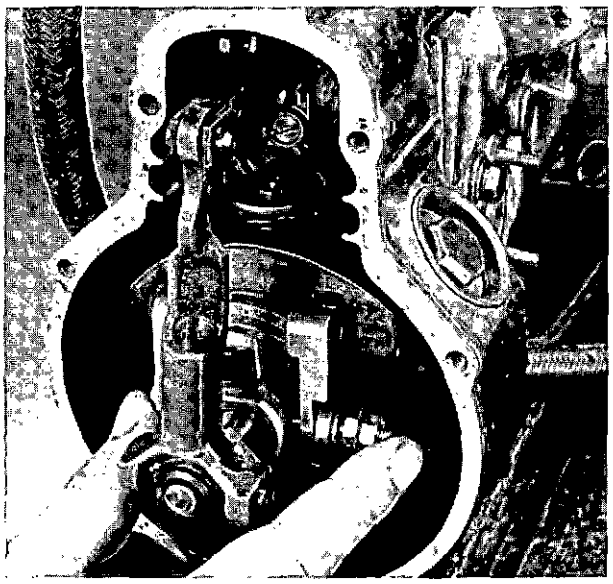


Fig. 52 Coupling bolt, floating lever and slider.

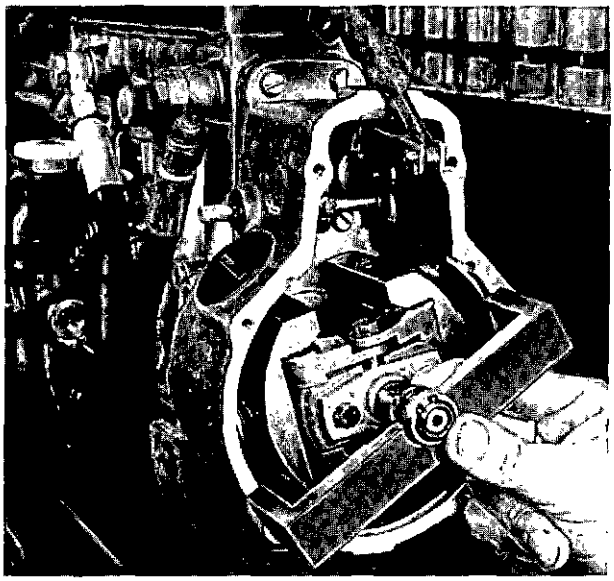


Fig. 51 Gauge for checking sliding sleeve position.

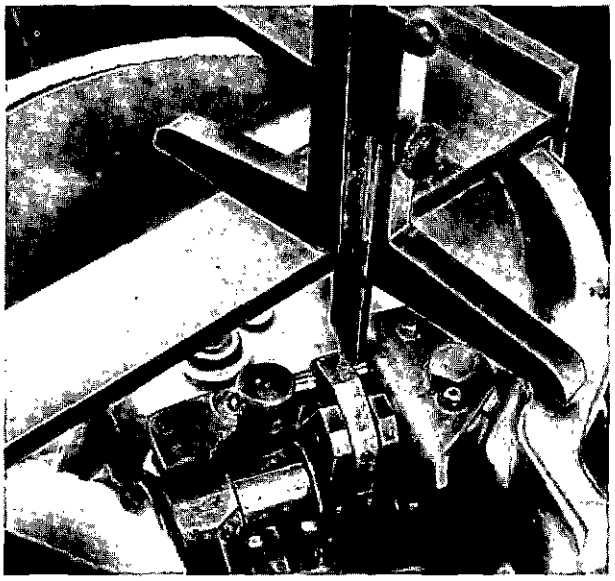


Fig. 53 Checking position of 'S' plate.

PART 3

FEED PUMP—TYPE FP/KD

Description

The feed pump is the spring-loaded plunger type and is mounted in the crankcase 'V' alongside the fuel injection pump. Two inlet and two delivery spring loaded nylon valves are carried in the pump body, the pump being operated by a cam on the engine 'A' bank camshaft.

A hand operated priming pump is an integral part of the fuel pump and it is essential that the plunger is screwed down against the sealing ring to prevent fuel leakage when the pump is not being used.

Dismantling and inspection

Prior to removing the feed pump from the engine, slacken the priming pump casing, the blanking plugs above the remaining three valves and the plug retaining the plunger spring. Remove the priming pump, dismantle the valve assemblies, unscrew the plunger capnut and remove the spring, plunger and spindle. Remove the circlip retaining the tappet assembly and withdraw the unit. Check that the valves are seating correctly and that the springs are in good condition.

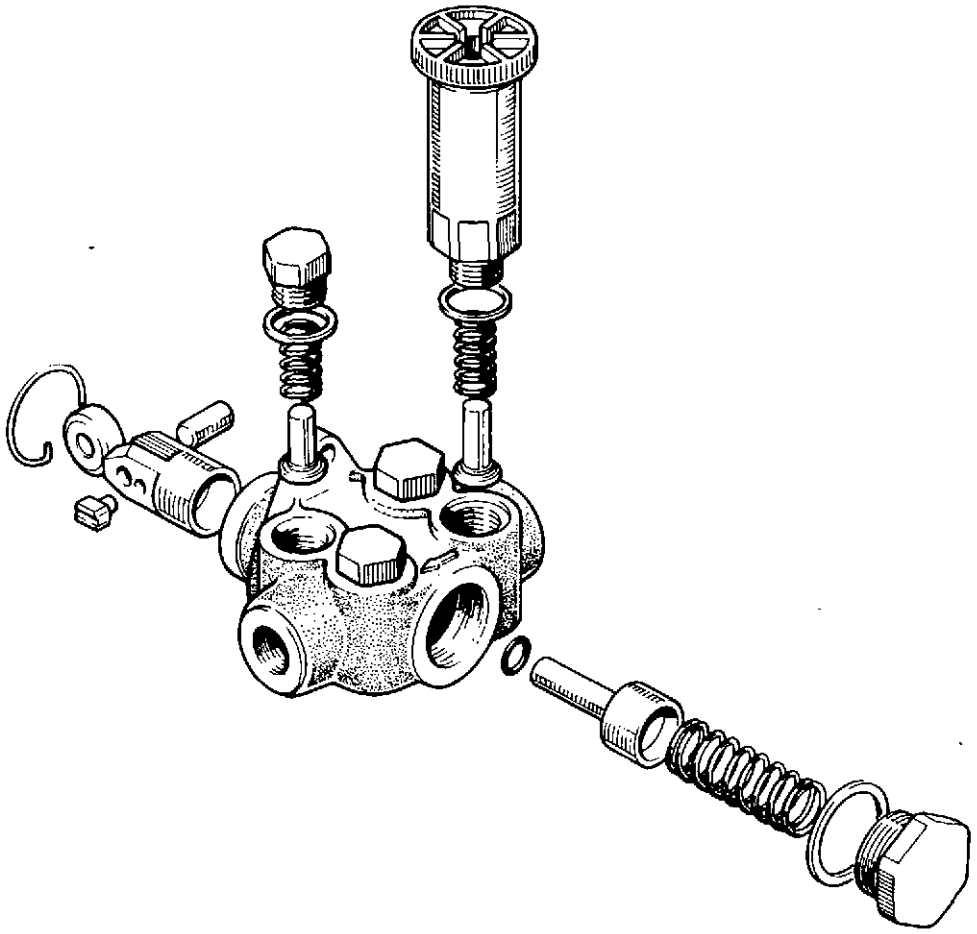


Fig. 54 Feed pump-exploded.

Inspect the plunger and spindle for wear or damage.

Note: The plunger and spring are supplied as a matched pair identified by a colour code, and if necessary must be replaced as such.

Examine the tappet and plunger bores in the housing for scores and wear. Dismantle the tappet assembly and inspect the components for wear and damage. Renew any items in doubtful condition. Permissible wear on the tappet face is 0.076 mm (0.003 inch).

Check the action of the hand priming pump and replace as a unit if found to be unserviceable.

Assembling

Thoroughly clean all parts and smear with a light coating of oil. Assemble the pump in the reverse sequence of dismantling, using new joint washers.

If possible, carry out a leakage test by blanking off the outlet connection and applying air pressure at 193 kN/sq. m (28 lbf/sq. inch) to the inlet connection with the pump immersed in fuel oil. Check for air bubbles, and at the same time operate the plunger to ensure that there is no leakage from the tappet bore.

Check the feed pump output during the 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 140 to 210 kN/sq. m (20 to 30 lbf/sq. inch); feed pump output pressure should easily exceed this. Particulars of further tests involving special apparatus are available from the pump Manufacturer, if required.

PART 4—TEST PROCEDURE

EQUIPMENT SPECIFICATION

Bosch Part No.	Description
—	Test Bench, Bosch 385
1681 443 022	*Test injector, 175 ats., 12 mm and 13 mm bore pumps (1 per element).
1680 750 060	*HP pipe, 12 mm and 13 mm bore pumps (1 per element).
1680 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.	Qty.	Description
—	7244-108	8	Test injectors, 175 ats., 12 and 13 mm, bore pumps.
OD 18514	—	8	HP pipe, 8 x 3 x 760 mm., 12 and 13 mm, bore pumps.
OD 18526	AFB 27	4	Holding-down bolt.
OD 18527	FP 164	4	Banjo union.
OD 18528	AT 16/24/8	3	Banjo bolt, 14 x 1.5 mm.
OD 18529	ALP 104	4	Pipe, flexible.
OD 18530	FP 383	1	Drive coupling, 25 mm. taper.
OD 17531	—	8	Washer, copper, 14 mm.

† Also listed in 'SPECIAL TOOLS, BOSCHE PE PUMP' (see Part 1)

Test Oils

Bosch: 01 61 v 11
Esso: Calibration Fluid iL 1838
Shell (Overseas): Calibration Fluid B
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.

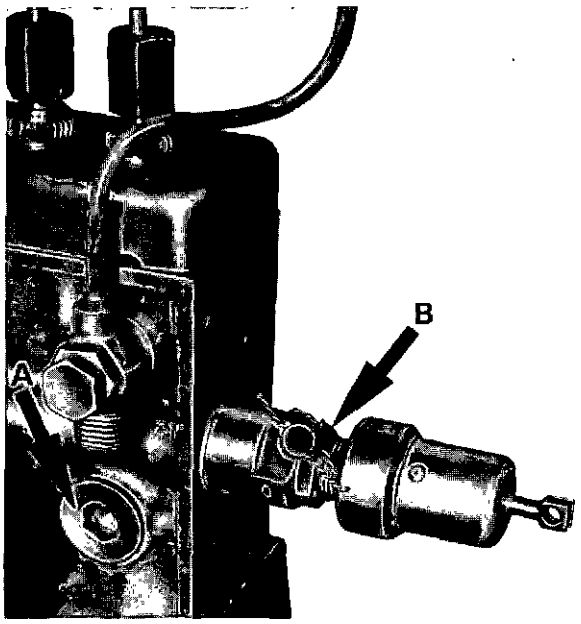


Fig. 55 Tappet access plug 'A'. Rack stop locknut 'B'.

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.

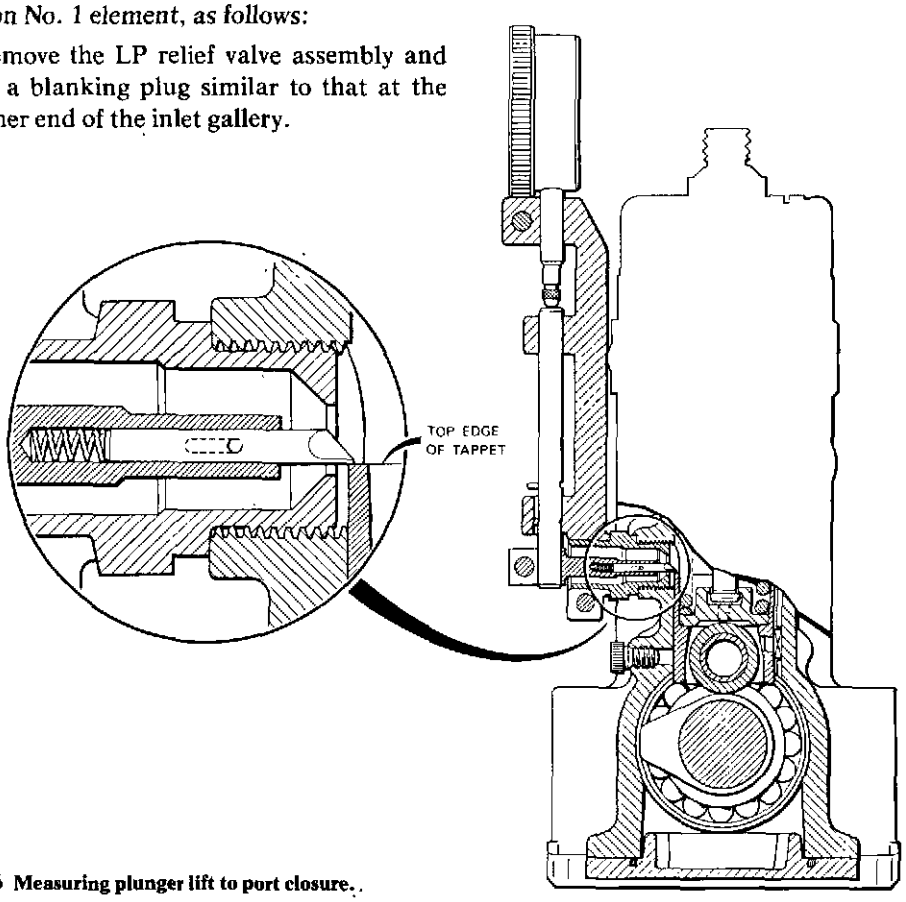


Fig. 56 Measuring plunger lift to port closure.

(ii) Unscrew the access plug to No. 1 tappet (see fig. 55, Item 'A') and turn the camshaft until No. 1 tappet is approximately at BDC.

(iii) Referring to fig. 56, 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.

(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. 57), 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. 55, Item 'A').

2. Phasing

Turning the camshaft in direction of rotation, check the port closures of the remaining elements in sequence order, as applicable, in multiples of 45 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

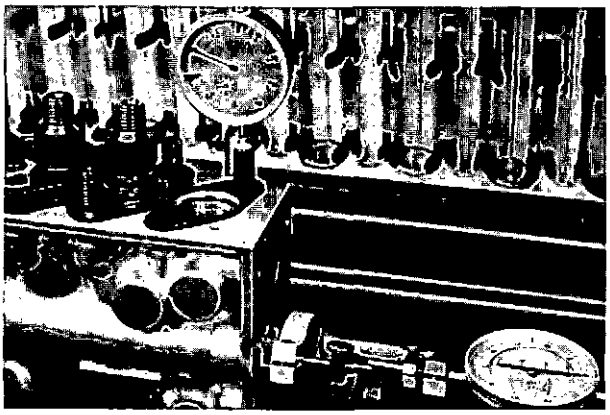


Fig. 57 Adjusting thickness of phasing shims.

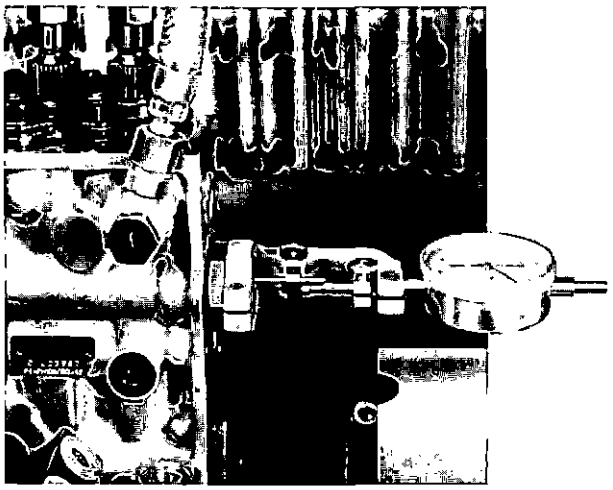


Fig. 58 Measuring rack travel.

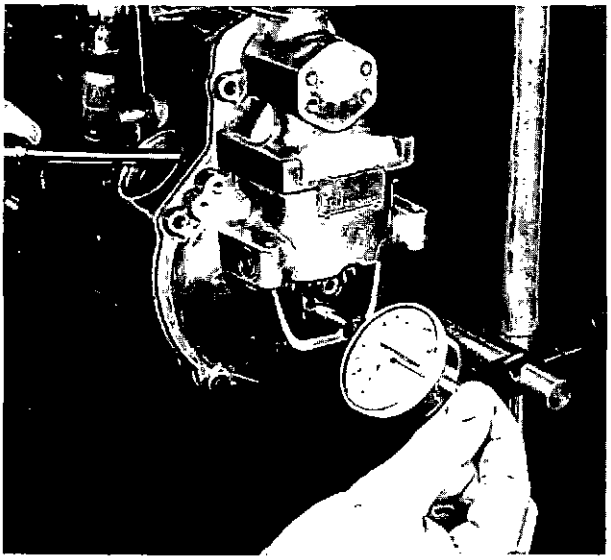


Fig. 59 Measuring sliding sleeve travel.

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 152 kN/sq. inch).

(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. 58. 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 700 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 39 to 43 Nm (29 to 32 lbf. ft). 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. 42).

(i) For protection, a cutaway rear cover should be fitted whilst this operation is carried out. Referring to fig. 59, 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 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 2 '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. 60. Note that the rack travel measuring rig used in Stage 'A' is still fitted.

(iii) Referring to Stage 'B' of the appropriate Test Schedule, run the pump at the speed specified at the top of Col. 1, measure the rack travel and compare it with the limits at the top of Col. 2. 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 $\pm$ 3 degrees.

(b) Alter the setting of the adjusting pin (figs. 48 and 50). 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. 53). Reducing shim thickness by 0.15 mm. reduces rack travel approximately 1 mm., and vice versa.

(iv) Leave the control lever set as the completion of (iii) above and carry out the subsequent tests in Cols. 1 and 2.

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. 55, slacken locknut 'B' and screw the stop clockwise to reduce fuelling, or vice versa as required.

(iii) On completion, tighten the locknut.

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. 40, 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. 61, 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. 61, 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 engine at installation.

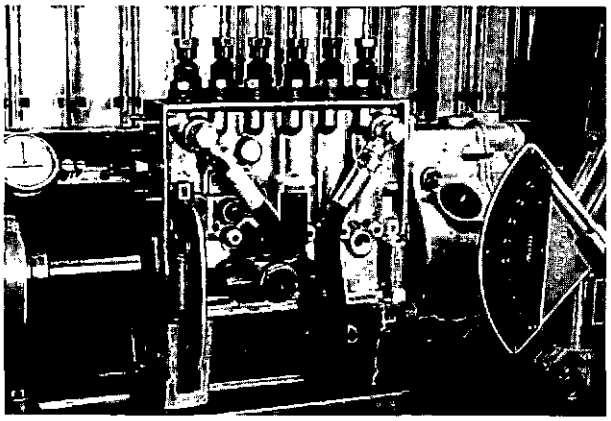


Fig. 60 Checking governor run-out

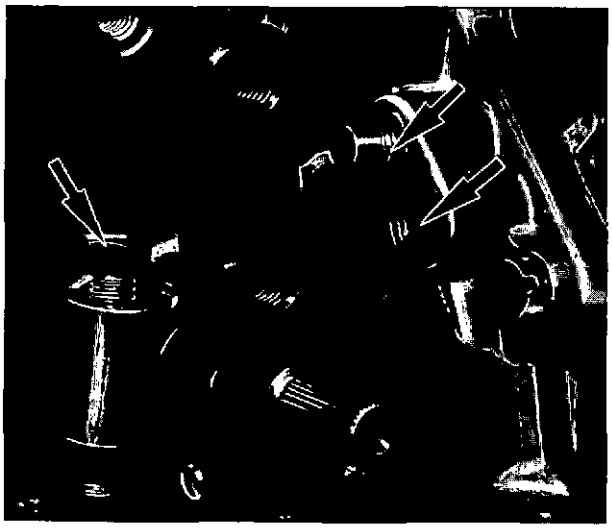


Fig. 61 Control lever stops and seal

TEST SCHEDULE

Engine specification : CV8-300G

Injection pump : PE8P 130A 120RS 3072.

Injection pressure : 178 bars (175 ats).

Governor : RQ 750 PA 533 R

Test oil temperature : 40 deg. C (104 deg. F).

Feed pressure : 22 lbf./sq. inch)152 kN/sq.m).

A. PUMP PRE-STROKE SETTING, PHASING AND CALIBRATING

Pre-stroke setting : *Set plunger lift to port closure at 3.50- 3.60±0.05 mm (3.45-3.65).* Set at 10. 5 mm rack travel.

Phasing : In multiples of 45 deg., using No. 1 as datum. Sequence 1, 3, 6, 5, 4, 8, 7, 2. Limits ± 0.5 deg.

Calibrating : As table below. Basic setting in heavy type.

Pump speed (r.p.m.)	Control rack travel (mm)	Delivery (ccs/100 strokes)	Max. spread (ccs/100 strokes)
700	**12.6**	**32.1 to 32.5**	0.5 (0.9)
300	4.9 to 5.1	4.0 to 4.6	0.8 (1.2)

B. GOVERNOR SETTING

RATED MAXIMUM SPEED		*INTERIM SPEED*			*RATED MINIMUM SPEED*			*SLIDING SLEEVE MOVEMENT*	
Pump speed (r.p.m.)	Control rack travel (mm)	Control lever position (degrees)	Pump speed (r.p.m.)	Control rack travel (mm)	Control lever position (degrees)	Pump speed r.p.m.	Control rack travel (mm)	Pump speed (r.p.m.)	Sleeve travel (mm)
750 to 755	11.6								
755 to 785	3.5								
900	0 to 1.0								

C. FINAL SETTING OF PUMP/GOVERNOR ASSEMBLY

Full load setting on control rack stop		Break-away (Control lever stop)	Excess fuel	
(r.p.m.)	(ccs/100 strokes)	(r.p.m.)	(r.p.m.)	rack travel (mm)
700	32.1 to 32. 5 (31.8 to 32.8)	750 to 755	100	19.5 to 21.0

TEST SCHEDULE

Engine specification : CV8TCA-250kW
Injection pump : PE8P 120A 120 RS3059
Injection pressure : 178 bars (175 ats)
Governor : RQ750 PA 416 R
Test oil temperature : 40 deg. C (104 deg. F)
Feed pressure : 22 lbf./sq. inch (152 kN/sq. m)

A. PUMP PRE-STROKE SETTING, PHASING AND CALIBRATING

Pre-stroke setting : Set plunger lift to port closure at 3.50-3.60 ± 0.05 mm (3.45-3.65). Set at 10.5 mm rack travel.

Phasing : In multiples of 45 deg., using No. 1 as datum. Sequence 1, 4, 3, 5, 8, 7, 6, 2. Limits ± 0.5 deg.

