Rolls Royce Diesels

Perkins Engines

T.S.D. PUBLICATION 3138

SERVICING MANUAL

CV12 ENGINES

PERKINS ENGINES (SHREWSBURY) LIMITED
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ROLLS-ROYCE MOTORS

Diesel Division

SERVICING MANUAL

CV12 Industrial engines

T.S.D. Publication 3138

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NOTES TO USERS

The purpose of this Manual is to provide Operators with all information necessary for the correct usage and efficient maintenance of Rolls-Royce CV12 industrial engines between overhauls.

Repair and overhaul information is contained in the Workshop Manual.

Service

Throughout the world, Dealers and Distributors appointed by Rolls-Royce can provide advice, spare parts and Factory trained staff, and the area based engineer and the Service Department of Rolls-Royce Motors Limited are always available for consultation.

To assist Operators in reducing 'down time' to a minimum, Rolls-Royce Motors have instituted a Service Exchange Scheme so that Dealers and Distributors can speedily supply a 'short engine' or major component, fully reconditioned and guaranteed for six months. Units always available are listed overleaf; in certain circumstances reconditioned complete engines can also be supplied.

Advice and assistance can be supplied more efficiently if enquiries are accompanied by the following information:

1. In all cases, the engine Number, Designation and Build Number as stamped on the crankcase data plate, and 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, details of service history etc.

Instruction

A five day course on servicing and overhaul of CV12 engines is available at the Factory. For details, apply to: The Superintendent, Customer Training Centre, Rolls-Royce Motors Limited, Shrewsbury, Shropshire, England. Telephone: 0743/52262.

Technical and Parts Bulletins

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

1. Changes occurring in Service Techniques are issued as Service Instructions for inclusion in Servicing Manuals held by Distributors and Operators.
2. Engine design changes are published as Modifications in Service Bulletins for information of Dealers and Distributors.

SERVICE EXCHANGE UNITS

For further details apply to Rolls-Royce Dealers and Distributors

Alternators	Fuel Injection Pumps
Coolant Pumps	Oil Pumps
Crankshafts	Short Engines
Cylinder Heads	Starters
Fuel Injectors	Turbochargers

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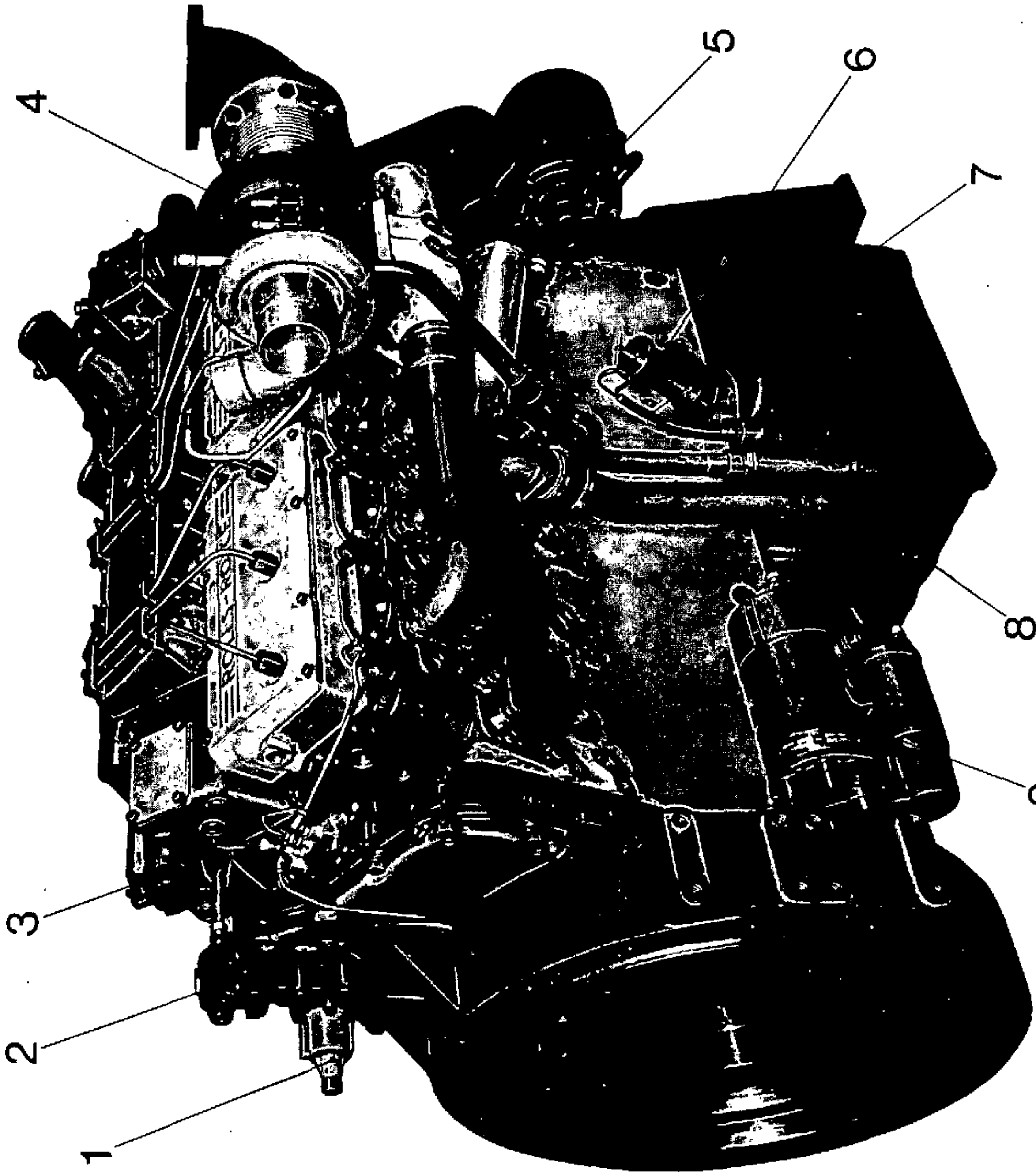
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FRONTISPIECE

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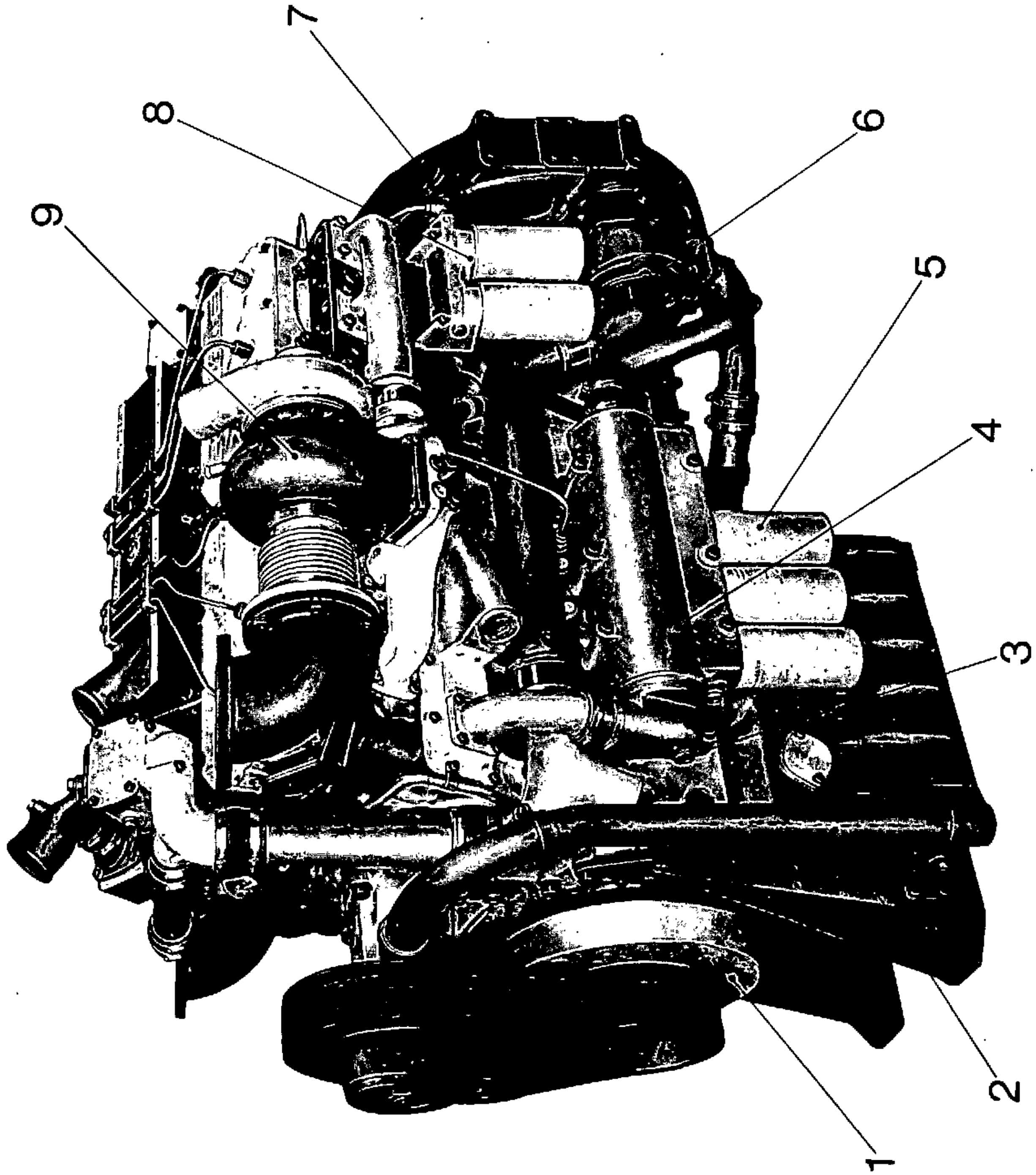
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CHAPTER 1—DESCRIPTION AND DATA

The Rolls-Royce CV12 is a turbocharged, charge cooled, 12 cylinder, direct injection, liquid cooled, four stroke compression ignition engine in a 60 deg. 'V.' configuration.

Engine identification

The engine number, designation and build line number are quoted on the plate attached to the crankcase.

Major assemblies such as the fuel injection pump, turbochargers and starter motor also carry their own identification plates.

These details should be quoted in full when ordering spare parts or raising a query.

Bank and cylinder bore identification

Viewed from the front (free end) of the engine, 'A' bank is to the left, 'B' bank is to the right.

The cylinders are numbered from front to rear A1 to A6 and B1 to B6.

Crankcase

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

Each bearing assembly is held in place by a forged steel bearing cap; the centre and each end cap are attached with four bolt fixings, the remainder with two bolts per cap.

Lateral security is by setscrews through the crankcase side walls into location pads on each side of the bearing caps.

Two banks each of six cylinders are formed in a 60 deg. included angle 'V' formation. The cylinder bores are in a conventional staggered pattern with 'B' bank leading

Cylinder bores are machined to accept full length slip fit liners.

Studs are fitted into the crankcase with thread locking adhesive to locate and secure the four monobloc cylinder heads, with smaller diameter setbolts centrally disposed between each pair of tappet bores.

Cylinder liners

The full length, slip fit, pre-finished liners are made from centrifugally cast iron and machined to close tolerances.

Crankshaft

The crankshaft is made from a chrome molybdenum steel forging, nitride hardened, with the exception of the rear end face, the dowel hole and the tapped holes.

The bearing surfaces consist of seven main journals and six crankpins, each crankpin serving two connecting rods.

The crankshaft is balanced statically and dynamically at the machining stage and requires no further compensation when assembled.

Oil transfer is by centrally machined holes through the diameter of each journal, with holes drilled through each crankshaft web to connect with journal oilways. These holes open into conventional sludge traps with oil flow to the crankpin bearings through two holes drilled from the crankpin periphery into each sludge trap.

Small holes are sealed with cup-plugs where necessary, the larger sludge traps being blanked off with an aluminium disc and 'O' ring seal secured with a spring clip.

Crankpins are disposed for each pair of cylinders in the following order. 1 and 6, 2 and 5, 3 and 4, with each pair 120 deg. out of phase with the others, giving a firing sequence of A1, B6, A4, B3, A2, B5, A6, B1 A3, B4, A5 and B2.

On the flywheel end of the crankshaft a 45 toothed helical gear is machined, serving as the primary drive to the gear train. The end face is drilled and tapped with 16 equally spaced holes which, with hexagon cap screws, are used to secure the flywheel which carries the starter ring.

At the forward end of the crankshaft a helical gear is machined which drives the lubricating oil pump through an idler gear.

The free end face is drilled and tapped to accomodate 12 equally spaced setscrews which secure the viscous damper and fan and alternator drive belt pulleys to the crankshaft.

Main bearings

The main bearings consist of steel backed half bearing shells with a lead bronze lining, and a precision plated lead indium surface.

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

The lower half is similar, but only shortened machined grooves are present. These grooves correspond to the peripheral groove in the upper half for smooth transfer of oil to the lower bearing surfaces.

Thrust washers

Two upper thrust washer halves made in similar material to the main bearing shells, but without lead indium plating, locate on either side of the centre main journal into recesses machined in the crankcase. Lubrication is from the centre main bearing with grooves in the surface of the thrust washers to allow oil flow. The lower half washers are similar but have an integral locating tang.

Connecting rods

The connecting rods, manufactured from chrome molybdenum steel forgings are machined to accept steel backed leaded bronze small end bushes. Each bush is fitted into position with the joint located at 45 deg. in the upper portion of the bore. This in turn positions the oil holes equally in a 120 deg. arc adjacent to the connecting rod shank.

The small end of each rod is of wedge design to assist pressure loading of the small end and piston. An oil hole bored centrally through the column allows pressurised oil to be transferred intermittently from the crankpin to provide small end and gudgeon pin lubrication.

Four special bolts with bi-hexagon nuts are used to secure each big end bearing cap to its specific rod. Markings on each connecting rod assembly give rod to cap correlation, weight, and when allocated the cylinder bore number.

The big end bearing shells are of the same composition as the main bearings but do not have machined grooves in the bearing surfaces. As the connecting rods run in pairs, it is important to note that the large internal chamfer on one face of each big end is to the outside of each pair.

Pistons

Cast from high silicon aluminium alloy with the crown machined to form an open toroidal combustion chamber, each piston carries three compression rings 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. A cooling gallery, cast into the piston body, is fed with pressurised oil from an oil jet supplied directly from the main oil gallery. This provides more efficient cooling of the piston than conventional surface cooling methods.

The gudgeon pin is fully floating and is secured by the conventional circlip method.

It must be noted that when assembling the connecting rod and piston, the flat face of the connecting rod big end and the 'U' shaped offset relief in the piston skirt, must be vertically in line.

Camshafts

The camshafts are manufactured in an alloy cast iron with the cam noses chill hardened. The cam lobes are of the high lift, short duration type with precision machined tapers.

Unidentical camshafts are necessary to accomodate the offsetting of the cylinder bores with 'B' bank leading.

'A' bank camshaft can be identified by a shorter bearing surface on the camshaft drive gear end and is also the shorter of the two shafts. The flanged end accomodates the camshaft phasing gear secured by six hexagon headed setbolts.

'B' bank camshaft has the longer bearing surface at the drive end. The flanged end accomodates the phasing and drive gear mounted in tandem and secured by six hexagon headed setbolts.

Each shaft operates six pairs of exhaust and inlet valves through conventional push rod and rocker assemblies.

Camshafts are high mounted inside the 'V' of the main crankcase and positioned axially by thrust plates.

Bearings are pre-finished steel backed leaded bronze bushes manufactured with clinch butt joints, disposed singly in the 'A' bank configuration with the exception of the centre position where two are used. In the 'B' bank assembly twin bearings are used in the centre and rear positions. All bushes are drilled and grooved for lubrication and to complete the assembly a large cup plug is pressed into each location bore in the front end of the crankcase.

Push rods and tappets

The pushrods are manufactured from medium steel bar with forged spherical seating ends. Each end is induction hardened with the convex foot end finally machine polished The mating ends of the pushrod and rocker adjusting screw are radiused to allow good surface contact during angular operation.

Tappets are made from an alloy cast iron with chill-hardened bases. Each is fully machined with a spherical face and subjected to a surface treatment to give an oil retaining surface finish. The tappets run in the parent crankcase metal and are lubricated by pressure feed from the auxiary oil galleries, with cam action transmitted to the valve rockers by conventional pushrods.

Gear train

The wheelcase, mounted on the rear of the engine, incorporates a train of helical gears with the crankshaft pinion driving an idler and compounded gearing which in turn drives the coolant pump, cam phasing gears and fuel injection pump.

The timing gears are positioned across centres using a machined spot on the side of one tooth locating between two timing spots on the engaged gear. Fixing is by hexagon headed setbolts. The cam drive gear which covers the 'B' bank phasing gear is located by a spring dowel and secured by six hexagon headed setbolts.

The fuel pump drive shaft runs in tapered roller bearings with end float controlled by the use of shims.

Lubrication is via the main gallery through the rear main bearing to the camshaft compounder and water pump idler. A separate supply feeds the camshaft idler whilst the fuel pump drive shaft bearings are lubricated from the 'A' bank auxiliary gallery.

The flywheel housing, attached to the wheelcase, accomodates the flywheel/starter ring assembly and the silicon rubber lip type crankshaft oil seal.

The flywheel assembly is secured to the crankshaft by 16 socket head cap screws and located by a dowel.

Cylinder heads

The four identical cylinder heads are manufactured from high duty, close grained cast iron and machined top and bottom, to provide joint faces for the rocker box and cylinder head gaskets respectively. Joint faces machined on the inner and outer edges accomodate the induction and exhaust manifolds. Internal coolant passageways are cast around the valve guides and injector pockets.

The valve guides are cast in high quality nickel chrome alloy and inserted under pressure into the cylinder head casting.

Valve seat inserts are frozen into position against machine shoulders in the cylinder heads.

All inlet valves are of solid forged steel; exhaust valves may be forged steel with sealed chambers in their stems part filled with sodium, or solid nimonic material. The forged steel valves have stellite seats and in addition the sodium filled exhaust valves have stellite stem tips. All valves, nimonic or forged steel, have chrome flashed stems.

A groove machined around the valve stem tip indicates a sodium filled valve stem. An instruction on the current method of disposal of this type of valve is given in Chapter 3—Servicing, (see Section 8).

All valves are secured by the conventional collet, spring and seat arrangement. The exhaust valves are fitted with valve rotators in place of the upper spring seats. Paired movement of the valves is controlled by valve bridges with an adjusting screw and locknut on the outer arm of each bridge. A nitride hardened button, inset into the top face of each bridge, connects with the rocker arm, pushrod and tappet and finally the camshaft.

The rocker arms, with tappet clearance adjusting screws, are assembled in each rocker box on a main shaft. The rocker boxes, located on spring dowels, are secured by socket head cap screws and setbolts, torque tightened to a specific figure. The rocker box covers are of cast aluminium.

The three fuel injectors carried in each head are secured by finger clamps and setbolts. The fuel inlet connections and fuel spill connections are sealed at the rocker box covers and rocker box side walls respectively against oil leakage and ingress of dirt.

Fuel system

The fuel injection pump, mounted on a platform in the engine 'V', is a conventional 12 element—in-line unit driven at 0.5 times engine speed from the main gear train. A constant speed governor integral with the injection pump maintains engine speed throughout the engine load range. The stop control lever on the governor is coupled directly to a solenoid, used in the energised-to-run mode, which in turn is actuated by the stop button and the engine protection devices. A vernier control, connected to the speed control lever, provides for fine adjustment of engine r.p.m.

Viewed from the rear of the engine, the fuel injection pump rotates anti-clockwise with the pump elements operating in the following sequence: 1, 9, 4, 11, 2, 7, 6, 10, 3, 8, 5 and 12 at 30 deg. intervals with No. 7 element at spill cut off point (A6 firing). Static timing in 20 deg. BTDC.

The high pressure fuel pipes are made from special steel tubing, 8 mm diam. x 2 mm bore. Zinc plated nuts and collars are incorporated at both ends of each pipe, with the cylinder numbers stamped on the nuts.

The low pressure fuel pipes are made from mild steel, with low pressure joints of tubing nuts and sleeves.

The fuel feed pump is cam driven from the rear end of the auxiliary drive shaft. Fuel is drawn through a primary filter from the supply tank and directed through twin canister type filters to the injection pump gallery. A low pressure relief valve, integral with the injection pump, maintains a constant feed pressure to the pump elements, and allows the excess fuel to return to the supply tank.

The feed connections, from each of the low spring type injectors, protrude through the rocker covers. Spill connections, passing through the side walls of the rocker boxes, are fitted with banjo unions and interconnecting pipework to return spill fuel unfiltered, to the supply tank.

