SERVICING MANUAL

'C' RANGE AND SF65C ENGINES

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successor to the business of
Rolls-Royce Motors Limited, Diesel Division
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T.S.D. PUBLICATION 980
(7th Issue)

ROLLS-ROYCE MOTORS LIMITED . DIESEL DIVISION
SHREWSBURY, ENGLAND

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(PE (S) L)
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Perkins Engines

SUCCESSOR TO THE DIESEL ENGINE DIVISION OF ROLLS-ROYCE MOTORS

ROLLS ROYCE Diesels

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.

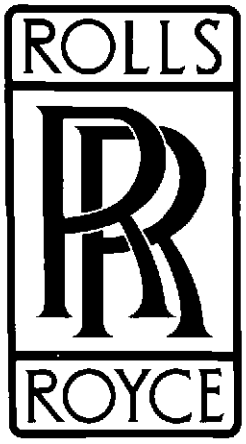
* Industrial engines only (column 4).

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.



SERVICING MANUAL

'C' RANGE AND SF65C ENGINES

T.S.D. Publication 980

Seventh Issue

February, 1984

NOTES TO USERS

The purpose of this Manual is to provide Operators with all information necessary for the correct usage and efficient maintenance of Rolls-Royce 'C' range and SF65C engines between overhauls. The main body of the Manual contains material common to all engines of the range but is primarily concerned with non-marine applications. Additional information, solely concerning marine engines, is printed separately as Appendix T.S.D. 3073 which, where necessary, is incorporated at the back of the Manual. Orders for replacement Manuals should specify when this Appendix is required.

Repair and overhaul information is contained in the Workshop Manual, T.S.D. 803.

Service

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

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

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

(1) In all cases, the engine Number, Designation and Build Number (or, on older engines, the Series and Model Numbers) as stamped on the crankcase data plates, and the operating units recorded by the Engine Service Counter (ESC).

(2) If a proprietary unit (e.g. injection pump, air compressor, turbocharger) is involved, the details on its data plate and the number of operating units run.

(3) Any other information logically connected with the subject, e.g. type of fuel, lubricating oil or coolant used, details of service history, etc.

Instruction

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

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 Servicing Manuals held by Dealers, Distributors and Operators. See under 'Service Instructions' at the rear of this Manual.

(2) Engine design changes are published, usually as Modifications, in Service Bulletins for information of Dealers and Distributors.

Associated Technical Publications for 'C' range engines

T.S.D. 803	Workshop Manual
T.S.D. 810	Service Bulletins
T.S.D. 965	Service Instructions
T.S.D. 968	Service Reclamation Schemes
T.S.D. 3001	Folder, 'Operators' Guide'
T.S.D. 3045	Booklet, 'Essential Information'
T.S.D. 3073	Marine Appendix to T.S.D. 980
T.S.D. 3083	Chart, 'Torque loadings'
T.S.D. 3085	Leaflet, 'Fuel, oil and coolant recommendations'
T.S.D. 3086	Chart, 'Servicing Schedule'
T.S.D. 3088	Charts, 'Fuel, oil and coolant systems' (set of three)

SERVICE EXCHANGE UNITS

For further details, apply to Rolls-Royce Dealers and Distributors

Air Compressors	Fuel Injectors
Alternators	Fuel Injection Pumps
Coolant Pumps	Oil Pumps
Crankshafts	Starters (Electric)
Cylinder Heads	Superchargers
Dynamos	Turbochargers

Short Engine (6-cyl. illustrated below)

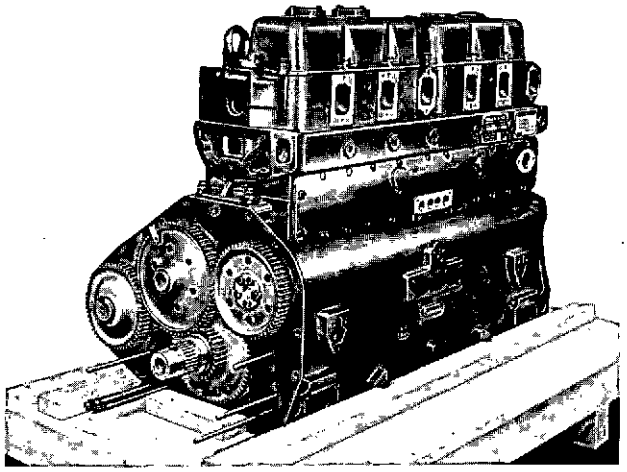


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Fig. 1 Short engine, front view

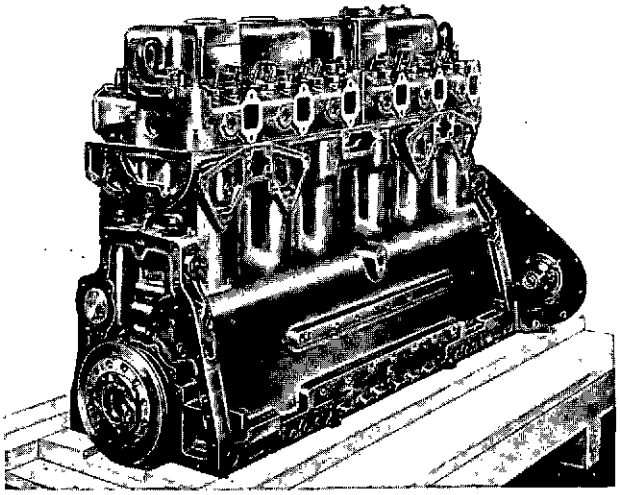

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Fig. 2 Short engine, rear view

Printed in Great Britain

CONTENTS

CHAPTER 1 — DESCRIPTION AND DATA

The Rolls-Royce 'C' range consists of three in-line liquid-cooled diesel engines, having 4, 6 and 8 cylinders respectively. These engines are all of the same bore and stroke, and have the maximum number of interchangeable components. They may be normally aspirated or pressure-charged, and are supplied for industrial or marine applications. The 6- and 8-cylinder versions are also supplied in horizontal form for railcars.

The SF65C is a lower-rated version of the 'C' range 6-cylinder vertical engine, and comes within the scope of 'C' range component rationalization. It may be normally aspirated or turbocharged, and is supplied for industrial and marine applications.

All models have detachable cylinder heads, carrying overhead valves which are operated, via pushrods, from a low-mounted camshaft driven by the crankshaft pinion. The crankcase and cylinder block are a one-piece casting in nickel-chrome iron, sealed internally to prevent oil contamination by casting residue. All oilways are drilled to ensure cleanliness and uniformity.

The push-fit 'wet' cylinder liners are of centrifugally-cast iron, differentially hardened and tempered, with honed bores. Pistons are of cast aluminium alloy with cavity combustion chambers, and carry three compression rings, one spring-backed scraper ring and a fully-floating gudgeon pin. The top ring has a molybdenum inlay and is carried in a cast-in austenitic iron insert.

Connecting rods are forged, machined to size, and drilled for lubrication of the small end. Dependent upon engine application, additional drillings supply oil for piston cooling or cylinder wall lubrication. On build, all rods in an engine fall within a weight group of 4 oz. (113 grammes) range. The big-end will pass through the cylinder bore.

The crankshaft is a chrome-molybdenum steel forging, fully machined and balanced. Each crankpin incorporates a centrifugal sludge-trap, and all bearing surfaces are nitride hardened. Location is by steel-backed lead-bronze thrust washers at the centre main bearing; 4-, 6- and 8-cylinder engines have 5, 7 and 9 journals respectively. Main and big-end bearings are steel-backed lead-bronze shells, indium flashed.

Fuel injection is by a plunger-type pump with individual elements, via multi-hole injectors direct into open combustion chambers.

Lubricating oil is drawn from the sump by a spur gear pump, driven from the front of the crankshaft, and is delivered via full-flow filters to the main bearings and thence throughout the engine.

The approved coolant is a mixture of inhibited ethylene glycol or, inhibited propylene glycol, and clean fresh water (see Chapter 3, Section 4) circulated by a belt driven pump to which is fitted a cooling fan. A triple-element wax-capsule thermostat, with radiator by-pass, ensures rapid warming up and an oil-to-coolant heat exchanger maintains the lubricating oil at a constant temperature.

All engines are designed to stand on their sumps when not installed, but wood packing should be used to level the engine and protect the aluminium.

A non-marine engine may be identified by the code (e.g. C6TFL) compiled from its design features, as listed below, and stamped on the crankcase data plate. For identification of marine engines, see Marine Appendix to this Manual.

C(SF65C) = range of engine
4 (6) (8) = number of cylinders
N = normally aspirated
S = supercharged
T = turbocharged
F = ferrous crankcase
L (R) = build of engine (L denotes camshaft on left-hand side)
(B) = crankshaft balancer fitted (4-cyl. engines)
H = horizontal engine
IV = individual 4-valve cylinder heads.

GENERAL ENGINE DATA

TYPE

C4, C6, C8 ..... 4, 6 or 8-cylinder in-line 4-stroke liquid-cooled diesel engine, normally aspirated or pressure-charged

SF65C ..... 6-cylinder in-line 4-stroke liquid-cooled diesel engine, normally aspirated or turbocharged

BORE

All engines ..... 5.125 inches (130.17 mm)

STROKE

All engines ..... 6.000 inches (152.4 mm)

CAPACITY (Swept volume)

C4 ..... 495.1 cu. inches (8.1 litres)

C6 and SF65C ..... 742.64 cu. inches (12.17 litres)

C8 ..... 990.19 cu. inches (16.2 litres)

COMPRESSION RATIO

Normally aspirated C4, C6, C8, SF65C 16:1

Supercharged C4, C6, C8 ..... 14:1

Turbocharged C4, C6, C8, SF65C (2-valve) 14:1

Turbocharged C6, C8 (4-valve) 15:1

VALVE TAPPET CLEARANCE (Engine stopped, hot or cold)

All engines except C8TCA

Inlet ..... 0.010 inch (0.25 mm)

Exhaust (Normally aspirated) ..... 0.015 inch (0.38 mm)

(Pressure charged) ..... 0.020 inch (0.51 mm)

C8TCA

Inlet ..... 0.015 inch (0.38 mm)

Exhaust ..... 0.025 inch (0.63 mm)

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

FIRING ORDER

4-cylinder ..... 1.3.4.2.

6-cylinder ..... 1.4.2.6.3.5.

8-cylinder ..... 1.6.2.5.8.3.7.4.

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

DRY WEIGHT

(Approximate, for handling purposes)

The following weights are for bare non-marine engines. The variation is due to auxiliary equipment (e.g. heat exchanger, air compressor) which may be fitted.

Engine	Minimum		Maximum	
	lb.	(kg.)	lb.	(kg.)
4-cylinder	2000	(907)	2100	(952)
6-cylinder	2500	(1134)	2613	(1185)
8-cylinder	3100	(1406)	3250	(1474)

COOLING SYSTEM

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

CAPACITY

(Bare engine, including oil/coolant heat exchanger)

4-cylinder ..... 4 Imp. gallons (18.2 litres)

6-cylinder ..... 4.5 Imp. gallons (20.4 litres)

8-cylinder ..... 5.5 Imp. gallons (25.0 litres)

PRESSURE ..... Atmospheric; 7 lbf/sq. inch (48 kN/sq. m.); or *10 lbf/sq. inch (69 kN/sq. m.)*

THERMOSTAT

Vertical engines ..... Western-Thomson triple-element wax capsule type, with radiator by-pass

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

TEMPERATURE (At sea level)

Normal ..... 70 to 90 deg.C. (158 to 194 deg.F.)

Maximum (Intermittent) ..... 98 deg.C. (208 deg.F.)

OIL/COOLANT HEAT EXCHANGER ..... Serck or Marston

SYSTEM CLEANING COMPOUNDS

Cargo Fleet Chemical Co. Ltd.....Symperonic 'N', 1% (45cc. per gallon)

FUEL SYSTEM

RECOMMENDED DIESEL FUEL... See leaflet T.S.D. 3085 in rear cover pocket

FUEL PRESSURE RELIEF VALVE SETTING

C.A.V. pump, parallel-flow filters.... 12 to 14 lbf/sq. inch (83 to 96.5 kN/sq. m.)

C.A.V. pump, change-over filters.....15 to 18 lbf/sq. inch (103 to 124 kN/sq. m.)

Bosch pump, spin-on filter.....15 to 22 lbf/sq. inch (103 to 152 kN/sq. m.)

INJECTION PUMP.....C.A.V., Type 'NN' or Majormec

or Bosch PE

GOVERNOR.....C.A.V. 'H' type all-speed hydraulic

or C.A.V. 2-speed or all-speed mechanical

or Bosch RQV

or Woodward PSG

INJECTORS.....C.A.V. long-stem, multi-hole, flange or clamp mounted

INJECTION PRESSURE.....240 atmospheres (243 bar)

PRIMARY FILTER..... Purolator FE-1 or PU464, wire-wound element or Harwood, Model 5-90

MAIN FILTERS.....C.A.V. 2FS or 3FS bowl-less parallel flow, with expendable cartridges

or Change-over, expendable elements

or Spin-on, single canister

WATER SEPARATOR..... AC

COLD STARTING CARBURETTOR..... Start Pilot, Model ER

INDUCTION SYSTEM

AIR CLEANERS

Oil-bath type..... Burgess

Dry type..... Purolator, Rotopamic, Cyclopac, Donaclone

TURBOCHARGERS

6-cylinder engines..... Holset, Model 4, 4LE or 4LEK

8-cylinder engines..... AiResearch, Series T.18 or TV.71

LUBRICATION SYSTEM

RECOMMENDED OILS ..... See leaflet TSD.3085 in rear cover pocket

SYSTEM CAPACITIES (Approximate)

Engine	Complete system Imp. gals. (litres)	Sump only Imp. gals. (litres)
4-cylinder, vertical	5.0 (23)	4.0 (18)
*6-cylinder, vertical	6.5 (30)	5.5 (25) *or* (4.5 (20)
8-cylinder, vertical	12.0 (55)	9.5 (43)
6-cylinder, horizontal	9.5 (43)	7.5 (34)
8-cylinder, horizontal	12.0 (55)	10.0 (45)

LUBRICATING OIL PRESSURE
(At working temperature and speed)

Normal ..... 50 to 70 lbf/sq. inch (345 to 483 kN/sq. m.)

* Minimum for continuous operation 30 lbf/sq. inch (207 kN/sq. m.)

***Note:** Critical for turbocharged engines.

FILTERS

4 and 6-cylinder engines ..... Full-flow, twin bowl, expendable elements

8-cylinder engines ..... Full-flow, triple bowl, expendable elements

* Depending on type of sump fitted.

ELECTRICAL EQUIPMENT

ALTERNATOR ..... C.A.V., AC5R or AC7, (24 or 32 volt)

CONTROL BOARD ..... C.A.V., Type 440

STARTER MOTOR ..... C.A.V., SL5A, S130L, 24 volt; or SP6A, (24 or 32 volt)
or Butec MS 1A, 24 volt

STOP CONTROL ..... C.A.V., solenoid-operated, Type 368

TACHOMETER GENERATOR ..... Smiths, Type LDG 3

WARNING AND SHUTDOWN SWITCHES

Low oil pressure ..... Drayton EP

High coolant temperature ..... Drayton ET

AUXILIARIES

AIR COMPRESSOR

Clayton Dewandre ..... Model PCGA 754 or PCGA 585-1X

Westinghouse ..... Tu-Flo 500

AIR STARTER ..... Ingersoll-Rand, Model 150 BM or 150 BMP

HYDRAULIC STARTER ..... Bryce 'Handraulic', Type B50 G51 S10

INERTIA STARTER ..... Bendix — AE, Type 53-110

OVERSPEED TRIP UNIT ..... Isospeedic, Type 656

SERVICE COUNTER ..... English Numbering Machines
(Geared to suit individual installation)

TRANSMISSIONS

COUPLINGS ..... Holset RB 0.8; Twiflex automatic C124 or C136

CLUTCH (Flywheel drive) ..... Rockford 14-inch, single or twin plate

RECOMMENDED LUBRICANTS AND FLUIDS FOR COMPONENTS

	Manufacturer	Brand or Specification
ALTERNATOR		
Drive end bearing grease	Shell	Retinax 'A' or Alvania 2
Diode grease	—	Silicon MS 200, MS 4, MS 5.
Diode cleaning fluid	I.C.I. Limited	Genklene 'N'
CLUTCHES		
All grease points	Shell	Retinax 'A' or Alvania 2
	BP	Energrease C3
COOLANT PUMP BEARINGS	Esso	H or TSD.807
	Shell	Retinax 'A' or Alvania 2
	Mobil	Mobilgrease MP
	BP	Energrease LS.2
	Regent	Caltex Multifak 2
	Castrol	LM

EXHAUST SYSTEM		
Anti-seize compound	Crane Packing	Thred-Gard
	K.S. Paul	PBC
	Rocol	Rocol J166
	Slip Group	Copaslip
FAN AND PULLEY BEARINGS	Various	As for coolant pump
OVERSPEED TRIP (Iso-Speedic)	—	Engine lubricating oil
STARTER (Bryce)		
Operating fluid	Shell	Clavus 17 or Donax A.1
	Mobil	Shock absorber light
	Castrol	'Shockol'
	Regent	Caltex Capella AA
	BP	Energol SA light
STARTER (C.A.V.)		
Drive end bearing	Shell	SAE 20 oil
Clutch plate grease	Shell	Nerita 3
	BP	Energrease N3
STARTER (Ingersoll-Rand)		
Gearcase and bearings	Shell	Retinax 'A' or Alvania 2
	BP	Energrease LS.2
Drive end bush pad	—	Engine lubricating oil
TACHOGENERATOR		
Flexible drive	Esso	Aviation GP grease No. 1
THERMOSTAT VALVES		
Silicone grease	Ambersil	MS4

TORQUE LOADINGS

	TORQUE	
AIR COMPRESSOR (CLAYTON DEWANDRE)	**lbf. ft.**	**Nm**
Crankshaft coupling nuts, tandem drive	70	95
Cylinder head nuts	16	22
ALTERNATOR PULLEY NUT		
C.A.V. AC5 alternator	40	54
C.A.V. AC7 alternator	60 to 70	81 to 95
Butec alternator	65 to 70	88 to 95
BALANCER GEAR DRIVE (4-CYLINDER)		
Secondary idler gear axle bolts	45	61

	lbf. ft.	Nm
CAMSHAFT		
Drivegear setbolts	45	61
Thrustplate setbolts	40	54
COMPOUNDER SHAFT GEAR RETAINING NUT	45	61
CONNECTING RODS		
Big end bolts and nuts	160	217
CRANKCASE REAR MOUNTING PLATE BOLTS (SERIES 148 ENGINES)	45	61
CRANKSHAFT HUB RETAINING NUT	700	949
DAMPER RETAINING SETBOLTS	30	40.7
FLYWHEEL RETAINING SETBOLTS	85 to 90	115 to 122
CYLINDER HEADS, 2-VALVE		
Centre two rows of head-retaining setbolts*	150	203
All other head-retaining setbolts and nuts*	130	176
Rocker pedestal setbolts	30	40.7
Tappet screw locknuts	30	40.7

** Applicable to 4- and 8-cylinder engines only. For 6-cylinder engines refer to Chapter 3, Section 2.*

CYLINDER HEADS, 4-VALVE (Mk. IV)		
All head-retaining setbolts	175	237
Oilway stud nuts	130	176
Rocker pedestal nuts and setbolt	45	61
Valve bridge screw locknut	30	40.7
Tappet screw locknut	30	40.7
FLYWHEEL HOUSING, BOLTS TO CRANKCASE	45	61
HYDRAULIC PUMP DRIVEGEAR NUT	50	68
INJECTION PUMP		
Camshaft hub nut, Bosch 'PE8P'	80	108
Camshaft hub nut, C.A.V. 'NN'	40	54
Camshaft hub nut, C.A.V. 'Majormec'	85 to 90	115 to 122
Camshaft hub nut, Simms 'BN'	35	47
Pump-to-mounting bolts, 'Majormec'	30	40.7
Spring drive bolts and nuts, $\frac{3}{8}$ inch, all pumps	35	47
INJECTOR NOZZLE CAPNUT	50	68
INJECTOR FLANGE NUTS (2-VALVE)	8.5	11.5
INJECTOR CLAMP NUT (4-VALVE Mk.IV)	30	40.7
LUBRICATING OIL FILTERS (PARALLEL FLOW)		
Central bolts, retaining bowls to header	20	27
LUBRICATING OIL PUMP DRIVEGEAR NUT	50	68

	lbf. ft.	Nm
MAIN BEARINGS, 4-CYLINDER		
Front, centre and rear bearing nuts	160	217
Intermediate bearing nuts	200	271
MAIN BEARINGS, 6-CYLINDER		
Front, centre and rear bearing nuts*	160	217
Intermediate bearing nuts	200	271
Lateral setbolts	70	95

** On external capnuts at front and rear of crankcase this torque is obtained by using extension spanner GA.21 at 140 lb.ft. (19.4 kg.m.).*

MAIN BEARINGS, 8-CYLINDER		
Front, centre and rear bearing nuts	200	271
Intermediate bearing nuts	320	434
Lateral setbolts	70	95
SEAWATER PUMP DRIVEGEAR NUT (JABSCO)	45	61
SUMP		
Insert for drain plug	225 to 250	305 to 339
Drain plug in insert	80 to 85	108 to 115
SUPERCHARGER DRIVES		
Coil-spring drive: Bearing retaining nut	100	135.5
Quillshaft drive: Quillshaft nut	80	108.5
TURBOCHARGER		
'V' band nut, Holset 4LE and 4LEK	10	13.5

CHAPTER 2 — OPERATING

PREPARING A NEWLY-INSTALLED UNIT

NOTE: Before a new or completely re-conditioned 'C' range or SF65C engine leaves the Factory it is fully run-in and tested, the cylinder head setbolts are re-torqued and tappet clearances reset. Instructions for running-in 'short engines' and engines repaired in service are given in Workshop Manual T.S.D. 803.

1. Remove all wrappings and blanks, with special attention to the crankcase breather. Refit any components removed for storage and transport purposes.

2. Check that drain cocks are closed and fill the system with approved coolant (see leaflet T.S.D.3085 in rear cover pocket) to approximately 3 inches (76mm) below the top of the filler neck, unless otherwise instructed by the Installation Manufacturer. Engine capacities, excluding radiator and pipework, are given in Chapter 1, 'Data'.

3. Check that the crankcase sump drain plug is secure. On later engines this plug is tightened to between 80 and 85 lbf. ft. (108 and 115 Nm) and wire-locked to its adaptor. Fill the sump to the upper mark on the dipstick (fig. 1), using a suitable grade of approved oil (see leaflet T.S.D.3085 in rear cover pocket). Sump capacities are listed in Chapter 1, 'Data'.

4. Iso-Speedic overspeed trip unit—check oil level, lubricate shutdown linkage and ensure that it operates freely. Set the unit to RUN by pulling the setting lever fully back. See Chapter 3, Section 5, 'Fuel System'.

5. Turbocharged engines—prime turbocharger bearings by injecting $\frac{1}{3}$ pint (0.2 litre) of clean engine lubricating oil at the filler on the turbocharger bearing housing (fig. 2).

6. Oil-bath air cleaners—fill the bowls to the LEVEL mark with clean engine lubricating oil. See Chapter 3, Section 7, 'Induction System'.

7. Prime the injection pump (and mechanical governor, if fitted) with engine lubricating oil as follows, according to type:

   C.A.V. 'NN' (fig. 3). If lubricated from the engine system, pour $\frac{1}{3}$ pint (0.2 litre) each into the governor and pump via their filler points (Items 1 and 2). If not lubricated from the engine system, fill the governor and pump to the level of their plug or pigtail pipe (Items 4 and 7). These pumps have a cambox drain plug (Item 6).

   C.A.V. Majormec (fig. 4). Pour $\frac{3}{4}$ pint (0.4 litre) into the pump and governor via the filler plug on the cambox cover (Item 1). Excess oil will drain to the sump via the return pipe on the governor rear face. This pump has a cambox drain plug (Item 4).

   Bosch PE (fig. 5). Pour or inject $\frac{1}{2}$ pint (0.3 litre) each into the governor and cambox via their fillers (Items 1 and 2). This pump has no cambox drain plug.

8. Fill the fuel tank with an approved grade of fuel (see leaflet T.S.D.3085 in rear cover pocket). Turn on the fuel cock and vent the fuel system components in the following order: Primary filter; main filters; injection pump; hydraulic governor (if fitted); high pressure pipes. Details are given in Chapter 3, Section 5, 'Fuel System'. The feed pumps have hand-operated devices for this purpose; an external lever on C.A.V. pumps (fig. 3, Item 5 and fig. 4, Item 5), and a plunger on the Bosch pump (fig. 5, Item 3). It is important to screw down the Bosch pump plunger finger-tight after use.

9. Lubricate all controls and check that they operate freely throughout their full range.

10. With the STOP control operated, motor the engine on the starter until oil pressure registers on the gauge.

Preparation for starting

1. Check that coolant level is approximately three inches (76mm) below the top of the filler neck. Top up, if necessary, with coolant to the same specification and strength as already in the system.
2. Check oil level in engine sump (fig. 1). Top up, if necessary, to upper mark on dipstick, with *engine stopped unless otherwise indicated on* filler cap. Do not mix brands or types of oil.
3. Turbocharged engines—if the engine has not been run for a month or more, prime the turbocharger bearings with 1/3 pint (0.2 litre) of clean engine oil at filler pipe on bearing housing (fig. 2).
4. Check level of fuel oil in tank. Turn on fuel cock, if fitted.
5. Prime injection pump by operating feed pump manually (**C.A.V.**: fig. 3, Item 5 and fig. 4, Item 5. **Bosch**: fig. 5, Item 3). Ensure that the Bosch pump plunger is screwed down finger-tight after use.
6. Air starter—check reservoir pressure. Maximum 150 lbf./sq. inch (1034 kN/sq. m.). See Chapter 3, Section 3 'Auxiliary Equipment'.
7. Hydraulic Starter—check accumulator pressure. Normal maximum 4250 lbf./sq. inch (29,303 kN/sq. m.). See Chapter 3, Section 3, 'Auxiliary 'Equipment'.
8. Cold ambient temperatures:
   (a) Excess fuel button—press and release (Fig. 6, C.A.V. 'NN' pump with Woodward or mechanical governor; fig. 7, C.A.V. 'NN' pump with hydraulic governor; fig. 8, C.A.V. Majormec pump with mechanical governor; figs. 9 or 10, Bosch pump with mechanical governor).

   Note: The excess fuel device must only be used by itself. If operated in conjunction with another cold starting aid the extra fuel could make starting more difficult.

   (b) 'Start Pilot' carburettor (where fitted)—*insert capsule, depress piercer cap, allow* capsule to empty. Repeat as required to maximum capacity of 4 capsules, generally sufficient for minus 22 deg. C (minus 8 deg. F), but using no more than necessary. Operate hand pump steadily during cranking and continue until engine reaches self-sustaining speed. See Chapter 3, Section 3, 'Auxiliary Equipment'.
9. Switch on engine protection devices, if applicable.
10. Operate 'Energise to run' button, if applicable.

Starting

Move speed control lever to MAX SPEED position. Operate starter button, and release when engine fires and reaches self-sustaining speed. Return *speed control lever to IDLE position, and if possible* run the engine at 600 to 800 r.p.m. until full operating oil pressure is registered on the gauge.

Note: Do NOT exceed 20 seconds continuous cranking when using an electric starter, and pause before making another attempt. On all starter systems investigate the cause after four unsuccessful attempts (see Chapter 4, 'Fault Diagnosis').

ROUTINE STOPPING

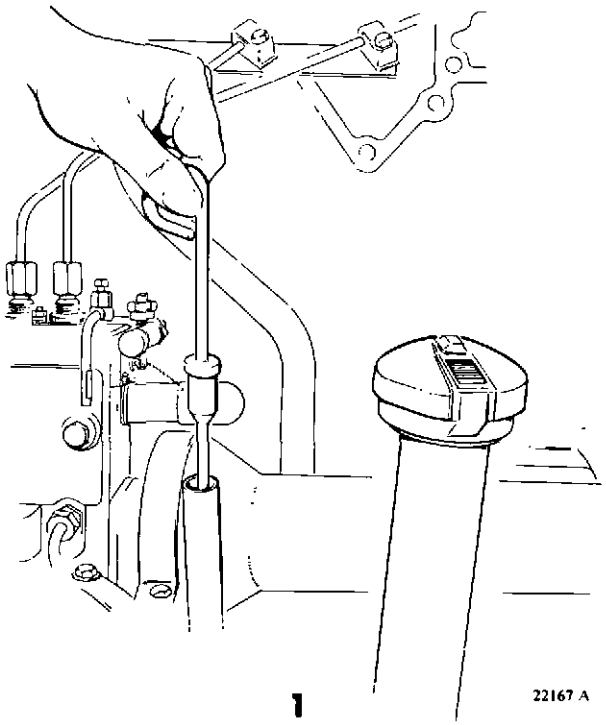
Caution: Before shutting down a turbocharged engine, allow turbocharger to cool by running engine under no load (at 600 to 800 r.p.m. if possible) for three minutes.

Single lever control

Move speed control lever to IDLE and then further to the STOP position, overcoming the spring-loaded idling stop.

Two-lever control

Move speed control lever to IDLE and then operate the STOP control.