Calibrating : As table below. Basic setting in heavy type.

Pump speed (r.p.m.)	Control rack travel (mm)	Delivery (ccs/100 strokes)	Max. spread (ccs/100 strokes)
700	**14.4 to 14.5**	**24.9 to 25.3**	0.5 (0.9)
300	6.1 to 6.3	40.0 to 46.0	0.8 (1.2)

B. GOVERNOR SETTING

RATED MAXIMUM SPEED		INTERIM SPEED			RATED MINIMUM SPEED			SLIDING SLEEVE MOVEMENT	
Pump speed (r.p.m.)	Control rack travel (mm)	Control lever position (degrees)	Pump speed (r.p.m.)	Control rack travel (mm)	Control lever position (degrees)	Pump speed r.p.m.	Control rack travel (mm)	Pump speed (r.p.m.)	Sleeve travel (mm)
750 to 755	13.4								
775 to 785	4.0								
900	0 to 1.0								

C. FINAL SETTING OF PUMP/GOVERNOR ASSEMBLY

Full load setting on control rack stop		Break-away (Control lever stop)	Excess fuel	
(r.p.m.)	(ccs/100 strokes)	(r.p.m.)	(r.p.m.)	rack travel (mm)
700	24.9 to 25.3	750 to 755	100	19.5 to 21.0

PART 5—AMBAC GOVERNING

Description

The modular designed Ambac governor is offered as an alternative on all CV8 engines.

The system consists of a magnetic pick-up, electronic control unit, a frequency trim potentiometer, and an electromagnetic actuator. The actuator and pick-up 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. 62 and fig. 63)

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.

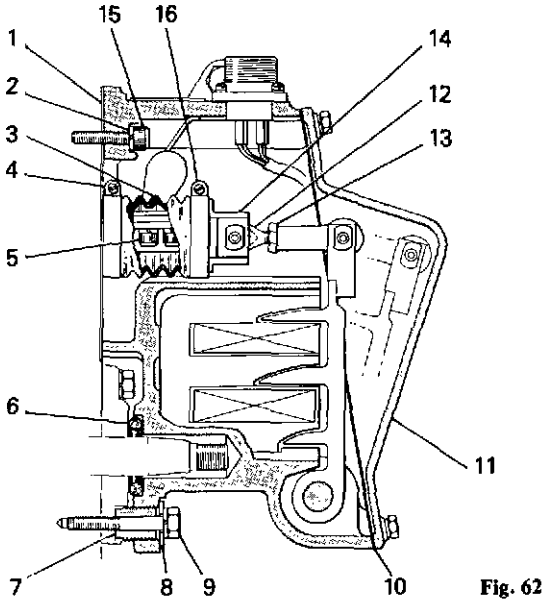


Fig. 62

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 lock-washers (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 9 to 11 Nm (80 to 90 lbf. in). Repeat this operation with the remaining hexagon screw.
9. Check the tightness of all four mounting screws to a torque loading of 9 to 11 Nm (80 to 90 lbf. in).
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.

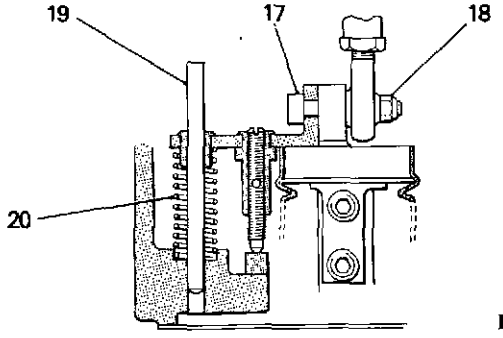


Fig. 63

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.	1. Defective magnetic pick up. 2. Gap too large between pick up and gear teeth. 3. Improper or defective wiring to the pick up.
K	10.1 ± .20 volts DC while energized (Internal regulated D.C. D.C. supply).	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	Above 5.1 volts D.C. while cranking. (Inverse speed error signal). Above 5.1 volts is under speed signal. Below 5.1 volts is over speed signal. On speed will indicate a steady 5.1 volts.	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).	1. Defective control unit. 2. Battery voltage may be too low while cranking.
B	2.5 volts D.C. maximum while cranking. (Transistor voltage).	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.	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.	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.	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 should move to full open position.	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. 64 (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 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.

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

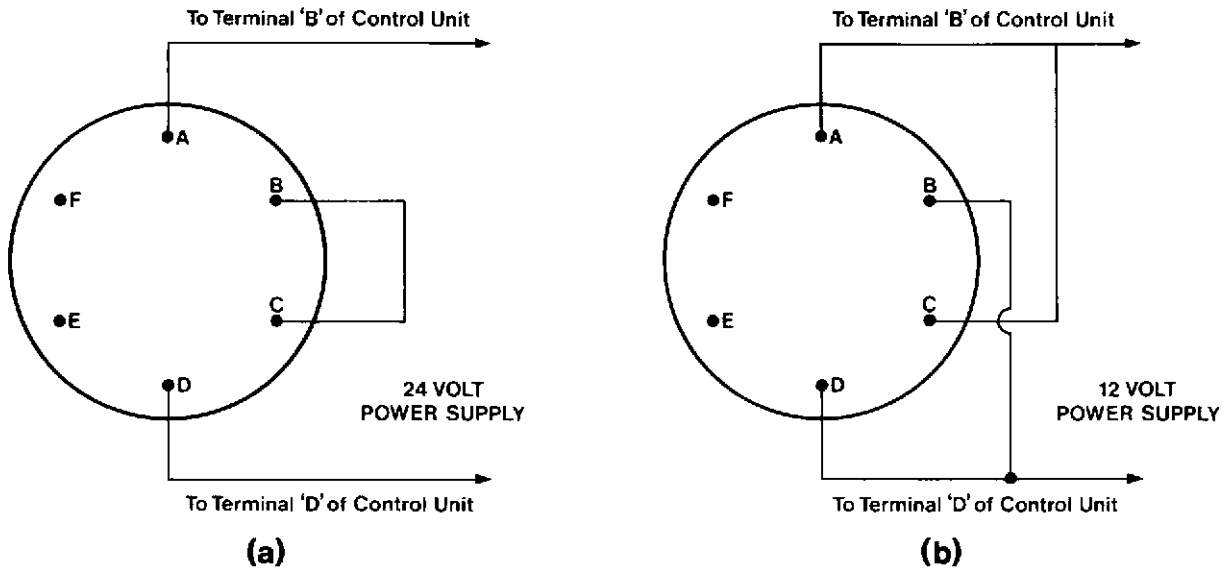


Fig. 64 Actuator connector wiring diagram.

PART 6—FUEL INJECTORS

Description

The Bosch type injector consists of a 'KBAL' type nozzle holder fitted with a 'DLL' type nozzle. The nozzle valve has six spray holes of 0.33 mm diameter x 0.7 mm long and is lapped into a mated body to form a nozzle assembly. It has an opening pressure of 240 bars (240 atmospheres) which may be adjusted by fitting shims of the required thickness under the spring. Shims are avaialable in varying sizes. A spill connector is fitted in the side of the injector body.

Dismantling

Secure the injector in a suitable clamp and remove the nozzle capnut. Withdraw the nozzle assembly, transfer block, spring cap and spring together with the adjusting shim, and place them in a suitable tray.

Note: The needle valve and nozzle body are a matched pair and must be kept together.

Cleaning

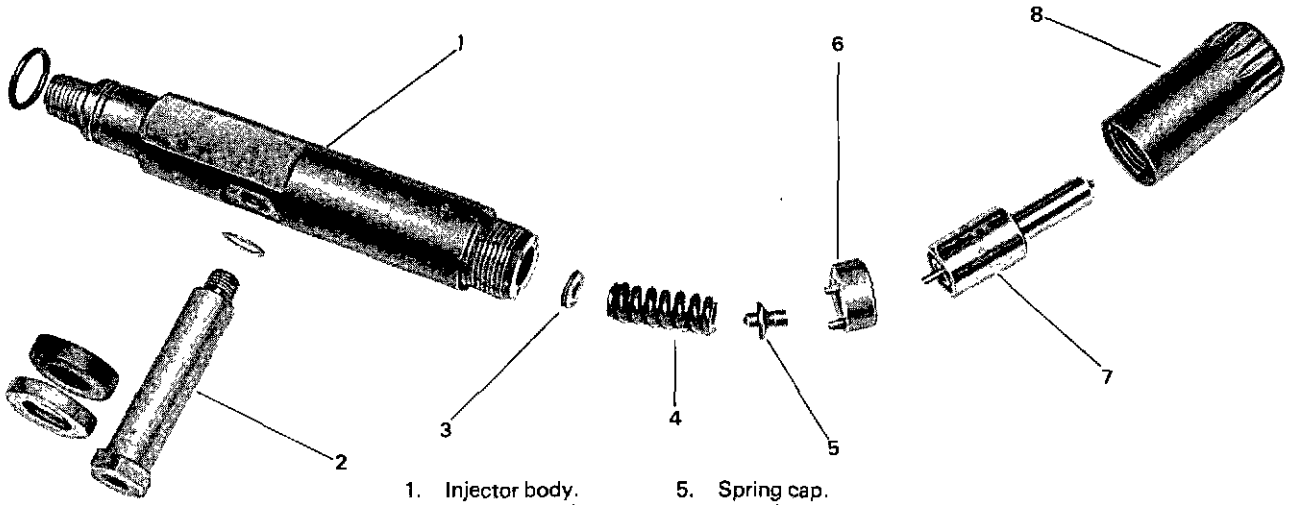
Wash the components in paraffin and dry off with compressed air. Remove any carbon or dirt from the nozzle assembly using the tools supplied in the Cleaning kits, CVK 508 or KRP 1089. Dip the needle valve in test oil and insert into the nozzle body. Nozzle spray holes have a diameter of 0.33 mm and it is important that they are free of all carbon. Use the correct cleaning wire supplied in the cleaning kit to remove any carbon from the holes and blow out with compressed air. When all the holes are clear, soak the nozzle in a carbon solvent such as 'Ardox' 690 or 1618 obtainable from Ardrox Limited, Commerce Road, Brentford, Middlesex.

Caution: Only tools supplied in either of the previously quoted cleaning kits should be used.

Inspection

After cleaning the nozzles carry out a visual examination using a magnifier, with particular attention to the following points:

1. Check the needle valves for pounded or rough valve seats and wear or damage.
2. Check the nozzle body for damage to the seat or worn injection holes.



1. Injector body.
2. Spill connection.
3. Shim.
4. Spring.
5. Spring cap.
6. Transfer block.
7. Nozzle assembly.
8. Nozzle capnut.

Fig. 65 Injector—Exploded view.

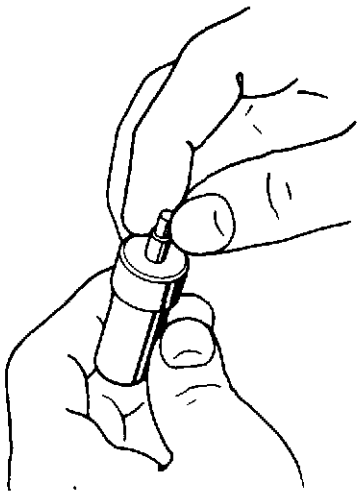


Fig. 66 Slide test.

Following the visual examination, a slide test as in fig. 66 should be conducted on all nozzles. Hold the nozzle body in a near vertical position and insert the needle valve, previously dipped in test oil. The needle valve when raised to approximately one third of its guide length and then released, should slide down on to its seating under its own weight.

Assembling

Assemble all the components to the injector body in the correct sequence. Use the shim as originally fitted and ensure that the transfer block is correctly located. Secure the injector in a suitable clamp and tighten the nozzle capnut to a torque load of 81 Nm (60 lbf. ft.).

Testing

Absolute cleanliness is essential during all tests. The testing should be carried out using a nozzle setting outfit filled with clean test oil. Open the air-vent screw and operate the hand lever until bubble-free oil flows from the vent screw bore. Tighten the air-vent screw and continue pumping until bubble-free oil emerges from the delivery line connection. The nozzle tester outfit is now ready for use.

Alternative recommended Test Oils

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

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.

Setting and Testing

The following tests must be carried out:

1. Opening pressure test.
2. Leakage test.
3. Spray pattern and chatter test.

Opening pressure test

The opening pressure of the injectors is specified under the Engine Data in this Manual and should be adjusted accordingly.

With the gauge open to pressure, slowly depress the hand lever until the nozzle ejects with a slight chattering and take note of opening pressure on gauge. If the reading differs from the specified opening pressure it must be adjusted by changing the total shim thickness; use only a single shim where possible. Increase shim thickness to obtain more pressure and lessen shim thickness to reduce pressure. When dismantling the injector to adjust shim thickness ensure that strict cleanliness is maintained. Continue with this process until the correct opening pressure is obtained.

Caution: When the pressure gauge is open to pressure, always increase or decrease pressure slowly to prevent any possible damage to the gauge.

Leakage test

Operate the hand lever of nozzle tester until a pressure of 20 bar (19.7 atmospheres) below the specified opening pressure is indicated. Under this pressure, the nozzle is considered leakproof if not one drop of oil emerges at the end of nozzle during a 10 second period.

Before rejecting a nozzle assembly ensure that leakage is not due to dirt on the seating faces.

Chatter test and spray pattern

Caution: For this test it is essential to by-pass the pressure gauge.

When the hand lever is operated at approximately two downward movements per second, it is normal to obtain nozzle chatter. During this test the spray need not be even and well atomised.

3. Release the heat exchanger-to-sump elbow connection.
4. Unscrew the heat exchanger retaining bolts and remove the assembly.

Dismantling

1. Secure the Assembly Fixture, VT 17038, in a vice with both the hand screw assemblies fully out.
2. Position the heat exchanger on the assembly fixture and remove the two tube pack locating screws.
3. Push one hand screw slide fully inwards and twist it into its lock position.
4. Turn the hand screw sufficient to force the tube pack out far enough to remove one 'O' ring seal.
5. Slacken off the hand screw and slide to the original position.
6. Repeat the operation from the opposite end to remove the second 'O' ring seal.
7. Remove the heat exchanger from the assembly fixture and carefully withdraw the tube pack.

Inspection and cleaning

Wash the tube pack in paraffin, blow through the tube bores with an air jet then wash the pack in hot fresh water.

Hard deposits in the tube bores may be removed by soaking the pack in a solution of 1 part inhibited hydrochloric acid to 3 parts fresh water. When the frothing ceases, immerse the pack in a solution of washing soda (sodium carbonate) in hot fresh water 0.5 kg to 25 litres (1 lb to 5 Imp. gallons). Finally blow through the tube bores with an air jet and wash the pack in hot fresh water.

Inspect the tube pack for corrosion or damage and if possible subject the pack to a pressure test by applying air at 172 kN/sq. m (25 lbf./sq. inch) to the tube bores with the pack submerged in water at 80 deg. C.

Assembling

Clean out the housing, push the tube pack through from the rear end until the front groove is clear of the housing and fit a new 'O' ring. Push the tube pack back until the rear groove is visible and fit the other new 'O' ring. Carefully position the pack in the housing and fit the two small locating screws using new spring washers.

Refitting

Reverse the procedure as previously given for removal, using new 'O' rings and gaskets.

SUMP

Description

The cast aluminium sump has a capacity of 36.3 litres (8 Imp. gallons) with an oil well at the one end, and is reversible for certain applications. A suction intake strainer, fitted in the bottom of the sump, is retained by seven self-tapping screws. The strainer should be removed and cleaned each time the sump is removed.

Removal (Engine installed)

The following procedure should be followed when it becomes necessary to remove the sump:

1. Remove the sump drain plug and drain the oil into a suitable container.
2. Disconnect the heat exchanger to sump connection and remove the oil filler tube and dipstick tube.
3. Support the sump.

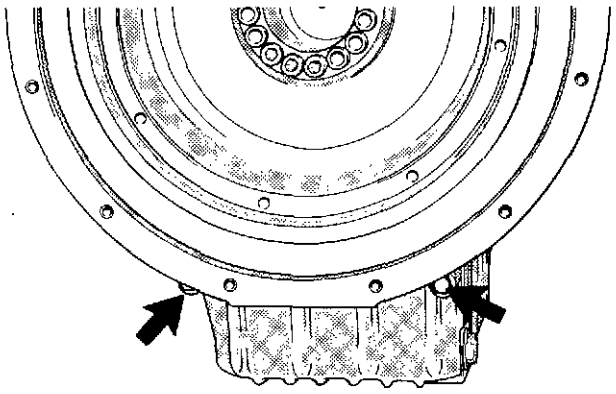


Fig. 3 Sump securing setbolts.

4. Remove the two setbolts which enter the sump through the bottom of the flywheel housing and two similar setbolts through the front engine mounting.

5. Unscrew and withdraw all the setbolts securing the sump to the crankcase.
6. Lower the sump from the engine.

Refitting

The refitting of the sump is a complete reversal of the removal procedure, with added attention to the following points:

Clean the crankcase and sump joint faces carefully, and lightly coat the faces with Wellseal.

Screw two Guide Studs VT 17846 into two holes in the crankcase and fit a new sump gasket in position.

Lift the sump into position over the guide studs, taking care not to disturb the gasket. Secure the sump in position with the retaining setballs and tighten to a torque loading of 55 Nm (40 lbf. ft.).

Fit new gaskets to the heat exchanger and oil filler connections.

Fit a new sealing washer to the sump drain plug and tighten the plug to a torque loading of 110 to 115 Nm (80 to 85 lbf. ft.).

Fill the sump with the approved grade of oil to the UPPER mark on the dipstick. Start the engine and run for a few minutes.

Stop the engine and check for leaks.

Check the oil level and replenish to the UPPER mark on the dipstick, if necessary.

OIL FILTERS

Description

Two expendable canister type filters are mounted beneath the header bracket, which is an integral part of the oil-to-coolant heat exchanger casing.

Each canister has a built-in by-pass valve which, if the element becomes blocked, opens to allow a continuous flow of oil through the system.

Filter replacement

Filters should be renewed at the periods given in the Servicing Manual T.S.D. 3115. If however it is necessary to replace filters in service the following sequence should be followed:

1. Place a container beneath the heat exchanger and remove the faulty filter, using the Filter Wrench, VT 18038, if necessary.
2. Clean the contact faces of the filter header and fill the new filter with the approved grade of lubricating oil.
3. Screw the filter into position until the rubber sealing rings *just* contact the seal face of the header. Tighten the filter a further three-quarters of a turn by hand. DO NOT OVERTIGHTEN.

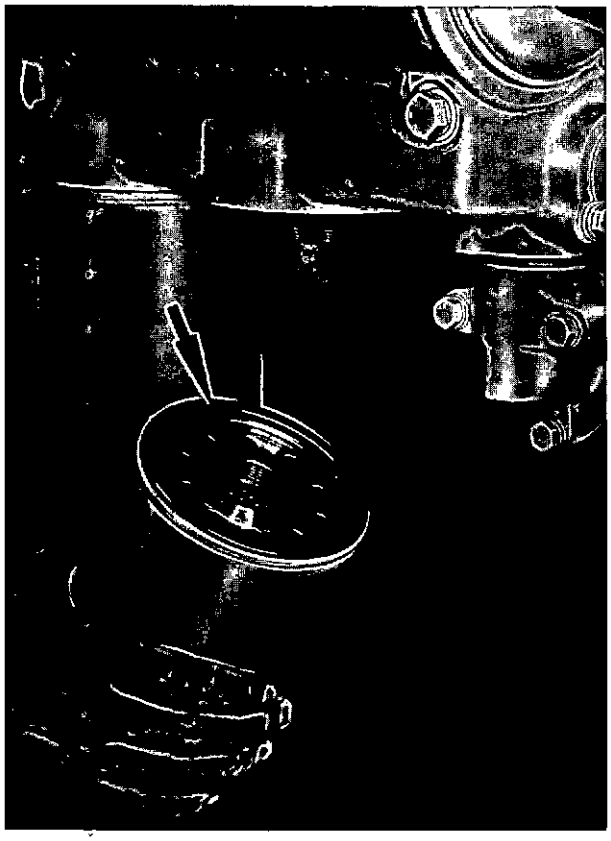


Fig. 4 Oil filter and sealing ring.

4. Fill the sump to the UPPER mark on the dipstick with the approved grade of oil, and start up the engine.
5. Stop the engine, check the oil level, and replenish to the UPPER mark on the dipstick, if necessary.

SPECIAL TOOLS

Part No.	Description
VT 17846	Guide stud, sump to crankcase.
VT 18386	Removal tool, oil relief valve spring.
VT 17038	Fixture assembly, heat exchanger.
VT 18038	Wrench, oil filter.

SECTION 13—INDUCTION/EXHAUST SYSTEM

Description

The induction system of the engine is supplied with air under pressure by means of a Holset type 4LGK turbocharger driven by the energy of the waste exhaust gases.

Cast iron manifolds direct the exhaust gases to the turbine wheel of the turbocharger rotor causing the rotor to spin. The turbocharger compressor wheel, which forms part of the rotor assembly draws air through the air cleaner and delivers it to the induction manifolds, under pressure, to be distributed to each cylinder as the inlet valves open.

Some engine applications require the use of charge coolers, which are interposed between the turbocharger and the induction manifolds and serve to lower the temperature of the compressed induction charge prior to it passing into the engine.

Air to air charge coolers are normally used and these form part of the radiator matrix.

The compressor directs air through pipework incorporated in the radiator to be cooled, together with engine coolant. The cooled air is then delivered via large bore pipework to the induction manifolds.

TURBOCHARGER

Description

The turbocharger is a turbine driven compressor which utilises the energy of the exhaust gases to increase the mass of the induction charge.

The unit consists of a core assembly which houses the rotor assembly and bearings and to which is secured the turbine housing and the compressor cover.

The rotor bearings are of the fully floating sleeve type. Lateral location of the rotor and control of end float is achieved using a shaft mounted thrust ring assembly and a thrust bearing plate. Drillings in the core assembly direct oil to the bearings and the thrust bearing, the rotor assembly is sealed at each end by piston ring type seals.

Dismantling (See figure 1)

1. Clamp the unit upright in a vice, grip on the turbine inlet flange.
2. Mark the relative positions of turbine housing, core assembly, compressor cover and 'V' clamp.
3. Remove the setbolts securing the compressor cover, lift away the cover.
4. Remove the 'V' clamp locknut and spring the 'V' clamp back on to the core assembly. Lift the core assembly away from the turbine housing.
5. Using a ring spanner on the turbine wheel hub, hold the rotor and remove the compressor wheel locknut.
6. Slide the compressor wheel off the shaft.
7. Using circlip pliers, remove the compressor insert retaining ring.
8. Using two screwdrivers, lift the insert from the core assembly and remove the 'O' ring seal.
9. The individual parts of the thrust assembly can then be removed:
   a. Flinger sleeve, to be gently pushed out of the insert.
   b. Oil deflector, positioned by two groove pins.
   c. First Thrust ring.
   d. Thrust bearing.
   e. Spacer.
   f. Second Thrust ring.