Cooling system

A gear driven pump, mounted at the rear end of the 'B' bank side of the engine delivers a flow of coolant throughout the system. The coolant flow is directed via a bifurcated pipe to both banks of cylinders, the flow to 'B' bank passing initially through an oil-to-coolant heat exchanger.

After passing through the cylinder block, the coolant is directed to the cylinder heads where it circulates around the injector pocket and valve guides. The coolant then enters galleries integral with the induction manifolds and is directed to the two thermostat valves, forward of the manifolds. Dependent on the operating temperature, the thermostats then direct the coolant through the radiator or directly back to the coolant pump suction.

Lubrication system

The wet sump lubrication system incorporates a spur gear type pump, driven from the front end of the crankshaft, which draws oil from the sump well to be delivered under pressure throughout the system.

The oil passes from the pump to the oil-to-coolant heat exchanger, mounted on the 'B' bank side of the crankcase. From the heat exchanger, the oil passes through the three full flow canister type filters, which are screwed directly to the bottom of the heat exchanger housing, and into the main oil gallery. Drillings from the main gallery supply oil to the main bearings, idler gear axles and two auxiliary galleries, which in turn supply oil to the camshaft bearings, valve gear and fuel injection pump.

Connecting rod big end and small end bearings are supplied with oil from the main bearings through drillings in the crankshaft and holes bored lonitudinally through the connecting rods.

Small pressure jets, bolted between the main bearing housing, supply cooling oil to galleries cast in each piston crown.

External pipework delivers oil from the heat exchanger mounting adaptor to the turbocharger bearings, and returns drain oil to the sump.

Oil-to-coolant heat exchanger
The heat exchanger, comprising of a single tube pack in an alloy casing, is mounted on an adaptor assembly on the 'B' bank side of the crankcase. Coolant flows through the tubes whilst the oil is directed over the outside of the tubes, by a series of baffles, to achieve maximum heat transference between the fluids.

Pressure relief valve
The pressure relief valve, integral with the heat exchanger mounting, is a conventional plunger and spring arrangement, and allows excess oil to return to the sump at pressures exceeding 414 kN/sq. m. (60 lbf./sq. inch).

Oil filler and dipstick
The oil filler, consisting of a simple tube with a sealing cap, is mounted over the 'A' bank side of the sump well.

The dipstick, held in a curved tube adjacent to the filler, consists of a flat spring-steel blade which is cranked to lie clear of the tube wall. Notches machined in the blade edge indicate maximum and minimum permissible lubricating oil levels.

Induction and exhaust systems
Turbochargers, mounted alongside each front cylinder head, draw induction air through the two dry element type air cleaners and discharge it to the induction manifolds via a charge cooler, integral with the coolant radiator.

Exhaust gases from each cylinder are directed, via a twin discharge on the front section of each exhaust manifold, to the turbine of each turbocharger. After passing through the turbines, the exhaust is directed through flexible bellows units and elbow connections to which appropriate pipework and silencers may be fitted, dependent on installation requirements.

Electrical system
The Butec A13 alternator provides a 24 volt, 30 amp output for battery charging, a Butec type R1 regulator being incorporated in the circuit.

The Butec MS/6 starter motor is fitted to the 'A' bank side of the flywheel housing and incorporates an externally mounted solenoid switch.

Two engine protection switches, which operate under conditions of low oil pressure or high coolant temperature, actuate a shutdown solenoid attached to the governor.

The solenoid is used in the energised-to-run mode.

Engine service counter (E.S.C.)
An E.S.C., mounted adjacent to the fuel feed pump, is geared to record one unit for each hour running at the r.p.m. rating stamped on its data plate.

Engine turning device
Machined slots in the crankshaft pulley serve to accomodate a flat barring tool, which allows the engine to be turned by hand to facilitate tappet adjustment etc.

TECHNICAL DATA

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

NUMBER OF CYLINDERS 12

ARRANGEMENT .... 60 deg. included angle 'V' configuration

BORE .... 135 mm (5.315 inches)

STROKE .... 152 mm (5.984 inches)

FIRING ORDER .... B6, A4, B3, A2, B5, A6, B1, A3, B4, A5, B2 and A1

COMPRESSION RATIO .... 14 : 1

CAPACITY (Total swept volume) .... 26.11 litres (1593.24 cu. inches)

MAXIMUM RATED SPEED .... 1800 r.p.m.

MAXIMUM POWER OUTPUT .... 484 kW (705 bhp)

VALVE TAPPET CLEARANCES (Cold)
Inlet valves .... 0.4 mm (0.016 inch)
Exhaust valves .... 0.7 mm (0.028 inch)

DRY WEIGHT OF BARE ENGINE .... 2120 kg (4674 lbs)
(approximate for handling purposes)

FUEL SYSTEM

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

APPROVED FUEL .... See leaflet T.S.D. 3085 in rear cover pocket of Manual

INJECTION PUMP .... 12 element, in-line, base mounted, C.A.V. Maximec SPE-12 MX unit

FEED PUMP .... Double acting Bosch mechanical with hand priming pump

INJECTORS .... C.A.V. axial feed, low spring type

INJECTION PRESSURE .... 24300 kN/sq.m. (240 atmospheres)

INJECTION TIMING .... 20 deg. B.T.D.C. (Static)

GOVERNOR .... C.A.V. mechanical Type GCSV-MX, integral with injection pump

MAIN FILTERS .... 2 spin on type expendable canisters, self venting

PRIMARY FILTER .... Washable, wire-wound element, with by pass valve

LUBRICATION SYSTEM

TYPE .... Wet sump

APPROVED LUBRICATING OIL .... See leaflet TSD 3085 in rear cover packet of Manual

CAPACITY
Sump .... 54 litres (11.8 Imp. gallons) to FULL mark on dipstick
System total .... 67.6 litres (14.8 Imp. gallons)

OIL PUMP .... Spur gear type driven from front crankshaft gear

OIL PRESSURE .... 415 kN/sq.m. (60 lbf/sq. inch) hot, under normal load conditions

*207 kN/sq.m. (30 lbf/sq. inch). Minimum permissible at rated speed

HEAT EXCHANGER .... Single, finned and baffled, tube pack and shell

PRESSURE RELIEF VALVE .... Non-adjustable, spring loaded plunger type

OIL FILTERS .... *3 spin-on, expendable canister type, self venting* with by-pass valves

MAXIMUM RECOMMENDED BULK OIL TEMPERATURE .... 120 deg. C.

* Important for the protection of turbocharger bearings.

COOLING SYSTEM

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

PUMP .... Centrifugal, gear driven unit

COOLANT CAPACITY
Engine and pipework .... 68 litres (15 Imp. gallons)
Engine/radiator pack .... 164 litres (36 Imp. gallons)

SYSTEM PRESSURE .... Up to 48 kN/sq.m. (7 lbf/sq. inch)

THERMOSTATS .... 2 Western Thomson wax capsule. Type 6-533

COOLING FAN .... 1400 mm (55 inch) diam. aluminium alloy, 8 blades, belt driven

INDUCTION/EXHAUST SYSTEM

AIR CLEANERS .... 2 Donaldson Cyclopac FHG 14 dry element with restriction indicators

CHARGE COOLERS .... Serck or Cov Rad, air cooled, integral with coolant radiator

TURBOCHARGERS .... Two Garret AiResearch Type TV61 side mounted on exhaust manifolds

EXHAUST SILENCERS .... Customer supply

ELECTRICAL SYSTEM

ALTERNATOR ....Butec A13, 24 volt, 30 amp output

REGULATOR ....Butec Type R1, non-adjustable

STOP SOLENOID .....................................C.A.V. Type 368 energised-to-run

SHUTDOWN AND WARNING SWITCHES .... Teddington Type DCA high coolant temperature and low oil pressure switches

STARTER MOTOR ....Butec Type MS6, 24 volt with externally mounted solenoid switch

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	Rocol J166
INDUCTION SYSTEM		
Emulsifying solvent	Morris's Shrewsbury	Pavan
JOINTS		
Jointing compound	Wellworthy Ltd	Wellseal
	Marston lubricants Ltd	Hylomar SQ 32
Sealant and thread locking where specified	Douglas Kane Sealants	Loctite 601, 542, 270, 241
STARTER MOTOR		
Commutator cleaning fluid	I.C.I. Limited	Genklene 'N'
	Applied Chemicals, Limited	Fluid grade 8-23
Lubricator wick oil	Various	Mineral oil SAE5W/20

TORQUE LOADINGS

Note: The following torque loadings apply to clean threads in oil wetted condition, unless the use of thread locking compound is advocated.

		Nm	lbf. ft.
ALTERNATOR			
Pulley nut		95	70
AUXILIARY DRIVE SHAFT			
Hub nut		150	110
CAMSHAFTS			
Drive gear setbolts 'A' bank	**Using Loctite 241**	40	30
Drive gear setbolts 'B' bank	**Using Loctite 241**	80	60
Thrust plate socket screws		85	63
CONNECTING RODS			
Big end bearing bolts		*60	42
CRANKSHAFT			
Damper and pulley setbolts		70	50
Flywheel setscrews		315	230
CYLINDER HEADS			
Securing setbolts		200	147
Securing nuts		200 (plus further 90 deg.)	147
Rocker box setbolts		41	30
Rocker box capscrews		35	26
Rocker cover setbolts		30	22
Bridge piece adjusting screw locknut		40	30
Tappet adjusting screw locknut		40	30
COOLANT PUMP			
Drive gear nut		90	65
Bearing locknut		176	130
EXHAUST MANIFOLDS			
Securing setbolts		48	35
FAN ADAPTOR			
Bearing Securing nuts		280	205
FUEL FEED PUMP			
Cam securing nut		55	40
FUEL INJECTION PUMP			
Camshaft hub nut		150	110
Mounting setbolts		40	30
Flywheel cupscrews		70	50
Delivery valve holders		122	90
Spring plate coupling bolts		102	75

	Nm	lbf. ft.
FUEL INJECTORS		
Clamp setbolts	40	30
Nozzle capnut	80	60
Spill connections	40	30
Spill banjo bolts	27	20
FLYWHEEL HOUSING		
Bolts to crankcase	95	70
GEAR TRAIN		
Compounded gear setbolts (Using Loctite 241)	40	30
Auxiliary drive gear setbolts	80	60
Idler gear axle setbolts	70	50
GOVERNOR		
Drive flange nuts	127	95
Spring drive nut	40	30
LUBRICATING OIL PUMP		
Gear retaining nut	122	90
Shaft locknut	80	60
Casing setbolts	21	15
MAIN BEARING CAPS		
Securing setbolts (Front, centre and rear)	177	130
Lateral setbolts (Front, centre and rear)	114	85
Securing setbolts (Intermediate)	488	360
Lateral setbolts (Intermediate)	177	130
SUMP		
Securing bolts	40	30
Insert for drain plug (Using Loctite 601)	305-339	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

* Big end bearing bolts to be tightened sufficiently to give a bolt stretch of 0.30 to 0.38 mm (0.012 to 0.015 inch).

CHAPTER 2—OPERATING

ROUTINE PROCEDURE WITH A NEW OR OVERHAULED ENGINE

Note: Every new or reconditioned engine supplied by Rolls-Royce Motors is run in before leaving the Factory.

1. Check that all wrappings and sealing blanks have been removed.
2. Refit any components removed for storage or transportation.
3. Ensure that all coolant and lubricating oil drain plugs are securely fitted.
4. Dependent on installation, connect remote control linkage, pressure gauge pipework, air intake ducting and electrical wiring.
5. Connect fuel supply and exhaust pipework.
6. Fill the fuel supply tank(s) with the correct grade of fuel (See leaflet T.S.D. 3085).
7. Fill the cooling system with the approved coolant mixture. (See leaflet T.S.D. 3085).
8. Fill the sump to the UPPER mark on the dipstick (fig. 1) with the correct grade of lubricating oil. (See leaflet T.S.D. 3085).
9. Prime the turbochargers (fig. 2) with clean engine lubricating oil. (See Chapter 3, Section 6 for details).
10. Bleed the fuel system of air as described in Chapter 3, Section 4.
11. Lubricate all control linkage and check for freedom of movement throughout its range.
12. With the stop control in STOP position, motor the engine on the starter until oil pressure is registered on the gauge.

ROUTINE STARTING

Carry out daily servicing checks.

Normal start:

Fuel cock	—	ON
Stop control	—	In RUN position
Starter button	—	Press and release when engine fires

After starting, check that correct oil pressure is registered on the gauge, and switch on the engine protection devices, if applicable.

Initial start of newly installed engine or after a period of more than 1 month storage or lay-up:

Carry out daily servicing checks

Prime the turbocharger bearings

Fuel cock	—	ON
Stop control	—	Secure in STOP position
Starter button	—	Press for 10 seconds Release for 10 seconds Press for 20 seconds Release for 20 seconds

With the stop control in the RUN position, proceed as for normal start.

STARTING IN LOW AMBIENT TEMPERATURES

An excess fuel device (fig. 3), integral with the stop control lever shaft, facilitates starting in ambient temperatures below freezing.

Before starting the engine, push the control rod of the excess fuel device fully inwards. When the starter button is pressed and the engine fires, the control rod will automatically return to its original position. The excess fuel device must not be used in conjunction with other types of cold starting aids as the excess fuel will make starting more difficult.

RUNNING THE ENGINE

The following precautions will help to ensure a long and trouble-free engine life:

1. Do not subject the engine to 'full load' until working temperature is reached.
2. Avoid long periods of 'off load' running.
3. Maintain full fuel tanks to avoid condensation.

STOPPING THE ENGINE

1. Run the engine for 3 minutes, off load, to allow the turbochargers to reduce speed and temperature.
2. Switch off engine protection devices if applicable and move the stop control to the STOP position.

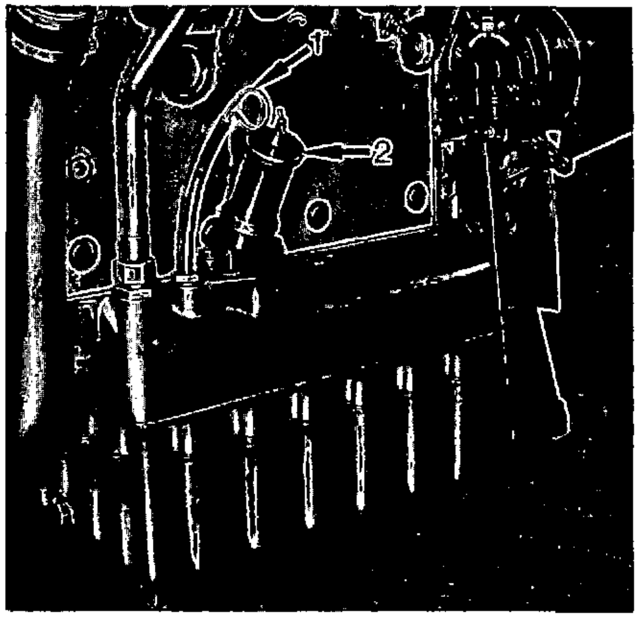


Fig. 1. Dipstick and oil filler
1. Dipstick
2. Oil filler cap

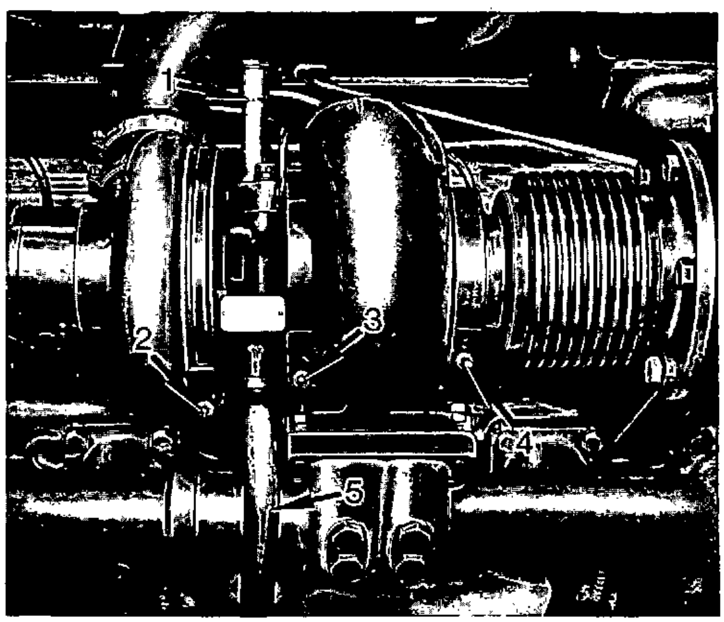


Fig. 2. Turbocharger
1. Oil priming pipe
2. Compressor housing clamp bolt
3. Turbine housing clamp bolt
4. Exhaust bellows clamp bolt
5. Oil drain pipe

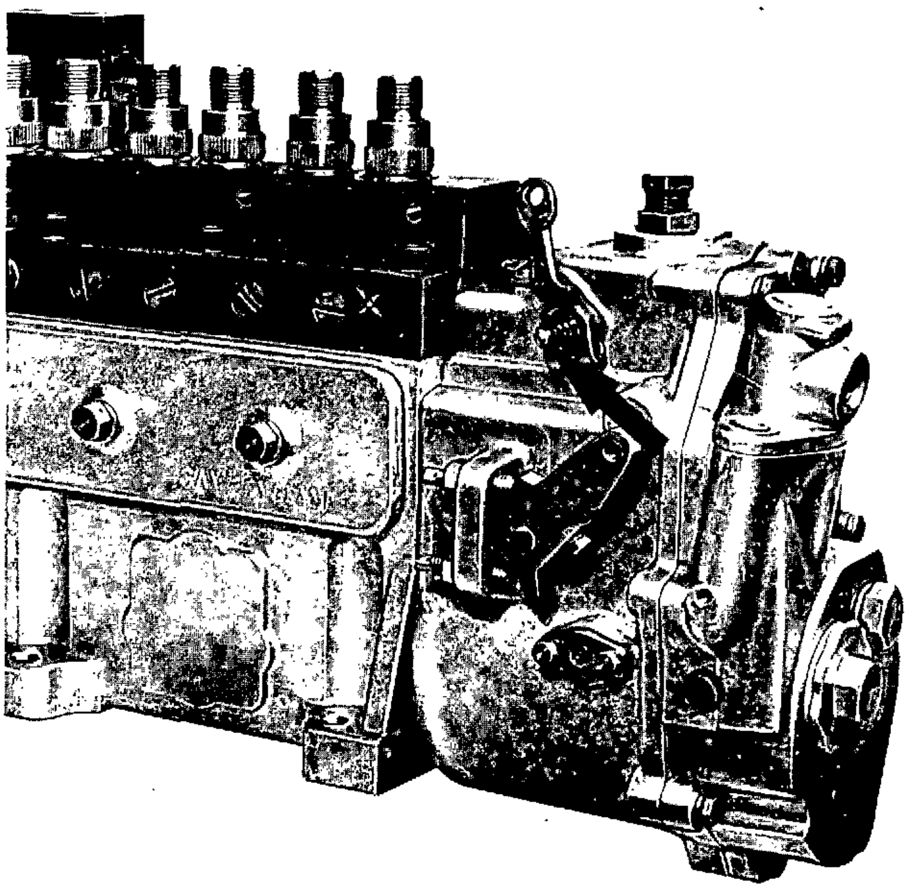


Fig. 3. Excess fuel device

CHAPTER 3—SERVICING

CONTENTS

SECTION 1—SERVICING SCHEDULES

IMPORTANT NOTES

1. If experience on a particular installation indicates the necessity for amendment of the Servicing Schedules, consult the Service Department of Rolls-Royce Motors Limited.
2. Engines under Guarantee must be serviced in accordance with the Servicing Schedules, unless otherwise agreed by Rolls-Royce Motors Limited.
3. To comply with the terms of the Rolls-Royce Guarantee use only genuine Rolls-Royce parts, which are themselves guaranteed for six months. The use of counterfeit spares, notably filter elements, not only invalidates any current Guarantee but can seriously reduce engine life and performance.
4. The servicing intervals quoted in the Schedules may be reduced at the discretion of the Operator to suit local conditions but must NOT be exceeded.
5. In addition to the servicing operations in the following Schedules, make regular checks to ensure that the fuel, cooling, lubrication, induction and exhaust systems are free from leaks. This will be made easier if the engine and surrounding areas are maintained in a clean condition.

ENGINES IN CONSTANT USE

The following Schedule is based on the number of units recorded by the Engine Service Counter (E.S.C.). This instrument is geared to record one unit for each hour of running at the rpm rating stamped on its data plate. The E.S.C., mounted over the flywheel housing (fig. 1), is driven from the end of the auxiliary drive shaft.

