



T.S.D. PUBLICATION 3115

SERVICING MANUAL

CV8 ENGINES

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T.S.D. Publication 3115

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NOTES TO USERS

The purpose of this Manual is to provide Operators with all the information necessary for the correct usage and efficient maintenance of Rolls-Royce CV8 engines, between overhauls.

Repair and overhaul information is contained in the Workshop Manual TSD. 3130.

Service

Throughout the world, Dealers and Distributors appointed by Rolls-Royce can provide advice, spare parts and Factory trained staff if required. 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 the Dealers and Distributors can speedily supply a 'short engine' or major component, fully reconditioned and guaranteed for six months. Units available are listed overleaf; in certain circumstances reconditioned complete engines can be supplied.

Advice and assistance can be provided 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 (ESC).
2. If a proprietary unit (e.g. injection pump, turbocharger) is involved, the details on its data plate and the number of ESC 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 CV8 engines is available at the Factory. For details, apply to: The Superintendent, Customer Training Centre, Rolls-Royce Motors Limited, Shrewsbury, Shropshire Telephone: 0743/52262.

Service Instructions and Bulletins

Service techniques and engine design are under constant review at Rolls-Royce, so that from time to time it becomes necessary to revise manuals and 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 in Service techniques are issued as Service Instructions for inclusion in Service Manuals by Dealers, Distributors and Operators.
2. Engine design changes are issued usually as Modifications in Service Bulletins for the information of Dealers and Distributors.

Associated publications for CV8 range of engines

T.S.D. 3130	Workshop Manual
T.S.D. 3128	Service Instructions
T.S.D. 3129	Service Bulletins
T.S.D. 3085	Fuel, oil and coolant recommendations. (See rear cover pocket)
T.S.D. 3125	Essential information for Operators (supplied with engine)
T.S.D. 3120	Operators guide

SERVICE EXCHANGE UNITS

The following units are available:
(For further details, apply to Rolls-Royce Dealers and Distributors)

Alternators

Coolant Pumps

Crankshafts

Cylinder Heads

Engines (complete)

Turbochargers

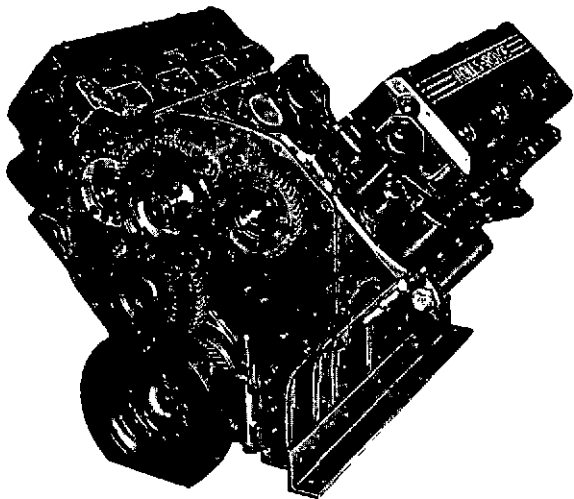
Fuel Injectors

Fuel Injection Pumps

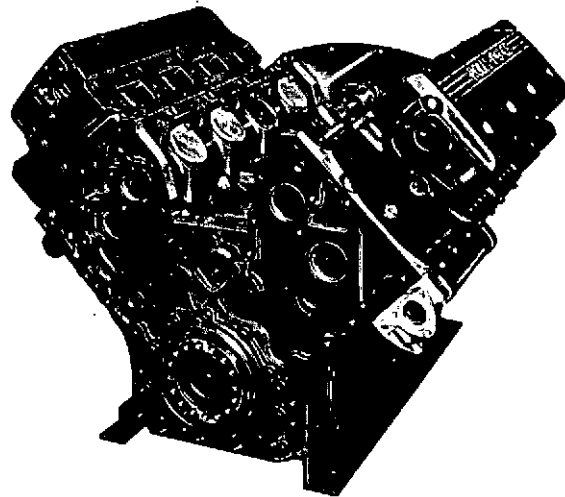
Oil Pumps

Short Engines

Starter Motors

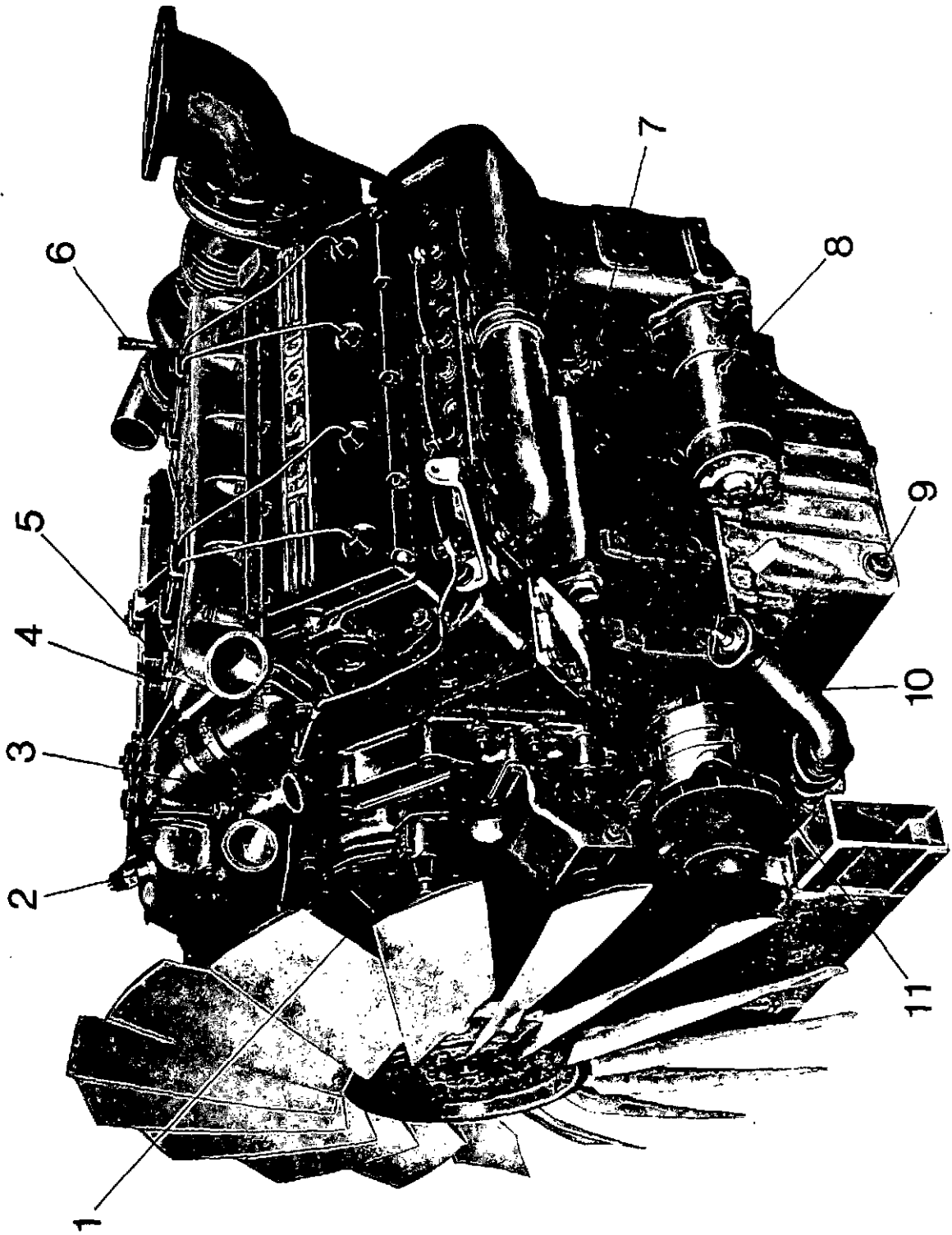


Front view



Rear view

CV8 Short engine

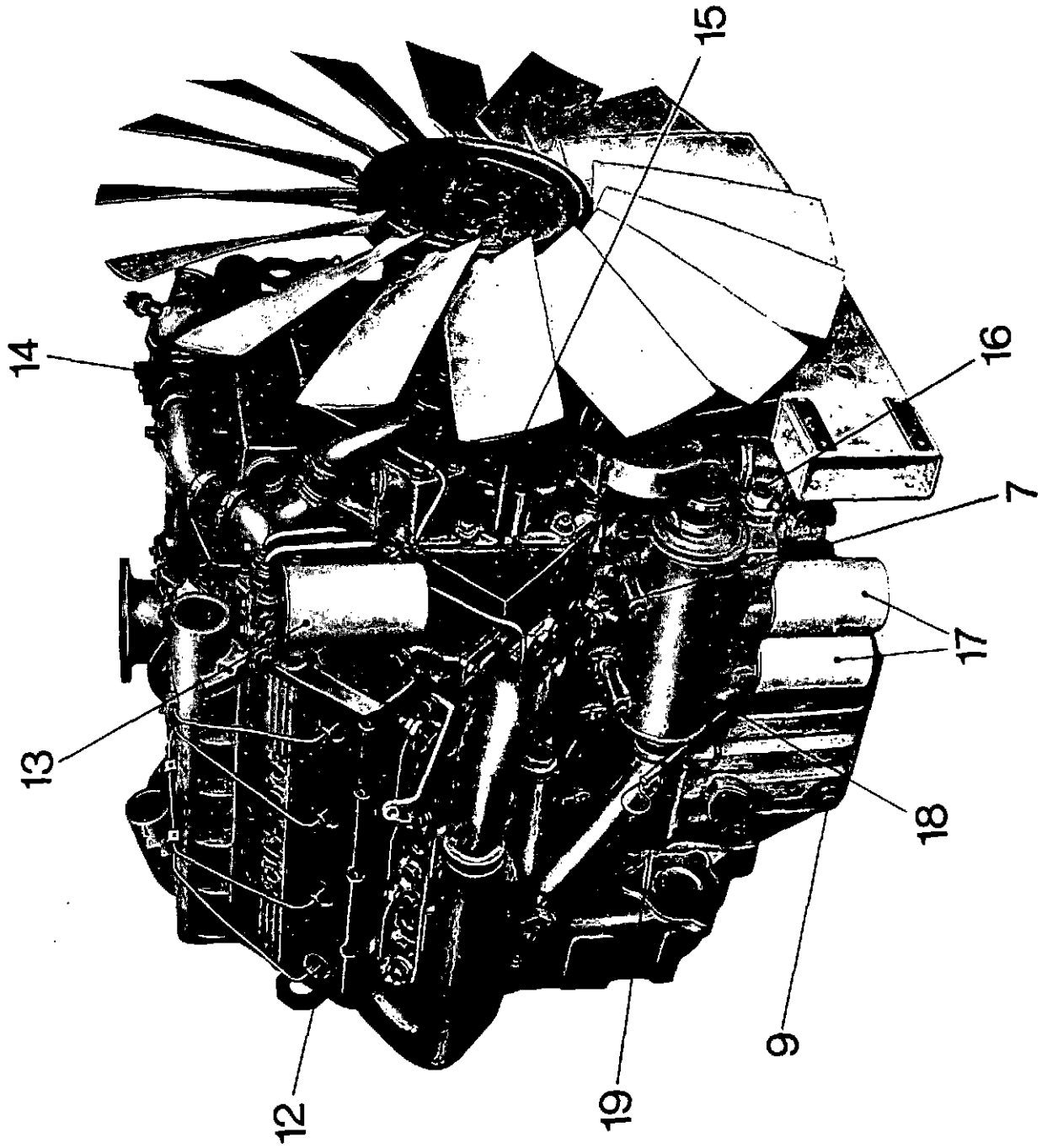


View on 'B' bank of engine

FRONTISPIECE

Fig. 2 View on 'A' bank

- 12. Injector gland nut (8)
- 13. Main fuel filter
- 14. Thermostat housing
- 15. Coolant pump
- 16. Oil pressure shutdown switch
- 17. Lubricating oil filters
- 18. Oil-to-coolant heat exchanger
- 19. Dipstick



View on 'A' bank of engine



CHAPTER 1—DESCRIPTION AND DATA

The Rolls-Royce CV8T is an eight cylinder, pressure-charged, direct injection, liquid cooled, four stroke, compression ignition engine in a 90 degree 'V' configuration.

Engine identification

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

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

Bank and cylinder bore identification

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

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

Crankcase

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

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

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

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

Crankshaft

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

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

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

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

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

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

Main bearings

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

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

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

Thrust washers

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

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

Connecting rods

These are chrome-molybdenum steel forgings machined to accept steel-backed lead-bronze small end bushes and big-end bearing shells similar in

composition to the main bearing shells. The small end is of wedge design to assist pressure loading of the small end bearing and piston.

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

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

Pistons

Cast from high silicon aluminium alloy with the crown machined to form an open toroidal combustion chamber, each piston carries three compression and one oil control ring in machined grooves. The top ring is carried in an austenitic iron insert. Ring sequence is as follows:

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

Each piston is tin-plated on all surfaces after machining, apart from the gudgeon pin bore. The gudgeon pin is fully floating and is retained by the conventional circlip method.

Camshafts

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

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

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

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

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

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

Pushrods and tappets

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

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

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

Cylinder heads

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

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

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

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

The valves are secured in a conventional collet, seat and spring arrangement, the exhaust valves being fitted with valve rotators in place of the upper spring seats. Paired movement of the valves is controlled by a

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

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

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

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

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

Gear train

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

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

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

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

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

Flywheel

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

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

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

Fuel system

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

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

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

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

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

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

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

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

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

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

Cooling system

The gear driven coolant pump consists of a conventional vaned impeller on a shaft, supported by twin ball races in a cast iron housing. The pump is designed to give a coolant flow of 295 litres/minute (65 imp. gallons/minute) at an engine speed of 1500 rpm.

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

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

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

Lubrication system

A conventional wet-sump system is used on CV8 industrial engines. The cast aluminium sump, with an

oil drainage well at one end, is reversible to suit the engine application.

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

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

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

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

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

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

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

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

Oil filler and dipstick

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

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

Induction and exhaust systems

Cast iron manifolds direct the exhaust gases through the rotor section of the turbocharger where the waste energy is used to drive the compressor wheel. This in turn draws air through the air cleaner and delivers it under pressure to the induction manifolds to be distributed to each cylinder as the inlet valves open.