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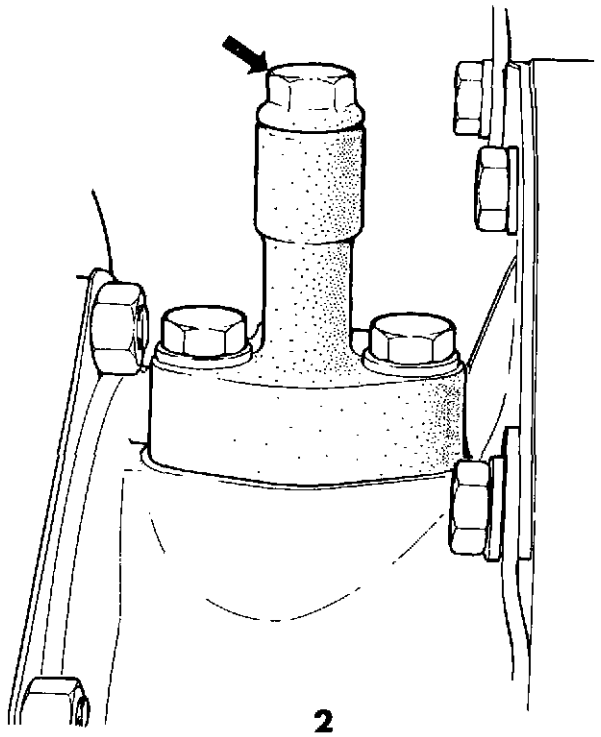

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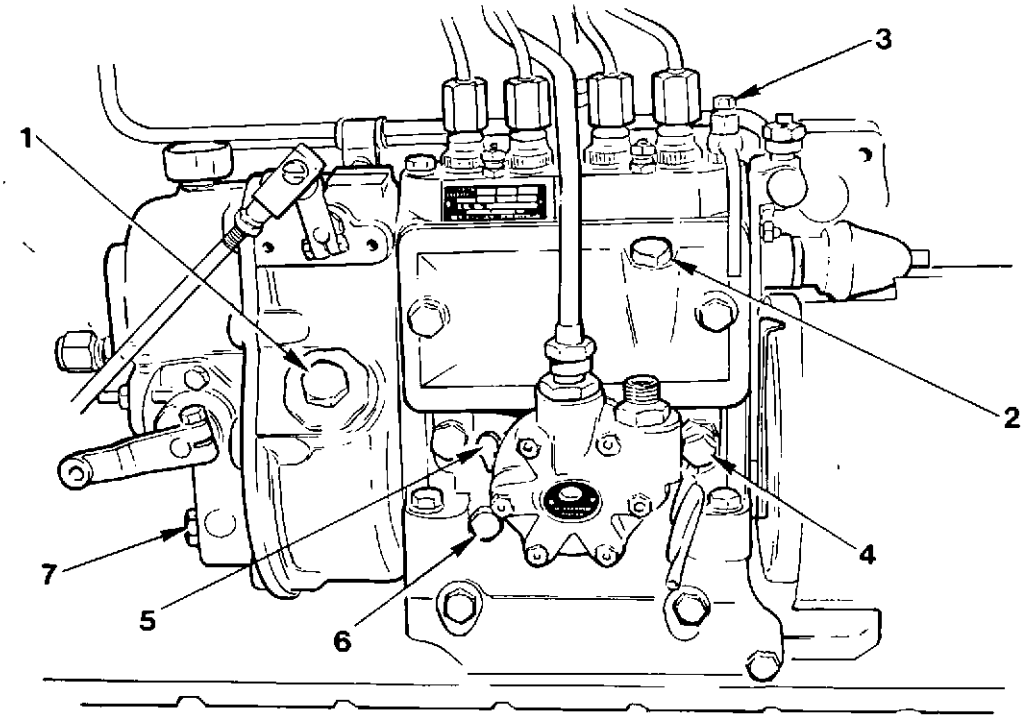

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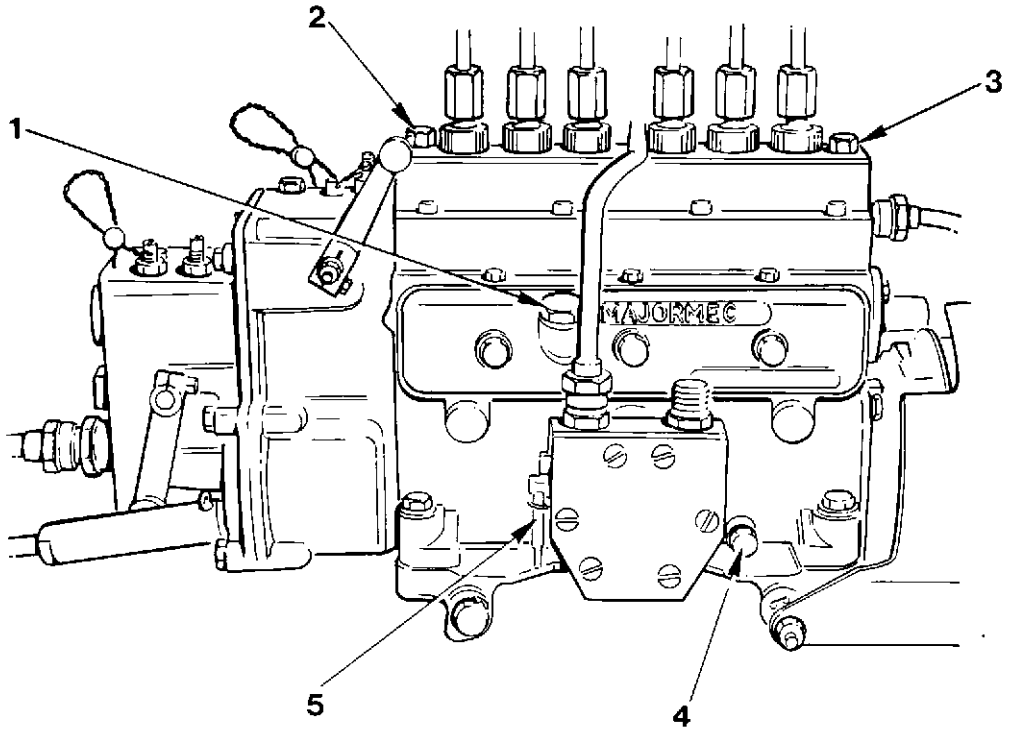

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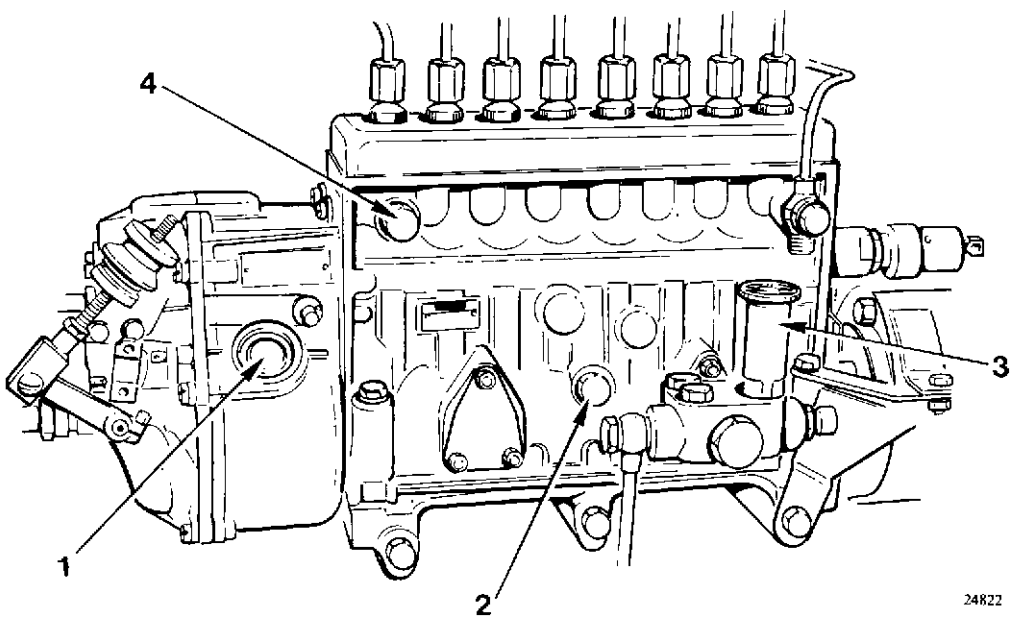

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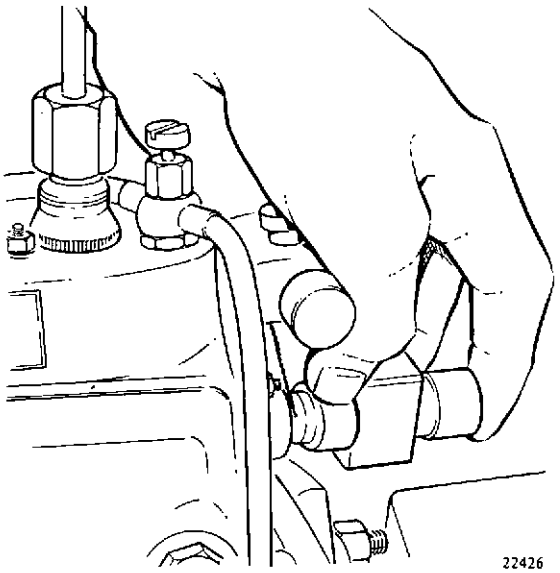

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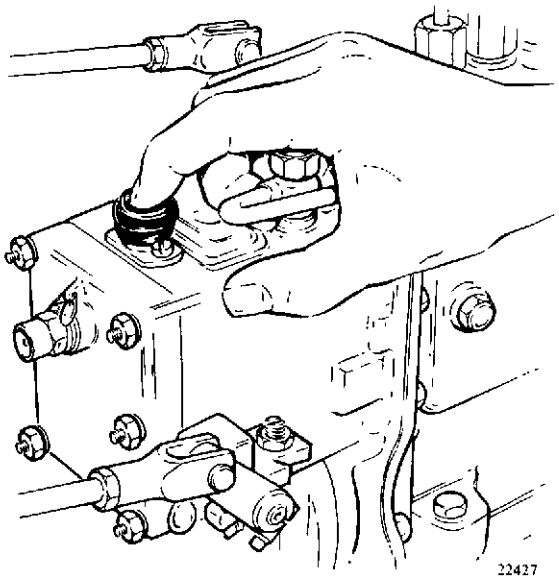

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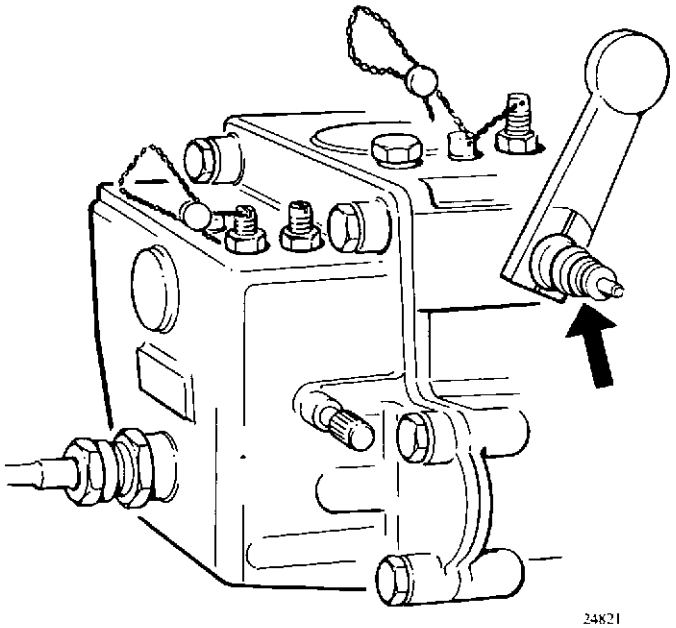

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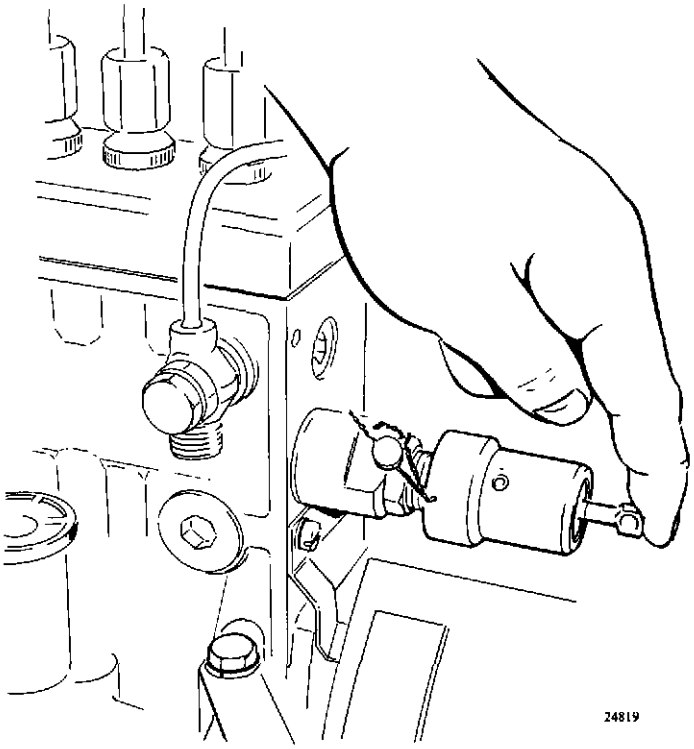

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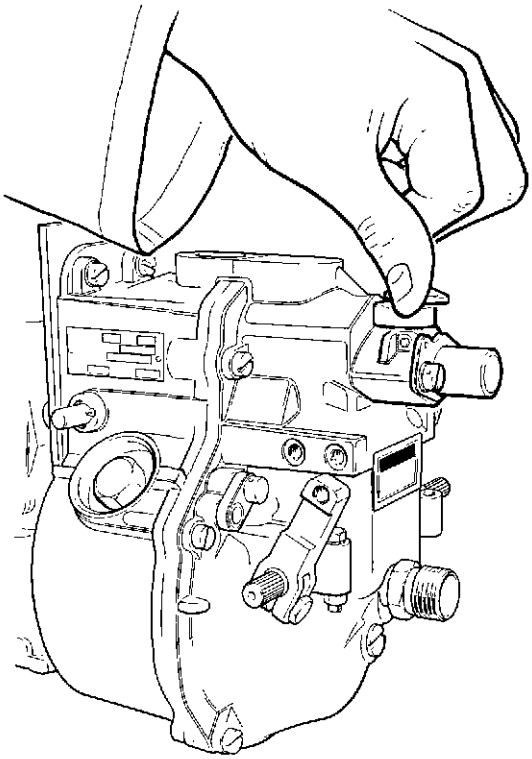

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CHAPTER 3 — SERVICING

CONTENTS

SECTION 1 — SERVICING SCHEDULES

IMPORTANT NOTES

1. In addition to the servicing operations in the following Schedules, make regular checks to ensure that the oil, fuel, coolant, induction and exhaust systems are free from leaks.
2. If experience on a particular installation indicates the necessity for amendment of the Servicing Schedules, consult the Service Department of Rolls-Royce Motors Limited.
3. Engines under Guarantee must be serviced in accordance with the Servicing Schedules, unless otherwise agreed with Rolls-Royce Motors Limited.
4. 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 also seriously reduce engine life and performance.

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 r.p.m. rating stamped on its data plate. The E.S.C. may be mounted on the wheelcase (fig. 1), or on the rear face of the Iso-Speedic overspeed trip unit (fig. 2).

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

Lubrication system

Check oil level, with engine stopped (or idling, if specified on filler cap). If necessary, fill to upper mark on dipstick, using oil of the same grade and specification as that already in the system. 6

Cooling system

Check that coolant level is approximately three inches (76 mm.) below the top of the radiator filler. Top up, if necessary, with coolant of the same type as that already in the system.

Warning: Take care when removing filler cap on a hot engine. 4

Fuel system

If applicable, rotate knob of primary filter at least one complete turn. 5

Induction system

Check air restriction indicator, if fitted, and service air cleaner immediately if red sleeve is showing. Subject to this, the periodicity of the following air cleaner servicings may be extended to a maximum of 100 E.S.C. units if operating conditions permit:

Oil bath cleaner — service element, and change oil in bowl.

Two-stage cylone type cleaner — empty dust bowl.

Paper element cleaner—service or renew element. 7

Power take-off

Grease clutch thrust bearing (for recommended grease, see Chapter 1, 'Data'). Do NOT overgrease, or clutch plates may be contaminated. 9

Every 100 E.S.C. Units

Power take-off

Grease output shaft bearing, pilot bearing and cross-shaft bearings (for recommended grease, see Chapter 1, 'Data'). Do NOT overgrease. 9

Refer to Section

Air starter (Ingersoll-Rand)
Drain water trap. Clean air filter. Replenish air-line lubricator (or lubricator incorporated in starter motor, as applicable), using engine lubricating oil.

Note: The frequency of this servicing may be varied to suit operating conditions. 9

Driving belts
Check tension, and adjust if necessary. 2

Every 200 E.S.C. Units
Lubrication system
Drain, whilst hot, and refill with fresh oil. Renew filter elements. Service element of crankcase breather. 6

Cooling system
Check specific gravity of anti-freeze mixture. Check pH value of coolant. 4

Fuel system
Drain water from primary and main filter bowls.
For fuel pumps not lubricated from engine oil system — drain cambox, and refill with engine lubricating oil.
For mechanical governors not lubricated from engine oil system — top up with engine lubricating oil. 5

Turbocharger
Check for security. 7

Every 600 E.S.C. Units
Fuel system

Check tightness of injection pump drive-shaft bolts. Torque loading 35 lb. ft. (47 Nm).

Primary filter: dismantle and clean.

Parallel-flow main filters: renew elements, unless servicing interval has been extended. (See 'FUEL FILTER SERVICING INTERVALS' at end of Schedule).

'Spin-on' filter: renew canister.

Changeover filters: change to unused bowl, and renew element in used bowl. 5

Every 1,200 E.S.C. Units
Fuel system
Check injection pump timing. 5
Service or renew injectors. (**Note:** Combine this operation with tappet check). 5
Check oil level and operation of overspeed trip unit (engines with Woodward governors) 5

Turbocharger
Remove induction trunk. Spin rotor and check for rubbing and bearing wear. 7

Tappets
Check clearances, and adjust as necessary. 2

Starter (Bryce)
Clean oil filter, and check operation of rack and pinion. Dependent on usage, more frequent servicing may be found necessary. 3

Every 2,400 E.S.C. Units
Cylinder heads
Check tightness of holding-down setbolts and nuts, before checking tappet clearances. 2

Air compressor
Overhaul, or fit replacement unit. —

Alternator
Grease drive end bearing of Type AC7. Clean slip ring and check brushgear (Types AC5 and AC7). 8

Every 3,600 E.S.C. Units
Top overhaul
Carry out on 2-valve head engines. Refer to Workshop Manual, T.S.D. 803, for details. —

Every 4,800 E.S.C. Units
Top overhaul
Carry out on 4-valve head engines. Refer to Workshop Manual, T.S.D. 803, for details. —

Fuel system
Calibrate and service injection pump, or fit reconditioned pump. —

Holset coupling
Dismantle for inspection and overhaul. 9

Refer to Section

Every 6 Months

Automatic warning system

Check operation of Drayton or Teddington switches 8

Every 12 Months

Cooling system

Drain system immediately after shutdown. Flush with clean water, and renew coolant. 4

FUEL FILTER SERVICING INTERVALS

The servicing interval of 600 E.S.C. Units may safely be used for all 'C' range and SF65C engines.

However, where these engines are fitted with C.A.V. **parallel-flow** fuel filters of the 'bowl-less' or 'expendable paper element' type the servicing interval may be extended in accordance with the following recommendations:

Every 600 E.S.C. Units

All engines over 350 b.h.p.

Engines from 250 to 350 b.h.p. with twin fuel filters.

Every 800 E.S.C. Units

Engines from 200 to 250 b.h.p. with twin fuel filters.

Engines from 250 to 350 b.h.p. with triple fuel filters.

Every 1,000 E.S.C. Units

Engines up to 200 b.h.p. with twin fuel filters.

Engines from 200 to 250 b.h.p. with triple fuel filters.

Every 1,200 E.S.C. Units

Engines up to 200 b.h.p. with triple fuel filters.

ENGINES IN INTERMITTENT USE

For engines in this category (e.g. those powering fire pumps and emergency generating sets), which are in use for an aggregate 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:

Refer to Section

Weekly

Check lubricating oil level, and replenish as necessary to upper mark on dipstick. 6

Check coolant level, and replenish as necessary to three inches (76 mm.) below top of radiator filler. 4

Monthly

Check pH value and, where applicable, specific gravity of coolant. 4

If engine has not been run during the month, prime turbocharger bearings (Chapter 2).

6-Monthly

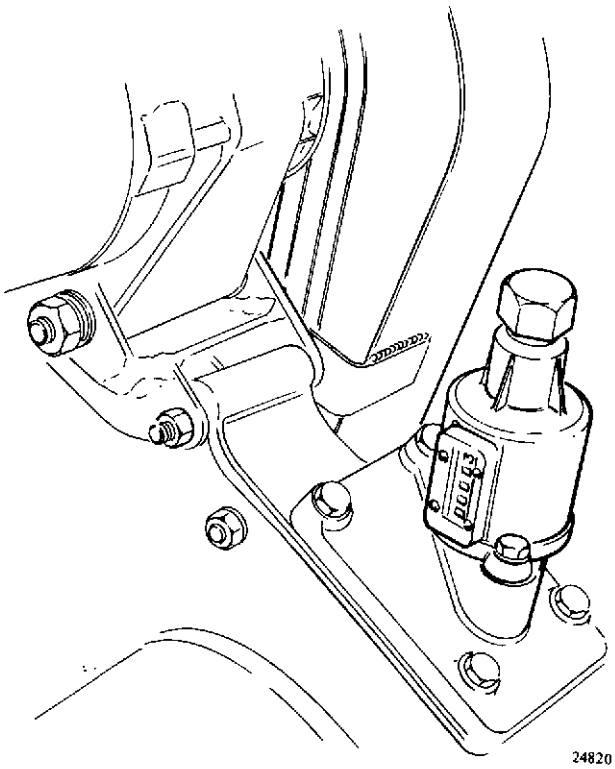
Change engine lubricating oil, and renew oil filter elements. 6

Check oil level and operation of overspeed trip unit (engines with Woodward governors). 5

12-Monthly

Remove fuel injectors, inspect for corrosion, and check on test rig. Service or renew as necessary, refit, and vent high-pressure fuel system. 5

Drain and flush cooling system. Refill with appropriate coolant.



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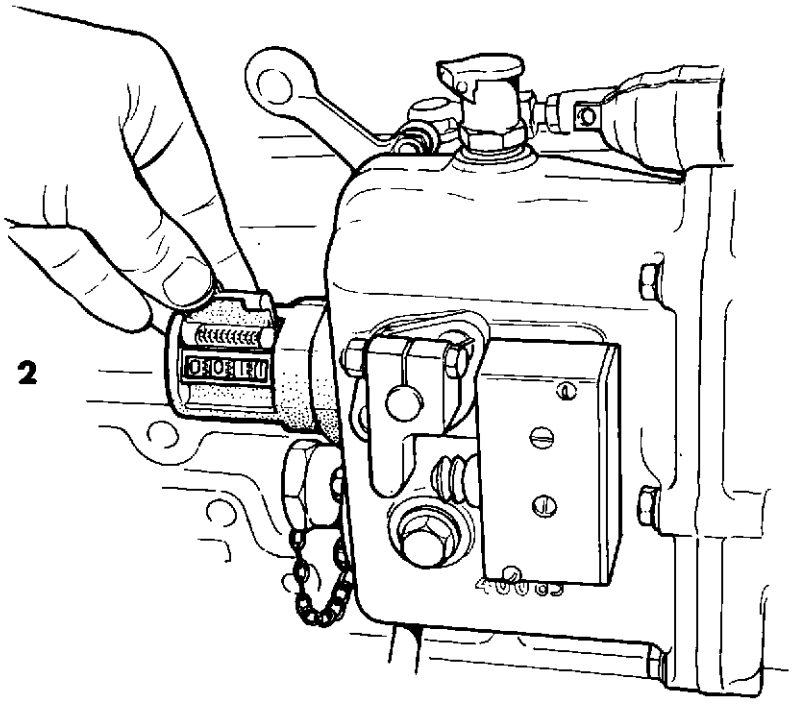

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SECTION 2 — ADJUSTMENTS

DRIVING BELTS

On SF65C and vertical 'C' range engines the coolant pump, radiator fan and alternator are belt-driven from a pulley at the front of the crankshaft. On horizontal 'C' range and earlier SF65C engines the coolant pump is gear driven.

Auxiliary components (e.g. air compressor, hydraulic pump, torque converter charge pump), where fitted, are belt driven from a pulley on the compounder shaft or from an additional groove on the coolant pump pulley. An extra pulley may also be fitted to the crankshaft nose to drive a power take-off.

Two makes of 'Alpha' section belt, Fenner and Rofan respectively, are currently used. These have different stretch characteristics and must *not* be mixed in a multi-belt drive.

To adjust main belt tension (fig. 1), slacken the alternator bolts (arrowed) and swivel the alternator until *on each belt* the deflection inwards at mid-point of the longest run is ½-inch (12mm) under the appropriate pressure, as follows. Tighten the bolts and re-check the tension.

Fenner 'Alpha'
7 to 8 lbf. (31 to 36 N.)
Rofan 'Alpha', Fenner 'A', Rofan 'A'
8.5 to 9.5 lbf. (38 to 42 N.)

For short belts driving other components a thumb pressure deflection of 5/32 inch (4mm) per 10 inches (250mm) between pulley centres is suitable.

Note: Always renew belts in sets, to ensure that an equal load is taken by each belt.

ENGINE TURNING DEVICE

This device is fitted to those engines which have no barring pulley, and is mounted on the flywheel housing (fig. 2). It consists of a gearwheel on a hexagon-headed shaft, and can be meshed with the teeth of the flywheel starter ring when pulled outwards into the 'engaged' position as shown in the illustration.

To rotate the engine in its normal direction, fit a 5/8 inch A/F spanner to the hexagon and turn the gearshaft in the direction of the arrow. The gear is designed to disengage if turned in the opposite direction, but it is possible to turn the engine backwards slightly (e.g. to take up backlash when checking injection timing) by holding the gearshaft out whilst turning it against the direction of the arrow.

After use, disengage the gearwheel from the flywheel starter ring by pushing the gearshaft into the housing until it is retained by its spring-loaded detent.

VALVE TAPPET ADJUSTMENT

If cylinder head torque-tightening is due, this work should be carried out before tappet clearances are checked (see later in this Section).

To save time and effort when checking tappet clearances, use the appropriate sequence from the table and carry out the work whilst the injectors are removed for servicing. The term 'Valves rocking' means 'exhaust valve just closing; inlet valve just opening'.

4-cylinder		6-cylinder		8-cylinder	
Valves rocking on	Adjust tappets on	Valves rocking on	Adjust tappets on	Valves rocking on	Adjust tappets on
No. 4	No. 1	No. 6	No. 1	No. 8	No. 1
No. 2	No. 3	No. 3	No. 4	No. 3	No. 6
No. 1	No. 4	No. 5	No. 2	No. 7	No. 2
No. 3	No. 2	No. 1	No. 6	No. 4	No. 5
		No. 4	No. 3	No. 1	No. 8
		No. 2	No. 5	No. 6	No. 3
				No. 2	No. 7
				No. 5	No. 4

Valve tappet clearances for all engines are given in Chapter 1, 'Data'.

Remove rocker covers, and secure the injection pump control in the NO FUEL position.

Turn the engine in the normal direction of rotation until the valves over the rear cylinder are 'rocking'. The No. 1 piston will then be near TDC on compression stroke, with No. 1 cylinder valves fully closed.

2-Valve head engines

Slacken the inlet rocker arm screw and insert the appropriate feeler gauge between the rocker arm pad and the valve stem tip (fig. 3). Adjust the screw and tighten the locknut to 30 lbf. ft. (41 Nm).

Repeat the operation for the exhaust valve rocker arm, using the correct feeler gauge.

Re-check each tappet clearance before proceeding to the next unit.

4-Valve head Mk. IV engines

Slacken adjusting screws on rocker arms and valve bridges. In turn, press on each bridge piece (fig. 4), adjust the screw until it *just* touches the valve stem tip, turn it *clockwise* ⅙ turn and tighten its locknut to 30 lbf. ft. (41 Nm).

Set the valve tappet clearances by inserting the appropriate feeler gauge between the rocker arm pad and the contact face of the bridge piece (fig. 5), over each pair of valves. After positioning the adjusting screws, torque tighten the locknuts to 30 lbf. ft. (41 Nm).

Re-check the clearances before proceeding to the next unit.

CHECKING VALVE TIMING

Remove the timing pointer cover, marked 'T', from the flywheel housing. Remove both rocker covers on a 2-valve head engine, or the front and rear rocker covers on a 4-valve head Mk. IV engine. Turn the engine in its normal direction of rotation until the valves of the rear cylinder are 'rocking' i.e. exhaust just closing, inlet just opening.

Set No. 1 cylinder inlet tappet clearance to 0.035 inch (0.89 mm) and turn the engine in its normal direction of rotation until a 0.005 inch (0.13 mm) feeler gauge is just nipped by the No. 1 inlet valve rocker. The inlet valve opening mark 'V.1' on the flywheel should now be in line with the timing pointer.

If satisfactory, reset the No. 1 cylinder inlet tappet to its correct running clearance (see Chapter 1—'Data'), and refit the rocker covers and timing pointer cover.

REFITTING CYLINDER HEADS

2-Valve head engines

Clean the joint faces but do *not* remove the anti-corrosion coating from the gaskets. Fit the large coolant bobbins to the crankcase and assemble the gaskets, corrugations uppermost, to their rollpins. Then fit the small bobbins. Screw in a guide bar opposite each oilway stud and lower the heads into position.

Fit a hardened steel washer to each setbolt and stud, lightly oiling the washers and threads. Do *not* apply oil excessively, since it could accumulate in the blind bolt holes and cause hydraulic pressure when the bolts are tightened. Fit the bolts and nuts finger-tight, and align the heads by temporarily fitting the inlet manifold, without joints, and nipping its bolts.

In the appropriate sequence (fig. 6, 7 or 8) tighten down the cylinder heads as follows:

(a) All bolts and nuts to 50 lbf. ft. (68 Nm)
(b) All bolts and nuts to 100 lbf. ft. (135 Nm)
(c) *4- and 8-cyl. engines* All bolts and nuts to 130 lbf. ft. (176 Nm). Finally, tighten the centre two rows of bolts (black circles, fig. 6 or 8), in rising numerical order, to 150 lbf. ft. (203 Nm).

6-cyl. engines All bolts and nuts to 150 lbf. ft. (203 Nm). Finally, tighten all bolts in black circles (fig. 7), in rising numerical order, to 175 lbf. ft. (237 Nm).

Fit the pushrods and rocker gear, tightening the pedestal setbolts to 30 lbf. ft. (41 Nm), and adjust the tappets as described in this Section. Oil the valve gear before fitting the rocker covers.

After 10 to 20 E.S.C. units running time, check the tightness of cylinder head setbolts and nuts as described in this Section.

4-Valve head Mk. IV engines

NOTE: At manufacture the cylinder head height is within a tolerance of 0.005 inch from standard, and this is indicated by a figure, 0 to 5, stamped on a machined corner of the top flange. If metal has been removed from the flame face during reconditioning this figure should be amended accordingly. The maximum variation between heights of adjacent heads is 0.008 inch and if necessary the heads may be interchanged to avoid exceeding this limit.

Thoroughly clean all joint faces, fit coolant transfer and air escape bobbins, with new sealing rings, and position the steel gaskets with corrugated face uppermost. Place the cylinder heads in position, oil the setbolts and capnuts and fit them finger-tight. Clamp setbolts are fitted with spherical washers; all other setbolts with plain washers. Capnuts are not fitted with washers.

Align the cylinder heads by fitting the inlet manifold and nipping its setbolts. Where applicable, also fit the water-cooled exhaust manifold.

In the appropriate alphabetical or numerical sequence (see fig. 9, 10 or 11, as applicable) tighten the setbolts and capnuts as follows:

(a) All setbolts and capnuts to 50 lbf. ft. (68 Nm)
(b) All setbolts and capnuts to 100 lbf. ft. (135 Nm)
(c) All setbolts (black circles) to 175 lbf. ft. (237 Nm)
(d) All capnuts (white circles) to 130 lbf. ft. (176 Nm)

Fit the valve bridges, with a smear of graphite grease in each guide, and, with each cylinder in turn on compression, assemble the pushrods and rocker gear, tightening the pedestal nuts and setbolts to 45 lbf. ft. (61 Nm). Check that rocker arm pads do not foul the sides of valve bridges. Adjust the tappet clearances as described in this Section, and oil the valve gear before fitting the rocker covers.

After 10 to 20 E.S.C. units running time, check the tightness of cylinder head setbolts and capnuts as described in this Section.

TORQUE-TIGHTENING CYLINDER HEADS

This check must be made within 10 to 20 E.S.C. units running time following the fitting of a cylinder head, and thereafter at the intervals stated in the Servicing Schedule (see Section 1). On completion of torque-tightening, check the valve tappet clearances and adjust as necessary.

The spanners GA.613 (2-valve head) and GA.614 (4-valve Mk. IV head) enable torque-tightening to be carried out without disturbing the valve gear, except on certain 2-valve head engines with hollow push-rods. If the valve gear is removed, on re-assembly the pedestal bolts must be tightened to 30 lbf. ft. (41 Nm) for 2-valve heads, or 45 lbf. ft. (61 Nm) for bolts and nuts on 4-valve Mk. IV heads.

Remove the rocker covers, and valve gear if necessary. Wipe clean the setbolt heads, nuts, and the areas surrounding them. Pencil mark each setbolt head and nut, and make a corresponding mark on the cylinder head. In turn, slacken each setbolt and nut half-a-turn and re-tighten to the specified torque loading or until the pencil marks are aligned, whichever is the tighter.

Do NOT slacken more than one bolt or nut at a time.

Referring to fig. 6 to 11, the numbers or letters represent the setbolts and nuts, and the sequence in which they are tightened. The final torque-tightening values are as follows:

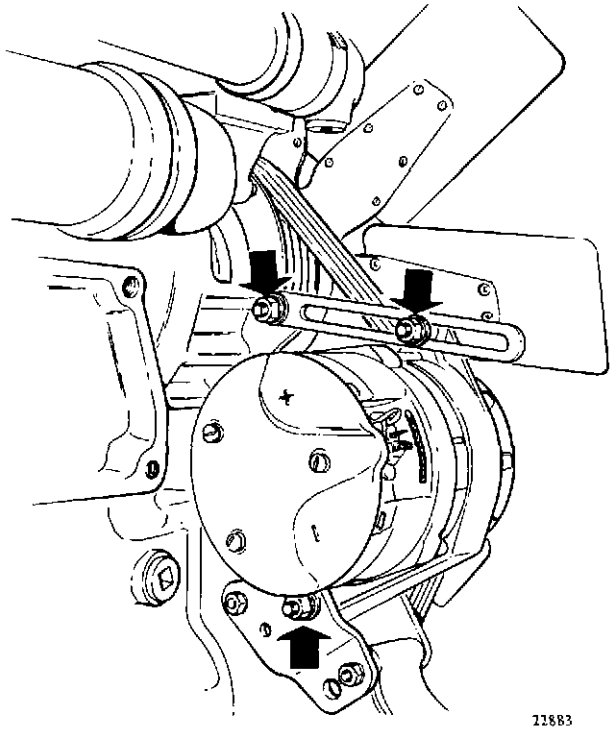
2-Valve head engines

4-cyl. (fig. 6) : 8-cyl. (fig. 8).
Numbers in white circles: 130 lbf. ft. (176 Nm)
Numbers in black circles: 150 lbf. ft. (203 Nm)

6-cyl. (fig. 7).
Numbers in white circles: 150 lbf. ft. (203 Nm)
Numbers in black circles: 175 lbf. ft. (237 Nm)

4-Valve head Mk. IV engines

Single head (fig. 9) : 6-cyl. (fig. 10) : 8-cyl. (fig.11)
Numbers (letters) in white circles: 130 lbf. ft. (176 Nm).
Numbers (letters) in black circles: 175 lbf. ft. (237 Nm).