Daily, or every 10 E.S.C. Units — **Section**

Cooling System — 3

Check that the coolant level is above the baffle in the radiator top tank. Replenish if necessary with the same type of coolant mixture as that already in the system.

Warning: Take care when removing the filler cap on a hot engine as the system will be pressurised.

Lubrication System

Check the oil level with the dipstick. The level should be above the LOWER mark with the engine running. With the engine stopped the oil level should be at the UPPER mark on the dipstick. Replenish with oil of the same grade and specification as that already in the system, if necessary. Do NOT overfill.

Induction System

Check the air restriction indicators. If the red warning sleeves are visible, service the air cleaners. Under favourable operating conditions, air cleaner servicing intervals may be extended to 100 E.S.C. Units.

Every 100 E.S.C. Units

Adjustments — 2

Check tension and condition of alternator and fan driving belts, adjust or renew as necessary.

Every 200 E.S.C. Units

Cooling System — 3

Check the specific gravity and pH value of the coolant mixture.

Induction System — 6

Check the turbochargers for security.

Section

Lubrication System 4
Drain, whilst hot and refill with fresh engine oil of the approved grade and specification.

Unscrew and discard the oil filter canisters. Fit new Rolls-Royce replacement canisters.

Every 600 E.S.C. Units

Fuel System 5
Dismantle and clean the primary filter.

Discard and renew the main filter canisters.

Check tightness of the injection pump drive coupling bolts; torque loading 102 Nm. (75 lbf. ft.).

Every 1200 E.S.C. Units

Fuel System 5
Check the injection pump timing.
Service or renew injectors. (See 'Adjustments'—below).

Induction System 6
Remove the induction trunking from each turbocharger and spin rotor to check for rubbing and bearing wear.

Adjustments 2
Check and adjust tappet clearances whilst injectors are removed.

Every 2400 E.S.C. Units

Adjustments 2
Torque-tighten cylinder head nuts and bolts followed by tappet clearance check.

Electrical System 7
Service the alternator.

Every 4800 E.S.C. Units

Top overhaul W.M.
Carry out a top overhaul. See the Workshop Manual, for full details.

Fuel System w. m.
Calibrate and service the injection pump or fit a replacement unit.

Every 6 months

Electrical System 7
Check operation of warning and shutdown switches.

Every 12 months

Cooling System 3
Drain system immediately after shutdown. Flush with clean water and refill with fresh coolant mixture.

ENGINES IN INTERMITTENT USE

For engines in this Category (e.g. those powering fire pumps and emergency generating sets, etc.), which are in use for a total of less than 500 E.S.C. units in twelve months, the Servicing Schedule should be supplemented by the following calendar-based Schedule to avoid deterioration due to prolonged intervals between servicing:

Weekly **Section**

Lubrication System 4
Check the lubricating oil level and top up if necessary to the UPPER mark on the dipstick.

Cooling System 3
Check the coolant level and replenish as necessary with the correct coolant mixture.

Monthly

Cooling System 3
Check the specific gravity and the pH value of the coolant mixture.

Induction System 3
If the engine has not been running during the month, prime the turbochargers with engine oil.

Every 6 months | **Section**

Lubrication System 4
Drain the engine lubricating oil and refill the system with the approved grade of oil. Discard and renew the oil filter canisters.

Every 12 months

Fuel System W.M.
Inspect the injectors for corrosion and check their operation on a test rig. Service or renew as necessary, refit, and vent the high pressure fuel system.

Cooling System 3
Drain and flush the cooling system. Refill with a fresh coolant mixture.

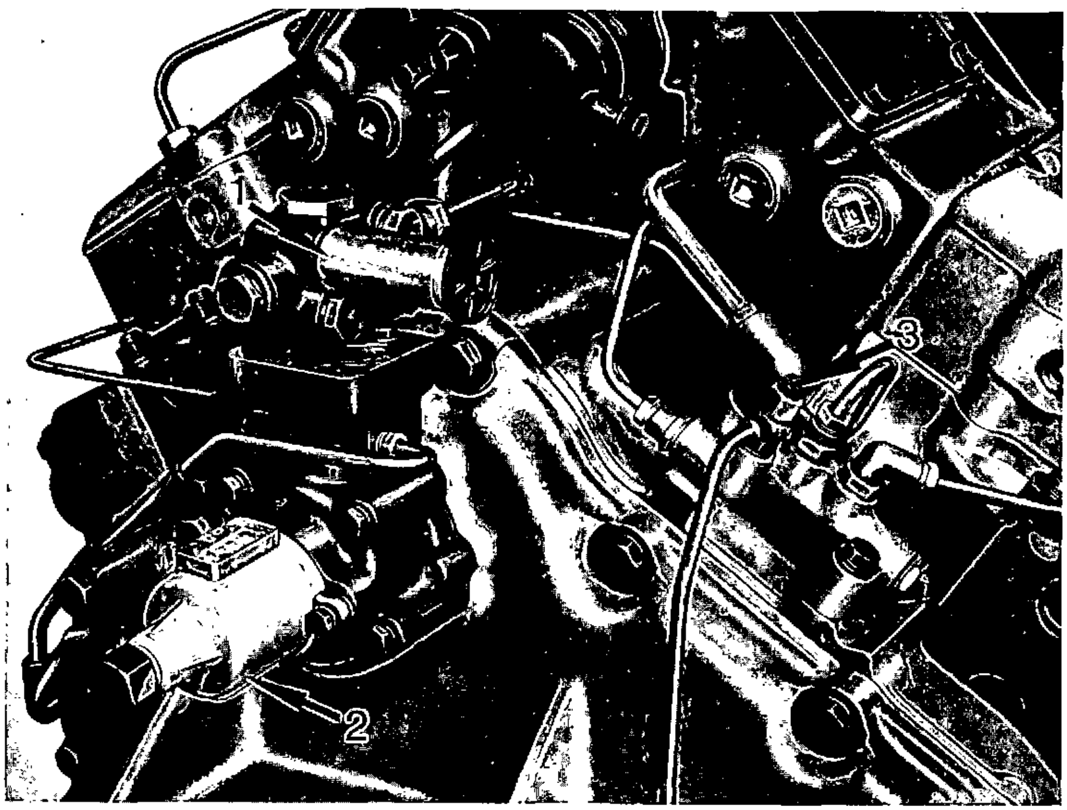


Fig. 1. Engine Service Counter
1. Fuel feed pump
2. Engine Service Counter
3. Fuel system bleed screw

SECTION 2—ADJUSTMENTS

Warning: To avoid personal injury or accidental damage to components, it is strongly advised that the batteries be disconnected prior to working on the engine.

DRIVING BELTS

The life and efficiency of driving belts depends, to a great extent, on correct alignment and tensioning. Where multi-belt drive is used, each belt must share equal loading. Should a driving belt fail, a new set of matched belts should be fitted. Do NOT mix new and used belts on the same multi-belt driving pulleys.

At the intervals specified in the Servicing Schedule (Section 1), check the tension and condition of all driving belts and adjust or renew where necessary.

To adjust the alternator belts (fig. 1) slacken the link bolts and the pivot bolt, move the alternator to the required position and re-tighten the three bolts.

The correct tension for the alternator belts is such, that deflection at mid-point of the belt run is 10 mm (0.4 inch) for each belt under a pressure of 3.5 to 4.5 kg (8 to 10 lb.).

Fan belt tensioning is facilitated by means of an adjustable jockey pulley mounted over the alternator driving belts (fig. 2). To tension the belts, slacken the large locknut and turn the adjusting bolt until the deflection at the arrow 5 (fig. 1) is 10 mm (0.4 inch) for each belt under a pressure of 4.5 to 5.5 kg (10 to 12 lb.); re-tighten the locknut.

The jockey pulley bearings are pre-packed with grease and do not require servicing between engine overhauls.

To renew the fan belts, slacken the six setbolts securing the fan to the pulley, and push the fan forward into the radiator cowling. Slacken the jockey pulley and lift off the old belts. Ensure that the pulley grooves are free from grease and dirt and fit a new set of belts. Refit the coolant fan and tighten the setbolts securely. Set the fan belts to the correct tension.

To renew the alternator belts, the fan belts must first be released from the crankshaft pulley.

Slacken the alternator adjusting bolts and lift the old belts clear of the drive pulleys. Check all grooves for dirt or grease and fit the new pair of belts. Adjust the new belts to the correct tension; refit and tension the fan belts.

After fitting new belts, run the engine for 15 minutes then re-check the belt tension. Check the tension of new belts each week for four weeks, then at the intervals specified in the Servicing Schedule.

VALVE TAPPETS

If cylinder head torque tightening is planned, this should be completed before tappet clearances are checked.

Secure the engine stop control in the STOP position, disconnect and remove the fuel injector high pressure feed pipes and the rocker box covers.

Insert a 12 x 25 mm (0.5 x 1 inch) flat steel bar in the holes in the periphery of the crankshaft pulley, and turn the engine in the normal direction of rotation until the valves on 'A6' cylinder are 'rocking', i.e. exhaust valves just closing, inlet valves just opening. The valves on 'A1' cylinder will then be closed with the piston at T.D.C. on compression stroke.

Using the appropriate feeler gauge, set the inlet valve tappet clearance to 0.4 mm (0.016 inch) as shown in figure 3 and torque tighten the adjusting screw locknut to 40 Nm (30 lbf. ft.). Adjust the exhaust valve tappet clearance to 0.7 mm (0.028 inch) and torque tighten the locknut as for the inlet valves. After torque tightening the locknuts re-check the clearances before proceeding to the next cylinder.

To simplify tappet clearance adjustment, the following sequence should be followed:

Valves rocking on	Set clearance on
A6	A1
B1	B6
A3	A4
B4	B3
A5	A2
B2	B5
A1	A6
B6	B1
A4	A3
B3	B4
A2	A5
B5	B2

Valve bridge pieces will not normally require adjustment between overhauls, but if adjustment is found to be necessary, the following procedure should be carried out:

With the valves closed, (as for tappet clearance setting), slacken the adjusting screw on the faulty unit, press down firmly on the bridge, via the rocker arm, and turn the adjusting screw until it is felt to *just* touch the valve stem tip, see figure 4. Tighten the screw a further 60 deg. (1/6 turn) and torque tighten the locknut to 40 Nm. (30 lbf. ft.).

Check tappet clearances after adjusting bridge pieces.

On completion of adjustments, oil the valve gear liberally and refit removed items using new gaskets on all joint faces. Ensure that the barring tool has been removed from the pulley holes before running the engine.

VALVE TIMING

As the camshafts are gear operated from the crankshaft, it is not possible for the valve timing to slip; however, during engine rebuild, if doubts exist it will be reassuring to check the valve timing in the following manner:

Turn the engine by hand until the valves over the 'A1' cylinder are rocking and the 'A6' T.D.C. mark on the flywheel is opposite the timing pointer (fig. 5). Set the 'A6' inlet valve tappet clearance to 1.1 mm (0.043 inch). Turn the engine one complete revolution until the 'A6' T.D.C. mark is again opposite the timing pointer. The 'A6' inlet valve pushrod should now be just trapped when twisted between the thumb and forefinger. This indicates that the 'A6' inlet valves are beginning to open and 'A' bank valve timing is correct.

It follows that if the timing marks on the gears are correctly meshed, then the 'B. bank valve timing is also correct. After checking the valve timing ensure that the tappet clearances are correctly set before running the engine.

FUEL INJECTION TIMING

Should the engine performance deteriorate during service it may become necessary to check the injection timing; the following procedure is recommended:

1. Secure the stop lever in the STOP position, remove the high pressure fuel pipes and rocker cover from the cylinder head serving cylinders A4, A5 and A6 and remove the timing cover, stamped 'T', from the flywheel housing (fig. 5).
   Turn the engine by hand in the normal direction of rotation until the injection timing figure (as stamped on the engine data plate) is opposite the pointer, with the valves on 'A6' cylinder closed, i.e. 'A6' piston on compression stroke. Check that the timing mark on the injection pump hub is in line with the pointer (fig. 6).
2. If the timing mark on the hub fails to coincide with its pointer, check the fuel injection pump drive shaft and couplings to ensure that they are secure and undamaged then proceed as follows:
   (a) With the flywheel timing set to the correct timing figure, slacken the socket capscrews which hold the drive coupling to the injection pump hub (fig. 7). Turn the hub in the normal direction of rotation by hand, then turn the hub back until the timing mark on the hub coincides with the pointer; retighten the capscrews.
   (b) Turn the engine back a quarter of a turn and then forward in the normal running direction until the flywheel timing pointer is once more correctly aligned. Check that the timing marks on the fuel injection pump are in line.

TORQUE-TIGHTENING CYLINDER HEADS

At the intervals specified in the Servicing Schedule (Section 1), torque-tighten the cylinder head nuts and bolts in the following manner:

Remove the injector spill pipework and spill connections and high pressure fuel pipes. Remove the rocker covers and rocker boxes and withdraw the alloy plugs over the setbolts fitted in each induction port. Wipe each bolthead and nut and surrounding areas. Make a pencil mark on each bolt-head and nut, and corresponding marks on the cylinder head top face. One by one and in the sequence shown in figure 8, slacken each setbolt or nut half a turn and re-tighten to the correct loading, or until the pencil marks are aligned, whichever is the tighter.

NOTE: If torque-tightening setbolts and nuts, after work requiring the removal and refitting of a cylinder head, tighten the setbolts and nuts evenly and progressively in the correct sequence, in steps of 50 Nm. (38 lbf. ft.), until the final torque figure is achieved.

Remove any gasket material or jointing compound adhering to the cylinder head top face. Check the induction port plug housings for cleanliness and refit the plugs using new 'O' ring seals. Ensure that the spring locating dowels are correctly positioned in the cylinder head top face. At this stage, the valve bridge pieces may be checked and adjusted if necessary.

Clean the top and bottom faces of the rocker boxes and refit each box to the cylinder head using new gaskets. Tighten the setbolts evenly and progressively to a torque loading of 41 Nm (30 lbf. ft.) and the socket capscrews to 35 Nm (26 lbf. ft.).

Set the tappet clearances as previously described, check the joint face on the rocker covers and refit each cover using new gaskets.

Torque-tighten the retaining setbolts evenly and progressively to 30 Nm (22 lbf. ft.).

Refit the high pressure fuel pipes, spill connections and pipework using new joint washers and vent the high pressure system as described in Section 4, 'Fuel System'.

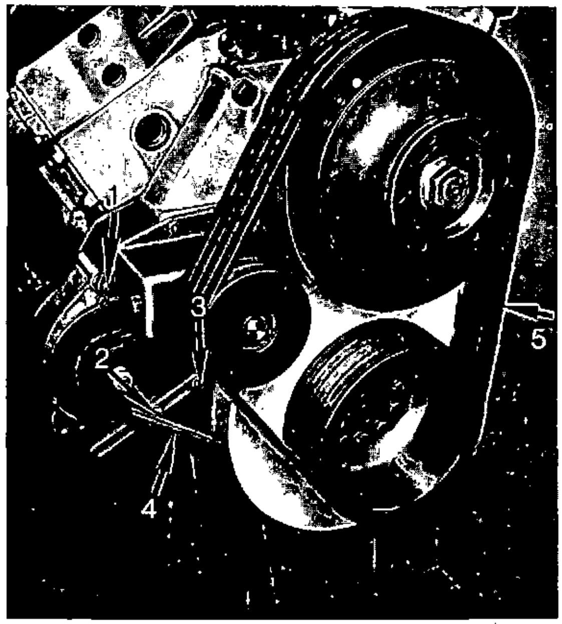


Fig. 1. Alternator belt adjustment

1. Pivot bolt
2. Sliding link bolt
3. Fixed link bolt
4. Alternator belt deflection test point
5. Fan belt deflection test point