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

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

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

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

Alternator

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

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

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

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

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

Engine protection

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

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

TECHNICAL DATA

TYPE	Direct injection, liquid cooled, pressure charged four stroke, compression ignition, with charge cooling.
CONFIGURATION	Eight cylinders in 90 deg. included angle 'V'.
BORE	135 mm (5.315 inches)
STROKE	152 mm (5.984 inches)
CUBIC CAPACITY	
(Total swept volume)	17.4 litres (1062 cu. inches)
COMPRESSION RATIO	14.5 : 1
DIRECTION OF ROTATION	Anti-clockwise viewed on flywheel
CYLINDER FIRING ORDER	
Paired Throw crankshaft	A1, B1, A2, B2, B3, A4, B4, A3
Cruciform crankshaft	A1, B1, B2, A3, B3, A2, A4, B4
ASPIRATION	Pressure charged by a single, rear mounted turbocharger
VALVE TAPPET CLEARANCES (Hot or cold)	
Inlet	0.2 mm (0.008 inch)
Exhaust	0.5 mm (0.020 inch)
INJECTION TIMING	As stamped on engine data plate
DRY WEIGHT OF BARE ENGINE (approximate)	1202 kg (2,650 lb)

COOLING SYSTEM

APPROVED COOLANT	See leaflet TSD. 3085 in rear cover pocket
CAPACITY (approximate)	91 litres (20 Imp. gallons)
TEMPERATURE (at sea level)	
Normal running	75 deg. C
Maximum intermittent	95 deg. C
SYSTEM PRESSURE	50 to 70 kN/sq. m. (7 to 10 lbf/sq. inch)
(at normal working temperature)	
COOLANT FLOW RATE	295 litres/minute (65 Imp. gallons/minute) at 1500 engine rpm
THERMOSTAT	Western Thomson single element, wax capsule type with radiator by-pass
RADIATOR	Marston 5658000 1.5 sq. m. (16 sq. ft.)

SYSTEM CLEANING COMPOUNDS

I.C.I. Limited	* Lissapol 'N', 1% (10 cc/litre-45cc/Imp. gallon) Lissapol 'NDB', 2% (20 cc/litre-90 cc/Imp. gallon)
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* Lissapol 'N' is available from Rolls-Royce Motors Limited in 5.5 litre (1 Imp. gallon) containers under part number OE 41334.

FUEL SYSTEM

APPROVED FUELS	See leaflet TSD. 3085 in rear cover pocket
TYPE	Pressurised supply to injection pump with through flow return to tank
INJECTION PUMP	Bosch S 3000, 8 element, in line unit
GOVERNOR	Bosch RQ (V) 2 speed, integral with injection pump or Ambac Electronic
FEED PUMP	Bosch FP/KD Camshaft operated
FUEL FEED PRESSURE	140 to 210 kN/sq. m. (20 to 30 lbf/sq. inch)
FUEL INJECTORS	Axial feed, low spring type
INJECTOR NOZZLES	6 hole, 0.33 mm x 0.7 mm long, 150 deg. included angle spray, zero offset
INJECTION PRESSURE	240 atmospheres
INJECTION TIMING	As stamped on engine data plate
MAIN FUEL FILTER	Single engine mounted, spin-on type expendable canister
PRIMARY FILTER	Single, Purolator PU 464, wire wound element or Harwood water separator/filter

LUBRICATION SYSTEM

APPROVED LUBRICANTS	See leaflet TSD. 3085 in rear cover pocket
TYPE	Wet sump
OIL CAPACITY	
Sump	36.3 litres (8 Imp. gallons) maximum 13.6 litres (3 Imp. gallons) minimum
System total	41 litres (9.4 Imp. gallons)
OIL PUMP	Conventional scavenge/pressure, gear type unit driven from main gear train
OIL PRESSURE	415 kN/sq. m. (60 lbf/sq. inch) under normal engine load conditions
	*170 kN/sq. m. (25 lbf/sq. inch). Minimum permissible at rated speed
	70 kN/sq. m. (10 lbf/sq. inch). Minimum permissible at idling speed. (Automotive)
OIL FLOW RATE	114 litres/minute (25 Imp. gallons/minute) at 80 deg. C. and 1500 engine rpm
PRESSURE RELIEF VALVE	
Type	Conventional spring and plunger (non- adjustable)
Opening pressure	415 kN/sq. m. (60 lbf/sq. inch)

OIL FILTERS Two spin-on type expendable canisters
(engine mounted)
MAXIMUM OIL TEMPERATURE 120 deg. C.
OIL-TO-COOLANT HEAT EXCHANGER Serck, shell and tube, baffled and finned

* Important for the protection of turbocharger bearings

INDUCTION SYSTEM

AIR CLEANERS Donaldson Cyclopac FHG 12 (2)
TURBOCHARGER Holset 4LGK

ELECTRICAL EQUIPMENT

ALTERNATOR Butec 24 volt 30 amp, belt driven
STARTER MOTOR Butec type MS1A or Lucas C.A.V. S130L
STOP CONTROL Lucas C.A.V. solenoid operated. Type 368/9B
WARNING AND SHUTDOWN SWITCHES Teddington temperature switch.
TYPE DCA/AB/096. 96 deg. C. setting.
Teddington pressure switch. Type DCA/BC/152.
152 kN/sq. m. (22 lbf/sq. inch) setting.

**LUBRICANTS AND FLUIDS APPROVED FOR USE
DURING SERVICING AND OVERHAUL**

(Equivalents of alternative manufacture are acceptable)

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

STARTER MOTOR

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

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 (Full nut - Nyloc)	95	70
(Thin nut)	50	37
AUXILIARY DRIVE SHAFT		
Hub nut (18 mm diam. thread)	200	148
(22 mm diam. thread)	300	220
CAMSHAFTS		
Drive gear setbolts (with Studlock 270)	40	30
Thrust plate countersunk screws	70	50
CONNECTING RODS		
Big end bearing bolts	60	44
CRANKSHAFT		
Pulley setbolts	95	70
Flywheel setscrews	315	232
CYLINDER HEADS		
Securing setbolts - Long	240	175
Securing setbolts - Short	175	130
	(plus further 60 deg.)	
COOLANT PUMP		
Drive gear nut	88	65
Bearing locknut	100	74
EXHAUST MANIFOLDS		
Securing setbolts	47	35
FAN ADAPTOR		
Bearing locknut	135	100

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

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 fuel injection pump (fig.2) with clean engine lubricating oil. (See Chapter 3, Section 4 for details).
10. Prime the turbocharger (fig. 3) with clean engine lubricating oil. (See Chapter 3, Section 6 for details).
11. Bleed the fuel system of air as described in Chapter 3, Section 4.
12. Lubricate all control linkage and check for freedom of movement throughout its range.
13. With the stop control in STOP position, motor the engine on the starter until oil pressure is registered on the gauge.

ROUTINE STARTING

Automotive engines

Carry out daily servicing checks

Normal start:

- | | | |
|----------------|---|--|
| Fuel cock | — | ON |
| Stop control | — | In RUN position |
| Accelerator | — | Depress fully |
| Starter button | — | Press and release when engine fires |
| Accelerator | — | Release to fast idle (800 rpm approximately) |

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 |
| Accelerator | — | Do NOT depress |
| Starter button | — | Press for 10 seconds |
| | | Wait for 10 seconds |
| | | Press for 20 seconds |
| | | Wait for 20 seconds |

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

Constant speed engines

Carry out daily servicing checks

Normal start:

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

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. 4), mounted over the injection pump drive coupling, 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:

Automotive engines

1. Do not subject the engine to high speeds and loads until working temperature is reached.
2. Avoid long periods of idling.
3. Do not exceed the governor run out speed, which can easily occur when descending a hill.
4. Maintain full fuel tanks to avoid condensation.

Constant speed engines

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

Automotive engines:

1. Put the gear lever into NEUTRAL.
2. Run the engine at fast idle speed (approx. 800 rpm) for 3 minutes to allow the turbocharger to reduce speed and temperature.
3. Move the stop control to the STOP position.

Constant speed engines:

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

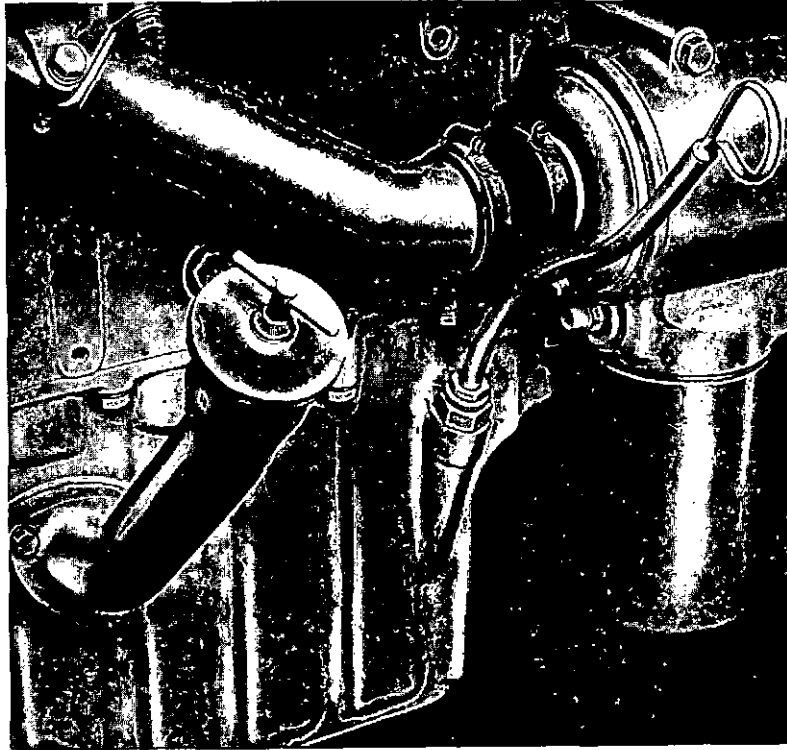


Fig. 1 Oil filler and dipstick

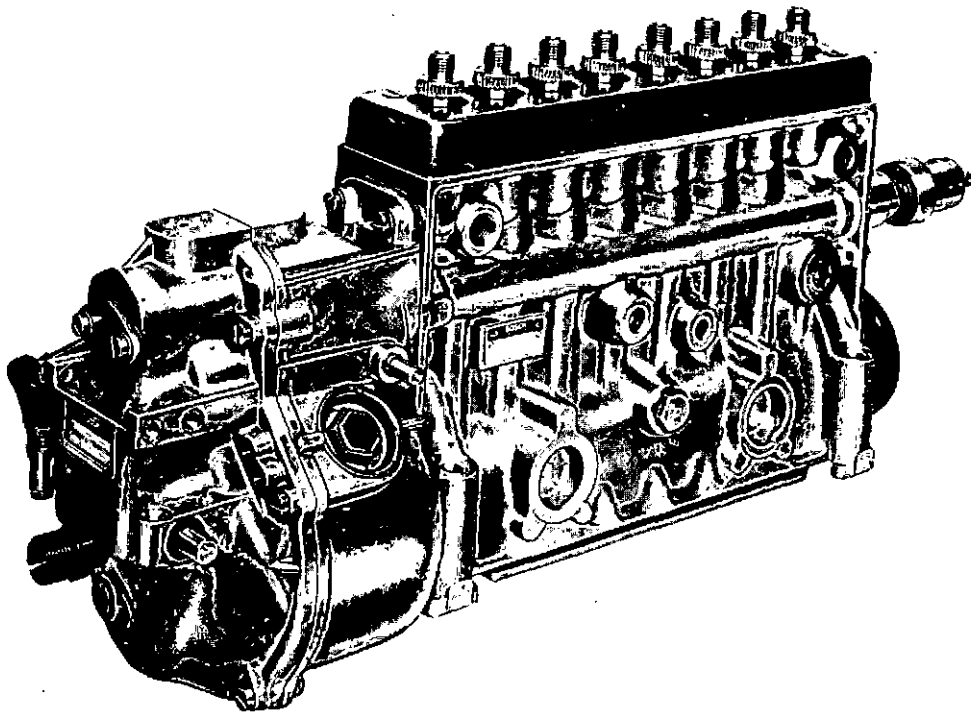


Fig. 2 Bosch fuel injection pump

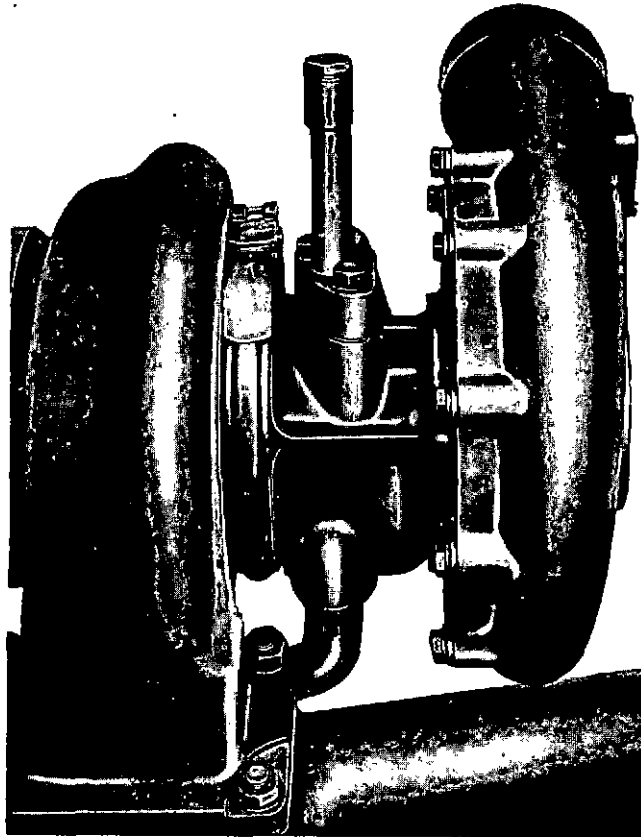


Fig. 3 Holset turbocharger

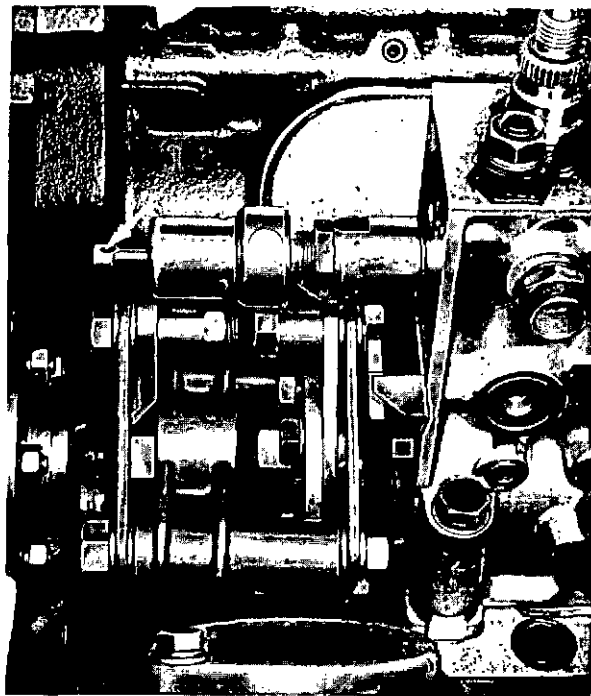


Fig. 4 Excess fuel device

CHAPTER 3—SERVICING

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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, may not only invalidate any current Guarantee but could 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 on the front of the wheel-case (fig. 1), is driven from the 'B' bank camshaft gearing.

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

Cooling System 3
 Check that the coolant level is approximately 76 mm (3 inches) below the top of the radiator

filler. 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.

Fuel System

Drain sediment/water from Harwood filter if fitted.

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 indicator. If the red warning sleeve is visible, service the air cleaner. 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 turbocharger for security.