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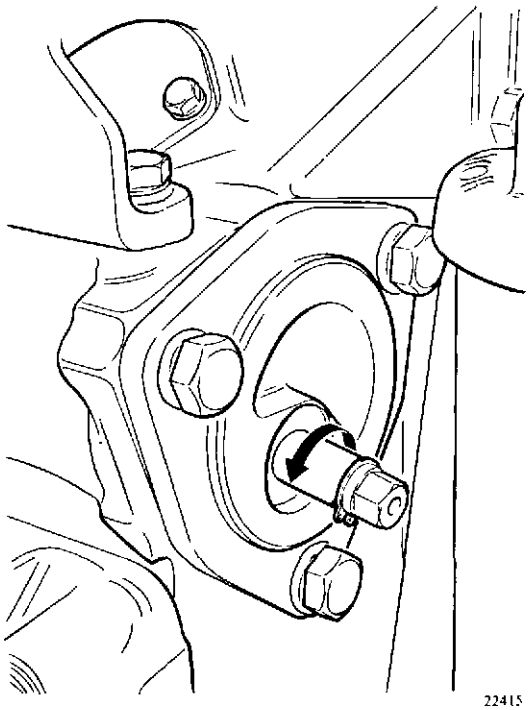

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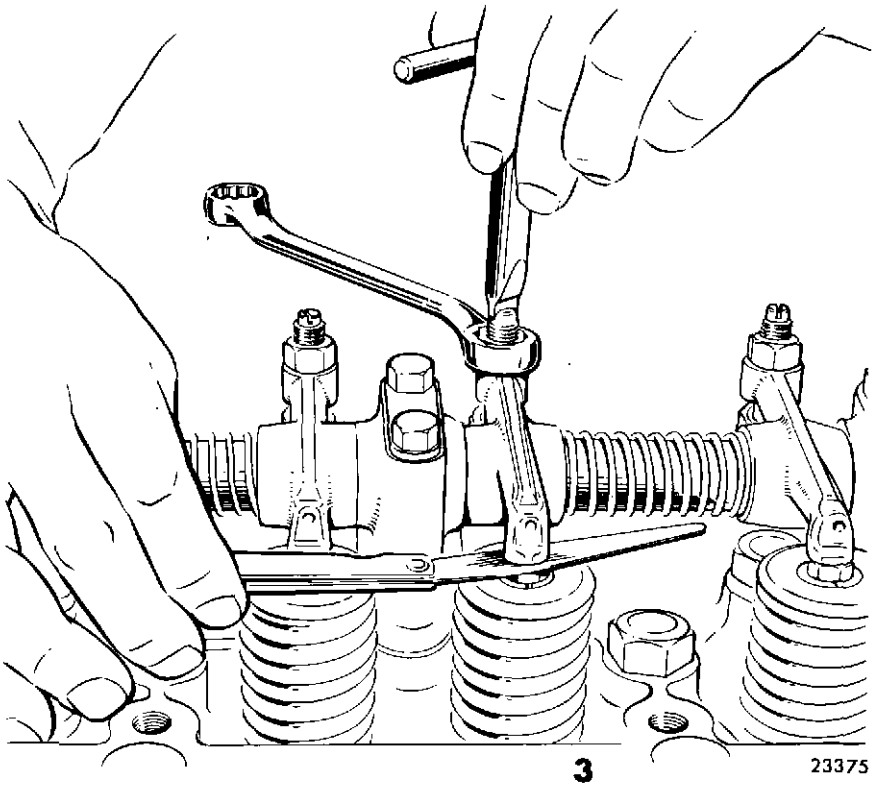

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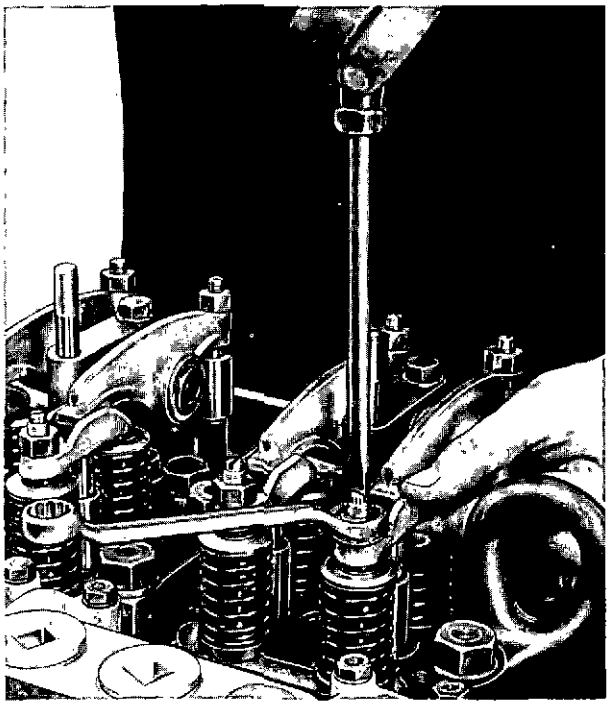

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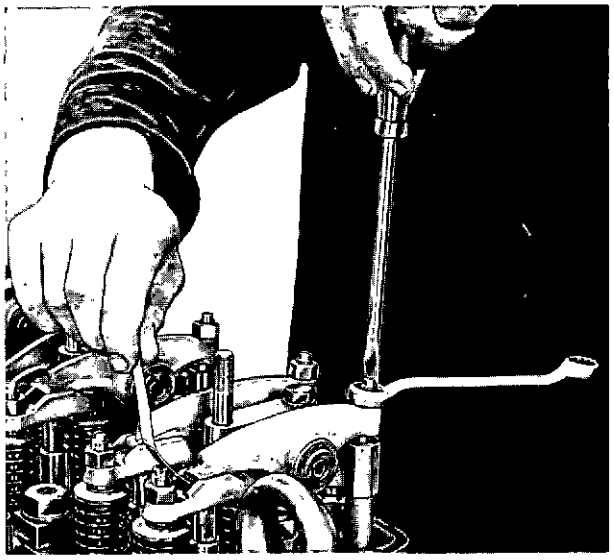

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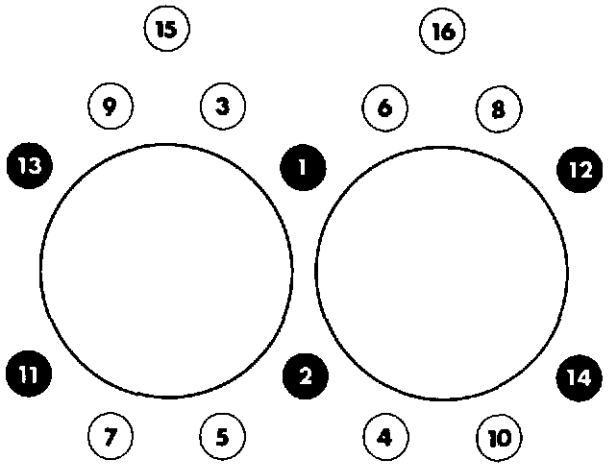

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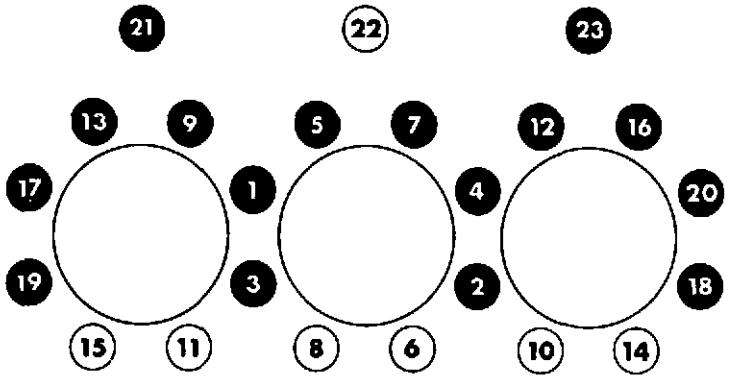

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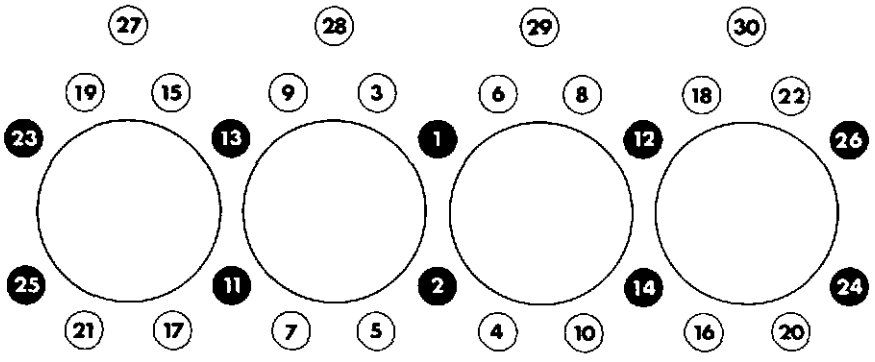

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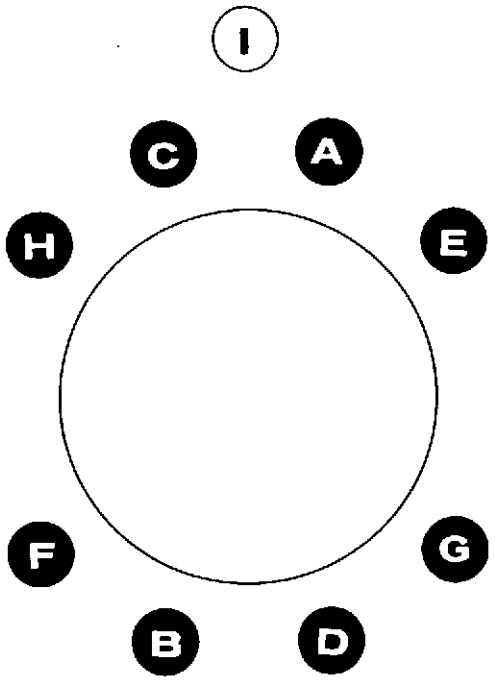

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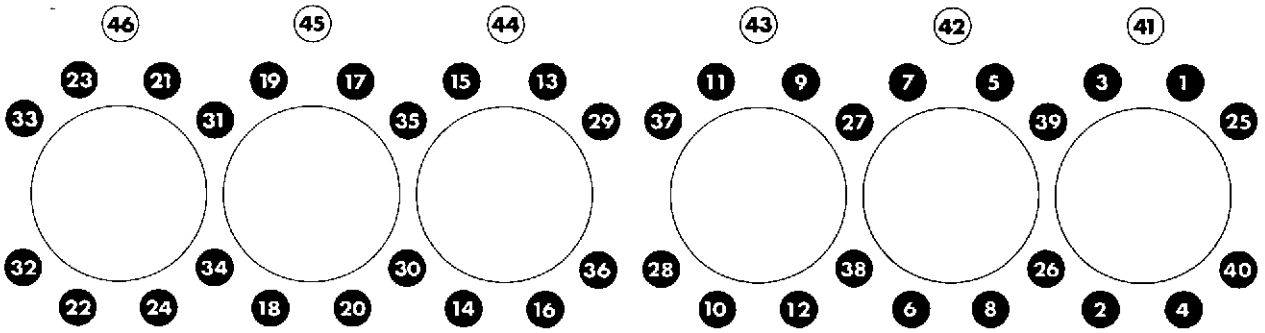

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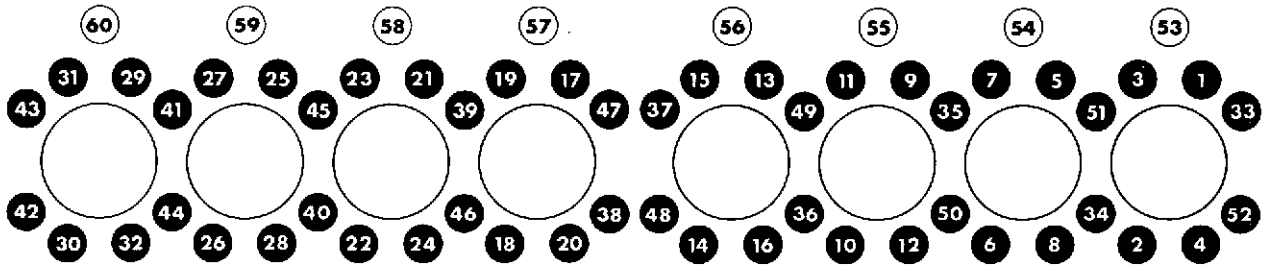

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SECTION 3 — AUXILIARY EQUIPMENT

AIR STARTER (INGERSOLL-RAND)

Description

The system (fig. 1) consists of a starter motor which is driven by air at 150 lbf/sq. inch (1034 kN/sq. m.), supplied from a reservoir via a pressure-reducing valve, filter/water trap, operating valve and, where specified, an airline lubricator.

The starter unit is an air-driven multi-vane motor, connected by reduction gearing to a Bendix drive which transmits the starter torque to the engine flywheel. Model 150BM starters are used for manually-controlled starting; Model 150BMP starters are used on engines which are unattended at start-up, and incorporate a device for engaging the Bendix gear with the flywheel starter ring before applying full air pressure to the motor vanes.

Operation

Open the air valve quickly, and hold it open until the engine fires and reaches self-sustaining speed. Then release the air valve quickly.

Servicing

This is confined to replenishment of the rotor vane lubricating oil and maintenance of the air filter/water trap. The servicing interval specified in the Schedule (Section 1) is for guidance and may be varied to suit operating conditions and frequency of use. It is emphasized, however, that inadequate servicing can result in seizure of the rotor vanes in their housing. When either form of lubricator is operating correctly a light oil mist is present in the starter exhaust.

1. Replenish the airline lubricator (1), fig. 1, if fitted, using engine lubricating oil.
   If no airline lubricator is fitted, inject the lubricating oil at the filler plug (2) on the end cover of the starter motor.
2. Empty the water trap (3) of the air filter bowl by opening its drain tap. This should be done, irrespective of other servicing, if the transparent bowl becomes filled with water.
3. Before cleaning the air filter, shut off the air supply. Remove the screw from the clamp ring securing the water trap carrier to the filter body. Rotate the carrier slightly, force it upwards, gently separate the clamp ring segments, and remove the carrier.
   Unscrew the deflector assembly from the filter body, remove the filter element, wash it in paraffin and dry with compressed air.
   When re-assembling the unit do not overtighten the deflector, or the element may be crushed. Apply silicone grease to the joint rings and their grooves.
   Turn on the air supply, and check for leaks.
4. The motor reduction gearcase is $\frac{1}{2}$ to $\frac{3}{4}$ filled with grease on assembly (see Chapter 1, 'Data') and should not require attention between overhauls.
5. The Bendix drive bearing in the starter nose is lubricated by a felt oiling pad. If the starter motor is temporarily removed for any reason the opportunity should be taken to soak this pad in engine lubricating oil.

HYDRAULIC STARTER (BRYCE)

Description

The system (fig.2) operates on the principle of two hydraulically-driven racks, meshed to a pinion which engages with the engine crankshaft. Lateral movement of the racks in opposite directions causes the pinion, and consequently the

crankshaft, to rotate for one revolution under power and approximately two further revolutions under momentum.

Hydraulic fluid is drawn from reservoir (1) by hand pump (2) and stored under pressure in accumulator (6), which is pre-charged with nitrogen at 2,800 lbf./sq. inch (19305 kN/sq. m.). For normal starting purposes a hydraulic pressure of 4,250 lbf./sq. inch 29303 kN/sq. m.), as registered on gauge (5), is adequate, but this may be increased to 5,000 lbf./sq. inch (34474 kN/sq. m.) for starting under very cold conditions.

Initial movement of the start lever (7) from A to B admits limited hydraulic pressure to the starting unit (3), and the two racks begin to move across the pinion, causing it to rotate and move rearwards into engagement with the crankshaft dog (4). Further movement of the start lever (7) from B to C admits full hydraulic pressure to the racks, driving them rapidly across the pinion and thus rotating the crankshaft at high speed.

When the engine fires and the start lever is released the pinion disengages from the crankshaft dogs and moves forward until it is retained by a spring-loaded detent. At the same time the racks are returned by their springs.

Operation

Check that the reservoir (1) is just over half-filled with hydraulic oil.

Operate the hand pump (2) until the pressure gauge (5) records 4,250 lbf./sq. inch (29303 kN/sq. m.), or 5,000 lbf./sq. inch (34474 kN/sq. m.) in very cold conditions.

Move the start lever (7) gently from A to B until resistance is felt as the starter dogs engage.

Move the lever firmly from B to C, and release when the engine fires.

Servicing

Periodically, check the system for leaks and rectify as necessary. If hydraulic oil is lost, replenish the reservoir, to just over half-full, using one of the approved oils listed in Chapter 1, 'Data'.

At the interval specified in the Servicing Schedule (Section 1), or more frequently if the usage of the starter dictates, carry out the following checks:

1. Remove and inspect the reservoir oil filter. Wash it in clean fuel, and refit.
2. Check the action of the starter unit racks and pinion as follows: Ensure that the oil pressure is fully discharged, and remove the front cover from the starter housing. Hold the start lever in position C (fig. 2) and operate the hand pump. The pinion should move slowly into engagement whilst rotating about ¾ turn. Release the start lever; the pinion should return freely, with an audible click from its spring-loaded detent. Failure to do so may be caused by dirt, hardened grease, or damage, and the unit should be removed for overhaul.

AIR COMPRESSOR

Servicing of Clayton Dewandre and Tu-Flo compressors is confined to periodic cleaning of the air filter (when fitted) and checking the cylinder head setbolts, air pipe unions and compressor mounting bolts for tightness. Overhaul the compressor, as described in the manufacturer's manual, at the intervals specified in the Servicing Schedule (Section 1).

Loss of pumping efficiency during service may be due to defective valves and springs, which may be serviced in the following manner:

Clayton Dewandre 15 c.f.m. models

If the cylinder head is water-cooled, drain the coolant system and disconnect the coolant pipes.

Shut off or release any air in the system, disconnect the air pipes and remove the cylinder head (fig. 3).

Unscrew the delivery valve caps (1) and remove the valves (2) and their springs. Use tool GA.265 to extract the inlet valve keepers (5), and remove the guides (4), springs, and inlet valves (3). Discard valves and springs, and clean all other components, including the delivery pipe.

Inspect the valve seats and, if necessary, reface them by lapping. The delivery valve seat may be unscrewed for lapping or renewal, using tool GA.86.

Use new valve discs and springs when re-assembling. Press the inlet valve keepers flush with the cylinder head face, and ensure that the delivery valve springs are fitted with their flared ends pressed fully home into the valve caps.

Refit the cylinder head, using a new joint, and tighten its setbolts evenly. Connect all pipes, and where applicable refill the coolant system.

Check cylinder head setbolts and pipe unions for tightness after a few hours' running time.

Tu-Flo 500

Instructions for servicing the valves are basically similar to those given for the Clayton Dewandre compressor. The inlet valve seats are pressed into the cylinder block, and the delivery valve seats are screwed into the cylinder head.

'START PILOT' CARBURETTOR

The carburettor (fig. 4) consists basically of a fluid reservoir, a diffuser, and a double-acting plunger pump by which a vaporised mixture of starting fluid and air is injected into the inlet manifold via an outlet connection (4). The number of fluid capsules required to effect a start will depend on the type of engine and the severity of the cold weather conditions. (See Chapter 2)

Operation

1. Prepare the engine for starting in the normal manner.
2. Remove capsule chamber cap (1) by turning it anti-clockwise, and pull piercer cap (2) fully out.
3. Insert a fluid capsule into the chamber, and refit the cap (1).
4. Push piercer cap (2) fully in, pause to allow capsule to empty, and repeat with further capsules as necessary. Then operate the pump (5) for two or three strokes.
5. Commence cranking the engine, and continue to pump steadily until the engine fires and reaches self-sustaining speed.

Servicing

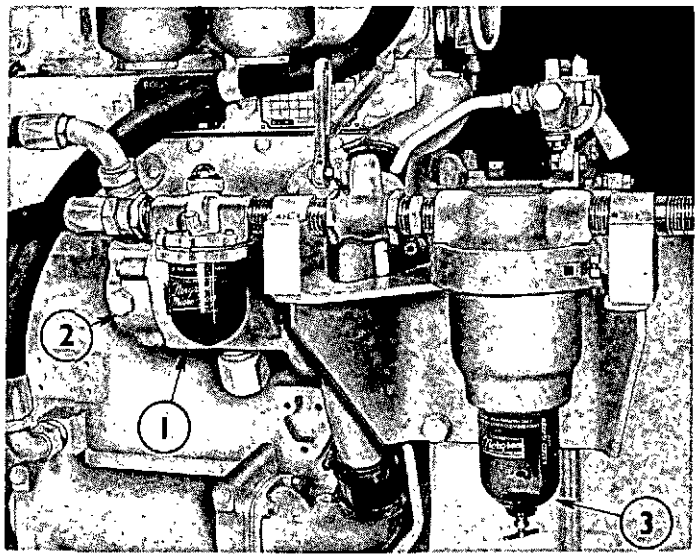
No routine servicing is required, but if the carburettor becomes inefficient the cause may be choked filters or dirt in the non-return valves.

To clean the air filters, unscrew capnut (6) and remove the plate and filters from the pump handle. Wash all parts in petrol, blow through with compressed air, and re-assemble. Note that the filters are fitted closed end outwards.

To clean the fluid filter, remove the diffuser plug (3), unscrew the diffuser jet beneath it, and remove the filter. Wash all parts in petrol, blow through with compressed air, and re-assemble.

Note that the closed end of the filter fits inside the diffuser jet.

Two non-return ball valves are fitted; one in the head of the pump piston chamber, which is located inside the pump casing, and the other in a holder (7) screwed into the carburettor body.



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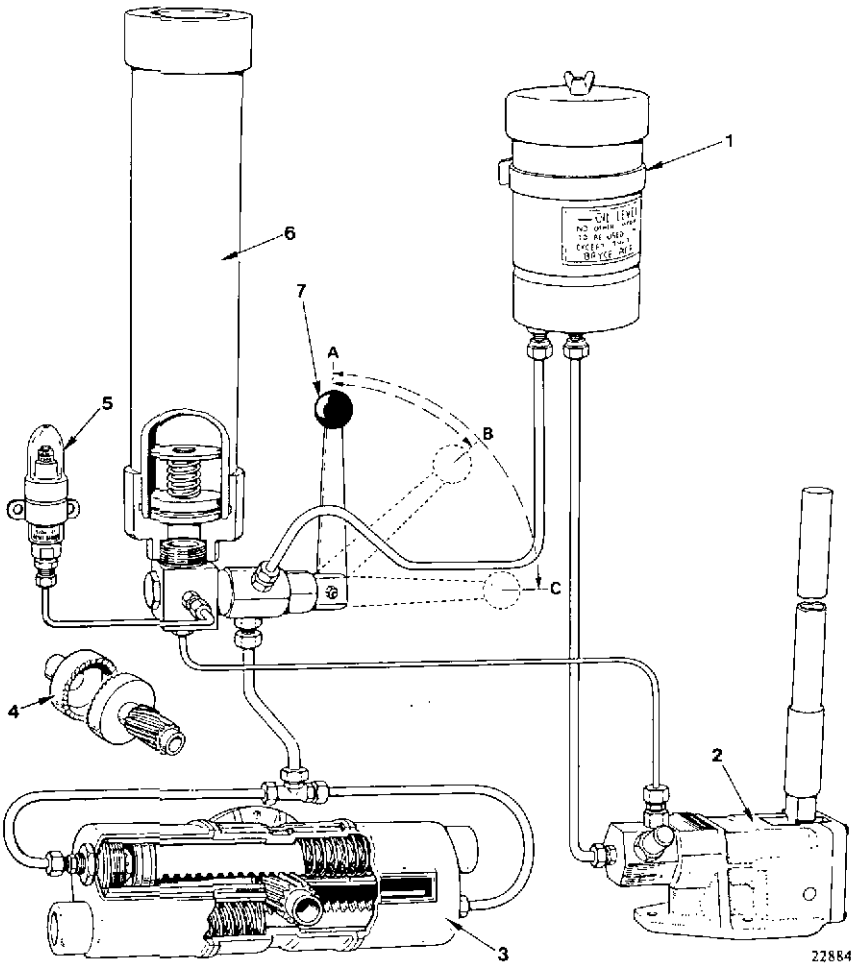

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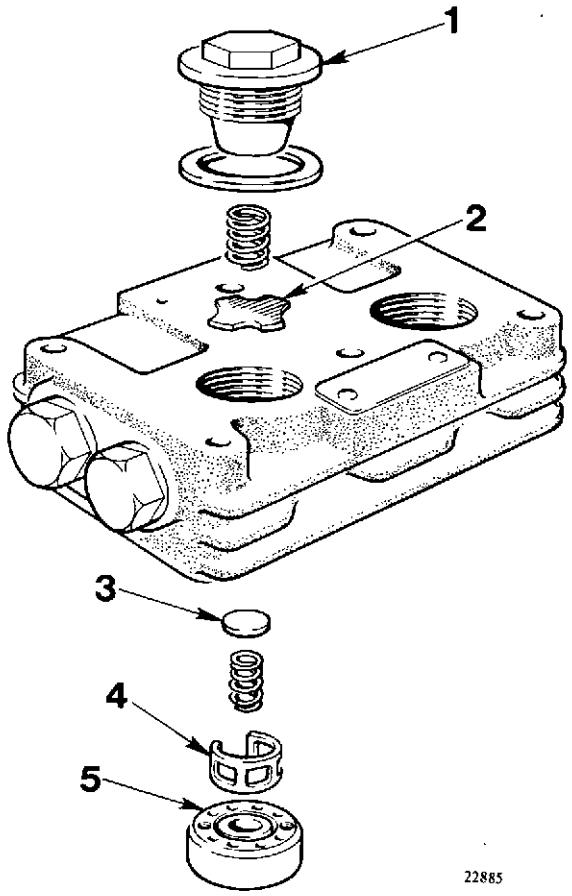

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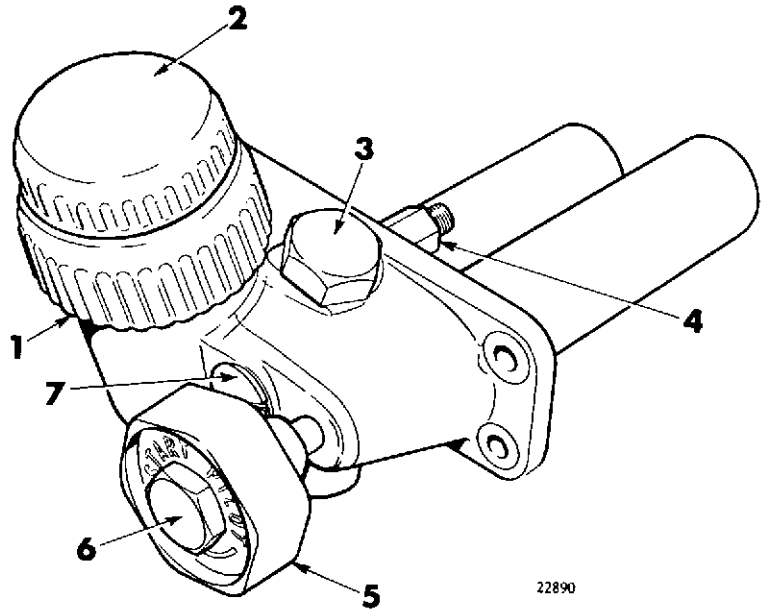

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SECTION 4 — COOLING SYSTEM

DESCRIPTION

Referring to fig. 1, coolant is drawn from the radiator by a centrifugal pump mounted at the front of the engine, and is delivered to the cylinder block inlet gallery either directly or via an oil-to-coolant heat exchanger. After circulating round the cylinder liners the coolant passes through transfer bobbins into the cylinder heads, where it circulates round the valves and injectors. On leaving the heads it joins a gallery pipe leading to the thermostat housing mounted above the coolant pump. If working temperature has not been reached the thermostat is closed and the coolant is re-circulated through the engine; at working temperature it passes through the thermostat to the radiator before returning to the pump.

COOLANT

(i) The coolant approved for use in all Rolls-Royce diesel engines 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.
The following mixtures will give protection against frost, down to the temperatures stated:

Anti-freeze/Water (% by volume)	**Protection down to:** deg. C. (deg. F.)
50/50	—35 (—31)
60/40	—40 (—40)

Anti-freeze mixtures supplied by most major chemical and Oil Companies are suitable, but the Operator is responsible for obtaining the Manufacturers assurance that the ethylene glycol or propylene glycol products they supply have an inhibitor 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 Rolls-Royce inhibitor, in the cooling system. This proportion is the equivalent of 0.5 litre of inhibitor to 50 litres (11 Imp. Galls.) of water. The inhibitor is obtainable in bottles under Rolls-Royce Part No's. OE 45141 (0.5 litre) and OE 45142 (1.0 litre), with instructions for use on the label of each bottle.

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

The inhibitor may also be added to anti-freeze mixtures to increase the level of inhibition, should the strength become low or depleted. Other advantages of the inhibitor are:

(a) It is non toxic.

(b) It contains a lubricant to help increase the life of coolant pump seals.

(c) Slight overdosing will have no harmful effects on cooling system components.

COOLANT CHECKS

The pH value and, where applicable, anti-freeze mixture specific gravity must be checked at the intervals stated in the Servicing Schedule (Section 1).

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 the ferrous metals to be attacked; alkalinity will affect the non-ferrous metals.

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 should be

within the range pH 7.5 to pH 9, and in any event 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 or inhibited glycol to the same specification as already in use. Alternatively, the system must be drained, flushed and refilled with new coolant.

Specific gravity

New anti-freeze solution should be mixed in a clean container, and its specific gravity measured with a suitable hydrometer and thermometer. Compare the readings with the graph (fig. 2) to ensure that mixture strength is adequate for the degree of protection required. This check is only suitable for ethylene glycol solution.

The same method should be used when checking a sample of anti-freeze mixture drawn from an engine in service.

ANTI-FREEZE

Anti-freeze blends are based on carefully balanced mixtures of several anti-corrosion inhibitors, each brand containing different inhibitor formulations. If different brands are mixed in a cooling system the balance of inhibitors can be upset, resulting in loss of anti-corrosion protection and/or sludging in the system.

Inhibited Ethylene Glycol

This means any commercially available ethylene glycol based anti-freeze product, which does not contain propylene glycol or methanol. The specific gravity of coolant mixtures containing inhibited ethylene glycol may be checked using a suitable hydrometer. The 'Polar Master' hydrometer, obtainable from most Lucas/CAV dealers, is capable of determining the specific gravity of ethylene glycol mixtures of up to 60% concentration levels.

Inhibited Propylene Glycol

This means any commercially available propylene glycol based anti-freeze product, which does not contain ethylene glycol or methanol. As the specific gravity of propylene glycol is very similar to that of water, it will not be easy to determine the specific gravity of the coolant mixture, using the hydrometer method. Rolls-Royce recommend the use of a 'Refractometer', obtainable from the manufacturer of the propylene glycol anti-freeze product. The advantage of propylene glycol over ethylene glycol is that it is considerably less toxic in content.

FILLING THE SYSTEM

The capacity of the complete system will vary according to the engine installation. The capacity of the engine is given in Chapter 1, 'Data'.

Fill the system slowly with the correct coolant, and open each drain cock (fig. 1) momentarily in turn to prevent any possibility of air locks. Continue filling until the coolant level is three inches (76 mm) below the top of the header tank.

Run the engine until the coolant reaches working temperature. Stop the engine, and when it has cooled check the coolant level and top up as necessary.

Caution: Care is necessary if the filler cap is opened on a hot engine.

CLEANING THE SYSTEM

It is important that cooling systems are kept free of deposits and contamination. Flushing out at least once every twelve months is essential. The system can be cleaned by using the Rolls-Royce Motors' inhibitor at normal strength. Drain the coolant whilst warm, before deposits have settled, and flush the system with clean water until it runs clear. Then fill with correctly inhibited clean fresh water. Run the engine in normal use for two weeks before repeating the draining and flushing. Refill with the appropriate coolant.

Caution: Do NOT flush by this method when there is the possibility of sub-zero temperatures.

Topping-up: Always 'top-up' with the same mixture as that already in the engine. Never 'top-up' with water alone. Every 'topping-up', even with approved coolant, adds contaminants. Therefore, to keep 'topping-up' to a minimum, make routine checks to locate and rectify coolant leaks.

THERMOSTAT

A triple-element wax-capsule Western Thomson thermostat is fitted (fig. 3). This illustration and the following information apply to the latest thermostats, which have stainless steel valves and straps.

The thermostat requires no servicing, and if defective must be renewed. Before rejecting a thermostat with sticking valves, apply a little silicone grease (see Chap. 1, 'Data') to the valve spindles and operate the valves by hand to work the grease into the

glands. If this appears to be successful, test valve operation by immersing the thermostat in water and heating it. Each valve should commence opening at about the temperature stamped on its capsule, and if the water is then heated to boiling point all valves should have opened fully to about 0.375 inch (9.5 mm) within 60 seconds. Then, with all valves fully open, plunge the thermostat into cold water and check that all valves close fully within 8 seconds.

It is essential that an engine is fitted with its correct thermostat. This is because valves with differing operating temperatures are used for various engine duties and also because the thermostat body may have either a vent pin or an open vent hole. Therefore the Rolls-Royce Part Number, which is listed in the Engine Parts Book and stamped on the thermostat body, should always be quoted when ordering a replacement.

When fitting a thermostat, note that it is located in its housing by a roll-pin which ensures that each element is directly above a by-pass port, so that as the valve opens the by-pass port is shut off.

Emergency action

If the thermostat is unserviceable and no replacement is 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, because the by-pass ports would then be permanently open, causing overheating.

OIL-TO-COOLANT HEAT EXCHANGER

See Section 6, 'Lubrication System'.

DO'S and DON'TS

The following points should always be observed:

a. DO use either the approved inhibitor or an approved inhibited anti-freeze AT ALL TIMES and in the recommended mixture strength.
DO NOT put in anti-freeze just for the winter and then forget all about it for the rest of the year.
NEVER USE ANY KIND OF WATER ALONE.

b. DO always maintain the inhibitor or anti-freeze mixture at the recommended strength.
DO NOT base the mixture strength of your anti-freeze solution solely on the temperature protection you require.

c. DO always 'top-up' with the correct solution of inhibitor or anti-freeze.
DO NOT 'top-up' with water alone.

d. DO drain and flush the cooling system, using Rolls-Royce Motors' inhibitor solution, at least once a year, and refill with new anti-freeze mixture or inhibitor solution.
DO NOT continue to use the same coolant for more than one year, even if 'topping-up' with a correct mixture.

e. DO remember that hard water contains mineral salts which will be deposited, causing restriction and abrasion.
DO NOT expect inhibitors to remove or absorb mineral salts; they will not, but -
Do remember that these salts will adversely affect any inhibitors you put in.

f. DO remember that corrosion can be virtually eliminated by careful maintenance of engine and coolant.
DO NOT expect inhibitors to do your work for you. They cannot cope with the effects of entrained air or combustion gases.

g. DO remember that although erosion may be caused by vibration and coolant flow characteristics, it is increased by lack of coolant control or inhibition.
DO NOT continue to run an engine with excessive vibration or an aerating cooling system.

If you are in doubt Rolls-Royce Motors' Service Department will be pleased to advise.