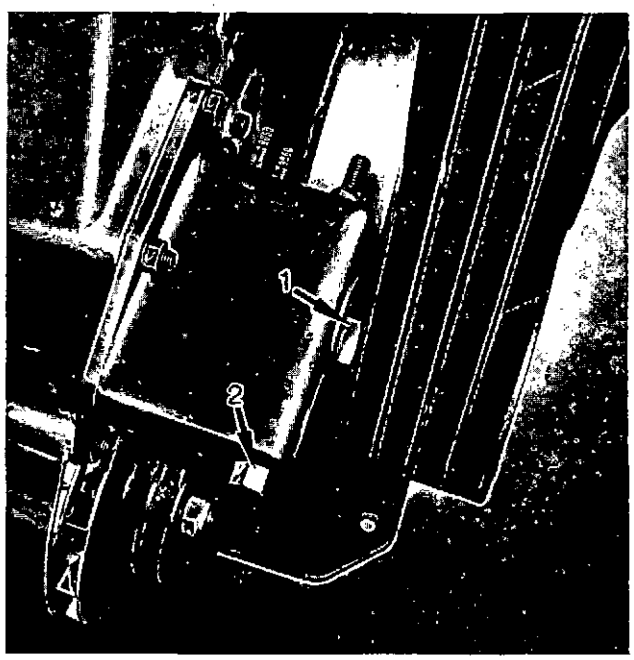


Fig. 2. Fan belt adjustment

1. Locknut
2. Adjusting bolt

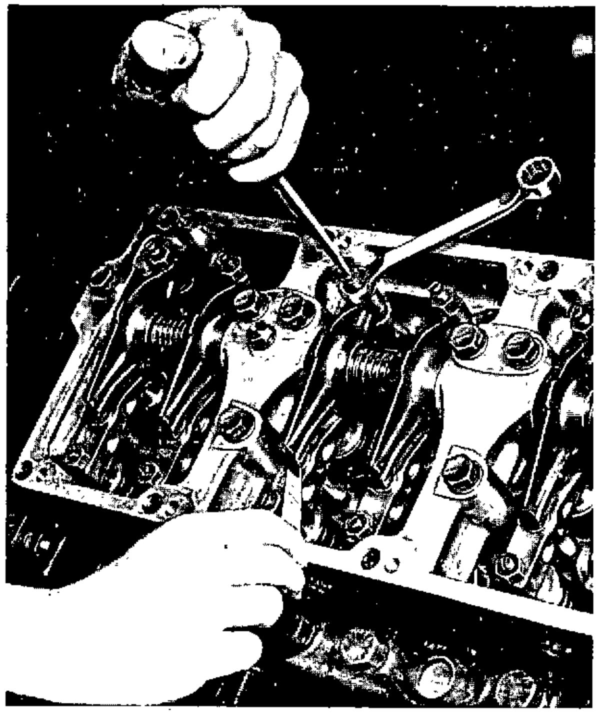


Fig. 3. Setting valve tappet clearances

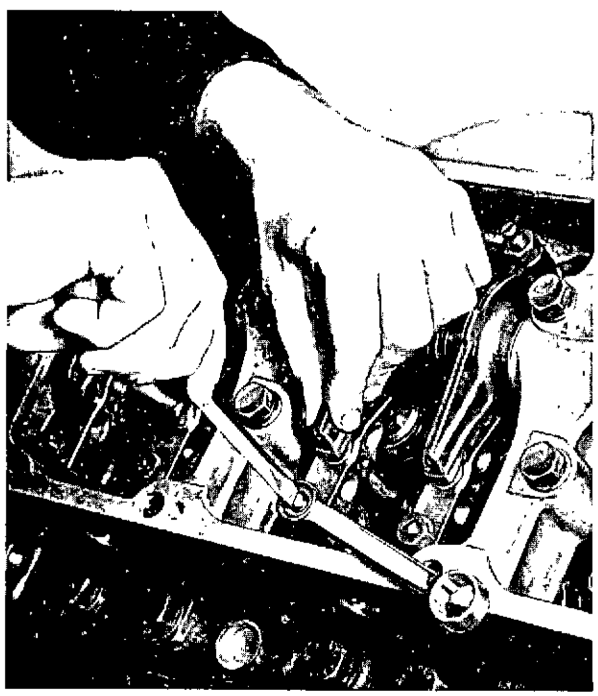


Fig. 4. Setting valve bridges

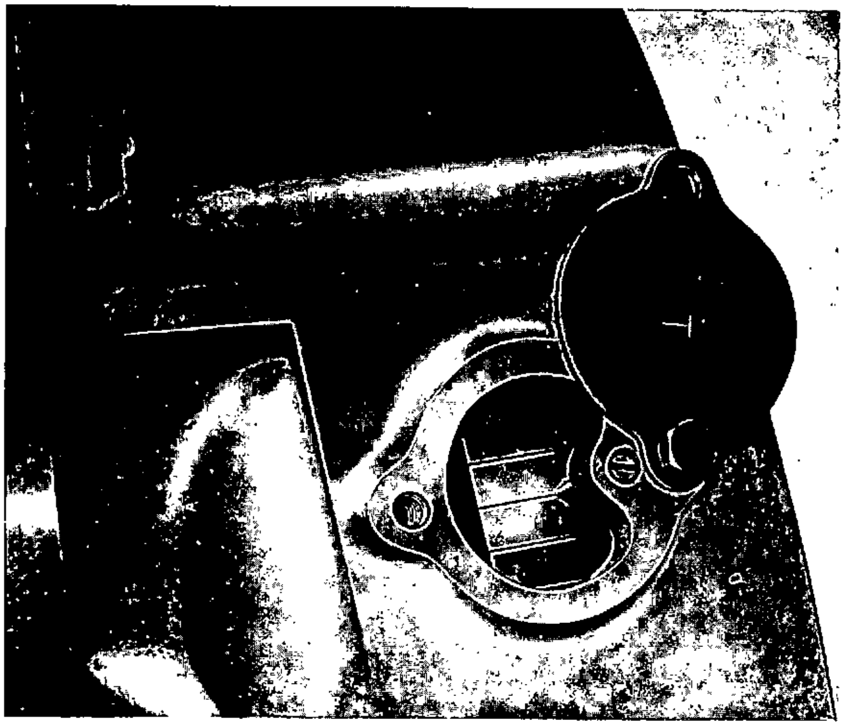


Fig. 5. Flywheel timing cover

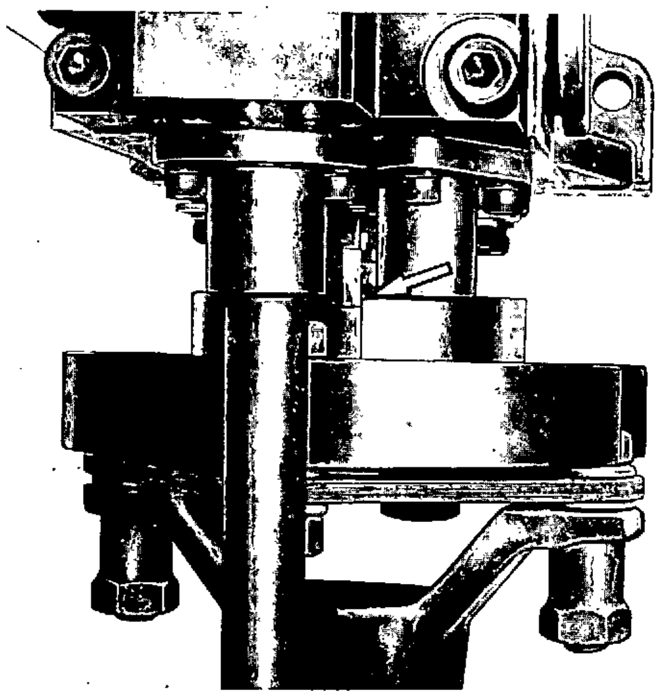


Fig. 6. Injection pump timing marks

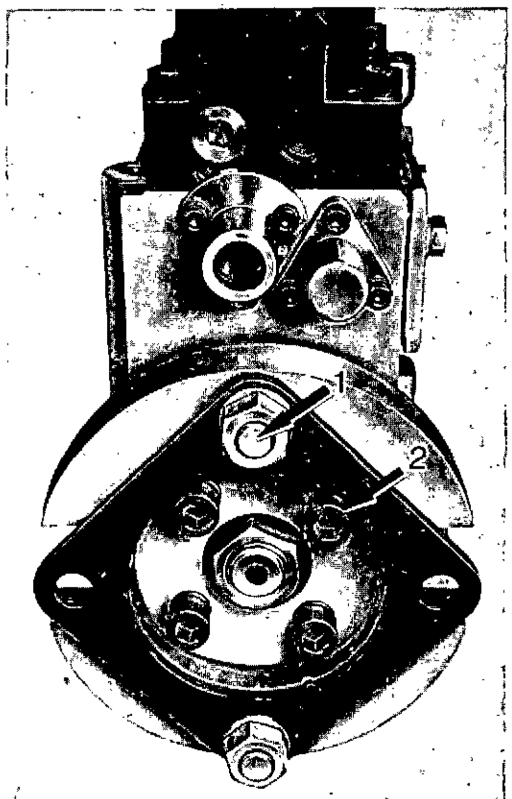


Fig. 7. Injection pump coupling
1. Spring plate coupling bolts
2. Adjustable coupling socket capscrews

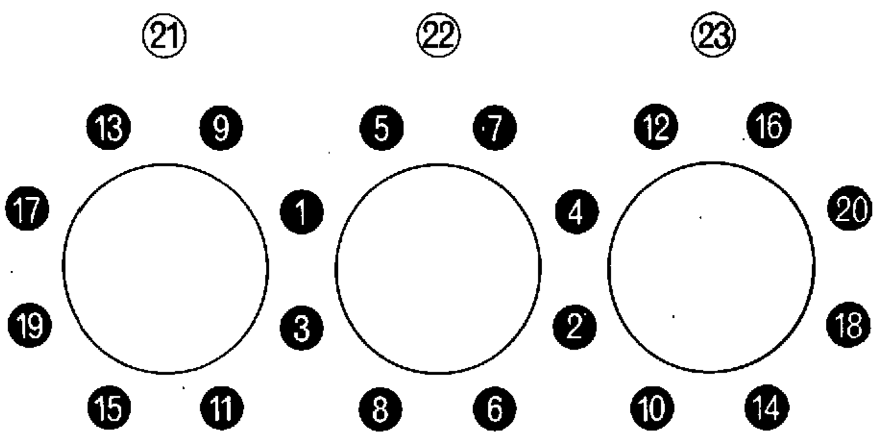


Fig. 8. Cylinder head torque-tightening sequence
Torque loadings:
Nuts (black circles) 200 Nm (147 lbf. ft.) plus a further 90 deg.
Setbolts (white circles) 200 Nm (147 lbf. ft.)

SECTION 3—COOLING SYSTEM

Description
Coolant is drawn from the radiator by a gear driven pump and delivered via a bifurcated pipe to the coolant galleries in each bank of cylinders, the 'B' bank coolant having first passed through the engine oil-to-coolant heat exchanger. From the cylinder block, the coolant is directed through the cylinder heads and into galleries integral with each induction manifold. Wax capsule type thermostats mounted at the front of each manifold then direct the coolant to the radiator or back to the pump suction for re-circulation of the engine.

COOLANT

Dependent on climatic conditions, the coolant may be inhibited water or an inhibited glycol/water mixture of appropriate strength. It is strongly recommended that a mixture of 50% clean fresh water and 50% inhibited ethylene glycol is used in the cooling system at all times.

Where inhibited glycol is not available it is recommended that Rolls-Royce inhibitor (Part Number OE. 45071) be added to clean fresh water in the ratio of 1 : 100. Clean fresh water is defined as:

1. Having a total hardness NOT exceeding 250 ppm.
2. The combined level of chlorides and sulphates does NOT exceed 150 ppm.

The aluminium components in the cooling system may suffer erosion if the water impurity levels are beyond the figures quoted. In such cases, Rolls-Royce inhibitor may be added to the water in the ratio of 1 : 80, and the system must be drained and flushed every 3 months.

Caution: 1. On no account should the inhibitor be used at stronger dilutions that 1 : 80, as sludging may occur.

2. Inhibited ethylene glycol (anti-freeze) must not be added to water already treated with the Rolls-Royce inhibitor as the two inhibitors may be incompatible, nullifying the protective properties for the aluminium components. For the same reason, different brands of anti-freeze should not be mixed in the engine cooling system.

COOLANT CHECKS

The coolant, if correctly maintained and checked, will give the required protection for 12 months. The pH value and the specific gravity of the coolant mixture must be checked at the intervals specified in the Servicing Schedule (Section 1), using a sample drained from the system after stopping the engine and before deposits have settled.

pH Value
The corrosion inhibitors added to the coolant are gradually consumed in service and the coolant can become excessively acid or alkaline. Acidity will cause corrosion in the ferrous metals while alkalinity similarly affects the non-ferrous metals in the cooling system.

The degree of acidity or alkalinity is known as the pH value and may be determined simply by means of test papers available from manufacturing chemists, or more accurately by the use of a pH meter.

The pH value of the coolant in the system must not be less than pH 7 or greater than pH 9.5. If these limits are exceeded the pH value may be restored by adding inhibitor to the same specification as that already in use.

Alternatively the system must be drained, flushed through and re-filled with a fresh coolant mixture.

Specific gravity

New anti-freeze solution should be mixed in a clean container and its specific gravity measured with a suitable hydrometer and thermometer. Dependent on the percentage of anti-freeze (inhibited ethylene glycol), protection against freezing is as follows:

Anti-freeze/water (% by volume)	**Protection down to** deg. C.
50/50	—35
60/40	—40

Compare the hydrometer reading with the chart (fig. 1) to ensure that mixture strength is adequate for the degree of protection required.

FILLING THE SYSTEM

Fill the system slowly to the required level with the approved coolant mixture. Run the engine until the coolant reaches normal working temperature. Stop the engine, check the coolant level and replenish as necessary.

Warning: Remove the filler cap carefully when the engine is hot as the cooling system will be under pressure.

CLEANING THE SYSTEM

Routine cleaning of the system as required by the Servicing Schedule, should be carried out by draining the coolant and flushing through with clean fresh water until it runs clear from all drain cocks or plugs, see figure 2.

A system which has become contaminated should be cleaned using one of the chemical compounds listed in Chapter 1. 'Data', in the following manner.

1. Fill the system with clean fresh water, adding the required amount of cleaning compound at the filler cap.
2. Run the engine until the coolant reaches normal working temperature, then run the engine at maximum rated rpm. for 10 minutes. See NOTE at end of sub-section.
3. Stop the engine and drain the coolant immediately from all drain cocks or plugs.
4. Allow the engine to cool, then refill the system with clean fresh water, allowing at least 5 litres (1 Imp. gallon) to run to waste before closing the drain cocks.
5. Run the engine as in operation 2, but maintain maximum rpm for 5 minutes only.
6. Repeat operations 3, 4 and 5.
7. *Finally drain the system completely and refill* with the correct coolant mixture.

Note: In very cold ambient conditions, the thermostats may not open to allow full circulation of the cleaning solution. In such cases, the radiator must be partially blanked off or the engine must be run on load. The simplest way to ascertain if the thermostats are open is to check the temperature of the pipe connection between the thermostat housings and the radiator. If the pipework is cool, the thermostat valves are closed.

THERMOSTATS

Each wax capsule type, Western Thomson thermostat (fig. 3) is factory set to operate at a pre-determined 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 valves 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.

To check the operating characteristics of a thermostat, drain the coolant to below the level of the thermostat housing (fig. 4), remove the housing cover and pipework where necessary and withdraw the thermostat unit.

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 connections and renew if necessary. Refit the housing cover using a new gasket lightly coated with jointing compound and top up the system with the approved coolant mixture.

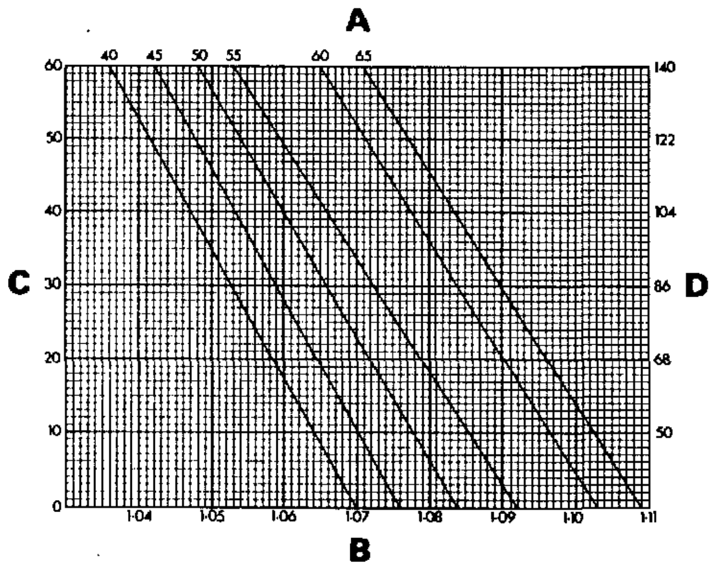


Fig. 1. Specific gravity chart
A = Percentage of anti-freeze by volume
B = Specific gravity
C = Mixture temperature (Deg. C.)
D = Mixture temperature (Deg. F.)

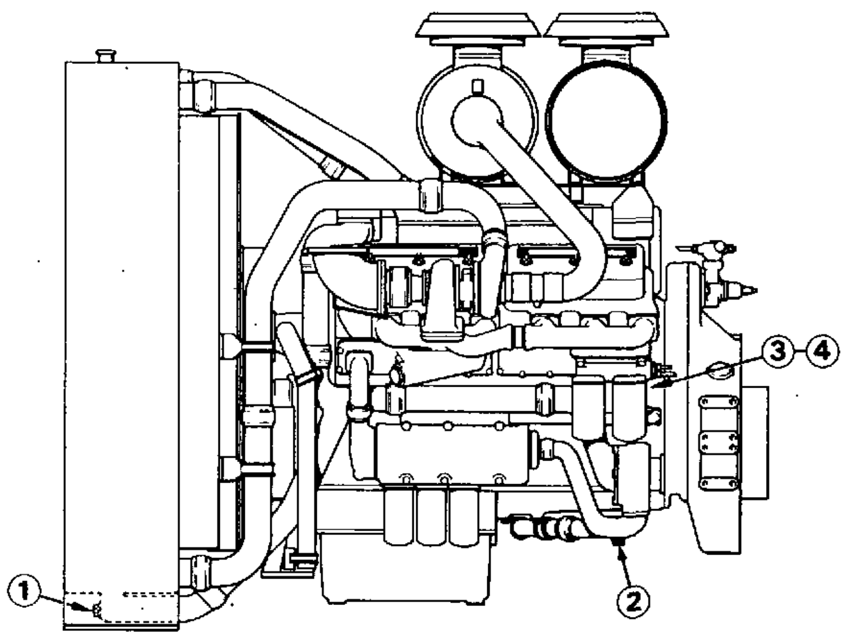


Fig. 2. Coolant drain cocks
1. Radiator drain plug
2. Engine system drain plug
3-4. Cylinder block drain cocks

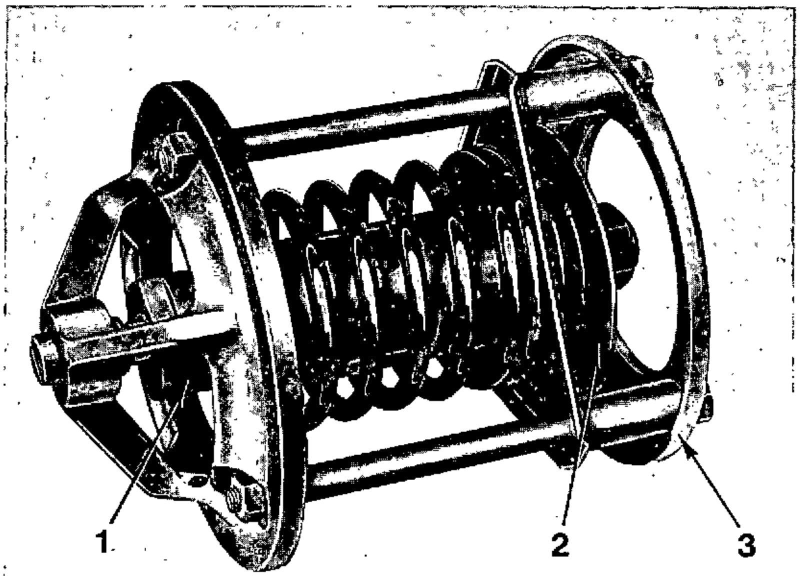


Fig. 3. Thermostat
1. Main flow valve opening
2. By-pass valve
3. By-pass valve seat

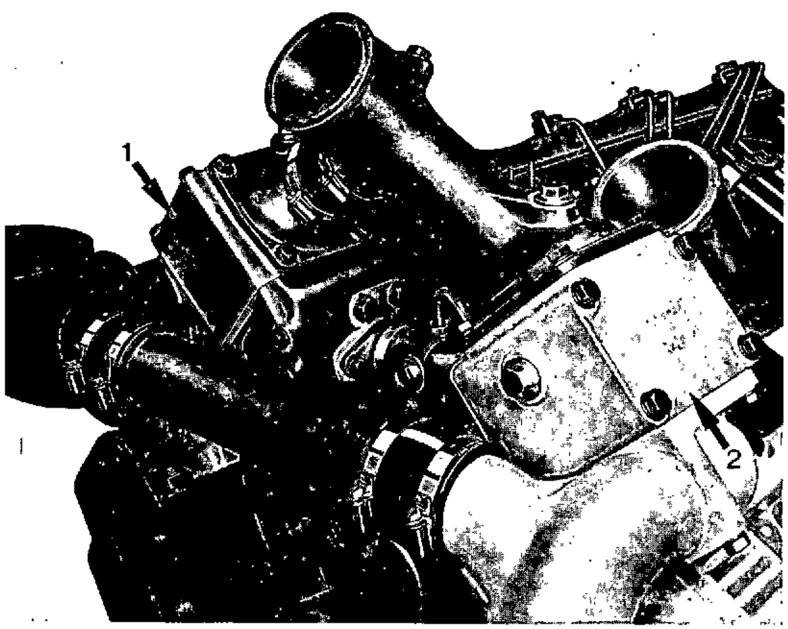


Fig. 4. Thermostat housing
1. 'A' bank thermostat housing
2. 'B' bank thermostat housing

SECTION 4—FUEL SYSTEM

Description

A fuel feed pump, cam-driven from the auxiliary drive shaft, draws fuel through a primary filter and delivers it via the main fuel filters to the injection pump gallery. The gallery supply is maintained at a constant pressure of 90 to 117 kN/sq. m. (13 to 17 lbf./sq. inch) by two low pressure relief valves mounted on the fuel injection pump casing. Fuel from the gallery enters the pump elements and is delivered at high pressure to the low spring type injectors which are set to operate at 24,300 kN/sq. m. (240 atmospheres).

A fuel spill block, with connections from the low pressure relief valves, injection pump and fuel injectors, is mounted on the 'B' bank side of the wheelcase and returns the spill fuel unfiltered to the supply tank(s).

CARE OF THE SYSTEM

Scrupulous cleanliness, careful handling of components and servicing in accordance with the Servicing Schedule (Section 1), will assist greatly in preventing serious trouble during service.

Thoroughly clean any component and its surrounding area before dismantling and fit blanks to all unions immediately following any disconnections.

HIGH PRESSURE FUEL PIPES

These pipes will require no attention between engine overhauls if the following precautions are observed:

1. Never bend or strain a pipe when changing injectors or for any other reason. If a pipe obstructs other work, remove it completely.
2. When slackening or tightening gland nuts, ensure that the pipe does not twist. DO NOT OVERTIGHTEN THE GLAND NUTS.
3. Immediately prior to fitting a pipe, blow through it with clean, dry, compressed air.
4. Ensure that each pipe lies naturally between its unions before the gland nut threads are engaged. When fitting securing clips and vibration dampers, check that the pipe is not pulled out of line and that the damper rubber is not distorted.

PRIMING AND VENTING

If air enters the fuel system the injection pump pressure may become insufficient to operate the injector valves and, depending on circumstances, the engine may stop, misfire or fail to start. To remove air from the system, the following procedure should be adopted:

Low pressure system

Unscrew the priming pump cap on the fuel feed pump (fig. 1), slacken the bleed screw two or three turns and operate the hand priming pump. When bubble-free fuel emerges from the drain pipe, tighten the bleed screw, press in the pump plunger and screw down the cap finger tight to prevent fuel leakage.

High pressure system

Air in the high pressure system must be released at the injectors. Set the stop control in the RUN position and motor the engine on the starter. Slacken each injector gland nut in turn and re-tighten when bubble-free fuel emerges. DO NOT OVERTIGHTEN.

If the engine fires during this operation but runs erratically, continue to vent each injector in turn until the high pressure system is free of air or until the engine note is steady. Return the stop control to the STOP position.

PRIMARY FILTER

The primary fuel filter (fig. 2), may be remote or engine mounted and consists of a bowl, with a washable wire wound element, bolted to a header bracket.

A conventional spring loaded ball valve, integral with the header bracket, allows fuel to by-pass the filter should the element become choked. The by-pass valve requires no servicing between engine overhauls. If it is suspected that the by-pass valve is faulty or damaged the header bracket must be renewed.

Service the filter at the intervals specified in the Servicing Schedule (Section 1), by unscrewing the bowl retaining setbolt and carefully withdrawing the element.