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	Section	Every 12 months	Section
<i>Fuel System</i> Dismantle and clean the primary filter. Discard and renew the main filter canister. Check tightness of the injection pump drive coupling bolts; torque loading 100 Nm. (75 lbf. ft.).	5	<i>Cooling System</i> Drain system immediately after shutdown. Flush with clean water and refill with fresh coolant mixture.	3
Every 1200 E.S.C. Units		ENGINES IN INTERMITTENT USE	
<i>Fuel System</i> Check the injection pump timing. Service or renew injectors. (See 'Adjustments'—below).	5 W.M.	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:	
<i>Induction System</i> Remove induction trunking from turbocharger and spin rotor to check for rubbing and bearing wear.	6	Weekly <i>Lubrication System</i> Check the lubricating oil level and top up if necessary to the UPPER mark on the dipstick.	4
<i>Adjustments</i> Check and adjust tappet clearances whilst injectors are removed.	2	<i>Cooling System</i> Check the coolant level and replenish as necessary with the correct coolant mixture.	3
Every 2400 E.S.C. Units		Monthly <i>Cooling System</i> Check the specific gravity and the pH value of the coolant mixture.	3
<i>Electrical System</i> Service the alternator.	7	<i>Induction System</i> If the engine has not been running during the month, prime the turbocharger with engine oil.	3
Every 4800 E.S.C. Units		Every 6 months <i>Lubrication System</i> Drain the engine lubricating oil and refill the system with the approved grade of oil. Discard and renew the oil filter canisters.	4
<i>Top overhaul</i> Carry out a top overhaul. See the Workshop Manual, publication TSD. 3130 for full details.	W.M.	Every 12 months <i>Fuel System</i> 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.	W.M.
<i>Fuel System</i> Calibrate and service the injection pump or fit a replacement unit.	W.M.		
Every 6 months			
<i>Electrical System</i> Check operation of warning and shutdown switches.	7		

Section

3

Cooling System

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

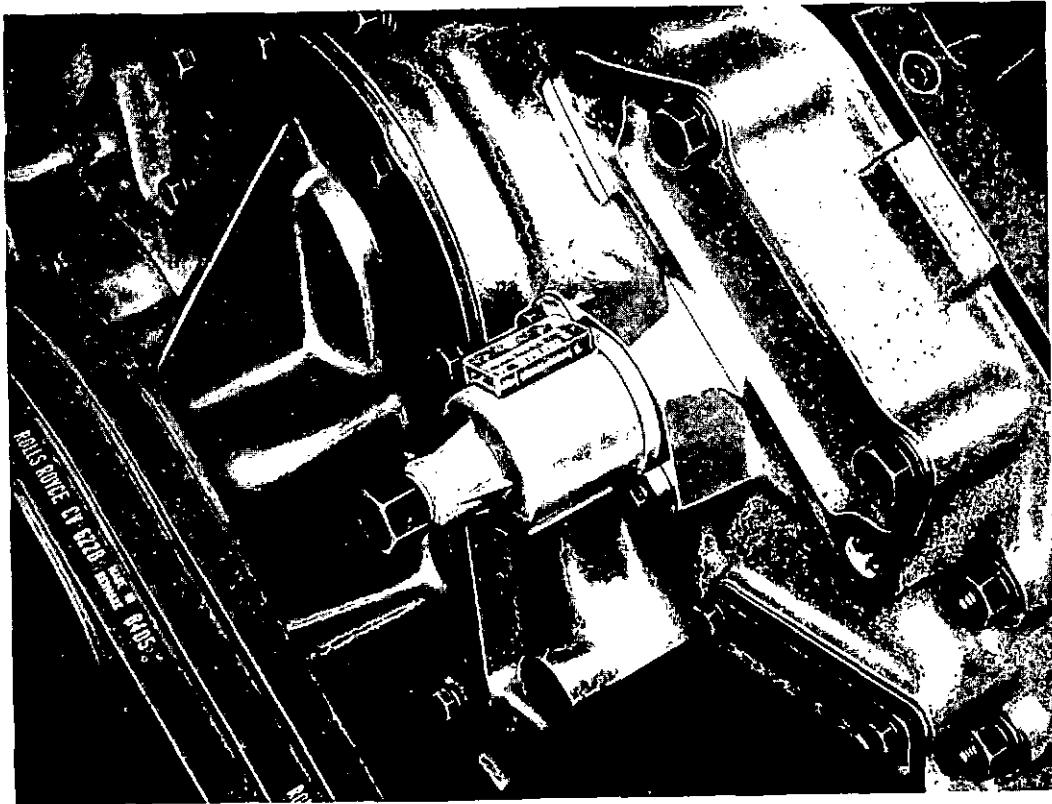


Fig. 1 Engine service counter



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 quadrant bolt and the pivot bolt, move the alternator to the required position and re-tighten the two bolts. The correct tension for the alternator belts is such, that deflection at mid-point of the belt run is 12 mm (0.5 inch) for each belt under a pressure of 3 to 4 kg. (7 to 8 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 (fig. 3) is 20 mm (0.75 inch) for each belt under a pressure of 3 to 4 kg. (7 to 8 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

Operators must ascertain the type of crankshaft fitted to their engine, prior to adjusting valve tappets, by checking under the 240 group number in the Parts Catalogue. 'Paired Throw' crankshafts may be either CV 2457 or CV 5299. 'Cruciform' crankshafts may be either CV 7693 or CV 9182. A table, given at the end of this Section, indicates the correct valve operating and adjusting sequences for both types of shaft.

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 the barring tool, Part Number CV 6497, in the holes in the periphery of the crankshaft pulley, between the fan and alternator belts, and turn the engine in the normal direction of rotation until the valves on 'A1' cylinder are 'rocking', i.e. exhaust valves just closing, inlet valves just opening. The valves on 'B3' 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 0.2 mm (0.008 inch) as shown in figure 4 and torque tighten the adjusting screw locknut to 40 Nm (30 lbf. ft.). Adjust the exhaust valve tappet clearance to 0.5 mm (0.020 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.

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 5. 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 driven from the crankshaft, it is not possible for the timing to slip; however, during rebuild, if doubts exist it will be re-assuring to check the timing using the following method:

With the rocker covers removed, turn the engine by hand until the valves on 'A4' cylinder are in the 'rocking' position with the inlet valves closed.

Set a Dial Test Indicator (D.T.I.) over the 'A4' inlet valves as shown in figure 6, for engines fitted with the Paired Throw crankshaft, or over the 'A2' inlet valves for engines fitted with the 'Cruciform' crankshaft. Turn the engine in its normal direction of rotation until the D.T.I. indicates that the valves have opened 0.7 mm (0.0275 inch).

The 'B1' piston will be on compression stroke with both pair of valves fully closed, and the timing pointer (fig. 7) should indicate 'B1' TDC on the flywheel periphery.

To check valve timing on the 'A' bank of the engine, remove the D.T.I. turn the engine in the normal direction of rotation until the valves on the 'B1' cylinder are in the 'rocking' position and set the D.T.I. on the 'B1' inlet valves.

Turn the engine by hand until the D.T.I. indicates that the valves have opened 0.7 mm (0.0275 inch).

The 'A4' piston, (Paired Throw crankshaft), or the 'A2' piston (Cruciform crankshaft), will then be on compression stroke with both pair of valves fully closed.

The timing pointer should once again indicate 'B1' TDC but this time the 'B1' piston will be on its exhaust stroke.

It is emphasised however that:

1. It is not possible for timing gears to slip, therefore it is not normally necessary to check valve timing when investigating an engine defect in the field or during normal servicing.
2. The valve timing check is usually undertaken only at complete engine overhaul in the workshops. The timing gears in the gear train are clearly marked to ensure correct meshing. If the gear train is assembled accurately during rebuild and as a further precaution, the timing physically checked, there is no need to carry out further timing checks once the engine has satisfactorily completed its test bed running in.

Fuel injection timing

Should 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 'B' bank cylinder head and remove the timing pointer cover from the flywheel housing (fig. 7). Turn the engine by hand in the normal direction of rotation until the injection timing figure is opposite the pointer (see the engine data plate), with the valves on 'B1' cylinder closed, (i.e. 'B1' piston at TDC on compression stroke).

Check that the timing mark on the fuel injection pump hub is opposite the pointer, (fig. 8).

2. If the timing mark on the hub fails to coincide with the pointer, check that the fuel injection pump drive shaft and couplings are secure and undamaged, then proceed as follows:

- (a) With the flywheel timing set as stamped on the engine data plate, slacken the setbolts (see figure 8) which secure the drive coupling to the injection pump hub. Turn the hub in the normal direction of rotation by hand to overshoot the timing marks, then carefully turn the hub back until the timing mark and pointer line up; retighten the setbolts.
- (b) Turn the engine back a quarter of a revolution and then forward in the normal

direction of rotation until the flywheel timing pointer is re-aligned with the timing figure, as stamped on the data plate. Check that the fuel injection pump timing marks are correctly aligned.

Cylinder head bolt torque tightening

All engines leaving the Factory have their cylinder head setbolts torque tightened and will not require any torque tightening until the top overhaul is carried out. See Workshop Manual T.S.D. 3130.

Tappet Setting Sequence

Paired Throw Crankshaft		Cruciform Crankshaft	
Valves rocking on	Set clearance on	Valves rocking on	Set clearance on
A1	B3	A1	B3
B1	A4	B1	A2
A2	B4	B2	A4
B2	A3	A3	B4
B3	A1	B3	A1
A4	B1	A2	B1
B4	A2	A4	B2
A3	B2	B4	A3