KEY TO FIG. 1

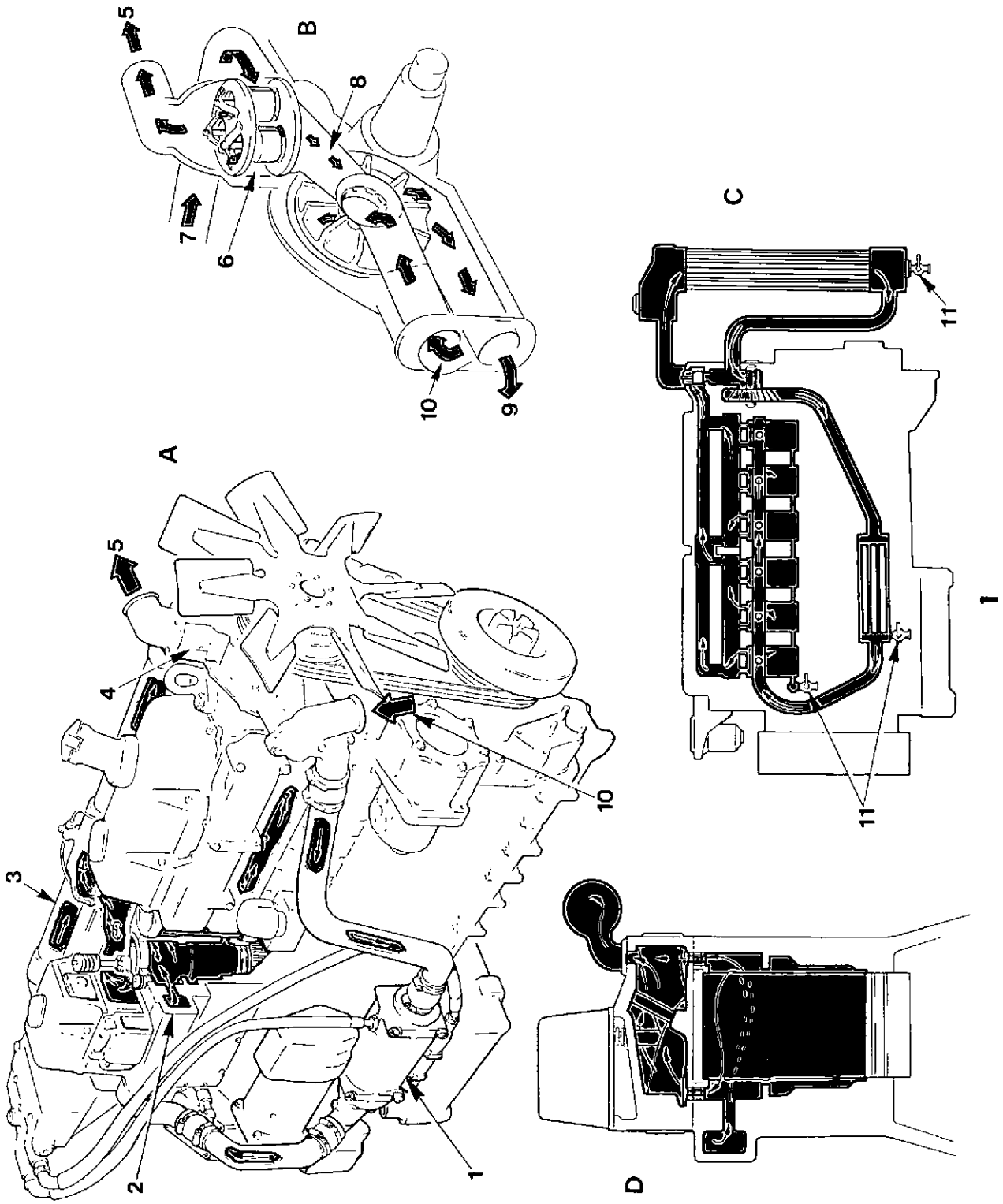
1. Oil/coolant heat exchanger
2. Coolant inlet gallery
3. Coolant outlet gallery
4. Thermostat housing
5. Coolant outlet to radiator
6. Thermostat
7. To thermostat from outlet gallery
8. Thermostat by-pass to pump
9. Pump to oil/coolant heat exchanger
10. To pump from radiator
11. Drain cocks (3)

A = General view of system

B = Flow through thermostat and pump

C = Diagrammatic circuit

D = Flow through cylinder block and heads


A
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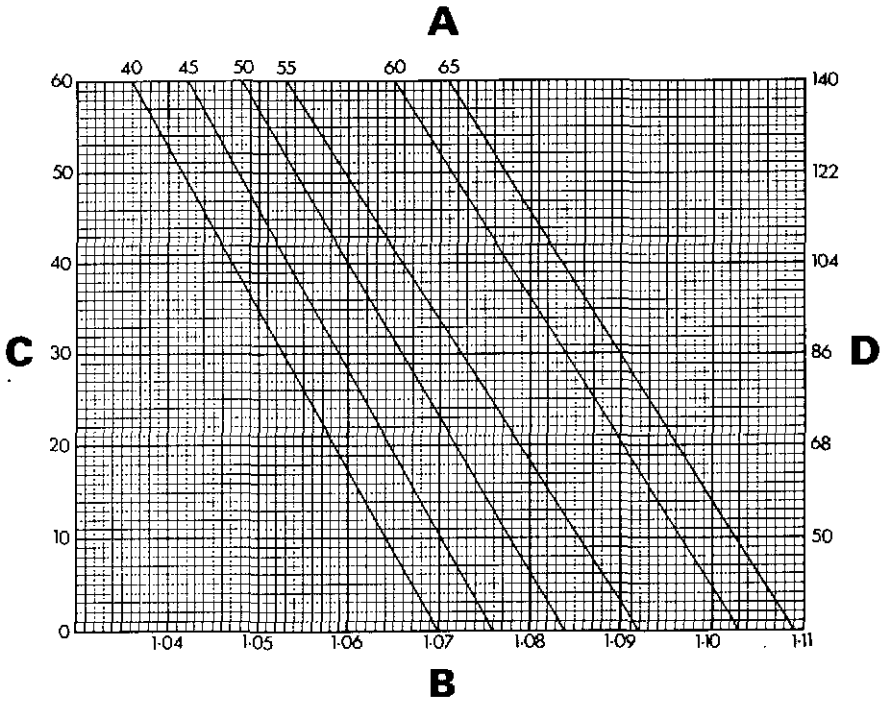

A = Percentage anti-freeze (by volume)
B = Specific gravity
C = Mixture temperature (deg. C.)
D = Mixture temperature (deg. F.)

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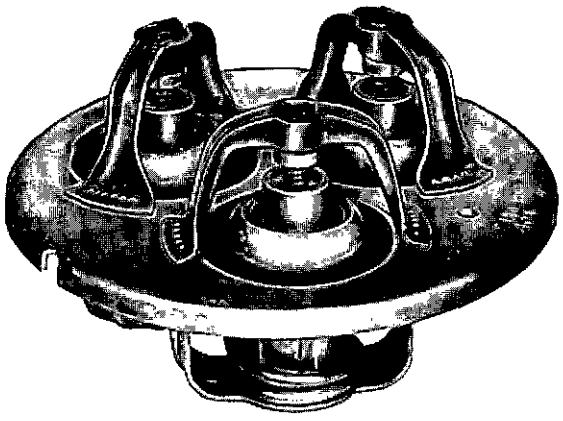

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SECTION 5 — FUEL SYSTEM

DESCRIPTION

Fuel from the tank passes through a primary filter (and, on some installations, a water trap) to one or two feed pumps mounted on the injection pump and is delivered to the main filter assembly at pressure controlled by a relief valve.

Filtered fuel then passes to the injection pump plungers which deliver it at high pressure to the injectors, operating at 240 atmospheres. Spill fuel from the injectors is piped to the spill side of the low-pressure relief valve and joins a common return to the tank, either directly or through a scavenge pump incorporated in the feed pump. A typical C.A.V. system is illustrated in fig. 1.

CARE OF THE SYSTEM

Scrupulous cleanliness, careful handling of the components, and servicing in accordance with the Schedule (Section 1) will do much to prevent serious trouble in service.

Thoroughly clean any component and its surrounding area before dismantling, and fit blanks to all unions immediately they are disconnected.

High-pressure fuel pipes

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

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

PRIMING AND VENTING

If air enters the fuel system the injection pump pressure may become insufficient to open the injector valves and, depending on circumstances, the engine may stop, misfire or fail to start.

The feed pumps, which are driven from the injection pump camshaft, are provided with a manually-operated device for priming and venting the low-pressure system to remove air. This is an external lever on the C.A.V. 'NN' pump (fig. 2, item 5) and Majormec pump (fig. 3, item 5) and a plunger on the Bosch PE pump (fig. 4, item 3).

Venting low-pressure systems

Turn on the fuel cock, operate the priming lever on C.A.V. pumps, or unscrew and operate the plunger on Bosch pumps. Whilst pumping steadily, open the vent screw on each component in turn, close it when bubble-free fuel emerges and then proceed to the next component in the following sequence:

1. Primary filter (vent screws arrowed, fig. 5)
2. Main filters (vent screws arrowed; fig. 6 C.A.V.; fig. 7 Purolator. No vent screw on Fram filter)
3. Injection pump. C.A.V. 'NN': fig. 2, item 3. C.A.V. Majormec: fig. 3, items 2 and 3. Bosch PE: fig. 4, item 4.
4. C.A.V. hydraulic governor (when applicable). Two vent screws with spill pipe on governor top face. Move control lever backwards and forwards whilst venting.

Venting high-pressure system

Move the speed control to MAX FUEL, turn the engine slowly in the direction of rotation and slacken the gland nut of each injector pipe in turn (fig. 9). When bubble-free fuel emerges, tighten each nut before proceeding to the next. DO NOT OVER-TIGHTEN. After venting system, return the speed control to NO FUEL.

PRIMARY FILTER

Harwood, Model 5-90

The Harwood filter unit may be mounted on the chassis or any other suitable position as near as possible to the fuel tank. The unit is fitted in the main fuel supply line prior to the feed pump and the main filters. Fuel enters the filter and passes round the outside of a swirl cone which centrifuges any water content to the periphery, from whence it falls to the bottom of the container. A minimum amount of servicing is necessary. Remove the drain plug weekly or at every 10 E.S.C. units, whichever is the earlier, and allow water and sediment to drain away. Refit the drain plug using a new seal Part No. OD 19725.

If it becomes necessary to dismantle the unit for any reason always use new seals on re-assembly.

Fuel capacity of the unit is 90 Imp. Gal/hr (409 litres/hr).

Purolator PU.464

This filter is superseding the FE-1 filter (fig. 5), now obsolete, and has a similar wire-wound element but no scraping device. The header incorporates a by-pass valve which opens at 12.5 to 16.5 lbf./sq. inch (86 to 114 kN/sq. m.)

To service the filter, remove the bowl by unscrewing its retaining nut, clean the bowl and wash the element in paraffin or fuel oil; if necessary blow through it in reverse-flow direction, using low-pressure air. Do NOT wipe the element with rag. Using new joints, refit the bowl and tighten its nut to between 10 and 15 lbf. ft. (13.5 and 20 Nm).

MAIN FILTERS

C.A.V. parallel-flow filter

This type of filter (fig. 6) consists of two or three expendable paper-element cartridges, each secured to the header by a base cup and central bolt. Each element cartridge is sealed by joint rings at top and bottom and a small 'O' ring in the recess of the centre spigot.

Renew the element cartridges at the invervals stated in the Servicing Schedule (Section 1). Turn off the fuel supply, and unscrew the securing bolt of each element. Discard the used elements and seals, clean the base cups and fit new element cartridges and seals.

Remove and inspect the pressure relief valve unit (fig. 10), and refit or renew it as necessary.

Turn on the fuel supply, and vent the filters as described in PRIMING AND VENTING.

Purolator changeover filter

This is a twin-bowl unit (fig. 7) with expendable fabric-covered paper elements, and incorporates a changeover cock by which one bowl may be isolated and serviced while the engine is running. Relative to the handle of the changeover cock, a data plate indicates which bowl is in use. The pressure relief valve is mounted separately, as described later.

Service the filter at the interval specified in the Servicing Schedule (Section 1). Turn the changeover cock to isolate the old element, and drain the filter bowl by removing the small screw in its base nut. Unscrew the base nut and remove the bowl and element.

Discard the element, and clean out the bowl. Fit a new element and re-assemble the bowl, using a new joint washer. With the engine running, slacken a vent screw (arrowed, fig. 7) above the newly-serviced bowl, and carefully move the changeover cock towards the vertical until bubble-free fuel emerges. Close the vent screw, return the changeover cock fully to its operating position, and check that the handle is firmly secured by the retaining spring.

Fram single-element filter

The unit is an expendable spin-on canister carried on a header bracket bolted to the crankcase (fig. 8). Venting is automatically provided by an internal stack pipe. The joints between canister and header are sealed by two rubber rings. A ¼-inch BSP drain plug and a pressure gauge tapping are carried in the header.

Renew the canister, as follows, at the interval specified in the Servicing Schedule (Section 1): Drain the header. Using wrench OE.43685, unscrew the canister and discard it. Clean the contact faces and ensure that new seals are correctly fitted, as shown by

arrows in fig. 8. Screw on the new canister until the joint faces are *just* in contact with the seals and then tighten further, by hand, for a *maximum* of ¾ turn. DO NOT OVERTIGHTEN. Run the engine and check for leaks.

LOW-PRESSURE RELIEF VALVES

Parallel-flow filter system

The valve is a sealed unit carried in the filter header (fig. 10), and controls fuel pressure to the limits stated in Chapter 1 'Data'. Remove and inspect the unit when the filter elements are serviced. A defective valve which cannot be rectified by washing in fuel must be renewed.

Changeover filter system

The valve is carried in a distributor block bolted to the crankcase (fig. 11). It is not adjustable and is designed to control fuel pressure to the limits stated in Chapter 1, 'Data'.

No servicing is required, and if defective the valve should be renewed as a unit. In emergency it may be dismantled for cleaning and inspection. Check the plunger for scores and sticking, and inspect the spring. It is essential that a replacement spring is of the same rating and strength as the original.

Bosch

This is a non-adjustable spring-loaded valve, designed to open at 15 to 22 lbf./sq. inch (103 to 152 kN/sq. m.). It is carried in the bolt securing the spill pipe banjo to the injection pump gallery (fig. 12).

No servicing is required but if necessary the unit may be dismantled for cleaning and inspection. Renew the nylon valve and its spring if worn or damaged. When re-assembling, ensure that the valve spigot is located in the spring. If the valve assembly and spill pipe banjo have been removed from the injection pump, note that they must be refitted with the thick copper washer between banjo and pump casing.

FEED PUMPS

C.A.V. DFP3 and PPS19

These pumps are used with 'NN' and Majormec injection pumps respectively and are very similar to one another (fig. 1). They are piston-type units, operated by an eccentric on the injection pump camshaft. Fuel enters and leaves via spring-loaded non-return valves beneath the inlet and outlet connections. A scavenge pump can be incorporated in the DFP3 feed pump if required by engine specification (fig. 1).

Some DFP3 pumps, and all PPS19 pumps, have a tell-tale drilling in the casing to give warning of internal leakage. Fuel or lubricating oil leaking from this drilling indicates failure of a diaphragm or piston rod seal and the pump must be changed immediately.

No servicing is necessary between overhauls and to save time it is general practice to renew a faulty pump. Before removing the pump, drain the lubricating oil from the injection pump cambox by removing the drain plug (fig. 2, item 6; fig. 3, item 4). Replace the plug securely and, after fitting the new feed pump, prime the cambox with lubricating oil as described in Chapter 2, 'Operating'.

If a replacement pump is not available it may be possible to service the faulty unit by cleaning the inlet and delivery valves and ensuring that they are seating correctly. The valves of the PPS19 pump are sealed units which must be renewed if they cannot be rectified by washing in fuel.

Bosch FPK22P

This also is a piston-type unit operated from the injection pump camshaft, but has no diaphragms. Four spring-loaded nylon valves, two inlet and two delivery, are mounted in the pump body, three are retained by hexagonal plugs on the top face and the fourth by the hand pump casing. These valves may be removed for inspection, cleaning and renewal if necessary.

The hand pump is a simple plunger which must be screwed down finger-tight after use to prevent leakage of fuel.

Removal of the feed pump will release the oil from the injection pump cambox, since no drain plug is provided. After fitting a feed pump, prime the cambox with lubricating oil as described in Chapter 2, 'Operating'.

INJECTION PUMP AND GOVERNOR

Pumps and mechanical governors which are not lubricated from the engine system must be drained and refilled with engine lubricating oil at the interval specified in the Servicing Schedule (Section 1). Instructions for this work are given in Chapter 2, 'OPERATING'.

Other servicing consists of torque-tightening pump drive bolts to 35 lbf. ft. (47 Nm), checking injection timing, as described later in this Section, and calibration of the pump (see Workshop Manual, T.S.D. 803). Periodicity of these operations is given in the Servicing Schedule (Section 1).

INJECTORS

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

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

Injector-renewal (2-valve heads)

1. Remove the spill pipe. Disconnect the high-pressure pipe at each end and slacken its clamps. If necessary, remove the pipe completely.

2. Unscrew the injector flange nuts and withdraw the injector (fig. 13). A sticking injector may be released by levering gently beneath the flange, using tool GA.454, or in severe cases by removing the capnut and fitting sliding weight extractor GA.627 on its thread.

3. Using kit GA.88, recondition the injector sleeve. This kit consists of reamer GA.304 for cleaning the nozzle hole, and cutter GA.299 for refacing the nozzle seating. Grease both tools before use to retain carbon and metal particles. Do not remove more metal than is necessary to restore the nozzle seating face. The maximum depth of the seating face, measured from the flange face on the cylinder head, is 3.54 inches (90 mm.).

4. Check that the seating is clean, and fit the new injector. Do NOT fit a washer between injector nozzle and the sleeve seating. Tighten the injector flange nuts to 8.5 lbf. ft. (11.5 Nm) using spanner OE.3311.

5. Refit the injector pipe carefully, as described under 'CARE OF THE SYSTEM' earlier in this Section.

6. When all injectors are fitted, refit the spill pipes, using new joint washers, and vent the high-pressure system as described under 'PRIMING AND VENTING' earlier in this Section.

Injector renewal (4-valve Mk. IV heads)

1. Remove the spill pipe. Disconnect the high-pressure pipe at each end and slacken its clamps. If necessary, remove the pipe completely.

2. Remove the rocker cover and injector clamp (fig. 14). Withdraw the injector (fig. 15). A sticking injector may be released in the manner recommended for 2-valve heads.

3. Using kit GA.88, recondition the injector sleeve. This kit consists of reamer GA.304 for cleaning the nozzle hole, and cutter GA.299 for refacing the nozzle seating. Grease both tools before use to retain carbon and metal particles. Do not remove more metal than is necessary to restore the nozzle seating face. The maximum depth of the seating face, measured from the top face of the cylinder head, is 3.67 inches (93.2 mm.)

4. Check that the seating is clean, and that the injector sealing grommet is serviceable. Fit the new injector. Do NOT fit a washer between injector nozzle and the sleeve seating. Fit the *injector clamp, tightening its retaining nut to* 30 lbf. ft. (40.7 Nm), and refit the rocker cover.

5. Refit the injector pipe, as described under 'CARE OF THE SYSTEM' earlier in this section. When all injectors are fitted, refit the spill pipes and vent the high-pressure system as described under 'PRIMING AND VENTING'.

INJECTION PUMP TIMING

Checking

A check should be carried out at the invervals specified in the Servicing Schedule (Section 1) or when a fault is suspected (see Chapter 4). The injection timing figure is stamped on the engine data plate.

Remove the front rocker cover, and the inspection plate (stamped 'T') on the engine flywheel housing. Turn the engine by hand in the normal direction until the injection timing figure on the engine flywheel is opposite the pointer, with No. 1 cylinder on compression. Check that the marks on the pump flywheel and pointer are in line (fig. 16).

Adjustment

If the check shows that the timing is incorrect, leave the engine set to the position described above, and slacken the bolts of the injection pump adjustable coupling (fig. 17). Turn the pump flywheel until its timing mark is opposite the pointer on the pump housing.

Lightly tighten the coupling bolts. Turn the engine backwards a little, and then in its normal direction until the engine flywheel timing mark is again in line with its pointer. Re-check the pump timing marks and, if they are correctly aligned, fully tighten the coupling bolts. Refit the front rocker cover and the timing pointer plate.

OVERSPEED TRIP UNIT

Description

The Iso-Speedic Type 656 unit (fig. 18) is a mechanical safety device fitted to engines which have an independently-mounted governor. It is bolted to the rear face of the injection pump and gear-driven from the pump camshaft. On some engines the Engine Service Counter (E.S.C.) (5) is mounted on the rear face of the trip unit and is also driven from the pump camshaft, via a quillshaft.

At overspeed conditions (usually 118% of rated engine speed) the unit shuts down the engine by closing the injection pump rack, a telescopic link in the control rod system permitting the governor speed setting to be overridden for this purpose.

The operating force is supplied by a tension spring within the unit. This spring is extended, and retained by interlocking linkwork, when the setting lever (1) is pulled fully back to the RUN position, as in fig. 18. The mechanism will remain in this 'cocked' condition, regardless of normal shut-down and starting, until it is operated by actual or simulated over-speeding. It may also be released manually while the engine is stopped, as described later.

At overspeed condition the spring-retaining interlock is disengaged by centrifugal force, releasing the spring which then returns the setting lever (1) to the STOP position. This movement of the setting lever is transmitted, via control rods and the telescopic link, to the injection pump rack, thus closing the rack and stopping the engine. A microswitch, actuated by a striker arm on the setting lever cross-shaft (see fig. 18), operates a 'tripped condition' indicator or an alarm system.

Servicing

Before an engine is put into service, and thereafter at the intervals specified in the Servicing Schedule (Section 1), carry out the following checks:

1. Lubricate the control linkage and ensure that it operates correctly and freely.
2. With the engine stopped, check the level of the lubricating oil in the unit by removing the plug (3). If necessary, top up with engine lubricating oil, via the filler (2), to the level of the plug orifice. Refit the plug.
3. Test the functioning of the unit by running the engine at rated speed and slackening the capnut (4) until the trip operates and shuts down the engine. It should not be necessary to slacken the capnut more than two or three turns. After shut-down, tighten the capnut firmly and return the setting lever to the RUN position.

Note: *Slackening of the capnut releases the preload on the trip speed adjusting screw, which is revealed when the capnut is removed. This screw is set at the factory and should NOT be disturbed unless a setting rig and trained operator are available. Turning the screw clockwise decreases trip speed, and vice versa.*

Releasing setting lever

To release the setting lever from the RUN position when the engine is stopped, proceed as follows:

1. Remove the E.S.C. (when fitted) from the rear face of the unit.

2. Unscrew the two Allen screws, and withdraw the E.S.C. mounting and quillshaft. Alternatively, when no E.S.C. is fitted, remove the blanking plate secured by two hexagon-headed setbolts.

3. Grasp the setting lever, and take the load of the trip spring. Insert a strong wire hook into the unit, and engage it with the trip spring interlock lever. Pull rearward until the setting lever is released, and allow the setting lever to return to the STOP position under control.

4. When refitting the E.S.C. mounting and quillshaft, take care to align the quillshaft slot with the tongue on the end of the pump camshaft before pushing the assembly home.

WOODWARD PSG GOVERNOR

Description

This is a flyweight-operated servo-assisted governor, mounted independently of the injection pump and operating the pump rack by levers and linkwork (fig. 20). The servo system incorporates a booster pump which is supplied with filtered oil from the engine lubrication system. A reservoir in the supply line prevents starvation of the booster pump at start-up. Scavenge oil drains to the sump, and it is essential that this drain is not restricted.

An Iso-Speedic overspeed trip unit is fitted in conjunction with this governor, and is described earlier in this Section. A telescopic link in the control rod system enables the trip unit to override the governor speed setting and close the injection pump rack in the event of overspeeding.

The governor is sealed and guaranteed by the manufacturers. No routine servicing is required, and in normal circumstances adjustment is restricted to minimum speed and droop. If a governor defect cannot be rectified in accordance with the following instructions a replacement unit must be fitted.

Initial settings

1. A governor fitted to an engine leaving Rolls-Royce is set to specification and no adjustment will be necessary when the engine is put into service.

2. A governor leaving Rolls-Royce *as a spare* has the following standard settings and must be adjusted as necessary to the installation requirements.

   (a) The MAX. SPEED stop has been set at 20 r.p.m. above engine rated speed. This setting is indicated by the Rolls-Royce Part Number of the governor.

   (b) The droop has been set to zero.

Maximum speed adjustment

The MAX. SPEED stop screw is carried on the governor body (external arrow, fig. 19). It is sealed and should *not* be disturbed unless absolutely necessary. Turning the screw anti-clockwise increases maximum speed, and vice versa.

Droop

The droop is calculated by running the engine at its specified speed under full load (or 100% electrical load for generator sets), throwing off the load, and noting the new steady speed.

The formula

$$\frac{(\text{No load speed} - \text{Full load speed}) \times 100}{\text{Full load speed}}$$

will then give the droop as a percentage.

The droop setting for each engine is decided when the specification is drawn up, and a replacement governor should be set accordingly (see 'Initial settings'). If this information is not available, the following broad recommendations should be followed:

1. For all generator sets in parallel, set droop to 4%.

2. For other engines a droop of 4% is normally adequate, but the aim should be to use the highest possible droop setting consistent with governing requirements. The minimum droop setting at which the governor will control is zero.

Droop adjustment

> **Caution:** *This adjustment must NOT be made with the engine running. It is sensitive and should be made in increments of about 1/32 inch or 1 mm.*

Remove the end cover and make a pencilled mark to indicate the position of the droop slide (fig. 19). Slacken the slide clamping screw and move the slide in the direction of the solid arrow to decrease droop, or the shaded arrow to increase droop. Using a screwdriver in one of the slide castellations, press the slide against its register whilst tightening the clamping screw, otherwise unstable governing may result.

Other adjustments

1. The MINIMUM SPEED stop, carried on the end cover, is secured by a locknut and is unsealed. Its setting is 100 r.p.m. below engine rated speed.
2. The terminal lever stop is set to give a range of 36 deg., measured at the lever. It is sealed and should NOT be disturbed.
3. The compensating needle on the side of the governor controls the stability of the engine. Should adjustment be necessary, screw the needle *out* until the engine begins to surge, and then slowly screw it *in* again until the surging has *just* stopped. Do NOT screw the needle fully in.

Control setting

The control linkwork is set on the test bench before the engine leaves Rolls-Royce, and should not be disturbed unnecessarily. The following basic information and its accompanying illustration (fig. 20) are supplied for guidance in the event of renewal of governor or injection pump.

1. Before removing output lever (6) from the terminal shaft mark its position on the splines so that it is refitted correctly.
2. Ensure that the ball end of link (1) is connected to the same hole in output lever (6) as was previously used. The four holes in this lever are to provide a selection of arcs of movement relative to pump fuelling figures for different engines.
3. Do NOT disturb the overall length of the control rod and telescopic link assembly (4). When fitting the rod to the rack, adjust side play on the pin (5) by shims. Check for free movement, and ensure that the telescopic link operates correctly.
4. Set the stop (2) so that it just touches shutdown lever (3) with the rack fully closed (i.e. in direction of arrow). Screw the stop (2) in $\frac{1}{8}$ turn further, and tighten its locknut.
5. Adjust link (1) so that it just fits when both governor and rack are at NO FUEL. Shorten the link by one turn, and lock it.
6. Check that the linkage operates fully to EXCESS FUEL on the pump. Hold the output lever (6) fully forward and check that the rack is closed when the manual shutdown lever (3) is pushed against its stop (2).
7. Adjust the control rod from the overspeed trip so that shutdown lever (3) is just held on its stop (2) when the trip lever is in the STOP position. Shorten the control rod by one flat of its turnbuckle, and tighten the locknuts. Check that when the trip unit lever is in the STOP position the output lever (6) can be moved fully forward whilst the rack remains stationary.
8. Check that all components are securely locked. Lubricate all joints, and carry out a final check of the linkage for full and free movement.

KEY TO FIG. 1

C.A.V. SYSTEM—DIAGRAMMATIC

1. Injector
2. Main filter
3. Pressure relief valve
4. Injection pump
5. Spill return
*6. Lubricating oil feed
*7. Lubricating oil return
*8. Scavenge pump
9. Feed pump
10. Fuel inlet
11. Feed pump without scavenge pump

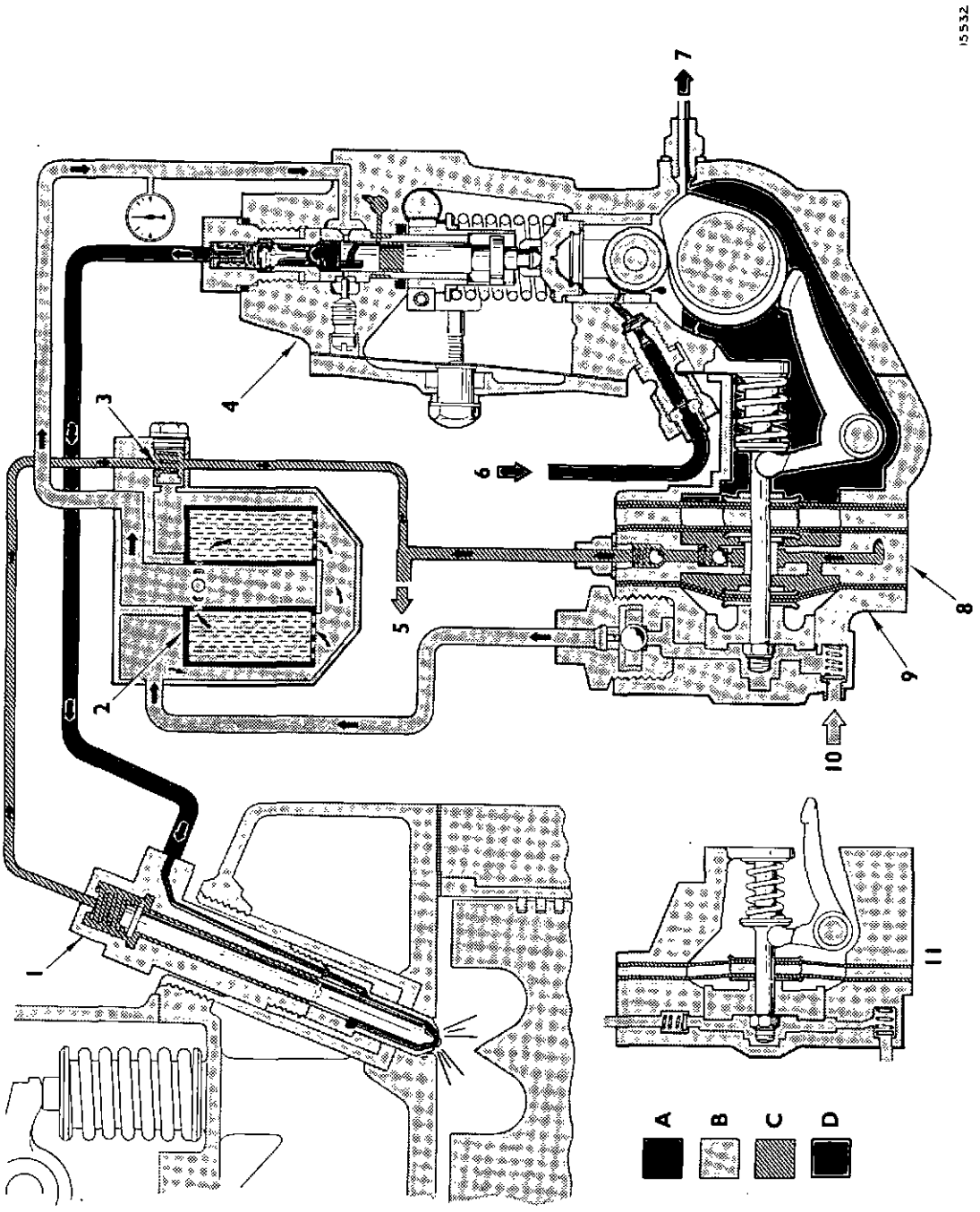
* *Where applicable*

A = High pressure fuel

B = Low pressure fuel

C = Spill fuel

D = Lubricating oil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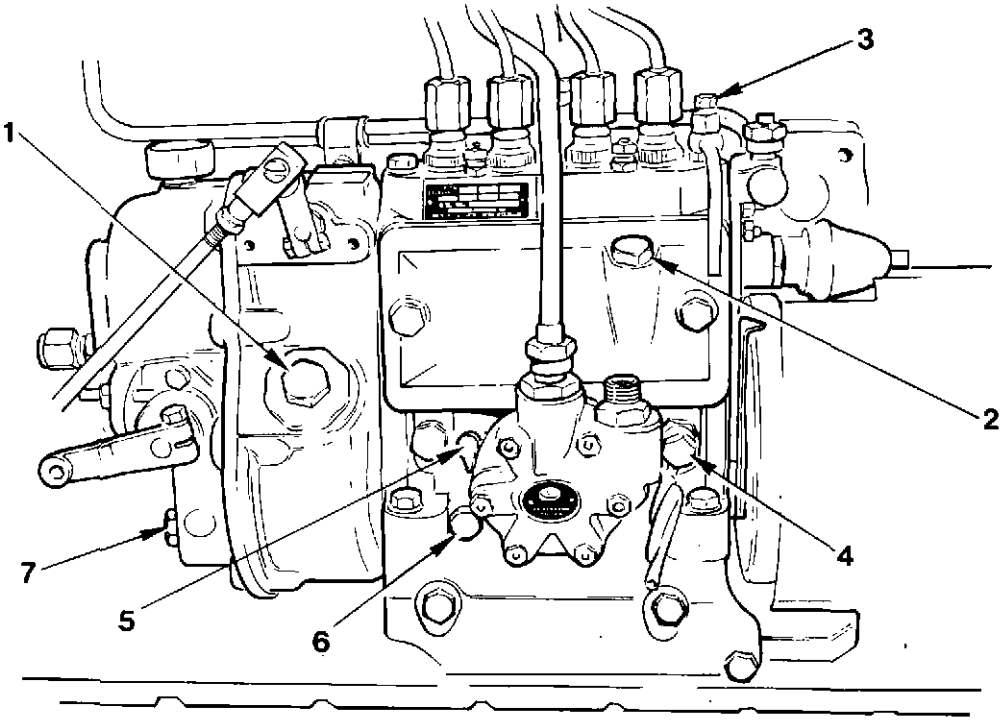