   Note: The groove pins are a press fit in the core assembly and should not be removed.
10. Remove the shaft and turbine wheel assembly taking care not to damage the piston ring type seals.
11. Remove the turbine backplate retaining ring, using circlip pliers, lift away the backplate.
12. Remove the bearing retaining snap ring from the compressor end of the core assembly.
13. With the finger tip, remove the bearing from the bore.

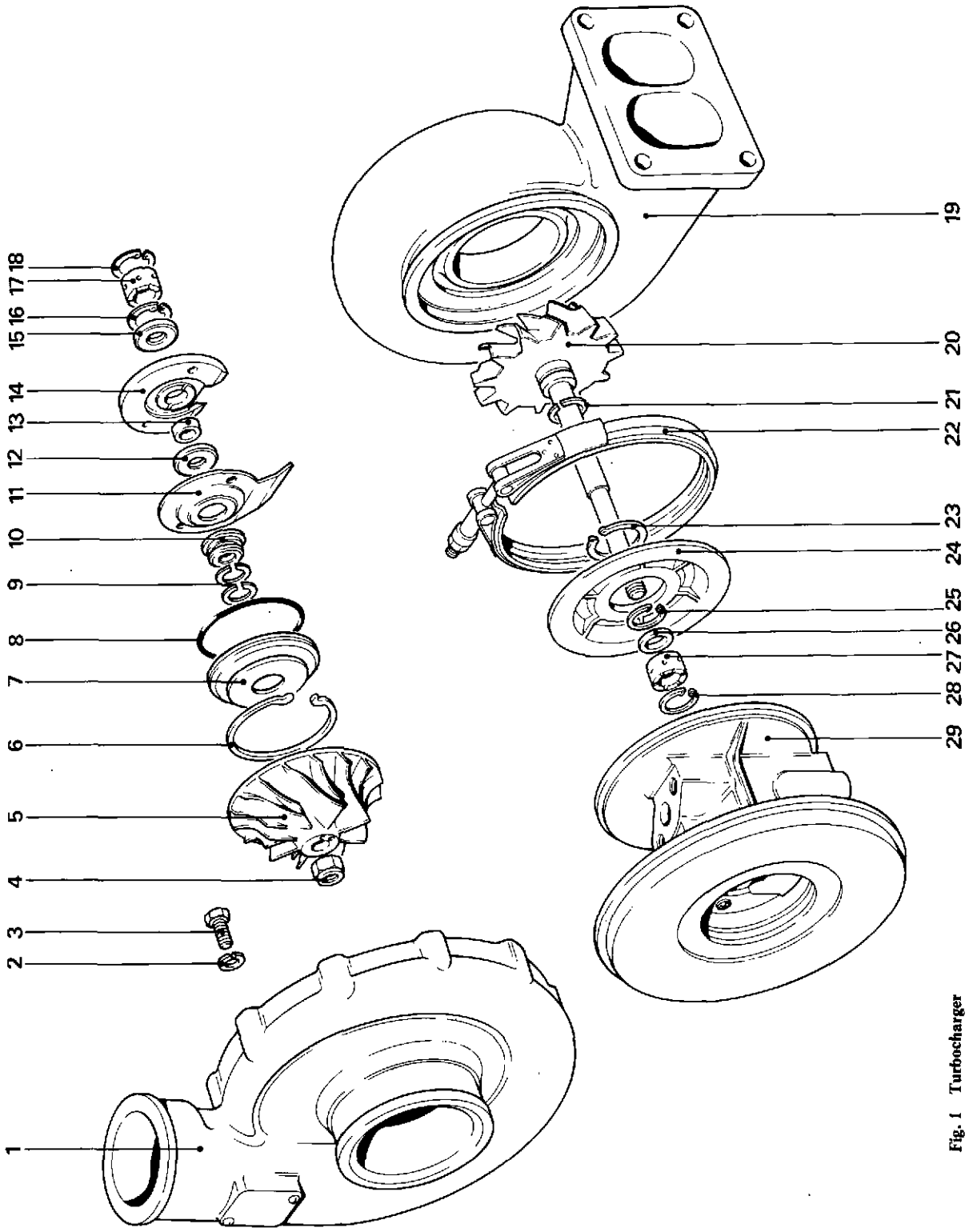


Fig. 1 Turbocharger

14. Remove the inner bearing retaining snap ring from the bore.

    Note: When removing snap rings, great care must be taken not to damage the bearing bore.

15. Repeat the above procedures to remove from the turbine end of the core assembly:
    a. Outer snap ring.
    b. Oil control sleeve.
    c. Turbine end bearing.
    d. Inner snap ring.

    Carefully expand and remove the piston ring seals from the rotor shaft and the flinger sleeve.

    Note: The over expansion of the piston ring seals will give a permanent set to the seals or cause them to break.

Cleaning

1. Using a suitable non-caustic cleaner, soak all parts until all deposits have been loosened.
2. With a plastic scraper or a bristle brush remove all deposits. Vapour blast may be used provided that the shaft and all bearing surfaces are protected.
3. Clean all drillings with a compressed air jet.
4. Give particular attention to the surfaces of stationary housings adjacent to rotating members, ensuring that these are free from deposits, clean and smooth.

Inspection

1. **Shaft and turbine wheel**

   a. Inspect bearing journals for wear and scratches. Minor scratches, those able to be polished out using a mild abrasive are acceptable, well defined scoring and ridges due to wear, render the assembly unserviceable.

   b. Inspect the piston ring seal groove for wear and scoring. Minor scratches only are, acceptable. A maximum groove width of 2.0mm (0.078 in.) is acceptable.

   c. Carefully check the turbine wheel for cracked, bent or damaged blades. Do not attempt to straighten bent blades.

KEY TO FIGURE 1

1 Compressor cover	16 Snap ring
2 Spring washer	17 Bearing
3 Set screw	18 Snap ring
4 Lock nut	19 Turbine housing
5 Compressor wheel	20 Shaft and turbine wheel assembly
6 Retaining ring	21 Piston ring seal
7 Insert	22 'V' clamp
8 'O' ring insert	23 Retaining ring
9 Piston ring seals	24 Turbine back plate
10 Flinger sleeve	25 Snap ring
11 Oil deflector	26 Oil control sleeve
12 Thrust ring	27 Bearing
13 Spacer	28 Snap ring
14 Thrust bearing	29 Core assembly
15 Thrust ring	

2. **Bearings**

   The bearings should be replaced if the surface coating shows any signs of wear or scoring. Only minor scratches are acceptable.

3. **Core assembly**

   Replace the core assembly if the bearing or piston ring seal bores are scored or worn. Minor scratches only are acceptable.

4. **Flinger sleeve**

   Examine piston ring seal grooves and replace sleeve if the grooves are damaged or if groove width exceeds 1.8mm (0.070 in.).

5. **Piston ring seals**

   The seals should be replaced if any sign of wear or scoring is visable.

6. **Thrust rings and thrust bearing**

   Rings and bearings should be replaced if the surfaces show any signs of scoring or pitting.

   Minor scratches only are acceptable.

   Ensure that the oil feed drilling in the thrust bearing is clean and free from obstruction.

7. **Compressor wheel**

   Carefully check the compressor wheel for cracked, bent or damaged blades. Do not attempt to straighten bent blades.

8. **Compressor wheel, shaft and turbine wheel assembly**

   With the compressor wheel mounted on the shaft together with the thrust ring assembly and the whole supported by the bearings on 'V' blocks, a run out of .02mm (0.0008 in.) measured on the outside diameter of the compressor wheel is acceptable.

TYPE A 13 ALTERNATOR

Description

This is a 3-phase delta-connected fan-cooled machine of the rotating field and stationary armature type. Rectification is by six renewable silicon diodes, mounted in two heat sinks across which is a 0.15 microfarad capacitor to smooth transient voltages. Three sensing diodes in a plastic capsule attached to the AC terminals permit the use of a warning light.

The rotor runs in sealed bearings carried in the end housings, and a fan at the driving end of the rotor shaft directs cooling air through the alternator.

Limitations are as follows:

Cut-in speed (alternator rpm)	750
Max. output at 28 volts	30 amps
Max. speed (alternator rpm)	10,000

Voltage regulator (Control board)

The *R1* regulator is fully transistorised and requires no servicing. To suit Operators' requirements the output voltage may be varied by means of an adjusting screw, mounted beneath a sealing plug in the regulator cover. Turn the screw clockwise to increase the voltage, and vice versa. Replace the sealing plug after adjustment.

DISMANTLING

1. Hold the pulley with wrench OE 44083 and unscrew the pulley nut. Withdraw the pulley, using extractor OE 44398, and remove the fan. Extract the Woodruff key from the rotor shaft.
2. Remove the brush cover, withdraw the brushes, unscrew the four screws securing the brush housing and remove the housing.
3. Remove the three through-bolts and, using a brass drift, gently tap on the slip ring end of the rotor shaft to part the slip ring end housing from the stator. Disconnect the three AC terminals before fully separating the units.
4. Support the drive end housing and carefully press out the rotor.

INSPECTION AND REPAIR

Stator

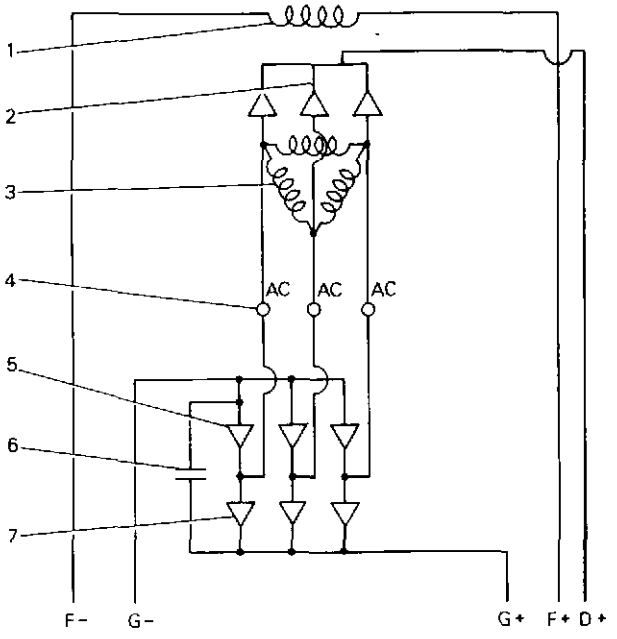
Clean the stator by blowing off dirt and carbon dust, and wipe clean using a cloth moistened with 'Genklene' N. When dry, inspect the windings and, using a 12 volt test lamp, make the following checks:

When dry, inspect the windings and, using a 12 volt test lamp, make the following checks:

1. Between each of the three terminals and the stator frame. The lamp should not light.
2. Between each terminal and the other two in turn. In each case the lamp should light.

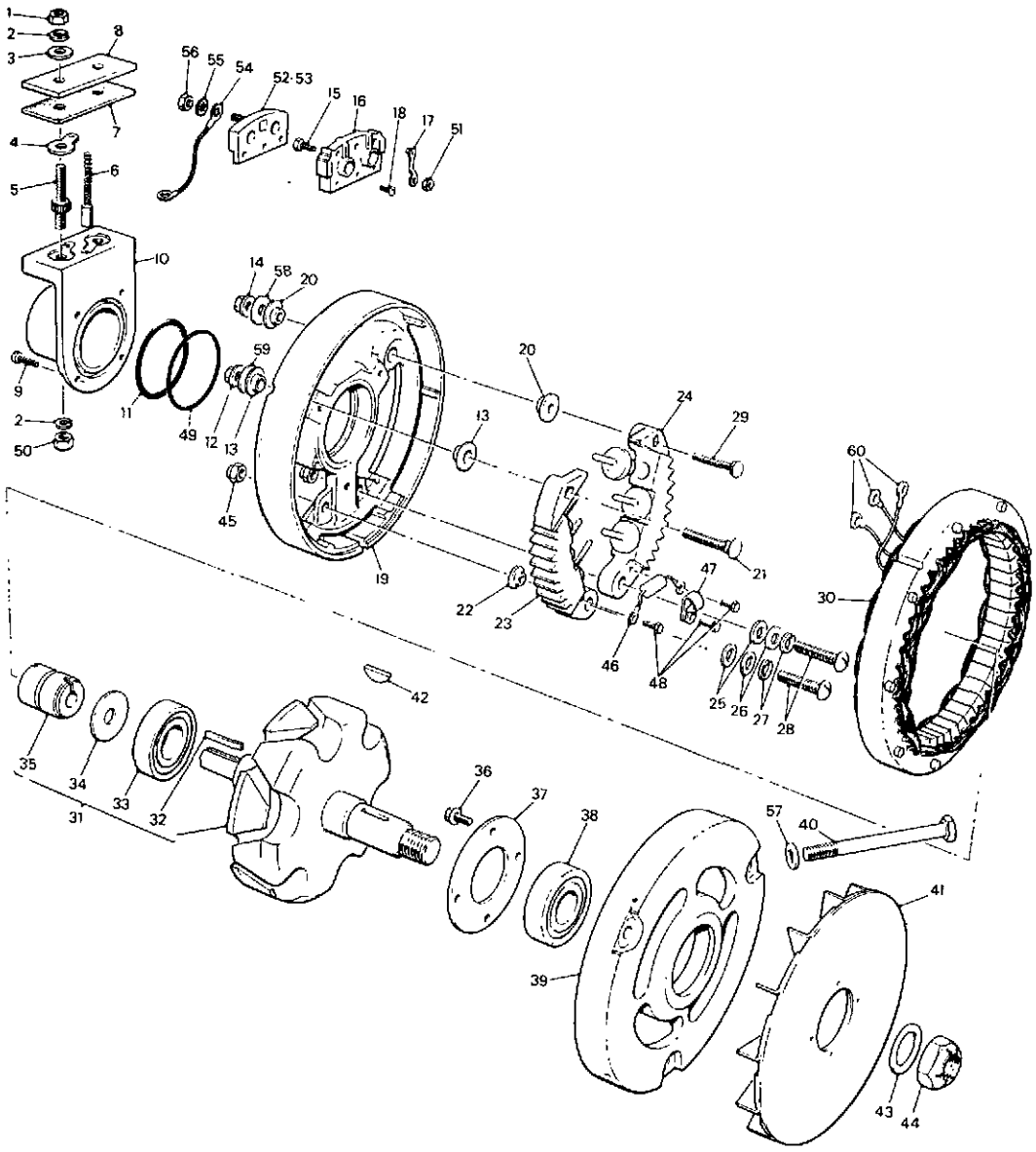
Bearings

Check the rotor bearings for wear and renew them if necessary. One bearing is retained by a plate in the drive end housing; the other is carried behind the slip rings on the rotor shaft. Both bearings are sealed and do not require lubrication. They should not be removed unless renewal is necessary.



1. ROTOR (FIELD) COIL
2. POSITIVE SENSING DIODE
3. STATOR WINDING
4. AC TERMINALS
5. NEGATIVE DIODES
6. CAPACITOR
7. POSITIVE DIODES

Fig. 1 Butec Type A 13 alternator circuit



1 Nut
2 Lockwasher
3 Washer
4 Jumper
5 Terminal stud
6 Brush assembly
7 Gasket
8 Cover
9 Screw
10 Brush housing
11 Sealing ring
12 Nut
13 Insulation bush
14 Nut
15 Screw
16 Insulator
17 Jumper assembly
18 Screw
19 Housing
20 Insulation bush
21 Terminal screw
22 Insulation bush
23 Rectifier assembly (+)
24 Rectifier assembly (−)
25 Insulation washer
26 Washer
27 Lockwasher
28 Screw
29 Terminal screw
30 Stator assembly
31 Rotor assembly
32 Wedge
33 Bearing
34 Insulation washer
35 Slip ring assembly
36 Screw
37 Retainer-bearing
38 Bearing
39 Housing
40 Bolt
41 Fan assembly
42 Woodruff key
43 Washer
44 Nut
45 Nut
46 Capacitor assembly
47 Clamp
48 Screw
49 Sealing ring
50 Nut
51 Nut
52 Diode Capsule
53 Diode Capsule
54 Lead assembly
55 Washer
56 Nut
57 Washer
58 Washer
59 Washer
60 Terminal

Fig. 2 Butec Type A 13 alternator

Rotor

Check the resistance between the slip rings. Limits are 13 to 14.2 ohms. If the resistance is outside these limits, or if the rotor coil is open circuited or earthed, the rotor must be renewed.

Inspect the slip rings for wear and damage. Unserviceable slip rings may be renewed as follows:

1. Unsolder the wire connecting the rotor coil to the outer slip ring; bend the wire until it is parallel to the shaft and unsolder the wire from the inner slip ring. Pull or press off the slip rings and remove the insulating washer.
2. Gently warm the new slip ring assembly to avoid cracking during fitting, Assemble a new insulating washer, position the slip ring assembly so that its slots are aligned with the rotor coil wires, and carefully press it up to the shoulder on the rotor shaft. Solder the coil wires to the new slip ring.
3. Set up the rotor assembly in a lathe and take a light, smooth cut from the faces of the slip rings to ensure they are concentric with the shaft within 0.05 mm (0.002 inch) total indicator reading.

Brushes

Renew the brushes if they are damaged or worn beyond the minimum length of 4.8 mm (0.188 inch).

Rectifier

Check each diode in turn, using a 12 volt lamp and battery between the diode terminal post and the corresponding heat sink, and making each test in both directions by reversing the probes. Failure of a diode involves renewal of its rectifier assembly.

1. If the lamp lights in one direction only, the diode is satisfactory.
2. If the lamp lights in both directions, the diode is 'shorted'.
3. If the lamp does not light in either direction, the rectifier circuit is 'open'.

ASSEMBLING

1. Press the drive end housing on to the rotor shaft.
2. Place the stator in position on the drive end housing and align its bolt holes. Connect the stator terminals to the insulator in the slip ring end housing, place the housing in position on the stator and loosely fit the three through-bolts and their nuts. Carefully press the complete assembly together and tighten the through-bolts to between 7.5 and 9.5 Nm (5.5 and 7.0 lbf. ft.).
3. Fit the brush housing and brushes.
4. Fit the sensing diode capsule and connect the lead wire to the field terminal.
5. Refit the Woodruff key and fit the fan and pulley. Torque tighten the securing nut to 88 to 95 Nm (65 to 70 lbf. ft.). Spin the rotor to check for freedom of rotation.

TYPE A 3024 ALTERNATOR

Description

This is a three phase star connected fan cooled machine of the rotating field and stationary armature type.

Rectification of the output is by six silicon diodes, contained in a rectifier assembly, mounted in the slip ring end housing. Output control is achieved by the use of an integral regulator unit.

Field excitation is provided through three auxiliary diodes mounted in the centre of the rectifier assembly.

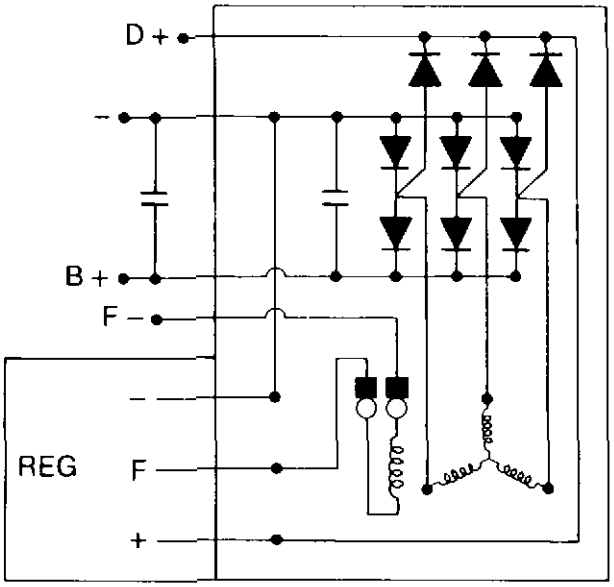


Fig. 1 Typical diagram of connections for the A3024 alternator

DISMANTLING

Before dismantling the alternator mark all housings to ensure the correct relationship during reassembly.

1. Unscrew the fan nut, remove the washer, fan, and drive pulley. Extract the Woodruff key from the shaft and secure the spacer.
2. Remove the suppression capacitor from the main output terminals, release the three screws and lift off the plastic end-cover.
3. Remove the two screws and Belleville washers securing the regulator and disconnect the Lucar terminals, two on the brush box and one on the negative rectifier.
4. Disconnect the remaining Lucar terminal from the brush box and lift out the brush box assembly.
5. Remove the four through-bolts (square nuts located in the drive end housing).
6. Separate the rotor and drive end housing assembly from the stator and slip ring end housing assembly.
7. Remove the three bearing retainer plate screws and, using a gear puller or a press, remove the rotor and the drive end bearing from the drive end housing.
8. Unsolder the three stator wires from the rectifier assembly and separate the stator from the slip ring end housing.

INSPECTION AND REPAIR

All parts should be thoroughly cleaned prior to inspection. Clean by blowing off dirt and carbon dust and wiping with a cloth moistened with 'Genklene' N.

Rotor

1. Check for damage to threads, keyways and bearing surfaces.
2. Using a 110 volt, 15 watt test lamp carry out an insulation test between the slip rings and windings, and the rotor body.
3. Using an ohmmeter, check the resistance of the rotor windings. Resistance to be: 14 ohms ± 0.2 ohm at 20°C (68°F) ambient temperature.
4. Check that the slip rings are concentric and not worn or scored. If necessary the rings may be lightly skimmed (after checking the tightness of the retaining screw) to a minimum diameter of 24.69 mm (0.972 inch).