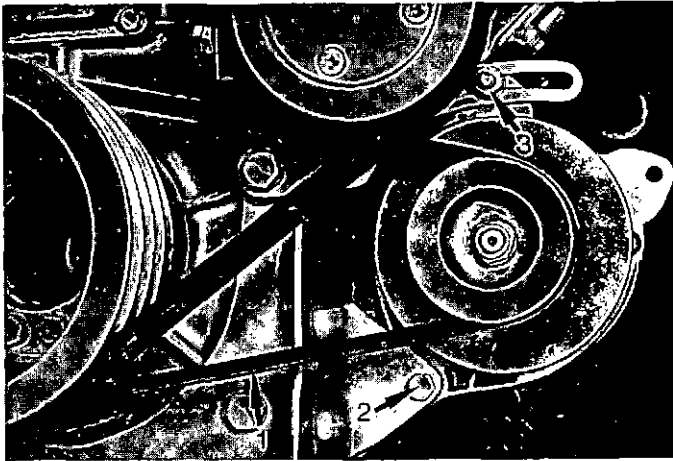


Fig. 1 Alternator belt adjustment

1. Deflection test point
2. Pivot bolt
3. Quadrant bolt

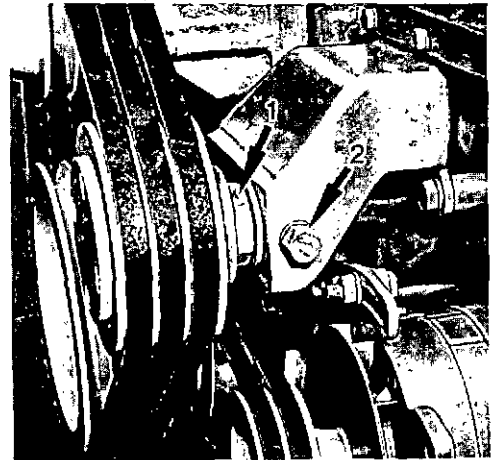


Fig. 2 Fan belt adjustment

1. Pulley locknut
2. Adjusting screw

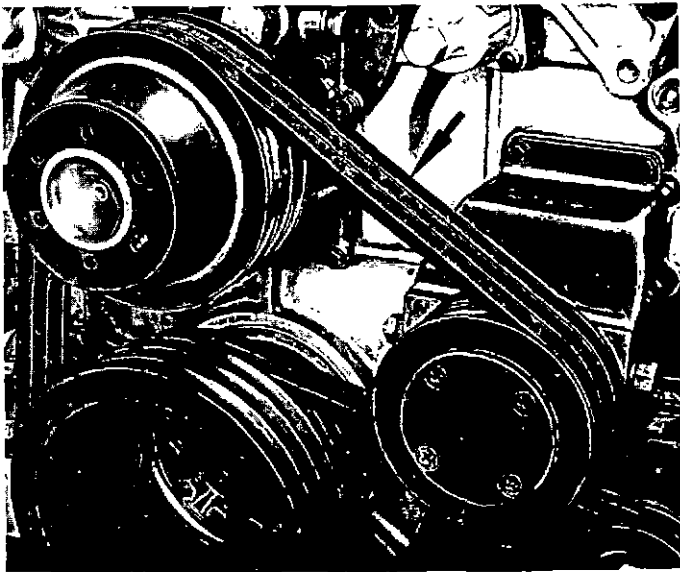


Fig. 3 Fan belt deflection test point

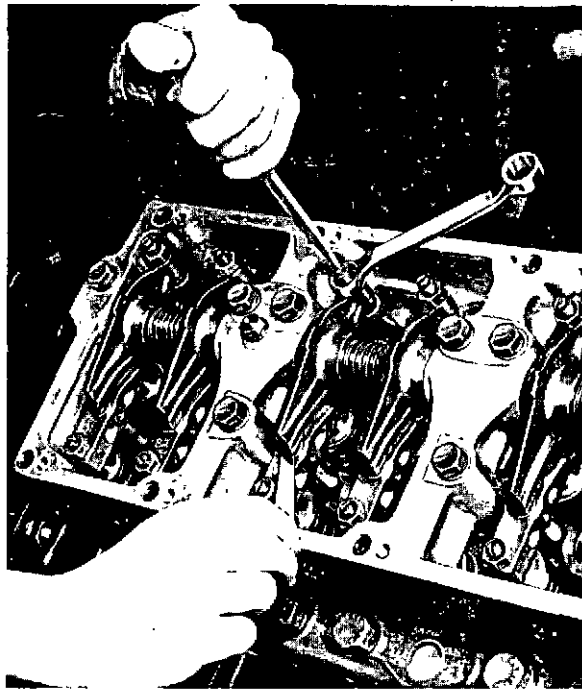


Fig. 4 Setting tappet clearances



Fig. 5 Setting valve bridges

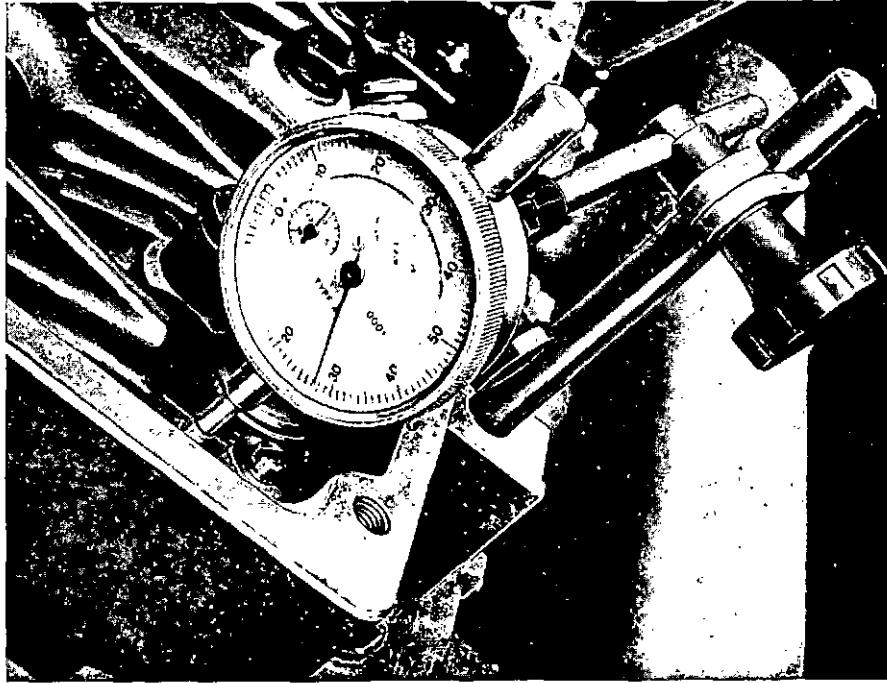


Fig. 6 Checking valve timing

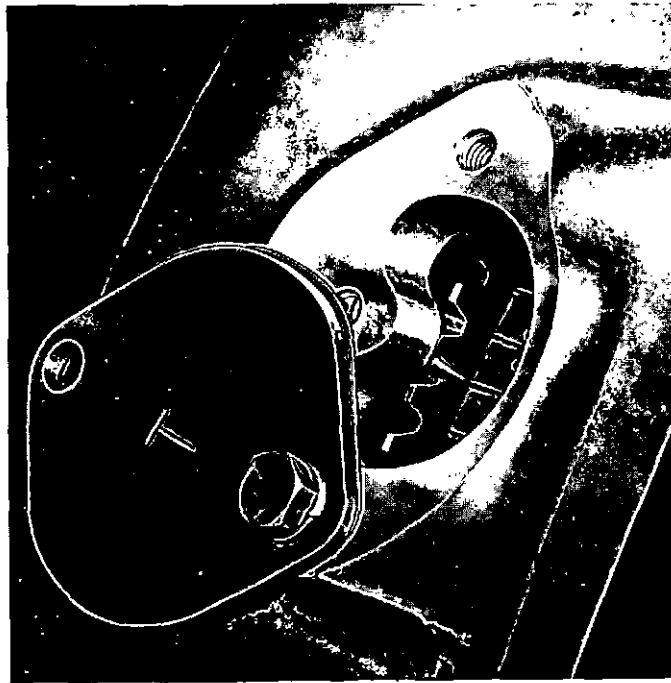


Fig. 7 Flywheel timing pointer

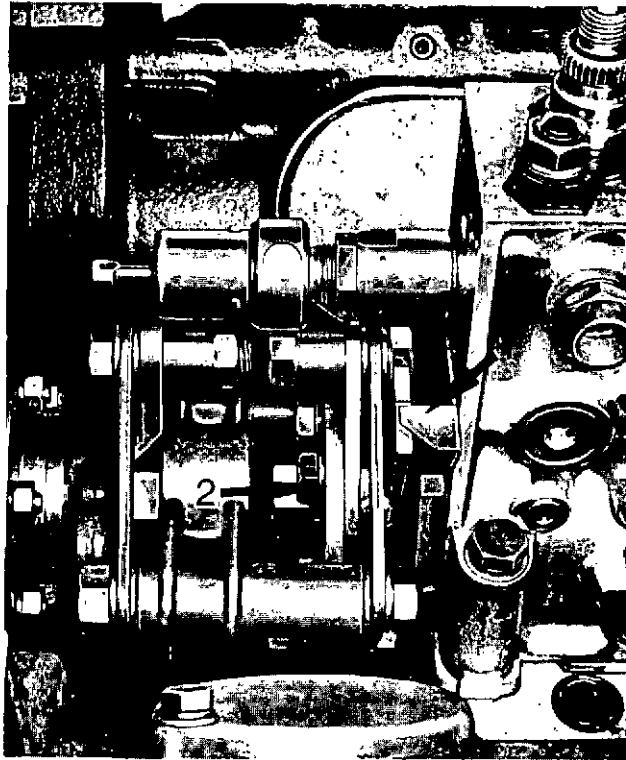


Fig. 8 Injection pump timing marks

1. Timing marks
2. Adjustable coupling setbolts

SECTION 3—COOLING SYSTEM

Description

Coolant is drawn from the radiator by a gear driven centrifugal pump and delivered, via the oil-to-coolant heat exchanger, to the coolant galleries in the 'A' and 'B' bank cylinder blocks. From the cylinder blocks the coolant is directed through the cylinder heads then into galleries incorporated in each induction manifold. The coolant then leaves the manifolds and merges at the thermostat housing where, depending on its temperature, it is directed either through the radiator before recirculation of the engine or directly to the coolant pump suction.

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 drinking 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 drinking water in the ratio of 1 : 100. Clean drinking 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 than 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 running 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 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 thermostat 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 thermostat is open is to check the temperature of the pipe connection between the thermostat housing and the radiator. If the pipework is cool, the thermostat valve is closed.

THERMOSTAT

Description

Early engines are fitted with a single element, wax capsule type, Western Thomson thermostat, Part Number CV 301. Later models are fitted with a triple element wax capsule type Western Thomson thermostat, Part Number OE 43404. These units are not interchangeable and in the event of thermostat failure, it is important that the correct Part Number is noted when ordering replacement units.

CV 301 thermostat

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

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

by compression of the by-pass valve spring.

Inspection

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

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

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

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

Check the condition of the discharge hose using a new gasket lightly coated with jointing compound and top up the system with the approved coolant mixture.

Emergency action

If a replacement thermostat is not available it will be necessary, as a temporary measure only, to jack the valves fully open and run the engine with the radiator partly blanked off. In no circumstances should the engine be run without a thermostat, since the by-pass ports would then be permanently open, causing over-heating.

OE 43404 thermostat

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

The opening temperatures differ slightly between the

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

Inspection

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

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

Note: Silicone grease should be applied, as above, to the valve spindles of a replacement thermostat, or a thermostat fitted to an engine which is to stand with the cooling system drained. MS4 Silicone grease manufactured by Ambersil Limited of Basingstoke, Hants is recommended for this purpose.

Checking operating temperature

1. Mark the strap of the leading valve and place the thermostat, right way up, in a container filled with water to the level of the valve platform. Position an accurate thermometer as close as possible to the valves.
2. Heat the water, and note the temperature at which the leading valve opens sufficiently to admit a 0.05 mm (0.002 inch) feeler gauge.
3. Continue heating and, in similar fashion, note the opening temperature of the two trailing valves.
4. Continue heating and note the temperature at which each valve is fully open, i.e. when it ceases to move after opening approximately 9.5 mm (0.375 inch).
5. Compare the readings with the following limits:
 Leading valve opens : 77 to 81 deg. C.
 Trailing valves open : 81 to 85 deg. C.
 All valves fully open : 93 to 97 deg. C.

Checking operating speed

1. With all valves fully closed, immerse the thermostat, right way up, in boiling water to the level of the valve platform and note the time after immersion at which each valve opens sufficiently

to admit a 0.5 mm (0.002 inch) feeler gauge.

2. Maintain the water at boiling point and note the time from immersion at which all valves are fully open.
3. Remove the thermostat and plunge it into cold water. Note the time taken for all valves to close fully.
4. Compare the readings with the following limits:
Leading valve commences opening : within 15 secs
Trailing valves commence opening : within 20 secs

All valves fully open : within 60 secs

All valves closed in cold water : 4 to 8 secs

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

Emergency action

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

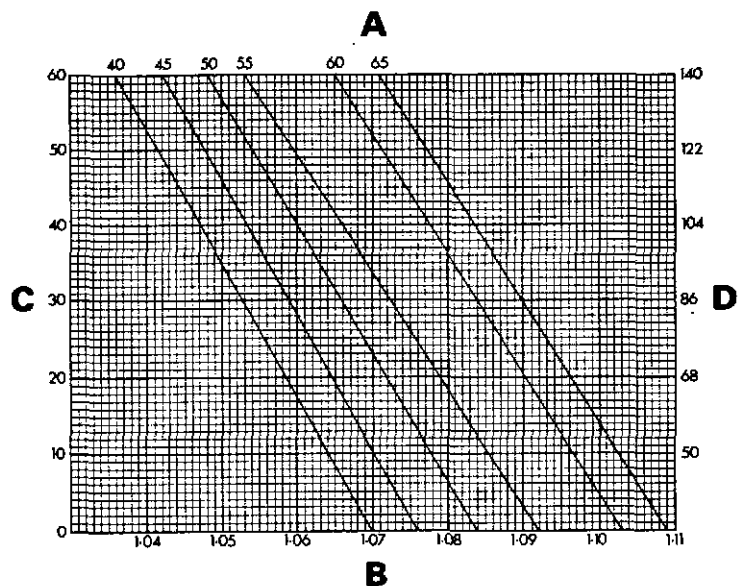


Fig. 1 Specific gravity chart
A = Percentage anti-freeze by volume
B = Specific gravity
C = Mixture temperature (Deg. C.)
D = Mixture temperature (Deg. F.)



Fig. 2 Crankcase drain cock (2)

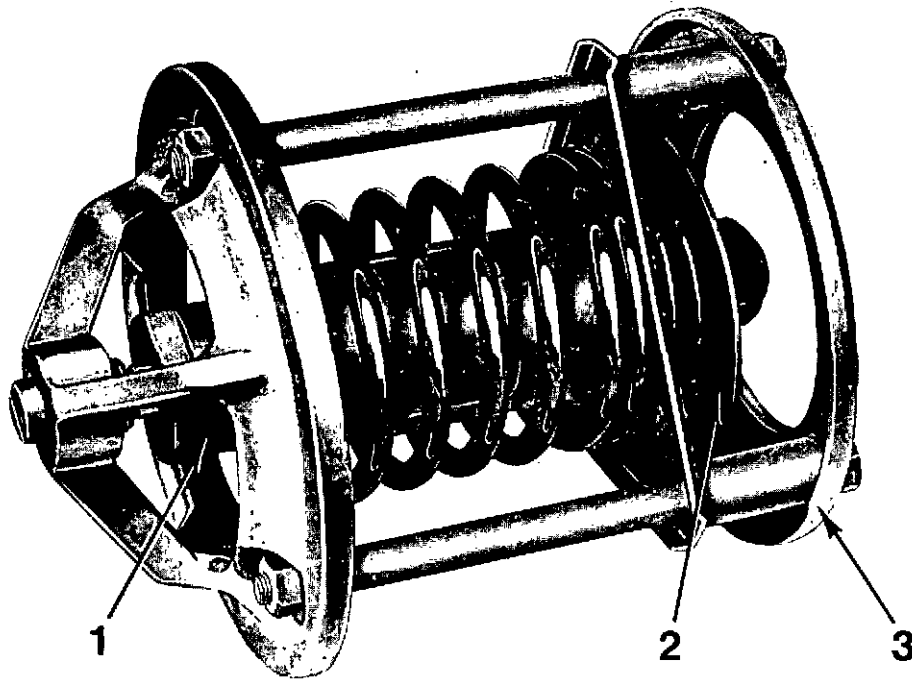


Fig. 3 Thermostat CV 301

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

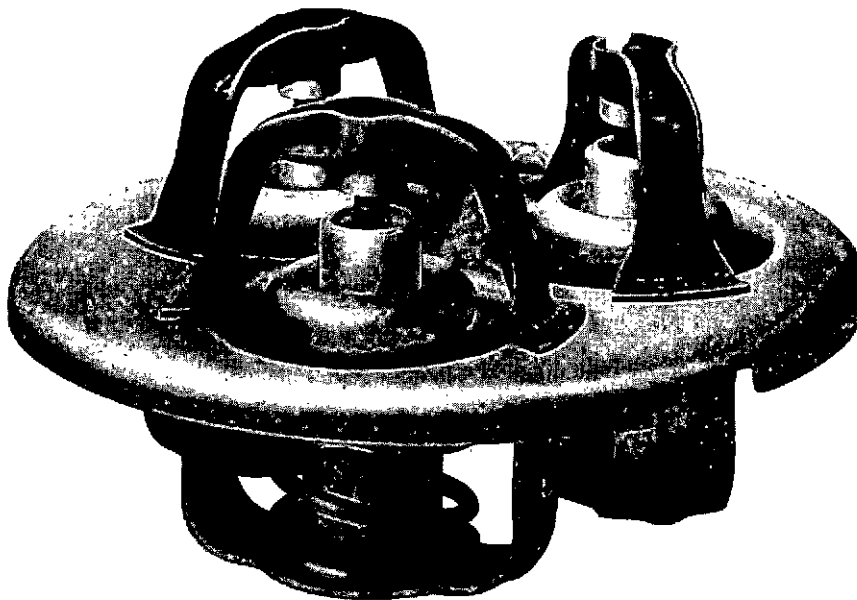


Fig. 4 Thermostat OE 43404

SECTION 4—FUEL SYSTEM

Description

A fuel feed pump, mounted in the engine 'V' and driven by the 'A' bank camshaft, draws fuel through a primary filter and delivers it via the main fuel filter to the injection pump gallery. The fuel supply to the gallery is maintained at a constant pressure of 140 to 210 kN/sq. m. (20 to 30 lbf/sq. inch), by a low pressure relief valve mounted on the 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 a pressure of 220 or 240 bar. Pipework from the injection pump relief valve connects with the fuel injector spill pipework to form a common return to the supply tank. A fuel interface bracket, mounted on the 'B' bank induction manifold, carries the appropriate unions for connecting the fuel supply and spill return pipework.

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 band 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 low pressure relief valve banjo bolt one or two turns and operate the hand priming pump. When bubble-free fuel emerges at the relief valve, tighten the banjo bolt; 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 FILTER

The main fuel filter (fig. 3), mounted in front of the 'A1' cylinder head, is of the expendable canister type and must be discarded at the servicing intervals specified in the Servicing Schedule.

Remove the inner sealing ring from the header bracket, check that the contact faces are clean and fit the replacement canister, with new sealing rings, to the header bracket as described:

Screw the canister on to its support until the sealing rings JUST touch the contact faces, then screw the canister a further three-quarters of a turn by hand. DO NOT OVERTIGHTEN.

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. 46045.

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 mounted in the engine 'V' and operated by a cam on the 'A' bank camshaft.

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 adaptor bolt. Each valve may be removed for inspection, cleaning or renewal as necessary.

The angled hand pump is of the simple plunger type. After use, the hand pump cap must be screwed down finger tight to prevent fuel leakage.

LOW PRESSURE RELIEF VALVE

This is a non-adjustable spring-loaded valve designed to operate at 140 to 210 kN/sq. m. (20 to 30 lbf/sq. inch) and is carried in the banjo bolt securing the spill connection to the injection pump gallery. See figure 4.

The valve requires no servicing but the unit may be dismantled for inspection and cleaning. Renew the nylon valve and its spring if worn or damaged. When re-assembling, ensure that the valve spigot is located in the spring and that the thick copper washer is between the banjo and the pump casing.

INJECTOR PUMP AND GOVERNOR

The Bosch 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 Bosch governor, integral with the pump, gives engine governing at idling and rated speeds with the stop control lever being operated by a solenoid control used in the 'energised-to-run' mode.