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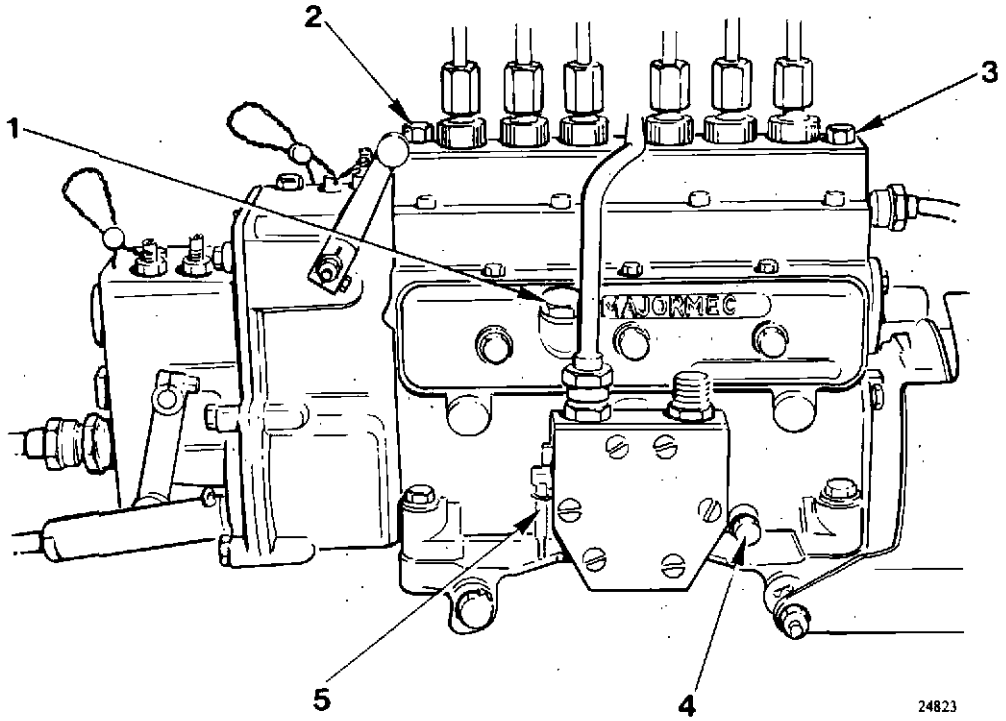

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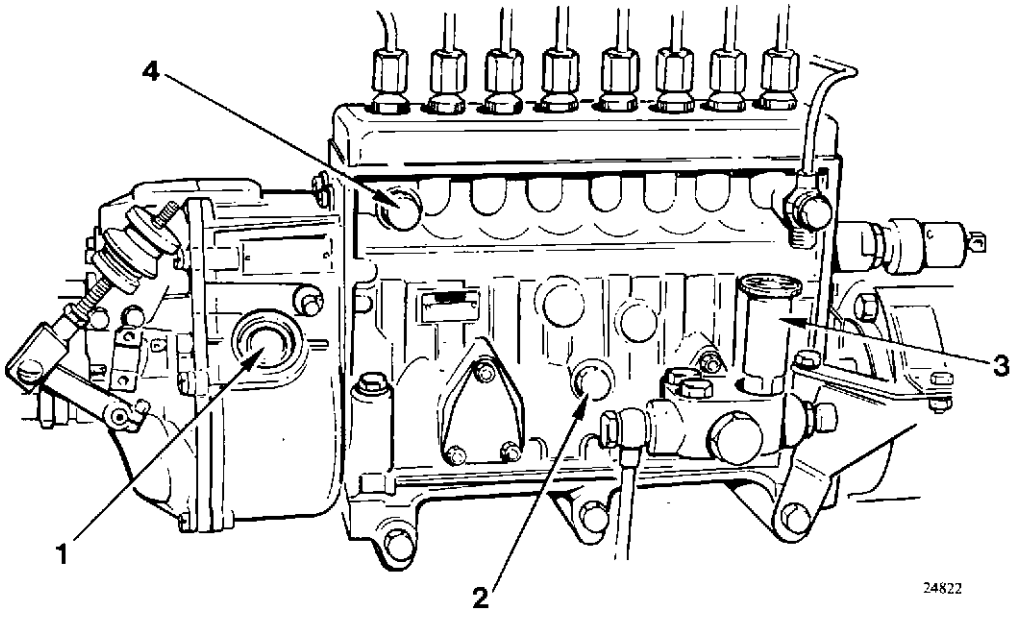

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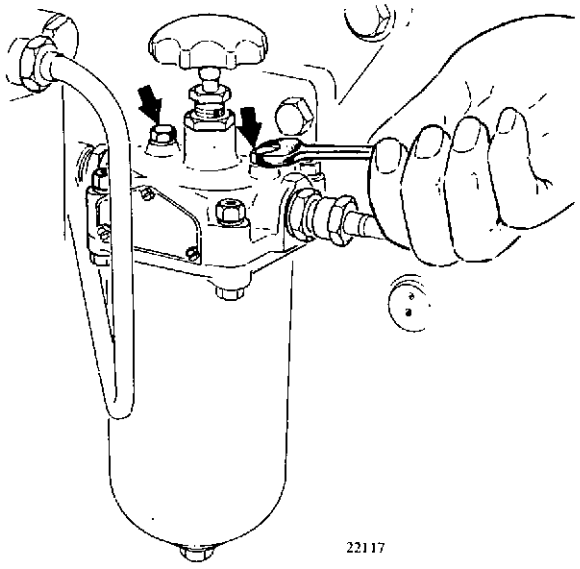

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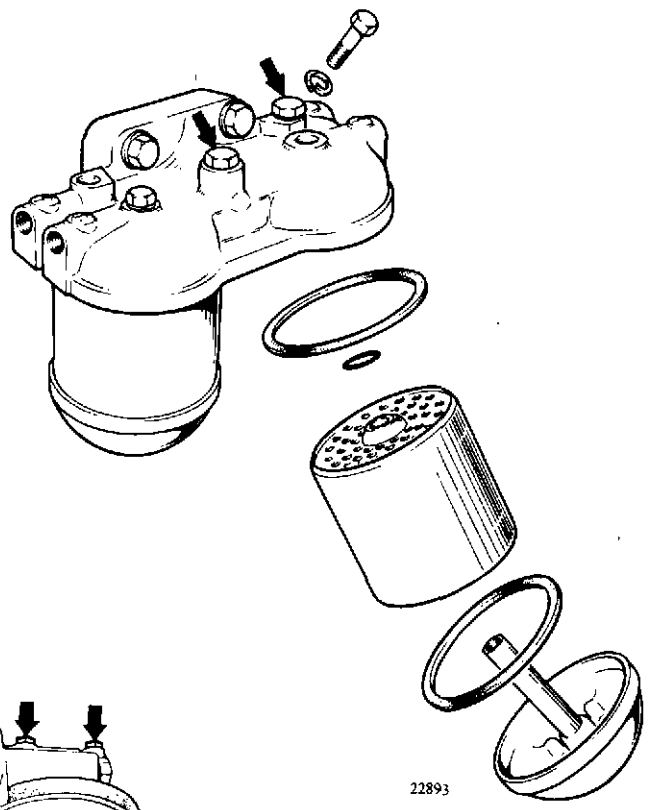

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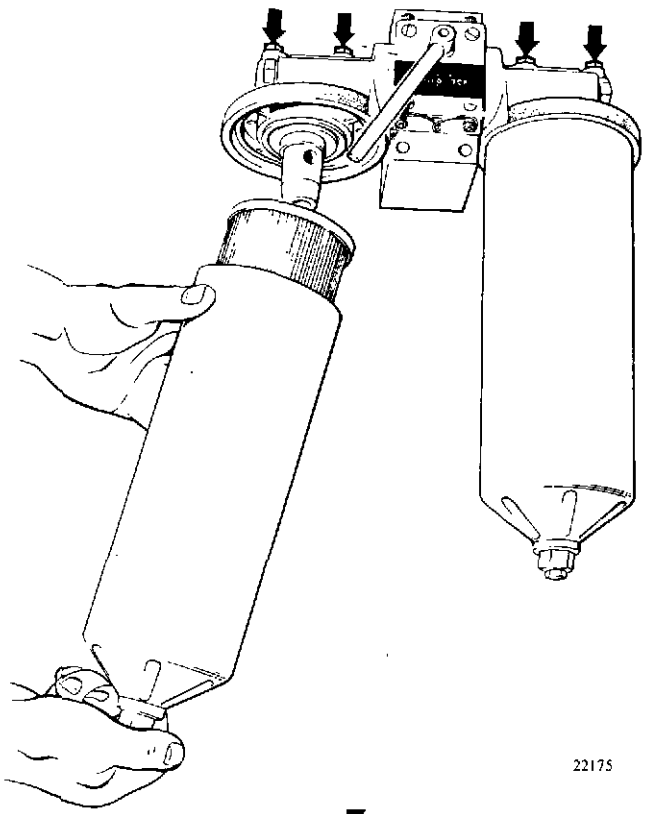

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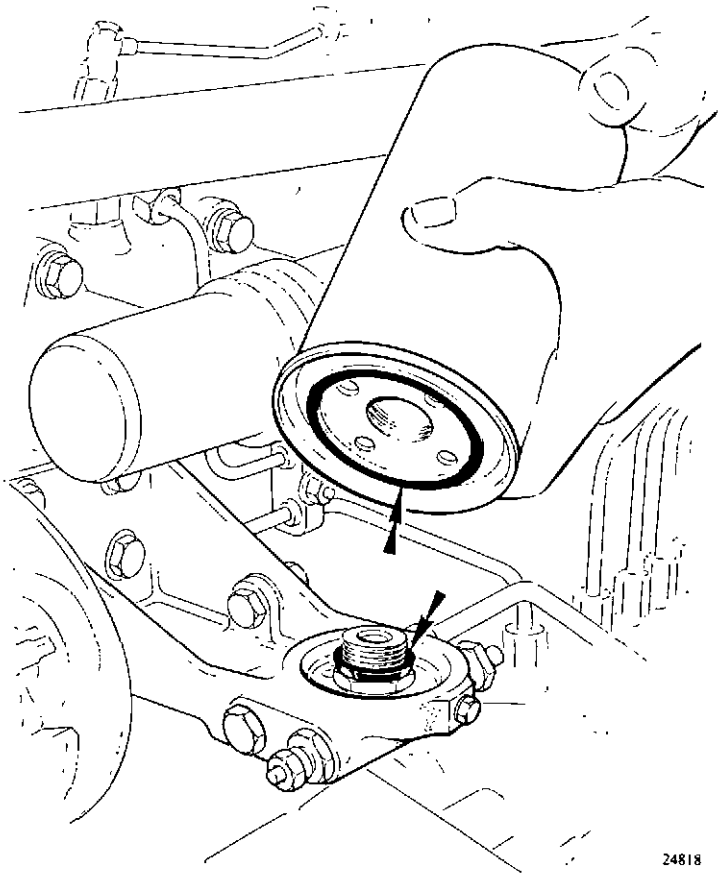

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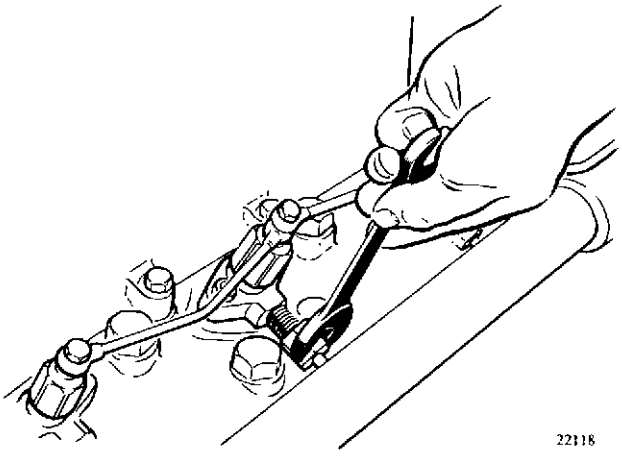

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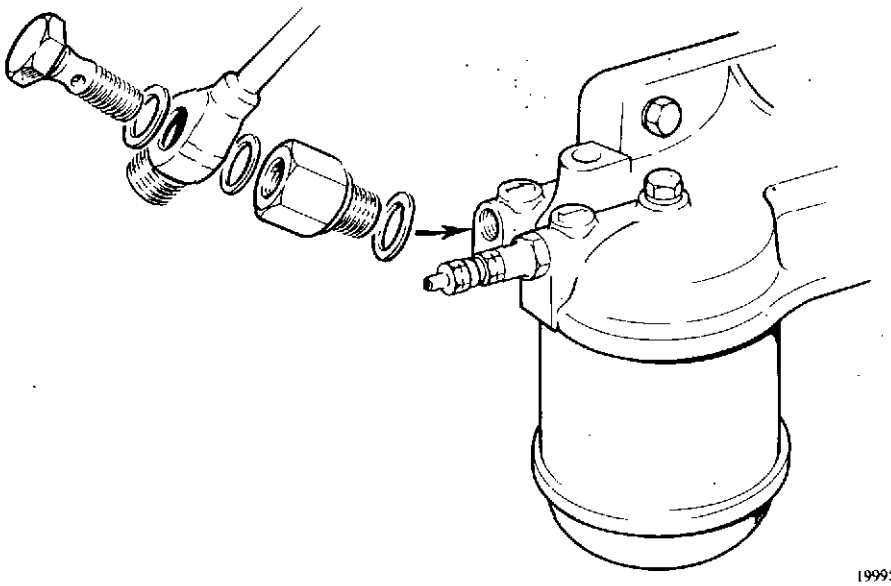

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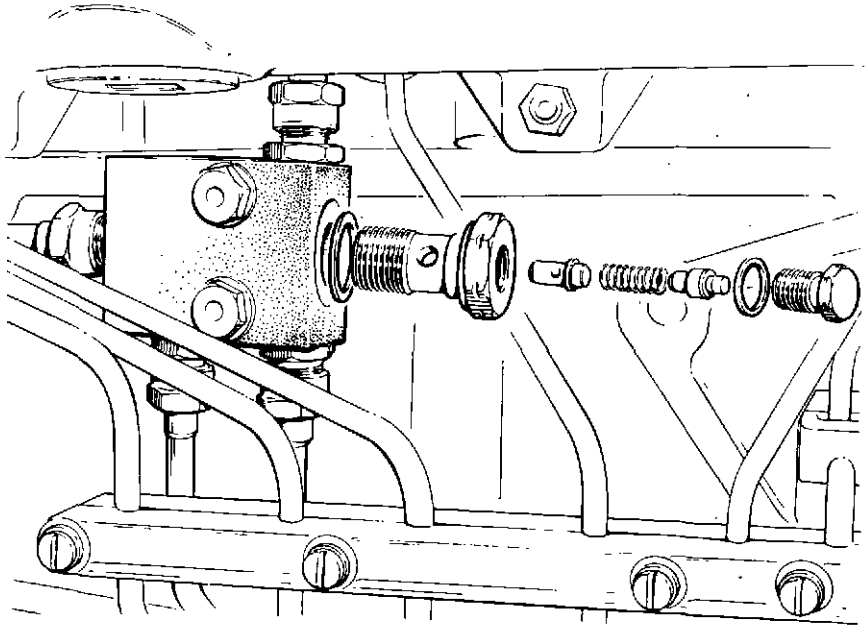

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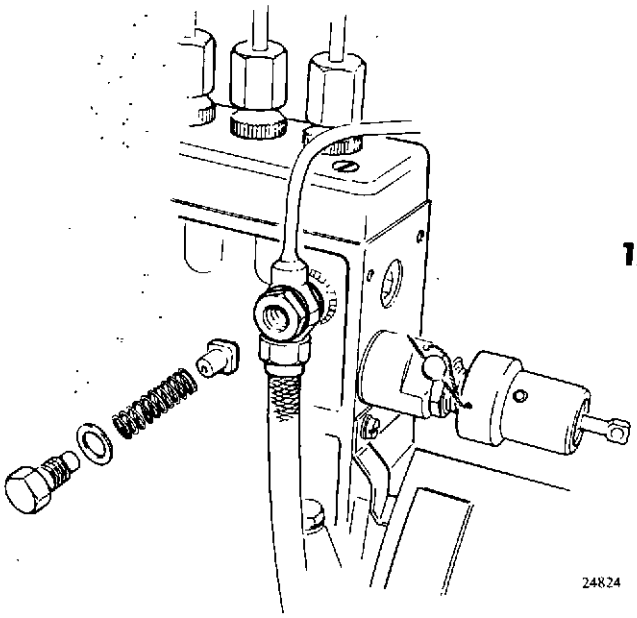

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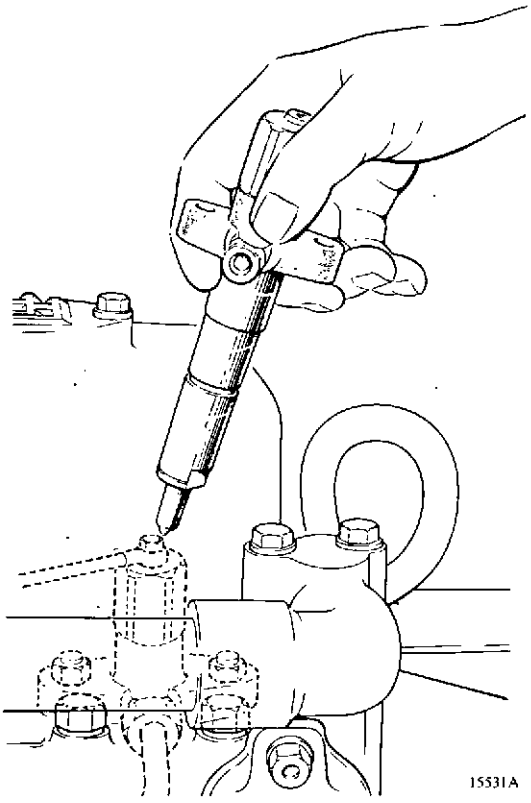

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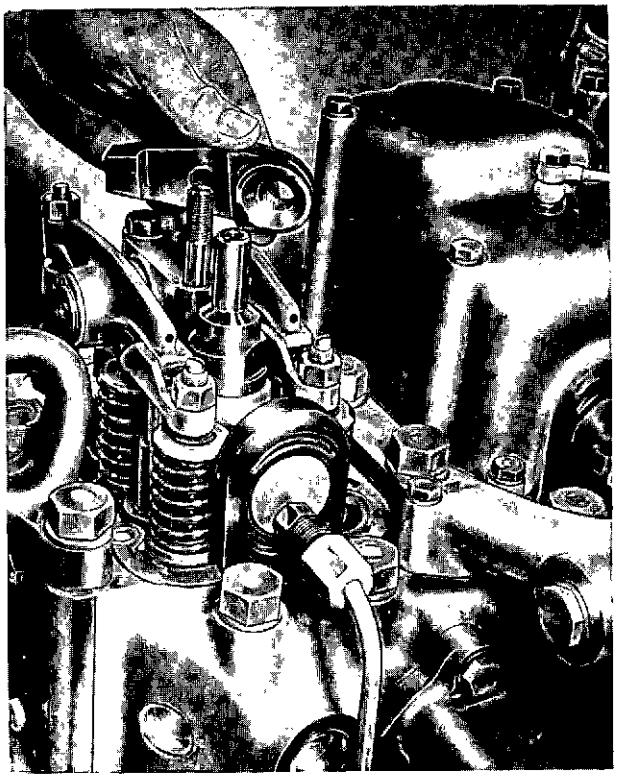

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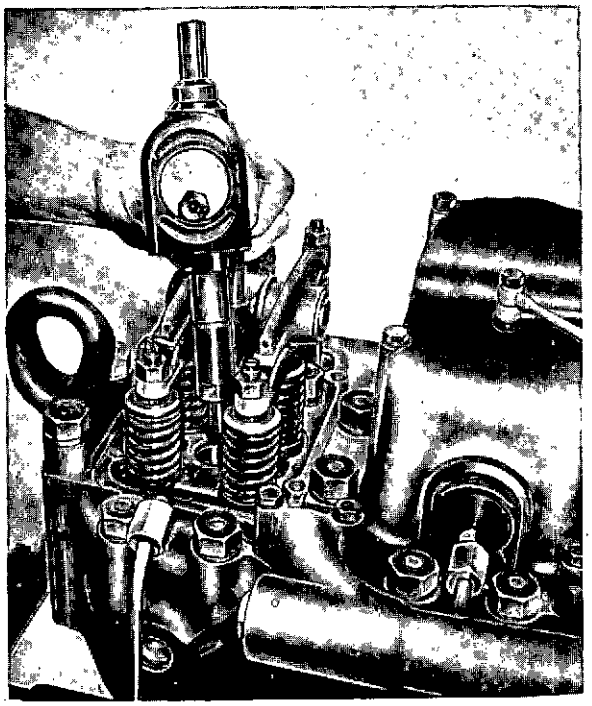

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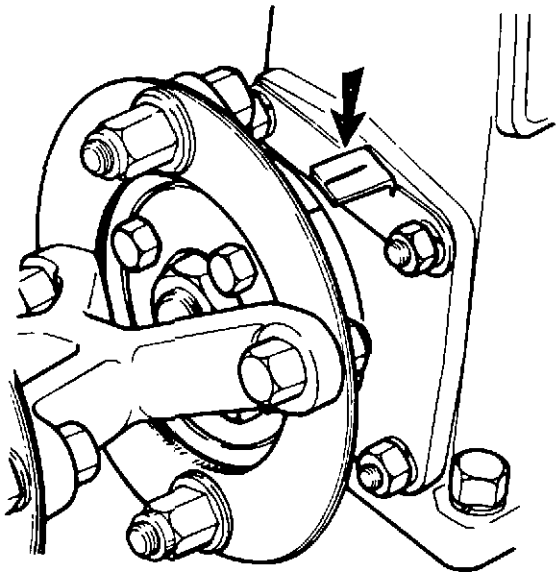

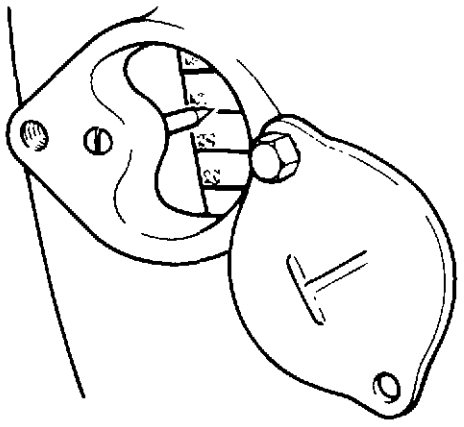

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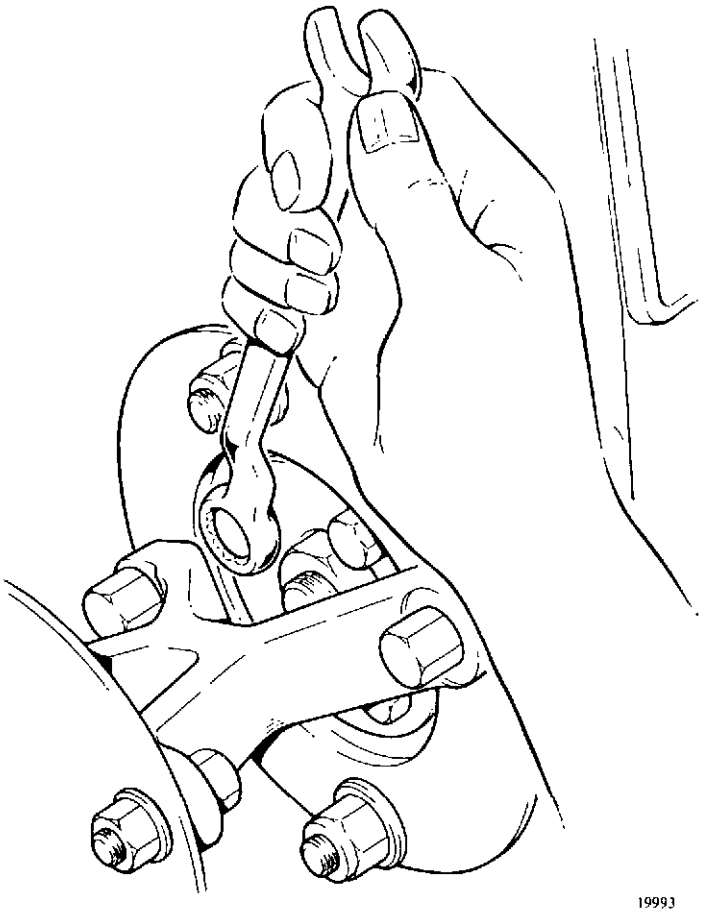

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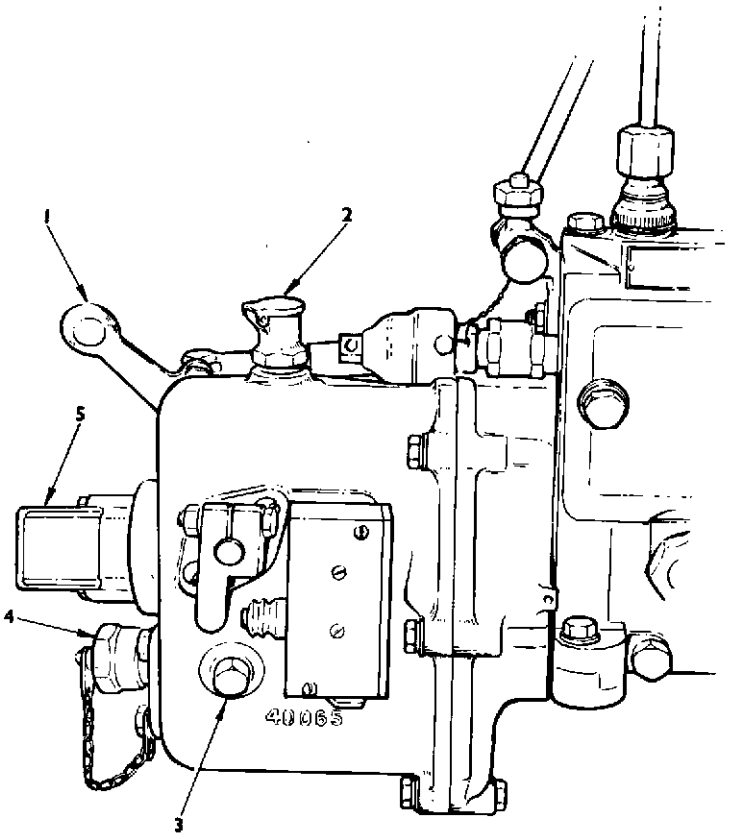

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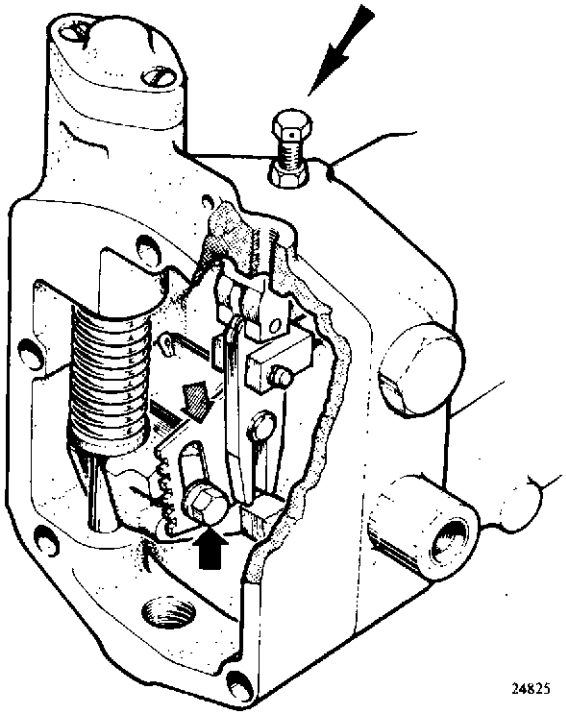

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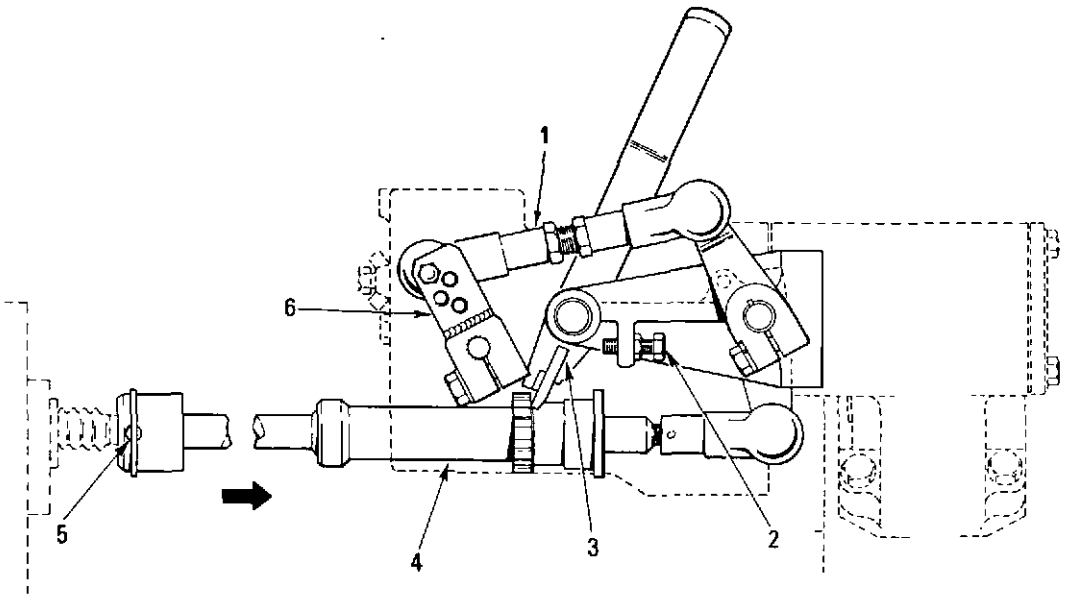

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SECTION 6 — LUBRICATION SYSTEM

DESCRIPTION

Typical systems for 4, 6 and 8-cylinder engines are illustrated in figs. 1, 2 and 3 respectively.

The lubricating oil is carried in a cast aluminium sump which has a pannier at the front end, except on some 6-cylinder engines where a rear pannier is fitted to suit a particular installation. The oil filler and dipstick are usually mounted on the pannier, two lines on the dipstick indicating maximum and minimum oil levels. Unless otherwise stated on the filler cap the oil level should be checked with the engine stopped, after oil in circulation has drained back to the sump. For oil capacities, see Chapter 1, 'Data'.

On all engines a spur-gear pump, driven from the crankshaft, draws oil through a filter in the pannier and circulates it under pressure throughout the engine. To ensure that the pressure pump intake remains submerged in oil at normal tilt angles, all 8-cylinder and some 6-cylinder engines have a scavenge pump driven in tandem with the pressure pump. The scavenge pump draws oil from the opposite end of the sump and discharges into the pannier.

Oil pressure is controlled at approximately 60 lbf./sq. inch (414 kN/sq. m.) by a spring-loaded relief valve which returns surplus oil to the sump. On leaving the pressure pump the oil passes via the relief valve, and usually a heat exchanger, to the full-flow main filters. Tappings for the turbocharger supply and pressure gauge are usually taken from the filter header. A by-pass valve in the header prevents oil starvation if the filters become choked or if the oil is too cold and viscous to pass readily through the elements.

From the filters the oil passes to the engine and is delivered at full pressure to the bearings of the crankshaft, connecting rods, camshaft and gear train. Line restrictors reduce the pressure of the feed to the valve gear and, where applicable, the injection pump.

LUBRICATING OIL

Use **only** a lubricating oil to the specification and grade approved by Rolls-Royce Motors Limited for the engine rating and application (see leaflet T.S.D. 3085). Change the oil and service the filters at the intervals specified in the Servicing Schedule (Section 1).

FILLING AND DRAINING

Ensure that the oil container and funnel are clean, and wipe the area of the filler cap. Pause periodically during filling, and check the level. Do NOT fill above the upper mark on the dipstick.

A drain plug is fitted in the base of the sump. Drain the oil whilst hot, before deposits have settled. Refit the plug securely; on later engines it is tightened to between 80 and 85 lbf. ft. (108 and 115 Nm) and wire-locked. Service the filters when the oil is changed.

PRESSURE RELIEF VALVE

Different designs of valve are fitted to 4, 6 and 8-cylinder engines respectively, but all are of the non-adjustable spring-loaded plunger type. They should not require attention between engine overhauls if the lubrication system is properly maintained. Dirt or other particles in the oil may cause the valve plunger to stick open, resulting in

a sudden drop in oil pressure which must be investigated and rectified immediately. Normally, this will involve dismantling and cleaning the valve assembly, and checking the plunger for free movement and correct seating.

4-cylinder engines (fig. 4)

The relief valve housing is bolted to the crankcase, the plunger and spring being carried in a hexagon-headed sleeve and retained by a circlip. If the plunger and sleeve are worn or badly scored the complete sleeve assembly must be changed.

6-cylinder engines (fig. 5)

The valve and spring assembly is carried in a casting bolted to the sump. To dismantle the valve, unscrew the capnut and withdraw the spring and plunger. Wash the components in paraffin, and clean the bore of the valve housing. If the valve slides freely in its housing and makes full contact with its seat reassemble the unit, using a new washer of correct thickness beneath the capnut.

8-cylinder engines (fig. 6)

The valve assembly is carried in an adapter bolted to the sump, spill oil being returned via an external pipe. Before dismantling the valve, drain the sump to a level below the spill pipe (1) and remove the pipe. Unscrew the valve body (2) and withdraw the stop (3), spring (4) and valve (5). Wash all parts in paraffin, and clean the bore of the valve housing. Inspect all components, and check that the valve slides freely and makes full contact with its seating. When assembling the unit, use a new joint washer (6) of correct thickness. Refill the sump to the upper mark on the dipstick.

MAIN FILTERS AND BY-PASS VALVE

Twin-bowl filters are fitted to 4 and 6-cylinder engines, triple-bowl filters to 8-cylinder engines. Elements, bowl components and by-pass valves are identical for both types.

To service the filters (fig. 7), unscrew the central fixing bolts and remove the bowls. Discard the elements and clean the bowls. Fit new elements and joints, fill bowls with clean oil, and reassemble to the header, tightening the bolts to 20 lbf. ft. (27 Nm).

> **Warning:** Use only genuine Rolls-Royce elements, which are clearly identified and supplied in a sealed plastic container. See Servicing Schedule. (Section 1).

The filter by-pass valve is a spring-loaded plunger retained by a hexagonal brass capnut in the filter header. It opens when the filters become choked, or when the oil is too cold and viscous to pass readily through the elements, and in these circumstances allows unfiltered oil to enter the engine. No routine servicing is required but if necessary the valve may be removed for inspection and cleaning. Check that the plunger is not scored and that it slides freely in its housing.