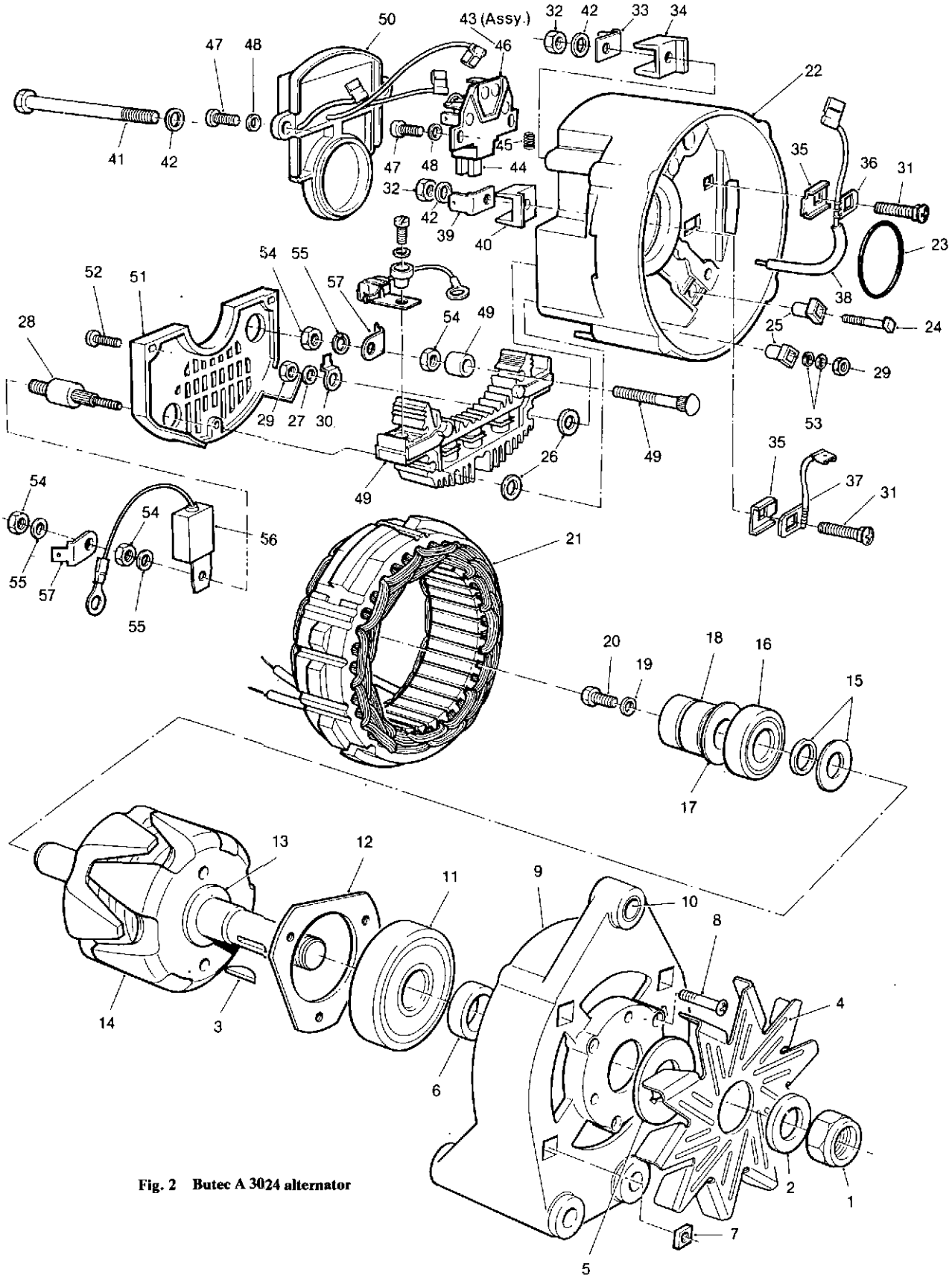


Fig. 2 Butec A 3024 alternator

5. If the slip rings are badly worn or scored they should be replaced as follows:
   Carefully unsolder the leads from the slip ring pegs.

   Remove the slip ring retaining screw and washer.

   Pull the slip ring assembly away from the shaft.

   Line up the rotor leads with the slots in the new slip ring assembly.

   Press the new slip ring assembly onto the shaft.

   Fit the retaining screw and washer. Tighten to 2.3 Nm (20 lbf. inch).

   Wrap the rotor leads approximately three turns around the slip ring pegs and solder the joints.

   Trim off any surplus peg and cable and remove any surplus solder so that the form of pins and cable can be seen.

Rectifiers and auxiliary diodes

Individual diodes cannot be changed. If a diode is found to be faulty the complete rectifier assembly must be replaced. The diodes can be readily checked by using an ohm meter or a 12 or 24 volt D.C. power supply and a low wattage test lamp.

KEY TO FIGURE 2 (OPPOSITE)

1	Nut	30	Terminal —ve Lucar
2	Washer	31	Terminal, D+, F—
3	Key	32	Nut, D+, F—
4	Fan	33	Terminal, Lucar D+
5	Fan washer	34	Terminal guard D+
6	Distance piece	35	Insulator terminal D+
7	Nut	36	Cable assembly D+
8	Screw	37	Cable assembly F—
9	Housing, D.E.	38	Insulation sheath
10	Liner bush	39	Terminal Lucar F—
11	Bearing, D.E.	40	Terminal guard F—
12	Bearing retaining plate	41	Through-bolt
13	Distance piece	42	Spring washer
14	Rotor assembly	43	Brush box assembly
15	Distance piece	44	Brush
16	Bearing, S.R.E.	45	Brush spring
17	Deflector	46	Brush box
18	Slip ring	47	Screw
19	Spring washer	48	Washer
20	Screw	49	Rectifier assembly
21	Stator assembly	50	Regulator
22	Housing, S.R.E.	51	Cover
23	'O' ring	52	Screw
24	Screw	53	Spring washer
25	Barrel insulator	54	Nut, main terminal
26	Spacer insulator	55	Washer, main terminal
27	Washer	56	Capacitor assembly
28	Terminal —ve	57	Terminal (Lucar)
29	Nut		

To test

Using an ohm meter:

Connect one probe to the rectifier body and the other probe to the three soldered diode connections in turn.

Reverse the probes and repeat this procedure.

These checks should show a low resistance in one direction and a very high resistance in the other, when the probes are reversed.

A low resistance in both directions indicates a short circuited diode.

A high resistance in both directions indicates an open circuit diode.

Using a test lamp:

The bulb should light in one direction only.

If the bulb lights in both directions, the diode is short circuited.

If the bulb does not light in either direction, the diode is open circuited.

Auxiliary diodes

The auxiliary diodes can be checked using the same equipment as for the main diodes. Place one probe on the terminal post (point where D+ cable is soldered) and the other on the three soldered main diode connections in turn. To complete the check reverse the probes.

Slip ring end housing—removing rectifier

1. Unsolder the D+ lead from the auxiliary diode post.

   Note: Do not attempt to turn the round section of the negative terminal as this bolt is splined to the negative rectifier.

2. From inside the housing, remove the small nut, two spring washers and the square-ended barrel insulator.
3. From outside the housing remove the small nut, the Belleville washer and the Lucar terminal from the negative rectifier.
4. Remove the rectifier and retrieve the two insulating washers, square-headed bolt and the remaining square headed barrel insulator.

Refitting rectifier

1. From inside the housing locate the square-headed bolt and barrel insulator; place the insulator washer on the bolt from the outside.

2. Fit the insulating washer to the negative terminal bolt on the rectifier and insert it in the housing.
3. Fit the Lucar terminal, Belleville washer and nut to the square-headed rectifier retaining bolt.
4. From inside the housing locate the barrel insulator correctly on the negative terminal bolt, refit the two spring washers and nut and tighten to 3.11 Nm (26.5 lbf. inch).
5. Tighten the rectifier mounting to 2.0 Nm (17 lbf. inch), ensuring that the Lucar terminal has adequate clearance from the auxiliary diode post when the leads are refitted.
6. Solder the D+ lead onto the auxiliary diode post.

D+ and F— leads –removing and refitting

Note: Do not attempt to turn screws from inside the housing.

1. From outside the housing remove the nut, Belleville washer, Lucar terminal and the terminal guard. Remove the screws, terminal, and the terminal insulator from inside the housing.
2. Check the continuity and insulation of D+ and F— leads.
3. From inside the housing fit the terminal insulator, with extension towards the bearing. Fit lead terminal with connecting lugs towards bearing and open ends upward. Correctly locate the squared section of the screw fully into the insulator.
4. From outside the housing fit the terminal guard, Lucar terminal, Belleville washer and the nut, tighten to 3.11 Nm (26.5 lbf. inch).

Brush holder assembly

Check the brush holder for signs of damage, in particular cracking.

Check the brushes for damage and that they are serviceable.

Minimum brush length to be 10.0 mm (0.394 inch).

Brushes—renewal

1. Unsolder the brush leads at the terminal posts and withdraw from holders. Retain the insulating sleeving if serviceable.
2. Fit the sleeving to the new brush leads and thread through the centre of the spring and the small exit hole.
3. Pull on the brush lead so that a maximum of 15.0 mm (0.590 inch) of the brush is protruding, make one complete turn of the lead around the terminal post and resolder. Trim off any excess lead.

Stator and housing

1. Check the stator windings for burned or broken wires and damage to the insulation.
2. Using a 110 volt, 15 watt test lamp carry out an insulation test between the stator body and each of the three cables in turn.
3. Check the resistance between pairs of leads in turn.
   Resistance across two phases to be 0.485 ohms.

Bearings

Bearings are sealed for life and cannot be serviced.

Slip ring end bearing—replacement

1. Remove slip ring assembly—see Rotor section.
2. Remove deflector washer.
3. Using a gear puller or a press remove the bearing from the shaft.
   Remove the spacer and the thin washer.
4. Examine the leads, relocate into grooves and refit washer and spacer.
5. Press the new bearing onto the shaft, applying pressure to the inner track only.
6. Replace the deflector washer and refit slip ring assembly, see Rotor section.

Drive end bearing—replacement

1. Using a gear puller or a press, remove the bearing from the shaft.
   Secure the spacer and note that the tapered side is towards the bearing.
2. Press the new bearing into the drive end housing, applying pressure to the outer track only.
3. Fit the bearing retainer plate and tighten the three screws to 1.69 Nm (15.0 lbf. inch), using Loctite 242 on screw threads.

Note: Original bearings should be checked for wear or roughness in operation.
The drive end bearing incorporates integral

seals which should be checked for damage or distortion. If there is any doubt as to the condition of the original bearings, new bearings should be fitted.

ASSEMBLING

1. Fit the spacer to rotor shaft with the large diameter next to the rotor.

   Press the drive end housing and bearing on to the rotor shaft, applying pressure to the inner track only.
2. Fit a new bearing 'O' ring to the slip ring end housing.
3. Examine the insulation sleeving and renew if necessary. Fit the stator assembly to the slip ring end housing, taking care to align the correlation marks and the through-bolt holes.
4. Carefully fit the rotor and drive end housing assembly into the stator and slip ring end housing assembly, taking care to align the correlation marks and the through bolt holes.
5. Fit the four through-bolts with a Belleville washer beneath the head of each bolt.

   Tighten the bolts evenly to the correct clamping torque of 4.9 Nm (44.0 lbf. inch).
6. Refit the brush box assembly, fit the screws and Belleville washers and tighten to 1.69 Nm (15.0 lbf. inch).

   Ensure that brushes move freely in their holders.
7. Connect D+ and F— leads to the Lucar terminals as in fig. 3.

   Ensure that both leads are located under the internal cast lugs.
8. After making the connections as in fig. 3, fit the regulator, using two screws and Belleville washers. Tighten the screws evenly to 1.69 Nm (15.0 lbf. inch).
9. Bend the negative diode tags down towards the heat sink.

   Bend each stator wire down and solder to its tag, together with the auxiliary diode lead.

   Tin the underside of each positive tag and bend the tags over the stator wires and solder.
10. Fit the plastic end cover and tighten the three screws to 1.69 Nm (15.0 lbf. inch).
11. Refit the suppression capacitor.

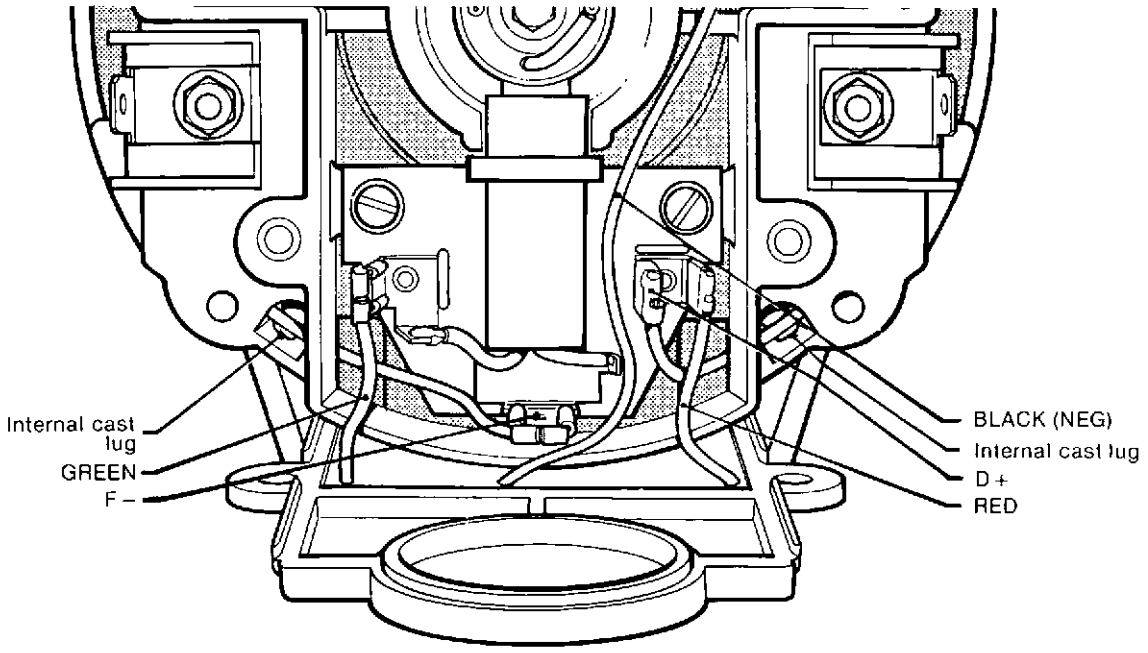


Fig. 3 Regulator connections

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.

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 then operates, allowing the pinion to rotate at a faster rate than the armature until both are at the same speed; the ratchet then 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.

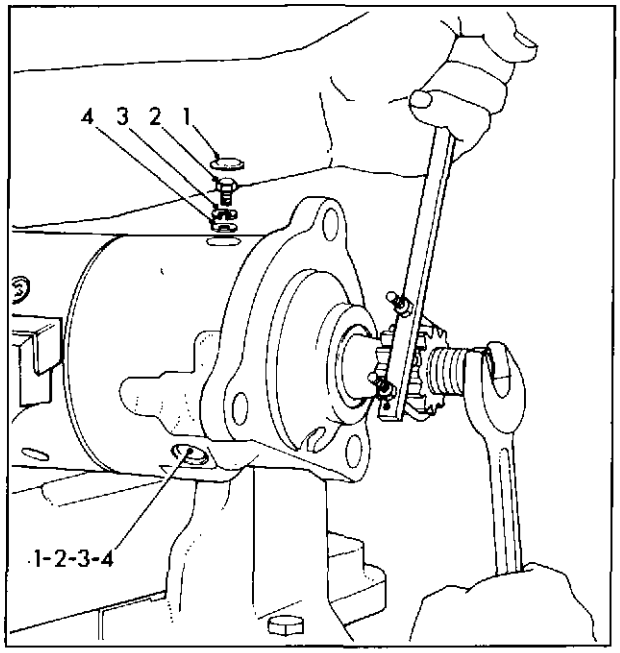


Fig. 1 Loosening pinion stop nut

DISMANTLING

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

1. 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.
2. 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.

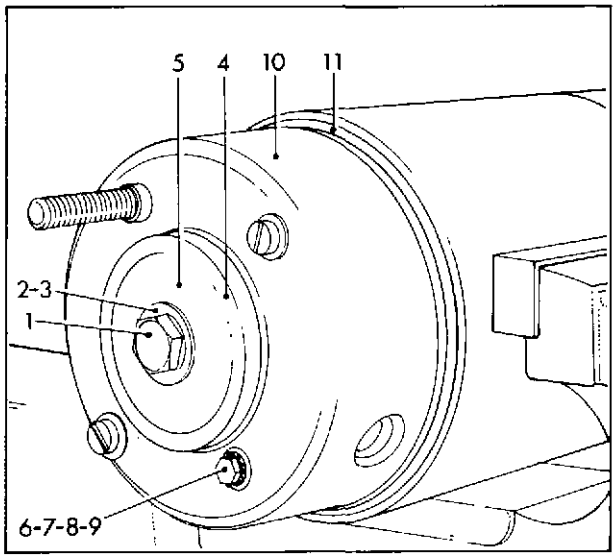


Fig. 2 Removing commutator end shield

3. Unscrew the commutator end terminal nut and remove the washers, seal and insulating bush.
4. Remove the commutator end shield cover, through bolts, and lift off the cover.
5. 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.
6. Remove the oiler sealing ring (4) and felt washer (5).
7. Remove screw (6) together with washer (7) washer (8) and bush (9). Remove the commutator end shield (10) and retain shims for use when re-assembling.

Brushgear (fig. 3)

Lift each brush spring (1) fig. 3 in turn and remove the brush (2) from its holder. Remove the screws (3) and spring washers (4) connecting leads and field coil connectors to brush boxes. Complete brushgear assembly can now be removed.

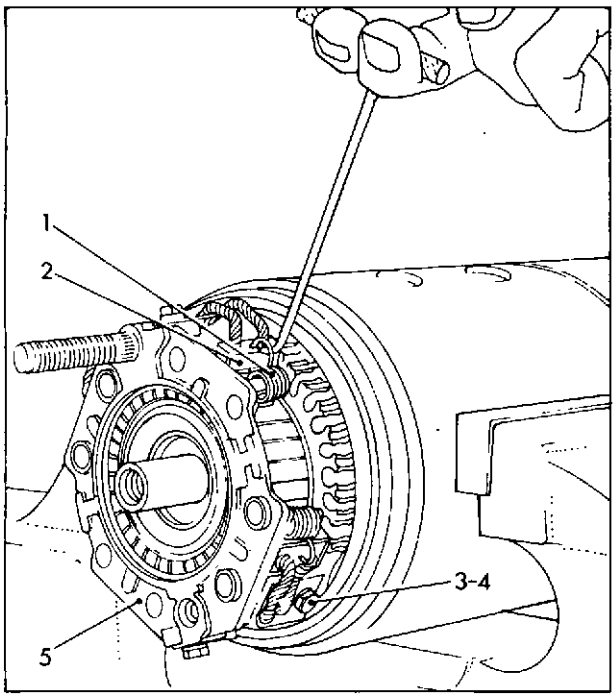


Fig. 3 Removing brushgear

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

1. 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.
2. Remove and discard the sealing ring (3).
3. Using a suitable tool remove the oiler core plug (4) and spring.
4. Discard the plug.
5. Remove the yoke from the vice.
6. Clamp the armature horizontally in a soft jawed vice and remove the 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.
7. Slide the pinion sleeve together with the drive end shield off the armature shaft. Retain the eight 5 mm (0.197 inch) steel balls. Place the 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).
8. Unscrew the pinion (3) two or three turns using the correct size C.A.V. pinion socket tool.
9. 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.
10. Remove the pinion sleeve from the drive end shield.

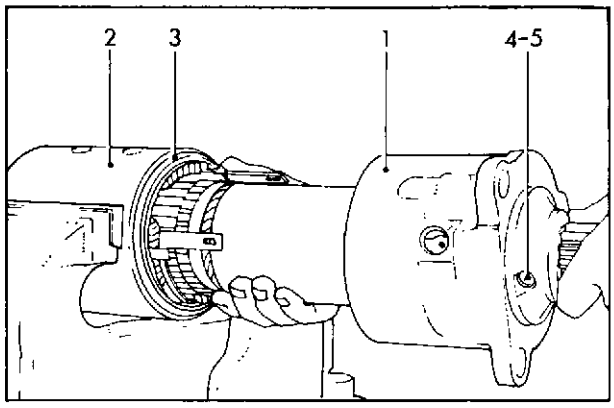


Fig. 4 Removing drive end shield

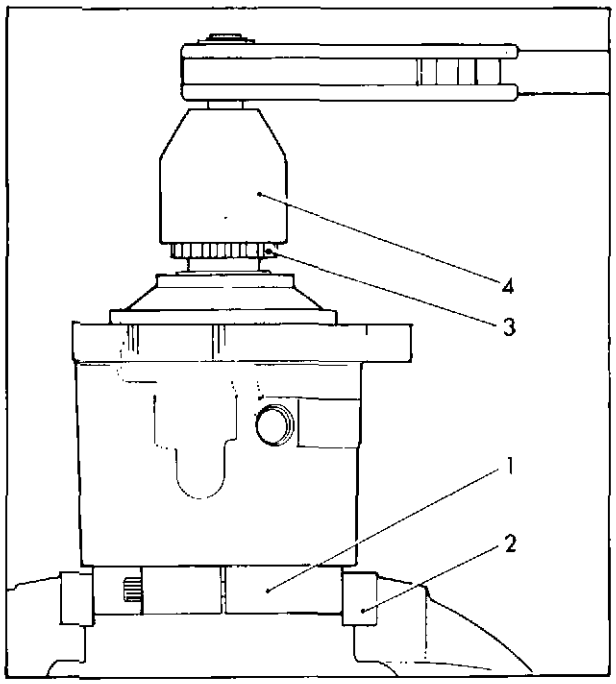


Fig. 5 Removing pinion sleeve

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

1. Remove screw (1), spring washer (2) and plain washer (3) connecting the flexible lead from the resistor to the moving contact of the switch.
2. Unscrew nuts (4) from the solenoid terminals and remove spring washers (5), plain washers (6), insulating bushes (7) and rubber sealing rings (8). Withdraw the solenoid terminals inwards until they are clear of the resistor plate (10).
3. 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 'Pozidrive' screws (16) with spring washers (17).
4. Withdraw the switch assembly (18) from the drive end shield and lift out the plunger return spring.
5. Remove 'Spirolox' circlip (1) fig. 7 by levering the end inwards and 'winding' it out of its groove.
6. Remove retaining washer (2) and lift out the four segments (3), together with the garter spring.
7. 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.
8. Lift out the terminal assembly from inside the end shield.