Lubrication for the pump and governor is provided through pipework from the 'B' bank auxiliary oil gallery direct to the 'B' bank side of the injection pump cambox. Oil return is via a large bore pipe from the rear end cover of the governor.

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 coupling bolts and nuts (fig.5) to 120 Nm (88 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 assembly nuts to 40 Nm (30 lbf. ft.), and the delivery valve connectors to 80 Nm (60 lbf. ft.).

After fitting a replacement injection pump and before engine start up, the cambox must be primed with clean engine oil in the following manner:

Remove the governor access cap (fig. 6) and using a clean container and funnel, pour in at least 0.5 litre (1 pint) of lubricating oil to Rolls-Royce specifications. See leaflet T.S.D. 3085 in the rear cover pocket. Refit the governor access cap securely.

If the shutdown stop screw (fig. 7) has been disturbed it must be reset as follows:

Slacken the locknut and turn the screw sufficiently to allow the stop control lever to move to the limit of its travel in the shutdown position. Run the screw up to touch the lever, then give it a further 1 to 2 turns against the lever and tighten the locknut.

For details of pump calibration and governor checks, refer to the Workshop Manual, T.S.D. 3130.

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. 8) 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 and adaptor VT. 17973. Care must be taken to avoid slackening the copper injector sleeve in its housing when using the extractor (fig. 9).

4. Recondition the injector sleeve using the reamer Part No. VT. 12769 (fig. 10), and seat cutting tool, Part No. VT. 12767 (fig. 11). 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. 12).

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 seating face. Screw in the spill connection using a new copper sealing washer and new outer rubber seal. Torque tighten the spill connection to 27 Nm (20 lbf. ft.).

Fit the injector clamp and torque tighten the socket capscrew to 60 Nm (44 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 21 Nm (15 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'.

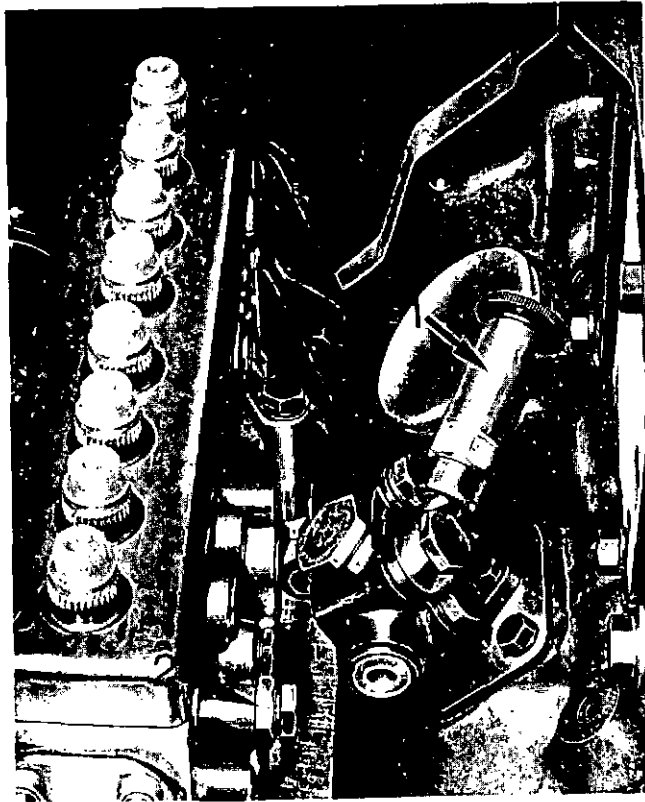


Fig. 1 Fuel feed pump

1. Hand priming pump
2. Relief valve banjo bolt

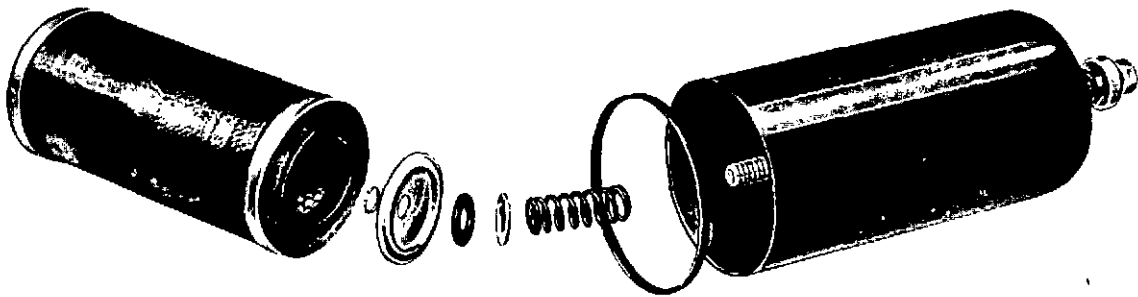


Fig. 2 Primary fuel filter



Fig. 3 Main fuel filter

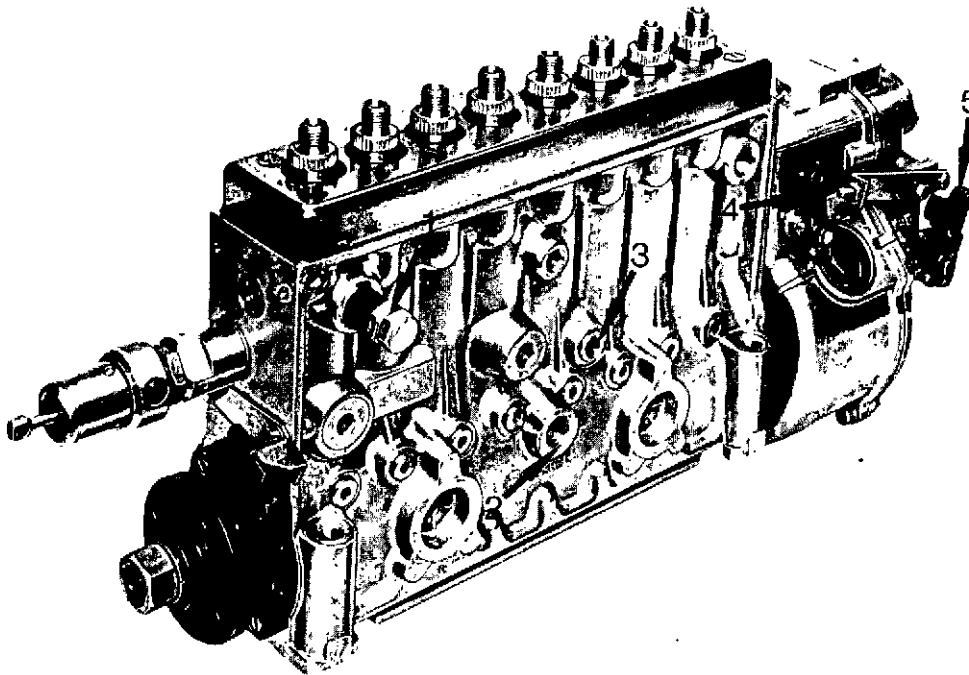


Fig. 4 Bosch fuel injection pump

1. Relief valve banjo bolt
2. Cambox plug (2)
3. Lubricating oil feed connection
4. Stop control lever
5. Speed control lever

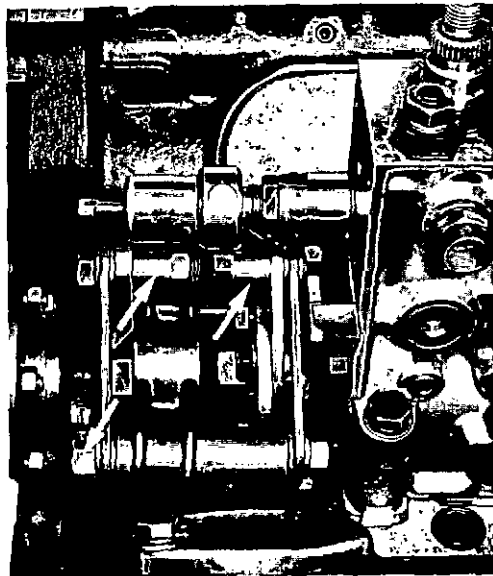


Fig. 5 Drive coupling bolts

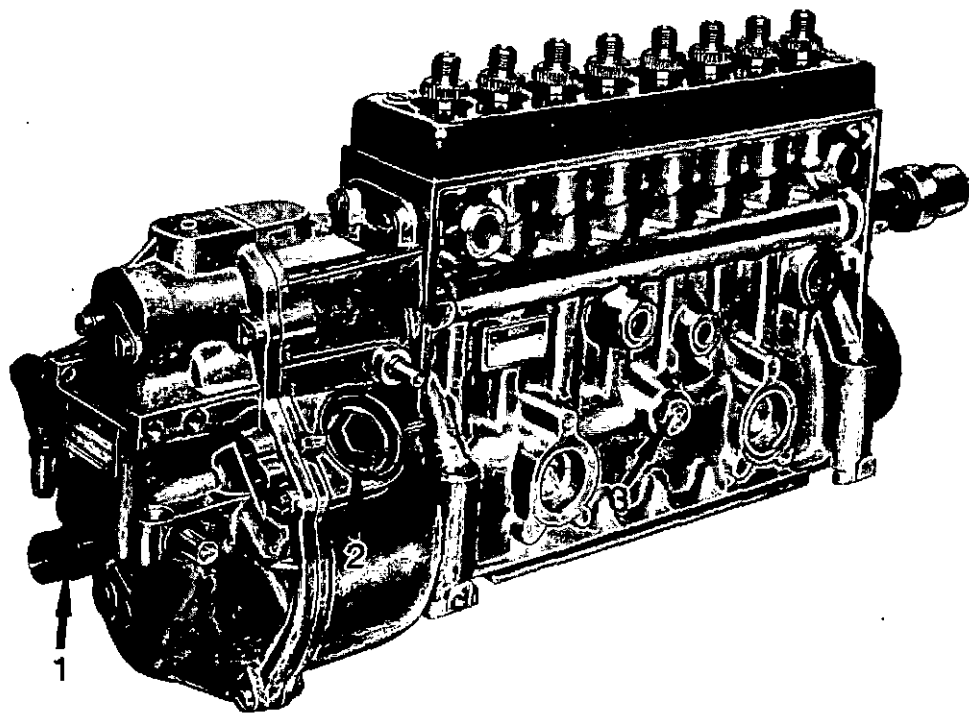


Fig. 6 Bosch fuel injection pump

1. Lubricating oil return connection
2. Governor access cap
3. Cambox plug

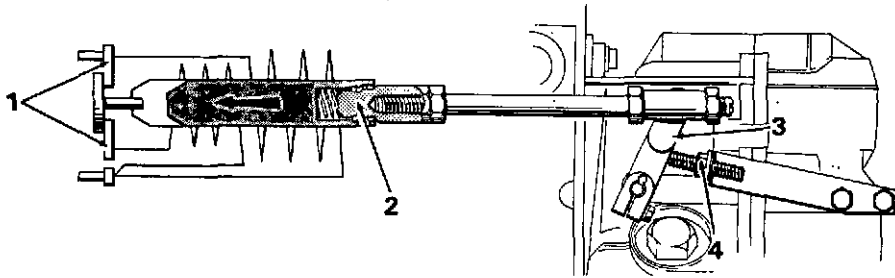


Fig. 7 Solenoid stop control linkage

- 1. Switch
- 2. Spherical joint
- 3. Injection pump stop lever
- 4. Shutdown stop screw

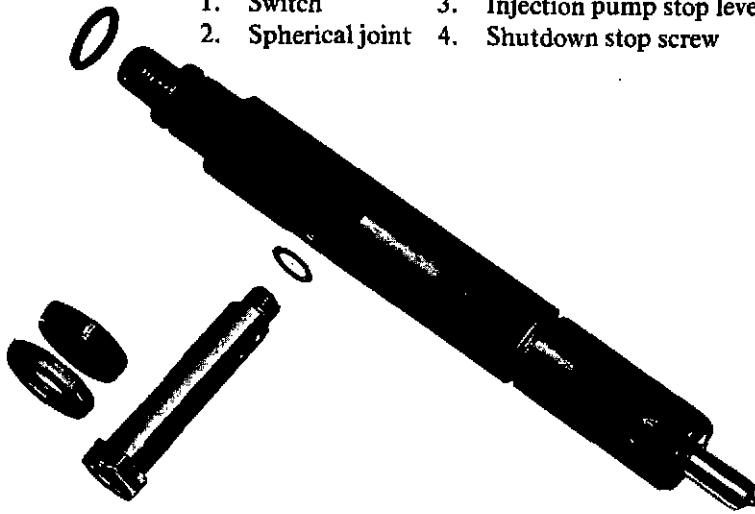


Fig. 8 Bosch fuel injector with spill connection

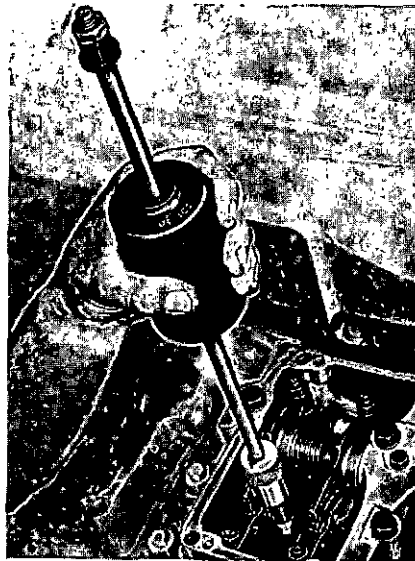


Fig. 9 Using inertia extractor

ROLLS-ROYCE DIESELS

SECTION 5—LUBRICATION SYSTEM

Description

A spur gear type pump, driven from the crankshaft gear, draws oil from the sump well and delivers it under pressure to the moving parts of the engine.

From the pump the oil is delivered to two parallel flow filters before passing through the oil-to-coolant heat exchanger. The oil is then directed to a main gallery running the length of the crankcase and on into auxiliary galleries in each bank of cylinders.

Drillings from the main oil gallery direct oil to the main bearings, through the crankshaft to the big end bearings and via a drilling through each connecting rod to the small end bearings. Other drillings from the main gallery, with curved pipe outlets, direct a jet of cooling oil to the underside of each piston crown.

Drillings from the auxiliary galleries supply oil to the cylinder liner outer walls, camshaft bearings and cam lobes, which in turn splash lubricate the tappets.

Restrictor bobbins, located centrally between each cylinder block and cylinder head, allow oil at reduced pressure to pass through drillings in the cylinder heads and rocker box cross members into the bored rocker shafts. For oilway alignment, the rocker shafts are located by special setbolts in each rocker box. Drillings in the periphery of each shaft deliver oil to the rocker arm bearings. Small holes drilled longitudinally through each rocker arm provide splash lubrication of the bridge and push rod bearing surfaces.

Oil drainage from the rocker boxes is by holes, drilled through each cylinder head and cylinder block, direct to the crankcase.

A small bore pipe, connected to a central point in the 'B' bank auxiliary gallery, provides oil at reduced pressure to the fuel injection pump and governor. A large bore pipe carries the return oil, from a connection on the governor end face, to the crankcase.

A connection and pipework over the rear end of the main oil gallery delivers oil to the turbocharger bearings, with a large bore drain pipe taking the return oil back to the crankcase.