Wash the element in petrol or paraffin and blow dry, in the reverse flow direction, with a compressed air jet. DO NOT wipe the element with rag.

Wash out and dry the bowl, then reassemble the components to the header bracket using new sealing rings. DO NOT overtighten the bowl retaining setbolt.

If the element windings become damaged, a replacement unit, Rolls-Royce Part No. OF.1609, is available from Dealers and Distributors.

MAIN FILTERS

The two parallel flow main filters (fig. 3) are of the expendable canister type and must be discarded at the intervals specified in the Servicing Schedule (Section 1).

Unscrew the canisters and remove the inner sealing rings from around the screw adaptors. Check that all contact faces are clean and fit new inner sealing rings. Ensure that the outer sealing rings are correctly located in their housings before fitting the new canisters.

Screw each canister up until the sealing rings are just touching the contact face, then tighten the canister a maximum ¾ of-a-turn by hand. DO NOT OVER-TIGHTEN.

After servicing the fuel filters, turn the fuel supply ON and vent the low pressure system as previously described in 'PRIMING AND VENTING', in this Section.

Replacement filter canisters are available from Dealers and Distributors under Rolls-Royce Part No. OE.47449.

Note: Stubborn filter canisters may be removed using the filter wrench, Rolls-Royce Part No. VT.12918.

FUEL FEED PUMP

The feed pump (fig. 1), is a piston type unit, cam-operated from the auxiliary drive shaft.

Four spring loaded nylon valves, two suction and two delivery, are housed in the pump body. Three valves are retained by hexagonal headed plugs, and the fourth by the hand priming pump housing. Each valve may be removed for inspection, cleaning or renewal as necessary.

The hand priming pump is of the simple plunger type and is secured in its housing when not in use by a screw cap, which must be screwed down finger tight to prevent fuel leakage.

LOW PRESSURE RELIEF VALVES

Two low pressure relief valves, working in parallel, are mounted over the fuel injection pump gallery. The valves are designed to operate at 90 to 117 kN/sq. m. (13 to 17 lbf./sq. inch.) and allow excess fuel to return to the supply tank(s). No servicing is necessary and if a valve becomes faulty, a new unit must be fitted.

INJECTOR PUMP AND GOVERNOR

The fuel injection pump (fig. 4), centrally mounted in the engine 'V', is driven from the main gear train at 0.5 x engine speed through flexible spring steel couplings.

The mechanical governor, integral with the pump, controls engine rpm under varying load conditions, with the stop control lever being actuated by a solenoid control unit. A vernier control, coupled to the speed control lever, provides for fine setting of engine speed.

Lubrication for the pump and governor is provided, via external pipework, from the oil gallery in the heat exchanger mounting adaptor. Oil return is by a large bore pipe at the drive end of the pump and a connection and pipework, adjacent to the oil supply inlet, on the governor casing.

Routine servicing

1. At regular intervals, lubricate the control linkage and check for security, freedom and range of movement. Check all bolts, nuts and unions for tightness and check the pump and governor for leaks.
2. At the intervals specified in the Servicing Schedule (Section 1), check the injection timing, as described in Section 2, and torque tighten the pump drive spring-coupling bolts and nuts to 102 Nm (75 lbf./ft.).
3. At the intervals specified in the Servicing Schedule (Section 1), remove the injection pump and governor for calibrating and servicing. Torque tighten the delivery valve holders to 122 Nm (90 lbf. ft.).

Before fitting a replacement fuel injection pump, the cambox of the pump must be filled with clean engine oil to Rolls-Royce specifications. See leaflet TSD 3085 in the rear cover pocket. A screw plug in the top face of the governor casing is provided for this purpose. Remove the plug and, using a clean funnel and container, pour in the oil until it reaches the oil drain port at the drive end of the pump casing. Refit the filler plug and fit the pump on to its mounting.

As the governor stop control lever is unaccessible when the unit is bolted in the engine 'V', it is important that the lever be set in the correct position before a replacement pump is fitted, (see figure 5). The stop control lever should be positioned on its shaft so that in the NO FUEL position, the lever dips just below the horizontal line taken from the centre of the shaft.

The speed control lever should be positioned so that under MAX. fuel conditions, the face of the 'cam' is parallel to the stop screw bracket. The stop screws should be backed off, completely clear of the lever, and locked into position with the locknuts provided.

When the shutdown solenoid is connected to the stop lever, the movement must be checked manually to ensure that the solenoid rod reaches the limit of its travel before the stop lever reaches the position shown in figure 5. This is to ensure that no damage occurs to the fuel rack, or the governor, under NO FUEL conditions. Similarly, under RUN conditions, the solenoid switch contacts must be checked to ensure that the switch is in the open position to prevent damage to the coil windings. See Section 7—'Electrical System'.

For details of pump calibration and governor checks, refer to the Workshop Manual.

INJECTORS

Service or renew the injectors at the intervals specified in the Servicing (Section 1). Do not attempt to service an injector unless proper workshop facilities are available.

If the engine is misfiring and a faulty injector is suspected, it is sometimes possible to locate it by momentarily slackening the gland nut of each injector in turn whilst the engine is running. If the injector is serviceable, the misfiring will increase; if the injector is faulty the engine note will not change.

Injector Renewal

1. Disconnect and remove the high pressure pipework over the cylinder head concerned and remove the appropriate injector spill pipework.

2. Unscrew the injector spill connection (fig. 6) from each injector to be renewed and remove the rocker cover.

3. Remove the injector clamp and withdraw the injector. A sticking injector may be freed using the inertia extractor, Rolls-Royce Part No. VT. 11692. Care must be taken to avoid slackening the copper injector sleeve in its housing when using the extractor (fig. 7).

   Recondition the injector sleeve using the reamer Part No. VT.12769 (fig. 8), and seat cutting tool, Part No. VT.12767 (fig. 9). Grease both tools before use to retain carbon and metal particles. Do not remove more metal than is absolutely necessary to restore the seating face. The maximum permissible depth of the seating face measured from the cylinder head top face is 104.25 mm (4.104 inch).

   The reamer and seat cutting tool form part of the injector sleeve renewal and servicing kit, Part No. VT.12772 (fig. 10).

5. Check that the replacement injector is fitted with a new 'O' ring seal in the machined groove near the top of the stem, then fit the injector. DO NOT use a sealing washer between the injector and the sleeve face. Screw in the spill connection using a new copper sealing washer and new outer rubber seal. Torque tighten the spill connection to 40 Nm (30 lbf. ft.).

   Fit the injector clamp and torque tighten the setbolt to 40 Nm (30 lbf. ft.).

6. Clean the rocker box cover joint faces and refit the cover using a new gasket lightly coated on both sides with the recommended jointing compound. Torque tighten the cover securing setbolts evenly and progressively to 30 Nm (22 lbf. ft.).

7. Refit the high pressure fuel pipes as described in 'CARE OF THE SYSTEM' in this Section. Refit the spill pipework using new copper sealing washers and vent the high pressure system as described in 'PRIMING AND VENTING', this Section.

FUEL INJECTION TIMING

Check the fuel injection timing at the intervals specified in the Servicing Schedule (Section 1), or when a fault is suspected. The injection timing figure is stamped on the engine data plate; for further details, see Section 2—'Adjustments'.

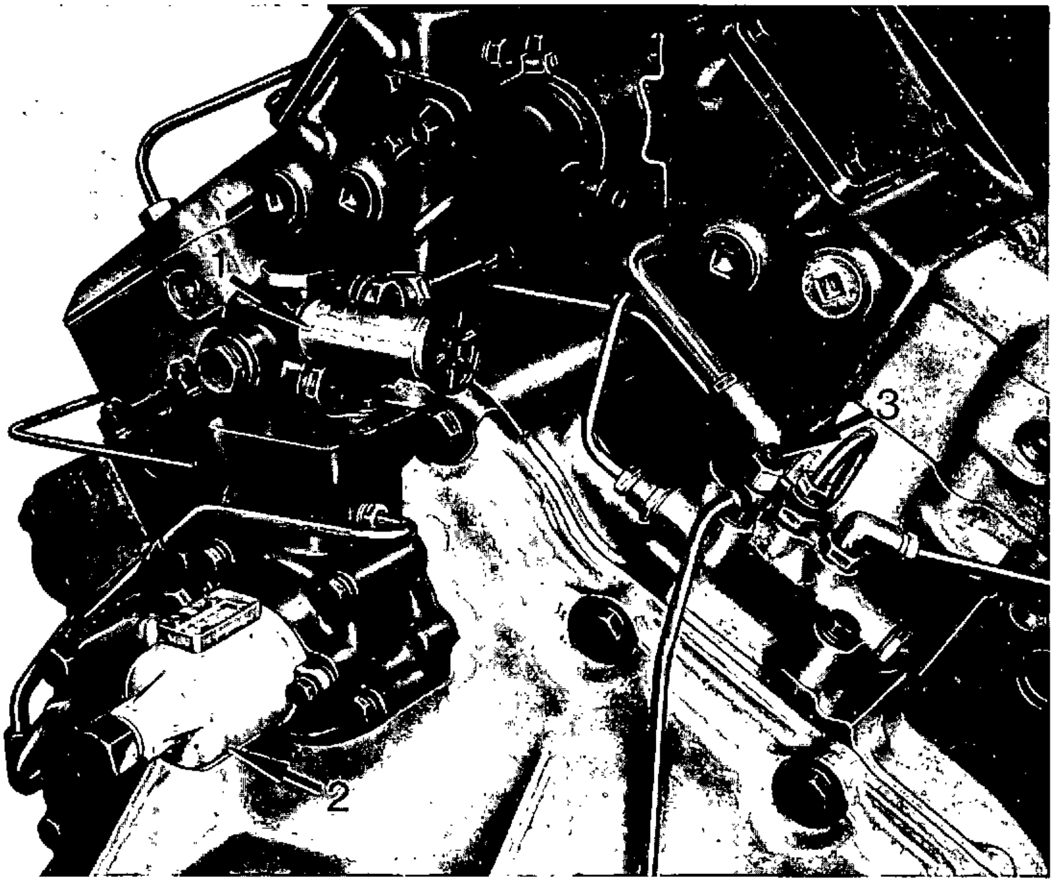


Fig. 1. Fuel feed pump

1. Fuel feed pump
2. Engine Service Counter
3. Fuel system bleed screw

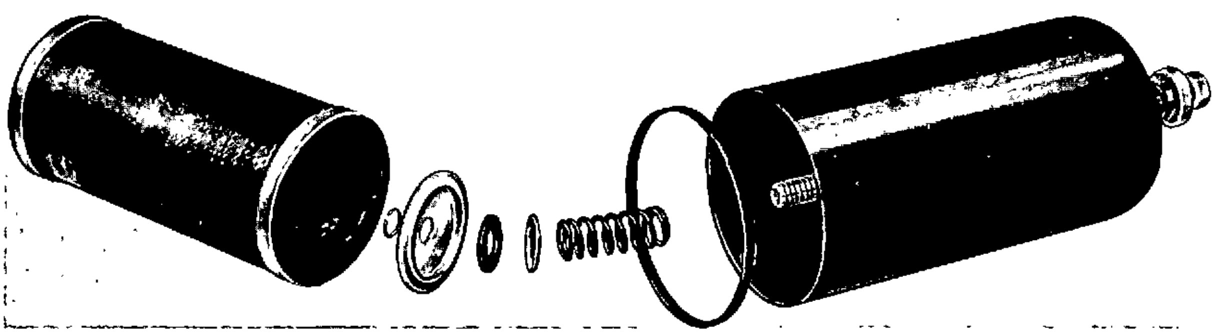


Fig. 2. Primary fuel filter

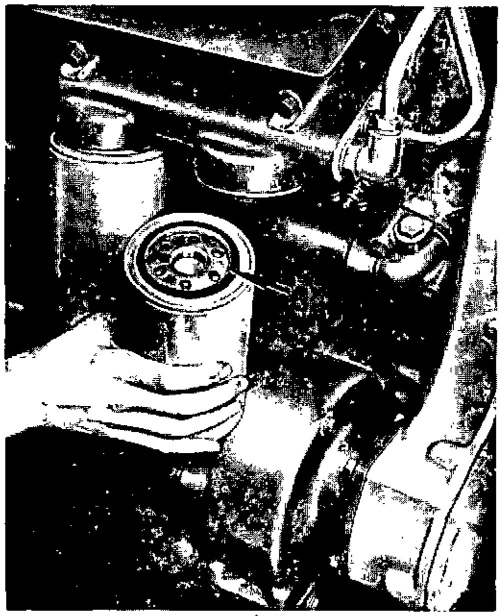


Fig. 3. Main fuel filters
Outer sealing ring arrowed

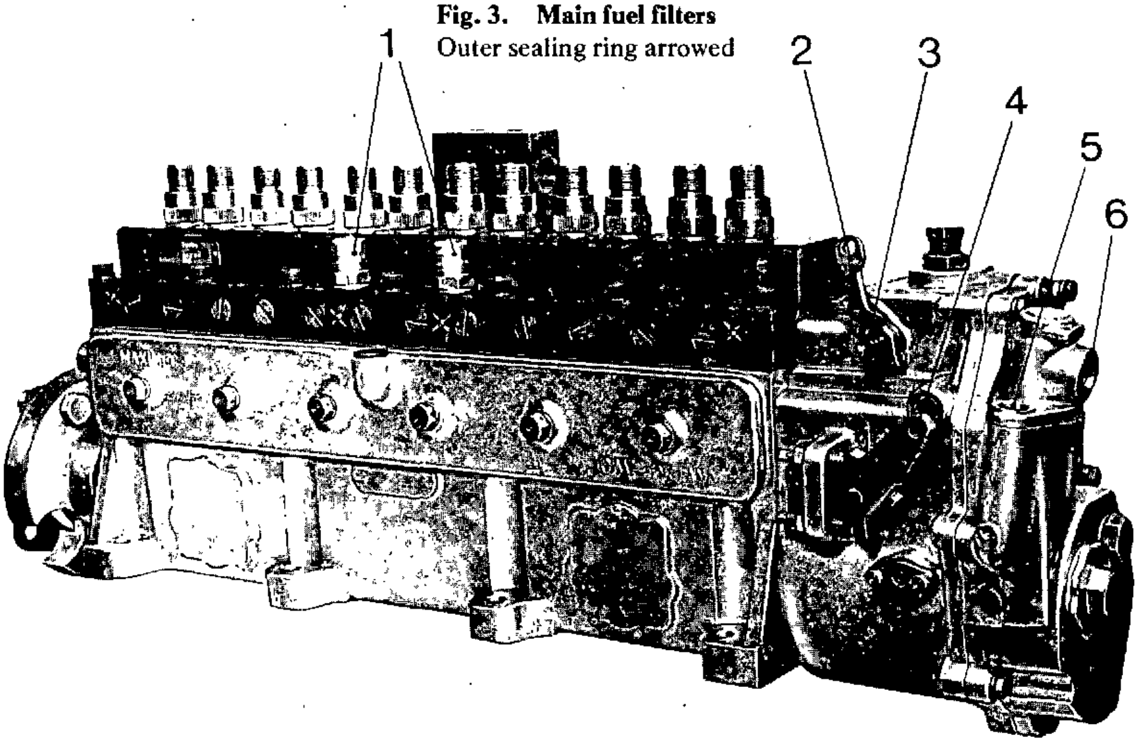


Fig. 4a. Fuel injection pump and governor

1. Low pressure relief valves
2. Stop control lever
3. Excess fuel device
4. Speed control lever
5. Governor oil feed connection
6. Governor oil drain connection

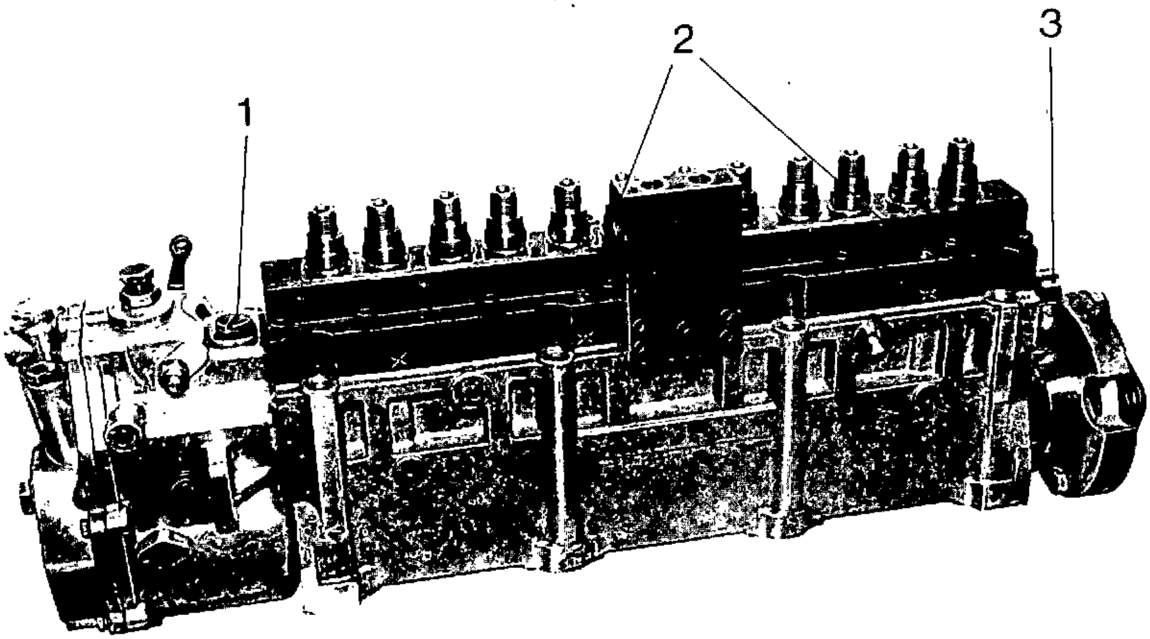


Fig. 4b. Fuel injection pump and governor
1. Oil priming plug
2. Engine oil feed connections
3. Injection pump oil drain connection

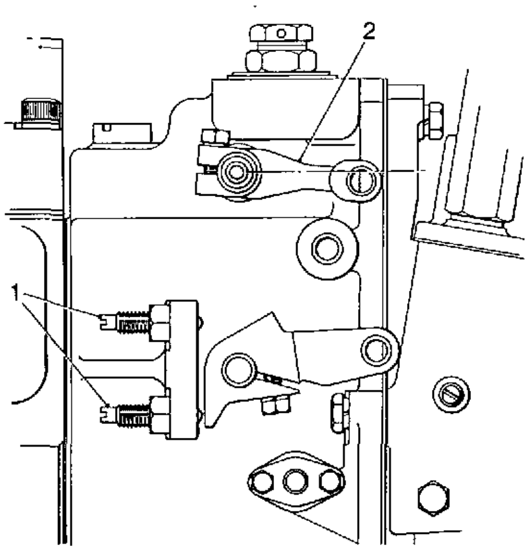


Fig. 5. Governor controls
1. Speed control lever stop screws
2. Stop control lever at NO FUEL position