OIL-TO-COOLANT HEAT EXCHANGER

Two types of heat exchanger are currently in use, a flange-ended type (fig. 8) and an open-ended type (fig. 9). They are similar in construction and principle, consisting of a finned tube pack in a housing. The coolant flows through the tube bores whilst the lubricating oil is directed over the fins by a series of baffles. Both types are provided with a coolant drain tap, either in the casting or in an adjacent pipe.

Neither type should require servicing between engine overhauls, provided that the lubrication and coolant systems are properly maintained. Dirt or deposits in either system will foul the tube pack, causing high temperatures and low oil pressure. If this occurs in service, drain the coolant system and proceed as follows:

Dismantling

Flange-ended type (fig. 8)

Unscrew the four nuts securing the end cover and carefully tap off the cover, noting that it is located by a dowel. Withdraw the tube pack, remove and discard the joints from the flange and the two sealing rings from their grooves at the opposite end of the housing bore.

Open-ended type (fig. 9)

Remove the 2BA screw from each end of the housing. Push the tube pack in either direction, as

convenient, until a rubber sealing ring is *just* exposed. When this ring has been removed the tube pack may be withdrawn in the opposite direction. Do NOT attempt to push a sealing ring through the housing, or it may foul an oilway port and cause the pack to become jammed. Discard both sealing rings.

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

Cleaning

This is the same for both types. Wash the pack in paraffin, blow through the tubes with an air jet and wash the pack in hot fresh water. To remove hard deposits in the tube bores, soak the pack in a solution of one part inhibited hydrochloric acid to three parts of water. When frothing ceases, immerse the pack in a solution of washing soda in hot water, 1 lb. to five gallons (0.5 kg. to 25 litres). Finally, blow through the tube bores with an air jet and wash the pack in hot fresh water. Thoroughly clean the housing in paraffin and dry with an air jet.

Inspecting and testing

Inspect the pack and housing for corrosion, damage, and security of the soldered joints. If possible, pressure-test the pack by applying air at 25 lbf./sq. inch (172 kN/sq. m.) to the tube bores with the unit immersed in water at 80 deg. C (175 deg. F).

Assembling

Flange-ended type

Fit two new rubber sealing rings, lightly lubricated, to the internal grooves of the housing. Assemble a new joint to the tube pack flange, enter the pack into the housing with the dowel hole aligned and push it fully home. Fit the second flange joint and end cover, aligning them with the dowel and tightening the retaining nuts evenly.

Open-ended type

Use the following method to prevent the sealing rings from being damaged by contact with the edge of an oilway port:

1. Ensure that the housing bore is clean and smooth. Lightly smear the bore at both ends with rubber grease or oil.
2. Insert the tube pack, *without* sealing rings, at either end of the housing, as convenient, and align the locating screw recesses with their tappings (fig. 9). With one sealing ring groove *just* exposed, fit a lubricated ring to it and push the pack back into the housing until the other sealing ring groove *just* emerges. Do NOT greatly exceed this protrusion or the first ring may be damaged.
3. Fit the second sealing ring and carefully push the tube pack back into the housing until the locating screw recess is flush with the housing face. See NOTE under 'Dismantling' concerning use of pressure on the tube pack.
4. Check that the tube bores are clear and undamaged. Fit a 2BA locating screw with plain and spring washer at each end of the housing.

CRANKCASE BREATHER

Two types of breather are fitted, either a one-piece unit with an integral wire-wool filter element (fig. 10), or an alternative type having a detachable nylon filter element and an elbow adapter for a rubber extension pipe (fig. 11).

Service the breather at the intervals specified in the Servicing Schedule (Section 1), or more frequently if found necessary in severe conditions.

This is particularly important on turbocharged engines, since crankcase pressure can prevent the free return of oil from the turbocharger, resulting in oil leakage through the turbocharger bearings into the induction and exhaust systems.

Clean the wire-wool type by removing the breather (fig. 10) and washing it in petrol. Immerse it in engine oil, and allow to drain before refitting.

To clean the nylon type, slacken the clip, remove the elbow, and withdraw the filter element (fig. 11). Wash the element in petrol, immerse it in engine oil, and allow to drain before refitting. Clean out the elbow and check that the rubber extension pipe is unobstructed. Reassemble the parts and tighten the securing clip.

KEY TO FIG. 1

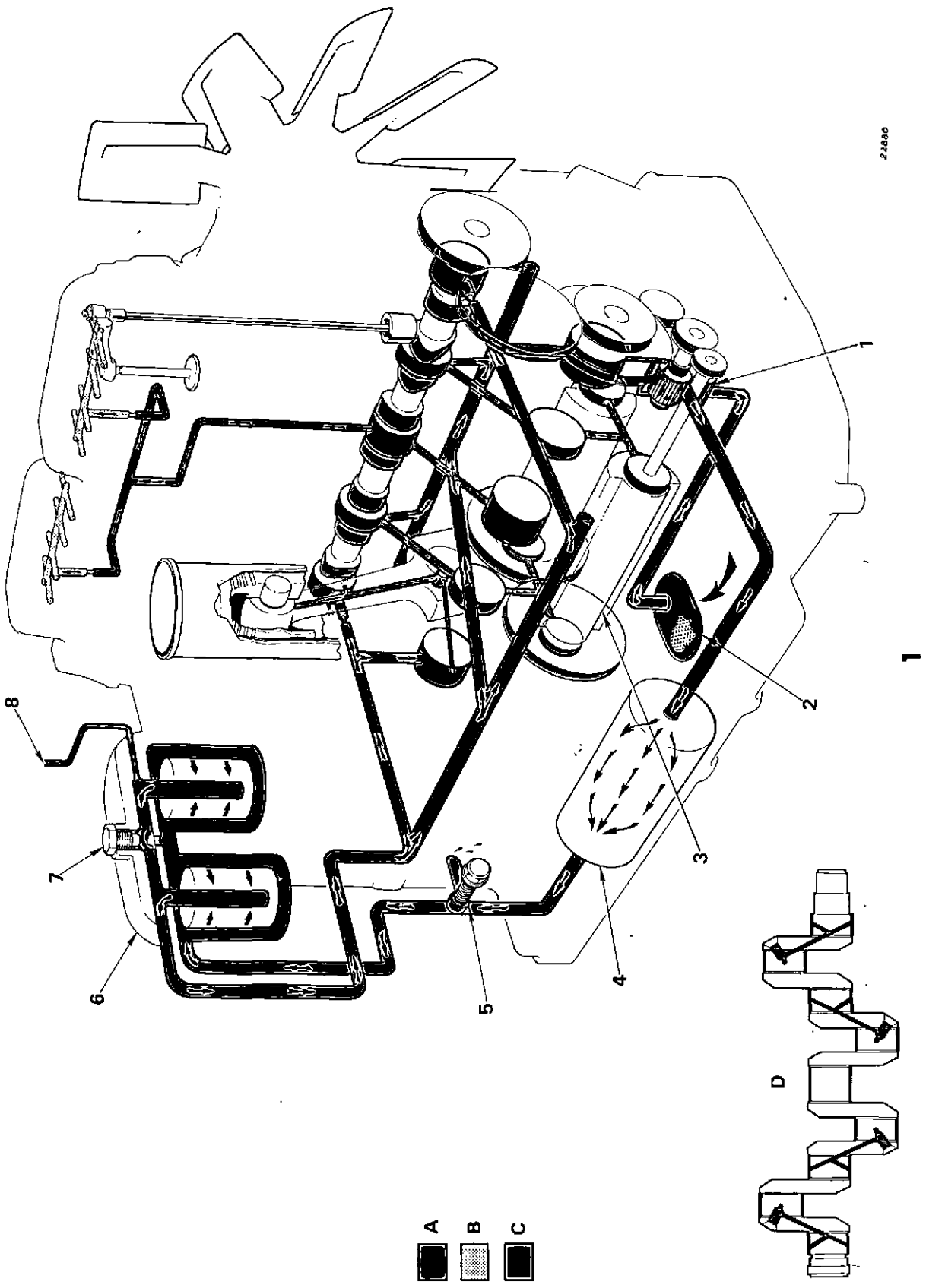
1. Pressure pump
2. Suction filter
3. Crankshaft balancing gear
4. Oil/coolant heat exchanger
5. Pressure relief valve
6. Parallel-flow main filters
7. Filter by-pass valve
8. Pressure gauge connection

A = High pressure system

B = Low pressure system

C = Suction, spill and splash lubrication

D = Crankshaft oilways



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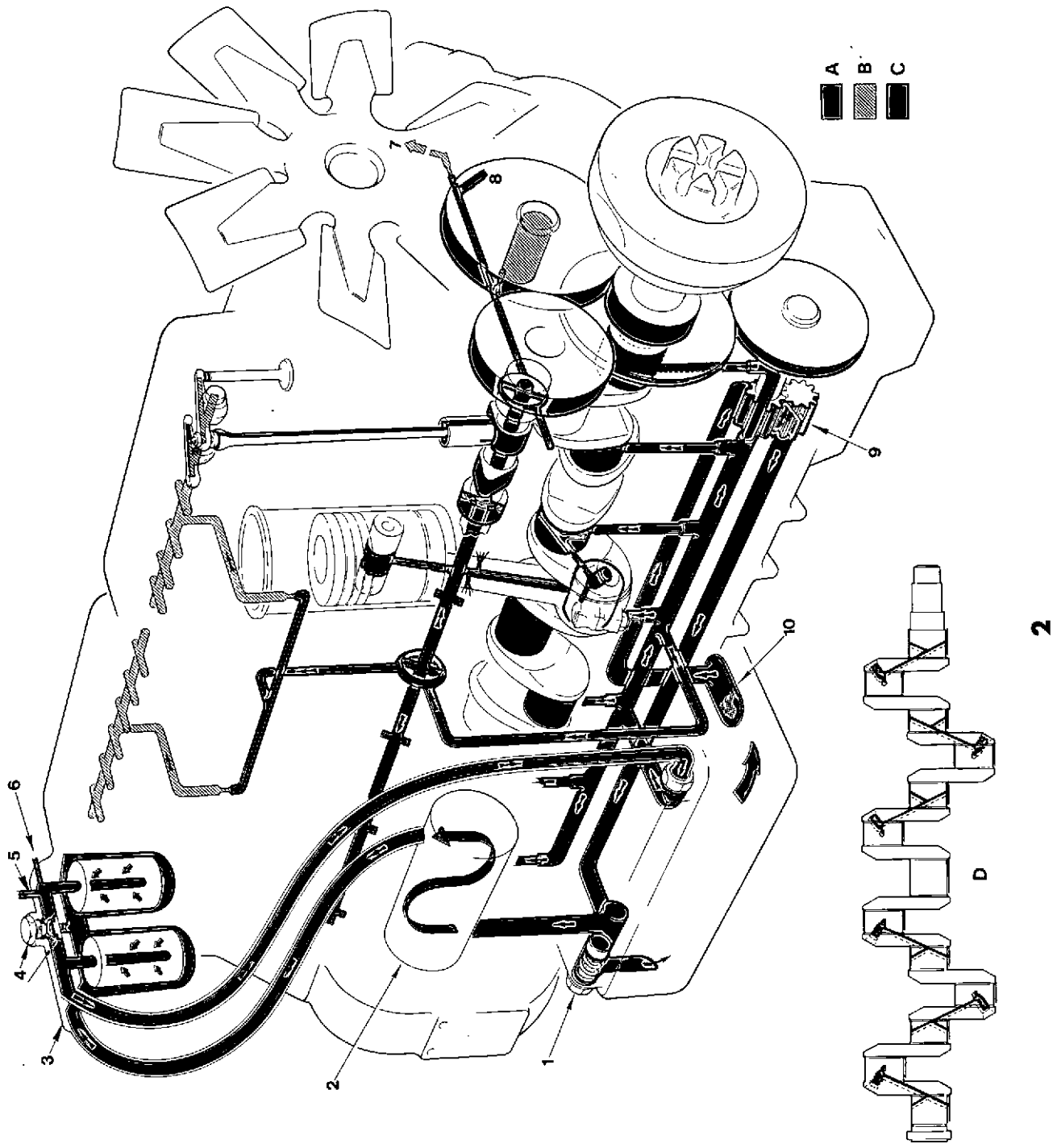

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KEY TO FIG. 2

1. Pressure relief valve
2. Oil/coolant heat exchanger
3. Parallel-flow main filters
4. Filter by-pass valve
*5. Feed to turbocharger
6. Pressure gauge connection
*7. Feed to air compressor
*8. Feed to injection pump
9. Pressure pump
10. Suction filter

** Where applicable*

A = High pressure system

B = Low pressure system

C = Suction, spill and splash lubrication

D = Crankshaft oilways

KEY TO FIG. 3

1. Scavenge pump delivery
2. Pressure pump suction filter
*3. Feed to injection pump
4. Pressure relief valve
5. Oil/coolant heat exchanger
6. Scavenge pump suction filter
7. Parallel-flow main filters
8. Filter by-pass valve
*9. Feed to turbocharger bearings
10. Pressure gauge connection

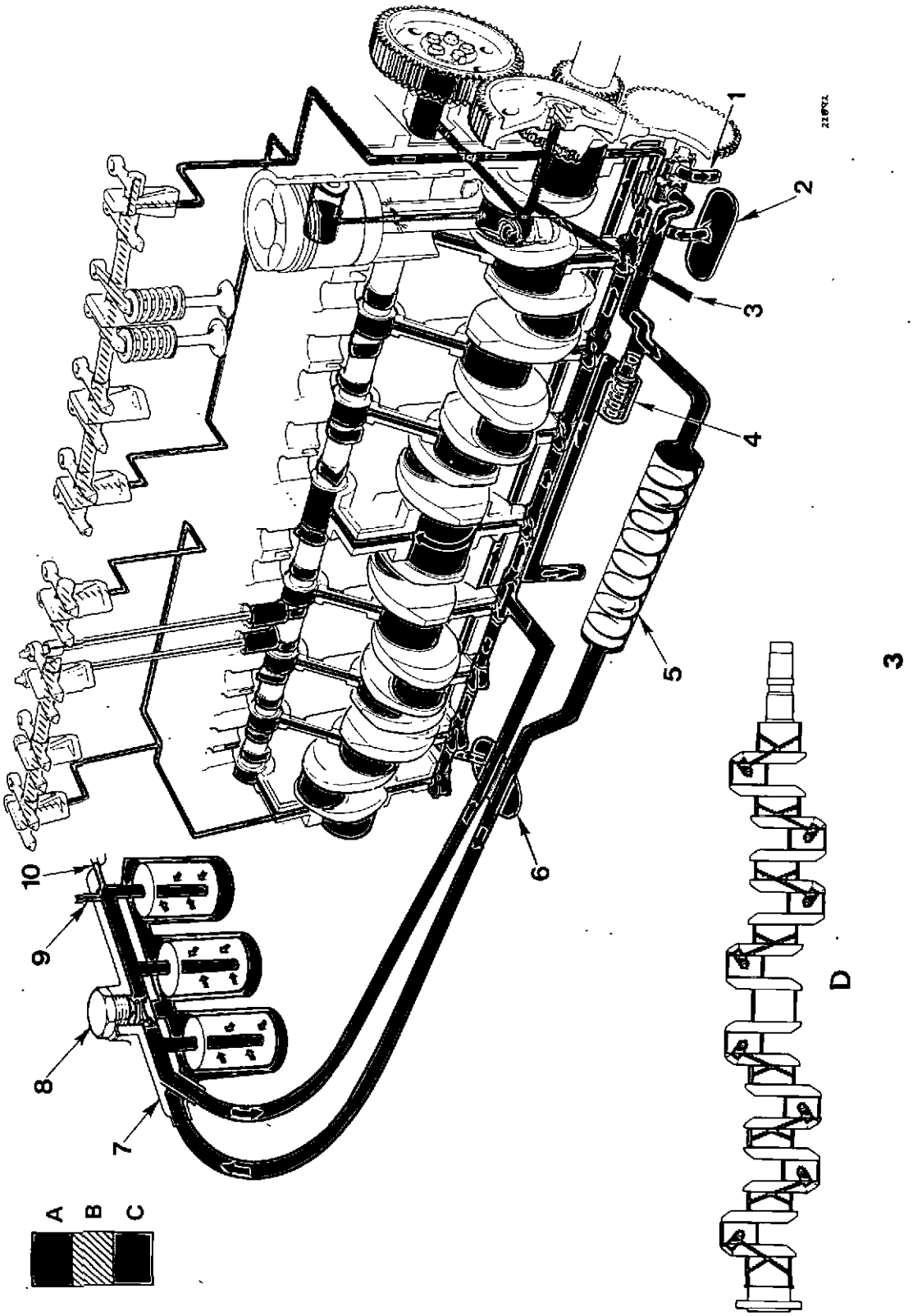
* *Where applicable*

A = High pressure system

B = Low pressure system

C = Suction, spill, and splash lubrication

D = Crankshaft oilways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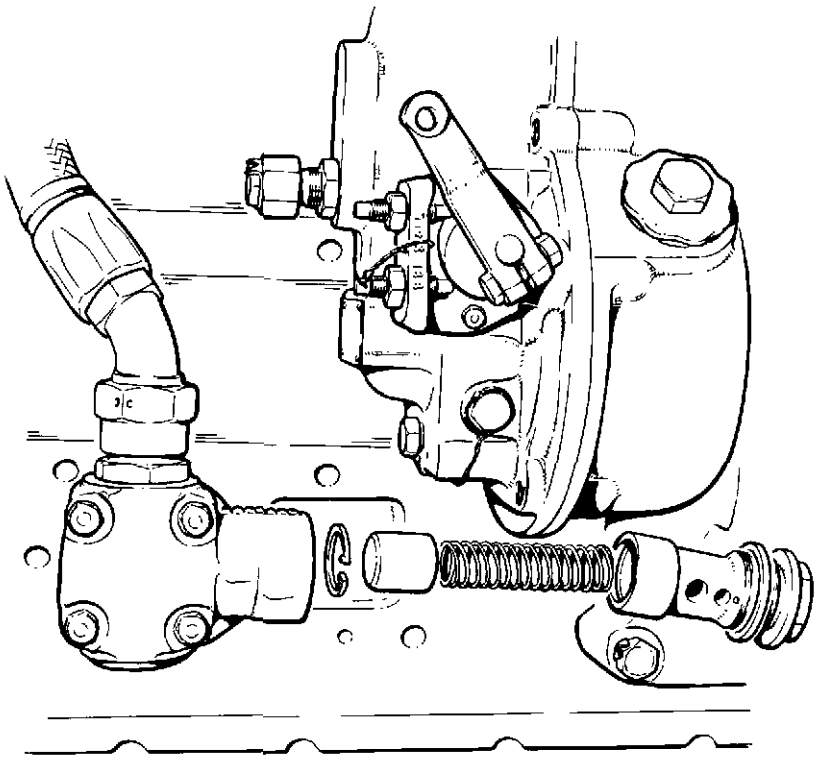

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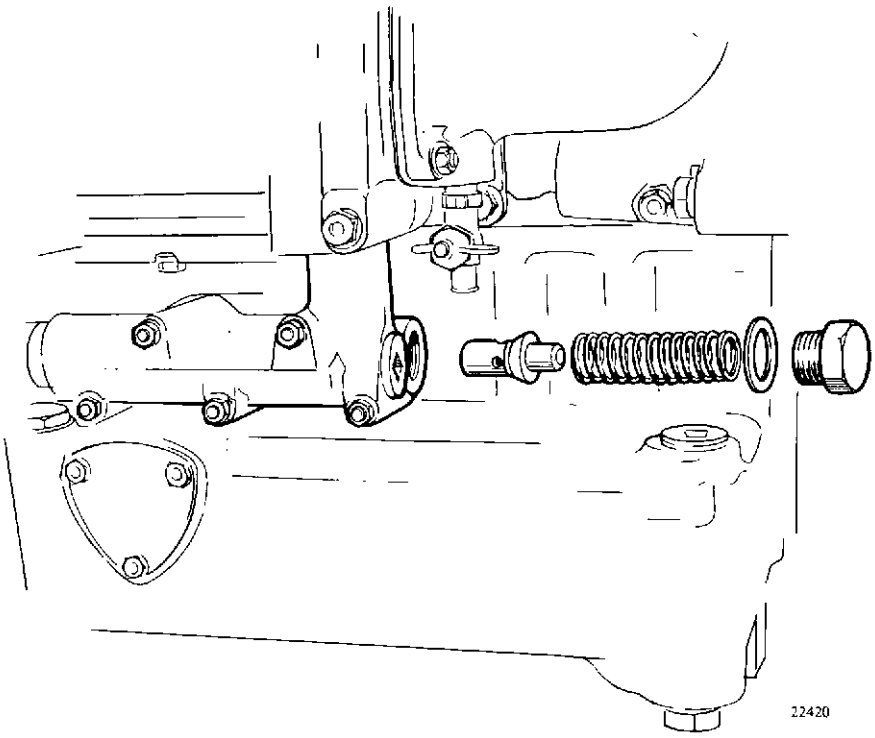

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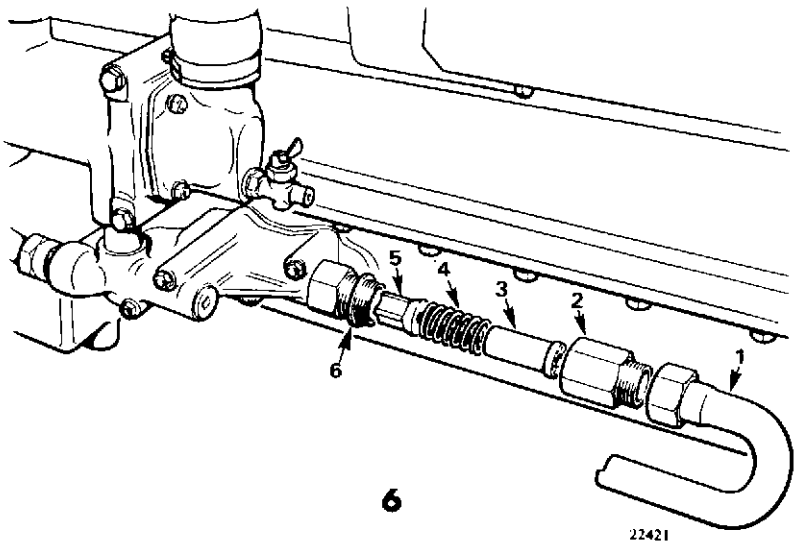

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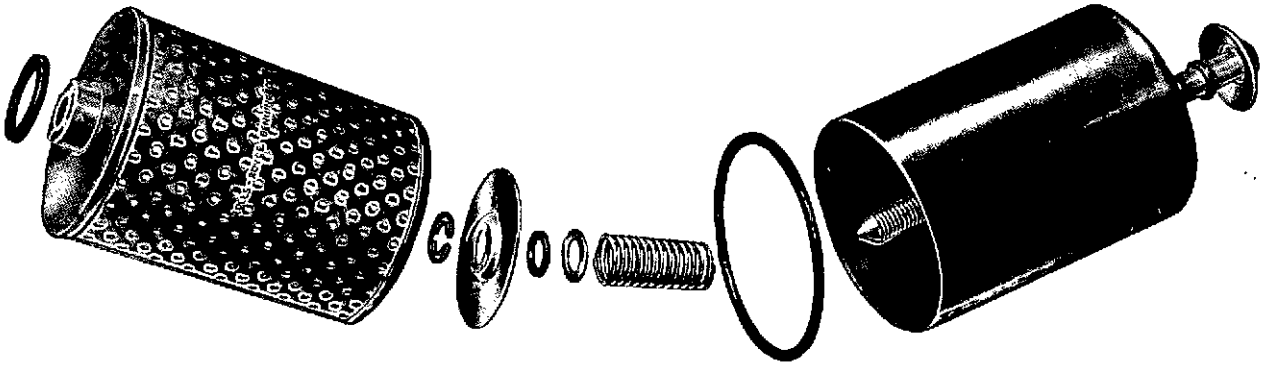

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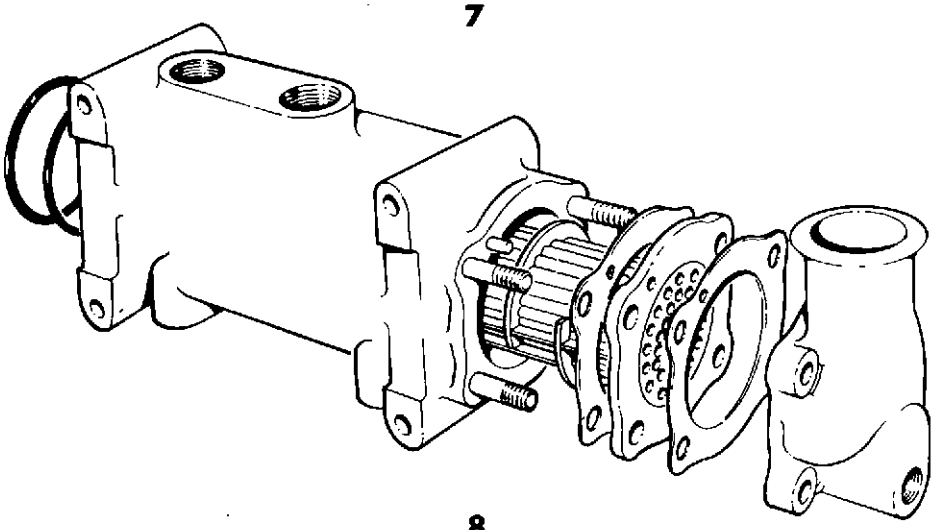

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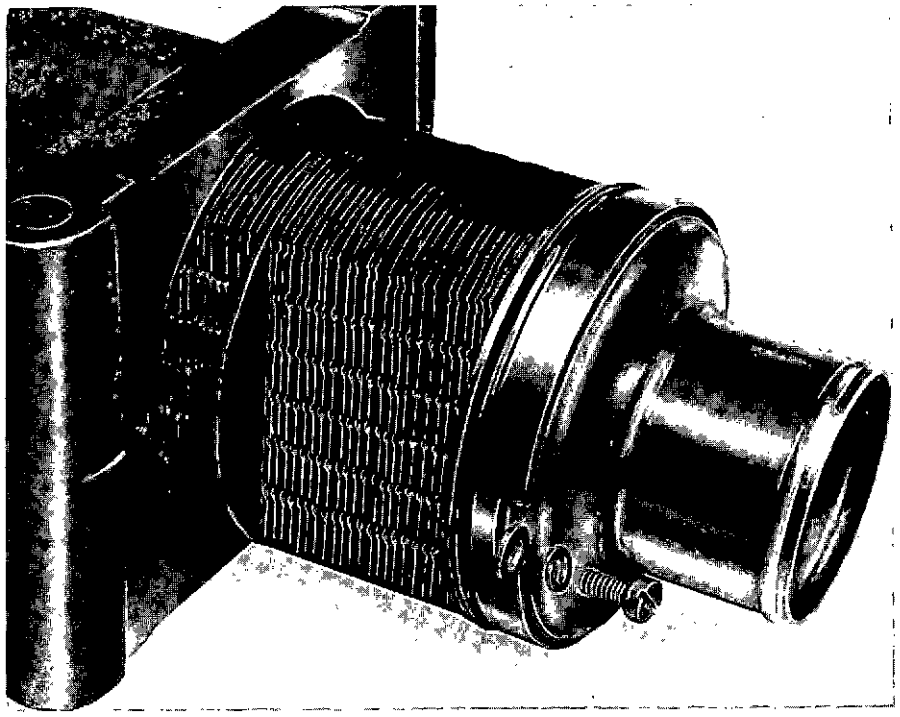

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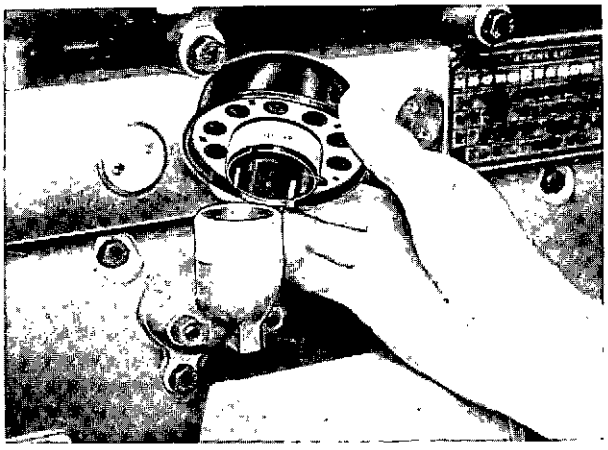

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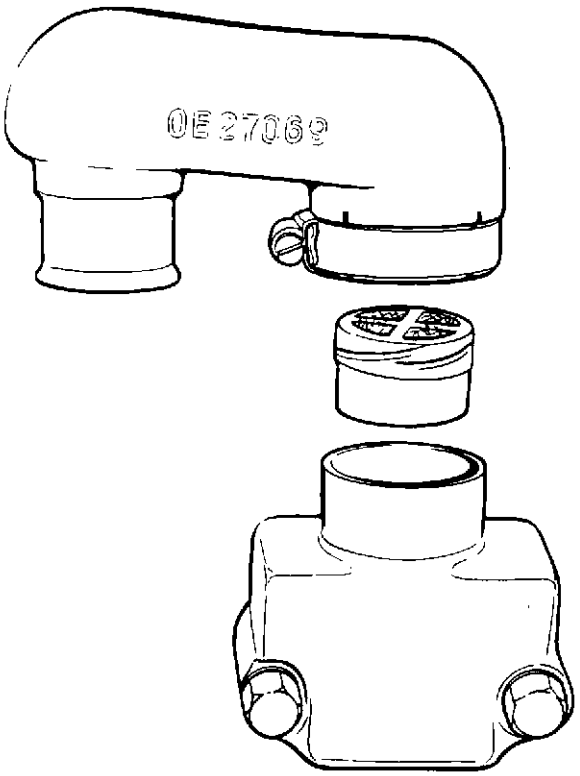

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SECTION 7 — INDUCTION SYSTEM

AIR RESTRICTION INDICATOR (fig. 1)

This device is usually fitted to air cleaners of the 'dry element' type to give warning that the element has reached the limit of fouling. It is connected to the 'clean air' side of the unit and is therefore sensitive to the restriction caused by the element. This restriction is approximately 1 inch w.g. for a new element but will progressively increase as fouling occurs. At the limit of fouling, a red sleeve becomes visible indicating that the air cleaner must be serviced immediately.

After servicing, reset the indicator by pressing the reset button in the top or bottom of the unit as appropriate. If necessary, an indicator may be tested for correct functioning by applying mouth suction at its connection. *Do not apply air pressure at this point.*

AIR CLEANER — BURGESS OIL BATH (fig. 2)

Description

Air enters via a centrifugal pre-cleaner, which ejects large dust particles, and passes down the central tube to the oil bath. Here the airflow direction is reversed, oil is picked up from the centre cup, and the oil-laden air passes upwards through two knitted-wire elements, one detachable, one fixed. The elements remove the oil and dirt, which fall into the annular portion of the oil bath, and the oil flows through the transfer holes back into the centre cup.

Servicing

> **Caution:** *When multiple cleaners of this type are fitted, all must be serviced at the same time. Otherwise, excessive airflow through the serviced cleaner may result in oil pull-over.*

1. Release the toggle clips and detach the oil bath, avoiding damage to the sealing ring and joint clip. Empty the oil bath and wash it in petrol or paraffin.

2. Remove the detachable element, wash it in petrol or paraffin, and dry off with compressed air. Immerse it in clean engine oil, and allow to drain for at least 15 minutes.

3. Remove and wash the pre-cleaner, and inspect it for damage.

4. Dismantle the cleaner body from the installation and wash it in petrol or paraffin. Ensure that the central tube and fixed element are clean, and dry the unit with compressed air. Do NOT oil the fixed element unless the cleaner is to be put into storage. Refit the cleaner body to the installation, and assemble the pre-cleaner.

5. Fill the oil bath to the LEVEL mark with clean engine oil. Pour the oil into the outer part, and check that it flows through the transfer holes into the centre cup before the oil level is reached.

   > **Caution:** Underfilling below the transfer holes will allow unfiltered air to enter the engine; overfilling above the LEVEL mark will cause oil pull-over.

   If the oil bath is correctly filled there is no need for topping-up between servicings.

6. Assemble the detachable element and oil bath to the cleaner, and ensure that all joints are sound and tight.

AIR CLEANER — DONACLONE (fig. 3)

Description

Air enters the cleaner body at the centrifuge assembly (4) and the heavier dust particles are deposited in the bowl (5). The air then passes up the tube bores to the inside of the element (3) and through the element to the engine. The level of dust in the bowl must not be nearer than 1 inch (25 mm.) from the bottom of the centrifuge tubes.

Servicing

1. Remove, empty, and clean the dust bowl (5). Clean the tube bores of the centrifuge assembly (4) by means of a bottle-brush.
2. Remove the top cover (1), unscrew the wingnut (2) and withdraw the element (3). Tap the element by hand to remove loose dust, and blow through it from the 'clean' side, along the length of the pleats, using dry compressed air not exceeding 100 lbf./sq. inch (689 kN/sq. m.).
3. If the element is oil-contaminated it may be washed in a solution of 2 oz. (57 grammes) of 'Cooper-Kleen', or 1 oz. (28 grammes) of 'Soilax', per gallon (4.5 litres) of warm water. 'Cooper-Kleen' is available from the manufacturers of the air cleaner.
4. After cleaning, inspect the element and discard it if the paper is perforated. Check that all joints are in good condition.
5. Reassemble the cleaner, and if necessary reset the restriction indicator.