Drillings from the front main bearing housing provide

oil for the idler gear axles. All other gears are splash lubricated, with drainage to the sump.

A pressure relief valve, integral with the oil pump, releases oil to the sump when the system pressure exceeds 455 kN/sq. m. (66 lbf./sq. inch).

A probe type pressure switch actuates the shutdown solenoid if the system pressure falls below 152 kN/sq. m. (22 lbf./sq. inch) at rated rpm. The pressure switch is by-passed at engine start-up.

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 type cap. To remove the cap the 'T' piece handle must be turned anti-clockwise. When replacing the cap, DO NOT overtighten.

Note: The dipstick and filler may be fitted to either side of the sump to suit engine application.

DRAIN PLUGS

To enable oil draining to be carried out from either side of the engine, two drain plugs (fig. 2) are fitted to the sump well. The plugs are torque tightened to 110 to 115 Nm. (80 to 85 lbf./ft.).

OIL FILTERS

Two expendable canister type filters (fig. 3) are mounted beneath the oil-to-coolant heat exchanger. Each canister 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 two 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 two 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 further three-quarters of a turn by hand. **DO NOT OVERTIGHTEN.**

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. 4) is a single tube pack unit in an alloy housing, crankcase mounted on the 'A' 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 two filter canisters and contains the pressure switch tapping.

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. Disconnect and remove the coolant inlet pipe at the front of the heat exchanger.
4. Disconnect and remove the coolant discharge to cylinder block pipe.
5. Remove the dipstick, unscrew the tube gland nut and lift off the tube.
6. Remove the tube pack locating screws and washers from each end of the heat exchanger housing.

Push the tube pack forward sufficiently to uncover the front end 'O' ring. Remove the 'O' ring and push the tube pack backwards and out of its housing, taking care not to damage the fins and baffles. Remove the rear 'O' ring.

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

Refit the coolant pipes using new gaskets and hose connections then refit the tube and dipstick.

Fill two 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.

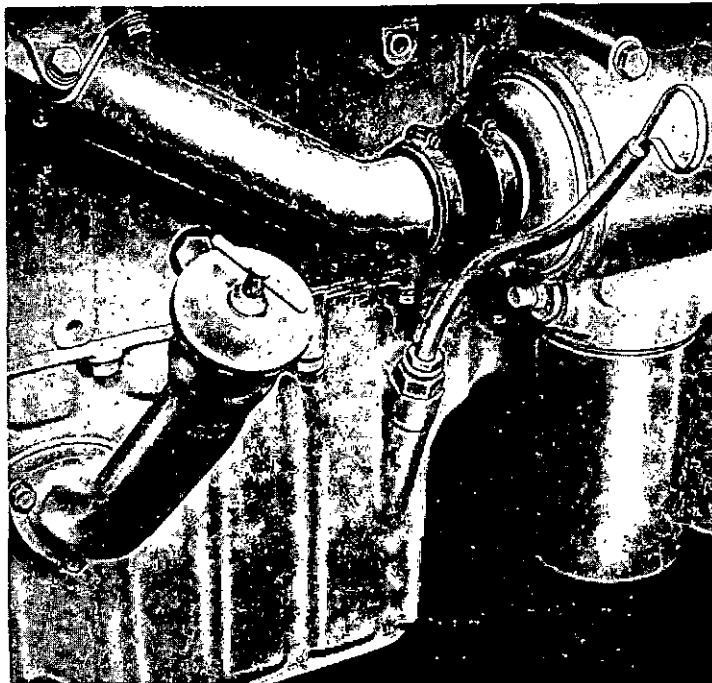


Fig. 1 Oil filler and dipstick (positions may vary)

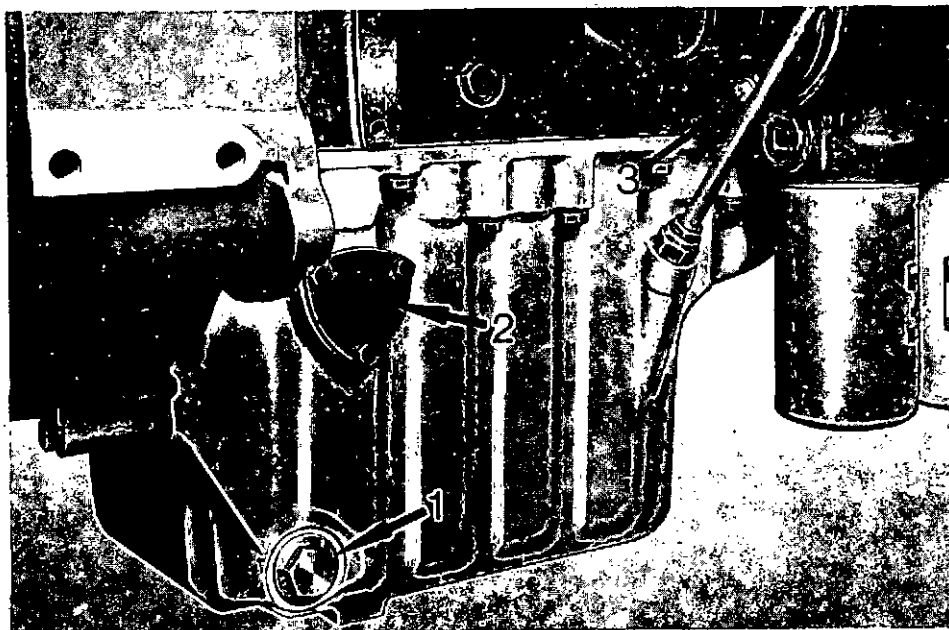


Fig. 2 Sump well
1. Sump drain plug
2. Oil filler location
3. Heat exchanger coolant drain plug



**Fig. 3 Lubricating oil filter canisters
(Sealing ring arrowed)**

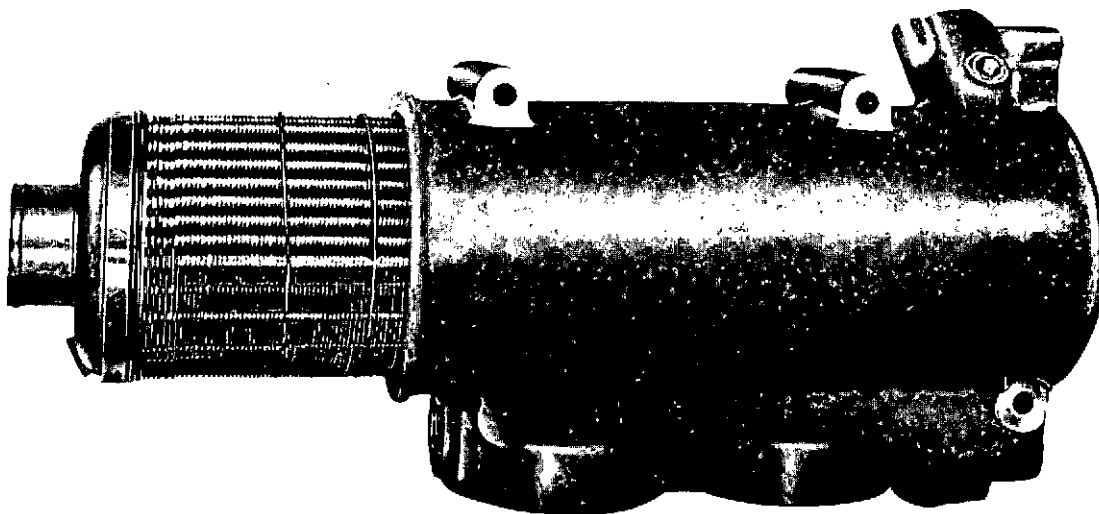


Fig. 4 Oil-to-coolant heat exchanger

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 single engine-mounted turbocharger 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 INDICATOR

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

Dependent on engine application, one or two Donaldson Cyclopac dry element type air cleaners (fig. 2) will be 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.

TURBOCHARGER

A Holset 4 LGK turbocharger (fig. 3) is incorporated in the system. Though simple in principle, it is manufactured to fine tolerances and requires careful handling during any 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 the main oil gallery, with a large bore pipe return 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 expandable 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 170 kN/sq. m. (25 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 the 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, cleaned 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 on the compressor inlet and charge cooler ducting, slacken the 'V' band clamp or remove the securing setbolts on the exhaust bellows connection, whichever is applicable. Disconnect the oil feed and drain pipework from the bearing housing.

Remove the four nuts and washers from the exhaust flange studs and lift off the turbocharger. Cover all openings on the engine to prevent ingress of dirt.

Unscrew the ten setbolts securing the compressor housing and slacken the 'V' band clamp securing the turbine housing to the bearing housing. Remove the two outer housings taking care not to damage the rotor blades.

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

Check the radial movement of the assembly by clamping the turbocharger vertically with the compressor wheel uppermost and setting up a dial test indicator as shown in figure 4, with the indicator button resting against the side of the wheel nut. Holding the compressor wheel and turbine, rock the assembly towards the indicator button then back in the opposite direction. The maximum indicator reading should not be in excess of 0.61 mm (0.024 inch).

Check the end float of the assembly by mounting the indicator as shown in figure 5, with the button resting on the end of the rotor shaft. Move the assembly axially to its full extent in both directions and note the indicator readings. The total movement should be between 0.08 and 0.15 mm (0.003 and 0.006 inch).

Readings beyond these limits indicate that a complete overhaul of the turbocharger is necessary. For relevant information, consult the Engineering Department of Rolls-Royce Motors Limited.

Re-assemble the turbocharger housings, using new spring washers where applicable, and lightly nip the setbolts and 'V' band clamp nut. Spin the rotor assembly and listen for sounds of rubbing.

Clean off the oil feed, oil drain and exhaust flange contact faces, and check the ducting hose connections for serviceability.

Refit the turbocharger using new locking washers, smear each stud with anti-seize compound and tighten the four nuts securely; tab up the locking washers. Slacken the 'V' band clamp to align the bearing housing if necessary, then re-tighten the clamp.

Slacken the compressor housing securing setbolts and turn the housing to align with the charge cooler ducting; slide the hose connection into position. Torque tighten the compressor housing setbolts to 5.5 to 8 Nm (4 to 6 lbf. ft.). Tighten the hose connection clips securely.

Using a new gasket, refit the oil feed pipe and prime the turbocharger bearings, (See 'Operating precautions' in this Section). Spin the rotor assembly by hand to work the oil into the bearings.

Reconnect the exhaust bellows and pipework to the turbocharger. Place a container beneath the turbocharger bearings oil drain and holding the rotor assembly with a ring spanner, run the engine briefly to check for an adequate oil flow through the bearings; stop the engine and remove the spanner.

Using a new gasket, refit the turbocharger oil drain pipe and re-connect the compressor air inlet ducting. Torque tighten 'V' band clamp nuts to 12 to 15 Nm (9 to 11 lbf. ft.).

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.