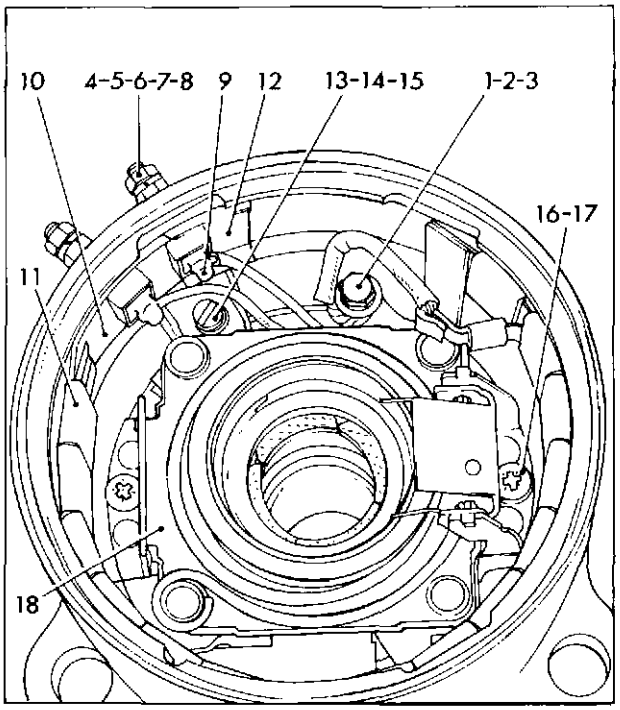


Fig. 6 Removing solenoid switch unit

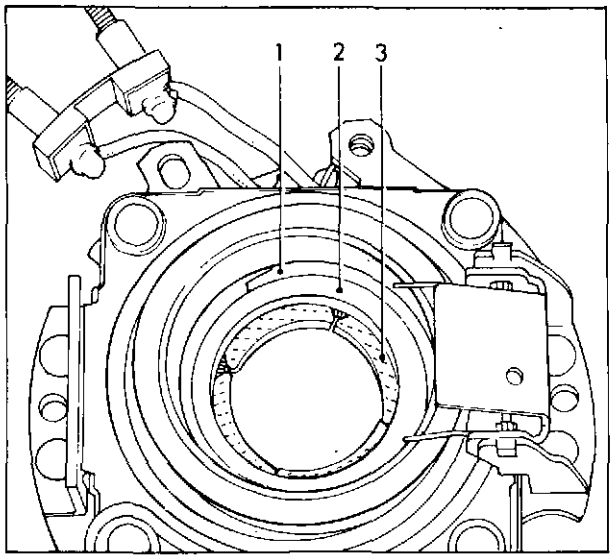


Fig. 7 Removing solenoid plunger segments

Armature (fig. 8 and fig. 9)

1. Lightly clamp the shaft vertically in a soft jawed vice with the commutator uppermost as shown in fig. 8.
2. Remove the recoil housing (1) from inside the 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.
3. Slide the two annular keys (4) outwards from the groove in the shaft.
4. The armature can now be removed from the shaft, using a twisting movement.
5. 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 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.
6. 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.

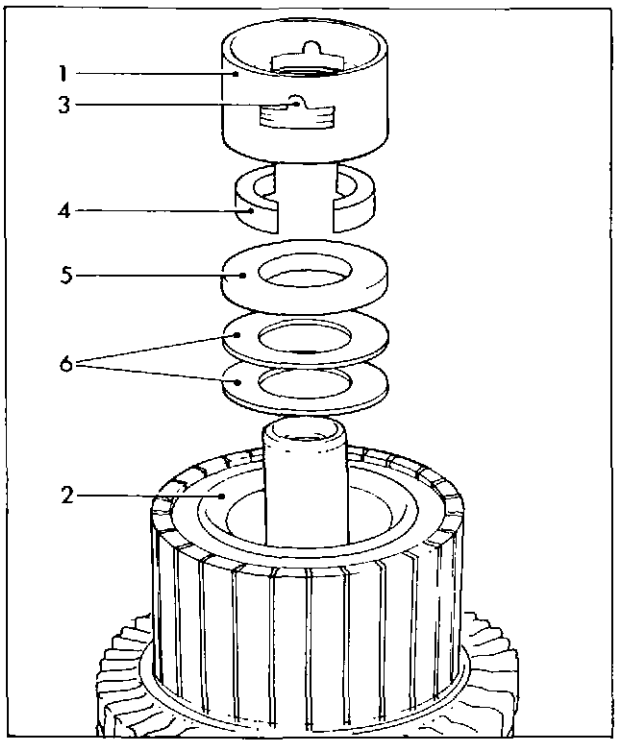


Fig. 8 Removing armature shaft

7. 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.

INSPECTION AND REPAIR

Armature

1. Examine the windings visually for damage and ensure that the bindings are secure and in good condition.
2. Remove all dust with dry compressed air before testing the windings for continuity, shorted turns and insulation, with a 'Growler' armature testing machine.
3. Measure the internal diameter of both bushes. The maximum permissible bore size is 20.075mm (0.790 in.) for the drive end bush and 16.118mm (0.635 in.) for the commutator end bush. If the internal diameter of either bush is greater than these limits, it must be renewed.
4. Remove the ratchet assembly from inside the armature and examine for wear; renew parts as necessary.
6. C.A.V. Tools, Nos. 6244-31, 6244-32, 6244-33, 6244-36 and 6244-37 are necessary for the removal and refitting of bushes.

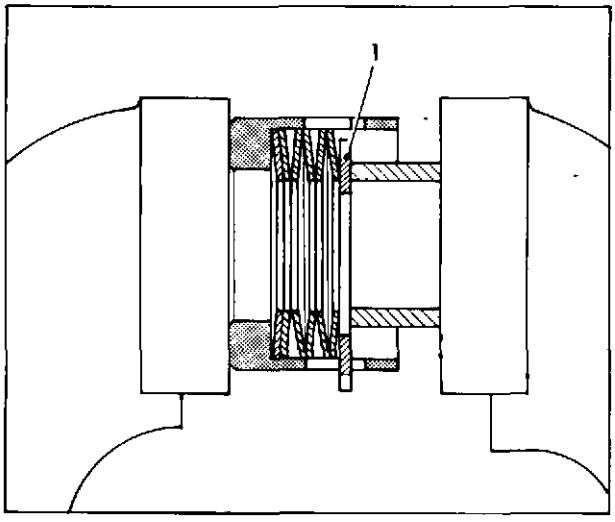


Fig. 9 Dismantling recoil unit

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.

8. 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.
9. 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).
10. Position the new drive end bush on the 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 force required will be 29.42 to 58.84 kN (2.91 to 5.9 ton. f.).
11. Examine carefully the complete armature shaft for signs of wear or damage, paying particular attention to the ratchet and pinion helices and the shoulder of the annular groove for the steel locking balls.

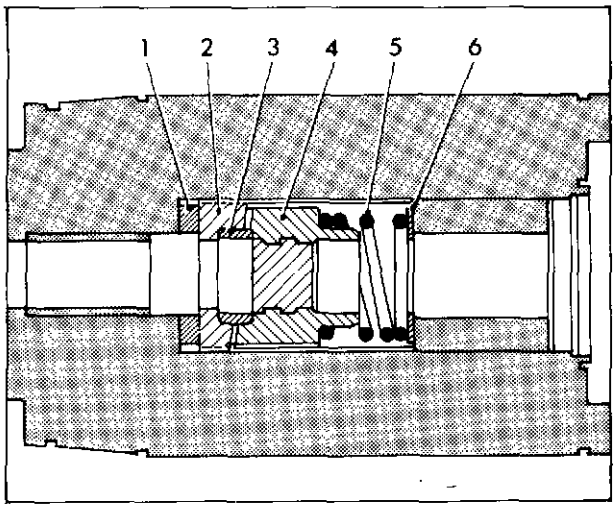


Fig. 10 Assembling ratchet mechanism

12. 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.
    Note: The commutator must be concentric with the armature bearings to within ±0.05mm (0.002 inch) and may be machined to a minimum diameter of 58.90 mm (2.319 inch).
13. The full width of the commutator segment insulators should be undercut to a minimum depth of 1 mm (0.040 inch).

Brushgear

1. Remove all dust with dry compressed air and inspect visually for signs of wear or damage.
2. Test the insulation between positive and negative brush boxes using a suitable test instrument; a reading of 1 megohm should be obtained.
3. Brushes should be renewed if damaged or less than 10 mm (0.394 inch) in length.
4. New brushes should be bedded in until 80% of the contact area conforms to commutator curvature.

Drive end shield and pinion sleeve

1. Lever out and discard the bearing bush oil seal.
2. Visually inspect the drive end shield casting for cracks or damage to the sealing ring recess, mounting flange, or threads.
3. Check the bearing for wear and if the internal diameter exceeds 32.10 mm (1.264 inch) the bearing must be renewed as follows:
4. 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.
5. 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.
6. After fitting, the bush must be fine bored to the correct internal diameter of 32+0.03 mm (1.260+0.001 inch).

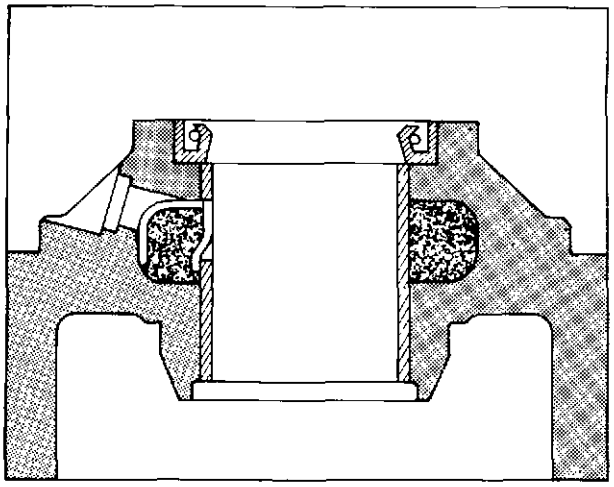


Fig. 11 Drive end oil seal

7. 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.

   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.

8. 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.

9. 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.

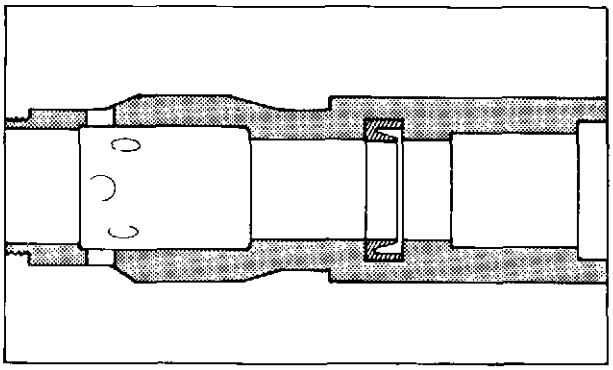


Fig. 12 Pinion sleeve oil seal

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

11. 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

1. Inspect the complete unit for damage and excessive wear, paying particular attention to the insulation of coil and leads. Ensure that the 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 the coil leads and plunger sleeve.

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

3. 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.

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

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

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

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

7. 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.

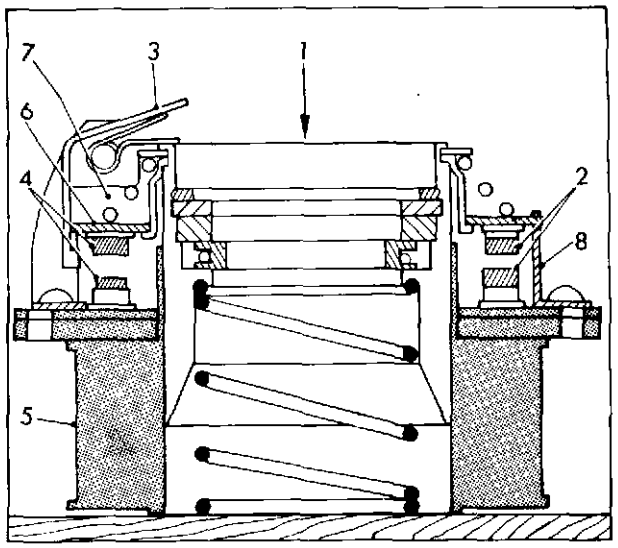


Fig. 13 Checking switch unit operation

8. 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).
9. 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.
10. Reassemble 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 position shown.

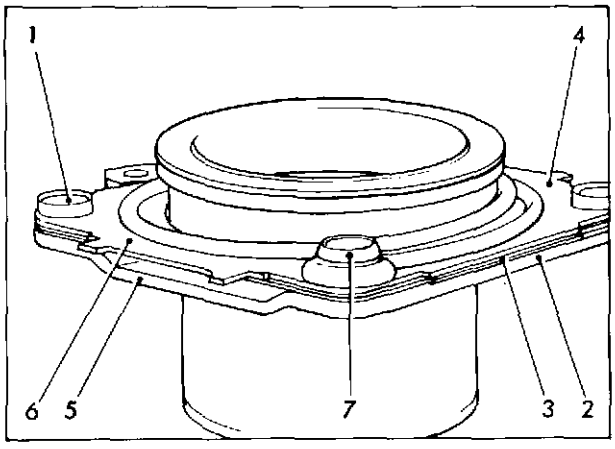


Fig. 14 Renewing switch moving contract

11. 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.
12. 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 the ends.
13. Secure the contact stop in position with two rivets.
14. 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.
15. 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)

1. 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.
2. 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.
3. 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 in a clockwise direction, should be number 3, followed by numbers 4, 1 and 2.

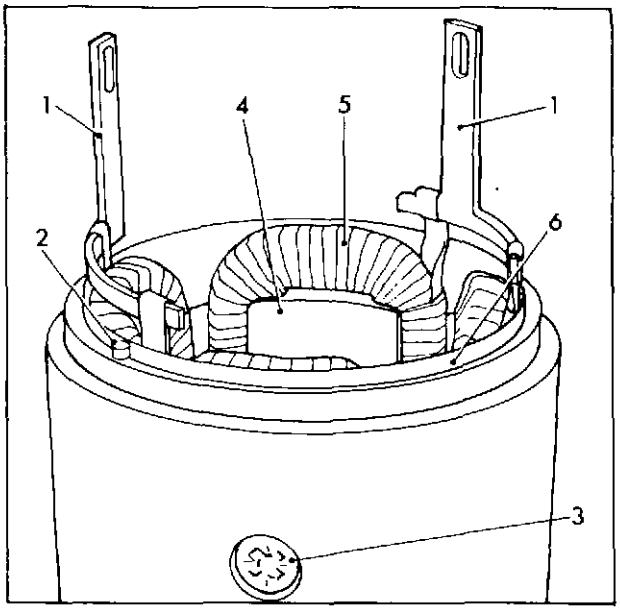


Fig. 15 Dismantling field coils

4. 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)

1. Ensure the bearing is tight in the housing. If the bore of the bearing (1) exceeds 16.087 mm (0.633 inch) the bearing must be renewed.
2. 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).

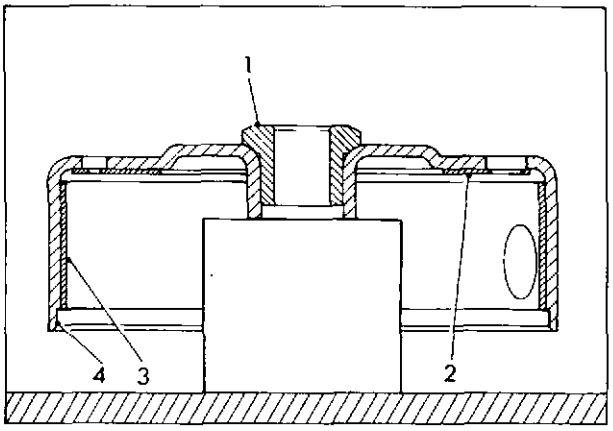


Fig. 16 Commutator end shield bearing

ASSEMBLING

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

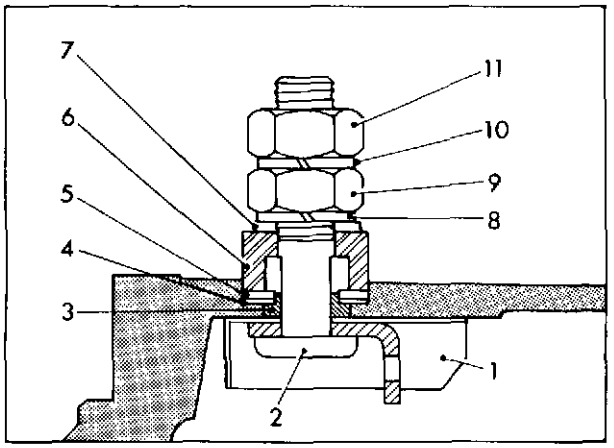


Fig. 17 Drive end terminal assembly

Solenoid switch unit (fig. 17)

1. Place the moulded insulator (1) over the terminal (2) as shown and place the 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 items 4—7 inclusive in position and secure with the spring washer (8) and nut (9); tighten the nut to a torque loading of 12.2 to 13.6 Nm (9 to 10 lbf. ft.). Place the spring washer (10) in position and screw on the nut (11) finger tight.
2. Ensure that the segments and inside of the plunger are clean and free from all oil or grease.
3. 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.

4. Smear the solenoid plunger return spring with Aero Shell 16 grease and place it in the drive end shield. Insert the 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 to a torque value of 2.03 to 2.26 Nm (18 to 20 lbf. inch). Insert screw (3) together with washers (4) and (5) and tighten to a torque value of 2.03 to 2.26 Nm (18 to 20 lbf. inch). Fit the leatheroid insulator (6) in the resistor groove and assemble resistor (7) into position in the drive end shield.
5. Fit the insulator (8) over the terminals (9) and insert the 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 a torque value of 2.03 to 2.26 Nm (18 to 20 lbf. inch).
6. Secure the resistor flexible lead to the switch with screw (16), spring washer (17) and plain washer (18) and tighten to a torque value of 1.69 to 2.03 Nm (15 to 18 lbf. inch).

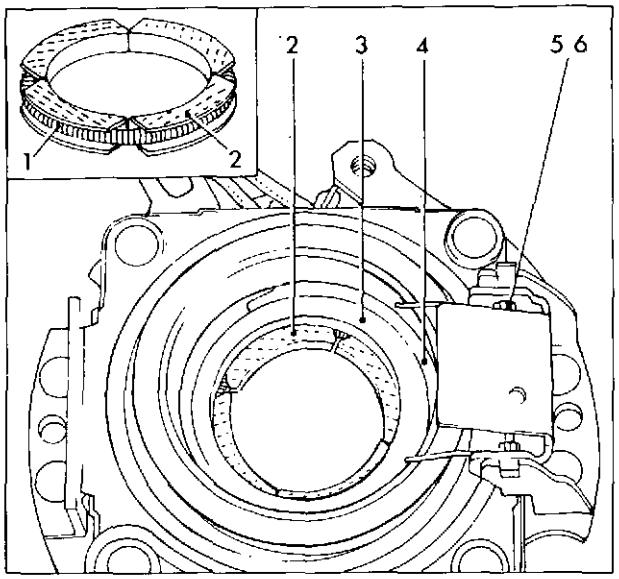


Fig. 18 Assembling solenoid plunger segments

Pinion sleeve

1. Check that the leatheroid pad has been removed from the drive end shield bush.
2. Fit the Collar Tool No. 6244-43 into the drive end seal and lubricate the bearing bore and pinion sleeve with Tellus T27 oil before inserting the pinion sleeve into the end shield bearing. Remove the split collar when the sleeve is nearly home and guide the sleeve carefully through the four segments.

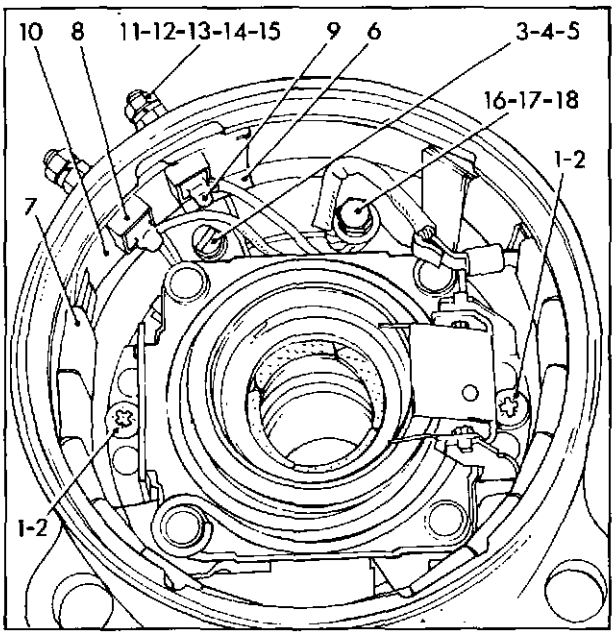


Fig. 19 Replacing solenoid switch unit

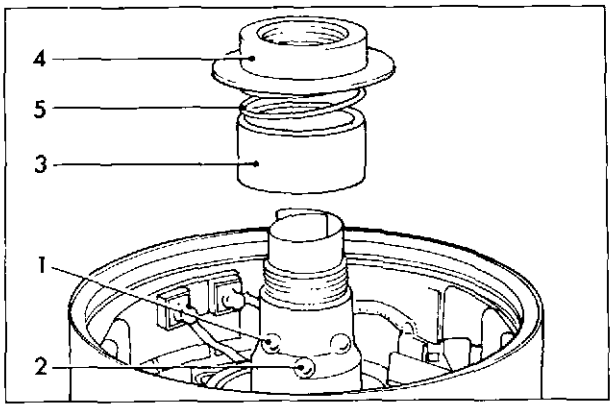


Fig. 20 Assembling pinion sleeve

3. Grip the pinion teeth firmly in a soft jawed vice so that the threaded end is uppermost as shown in fig. 20.
4. Form a piece of stiff paper into a tube and insert it into the pinion sleeve bore to prevent the balls from falling inside.

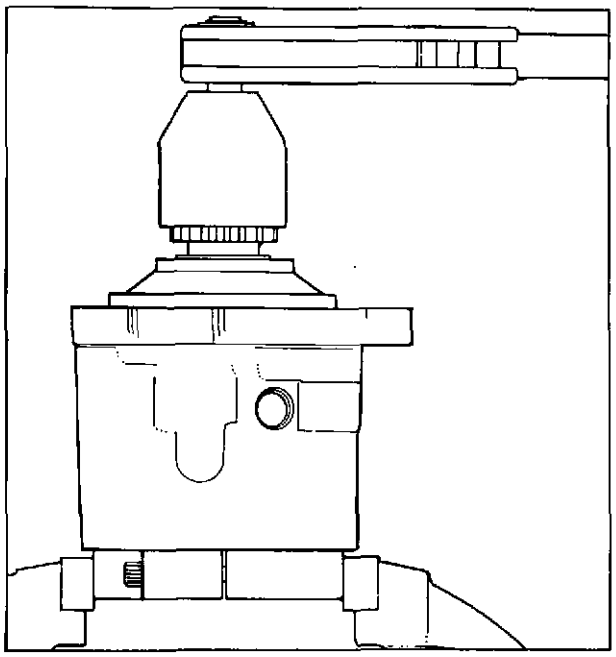


Fig. 21 Tightening trip plate

5. 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.
6. Degrease the threads of the pinion sleeve and trip plate (4) and then smear both threads with 'Loctite' green retaining compound No. 290.
7. Place spring (5) in position and screw on the trip plate finger tight.
8. Secure tool No. 6244-50 over the trip plate boss and clamp the assembly in a vice as shown in fig. 21. Using the correct pinion socket, tighten the pinion to a torque value of 54.2 to 67.8 Nm (40 to 50 lbf. ft.).

Armature shaft

1. Lightly smear the Belleville washers (1) fig. 22 with Aero Shell 16 grease and assemble them into the recoil housing (2) as illustrated.
2. Insert one side of lock washer (3) in the slot in the 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.
3. 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.