AIR CLEANER — CYCLOPAC (fig. 4)

Servicing

1. Slacken the clamp ring and remove the dust bowl and baffle assembly. Unscrew the wingnut and separate the dust bowl and baffle. If the level of the dust in the bowl is less than ½ inch (12 mm.) from the baffle, the cleaner must be serviced more frequently. Empty the bowl, clean it and the baffle, and reassemble them together.
2. Unscrew the wingnut securing the element and withdraw the element downwards, taking care not to damage the plastic pre-cleaner fins.
3. The element may be cleaned by either of the following methods:
   (a) Working from the 'clean' side, direct a jet of dry compressed air up and down the element pleats. Air pressure must not exceed 100 lbf./sq. inch (689 kN/sq. m.), and the nozzle must not be brought too close to the element.
   (b) Wash the element in a solution of special detergent D1400. Full 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 accredited agents.
   The element should not be washed more than 6 times during its service life.
4. Inspect the element for damage by placing a light inside it. If the paper has thin spots or perforations the element must be scrapped.
5. Reassemble the cleaner, and if necessary reset the restriction indicator.

AIR CLEANER — ROTOPAMIC (fig. 5)

Description

The cleaner consists of a rectangular casing containing a number of 'Pamic' paper filter cartridges (2), sealed to a PVC face plate. The cartridge assembly is retained by a 'Rotonamic' pre-cleaner panel (1), clamped to the filter casing. The inner face of the pre-cleaner is perforated with fixed fan-type deflectors, each of which is concentric with a filter cartridge.

Air enters the pre-cleaner (1) and is spun by the deflectors, thus centrifuging the dust to the walls of the primary tube. Approximately 10 per cent of the air and 90 per cent of the dust enters the self-cleaning bin, which is connected by metal hose to an aspirator (3) in the engine exhaust system.

The remainder of the air passes through the filter cartridges (2) and thence to the engine.

Servicing

The filter cartridges cannot be cleaned and must be renewed as a set. Ensure that the pre-cleaner panel is securely clamped to the filter casing, so that no leakage occurs at the seal.

AIR CLEANER—PUROLATOR (fig. 6)

Description

The air cleaner consists of a pleated paper dry element, carried in a cylindrical metal container and retained by an end cover.

Servicing

Remove the end cover and withdraw the element. Renew if damaged or oil-contaminated. Do NOT attempt to clean it by washing.

If serviceable, clean the element by a low-pressure jet of dry air from the inside, or by lightly tapping by hand.

Clean the interior of container and cover, ensure that the joint ring is in good condition, and refit the element.

AIR DUCTING AND HOSE CONNECTIONS

These should be regularly inspected for tightness, leakage and signs of internal collapse. Renew hose connections whenever they are dismantled. Pay particular attention to the silicon glass fibre hose connections used on turbochargers, and do not replace them by an unapproved type of hose.

TURBOCHARGERS—OPERATION AND MAINTENANCE

Description

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

> **Note:** *Although simple in principle and construction, the turbocharger is a precision-built machine operating at very high speeds. Its performance and life are dependent on correct usage and efficient maintenance as described in this Section.*

Operating precautions

1. Before new or overhauled engines equipped with Holset 4LE and 4LEK, or AiResearch T.18 and TV.71 turbochargers are run at Rolls-Royce an expendable filter OE.43712 is fitted to the turbocharger oil inlet flange; this protects the turbocharger bearings during initial running and is then removed and destroyed. Dealers and Operators adopting this precaution are reminded that (1) the filter *must* be removed before the engine goes into service and (2) the filter cannot be cleaned and *must* be destroyed on removal to prevent re-use. This does not apply to the Holset Model 4 turbocharger, which has a permanent filter.

2. If the engine has been out of use for a month or longer, prime the turbocharger bearings as described in Chapter 2, 'Operating' before starting-up.

3. Before shutting down, allow the turbine to cool by running the engine at 800 r.p.m. for 3 minutes.

4. Never continue to run a turbocharged engine if the oil pressure falls below 30 lbf./sq. inch (207 kN/sq. m.) at normal working conditions.

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), or more frequently if found necessary under severe conditions.

2. At frequent intervals inspect the induction and exhaust systems for leakage and deterioration of hose connections, which would cause overheating. If the systems are disturbed they must be reassembled carefully to ensure perfect joints, and to prevent cracking of manifolds due to uneven tightening.

3. During servicing, take special care to prevent dirt and loose articles from entering the induction and exhaust systems where they could damage the compressor or turbine.

4. The exhaust manifolds of turbocharged engines are of special alloy to protect the turbine from damage by loosened scale. Manifold components

designed for non-turbocharged engines are unsuitable for use in conjunction with a turbocharger.

5. At frequent intervals check that the turbocharger oil feed and drain pipes are undamaged. Restriction of oil flow in either pipe may result in turbocharger bearing failure. Check the bore of the drain pipe at oil change intervals.

6. Service the crankcase breather at the intervals specified in the Servicing Schedule (Section 1). Pressurization of the crankcase will prevent the free return of oil from the turbocharger bearings.

7. Use an approved lubricating oil to the appropriate grade and specification (see leaflet T.S.D.3085), and maintain the engine lubrication system in accordance with the Servicing Schedule (Section 1).

8. Make periodic checks to ensure that the exhaust system is unrestricted (e.g. by choked silencer or damaged exhaust pipe). Overheating and loss of performance will occur if the exhaust back-pressure exceeds 2 inches (51 mm.) Hg. *under full load.*

9. If investigation of an engine fault (see Chapter 4) involves checking the turbocharger, remove the induction trunking and spin the rotor assembly by hand. Check for freedom to rotate, and listen for noises indicating binding or rubbing. If necessary, remove the turbocharger for cleaning and bearing checks, as described later.

Turbocharger failure

The cause of turbocharger failure must be found and rectified before a replacement is fitted. It will also be necessary to check whether the failure has caused damage to other 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 cleared of debris. If charge coolers are fitted, inspect them for damage, fouling of the matrix, and leaks.

2. A damaged turbine may be due to loose particles from the cylinders or exhaust manifold. 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 liner wear and piston scuffing.

4. Failure of turbocharger bearings is usually due to faulty lubrication. This may be caused by low oil pressure or restricted oil flow, but is more often attributable to dirty or diluted oil. Following turbocharger bearing failure the engine lubricating oil must be changed and the filter elements renewed.

Incorrect air delivery pressure

1. Pressure *below* normal may be caused by:
   (a) Dirty or damaged compressor
   (b) Damaged turbine
   (c) Leaks in induction or exhaust system
   (d) Insufficient fuelling.

   Inspect the turbocharger, and induction and exhaust systems. Verify that the governor operates the fuel pump rack over its full range.

2. Pressure *above* normal may be caused by:
   (a) Excessive fuelling
   (b) Damaged nozzle ring assembly.

   Inspect the MAX. FUEL stop seal on the injection pump. If the seal is broken, remove the pump for correction of the fuelling on a test rig. If the seal is unbroken, dismantle the turbocharger for inspection.

TURBOCHARGER—HOLSET 4, 4LE, 4LEK

Cleaning the compressor

On Models 4 and 4LEK, unbolt and remove the compressor cover, marking it to ensure correct refitting.

On Model 4LE turbochargers unscrew the nut from the V band securing the compressor housing, remove the band, and withdraw the housing

squarely. **Note:** The nuts of the 'V' bands used on Models 4LE and 4LEK must be fitted hexagon outwards and tightened to 10 lbf. ft. (13.5 Nm).

Support the turbocharger so that the compressor wheel is vertically downwards and not carrying any weight. Immerse the wheel in a non-caustic cleaning fluid and allow to soak. Remove loosened deposits, using a non-metallic scraper or brush. Ensure that no deposits remain, or the balance of the rotor assembly may be affected.

Serviceability checks

These checks should be made after the compressor and turbine have been cleaned, and if the turbocharger appears to be otherwise serviceable.

1. To check radial movement of the rotor assembly, clamp the turbocharger so that the rotor shaft is vertical, turbine wheel uppermost.
   Fix a dial test indicator rigidly, as shown in fig. 7, and push the turbine wheel against the indicator button whilst at the same time pushing the compressor wheel in the opposite direction. Note the total indicator reading, then reverse the load and again note the reading. Turn the rotor 90 degrees, repeat the check, and again note the readings. Invert the turbocharger and carry out the same checks with the compressor uppermost.
   The greatest reading must not exceed 0.023 inch (0.58 mm.) on Model 4, or 0.021 inch (0.53 mm.) on Models 4LE and 4LEK.

2. To check end float of the rotor assembly, adjust the dial test indicator so that its button rests on the end of the rotor shaft (fig. 8). Move the shaft vertically to its full extent in both directions and note the total indicator reading. End float limits are 0.004 to 0.006 inch (0.10 to 0.15 mm.) for Model 4, and 0.003 to 0.006 inch (0.08 to 0.15 mm.) for Models 4LE and 4LEK.

Readings beyond the limits in 1 and 2 above will involve overhaul of the turbocharger. Instructions for this are available from The Holset Engineering Company Limited, Turnbridge, Huddersfield, England.

TURBOCHARGER—AIRESEARCH T.18, TV.71

These turbochargers (fig. 9) are similar in design to the Holset and require the same operating precautions, maintenance and defect procedure. Cleaning and serviceability checks are slightly different and are described below:

Cleaning the compressor

Remove the compressor housing and clean it with a suitable solvent. Clean the compressor in the manner already described for the Holset turbocharger.

Serviceability checks

These checks should be made after the compressor and turbine have been cleaned, and if the turbocharger appears to be otherwise serviceable.

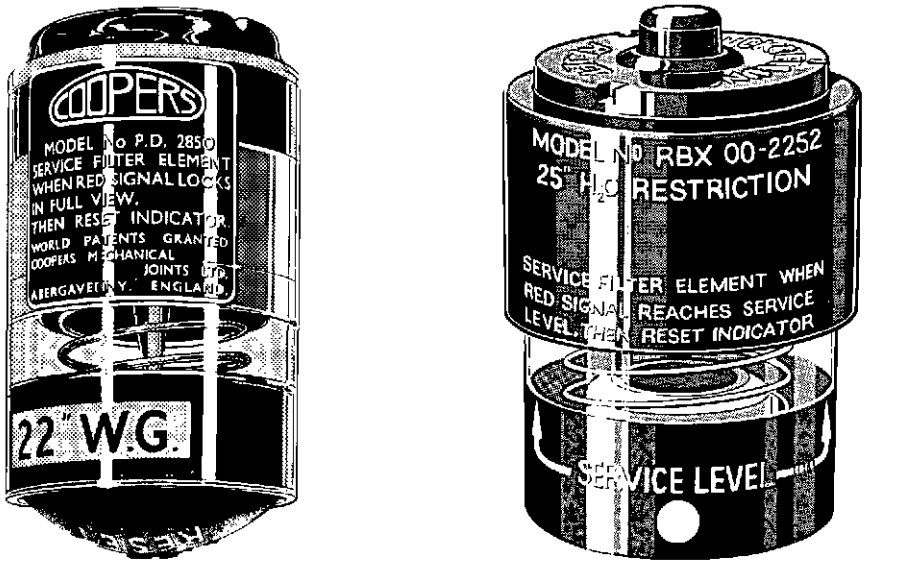
1. To check radial movement of the rotor assembly, make an adapter plate to hold the dial test indicator (fig. 10). Bolt the adapter plate to the turbocharger bearing housing at the oil drain connection (fig. 11) and fit the dial test indicator so that its button rests on the rotor shaft.
   Applying an equal load in the same direction at each end, raise and lower the rotor shaft assembly to its full extent, and note the total indicator reading. Limits are:

   T.18 0.004 to 0.009 inch (0.10 to 0.23 mm).
   TV.71 0.005 to 0.007 inch (0.13 to 0.17 mm).

2. To check end float of the rotor assembly, mount the dial test indicator as shown in fig. 12, with the button resting on the compressor end of the rotor shaft. Move the shaft axially to its full extent in both directions and note the total indicator reading. Limits are:

   T.18 0.004 to 0.009 inch (0.10 to 0.23 mm).
   TV.71 0.004 to 0.010 inch (0.10 to 0.25 mm).

Readings beyond these limits will involve overhaul of the turbocharger. For this information consult the manufacturer, Garrett AiResearch Limited, Turbocharger Division, East Pimbo, Skelmersdale, Lancashire, England.


COOPERS
MODEL No P.D. 2850
SERVICE FILTER ELEMENT
WHEN RED SIGNAL LOCKS
IN FULL VIEW.
THEN RESET INDICATOR
WORLD PATENTS GRANTED
COOPERS MECHANICAL
JOINTS LTD.
ABERGAVENNY. ENGLAND.
22" W.G.
MODEL NO RBX 00-2252
25" H2O RESTRICTION
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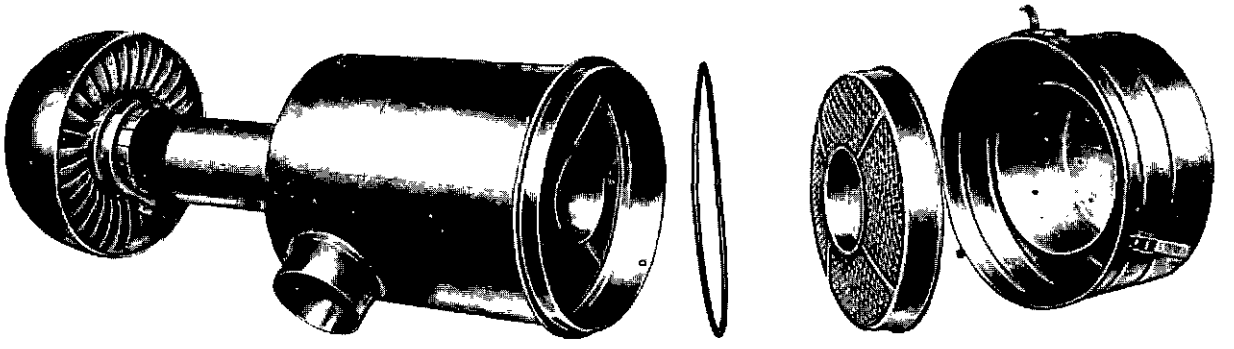
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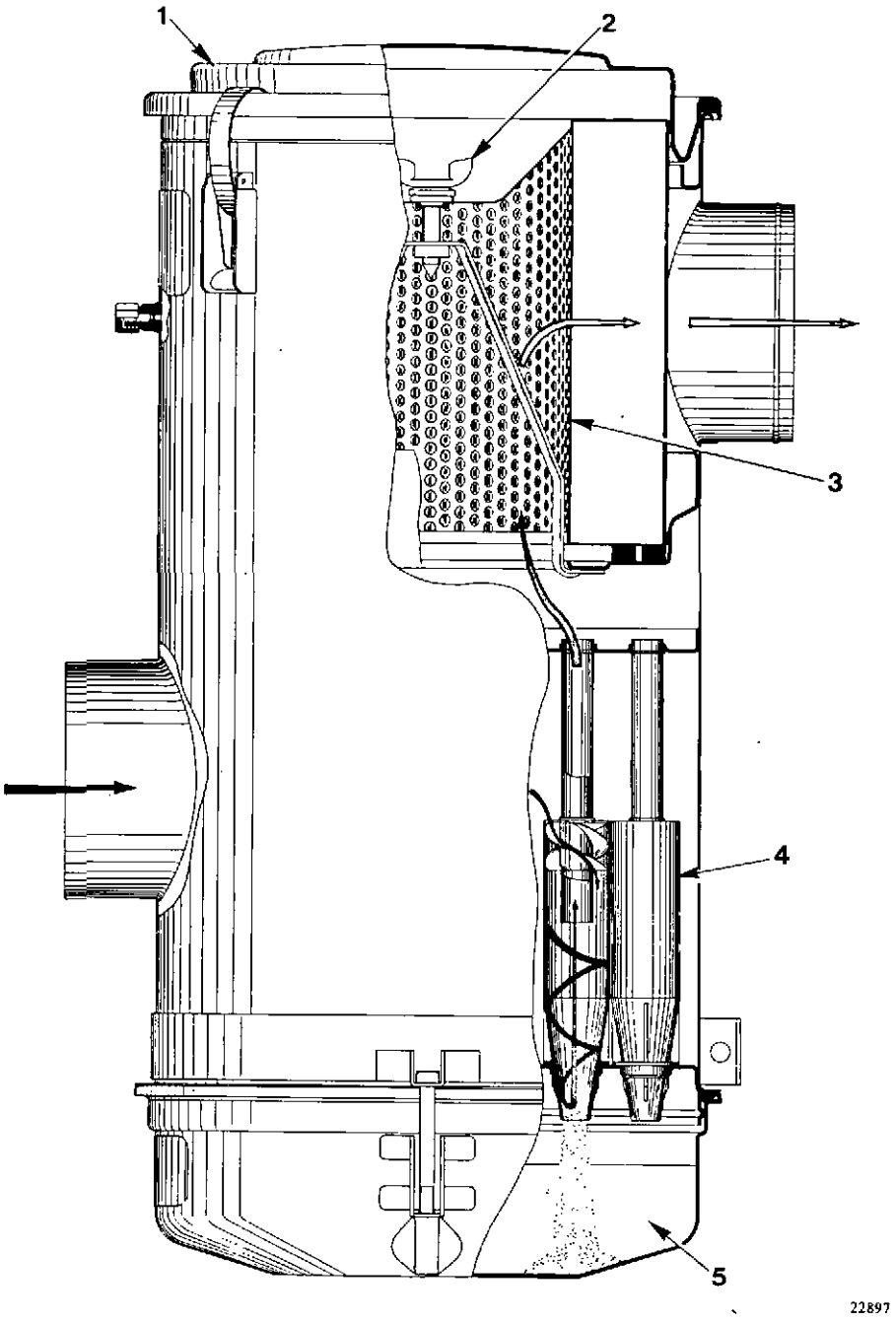

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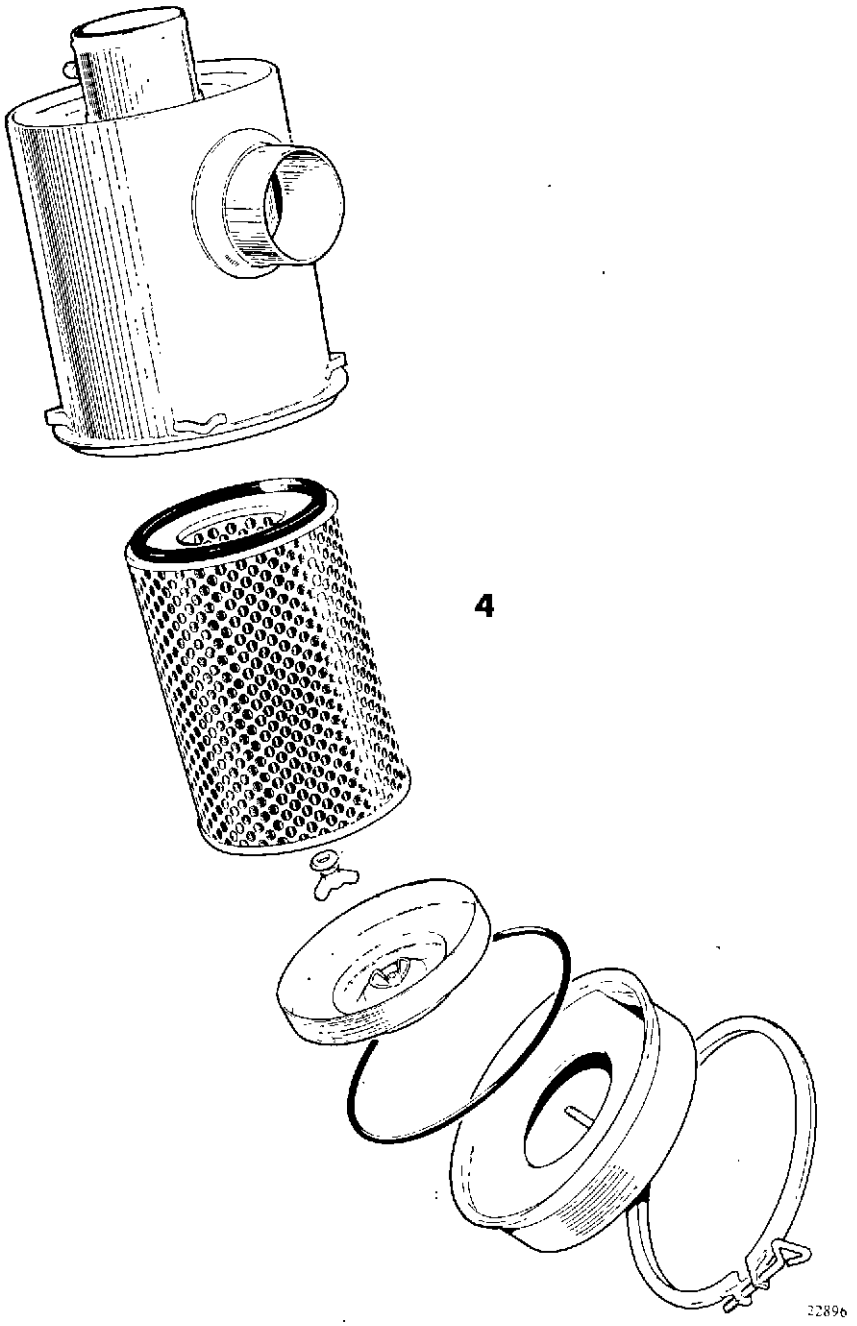
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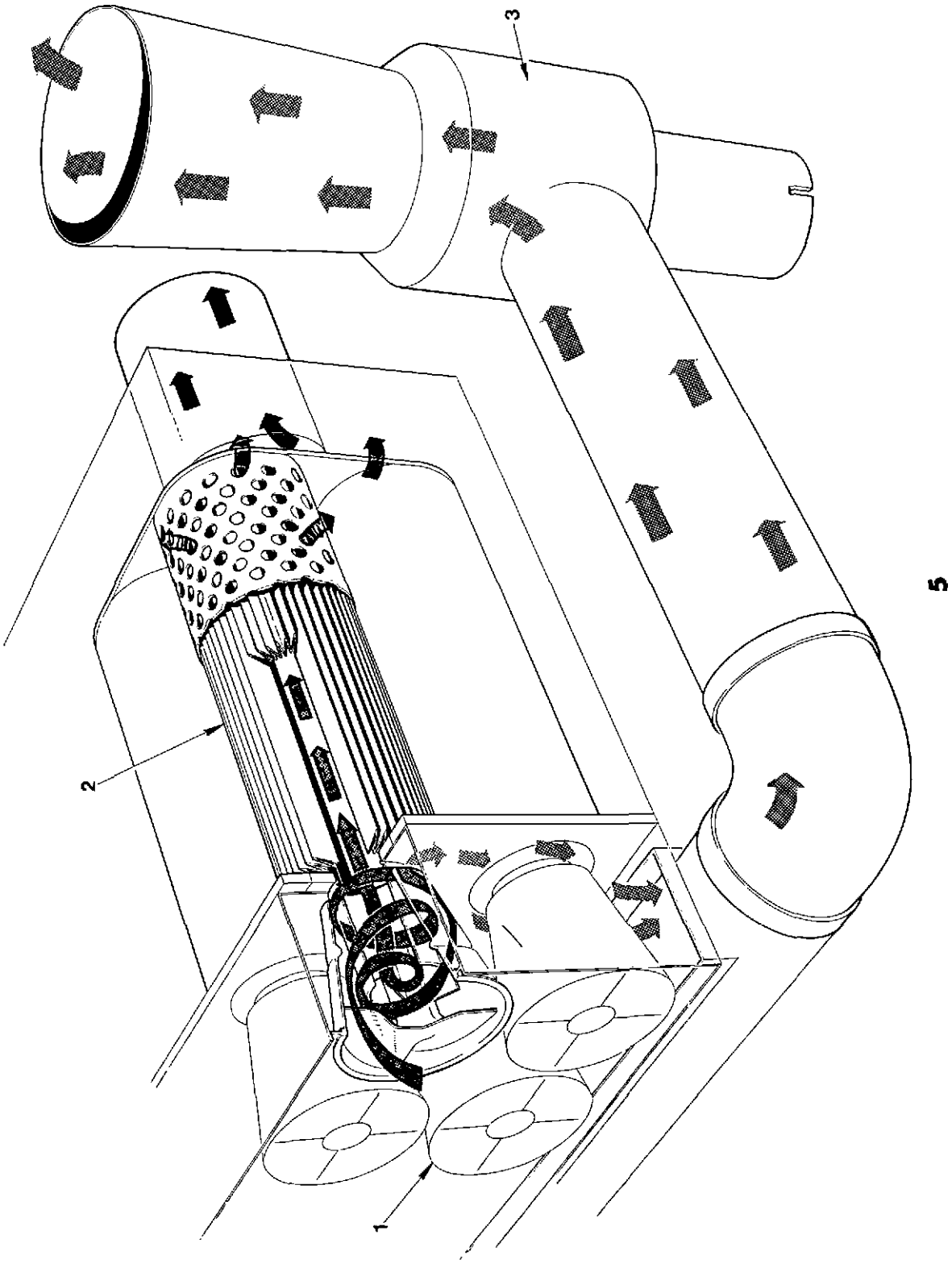
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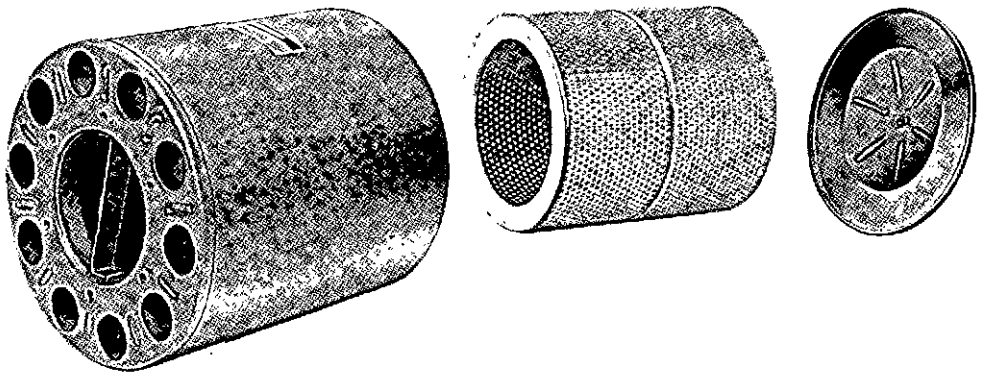

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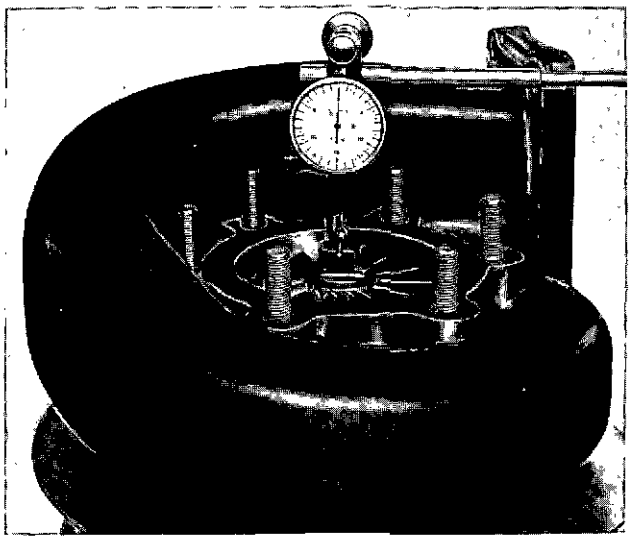

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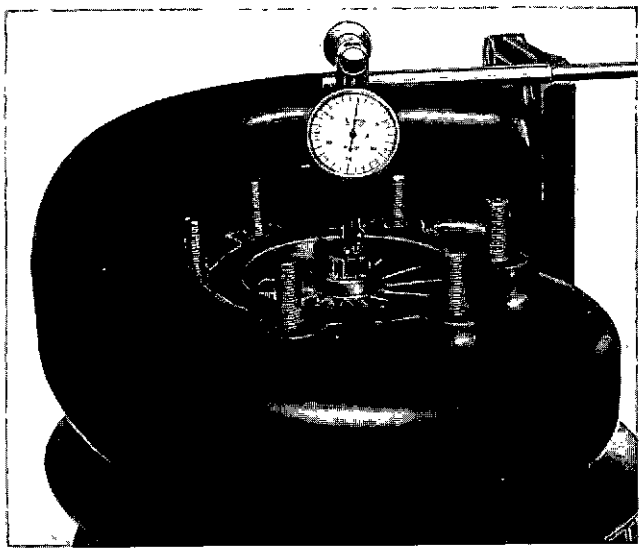

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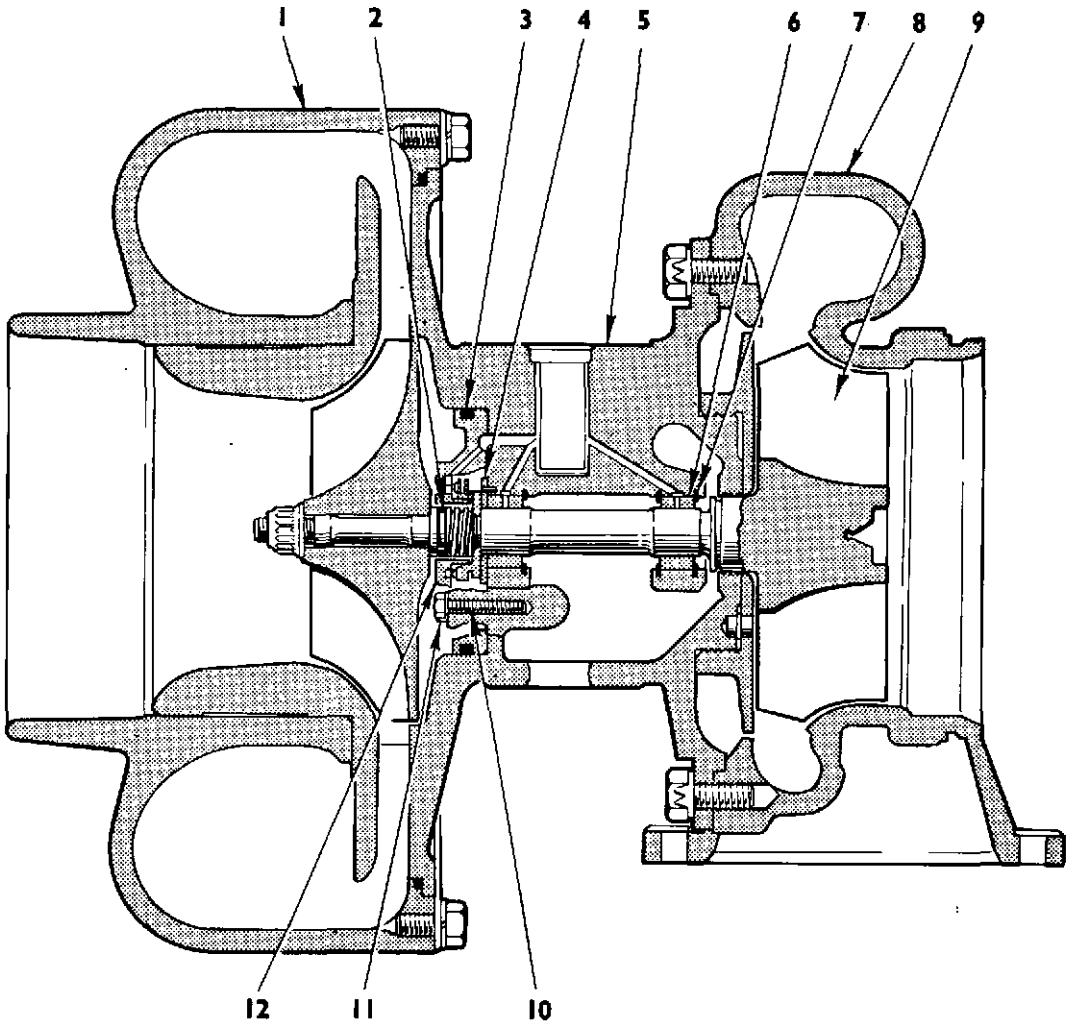

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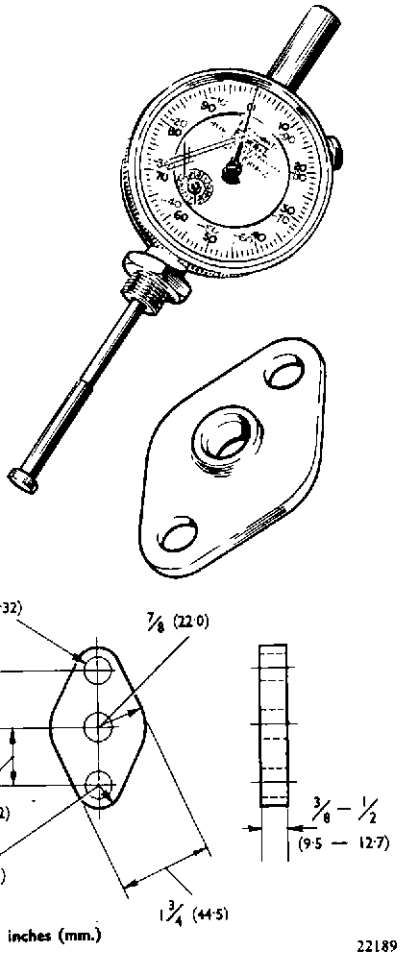
KEY TO FIG. 9

1. Compressor housing
2. Piston ring
3. 'O' ring
4. Thrust bearing
5. Centre housing assembly
6. Plain bearing
7. Snap ring
8. Turbine housing
9. Rotating assembly
10. Bolt
11. Lockplate
12. Thrust plate assembly



Dimensions : inches (mm.)