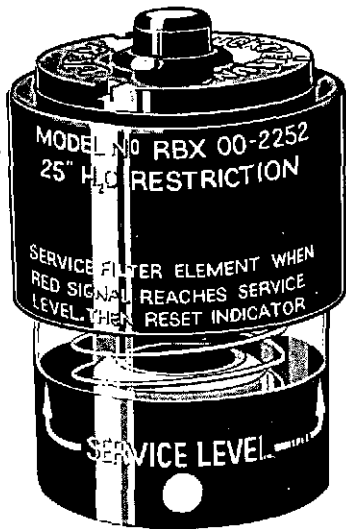


Fig. 1 Air restriction indicator

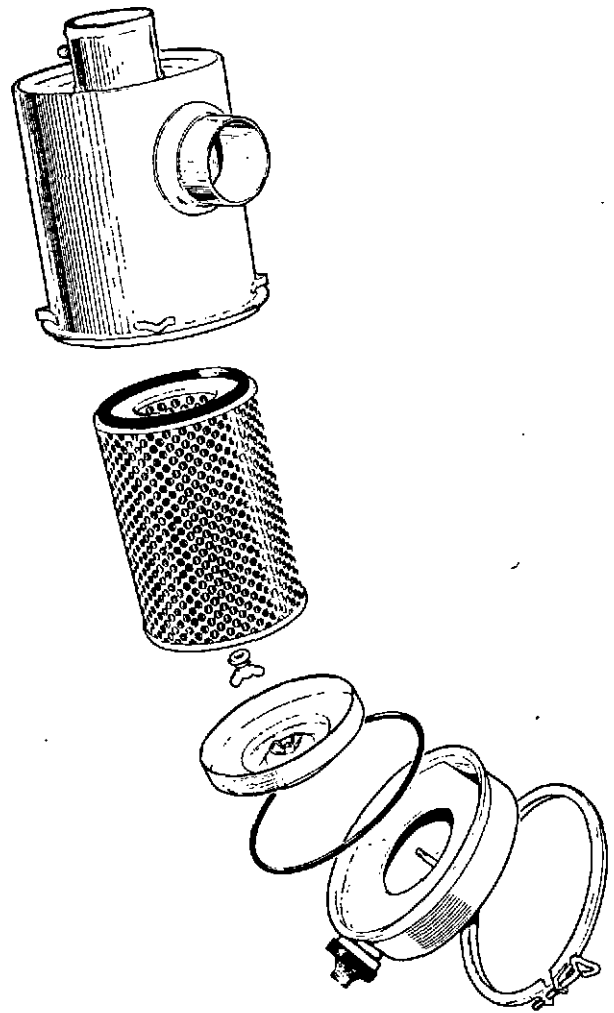


Fig. 2 Cyclopac air cleaner

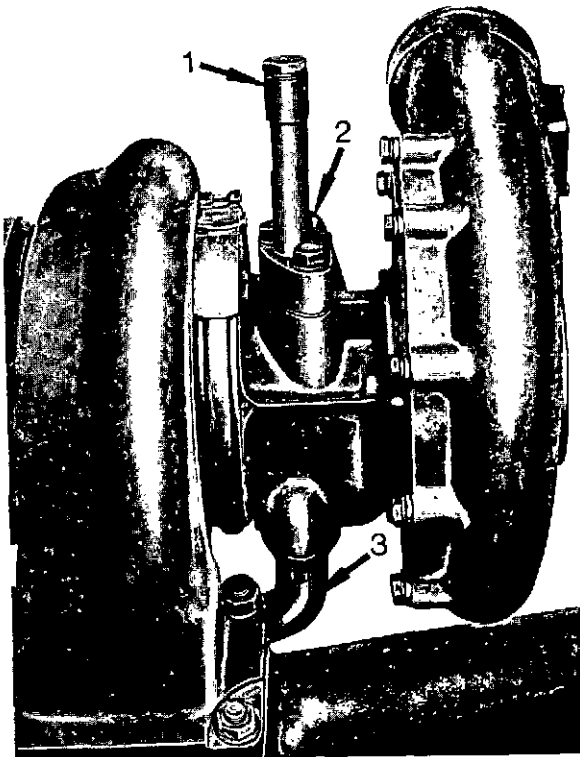


Fig. 3 Holset turbocharger

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

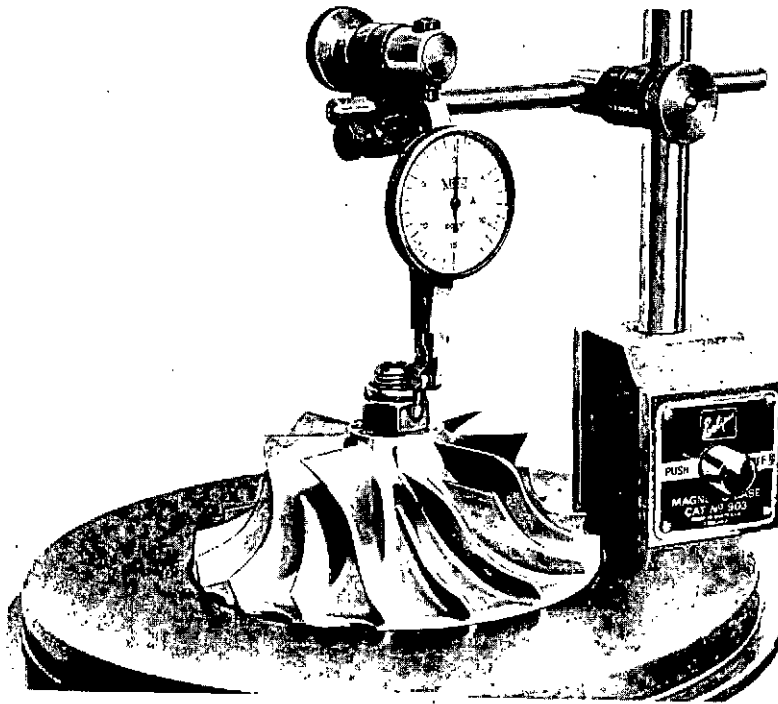


Fig. 4 Checking turbocharger bearing wear

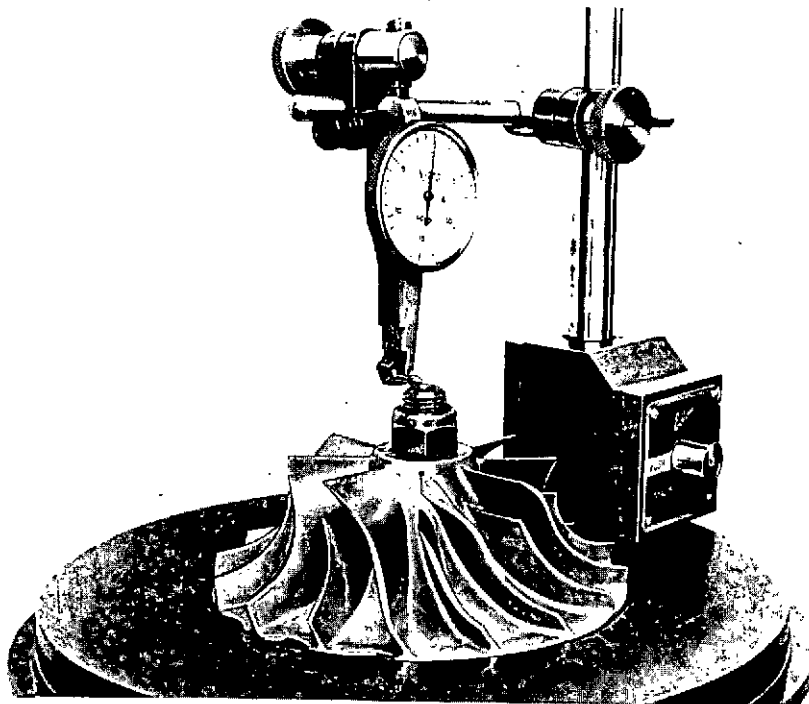


Fig. 5 Checking rotor assembly end float.

SECTION 7—ELECTRICAL SYSTEM

Description

The starter batteries are provided with a 30 amp capacity charging circuit.

Two types of belt driven alternator can be fitted

The Butec Type A13 alternator coupled with the Butec Type R1 voltage regulator provide a nominal output of 24 volts, continuously variable over a short range to suit individual application requirements. The Butec Type A3024 alternator, which can also be fitted, incorporates integral voltage regulation.

Two types of starter motor can be fitted. Both types are flange mounted onto the flywheel housing and engage with a conventional toothed starter ring gear integral with the flywheel.

The C.A.V. Type S130L starter motor is of the coaxial type construction with a two stage operating solenoid switch mounted around the armature shaft. The alternative starter motor, the Butec Type MS1A, incorporates an externally mounted solenoid.

A C.A.V. Type 368 solenoid unit, used in the energised-to-run mode, is mounted inside the engine 'V' and connected directly to the stop control of the fuel injection pump governor. The solenoid has two coils, a pull-in coil and a low consumption hold-in coil.

Two Teddington Type DCA switches are fitted into the cooling and lubrication systems and are coupled to the stop control solenoid. The switches provide protection engine shutdown, in the event of coolant temperature or lubricating oil pressure exceeding the permissible ranges.

The switches may be wired to operate on rising or falling pressures and temperatures to suit the individual application requirement.

Type A 13 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 assembly, 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, T.S.D. 3130.

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.

TYPE A 3024 ALTERNATOR

Description

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

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

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

Servicing

The servicing consists mainly of keeping the alternator clean as for the Type A13 (page 21), and checking the condition of the brush gear.

Renew brushes in sets if they wear down to the permissible limit of: 10 mm (0.394 inch).

Warning: The same warning applies to all alternator circuits as that given on page 21.

STARTER MOTOR (C.A.V.)

The S130L Type starter motor is of co-axial construction with a two stage operating solenoid switch mounted internally around the armature shaft. Pinion engagement with the starter ring is under reduced power to avoid excessive wear on the teeth. When the pinion is fully engaged, full power is applied and the pinion is locked in position to prevent premature ejection. A ratchet device prevents rapid acceleration of the heavy armature when the engine fires and drives the pinion. When the armature reaches the pinion speed, the ratchet ceases to function but at speeds of 10,000 to 13,000 rpm an overspeed device unlocks the pinion which is driven back along its helix to its original position.

Provision is made for the fitting of a repeat relay, in situations where automatic starting is required.

Servicing

No routine servicing is called for, the life of the starter being governed by frequency of use.

The following precautions will ensure that maximum starter life and efficiency are obtained:

1. When fitting a starter, ensure that the spigot is squarely located in the flywheel housing before tightening the securing setbolts.
2. Periodically check the security of the setbolts and terminal connections and inspect the cables for damage.
3. At long intervals of 7,000 to 10,000 ESC Units, remove the starter and service it as follows:
 - (a) Remove the end terminal nut, spring and plain washers, seal locator, rubber seal, sealing washer and insulating bush. Unscrew the two through bolts and lift off the commutator end shield cover (fig. 2). Lift off the rubber sealing ring and felt washer and remove the small hexagon headed setscrew together with its shakeproof

washer, plain washer and insulating bush.

Holding the starter pinion with a strap wrench or in a soft jawed vice, unscrew and remove the commutator end bolt together with its thrust washer and shims.

Note: The drive end shield may come away from the yolk when carrying out this operation.

Lift off the commutator end shield, taking care not to lose any of the shims from the recoil housing.

- (b) Using a jet of dry compressed air, blow out any dirt and carbon particles from the brush gear and clean the commutator with a soft cloth moistened with 'Genklene N', available from the manufacturers I.C.I. Limited, Mond Division, Runcorn, Cheshire, England, or their agents.
- (c) Check the commutator for wear or damage. A dark brown discoloration is normal. Slight score marks may be removed with very fine glasspaper, NOT emery or carborundum paper. Blow out any abrasive dust with an air jet. A badly worn or damaged commutator will entail removal and reconditioning of the armature as described in the Workshop Manual, T.S.D. 3130.
- (d) Check the brushes for wear or damage. Renew brushes in sets, bedding each brush to the curvature of the commutator with fine glasspaper, NOT emery or carborundum paper. Minimum permissible worn length of brushes is 10 mm (0.39 inch). Ensure that the brushes slide freely in their holders and check the spring pressure with a tension gauge. The correct tension is 2.4 to 2.5 kgf. (5.25 to 5.5 lbf.), when the brush is just breaking contact with the commutator.
- (e) Check the starter pinion for wear or damage and renew it if necessary. Ensure that the replacement pinion has the correct number of teeth and is of the same material as the original. Lightly smear the helix with Aero Shell 16 grease after removing accumulated dirt, or before fitting a new pinion. Torque

tighten the stopnut to 54 to 68 Nm (40 to 50 lbf. ft.).

- (f) Ensure that the insulating plate and insulating strip are in position inside the commutator end shield. Check that the recoil housing shims are in position. Smear the end shield bush and end of the armature shaft with Shell Turbo 41 oil and slide the end shield on to the yoke taking care not to trap the brush leads. Ensure that the notch in the end shield locates with the register pip on the yoke. Insert the two through bolts with sealing washers and torque-tighten to 13 to 13.5 Nm (9.5 to 10 lbf. ft.).
- (g) Assemble the end bolt, thrust washer and shims with the thickest shim against the bush, and torque-tighten the bolt to 34 to 41 Nm (25 to 30 lbf. ft.).
Using feeler gauges, measure the gap between the thrust washer and the shims, and if necessary, remove the bolt and add or subtract shims to give an end float clearance of 0.1 to 0.3 mm (0.004 to 0.012 inch). Re-fit and torque-tighten the bolt and re-fit the felt washer and rubber sealing ring.
- (h) Fit the insulating bush over the end terminal and push it fully home. Fit the small set-screw together with its shakeproof washer, plain washer and insulating bush, and torque tighten to 1.7 to 2.0 Nm (15 to 18 lbf. inch). Remove the two through bolts and washers.
- (j) Using a new cover sealing ring, fit the commutator end shield cover and insert the two through bolts complete with sealing washers. Torque-tighten to 13 to 13.5 Nm (9.5 to 10 lbf. ft.).
- (k) Fit the thin sealing washer, rubber seal, seal locator, plain washer, spring washer and nut on the return terminal. Torque tighten the nut to 12 to 13.5 Nm (9 to 10 lbf. ft.). Place a second spring washer and nut on the terminal and tighten by hand.

STARTER MOTOR (BUTEC)

Description

The MS 1A 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 MS 1A 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 re-conditioned as detailed in the Workshop manual, T.S.D. 3130.
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. 3) 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. 14) 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 occurrences, 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. 5) 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.

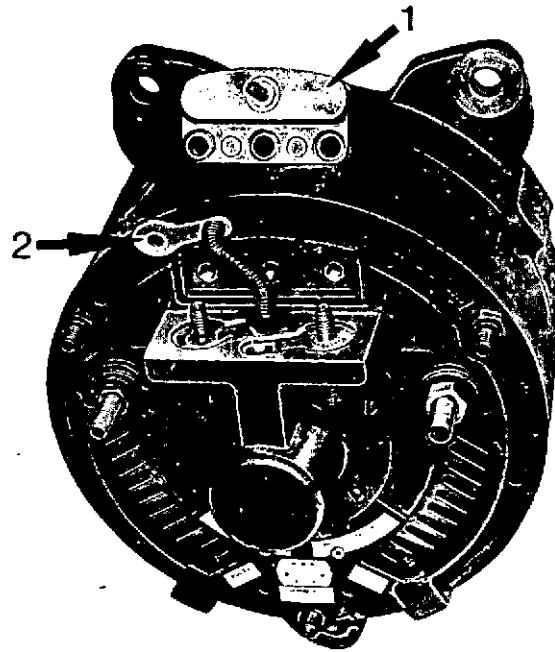


Fig. 1 Butec alternator
1. Auxiliary diode capsule removed
2. Brush assembly

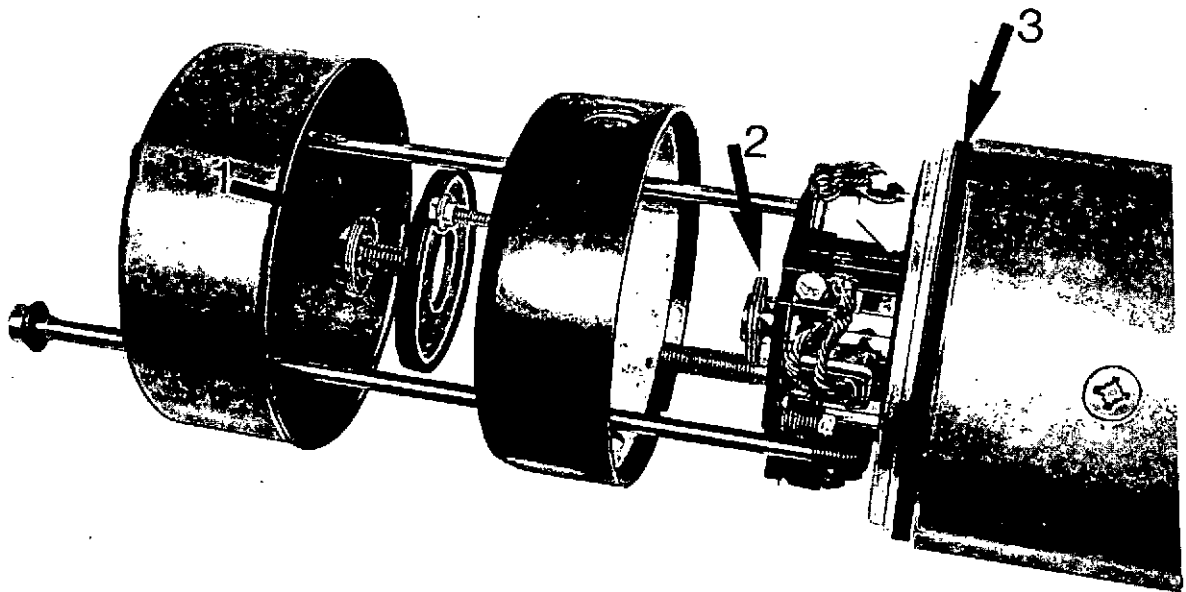


Fig. 2 C.A.V. S 130L starter motor brush gear
1. Commutator end bolt and shims
2. Recoil housing shims
3. Cover sealing ring

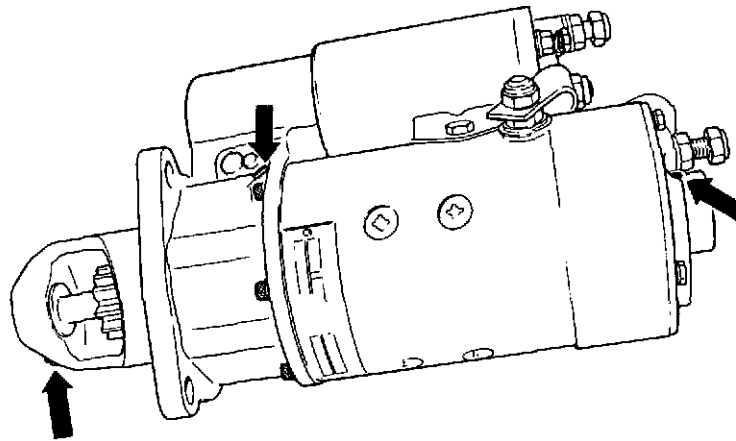


Fig 3. Butec starter motor
(Grease points arrowed)