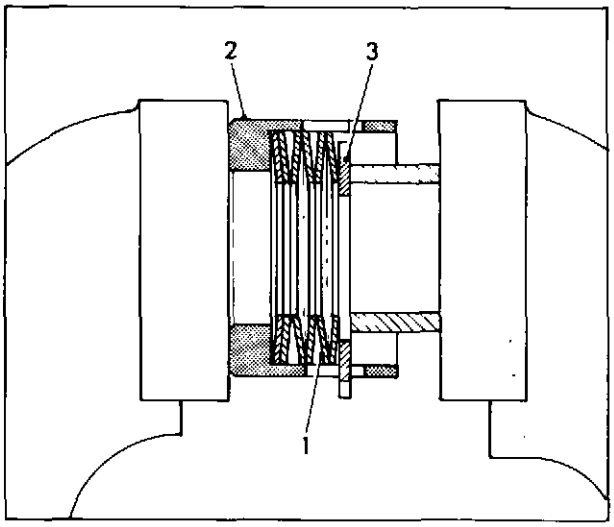


Fig. 22 Assembling recoil unit

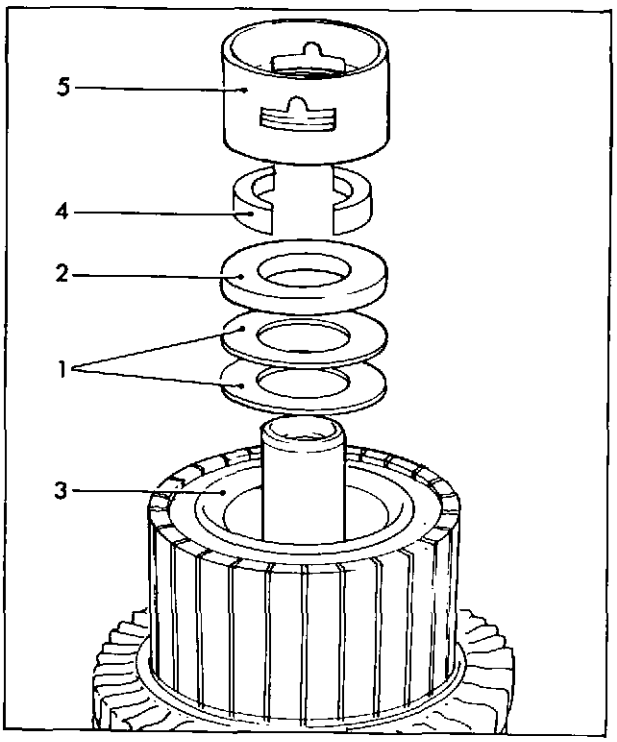


Fig. 23 Replacing armature shaft

4. Smear the original shims (1) fig. 23 and thrust washer (2) with grease and insert, in correct order, into the 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.
5. Check the 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 0.05 and 0.35 mm (0.002 and 0.014 inch) 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.
6. Fit the assembled recoil unit (5) into the armature sleeve ensuring that the bore in the lower part locates over the two keys.
7. Check the operation of the ratchet mechanism by turning the armature which should only rotate in one direction.
8. Remove the armature assembly from the vice.

Drive end shield

1. 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.
2. Pull the pinion (1) fig. 24 fully out of the drive end shield and retain it in this position.
3. Slide the pinion and drive end shield onto the armature shaft and release the pull on the pinion.
4. Remove the paper tube from the pinion before the end shield is fully in position.
5. Fit the pinion return spring (3) and thrust washer (4) and secure with the pinion stop nut (5), finger tight only; remove the armature from the vice.
6. Oil the bearing wick with Tellus T27 oil and fit oiler spring and new core plug.

Armature and brushgear

1. Secure the yoke in a 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 the yoke engages with the hole in the drive end shield (4). If necessary tap the shield into position with a soft faced mallet.
2. 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.
3. Fit screw (2) with spring washer (3) through each positive brush lead tag (4) and screw through the brushgear into the brushgear assembly. Do not fully tighten the screw.
4. Insert the brushes into their holders and secure the remaining two unattached leads with screws (5) and spring washers (6), tightening to a torque value of 1.69 to 2.03 Nm (15 to 18 lbf. inch).
5. Smear the original shims (7) with Aero Shell 16 grease and replace them in the recoil housing, thickest shim last.
6. Renew the sealing ring (8).

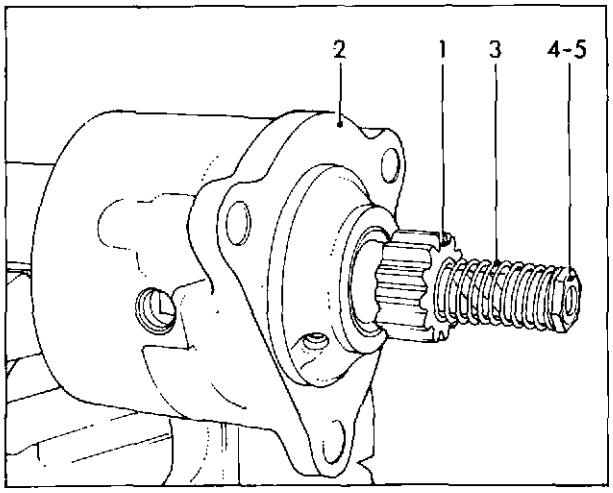


Fig. 24 Assembling drive end shield

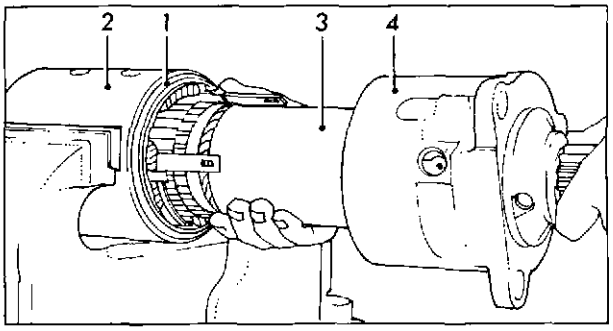


Fig. 25 Replacing armature into yoke

7. Check brush spring tensions with a gauge as shown. Indicated pressure when the spring starts to leave the brush should read 23.34 to 24.42 N (5.25 to 5.50 lbf.).

Commutator end shield

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

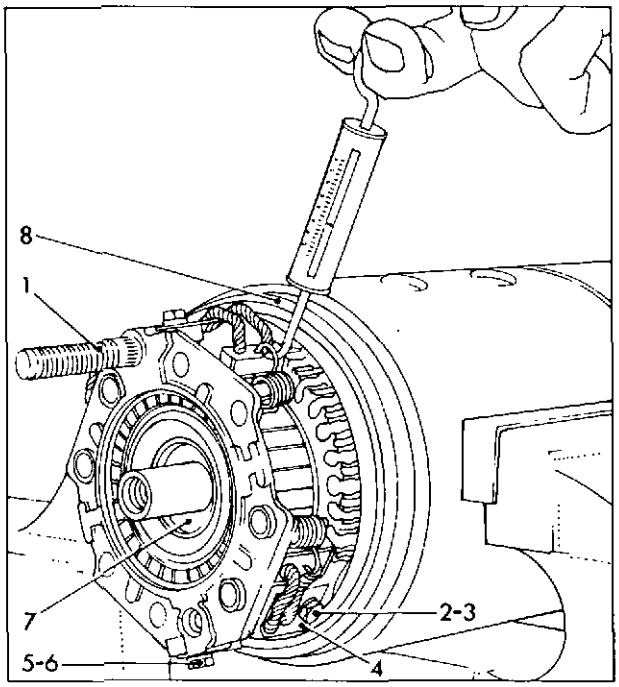


Fig. 26 Replacing brushgear

2. Smear the bush and the end of the armature shaft with Turbo 41 oil.
3. Assemble the end shield (1) fig. 27 onto the yoke, ensuring that it is correctly located and the brush leads are not trapped.
4. Insert both through bolts (2) with sealing washers (3) and tighten to a torque value of 12.9 to 13.6 Nm (9.5 to 10 lbf. ft.).
5. 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 34.0 to 40.7 Nm (25 to 30 lbf. ft.) while holding the pinion with Tool No. 6244-39. Add or subtract shims as necessary to obtain a clearance of 0.1 to 0.3 mm (0.004 to 0.012 inch between the thrust washer and the shims.

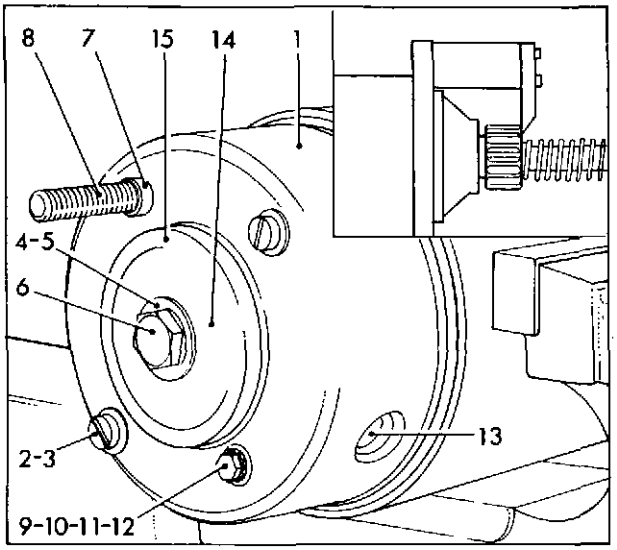


Fig. 27 Replacing commutator end shield

6. Hold the pinion and tighten the pinion stop nut to a torque value of 54.2 to 67.8 Nm (40 to 50 lbf. ft.).
7. Slide bush (7) over the return terminal (8) and press fully home.
8. Fit insulating bush (9), plain washer (10), shakeproof washer (11) and screw (12); tighten the screw to a torque value of 1.69 to 2.03 Nm (15 to 18 lbf. inch). Pull on the return terminal (8) and tighten the brush screws (13) through the access holes in the commutator end shield to a torque value of 1.69 to 2.03 Nm (15 to 18 lbf. inch).
9. Remove both through bolts and fit the 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 a torque value of 12.9 to 13.6 Nm (9.5 to 10 lbf. ft.).
10. 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

a torque value of 12.2 to 13.6 Nm (9 to 10 lbf. ft.). Add a second spring washer and nut to the terminal and screw up finger tight.

11. Insert the two field coil connecting screws, spring washers and plain washers through the holes in the drive end shield and tighten to a torque value of 1.69 to 2.03 Nm (15 to 18 lbf. inch).
12. Fit a new core plug to each hole using Tool No. 6244-45.

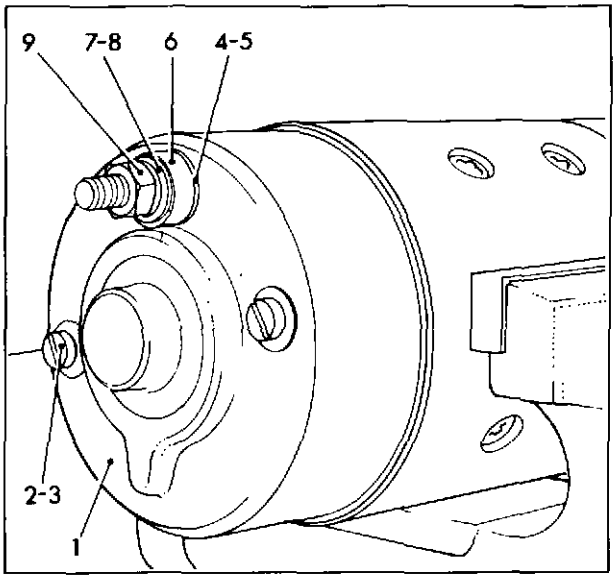


Fig. 28 Replacing commutator end shield cover

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 the 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 volts 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 solenoid 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.

STARTER MOTOR (BUTEC MS1A)

Description

This is a 24 volt machine, actuated by an externally mounted solenoid switch via a lever arm. The pinion assembly incorporates a positive engagement device, an overload clutch and a freewheel ratchet.

OPERATION

Referring to figs. 2 and 3, operation of the starter switch energises the pull-in and hold-in coils, causing the solenoid, via the lever arm, to move the pinion into mesh with the starter ring. If the teeth abut, the pinion rotates slightly until engagement occurs.

The starting contacts then close, in parallel with the pull-in coil which is thus de-energised, and full torque is exerted. If engine resistance is excessive the pinion clutch comes into operation.

When the engine starts, the pinion is enabled by its ratchet to run free, in mesh with the starter ring, until the starter switch is released. The hold-in coil is then de-energised, allowing the return spring in the solenoid switch to disengage the pinion, via the lever arm.

DISMANTLING

1. Remove both jumper leads between the solenoid switch and starter body. Extract the rubber plug from the solenoid base, insert Tool CET 55/105, engage it with the solenoid shaft nut and turn the tool anti-clockwise until the plunger and lever arm are released from the shaft. Unscrew the two remaining bolts and remove the solenoid switch.
2. To dismantle the solenoid switch, remove the terminal nuts, washers and sealing rings. Remove the base and disconnect the coil lead. Unscrew the retaining nut and remove the contactor, spring and associated parts. Withdraw the solenoid shaft and return spring from the opposite end.
3. To dismantle the starter, first mark all housings to ensure reassembly in correct relationship. Remove the brush cover, disconnect the brush tabs and carefully withdraw the brushes. Disconnect the two field leads, unscrew the four retaining bolts and withdraw the commutator housing. Remove the nose housing, disconnect the shift lever and remove it together with the pinion assembly. Withdraw the armature and detach the shift housing from the field ring.

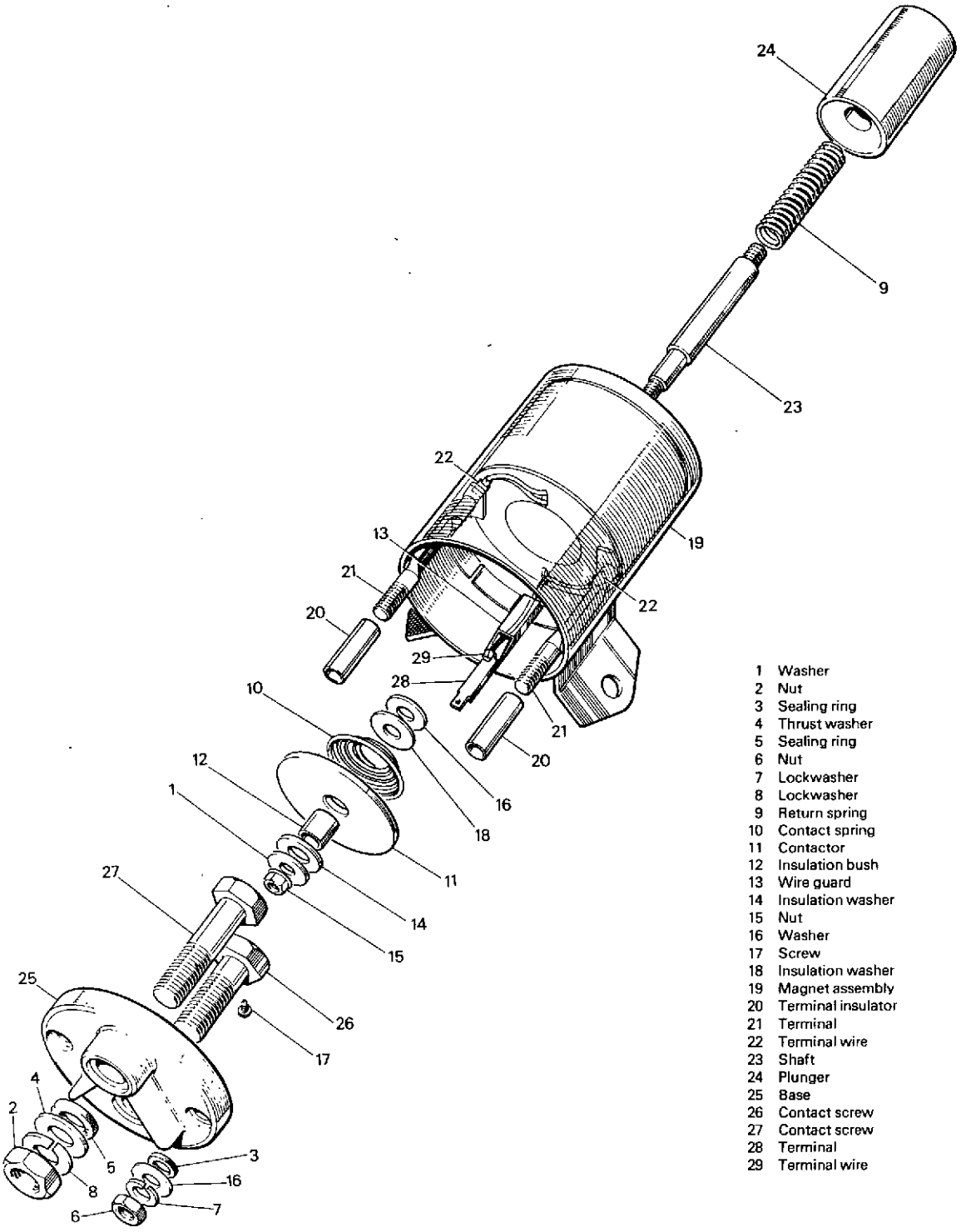
CLEANING

Use a cloth moistened with 'Genklene' N to remove dirt and grease. Wash metal parts as necessary, but do NOT immerse the pinion assembly in a solvent since it contains a special lubricant.

INSPECTION, TEST AND REPAIR

1. Using an Avometer, check the resistance of the pull-in coil (1.34 ohms) and hold-in coil (2.7 ohms). Renew the solenoid switch if the coils are defective.
2. Examine the field ring and housings for damage. Using a flash tester at 500 volt setting, check the field coils for insulation failure and open circuits. Renew the field ring if any coil is defective.
3. Inspect the armature for wear and damage, particularly to the splines. Check the shaft for bowing and the commutator for concentricity.

   Renew the shaft if its run-out exceeds 0.13 mm (0.005 inch). The commutator should have a highly-burnished finish, deep copper in colour and be concentric within 0.08 mm (0.003 inch); if the armature is otherwise serviceable the commutator surface may be restored, subject to a minimum diameter of 52.39 mm (2.062 inches).
4. Using a 'growler' and 230 volt test lamp, check the armature for earthing, continuity and open circuits.
5. Inspect the bushes in the nose housing and commutator end housing. If either bush is to be renewed, align its oil hole and afterwards ream the bore to between 19.10 and 19.15 mm (0.752 and 0.754 inch) diameter.
6. Inspect the bush in the shift lever housing. When renewing, align the oil holes and afterwards ream the bore to between 22.20 and 22.25 mm (0.874 and 0.876 inch diameter.



1 Washer
2 Nut
3 Sealing ring
4 Thrust washer
5 Sealing ring
6 Nut
7 Lockwasher
8 Lockwasher
9 Return spring
10 Contact spring
11 Contactor
12 Insulation bush
13 Wire guard
14 Insulation washer
15 Nut
16 Washer
17 Screw
18 Insulation washer
19 Magnet assembly
20 Terminal insulator
21 Terminal
22 Terminal wire
23 Shaft
24 Plunger
25 Base
26 Contact screw
27 Contact screw
28 Terminal
29 Terminal wire

Fig. 1 Butec solenoid switch

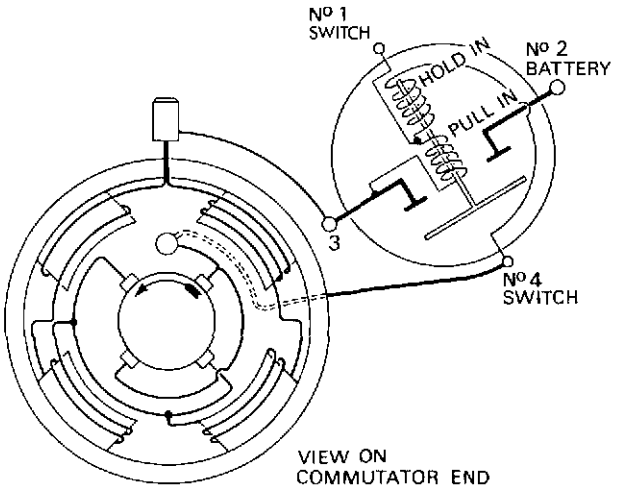


Fig. 2 Butec solenoid switch circuit

7. Examine the lever arm and shaft for wear and damage, and check that the nylon locking insert in the screwed position of the shaft is effective.

8. Inspect the pinion assembly and renew it if excessively worn or damaged.

9. Test the insulation of the brush holders. Renew the brushes if damaged or worn. Minimum length 15.9 mm (0.625 inches).

ASSEMBLING

1. Renew all sealing rings, and smear them with glycerine before assembly. Treat all fibre thrust washers, lubricating wicks and bearing bushes with SAE 5W/20 engine oil. When assembling the housings, align the location marks made before dismantling.

2. Bolt the shift lever housing to the field ring, and assemble the lever arm, linkage and pinion assembly into it, lubricating the linkage with light graphite grease. Insert the armature, together with its washers, and fit the nose housing and steel thrust washer.

3. Assemble the commutator end cover and fit the brushes. Check the brush spring loadings; limits are 13.9 to 16.4 N (50 to 59 oz.f.). Fit the brush cover, with a smear of glycerine on its gasket, and position the joint over a rib of the field ring.

4. Insert the shift lever screwed link into the solenoid switch and using Tool CET 55/105 on the solenoid shaft nut screw the link fully home, and then unscrew it five turns. Enter the switch into its housing on the starter and fit its securing bolts. Connect a 24 volt supply to terminals 1 and 3, push back the pinion assembly and check the clearance between the pinion front face and its thrust washers, using a 4.76 mm (0.187 inch) gauge. Adjust as necessary by turning the shift lever with Tool CET 55/105; this adjustment should be made with the switch de-energised. Do NOT leave the switch energised for more than 30 seconds.

5. Replace the rubber plug in the solenoid switch, fit both jumper leads and apply a few drops of SAE 5W/20 oil to each of the three lubricating points (fig. 4).

6. Test the solenoid switch for correct operating sequence, as follows: Fit Tool CEG 14/3 to the pinion shaft to retain the drive, connect a 24 volt supply across terminals 1 and 3, and check with an Avometer that no reading is recorded between terminals 2 and 3.