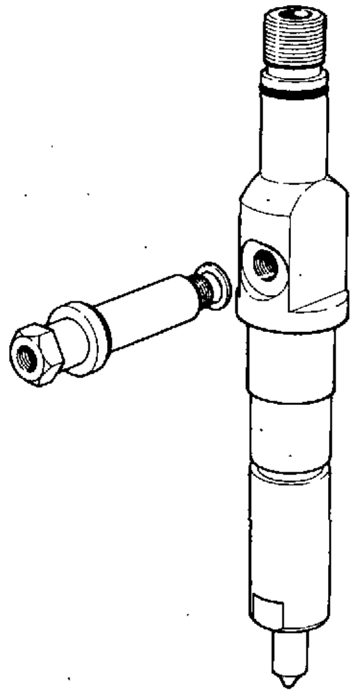


Fig. 6. Fuel injector spill connection

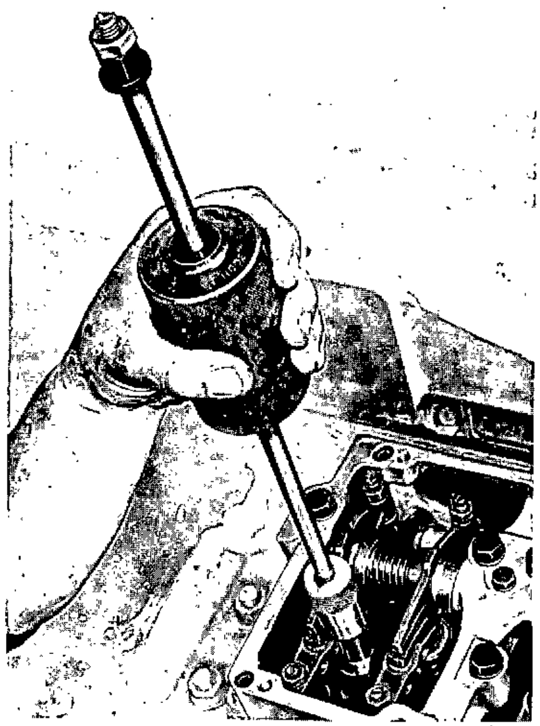


Fig. 7. Using inertia extractor

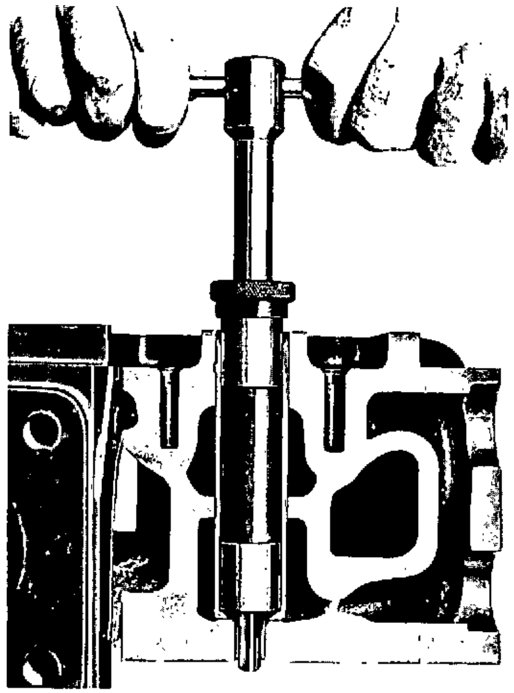


Fig. 8. Reaming injector sleeve

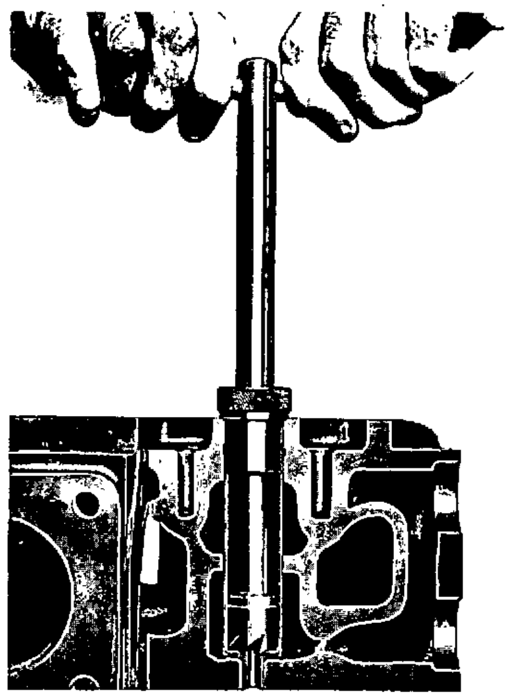


Fig. 9. Reconditioning injector seating face

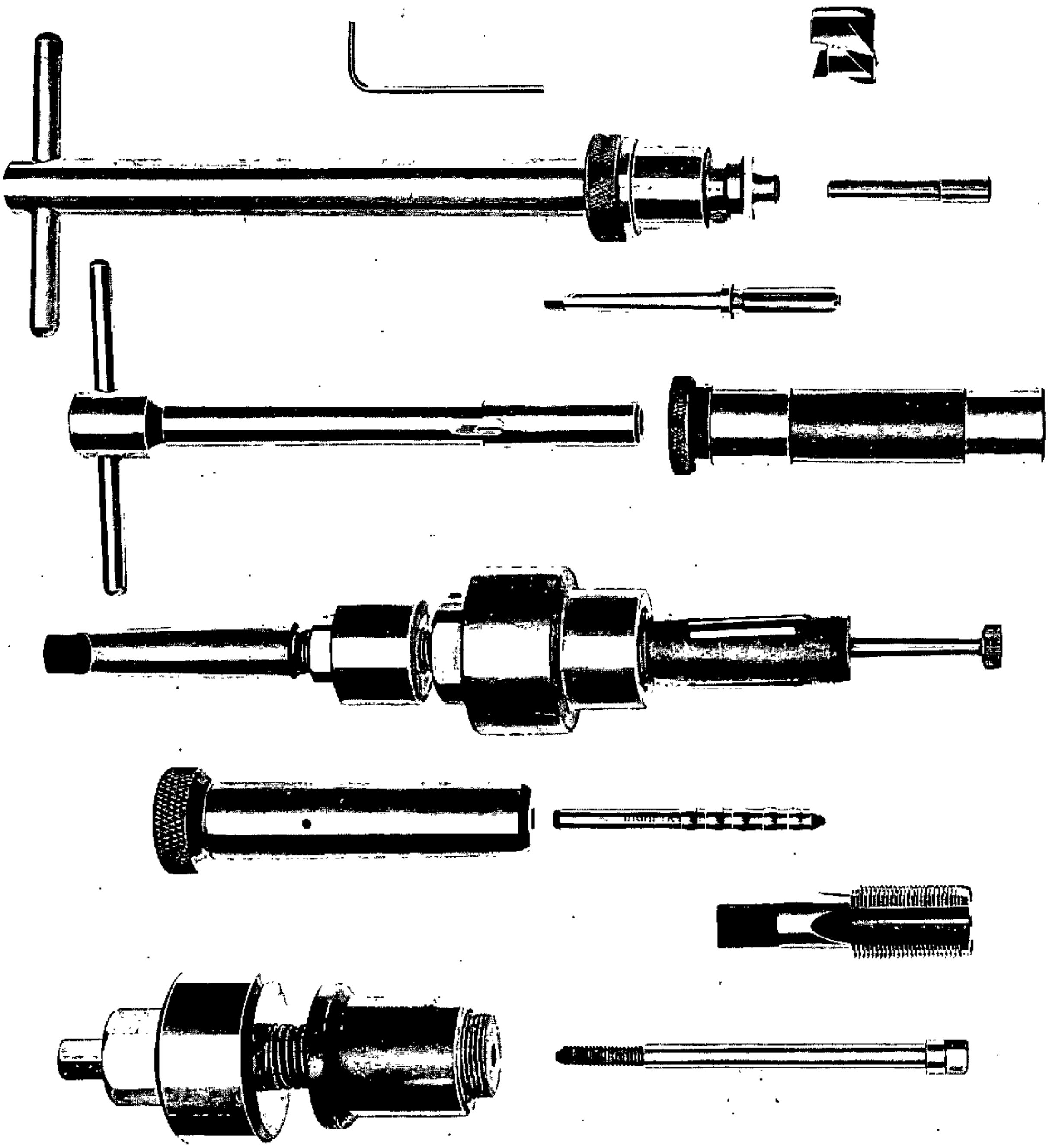


Fig. 10. Injector sleeve renewal and servicing kit

SECTION 5—LUBRICATION SYSTEM

Description

The wet sump system incorporates a conventional spur gear type pump driven from the crankshaft front gearing. The pressurised oil is directed through the oil-to-coolant heat exchanger then through the parrallel flow filters before entering the main oil gallery. Drillings into the main gallery carry oil to the main bearings then into the big end and small end bearings via crankshaft and connecting rod oilways respectively. Two auxiliary galleries, fed from the main gallery, deliver oil to the valve gear, tappets and camshaft bearings. The main gear train is lubricated from the front main bearing via the idler axles. Oil jets from the main gallery are directed into cooling galleries cast in each piston body, with holes bored for drainage back to the engine sump. External pipe-work delivers oil, direct from the heat exchanger mounting adapter, to the turbochargers with a branch line, from a 'T' piece connection in the 'A' bank turbocharger supply pipework, feeding the fuel injection pump and governor. A pressure relief valve, integral with the heat exchanger mounting adaptor, directs excess oil back to the sump if the pressure exceeds 414 km/sq.m. (60 lbf./sq. inch).

Servicing

This consists of maintaining the correct level of oil in the sump by daily checks with the dipstick, and changing the filters and lubricating oil at the intervals specified in the Servicing Schedule (Section 1).

DIPSTICK AND FILLER

The dipstick (fig. 1) carried in a tube on the sump well, consists of a flat spring steel blade cranked at the lower end to lie clear of the tube wall. Notches cut into the cranked section indicate the maximum and minimum permissible operating oil levels. A mild steel plug with a ring pull handle is brazed to the upper end of the dipstick blade.

The oil filler pipe (fig. 1) is fitted with an expanding rubber plug cap. To remove the cap the 'T' piece handle must be turned anti-clockwise. When replacing the cap, DO NOT overtighten.

DRAIN PLUG

The sump drain plug (fig. 2) is set in the rear wall of the sump well and torque tightened to 110 to 115 Nm (80 to 85 lbf. ft).

OIL FILTERS

Three expendable canister type filters (fig. 2) are mounted beneath the oil-to-coolant heat exchanger. Each cannister has a built-in by-pass valve which opens to allow oil circulation of the system if the element becomes choked.

FILLING AND DRAINING

At the intervals specified in the Servicing Schedule, drain the oil from the sump whilst still hot and before sediment has had time to settle.

Place a container beneath the heat exchanger and remove and discard the oil filter canisters. Stubborn canisters may be slackened using the filter wrench Rolls-Royce Part Number VT. 18038.

Refit the sump drain plug using a new sealing washer and tighten to the correct torque loading.

Clean the contact faces of the filter header, fill three new canisters with the approved type of lubricating oil and screw the canisters onto their mounts until the rubber sealing rings *just* touch the contact face of the header. Tighten each canister a maximum three-quarters of a turn by hand. DO NOT OVER-TIGHTEN.

Using a clean funnel and oil container, fill the sump with the approved type of oil to the UPPER mark on the dipstick. Pause periodically during filling to check the oil level.

Refit the filler cap and run the engine to circulate the oil. Stop the engine and check the oil level. Replenish to the UPPER mark on the dipstick if necessary.

OIL-TO-COOLANT HEAT EXCHANGER

The heat exchanger (fig. 2) is a single tube pack unit in an alloy housing, crankcase mounted on the 'B' bank side of the engine. Coolant flows through the tubes, whilst the oil is directed over the outside of the tubes by a series of baffles. The multi-finned tube pack construction ensures maximum heat transference efficiency.

The lower part of the housing forms a header for the oil filter canisters.

Under normal operating conditions no servicing of the oil-to-coolant heat exchanger should be necessary between engine overhauls. If scale or sediment is allowed to build up in either system, it may cause overheating which will necessitate the cleaning of the tube pack. In such cases, proceed as follows:

1. Drain the coolant to below the heat exchanger level.
2. Drain the lubricating oil from the heat exchanger by removing the filter canisters.
3. Release the hose connections on the coolant inlet and outlet pipes.
4. Unscrew the six securing setbolts and lift the heat exchanger clear of its mounting adaptor.

With the assembly on a work bench, remove the two tube pack locating screws and washers. Push the tube pack backwards until the rear 'O' ring seal is clear of the housing. Remove the seal from the groove in the tube pack and push the tube pack forwards and out of its housing,taking care not to damage the fins and baffles. Lift off the front 'O' ring seal.

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.

Clean out the housing, push the tube pack through from the front until the rear groove is clear of the housing and fit a new 'O' ring seal. Carefully push the pack forward until the front groove is clear of the housing and fit a new 'O' ring seal. Push the pack backwards until both the locating screws, with new spring washers, can be inserted finger tight. Fit new hose connections loosely on the coolant inlet and outlet pipes, prior to replacing the heat exchanger assembly.

Check that the mounting adapter and contact face of the heat exchanger are clean and refit the heat exchanger using four new 'O' ring seals (fig. 3) around the oil transfer ports. Tighten the six securing setbolts.

Line up the inlet and outlet pipework and fit the new hose connections.

Nip up the tube pack locating screws.

Fill three new filter canisters with oil of the same specification as that already in use and fit them as described in 'FILLING AND DRAINING', this section.

Replenish the cooling and lubrication systems as necessary and run the engine to test for leaks.

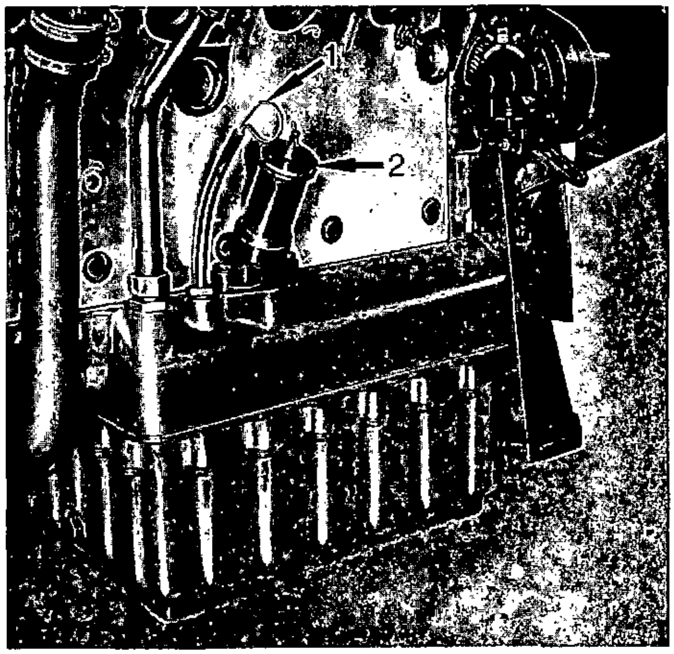


Fig. 1. Dipstick and oil filler
1. Dipstick
2. Oil filler cap

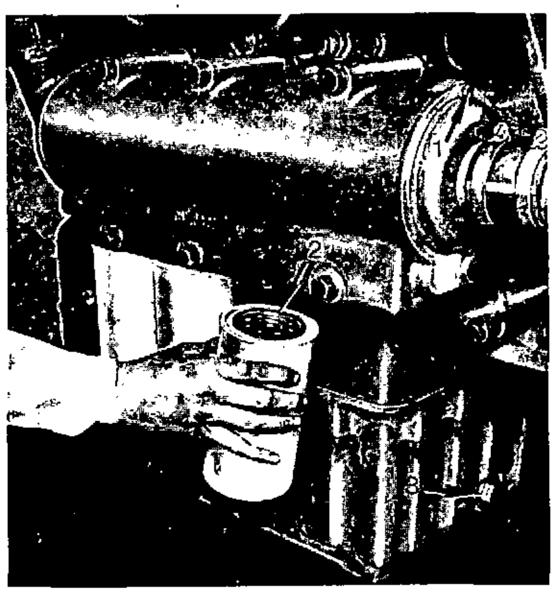


Fig. 2. Heat exchanger and oil filters
1. Tube pack locating screw (2)
2. Oil filter sealing ring
3. Sump drain plug

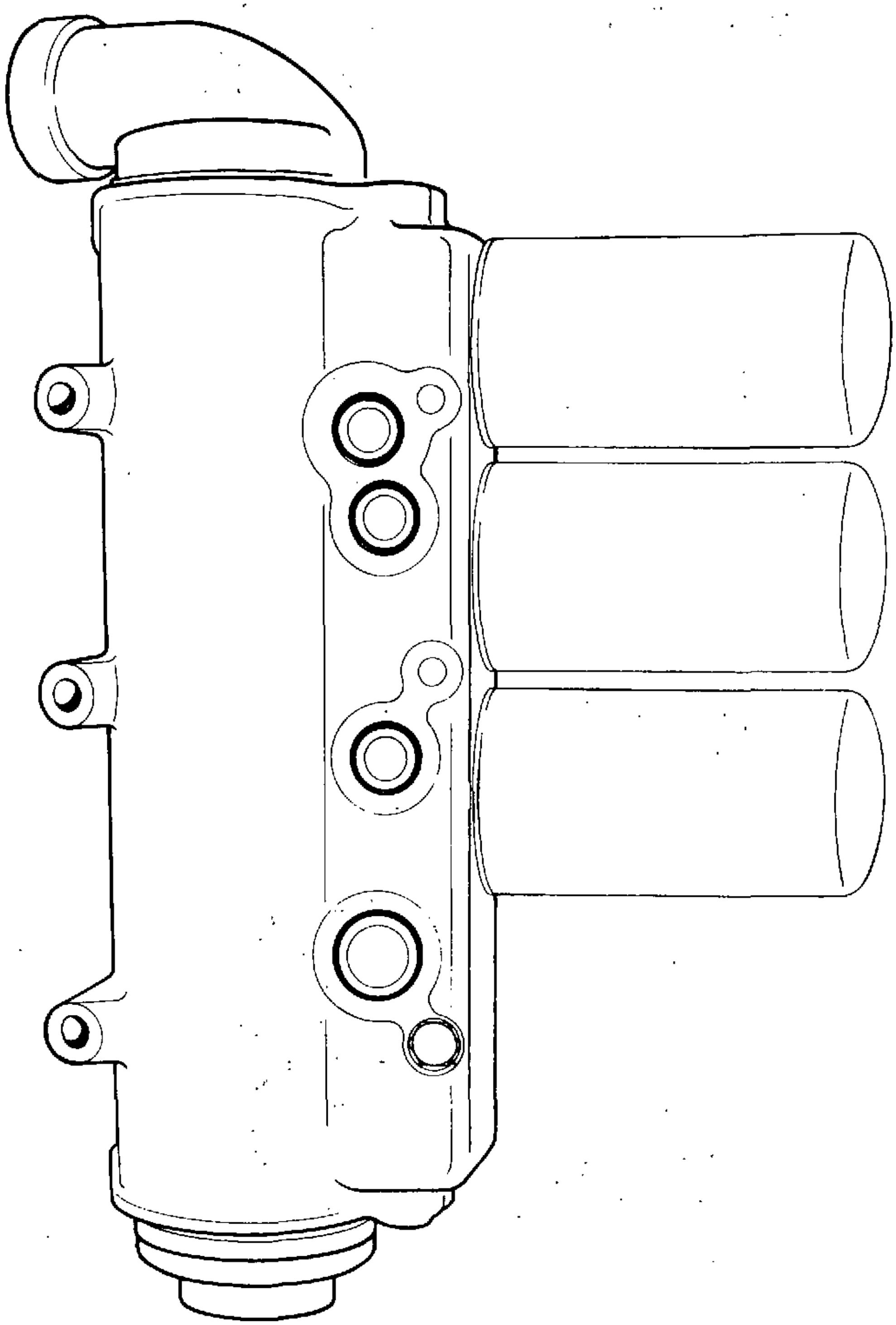


Fig. 3. Heat exchanger oil port seals

SECTION 6—INDUCTION SYSTEM

Description

The induction system is designed to provide an adequate volume of clean air to each cylinder to enable complete combustion of the fuel/air mixture to take place under all engine operating conditions. Leaks or restrictions in the system will adversely affect engine performance.

Ambient air is drawn through the air cleaners by a pair of engine-mounted turbochargers and delivered under pressure to the air-to-air charge cooler which is integral with the coolant radiator. The charge air passes through rows of finned tubes which are cooled by the engine driven cooling fan. Connections at each side of the radiator direct the air charge through separate pipes to each induction manifold.

RESTRICTION INDICATORS

Each air cleaner is fitted with an indicator (fig. 1) which gives visual warning when fouling of the element takes place.

As fouling increases, a red sleeve gradually moves into view in the indicator 'sight glass'. At the limit of fouling the sleeve will reach the 'service level' and will remain there when the engine is shutdown. At this stage the air cleaner must be serviced immediately.

If during engine operation the sleeve shows partial restriction of the cleaner element, there will be no immediate need to service the air cleaner if engine shutdown would be impracticable or inconvenient. It is strongly advised however that servicing of the cleaner be undertaken at the normal shutdown, before restarting the engine.

After servicing the air cleaner, press the reset button in the top of the restriction indicator to return the red sleeve to its original position, if necessary.

AIR CLEANERS

Two Donaldson Cyclopac dry element type air cleaners (fig. 2) are mounted over the engine. The air cleaners are of simple construction and are easily dismantled for servicing.

To service the air cleaner:

1. Slacken the clamp ring and remove the dust bowl and baffle assembly.
2. Unscrew the wing nut and separate the bowl and baffle.
3. Empty the bowl, clean both components and reassemble them.
4. Unscrew the element-securing wing nut and carefully withdraw the element.
5. Direct a jet of compressed air up and down the inside of the element pleats.
   DO NOT use air pressure greater than 700 kN/sq. m. (100 lbf./sq. inch).
   DO NOT hold the jet nozzle too near the element.
6. Inspect the element for damage by placing a light bulb inside. Thin areas or perforations indicate that the element must be renewed immediately.
7. Clean out any dirt from the air cleaner body, refit the element and dust bowl assembly and tighten up the clamp ring.
8. Reset the restriction indicator.