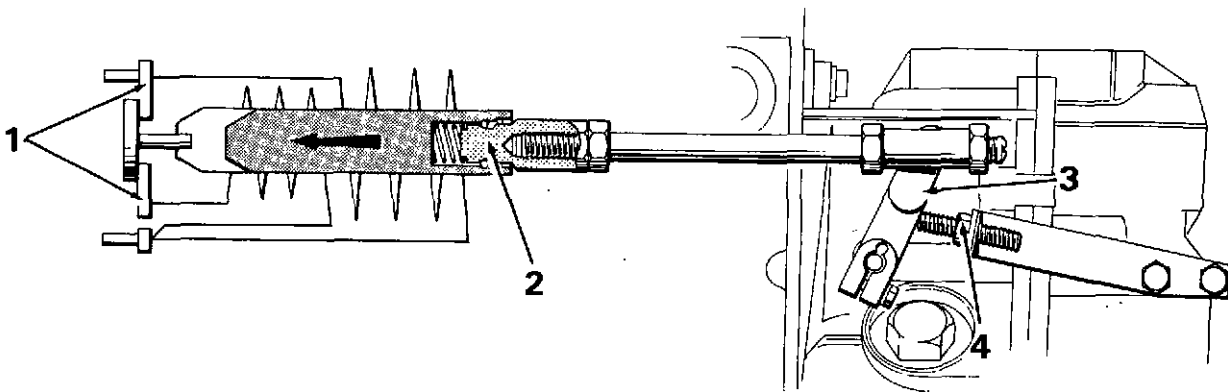


Fig 4 Solenoid stop control circuitry
1. Switch 3. Injection pump stop lever
2. Spherical joint 4. Shutdown stop screw

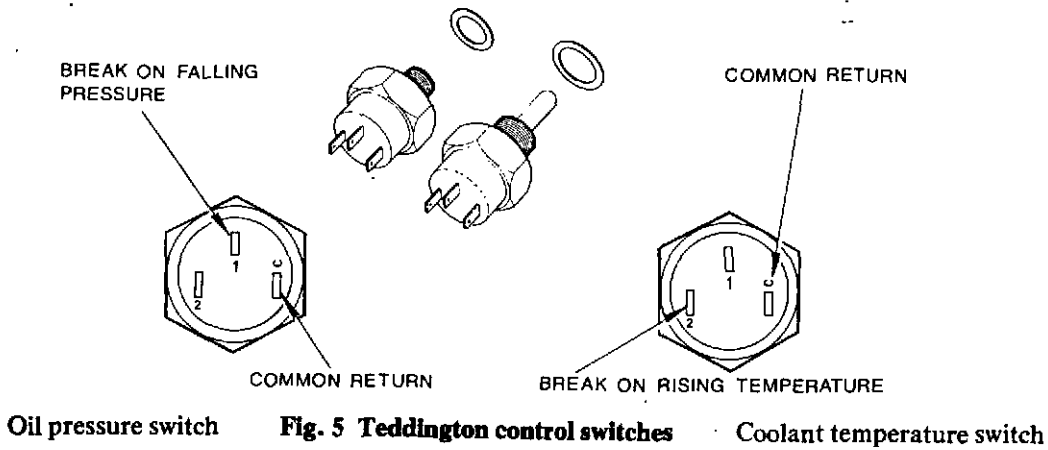


Fig 5 Teddington control switches
Oil pressure switch Coolant temperature switch

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 a temporary lubricating oil filter fitted to the turbocharger oil inlet connection. This filter 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

When the engine is out of use, whether temporarily or for a longer period, it must be protected against corrosion. The extent of the anti-corrosive treatment will depend on the anticipated duration of the storage period and the condition under which the engine will be kept. Where necessary, precautions against frost damage must also be taken.

Short-term storage

For out-of-use periods of up to seven days no anti-corrosive treatment is necessary. For out-of-use periods of up to one month no external treatment is necessary, but to prevent internal corrosion the engine should be run, until normal temperatures are reached, once every seven days. Engines which cannot be run should be turned by hand, for at least three revolutions, every seven days.

Long-term storage

Before being stored for a period longer than one month the engine must be fully protected against internal and external corrosion.

A list of approved inhibiting products is given at the end of this section.

Preparation

Carry out the inhibiting procedure in the following sequence:

1. Remove and clean the thermostat as described in Section 10 of the Workshop Manual, TSD 3130. Apply silicone grease to the thermostat spindle(s), operating the valve(s) manually to work the grease between the spindle(s) and the gland(s). Re-assemble the thermostat to its housing.
2. Run the engine until normal working temperature is reached, shut the engine down and immediately drain the lubricating oil from the sump and oil filter bowls.
3. Fill the oil filter bowls with PX4 inhibitor, (see end of Section), and refit the bowls to the header bracket.
4. Fill the sump to the normal oil level with PX4 inhibitor and once again run the engine until normal working temperature is reached.
5. Stop the engine, disconnect the fuel supply and re-connect to a supply of PX4 inhibitor. Restart the engine, whilst still hot, and run it for ten minutes, off load. Stop the engine.

If the engine coolant passes through a sea-water heat exchanger, as on certain marine engines, the sea-water inlet and discharge valves must be closed and the sea-water system drained.

6. Flush the sea-water system through with clean fresh water and connect the sea-water pump inlet to a slave tank containing a standard coolant mixture, i.e. 50% inhibited ethylene glycol to which 1% of soluble oil (e.g. Shell-Dromus oil or equivalent), has been added. Route the outlet of the sea-water system back to the tank to complete the circuit.
7. Run the engine briefly to ensure a thorough circulation of the sea-water system then stop the engine and drain the system completely.
8. Disconnect the supply of PX4 inhibitor and blank off the end of the fuel feed pipe. Attach a label in a prominent position to indicate that the fuel supply has been disconnected.

9. Remove the fuel injectors and immerse them in a container of PX4 inhibitor.
10. Set the fuel control to the 'NO FUEL' position, remove the rocker covers and disconnect the air inlet ducting from the induction manifold.
11. Motor the engine on the starter and simultaneously, spray PX4 inhibitor into the manifolds until vapour emerges from each fuel injector orifice. Re-connect the air inlet ducting.
12. Using a suitable self-metering spray gun, spray 40 ccs. of PX4 inhibitor into each cylinder through the fuel injector orifice, then refit the injectors.
Note: The engine must not be rotated after this operation and should carry a prominent notice to this effect.
13. Spray the valve gear with PX4 inhibitor, then refit the rocker covers.
14. Drain the PX4 inhibitor from the engine sump and oil filter canisters. Attach a 'NO OIL' notice to the filler cap.
15. Drain the cooling system and refill with a fresh coolant mixture of inhibited ethylene glycol and clean water.
Note: The mixture must not contain less than 50% inhibited ethylene glycol and may contain up to 90% by volume.
Allow the system to settle for 15 minutes, then completely drain off the coolant mixture. Attach a 'NO COOLANT' notice to the coolant filler cap.
16. Disconnect the exhaust system at the turbo-charger diffuser outlet or, on normally aspirated engines, at the junction of the manifolds. Inject two grammes of VPI 260 powder, (see end of Section), and fit a blanking plate. Do NOT reconnect the exhaust pipe.
17. Disconnect the air cleaner(s) and inject two grammes of VPI 260 powder into Cyclopac type air cleaners. Oil-bath, wire mesh or dry nylon type air cleaners may be sprayed internally with PX4 inhibitor or VPI 260 powder.
18. Inject two grammes of VPI 260 powder into the turbocharger. Reconnect the air cleaner(s).
19. Brush coat or spray all unpainted areas of the engine and auxiliary equipment with 'Crodaf fluid'

PM47 (see end of Section), paying special attention to the fuel control linkage.

Caution: Do NOT spray PM 47 into the vent apertures of the alternator.

20. Wrap the alternator and starter motor in mouldable wax wrapping and seal with adhesive tape.
21. Seal the air cleaner inlet, crankcase breather and any other openings with mouldable wax wrapping and adhesive tape or plastic caps as appropriate.
22. Remove all driving belts, dust them liberally with french chalk and place them in a sealed polythene bag attached to the engine.
23. Finally, affix a label in a prominent position on the engine stating:
 - (a) That the exhaust system has been blanked off.
 - (b) The date on which the engine was inhibited and the date on which the engine will require re-inhibiting.

If the engine is to remain in storage for more than one year, the above procedure must be carried out at the end of each 12 month period.

REMOVAL FROM STORAGE

Instructions for preparing the engine for running after storage can be found in CHAPTER 2 - OPERATING. The information given applies equally to newly installed engines and those removed from storage.

APPROVED PRODUCTS FOR ENGINE INHIBITING

Cooling and sea-water systems.	
Inhibited ethylene glycol as listed in leaflet T.S.D. 3085.	
Thermostats	
Ambersil	MS4 Silicone grease
Lubrication system	
Croda Chemicals Ltd.	PX4
Induction and exhaust systems	
Shell Chemicals Ltd.	VPI 260 powder
Fuel system	
Croda Chemicals Ltd.	PX4
External protective oils	
Croda Chemicals Ltd.	'Crodaf fluid' PM 47

CHAPTER 4—FAULT DIAGNOSIS

Symptom 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 canister	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 filter choked	Renew filter canister	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
Slipping, broken or damaged fan belt(s)		Adjust or renew fan belt(s)	2
Fouled cooling system		Clean and refill system	3
Faulty thermostat		Test, and renew if necessary	3
Choked radiator matrix		Clean matrix	—
Injection pump timing incorrect		Re-set timing	4
Turbocharger failure		Inspect turbocharger, fit replacement 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	Change or service the valve	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 turbocharger	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 turbocharger	6

ROLLS-ROYCE DIESELS

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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 **Perkins**

Engines

SUCCESSOR TO THE DIESEL ENGINE
DIVISION OF ROLLS-ROYCE MOTORS



**FUEL, COOLANT AND LUBRICATING OIL
RECOMMENDATIONS FOR EAGLE,
'C', 'CV', 'SF65C' AND 'D' RANGE
DIESEL ENGINES**

1. DIESEL FUEL

A distillate fuel with at least 85% recovery by 350 deg. C. (IP 123) having a maximum sulphur content of 1% by weight (Industrial engines) or 0.5% (Automotive engines) with a Cetane Number not less than 45.

The following specifications meet these requirements:

- (i) British Standards Institution B.S. 2869 : 1983 Class A1 - (0.3% Sulphur - 50 min. Cetane) or B.S. 2869 : 1983 Class A2 - (0.5% Sulphur - 45 min. Cetane).
- (ii) ASTM Diesel Fuel Classification: D.975 No. 1-D or
ASTM Diesel Fuel Classification: D.975 No. 2-D.

The use of fuels not meeting the above requirements may result in damage and/or reduced engine life and may affect the Warranty. If in doubt please consult Perkins Engines (Shrewsbury) Limited.

2. COOLANT

- (i) The coolant approved for use in all diesel engines manufactured by PE(S)L is a mixture of 50% inhibited ethylene glycol or 50% inhibited propylene glycol and 50% clean fresh 'soft' water.

Mixtures containing methanol are **not** approved.

Anti-freeze mixtures supplied by most major Chemical and Oil companies are suitable, but the Operator is responsible for obtaining the Manufacturer's assurance that the ethylene glycol or propylene glycol products they supply have an inhibitor performance level suitable for a multi-metal cooling system.

- (ii) If anti-freeze is not available, and there is no likelihood of ambient temperatures below 10 deg. C., then clean fresh 'soft' water may be used, treated with 1% by volume of PE(S)L inhibitor, in the cooling system. This proportion is the equivalent of 0.5 litre of inhibitor to 50 litres or 11 Imperial gallons of water. The inhibitor is available in bottles under PE(S)L Part Nos. OE. 45141 (0.5 litre) and OE. 45142 (1.0 litre).

Caution: The use of any other product may cause serious problems in the cooling system, and the use of insufficiently inhibited coolant mixtures may lead to erosion and/or corrosion of aluminium or cast iron components in the system.

- (iii) If the acceptability of the available water supply is in doubt, refer to the appropriate Service Instruction, obtainable free of charge from PE(S)L Dealers and Distributors.

Engine range	Service Instruction
Eagle	E.S.I. 70
'CV'	CV.I. 14
'C' and 'SF65C'	S.I. 128
'D'	D.S.I. 48

3. LUBRICATING OIL

(i) PE(S)L recommend the use of a multi-grade oil, with a viscosity rating of S.A.E. 15W/40, for all engines operating at ambient temperatures above -15 deg. C (5 deg. F). The oil selected must adequately meet the requirements for high quality monograde oils, as described in specification: MIL-L-2104C/2104D: API - CD/SF.

(ii) **Eagle engines only.**

Further information on oils selection is contained in Publications TSD.3034/ESI.68 obtainable free of charge from PE(S)L and Distributors.

(iii) **Industrial engines only.**

For continuous running engines, with infrequent starting, a monograde oil of S.A.E. 30 or S.A.E. 40 viscosity rating, may be used. Engines operating for long periods in ambient temperatures exceeding 32 deg. C. (90 deg. F.), should use a monograde oil of S.A.E. 40 viscosity rating. These oils should adequately meet the requirements of specification: MIL-L-2104C/2104D: API - CD/SF.

The following abbreviated list of oils are amongst those which comply with the Perkins recommendations. The onus is on the Operator to ensure that the oil used does meet the above requirements.

* Industrial engines only (column 4).

Manufacturer	Preferred Multi-grade oils	Acceptable Multi-grade oils	*Special Conditions see Para. 3 (iii) Mono-grade oils
Agip	Agip Sigma Turbo 15/40	Super Diesel Multi-grade 15W/40	Agip Sigma 30 and 40
BP	Vanellus C3 Extra 15W/40 Vanellus FE 15W/30	Vanellus C3 Multi-grade 15W/40	- -
Burmah Castrol	Deusol Turbomax 15W/40	Deusol RX Super 15W/40	Deusol RX Super 30 and 40
Caltex	RPM Delo 450 15W/40	RPM Delo 400 15W/40	RPM Delo 400 30 and 40
Daltons	Silkolene Turbolene 15W/40	Silkolene Ashford 15W/40	Silkolene Hardwick 30 and 40
Elf	Multi-performance 4D 15W/40	Multi-performance 3C 15W/40	Performance 3C 30 and 40
Esso	Diesel Motor Oil 500 15W/40	Essolube XD3 15W/40	Essolube XD3 30
Mobil	Delvac 1400 Super 15W/40	Delvac Super 15W/40	Delvac 1300 30 and 40
Morris's	Golden Film Ring-Free XHD 15W/40	Golden Film Ring-Free XS 15W/40	Golden Film Ring-Free XHD 30 and 40
Petrofina	Fina Kappa LDO 15W/40	Dilano HPD 15W/40	Dilano HPD 30 and 40
Shell	Myrina 20W/40	Rimula X 15W/40	Rimula 30 and 40 Rimula X 30 and 40

For information regarding engines operating in ambient temperatures below -15 deg. C., please contact the PE(S)L Service Department.

GUARANTEE

It is explicit in the PE(S)L Guarantee that an engine must be operated with approved fuel, lubricant and coolant, and maintained in accordance with the Schedule contained in the Servicing Manual.