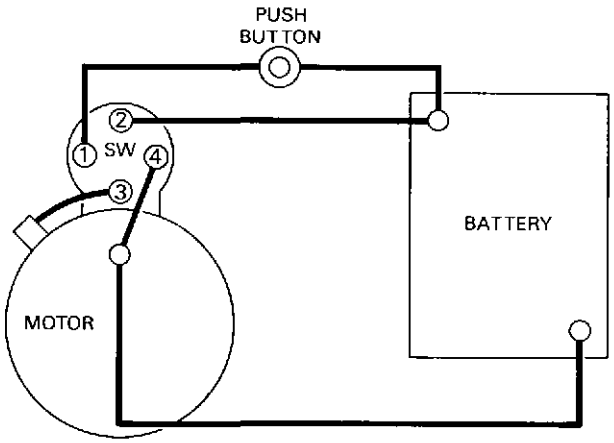


Fig. 3 Butec installation wiring

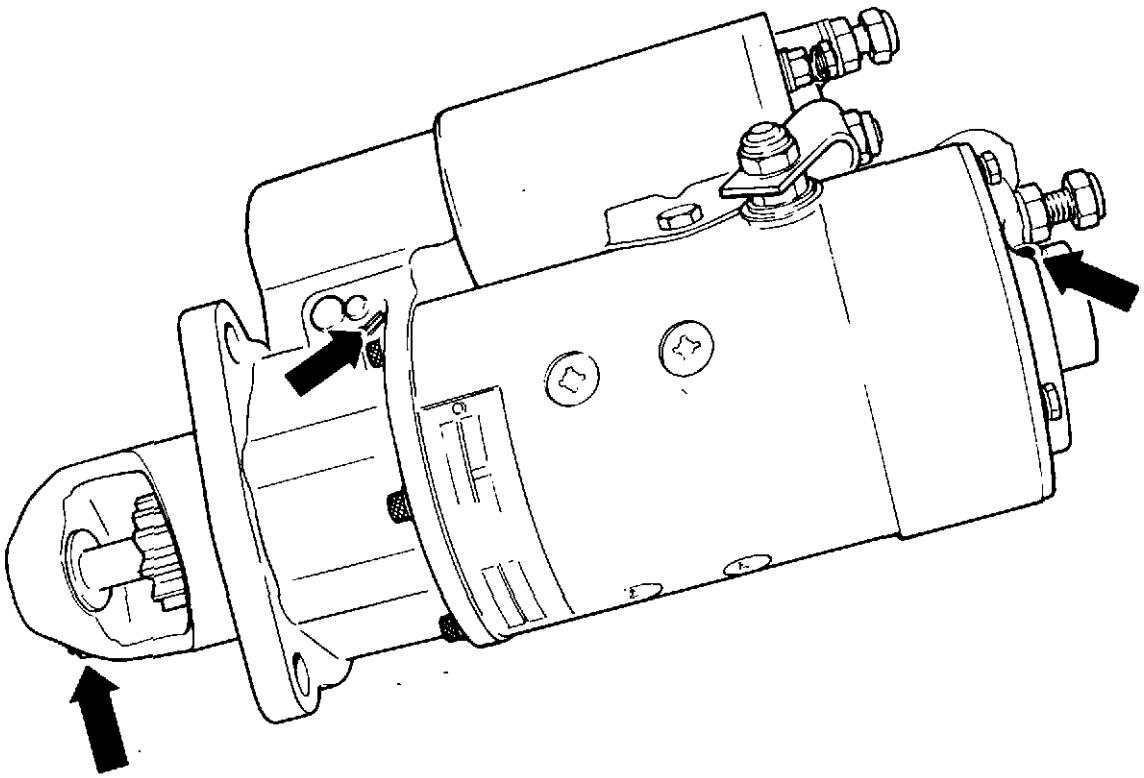


Fig. 4 Butec starter motor — lubrication points

SECTION 15—WHEELCASE, TIMING GEARS AND FAN ADAPTOR

WHEELCASE

Description

A cast aluminium wheelcase, bolted to the front end of the crankcase, houses the main gear train and provides mounting points for the coolant pump, E.S.C., and various other engine components. See the illustration.

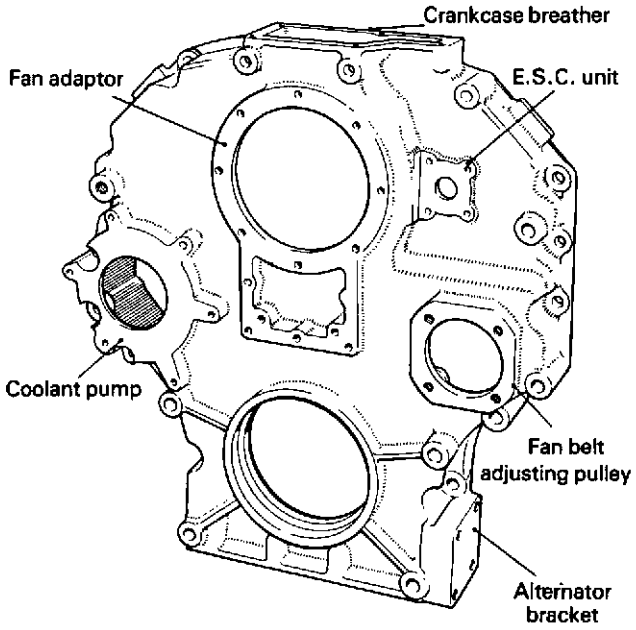


Fig. 1a Wheelcase CV 8095.

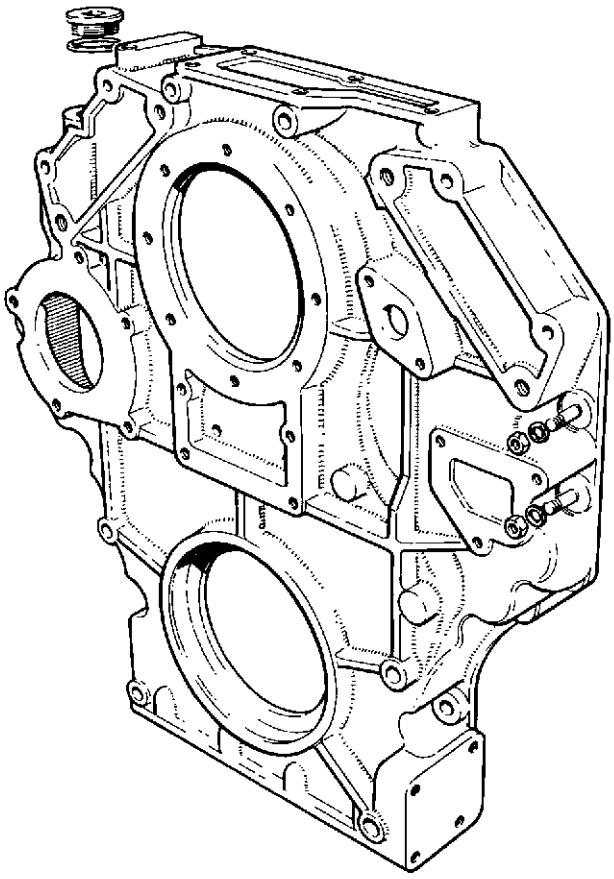


Fig. 1b Wheelcase CV 2680.

Dependent upon application, the engine may be fitted with either of the two wheelcases shown, but all instructions apply to both types.

Removal

Before wheelcase removal, the radiator, fan, alternator, etc., must first be removed as for the camshaft removal. See Section 5.

Remove a securing bolt from each side of the wheelcase and fit Guide Studs, VT 17845, hand tight, into each bolt hole. Remove the remainder of the securing bolts and slide the wheelcase free. Remove the guide studs.

Cleaning and inspection

Tap out the front end oil seal from the crankshaft bore and clean the casting in a non-caustic degreasing solution. Check all the joint faces and oil seal bore for damage.

TIMING GEARS

Description

The main gear train consists of the crankshaft drive gear, oil pump idler, main compounded idler, auxiliary drive compounded gear and two camshaft

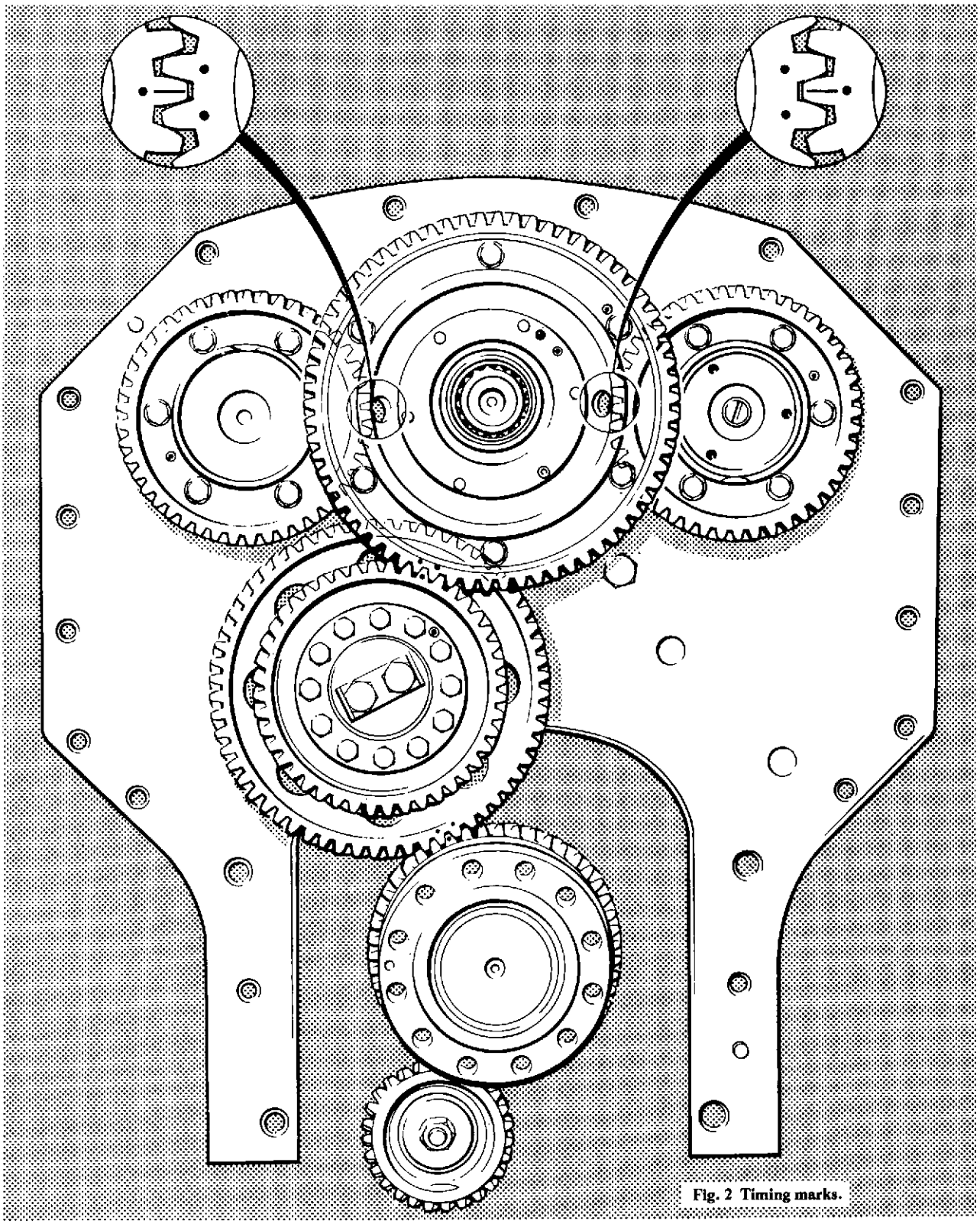


Fig. 2 Timing marks.

drive gears. The coolant pump and lubricating oil pump each have their drive gear built into the assembly.

The oil pump idler axle is secured to the front main bearing housing with a single bolt and self locking nut. The main compounded idler axle, with two thrust washers and the thrust plate, is secured by two bolts and a locking plate.

Timing marks on the crankshaft gear, main idler, auxiliary drive gear and cam drive gears are provided, to ensure correct valve timing during engine operation.

Removal

1. Unscrew the axle securing bolts and remove the compounded and oil pump idler gears and their associated axle assemblies.
2. Remove the 12 setbolts and washers from the main idler assembly and separate the two gears. Withdraw the locating dowel.
3. Disconnect the auxiliary drive coupling, remove the drive flange and lift out the woodruff key. Remove the six nuts and washers from the oil seal housing and withdraw the housing and the auxiliary drive assembly. Retain the shim pack.

   Remove the six setbolts and washers from the auxiliary drive gear and separate the two gears. Withdraw the locating dowel.
4. Remove the six setbolts and washers from each of the camshaft drive gears and withdraw the gears. Withdraw the two locating dowels.

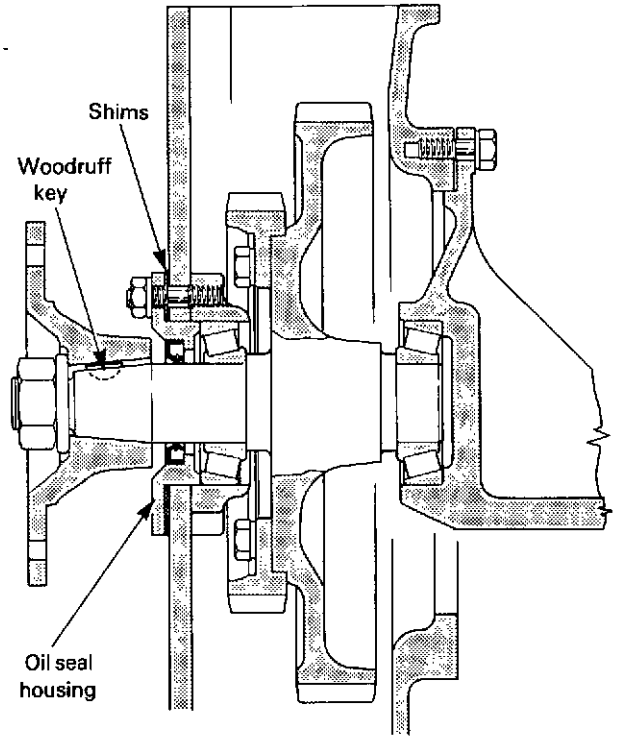


Fig. 3 Auxiliary drive assembly.

Cleaning and inspection

Wash all the gears in paraffin, remove any traces of of thread sealing compound and examine the teeth for wear. Wear on the tooth profile is acceptable provided that the backlash is within the permissible limits and there are no signs of pitting. Crack test all the gears, using the electro-magnetic method if available.

Check the idler gear bushes and axles for wear. Insertion and extraction tools are available for bush renewal, see end of Section. Replacement bushes are pre-finished and require no further treatment after fitting.

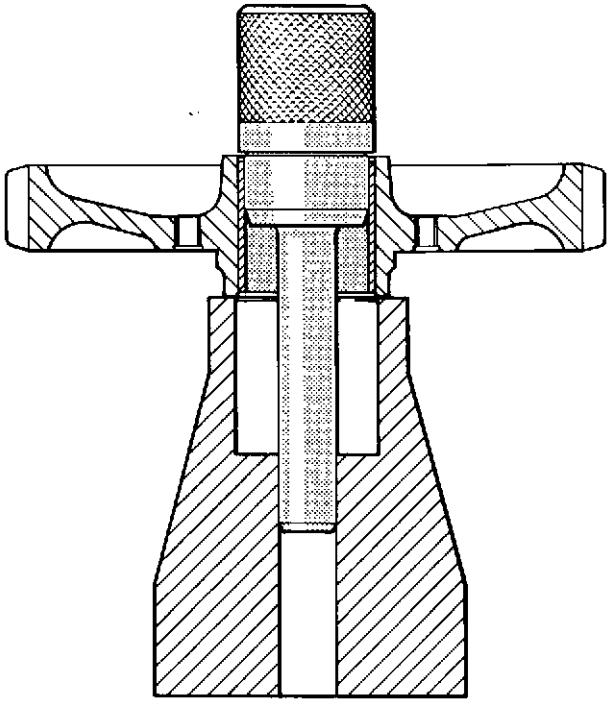


Fig.4 Extracting main idler bush.

Check the end float and inspect the thrust faces of the oil pump idler and the axle flange; renew items which show excessive wear or scoring.

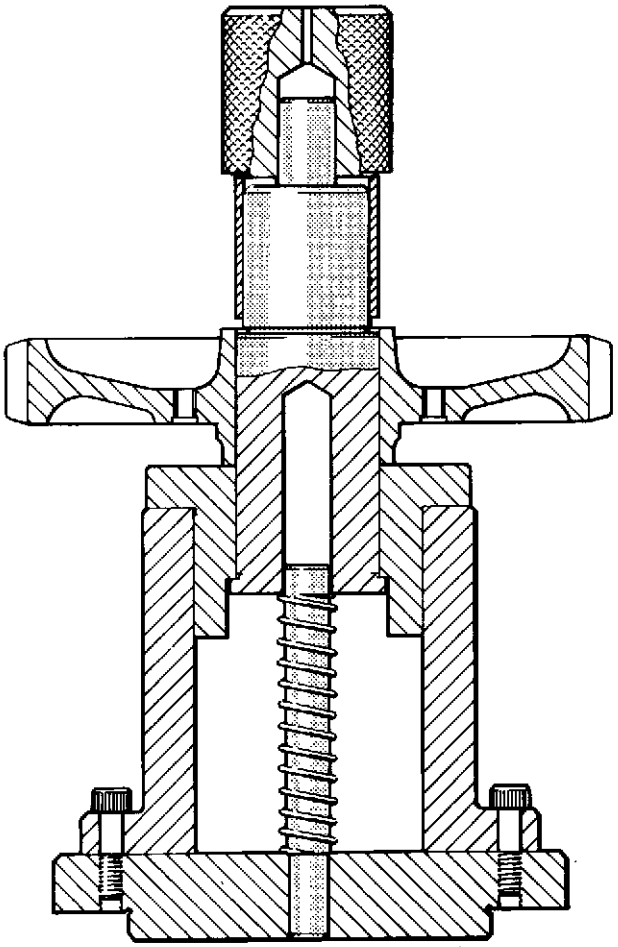


Fig. 5 Inserting main idler bush.

Check the main idler end float and inspect the thrust washers. Thrust washers must be renewed if the oil grooves begin to disappear in the thrust faces. Normal depth of the oil grooves is between 0.18 and 0.38 mm (0.007 and 0.015 inch).

Assembling compound gears

Ensure that the gears are clean and dry, then assemble the two auxiliary drive gears and tap in the locating dowel. The timing marks on the small gear must be visible through the sight holes, in the large gear. Coat the threads of the setbolts with 'Studlock' 270 and insert the setbolts into the bolt holes complete with plain washers. Tighten each setbolt to a torque loading of 30 Nm (22 lbf. ft.).

Fit the small idler to the large idler and tap in the locating dowel. The timing marks on both gears should be on the same side of the assembly. Coat the threads of the securing setbolts with 'Studlock' 270 and insert the bolts, complete with plain washers through the small gear bolt holes. Tighten the setbolts to a torque loading of 40 Nm (30 lbf. ft.).

Fitting the gear train

Position the camshaft drive gears on the camshaft flanges. Tap in the locating dowels, coat the setbolt threads with 'Studlock' 270 and screw in the setbolts, complete with plain washers. Tighten the setbolts to a torque loading of 40 Nm (30 lbf. ft.).

Fit the main idler assembly to the crankcase as shown in figure 2, ensuring that the timing marks on the large gear are correctly positioned relative to the timing mark on the crankshaft driving gear. Tighten the two securing setbolts to a torque loading of 71 Nm (52 lbf. ft.). Tab up the locking plate.

Check that the camshaft gear timing marks face in towards the centre line of the engine and fit the auxiliary drive assembly to the wheelcase backplate, ensuring that the timing marks are correctly positioned relative to the main idler and camshaft gears.

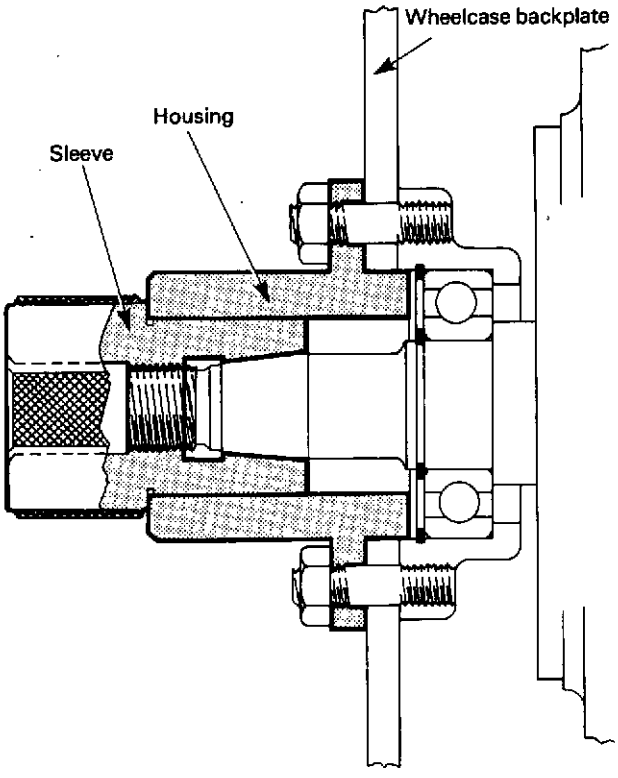


Fig. 6 Alignement tool.

Secure the assembly in position using the Alignment Tool, VT 17974.

Fit the oil pump idler assembly to the front main bearing cap and, using a new self-locking nut, tighten the securing bolt and nut to 80 Nm (60 lbf.ft.).

Check the backlash of all the gears, renew any gear having excessive wear on the tooth profile and renewing any idler bushes which are worn sufficient to cause the idler backlash to exceed the permissible limits.

Fitting the wheelcase

Press a new front end oil seal into the crankshaft bore with the lip facing inwards, (see illustration), using the Insertion Tool, VT 17032.

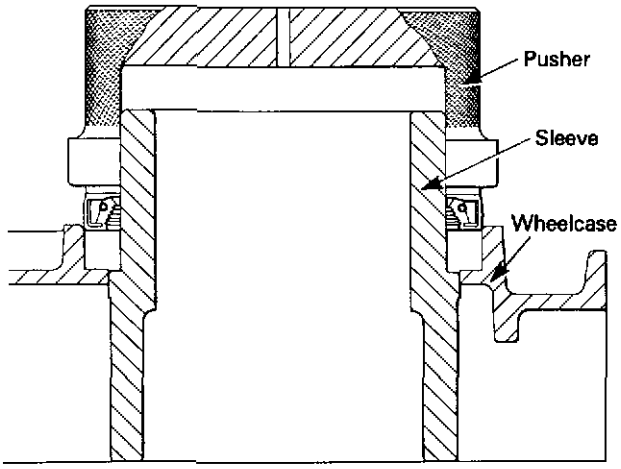


Fig. 7 Inserting wheelcase oil seal.

Check the backplate joint face for cleanliness, apply a thin coating of Wellseal jointing compound and position a new gasket on the backplate. Apply a further coating to the outer face of the gasket, to ensure that the two locating dowels are fitted to the crankcase/backplate assembly, then screw in the two guide studs hand tight, into suitable bolt holes in the assembly.

Lift the wheelcase on to the guide studs and carefully slide it up to the gasket, taking care not to damage the crankshaft oil seal.

Fit the wheelcase bolts and nuts, with spring and plain washers, and tighten to a torque loading of 95 Nm (70 lbf. ft.).