An alternative method of cleaning the element is to soak it in a solution of special detergent D1400. Instructions for use are given on the packet. Supplies of D1400 may be obtained direct from the filter manufacturers: Donaldson Filter Components Limited, Haydock, Lancashire, or their agents.

TURBOCHARGERS

Two Garrett-AiResearch TV61 turbochargers (fig. 3) are incorporated in the system. Though simple in principle a turbocharger is manufactured to fine tolerances and requires careful handling during maintenance operations.

A turbine and compressor wheel, mounted at either end of a common shaft, are supported by fully floating bearings. The compressor and turbine housings are attached to the bearing housings and are rotationally adjustable to suit exhaust inlet and compressor outlet connections.

The waste energy of the exhaust gases is used to drive the unit to increase the induction air flow to the cylinders. Depending on the application, the exhaust gases then pass through a silencer and out to atmosphere.

The turbocharger bearings are provided with oil direct from connections on the heat exchanger mounting adaptor, with large bore pipe returns to the crankcase.

Note: For optimum turbocharger efficiency, exhaust back pressure should not exceed 51 mm (2 inches) Hg.

Operating precautions

1. Before a new or overhauled engine equipped with a turbocharger is run at the Factory, an expendable filter is fitted in the turbocharger oil feed pipework. This filter protects the turbocharger bearings during the initial running-in period; afterwards the filter is removed and destroyed. Operators wishing to adopt this precaution are reminded that the filter MUST be removed before the engine goes into service. As the filter cannot be cleaned, it is important that it is destroyed to prevent re-use.
2. If the engine has been out of use for a month or longer, the turbocharger bearings must be primed as follows:

   Unscrew the stand pipe plug and using a clean funnel and oil container, pour in 0.2 litre (1/3 pint) of clean engine lubricating oil. Refit the plug securely.
3. Before shutdown, allow the turbocharger to cool and reduce speed by running the engine 'off-load' for 3 minutes.
4. Never continue to run an engine if the oil pressure drops below 210 kN/sq. m. (30 lbf./sq. inch) at rated speed.

Maintenance in service

The following points should receive particular attention:

1. Service the air cleaner at the intervals specified in the Servicing Schedule (Section 1).
2. At frequent intervals inspect the induction and exhaust systems for leaks and deterioration in hose connections which could cause overheating. If either system is disturbed, the components must be re-assembled carefully to ensure perfect joints and to prevent cracking of manifolds due to uneven tightening.
3. During servicing take care to prevent dirt or loose articles from entering the induction and exhaust systems where they could cause damage to the compressor wheel or turbine blades.
4. At frequent intervals check that the turbocharger oil feed and drain pipes are undamaged. Restriction of oil flow in either pipe may result in bearing failure. At oil change intervals, check the drain pipe bore.
5. Ensure that the crankcase breather pipe is unrestricted at all times. Pressurisation of the crankcase will prevent free return of oil from the turbocharger bearings.
6. Use the recommended grade of lubricating oil and maintain the lubrication system in accordance with the Servicing Schedule (Section 1).
7. Periodically check the exhaust system for restrictions, (e.g. choked silencer or damaged exhaust pipe). Overheating and loss of performance will occur if the exhaust back pressure exceeds 51 mm (2 inches) Hg under full load conditions.
8. If investigation of an engine fault involves checking a turbocharger, remove the induction trunking and spin the rotor assembly by hand.

   Check for freedom of movement and listen for sounds indicating rubbing or binding. To avoid imbalance of the assembly it is not advisable to remove deposits from the turbine or compressor wheel. If necessary, remove the turbocharger for cleaning and bearing checks as described later.

Turbocharger failure

The cause of failure must be found and rectified before a replacement unit is fitted. It will also be necessary to check if the failure has caused damage to other engine components.

1. A damaged compressor will necessitate inspection of the entire induction system to locate the cause. The engine cylinders must be checked for damage and the induction and exhaust systems, including the charge cooler tube bores, cleared of debris.
2. A damaged turbine may be due to loose particles from the exhaust manifold or the engine cylinders. These components must be examined and the exhaust system cleaned out before a replacement turbocharger is fitted.
3. Excessive bearing wear can result in the compressor rubbing on its housing. Particles of aluminium produced by this contact may be drawn into the engine cylinders causing piston scuffing and liner wear.
4. Faulty lubrication is the most probable cause of turbocharger bearing failure. This may be the result of low oil pressure or restricted oil flow but it is more likely to be attributable to contaminated or diluted oil.

   Following turbocharger bearing failure, the engine lubricating oil must be changed and the oil filters renewed before fitting a replacement turbocharger.

Incorrect air delivery pressure

1. Pressure below normal may be caused by:
   (a) Choked air cleaner
   (b) Insufficient fuelling
   (c) Leaks in induction or exhaust system
   (d) Damaged turbine
   (e) Dirty or damaged compressor
2. Pressure above normal may be caused by:
   (a) Excessive fuelling
   (b) Build up of carbon in the turbine housing

   If the injection pump MAX FUEL stop seal is broken, the pump must be removed for fuelling adjustment on a test rig.

   If the seal is unbroken, the turbocharger must be dismantled for inspection of the turbine housing.

Cleaning and serviceability checks

Slacken the hose connections to the compressor inlet and charge cooler ductings, remove the 'V' band clamp at the exhaust bellows connection, disconnect the lubricating oil inlet and drain pipes from the bearing housing then remove the four retaining nuts and washers from the exhaust manifold flange connection. Lift off the turbocharger and cover all openings to prevent ingress of dirt.

Remove the 'V' band clamps securing the compressor and turbine housings and carefully remove the two outer housings, taking care not to damage the rotor blades.

Check the housings and rotor assembly for signs of rubbing and clean the components with a non-caustic cleaning solution. Remove any build up of carbon or dirt with a bristle brush or a non-metallic scraper. Ensure that no deposits remain or the balance of the rotor assembly might be impaired.

To check radial movement of the rotor assembly, mount a dial test indicator as shown in figure 4, with the button resting on the rotor shaft. (It may be necessary to make an adaptor plate for this operation). Holding each side of the rotor assembly, raise and lower the assembly to its full extent and check the indicator reading: the total reading should not exceed 0.15 mm (0.006 inch).

To check the end float of the rotor assembly, mount the dial test indicator as shown in figure 5, with the button resting on the compressor end of the rotor shaft. Move the shaft axially to its full extent in both directions and check the indicator reading; the total reading should not exceed 0.25 mm (0.010 inch).

Readings beyond these limits will involve a complete overhaul of the turbocharger. For relevant information, consult the Engineering Department of Rolls-Royce Motors Limited.

Reassemble the turbocharger housings, lightly nipping the two 'V' band clamp nuts. Spin the rotor assembly and listen for any sounds of rubbing or binding. Clean the exhaust manifold supporting flange, oil inlet and drain pipe flanges, exhaust bellows unit contact face and check ducting hose connections for serviceability.

Refit the turbocharger to the exhaust manifold using new locking washers, smear the stud threads with

'Rocol J.166, anti-seize compound and tighten the retaining nuts securely; tab up the locking washers.

Re-align the compressor housing discharge with the charge cooler ducting and slide the hose connection into position.

Tighten the hose connection and, using a new gasket, refit the oil inlet pipe. Prime the bearing housing with clean engine lubricating oil and spin the rotor assembly by hand to work the oil into the bearings.

Re-connect the exhaust pipework to the turbocharger and holding the rotor assembly stationary with a ring spanner on the compressor end nut, run the engine briefly to check for an adequate flow of oil from the turbocharger drain connection.

Stop the engine, remove the spanner and using a new gasket refit the turbocharger oil drain pipe. Finally re-connect the compressor intake ducting, and ensure that all 'V' band clamp nuts are torque-tightened to their correct loading. (See Section 1—'Data').

CHARGE COOLER

The charge cooler, of aluminium construction, is integral with the radiator and consists of a series of finned tubes over which air is forced by the engine driven fan. Servicing of this component is minimal and consists of maintaining the induction system in a clean condition and ensuring that the tube fins are not allowed to become choked with dirt. To remove oil or dirt adhering to the fins, use a bristle brush and detergent solution, rinse with clean water and blow dry with a compressed air jet.

Cleaning aluminium components

If the induction system is allowed to become contaminated with oil, as could happen if the turbocharger oil deflector or piston rings become damaged or worn, the components may be cleaned using an emulsifying solvent. Ideally, each component should be immersed for about 10 to 15 minutes in a bath of the solvent, then washed thoroughly with clean water and dried before refitting. Repeat the operation if necessary.

As it may be impracticable to immerse the charge cooler, the radiator must be partially dismantled to enable the solvent to be sprayed into each tube. Ensure that all deposits are thoroughly wetted and allowed to soak for 10 to 15 minutes. Wash the tubes with a steam cleaner or high pressure water jet and dry thoroughly before re-assembling the radiator.

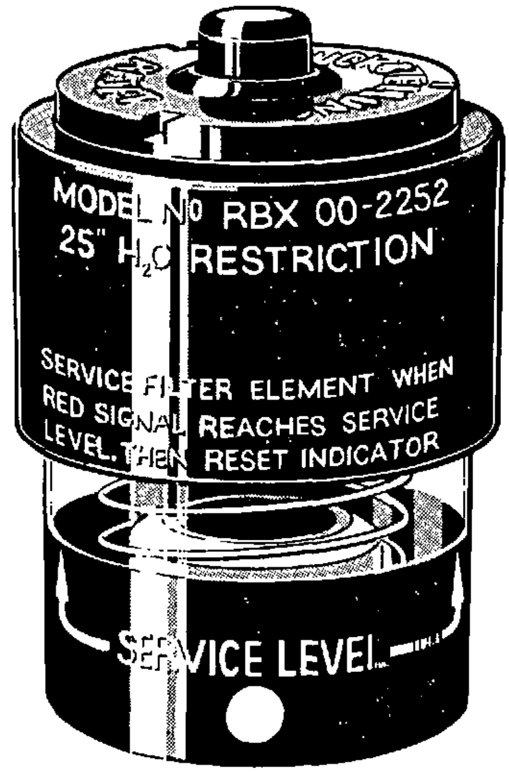


Fig. 1. Air restriction indicator

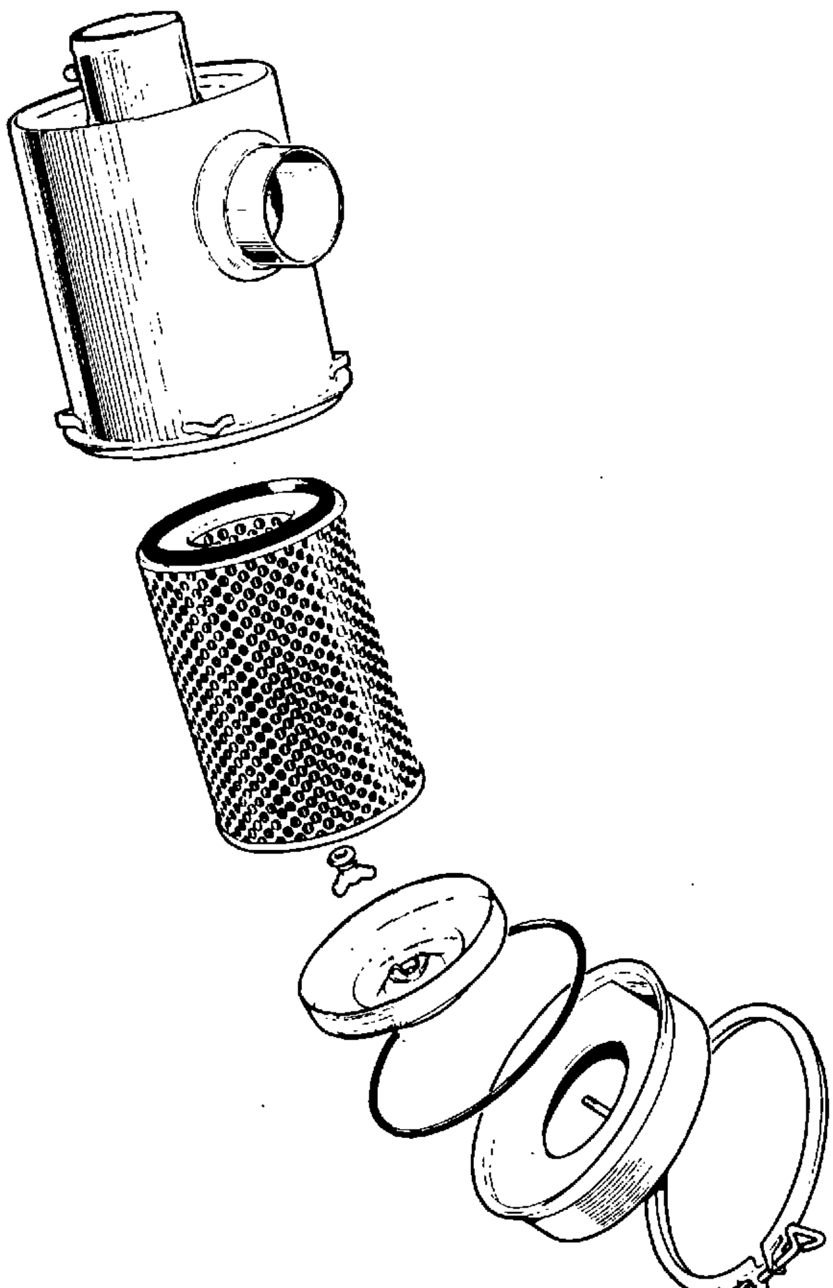


Fig. 2. Air cleaner

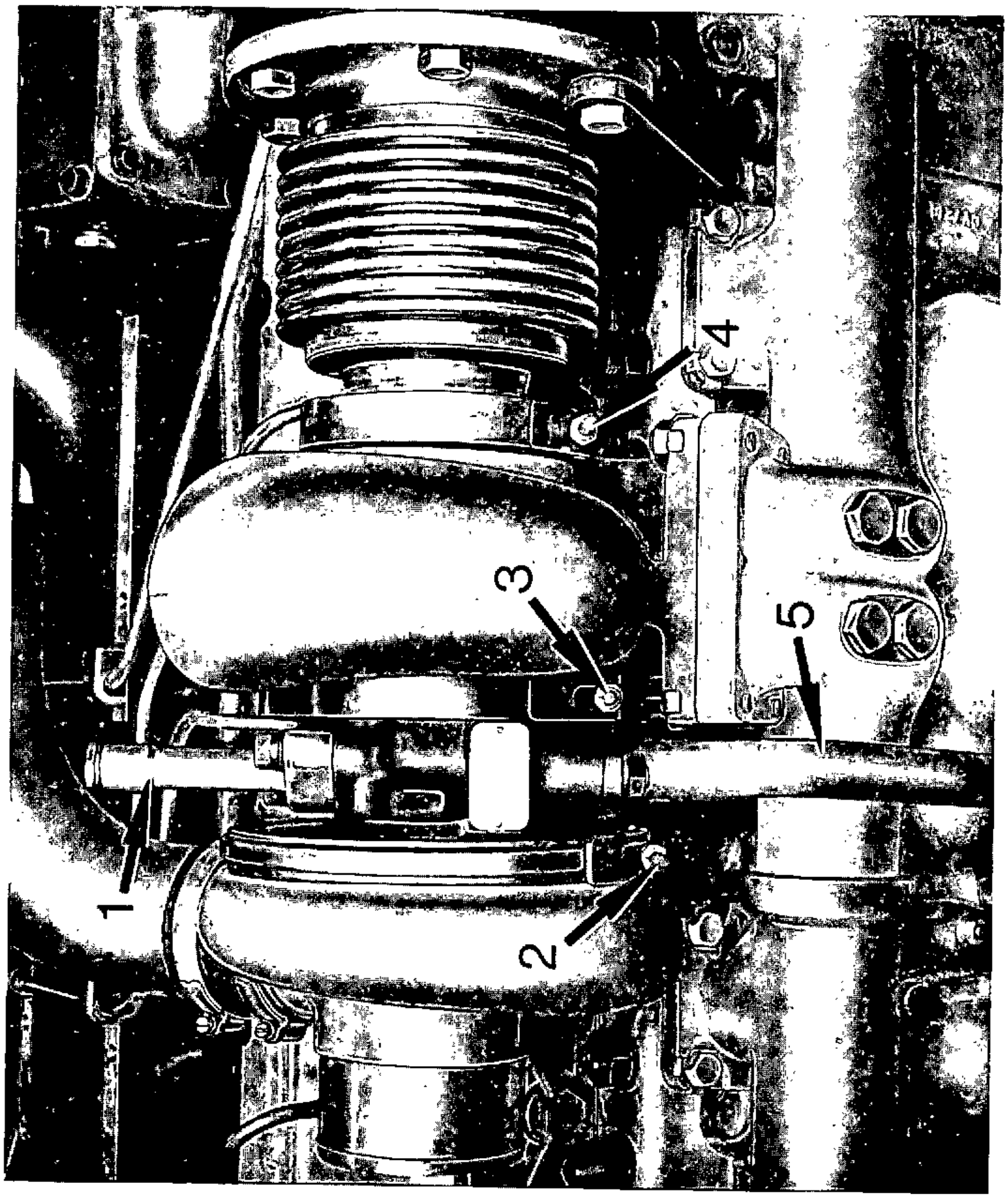


Fig. 3. Turbocharger ('A' bank)

1. Oil priming pipe
2. Compressor housing clamp bolt
3. Turbine housing clamp bolt
4. Exhaust bellows clamp bolt
5. Oil drain pipe

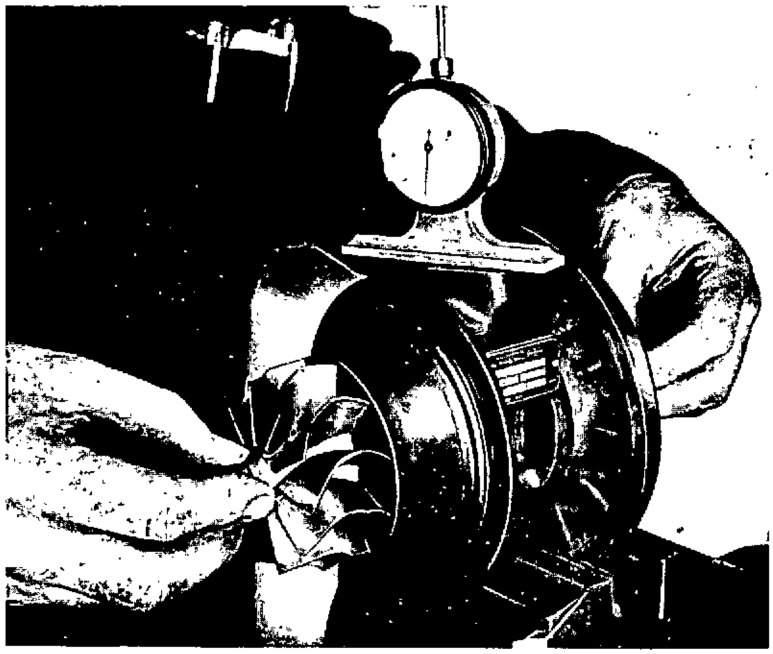


Fig. 4. Radial movement check

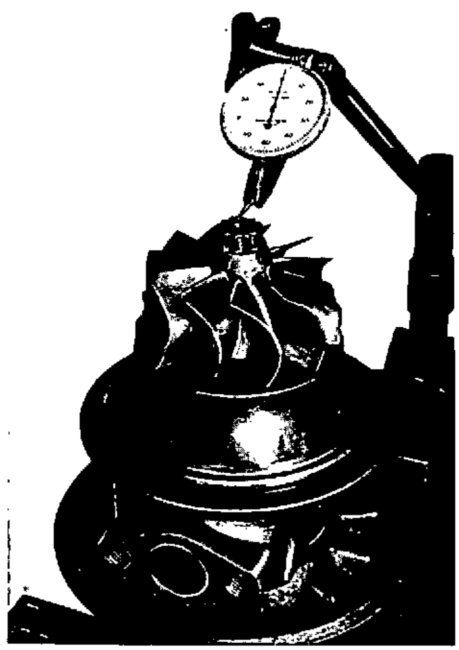


Fig. 5. Checking end float

SECTION 7—ELECTRICAL SYSTEM

Description

A belt driven Butec Type A13 alternator provides a 30 amp charging circuit for the starter batteries. The alternator voltage is governed by a Butec Type R1 regulator to provide a nominal output of 24 volts, which is continuously variable over a short range to suit individual installation requirements. A Butec Type MS6 starter motor, flange mounted on the flywheel housing, engages with a conventional toothed starter ring, integral with the flywheel.