Refit all components previously removed. For necessary details see the relevant Sections in the Manual.

FAN ADAPTOR

Description

The fan adaptor consists of a steel shaft, supported by one roller bearing and one ball bearing, in an aluminium alloy housing.

A lip type oil seal is fitted around the shaft collar and the fan belt pulley is secured to the shaft flange with six setbolts and spring washers. Shims between the pulley and flange provide adjustment for fan belt alignment.

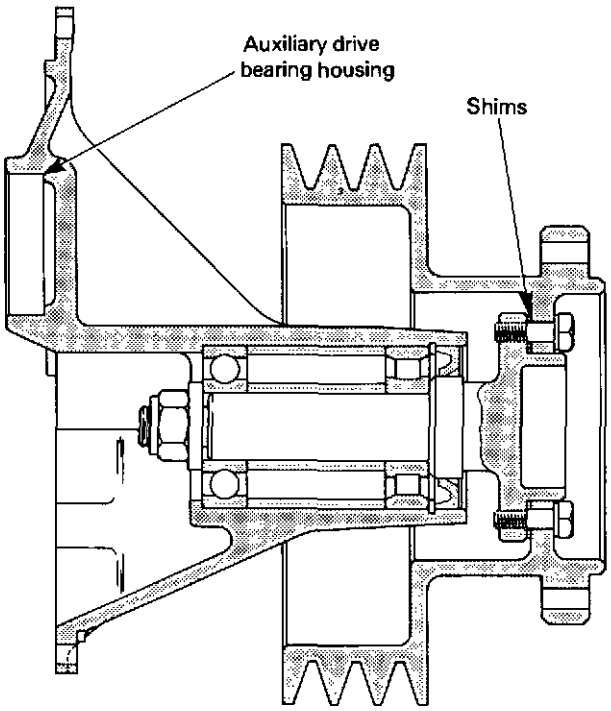


Fig. 8 Fan adaptor.

The two bearings, complete with inner and outer spacers, are secured to the shaft with a single nut and washer. Axial movement of the shaft assembly is controlled by a standard circlip fitted in a groove in the housing between the oil seal and roller bearing.

The housing incorporates the location for the outer race of the auxiliary drive tapered roller bearing.

Dismantling

Release the six pulley securing setbolts and washers and lift off the pulley and associated shims. Retain the shims for re-use.

Using the Holding Device, VT 17033, remove the securing nut and washer. Tap out the shaft, using a soft metal drift. Retain the inner distance piece and, using the appropriate type puller, remove the inner race of the roller bearing from the shaft. Tap out the oil seal and, with the housing on a suitable support, drive out the ball bearing complete with the outer spacer and outer roller race.

Cleaning and inspection

Thoroughly clean the components and check the bearings for wear. If either bearing sounds rough or there is an indication of excessive slackness between the inner and outer races, it is advisable to renew the bearings.

Assembling

Using the Insertion Tool, VT 17037, press the ball bearing into the housing and position the outer distance piece in the housing.

Using the Insertion Tool VT 18215, fit the outer race of the roller bearing and insert the circlip into its groove.

Position the inner distance piece centrally over the inner race of the ball bearing and locate the inner race of the roller bearing.

Using the Insertion Tool, VT 18214, press in a new oil seal.

Mount the assembly on a suitable stand and, using the Insertion Tool , VT 17036, press the shaft fully home.

Fit the nut and washer to the end of the shaft and tighten to a torque loading of 135 Nm (100 lbf. ft.).

Using a new gasket, lightly coated with Wellseal jointing compound, fit the adaptor assembly to the wheelcase and secure with setbolts and spring washers.

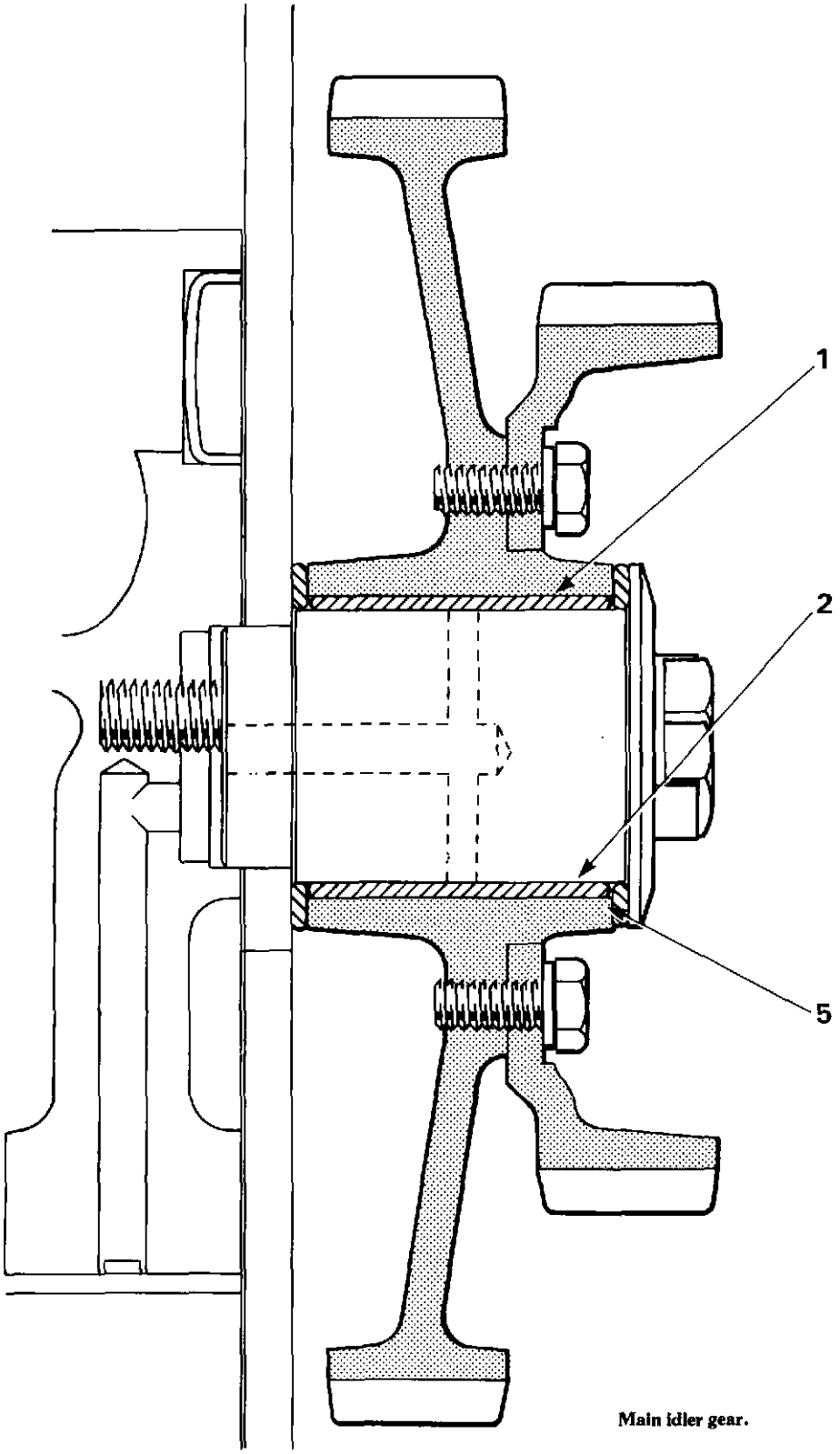
Refit the shims and fan belt pulley to the shaft flange and nip up the six securing setbolts and spring washers. Check the belt alignment and adjust the shim pack accordingly before finally tightening the setbolts securely.

SPECIAL TOOLS

Part No.	Description
Wheelcase	
VT 17845	Guide studs, wheelcase fitting/removal.
VT 17032	Insertion tool, oil seal.
Timing gears	
VT 12036	Insertion tool, main idler bush.
VT 12037	Insertion tool, oil pump idler bush.
VT 12818	Extraction tool, main idler bush.
VT 12819	Extraction tool, oil pump idler bush.
VT 17974	Alignment tool, auxiliary drive.
Fan adaptor	
VT 17033	Holding device, adaptor shaft.
VT 17037	Insertion tool, ball bearing.
VT 18215	Insertion tool, roller bearing.
VT 18214	Insertion tool, oil seal.
VT 17036	Insertion tool, shaft.

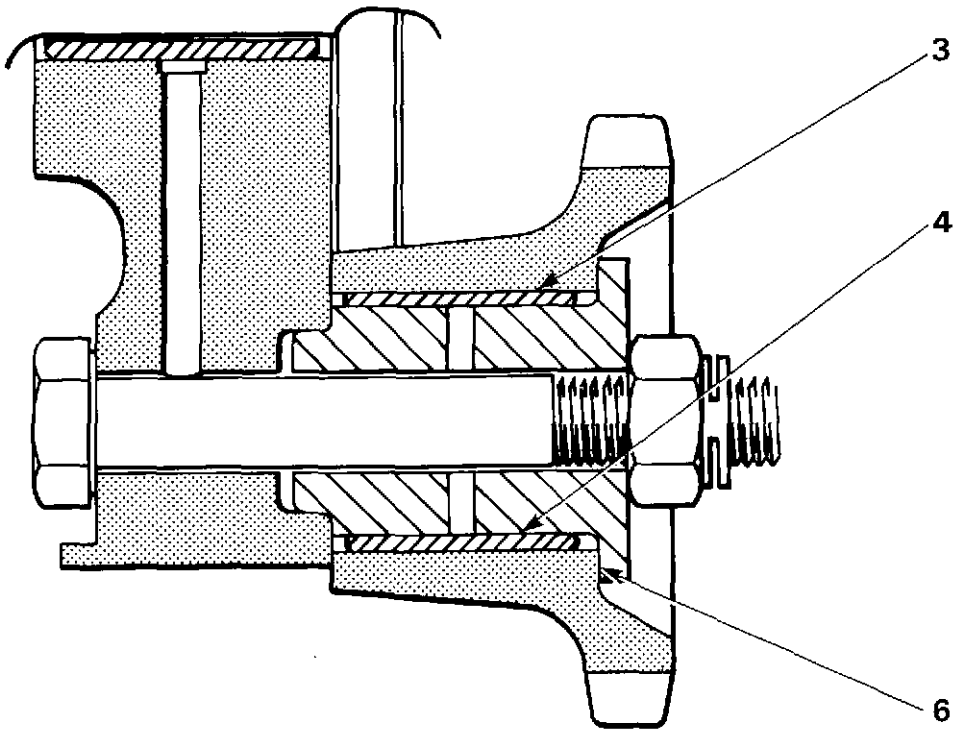
FITS AND CLEARANCES

WHEELCASE, TIMING GEARS AND FAN ADAPTOR



Main idler gear.

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		mm	inch	mm	inch	mm	inch	mm	inch	
	BACKLASH BETWEEN GEARS									
	Aux. drive—camshafts					0.10 to 0.233	0.004 to 0.009			
	Aux. drive—main idler					0.10 to 0.252	0.004 to 0.010			
	Coolant pump—main idler					0.10 to 0.277	0.004 to 0.011			Imperial dimensions have been 'rounded up' to nearest 1/1000 inch for convenience.
	Main idler—crankshaft					0.10 to 0.239	0.004 to 0.009			
	Oil pump idler—crankshaft					0.10 to 0.235	0.004 to 0.009			
	Oil pump idler—oil pump					0.10 to 0.380	0.004 to 0.015			
	IDLER GEARS ON AXLES									
	Main idler									
	Gear bore	50.00	1.9685							
1		to	to			Interference				
		50.023	1.9694			0.066	0.0025			
						to	to			
	Bush diameter	50.059	1.9720			0.127	0.0049			
		to	to							
		50.127	1.9735							
	Bush bore	44.983	1.7709							
		to	to							
2		45.034	1.7729			0.033	0.0013			
						to	to	0.199	0.0078	
	Axle diameter	44.91	1.7681			0.124	0.0048			
		to	to							
		44.95	1.7697							



Oil pump idler.

No. ON DIAG.	DESCRIPTION	DIMENSIONS NEW		PERMISSIBLE WORN DIMENSIONS		CLEARANCE NEW		PERMISSIBLE WORN CLEARANCE		REMARKS
		mm	inch	mm	inch	mm	inch	mm	inch	
	Oil pump idler									
	Gear bore	34.0 to	1.338 to			Interference				
3		34.025	1.339			0.062 to	0.024 to			
	Bush diameter	34.087 to	1.342 to			0.125	0.0049			
		34.125	1.343							
	Bush bore	29.997 to	1.1809 to							
4		30.023	1.1820			0.037 to	0.001 to	0.151	0.0059	
	Axle diameter	29.947 to	1.179 to			0.076	0.003			
		29.960	1.1795							
	IDLER GEAR END FLOAT									
	Main idler axle									
	Shaft length	56.15 to	2.2106 to							
5		56.20	2.2126							
	Gear hub width	50.875 to	2.0029 to			*0.10 to	*0.004 to	See 'REMARKS' column		Check thrust washer oil grooves and renew the washers before the grooves blend into the thrust faces—Nominal depth of oil grooves 0.18 to 0.38 mm (0.007 to 0.015 inch). *These dimensions take into account possible slight 'bowing' of the thrust washers.
		51.0	2.0079			0.425	0.017			
	Thrust washer thickness	2.4 to	0.0949 to							
		2.45	0.0965							
	Oil pump idler axle									
	Shaft length	35.20 to	1.385 to							
6		35.30	1.389			0.15 to	0.006 to			
	Gear hub width	35.00 to	1.377 to			0.30	0.012			
		35.05	1.379							

SECTION 16—RUNNING-IN AND TESTING

Every new or reconditioned engine supplied by Rolls-Royce is run and tested before being despatched from the factory. It requires no special treatment when put into service but the Operator is recommended to follow the instructions given in the Servicing Manual, T.S.D. 3115, Chapter 2.

When a CV8 engine in service has been completely overhauled or built up from a 'short engine', or when a partial overhaul has involved renewal of cylinder liners, piston rings and bearings, a running-in schedule applicable to the engine rating should be carried out, as described in the following text.

Note: Prior to running-in an engine, refer to Section 13 of this Manual for details concerning precautions adopted by Rolls-Royce Motors Limited to protect the turbocharger bearings from possible contamination during running-in at the factory.

RUNNING-IN

1. Prepare the engine for running and start up as described in the Servicing Manual T.S.D. 3115, Chapter 2.
2. Start the engine, run it at approximately 800 r.p.m. (automotive) or off load (industrial) and check that the correct oil pressure is registered steadily on the gauge. Inspect all the systems for leaks and shut down the engine. Rectify any leaks and top up the coolant and engine oil to the correct levels.
3. At the satisfactory conclusion of the running-in schedule, it is advisable to carry out an oil cosumption check in the manner described.

Running-in schedule

Start the engine and proceed with the following schedule:

CV8 engines rated at 1500 r.p.m. or 1800 r.p.m.

Period	R.p.m.	Load or rated power	Duration (minutes)
1	1500/1800	*MBL	5
2	1500/1800	25%	5
3	1500/1800	50%	10
4	1500/1800	75%	10
5	1500/1800	100%	10

*Minimum brake load.

At the start of period 5, load and speed must be checked to prevent possible overload.

During the running-in period the cause of any obvious noise or vibration should be sought, and the engine checked for leaks, which should be rectified after the run-in period is completed.

Engine shutdown must only take place at the end of a period, or in the case of an emergency.

OIL CONSUMPTION CHECK

Where practicable it is advisable to carry out the following check which is suitable for both the 1500 and 1800 r.p.m. rated engines.

Check schedule

1. Ensure that the engine oil level is *exactly* to the MAXIMUM mark indicated on the dipstick.
2. Run the engine at rated speed and power until the oil and coolant reach the normal working temperatures:
   Coolant outlet : 68 to 85 deg. C.
   Oil reservoir : 90 to 105 deg. C.
3. Allow the engine to run at idling speed, minumum brake load for two minutes, and then shut down. Wait for two minutes and then ensure that the oil level is to the MAXIMUM mark on the dipstick. Replenish if necessary to reach this level but DO NOT OVERFILL.

4. Drain the sump and oil-to-coolant heat exchanger into suitable separate containers for a period of 20 minutes. The heat exchanger should be drained from the oil pressure tube fitting in the elbow, this being the lowest drain point. Open up the heat exchanger inlet tapping to assist in free draining.
5. Weigh the both containers together with the oil separately and record the weights.
6. Refit the drain plug and heat exchanger fittings and return both quantities of oil to the engine. Weigh both the containers separately and record the weights.
7. Subtract the combined weight of both the empty containers from the total weight recorded in (5) to obtain the 'initial total' weight of the oil only. Record the weight.
8. Run the engine continuously at 90% full load power for a period of two hours.

Note: If for any reason the engine is stopped during this period the test must be re-started from para. 1.

9. On completion of para. 8 allow the engine to run at idling speed for two minutes. Stop the engine and repeat the procedures in para's 4 to 7 inclusive. Record the 'final total' weights of oil in the sump and heat exchanger.
10. The method for calculation of engine oil consumption where the oil weights are recorded in pounds (lbs), is as follows:

$$\frac{\text{'Initial total' oil weight—'Final total' oil weight}}{2.2} = \text{litres/hour}$$

Acceptable consumption limits:
Up to 0.682 litres/hour per engine.

SECTION 17—STORAGE

When the engine is out of use, whether temporarily or for a longer period, it must be protected against corrosion. The extent of the anti-corrosive treatment will depend on the anticipated duration pf the storage period and the condition under which the engine will be kept. Where necessary, precautions against frost damage must also be taken.

SHORT-TERM STORAGE

For out-of-use periods of up to seven days no anti-corrosive treatment is necessary. For out-of-use periods of up to one month no external treatment is necessary, but to prevent internal corrosion the engine should be run, until normal temperatures are reached, once every seven days. Engines which cannot be run should be turned by hand, for at least three revolutions, every seven days.

LONG TERM STORAGE

Before being stored for a period longer than one month the engine must be fully protected against internal and external corrosion.

A list of approval inhibiting products is given at the end of this section.

Preparation

Carry out the inhibiting procedure in the following sequence:

1. Remove and clean the thermostat as described in Section 10. Apply MS 4 silicone grease to the thermostat spindle(s), operating the valve(s) manually to work the grease between the spindle(s) and the gland(s). Reassemble the thermostat to its housing.
2. Run the engine until normal working temperature is reached, shut the engine down and immediately drain the lubricating oil from the sump and oil filter bowls.
3. Fill the oil filter bowls with PX4 inhibitor, (see end of Section), and refit the bowls to the header bracket.
4. Fill the sump to the normal level with PX4 inhibitor and once again run the engine until normal working temperature is reached.
5. Stop the engine, disconnect the fuel supply and re-connect to a supply of PX4 inhibitor. Restart the engine, whilst still hot, and run it for ten minutes, off load. Stop the engine.

If the engine coolant passes through a sea-water heat exchanger, as on certain marine engines, the sea-water inlet and discharge valves must be closed and the sea-water system drained.

6. Flush the sea-water system through with clean fresh water and connect the sea-water pump inlet to a slave tank containing a standard coolant mixture, i.e. 50% inhibited ethylene glycol to which 1% of soluble oil (e.g. Shell-Dromus oil or equivalent), has been added. Route the outlet of the sea-water system back to the tank to complete the circuit.
7. Run the engine briefly to ensure a thorough circulation of the sea-water system then stop the engine and drain the system completely.
8. Disconnect the supply of PX4 inhibitor and blank off the end of the fuel feed pipe. Attach a label in a prominent position to indicate that the fuel supply has been disconnected.
9. Remove the fuel injectors and immerse them in a container of PX4 inhibitor.
10. Set the fuel control to the 'NO FUEL' position, remove the rocker covers and disconnect the air inlet ducting from the induction manifold.
11. Motor the engine on the starter and, simultaneously, spray PX4 inhibitor into the manifolds until vapour emerges from each fuel injector orifice. Re-connect the air inlet ducting.
12. Using a suitable self-metering spray gun, spray 40 ccs. of PX4 inhibitor into each cylinder through the fuel injector orifice, then refit the injectors.

Note: The engine must not be rotated after this operation and should carry a prominent notice to this effect.

13. Spray the valve gear with PX4 inhibitor, then refit the rocker covers.
14. Drain the PX4 inhibitor from the engine sump and oil filter canisters. Attach a 'NO OIL' notice to the filler cap.
15. Drain the cooling system and refill with a fresh coolant mixture of inhibited ethylene glycol and clean water.
    Note: The mixture must not contain less than 50% inhibited ethylene glycol and may contain up to 90% by volume.
    Allow the system to settle for 15 minutes, then completely drain off the coolant mixture. Attach a 'NO COOLANT' notice to the coolant filler cap.
16. Disconnect the exhaust system at the turbocharger diffuser outlet or, on normally aspirated engines, at the junction of the manifolds. Inject two grammes of VPI 260 powder, (see end of Section), and fit a blanking plate. Do NOT reconnect the exhaust pipe.
17. Disconnect the air cleaner(s) and inject two grammes of VPI 260 powder into Cyclopac type air cleaners. Oil-bath, wire mesh or dry nylon type air cleaners may be sprayed internally with PX4 inhibitor or VPI 260 powder.
18. Inject two grammes of VPI 260 powder into the turbocharger. Re-connect the air cleaner(s).
19. Brush coat or spray all unpainted areas of the engine and auxiliary equipment with 'Crodafluid' PM 47, (see end of Section), paying special attention to the fuel control linkage.
    Caution: Do NOT spray PM 47 into the vent apertures of the alternator.
20. Wrap the alternator and starter motor in mouldable wax wrapping and seal with adhesive tape.
21. Seal the air cleaner inlet, crankcase breather and any other openings with mouldable wax wrapping and adhesive tape or plastic caps as appropriate.
22. Remove all driving belts, dust them liberally with french chalk and place them in a sealed polythene bag attached to the engine.
23. Finally, affix a label in a prominent position on the engine stating:
    (a) That the exhaust system has been blanked off.
    (b) The date on which the engine was inhibited and the date on which the engine will require re-inhibiting.

If the engine is to remain in storage for more than one year, the above procedure must be carried out at the end of each 12 month period.

REMOVAL FROM STORAGE

Instructions for preparing the engine for running after storage can be found in CHAPTER 2—OPERATING, in the SERVICING MANUAL, TSD 3115. The information given applies equally to newly installed engines and those removed from storage.

APPROVED PRODUCTS FOR ENGINE INHIBITING

Cooling and sea-water systems.
Inhibited ethylene glycol as listed in leaflet T.S.D. 3085.

Thermostats	
Ambersil Ltd	MS 4
Lubrication system	
Croda Chemicals Ltd	PX4
Induction and exhaust systems	
Shell Chemicals Ltd	VPI 260 powder
Fuel system	
Croda Chemicals Ltd	PX4
External protective oils	
Croda Chemicals Ltd	'Crodafluid' PM 47

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