Two Teddington switches, incorporated in the lubricating oil and cooling systems , are connected to a C.A.V. solenoid control unit which is linked directly to the fuel injection pump stop control. The switches operate at a pre-selected oil pressure or coolant temperature to shutdown the engine for component protection.

ALTERNATOR

The three phase, delta connected alternator (fig. 1) is *of the rotating field, stationary armature (stator) type* with a self-limiting current output. Rectification is by replaceable heavy duty silicon diodes carried in suitably finned heat sinks. The rotor bearings are sealed for life and the slip-ring assembly and brush gear are shielded to prevent ingress of dirt. A centrifugal type fan mounted on the drive end of the rotor shaft draws cooling air through the alternator and over the heat sink fins.

Technical data:

Maximum rated output (hot)	30 amps at 28 volts
Cut in speed (hot)	830 rpm
Max. continuous operating speed	10,000 rpm
Stator phase resistance (assembled)	0.454 to 0.494 ohms at 20 deg.C.
Rotor resistance	13.6 to 15.2 ohms at 20 deg.C.
Rotation	Reversible
Max. ambient temperature	93 deg.C.

Servicing

Periodically, dependent on operating conditions, clean the exterior of the alternator and ensure that the ventilation apertures are clear. Fouling in the vicinity of the diodes can cause flashover and should be removed by spraying with an approved cleaning fluid, a recommended type being Electronic Cleaning Fluid, Grade 8—23, available in aerosol or bulk form from Applied Chemicals Limited, Uxbridge, Middlesex.

At the intervals specified in the Servicing Schedule (Section 1):

1. Check the condition and tension of the driving belts and adjust or renew them if necessary as described in Section 2.
2. Remove the two securing nuts, cover and gasket from the brush gear. Lift out each brush assembly and check the brush condition and spring tension. The minimum permissible worn length is 4.76 mm (0.187 inch). To inspect the slip ring asssembly, remove the four securing screws and withdraw the brush gear housing.

   Clean off any grease and dirt from the components with a soft cloth moistened with petrol or white spirit and check the slip rings for damage. Worn or scored slip rings must be renewed as described in the Workshop Manual.

VOLTAGE REGULATOR

The self-limiting properties of the alternator allow the use of a regulator of simple and reliable design. The Butec R1 regulator utilises a printed circuit board with no moving parts and is suitable for positive, negative or earth return systems. The semi-conductors in the circuit control the alternator field current which regulates the output current over the full operating range. The unit requires no maintenance during service.

Warning: The diodes and transistors in the battery charging system will be destroyed if they are subjected to voltage changes or high temperatures. To prevent this from occurring. DO NOT:

1. Disconnect the battery whilst the alternator is running.
2. Disconnect any leads without first stopping the alternator and turning all switches to OFF.
3. Connect any lead without ensuring that it is being fitted to the correct terminal.
4. 'Flash' a connection to check current flow.
5. Permit anyone other than a qualified electrician to work on the system.
6. Permit any arc-welding to be carried out in the vicinity of the electrical circuits without first isolating all the components.

STARTER MOTOR

Description

The Butec MS6 starter motor incorporates an externally mounted solenoid switch.

When the starter button is pressed, a pull-out circuit in the solenoid moves the plunger until the starter contacts close. At this point, the pull-in circuit will be in parallel with the contacts and no current will flow in the circuit. A second circuit in the solenoid flows through a hold-in coil which maintains the plunger in the starter operating position until the starter button is released.

The solenoid plunger action is transmitted to the starter pinion via a hinged lever arm arrangement. An over-running clutch, incorporated in the pinion assembly, prevents damage to the starter ring teeth, pinion teeth and armature when the engine fires. When the starter button is released, a return spring drives the pinion back along the splined armature shaft to its original position.

Servicing

The MS6 starter motor is designed to operate with the minimum of servicing.

1. Every 12 months, disconnect and remove the starter motor from the flywheel mounting. Clean the starter casing and remove gummy deposits from the drive splines with petrol or paraffin.
2. Remove the commutator cover band and using an air jet, blow out any dirt or carbon particles from the brush-gear. Check the commutator for wear or damage; a dark brown discoloration indicates a satisfactory condition. A worn or damaged commutator must be renewed or reconditioned as detailed in the Workshop Manual.
3. Ensure that the brushes slide freely in their holders and that the spring loading is 1.42 to 1.68 kg (50 to 59 ozs) as each brush *just* clears the commutator. A significantly lower figure indicates worn brushes which must be renewed as a set and bedded to the curvature of the commutator with fine glasspaper NOT emery or carborundum paper. The minimum permissible brush length is 15.9 mm (0.625 inch).
4. Blow out any abrasive particles from the brush gear with an air jet and check that all brush leads are clear of other parts. Apply glycerine to the cover band gasket and re-fit the band so that the joint is over a rib of the starter casing.
5. Remove the Allen screw plugs (fig. 2) and apply two or three drops of clean S.A.E. 5W/20 engine oil to each lubricator wick.

   Replace the plugs securely.

   Note: Replacement starter motors should be lubricated in this manner before fitting.
6. Apply a thin film of light graphite grease to the drive splines and check that the pinion slides freely. Refit the starter to the engine, ensuring that the terminals are clean and firmly secured.

SOLENOID STOP CONTROL

Description

A C.A.V. Type 368 solenoid unit, used in the energised-to-run mode, is mounted in the engine 'V' and connected directly to the stop control on the governor housing.

The dual circuits in the solenoid actuate the plunger which, in turn, moves the stop control lever on the governor to the RUN position.

When the solenoid is energised, a pull-in coil draws the plunger in the direction of the arrow (fig. 3) until it opens the switch contacts. This operation breaks the circuit of the pull-in coil and leaves a low consumption hold-in coil energised. At this point the solenoid control rod will be holding the stop control lever in the RUN position.

On de-energisation of the solenoid, a coil spring returns the plunger to its rest position and the stop lever to STOP. This occurs when the STOP button is pressed, when an engine protection device breaks the circuit or as the result of an electrical failure.

Caution: Solenoid units are available in a variety of voltages and settings to suit individual installations and it is essential that a replacement corresponds exactly to the original.

Adjustment

The unit requires accurate adjustment of the control rod between the solenoid and the stop control lever. Incorrect setting can damage the fuel pump or cause the pull-in coil windings to overheat and eventually burn out.

To prevent such occurences, the following procedure should be followed, before the electrical connections are made:

1. Adjust the stop control lever as described in Section 4—'Fuel System'.
2. Remove the rubber cover from the terminal block to observe the switch.
3. Connect the solenoid control rod to the stop control lever and operate the unit manually to check that the switch opens when the plunger is pressed fully home, followed by a further movement of 0.5 to 0.8 mm (0.02 to 0.03 inch) to compress the spring in the spherical joint.
4. If necessary, slacken the control rod locknuts and adjust the rod length to achieve the above requirements. Tighten the locknuts.
5. Connect the electrical wiring to the terminals and fit the rubber cover, ensuring that the cover clips are securely tightened.

WARNING AND SHUTDOWN SWITCHES

Description

Two Teddington Type DCA switches are incorporated in the cooling and lubrication systems to provide engine protection should the coolant temperature or lubricating oil pressure extend beyond the permissible operating range. The switches may be wired to operate on rising or falling temperatures and pressures to suit the individual application. No servicing is necessary on the switches but it is strongly recommended that they be checked for operating efficiency at regular intervals, as engine operating conditions permit. Ideally, the checks should be carried out every six months or less.

The switches (fig. 4) are factory set to operate within a selected range of temperatures and pressures and no attempt must be made to alter the settings.

To test the oil pressure switch, screw the switch into a suitable pressure fitting and apply pressure in excess of 207 kN/sq. m. (30 lbf/sq. inch). Connect a battery and appropriate light bulb across the switch terminals and gradually reduce the system pressure. Note the pressure at which the light is extinguished; this should be between 138 and 165 kN/sq. m. (20 and 24 lbf/sq. inch).

To test the coolant temperature switch, connect a battery and appropriate light bulb across the switch terminals and immerse the switch sensor in a suitable container of oil. Place an accurate thermometer close to the sensor and heat the oil to 94 deg. C. Maintain the oil temperature at 94 deg. C. for 15 minutes then gradually increase the temperature and note the thermometer reading at which the light is extinguished; this should not be above 100 deg. C.

If the pressure or temperature readings extend beyond the above limits, replacement switches must be fitted where appropriate.

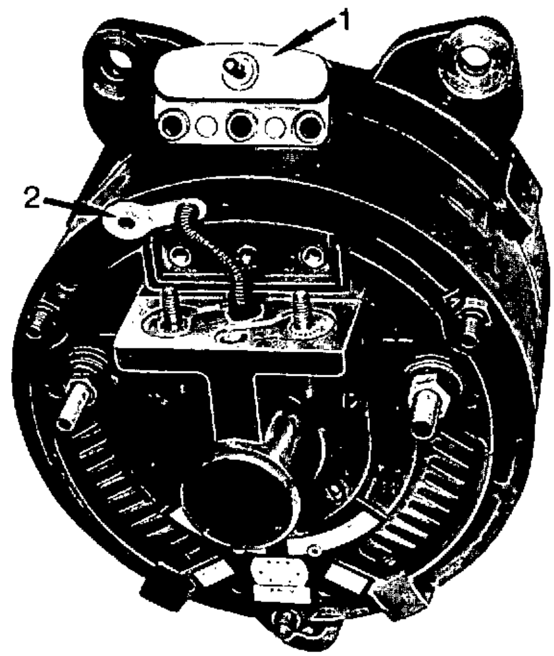


Fig. 1. Alternator
1. Auxiliary diode capsule removed
2. Brush assembly

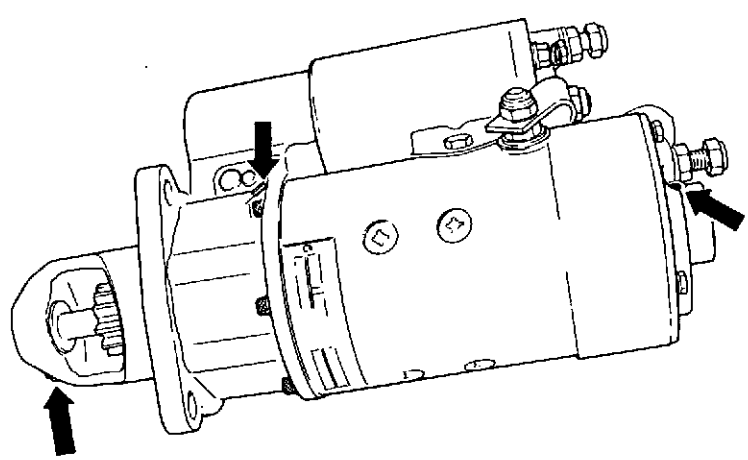


Fig. 2. Butec starter motor
(Grease points arrowed)

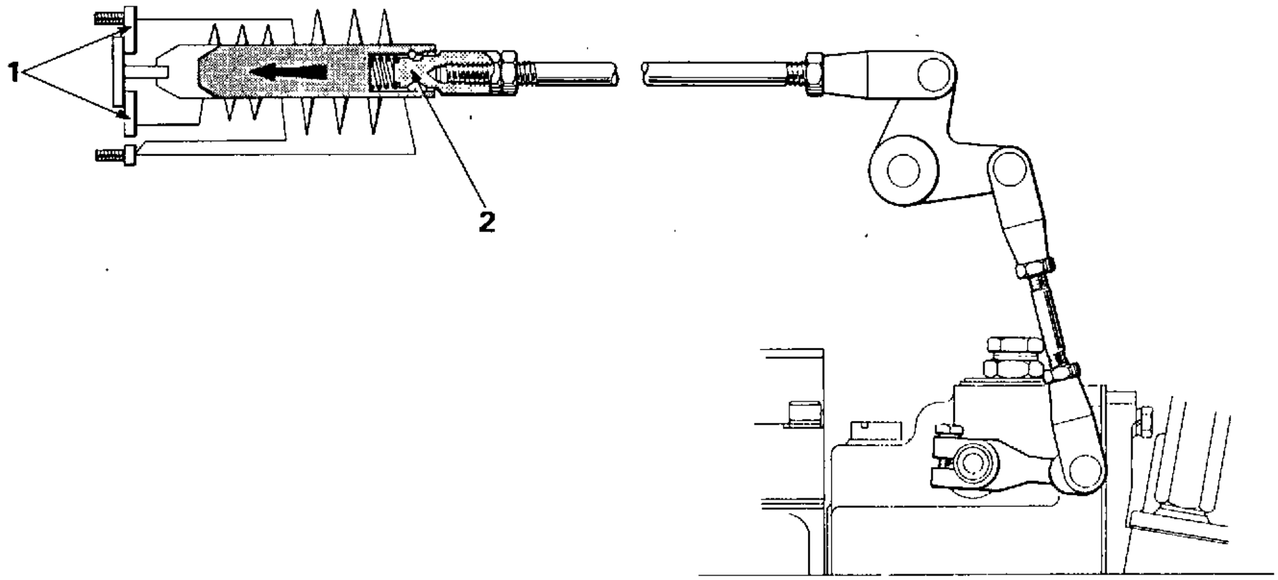
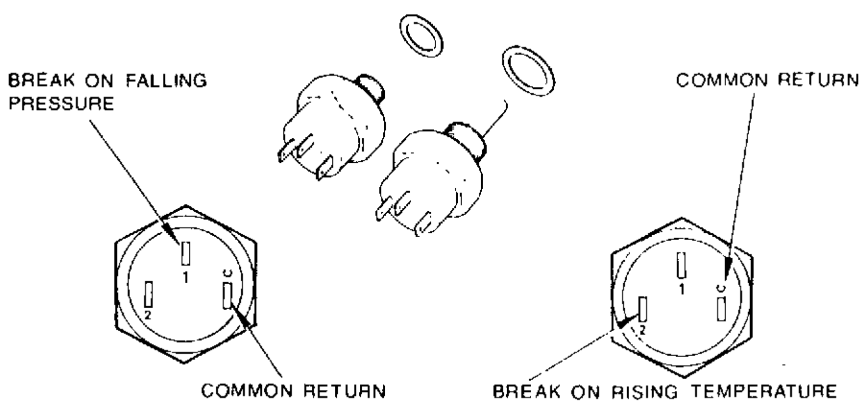


Fig. 3. Solenoid control
1. Switch contacts
2. Spherical joint



Oil pressure switch

Coolant temperature switch

Fig. 4. Teddington control switches

SECTION 8—MISCELLANEOUS

RUNNING-IN AFTER REPAIRS

Every new or reconditioned engine supplied by Rolls-Royce is run-in before leaving the factory and requires no special treatment when put into service.

When a partial overhaul has involved the renewal of cylinder liners and piston rings, it is advisable to subject the engine to a statutory running-in period on a fully equipped test bed, with temporary lubricating oil fillers fitted to the turbocharger oil inlet connections. These filters must be removed and discarded after the running-in period, before the engine goes into service.

Check the tightness of the cylinder head setbolts within 5 to 10 ESC Units of the running-in period. Re-torque to the correct loading.

STORAGE

Short term

Up to seven days. No treatment is necessary.

Up to one month. Run the engine each week until normal working temperature is reached. If it is impracticable to run the engine, turn the crankshaft for three or four complete revolutions.

Long term (over one month)

Lubrication and fuel systems

Drain the sump, refill with approved grade of oil and renew the lubricating oil filter-canisters.

Connect the fuel inlet pipe to a tank containing an inhibiting fuel oil (Shell Fusus 'A' or equivalent). Motor the engine on the starter until pressure is indicated on the lubricating oil pressure gauge, run the engine 'off load' until working temperature is reached, then shut the engine down.

Cooling system

After shut-down, drain the system. If required, refill the system with fresh coolant of approved type suitable for likely ambient temperatures.

Manifolds

Using a hand-operated spray-gun, inject V.P.I. powder (Shell Chemicals Limited) as follows:

Induction manifolds—5 c.c. into each manifold

Exhaust manifolds —5 c.c. into each section

Turbochargers —5 c.c. into each turbocharger

Blank off all induction and exhaust apertures.

Drive belts

Remove belts, coat with french chalk and place in a bag attached to the engine.

External treatment

Wrap all the electrical fittings in waterproof material and seal with adhesive tape.

Blank off the engine breather.

Grease all control linkage and unprotected metal areas. Attach a label giving details of lubricating oil and coolant in the systems and date of putting engine into storage.

REMOVAL FROM STORAGE

Instructions are given in Chapter 2 'Operating'.

DISPOSAL OF SODIUM FILLED VALVES

If it is necessary to renew a sodium filled exhaust valve during engine overhaul, the faulty valve must be disposed of in the following manner:

Dry grind the valve stem at mid-point until the sodium is just exposed, then immerse the valve in a tank containing at least 90 litres (20 Imp. gallons) of water. Hydrogen gas will be given off and the water will become a caustic solution, so extreme care must be taken to avoid splashing skin or clothing and naked lights must NOT be permitted near the tank. After a two hour soak, the valve may be removed with tongs and disposed of as normal metal scrap.

An approved method of waste disposal must be applied when emptying the tank.

Valves containing sodium may be identified by a groove machined around the valve stem close to the tip.

CHAPTER 4—FAULT DIAGNOSIS

Sympton or Condition	Possible Cause	Action	Refer to Chapter 3 Section
1. FAILURE TO START			
(a) Starter will not turn engine	Discharged battery	Renew battery	—
	Faulty starter circuit	Check switch terminals and starter motor. Check cables for damage	7
	Defective starter	Change starter	7
	Starter pinion not engaging	Bar engine round and try again	7
(b) Engine turns but will not fire	Insufficient engine rpm	Check battery state	—
	Air in fuel system	Check feed pump suction connections	4
	No fuel at injectors	Check fuel level and fuel cock	4
	Water or dirt in fuel	Drain water trap if fitted; renew filter canisters	4
	Faulty feed pump	Change or service pump	4
	Injection pump timing incorrect	Reset pump timing	4
2. ENGINE FIRES BUT FAILS TO RUN	Faulty fuel supply	Check system	4
	Faulty feed pump	Change or service pump	4
	Fuel filters choked	Renew filter canisters	4
	Air cleaner(s) choked	Service air cleaner(s)	6
	Faulty injector(s)	Change injector(s)	4

Sympton or Condition	Possible Cause	Action	Refer to Chapter 3 Section
3. MISFIRING	Air in fuel system	Check feed pump suction connections	4
	Fractured injector pipe	Change pipe	4
	Faulty injector(s)	Change injector(s)	4
	Incorrect tappet clearance	Re-set clearance	2
	Faulty injection pump	Change pump	4
4. LOW OIL PRESSURE			
(Sudden drop not due to normal wear)	Low oil level	Replenish sump	5
	Faulty pressure gauge	Renew gauge	—
	Filters choked	Renew filter canisters	5
	High oil temperature	See Item 5	—
5. OVERHEATING	Coolant level low	Replenish and check for leaks	3
	Slipping, broken or damaged fan belt(s)	Adjust or renew fan belt(s)	2
	Fouled cooling system	Clean and refill system	3
	Faulty thermostat(s)	Test, and renew if necessary	3
	Choked radiator matrix	Clean matrix	—
	Injection pump timing incorrect	Re-set timing	4
	Turbocharger failure	Inspect turbochargers, fit replacements if necessary	6
6. LOW FUEL PRESSURE	Leak in feed pump suction	Locate and rectify	4
	Faulty feed pump	Change or service pump	4
	Faulty relief valve(s)	Change the valve(s)	4

Sympton or Condition	Possible Cause	Action	Refer to Chapter 3 Section
7. **LOSS OF POWER**	Low fuel pressure	See Item 6	—
	Injection pump timing incorrect	Re-set timing	4
	Faulty injector(s)	Change injector(s)	4
	Air cleaner(s) choked	Service air cleaner(s)	6
	Incorrect tappet clearance	Re-set clearance	2
	Leaking joints at cylinder head or induction manifold	Renew joints	—
	Turbocharger failure	Inspect turbochargers fit replacements if necessary	6
8. **BLACK EXHAUST SMOKE**	Overfuelling	Check MAX. FUEL stop seal. If broken, change pump or reset on test rig	—
	Faulty injector(s)	Change injector(s)	4
	Injection pump timing incorrect	Reset timing	4
	Air cleaner(s) choked	Service air cleaner(s)	6
	Turbocharger failure	Inspect turbochargers	6

SERVICE INSTRUCTIONS

All Service Instructions issued subsequent to the publication of this Manual should be inserted behind this page and reference notes entered in the appropriate Chapter or Section.

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