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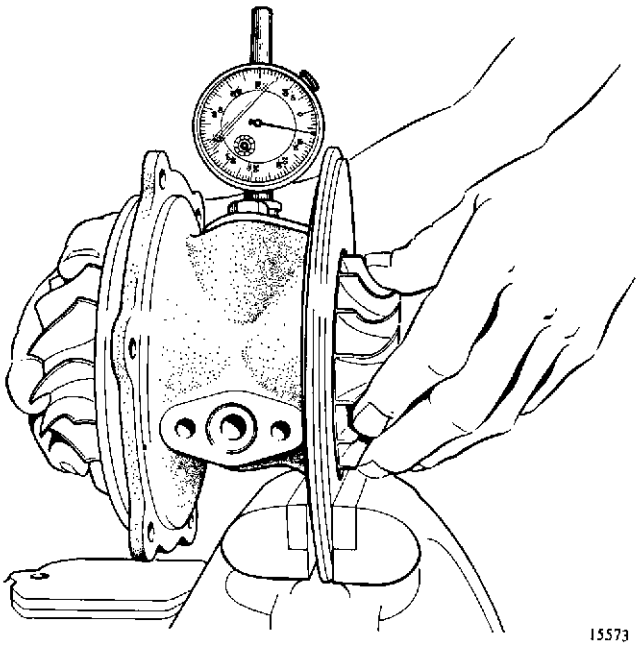

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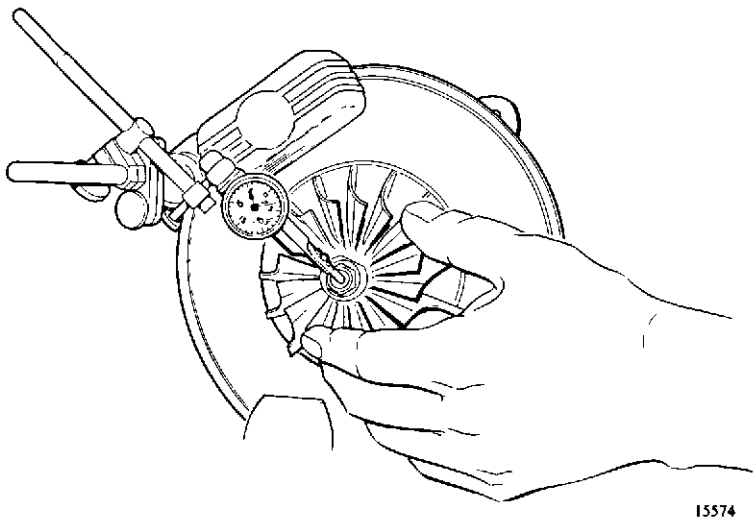

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SECTION 8 — ELECTRICAL SYSTEM

ALTERNATOR AND VOLTAGE REGULATOR (C.A.V.)

Description

The battery charging system consists basically of an AC5, AC7 or AC5R alternator, the first two being used in conjunction with a Type 440 voltage regulator. A Type 446 suppression box is also fitted on marine applications to prevent radio interference.

The AC5R alternator has an integral regulator which does not require servicing, and must be renewed if found to be faulty.

Alternators are fan-cooled units of the rotating field and stationary armature type, and are self limiting in output. Rectification is by silicon diodes carried in heat sinks, with the following limitations:

Alternator	AC5	AC5R	AC7
Cut-in speed (alternator rpm)	1,100	1,150	600
Max. output (hot)	30 amps @24 volts	37 amps @ 27.5 volts	60 amps @24 volts
Max. speed (alternator rpm)	10,000	10,000	800

The Type 440 regulator is fully transistorized. It is sealed and cannot be serviced, adjusted or repaired. Three terminals marked 'HI', 'MED' and 'LO' are provided to permit a change of setting to suit varying operating conditions. The regulator must be mounted in a dry position where the ambient temperature does not exceed 70 deg. C. (158 deg. F.).

Alternator servicing

Unless otherwise stated, carry out the following servicing operations at the intervals specified in the Servicing Schedule (Section 1).

1. Inspect the driving belts for condition and tension. Adjust, if necessary, as described in Section 2.
2. Periodically, dependent on operating conditions, clean the exterior of the alternator and ensure that the ventilating slots are clear. Remove and clean the cowl on marine models. Fouling in the vicinity of the diodes can cause flashover and should be removed using a soft cloth or brush moistened with Genklene 'N', obtainable from I.C.I. Limited, Mond Division, Runcorn, Cheshire, England, or their accredited Agents.
3. On AC7 alternators, inject $\frac{1}{8}$ oz. (3.5 gr.) of Shell Alvania 2 grease, or equivalent, into the drive end bearing via the screw plug or greaser on the bearing cap.
4. Remove the brush holder, and clean the slip rings by means of a clean cloth moistened with white spirit. Renew the brushes if their length is less than $\frac{5}{16}$ inch (8 mm.). Check that brush spring pressure is 8 oz. (227 gr.).

Warning: The diodes and transistors in the 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 a lead without first stopping the alternator and turning any switches OFF.

3. Connect a 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.

STARTER MOTOR (SL5A or SP6A)

The standard electric starter, dependent on engine type, is a 5 or 6 inch diameter axial engagement unit operating on 24 volts. The 5 inch starter is of the 'hold-on' type; the 6 inch starter may be 'hold-on' or 'non-hold-on', as required.

The 'hold-on' starter is used where starting is manually controlled, or where the start signal ceases when the engine reaches self-sustaining speed. The 'non-hold-on' starter is fitted to remotely or automatically-started engines. Both types are of similar appearance, and it is essential that a replacement unit should be carefully checked to ensure that it is correct for the engine application.

Servicing

No fixed routine servicing is called for, and the life of the starter will depend on the frequency with which it is used. The bearings are grease-packed and on average will not require attention for three years. However, the life of the unit will be considerably shortened if it is used to bar the engine over.

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

1. When fitting a starter, ensure that its spigot is squarely located in the flywheel housing before tightening the bolts.
2. Periodically, check the starter bolts for tightness, and inspect the cables for security and damage.
3. At long intervals (e.g. 7,000 to 10,000 E.S.C. Units, dependent on frequency of usage) remove the starter and service it as follows:
   (a) Take off the commutator cover and use a jet of dry air to blow away dust or particles from the brushgear.
   (b) Ensure that the brushes slide freely and check that their spring loading is 32 to 40oz. (0.91 to 1.13kg.). A lower figure indicates that the brushes are worn. Replacement brushes must be fitted as a set, and bedded to the commutator.
   (c) Inspect the commutator for wear and damage. A dark brown discoloration is normal. Use a dry cloth to clean the surface. Slight scores may be removed by the use of very fine glasspaper (NOT emery cloth or carborundum paper), followed by an air jet to blow away abrasive particles. A worn or damaged commutator will involve removal and reconditioning of the armature (see Workshop Manual, T.S.D. 803).
   (d) Inspect the starter pinion for wear and damage and renew it if necessary. Ensure that the replacement pinion has the same number of teeth and is of the same metal as the original.
   (e) Remove the lubricator screw and spring from the pinion bearing housing and pour about 12 cc. of S.A.E. 20 oil into the filler hole. When the lubricator pad is saturated, remove any surplus oil and replace the spring and screw.
   (f) Inspect the solenoid switch contacts. These may be cleaned by white spirit or fine carborundum paper, but if they are badly damaged the complete switch must be renewed.
   (g) Replace the commutator cover, and refit the starter.

STARTER MOTOR (S130L)

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. 1). 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.
   (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 0.39 inch (10 mm). Ensure that the brushes slide freely in their holders and check the spring pressure with a tension gauge. The correct tension is 5.25 to 5.5 lbf. (23.5 to 24.5 N), 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 40 to 50 lbf. ft. (54 to 68 Nm).
   (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 9.5 to 10 lbf. ft. (13 to 13.5 Nm).
   (g) Assemble the end bolt, thrust washer and shims with the thickest shim against the bush, and torque-tighten the bolt to 25 to 30 lbf. ft. (34 to 41 Nm).
   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 0.004 to 0.012 inch (0.1 to 0.3 mm). Refit

and torque-tighten the bolt and refit 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 15 to 18 lbf. inch (1.7 to 2.0 Nm). 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 9.5 to 10 lbf. ft. (13 to 13.5 Nm).

)k) Fit the sealing washer, rubber seal, seal locator, plain washer, spring washer and nut on the return terminal. Torque tighten the nut to 9 to 10 lbf. ft. (12 to 13.5 Nm). Place a second spring washer and nut on the termianl and tighten by hand.

SOLENOID STOP CONTROL

Description

Dependent on installation requirements, the C.A.V. Type 368 solenoid unit (fig. 1) may be used in 'energized to stop' or 'energized to run' form, reversal of action being obtained by fitting the injection pump stop lever (1) at diametrically opposite positions on its shaft. The illustration shows an 'energized to stop' system.

When the solenoid is energized the plunger moves in the direction of the arrow and at the limit of its travel opens switch 'C', de-energizing the 'pull-in' winding but leaving a low-consumption 'hold-in' winding energized to retain the plunger. On de-energization, a coil spring returns the plunger to its original position.

On an 'energized to stop' system the solenoid is not energized whilst the engine is running. The engine is stopped by energization of the solenoid, either when the STOP button is pressed or by operation of one of the automatic shutdown switches in the engine coolant and lubrication systems.

On an 'energized to run' system the solenoid is permanently energized whilst the engine is running, and is retained in this position by the 'hold-in' winding. The engine is stopped by de-energization of the solenoid due to operation of either the STOP switch or an automatic shut-down switch, or as the result of an electrical fault.

> **Caution:** The solenoid unit is supplied in a variety of voltages and settings to suit individual installations and it is essential to ensure that a replacement unit corresponds exactly to the original.

Adjustment

Referring to fig. 2, both 'energized to stop' and 'energized to run' systems require accurate adjustment of the control rod between solenoid and stop lever (1) to prevent damage to the pump or the solenoid windings. It is essential that, when the solenoid is energized, the plunger is able to travel fully inward and open switch 'C', otherwise the following may occur:

(a) On an 'energized to stop' system, if the control rod is too short the stop pawl (2) will move the pump rack, via pin 'A', to the limit of rack travel before the solenoid plunger has opened switch 'C'. This will overload taper pin (3) and damage the rack locating plate, and can also result in overheating of the solenoid 'pull-in' winding.

(b) On an 'energized to run' system, if the control rod is too short the stop pawl (2) will reach the limit 'B' before the solenoid plunger has opened switch 'C'. The solenoid 'pull-in' winding will therefore remain energized whilst the engine is running and will eventually burn out through overheating.

To prevent these situations from arising, adjust the length of the control rod so that when the system is operated manually the solenoid plunger is pushed fully home, followed by a further movement of 0.02 to 0.03 inch (0.5 to 0.8 mm.) to compress the spring at spherical joint 'D'.

AUTOMATIC WARNING AND SHUTDOWN SWITCHES

Drayton type

The Drayton Type EP pressure switch and Type ET temperature switch (fig. 3) are of basically similar construction and are fitted in the lubricating oil and coolant systems respectively.

Each switch incorporates two micro-switches, one of which actuates a warning device at a pre-

determined condition of low oil pressure or high coolant temperature, as applicable. The other micro-switch is available, where required, to actuate shutdown mechanism under similar or worsening conditions. When this micro-switch is not used it may be employed as a spare by transferring the leads from the original switch and adjusting it to operate at the required condition.

Testing

To ensure that the switches have not become inoperative or maladjusted in service they should be tested for correct functioning at regular intervals. Tests should be as frequent as operating conditions permit and in any event not exceeding six months apart.

The settings for individual switches are given in the accompanying tables. A switch may be identified by the Part Number etched on one face of the square above its mounting screw-thread, or by reference to the Engine Parts List.

Pressure switches

Ideally, these should be removed and checked on a test rig, with a lamp and battery connected across the micro-switches.

Failing this, a functional check may be made when the engine is at working temperature by one of the following methods:

1. Gradually reduce engine speed to IDLE and note the oil pressure gauge reading when the warning device operates.
2. If in Method 1 the oil pressure does not fall to the figure specified for switch operation, shut down the engine and, as the pressure gauge needle returns to zero, note the reading at which the device operates. Ensure that shutting down the engine does not also de-energize the Drayton switches.

Temperature switches

Although it is possible to test these switches *in situ* by running the engine with the radiator blanked off, or sea-water inlet reduced, this method is no longer recommended because of the risk of overheating the engine, which could occur, for instance, if the temperature were raised above the specified figure in an attempt to operate a faulty switch.

The approved method is to remove the switch, connect a lamp and battery across the micro-switches, and immerse the sensing bulb in a container of water. If the operating temperature exceeds 100 deg. C (212 deg. F) it will be necessary to use oil. Place an accurate thermometer close to the sensing bulb and heat the container, noting the temperatures at which the switches operate.

Adjustment

Referring to fig. 3, remove the switch cover and slacken locking screw 'C'. Turn screws 'A' and 'B' clockwise until both switches are clear of the bellows operating plate. If the switches are to operate at different pressures or temperatures for warning and shutdown, adjust the higher value first.

Turn the appropriate screw anti-clockwise until the switch operates at the required pressure or temperature. Adjust the other screw in a similar manner. Re-check the operation of the first switch, adjust if necessary and, when satisfactory, tighten the locking screw 'C'.

One complete turn of screws 'A' and 'B' varies the operating pressure 2 to 3 lbf./sq. inch (14 to 21 kN/sq. m.), or the operating temperature 5 deg. C. (9 deg. F.). Turning the screws clockwise increases the operating figure, and vice versa.

Settings for Pressure Switches, Type EP

Switch Part No.	Warning pressure (falling)		Shutdown pressure (falling)	
	lbf/sq. inch	kN/sq. m.	lbf/sq. inch	kN/sq. m.
OD 14895/1	20 to 22	138 to 152	10 to 12	69 to 83
OD 14895/2	10 to 12	69 to 83	10 to 12	69 to 83
OD 14895/4	18	124	12	83
OD 14895/5	7	48	7	48
OD 14895/6	28	193	22	152
OD 14895/8	20 to 22	138 to 152	20 to 22	138 to 152

Settings for Temperature Switches, Type ET

Switch Part No.	Warning temperature (rising)		Shutdown temperature (rising)	
	Deg. C	Deg. F	Deg. C	Deg. F
OD 14896/1	60	140	65	149
OD 14896/2	70	158	75	167
OD 14896/3	80	176	85	185
OD 14896/4	85	185	90	195
OD 14896/5	90	195	95	204
OD 14896/6	95	204	100	212
OD 14896/7	100	212	105	221
OD 14896/8	105	221	110	230
OD 14896/10	95	204	95	204

Teddington type switches

The switches may be wired to operate on rising or falling temperatures and pressures to suit the individual application. No servicing is necessary on the switches but it is strongly recommended that they be checked for operating efficiency at regular intervals, as engine operating conditions permit. Ideally, the checks should be carried out every six months or less.

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

To test the oil pressure switch, screw the switch into a suitable pressure fitting and apply pressure in excess of 30 lbf./sq. inch (207 kN/sq. m.). 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 20 and 24 lbf./sq. inch (138 and 165 kN/sq. m.).

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 extinguised; 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.

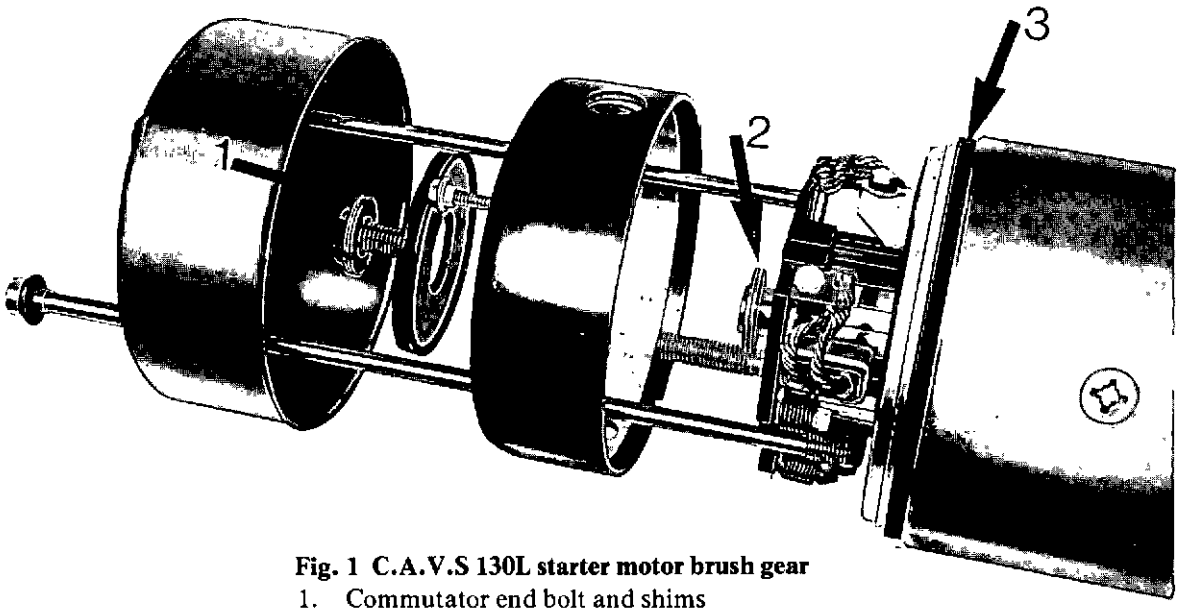
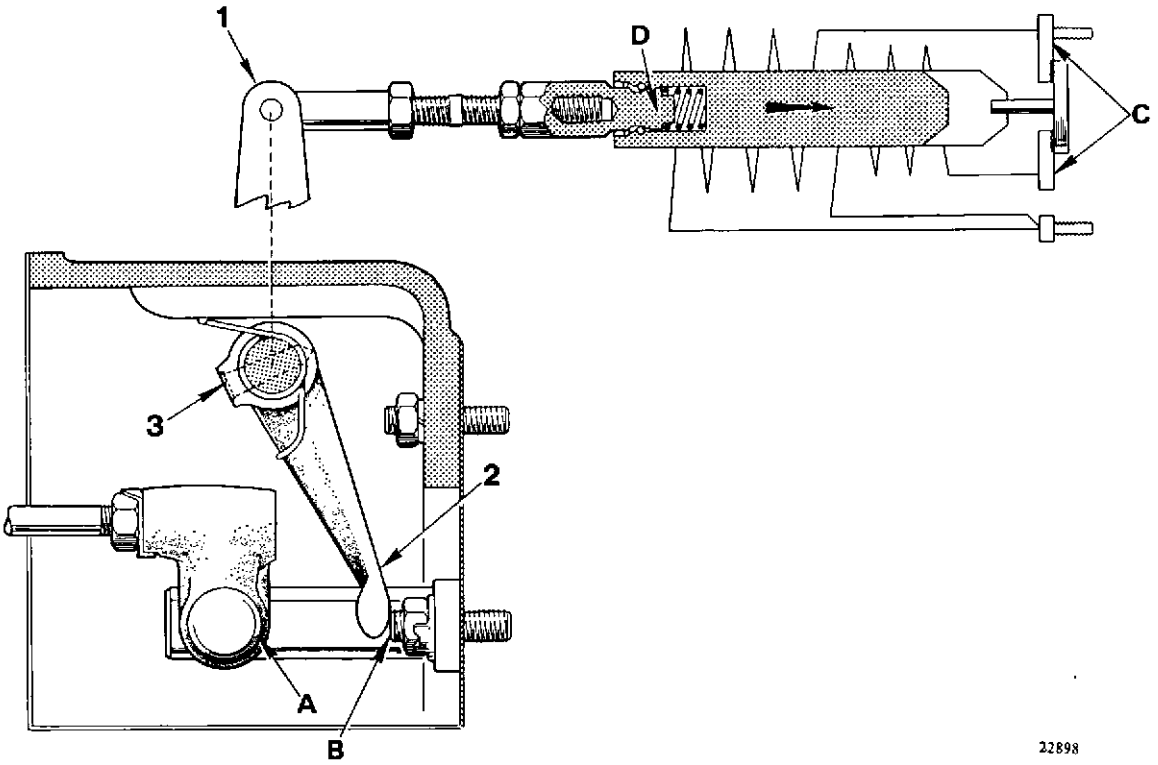


Fig. 1 C.A.V.S 130L starter motor brush gear

1. Commutator end bolt and shims
2. Recoil housing shims
3. Cover sealing ring

1



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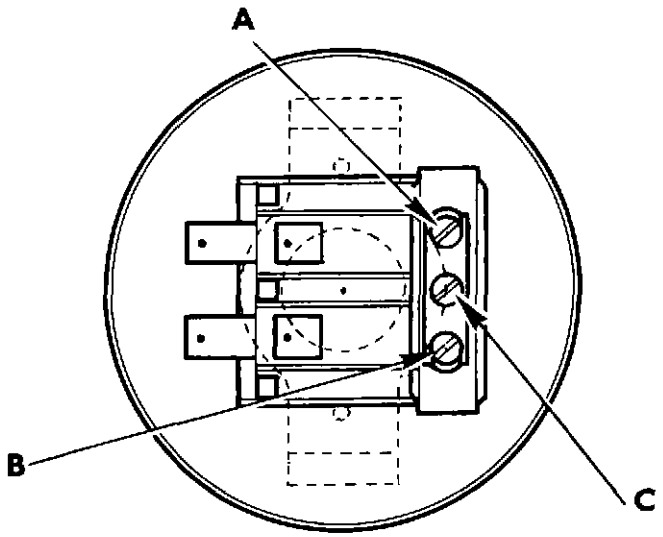

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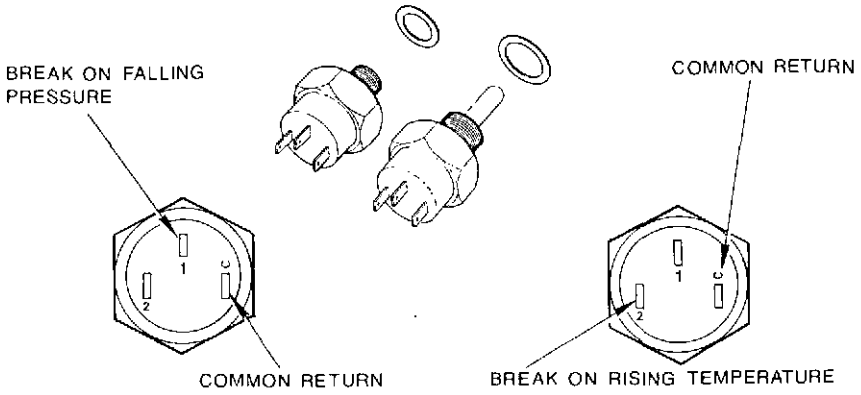


Oil pressure switch

Coolant temperature switch

Fig. 4 Teddington control switches

SECTION 9 -- TRANSMISSIONS

HOLSET COUPLING

The coupling should be dismantled for inspection at the intervals specified in the Servicing Schedule (Section 1). Overhaul instructions are given in the Workshop Manual, T.S.D. 803.

Periodically, inspect the coupling visually for signs of oil contamination and deterioration of the rubber blocks. A small amount of rubber dust in the vicinity is normal.

ROCKFORD OVER-CENTRE CLUTCH

Description

This is a 14 inch clutch, mounted on the engine flywheel housing and manually operated by an external lever. A single-plate unit is used for light duties on C4 and SF65C engines, and a twin-plate unit for heavy duties on SF65C, C6 and C8 engines. The following details and servicing instructions apply to both types of clutch.

The clutch is engaged by toggle action which forces the plates together as the lever is moved forwards. Under further pressure the toggles move 'over-centre' and lock the plates in this position. Rearward movement of the lever reverses the action and the plates are free to return to the disengaged position under the influence of four coil springs.

Adjustment

A firm pressure is required to engage the clutch, but should be no greater than is necessary to prevent slipping under full load. If insufficient pressure is applied the clutch will slip and the friction surfaces may be damaged; if excessive force is applied the toggle mechanism and thrust bearing will be overloaded and the clutch may jump out of engagement.

Note: A new clutch will require several adjustments before the friction surfaces are bedded-in.

To adjust the engagement pressure (fig. 1) remove the inspection plate from the bell-housing, disengage the clutch, and turn the output shaft until the locking device (1) can be reached. Unlock the adjusting ring by turning the locking tang outwards from the shaft serrations. Turn the adjusting ring (2) clockwise to increase engagement pressure, or vice-versa. Re-lock the adjusting ring and check, by turning the output shaft, that the plates do not drag when disengaged. Refit the inspection plate.

Lubrication

Use a high-temperature grease, as specified in Chapter 1, 'Data'.

Caution: Do NOT overgrease, or the clutch plates may be contaminated.

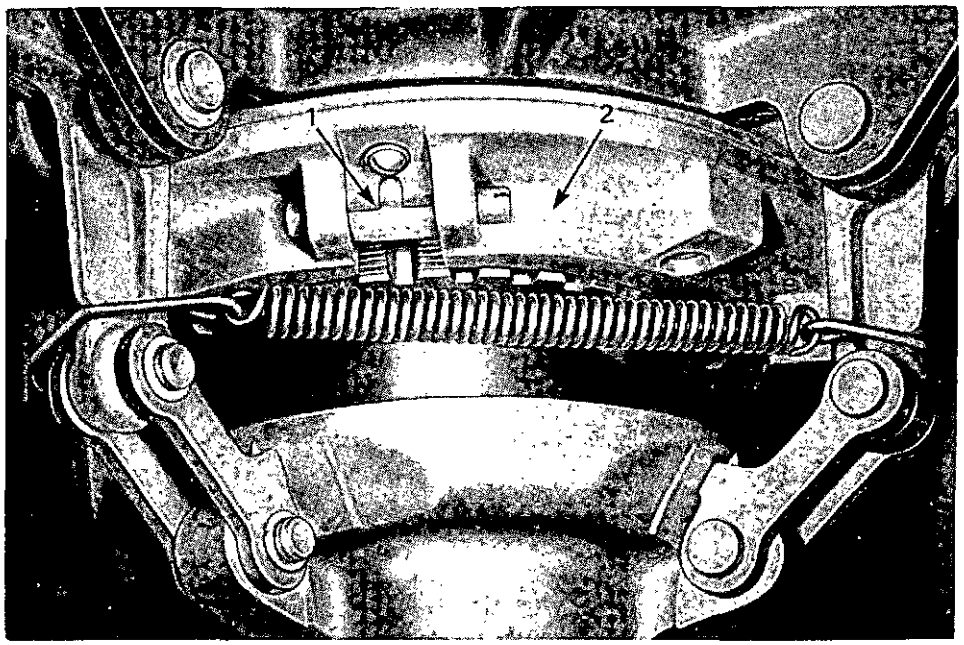
Refer to the Servicing Schedule (Section 1) for lubrication intervals. The thrust bearing is greased more frequently than the other components.

The grease points are shown in fig. 2, as follows:

1. Thrust bearing
2. Output shaft bearing
3. (A or B) Pilot bearing
4. Cross-shaft bearings

TWIFLEX AUTOMATIC CLUTCH

On initial assembly the clutch is set to operate at a predetermined engine speed. No routine servicing is required, but if slip occurs or the operating speed becomes incorrect the unit should be removed for overhaul. See Workshop Manual, T.S.D. 803.



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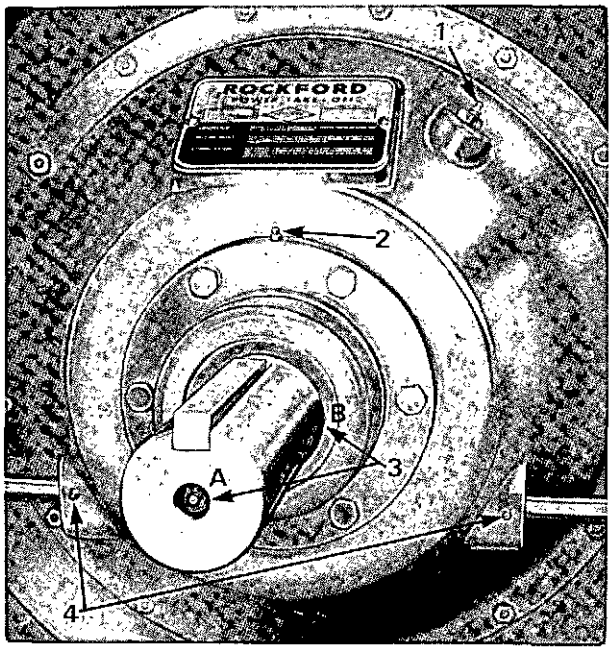

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SECTION 10—STORAGE

All new or reconditioned engines leaving the Factory have been treated with anti-corrosion inhibitors to Rolls-Royce standards. Each engine may be stored under cover, in dry conditions, for a period of up to 12 months from the date of despatch from the Factory, without the need for further inhibition.

Should the storage period exceed 12 months, the engine must be thoroughly examined and re-inhibited.

After the initial run of any engine the original inhibition will be lost and the following storage recommendations must be adhered to. Failure to observe these instructions could affect the Rolls-Royce Motors Guarantee.

RECOMMENDATIONS

Short-term storage

Up to seven days: No action is necessary.

Up to three months: Each week, run the engine until normal operating temperature is reached. If the engine cannot be run, turn the crankshaft by hand a minimum of three revolutions.

Long-term storage

If it is necessary to store an engine for a period of between three months and twelve months, the following inhibiting procedures must be followed:

1. Remove and clean the thermostat as detailed in Section 8 of the 'C' range Workshop Manual, T.S.D. Publication 803 (11th Issue). Apply a silicone grease, such as MS4, to the thermostat spindles, operating the valves manually to work the grease between the spindles and the glands. Reassemble the thermostat in 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. See 'Note' later.
3. Fill the oil filter bowls with PX4 inhibitor and refit the bowls to the header bracket.
4. Fill the sump to the normal oil level with the PX4 inhibitor and once again run the engine until normal working temperature is reached.
5. Stop the engine, disconnect the fuel supply and reconnect to a supply of PX4 inhibitor. Restart the engine, whilst still hot, and run it off load for ten minutes. 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 or inhibited propylene glycol to which 1% of soluble oil (e.g. Shell Dromus 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. Drain the fuel filter canisters. See 'Note' later.
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 cleaner(s).
11. Motor the engine on the starter and, simul-

taneously, spray PX4 inhibitor into the manifold until vapour emerges from each fuel injector orifice.

12. Using a suitable self-metering spray gun, spray 40ccs. 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 oil filler cap.
15. Drain the cooling system and refill with a fresh coolant mixture of inhibited ethylene glycol or inhibited propylene glycol and clean water.
    Note: The mixture must NOT contain less than 50% inhibited ethylene glycol or inhibited propylene glycol and may contain up to 90% by volume.
    Allow the system to settle for 15 minutes, then completely drain the coolant mixture. Attach a 'NO COOLANT' notice to the coolant filler cap.
16. Disconnect the exhaust system at the turbocharger diffuser outlet or, on normally aspirated engines, at the junction of the manifolds. Inject two grammes of VPI 260 powder and fit a blanking plate. Do NOT reconnect the exhaust pipe.
17. Inject two grammes of VPI 260 powder into the turbocharger, if fitted.
18. 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. Reconnect the air cleaner(s).
19. Brush coat or spray all unpainted areas of the engine and auxiliary equipment with Crodafluid PM47, paying special attention to the fuel control linkage.
    Caution: Do NOT spray PM47 into the vent apertures of the alternator.
20. Wrap the alternator, starter motor and tachometer generator 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 dates on which the engine was inhibited and 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 twelve month period.

Note:

Spin on type oil and fuel filter canisters are designed so that when mounted above the header bracket, the lubricating oil or fuel does not drain back into the sump or supply tank from their respective canisters, when the engine is stopped.

To drain a filter canister for inhibition purposes, hold the canister inverted over a suitable container and, using a small blunt instrument inserted into one of the fluid inlet openings, gently press open the rubber non-return seal.

During this operation, care must be taken not to damage the rubber seal or the internal element of the filter.

For list of approved inhibiting products see Page 81.

Approved products for engine inhibiting

Component	Product	Manufacturer
Thermostat	MS4 silicone grease	Ambersil Ltd Whitney Road Basingstoke Hants
Lubrication system	PX4 inhibitor	Croda Chemicals Ltd Thelson Works Churchill Road Doncaster Yorks
Fuel system	PX4 inhibitor	Croda Chemicals Ltd
Valve gear	PX4 inhibitor	Croda Chemicals Ltd
Cooling system	Inhibited ethylene glycol or inhibited propylene glycol	Various
Induction/exhaust systems	PX4 inhibitor VPI 260 powder	Croda Chemicals Ltd Shell Chemicals Ltd Stanlow Terminal Ellesmere Port Wirral Cheshire
Engine and auxiliaries—exterior	'Crodafluid' PM47 Mouldable wax wrapping	Croda Chemicals Ltd Carrs Paper Ltd Shirley Solihull West Midlands

CHAPTER 4 — FAULT DIAGNOSIS

Faults are given in order of probability for each symptom.

Symptom or Condition	Possible Cause	Action	Refer to Chapter 3, Section
1. FAILURE TO START			
(a) Starter will not turn engine	*Electric*		
	Discharged battery	Recharge or replace battery	
	Faulty starter circuit	Check switch terminals and starter motor	8
	Defective starter motor	Replace starter	8
	Starter pinion not engaging	Turn engine by hand, and try again	—
	Air (Ingersoll-Rand)		
	Insufficient pressure	Charge reservoir	3
	Starter motor seized	Change motor, and service airline lubricator	3
	Hydraulic (Bryce)		
	Insufficient pressure	Charge hydraulic accumulator	3
(b) Engine turns, but will not fire	No fuel at injectors	Check tank level and fuel cock	—
		Ensure that 'energize to run' solenoid is functioning correctly	8
		Check that overspeed trip unit is set to RUN	5
	Air in system	Vent system	5
	Water or dirt in fuel	Drain water trap, and service filters	5
	Faulty feed pump	Change or service pump	5
	Injector pump timing incorrect	Reset pump timing	5

2. ENGINE FIRES, BUT FAILS TO RUN	Faulty fuel supply	Check and vent system	5
	Faulty feed pump	Change or service pump	5
	Fuel filters choked	Service filters	5
	Air cleaner choked	Service air cleaner	7
	Faulty injectors	Change injectors	5
3. MISFIRING	Air in fuel system	Vent system. Check suction pipes for leaks	5
	Fractured injector pipe	Change pipe	5
	Faulty injector(s)	Change injector(s)	5
	Incorrect tappet clearances	Reset clearances	2
	Faulty injection pump	Change pump	5
4. LOW OIL PRESSURE (Sudden drop, not due to bearing wear)	Low oil level	Replenish sump	6
	Faulty pressure gauge	Replace gauge	—
	Filters choked	Service filters	6
	Relief or by-pass valve faulty	Examine and clean valves	6
	High oil temperature	See Item 5	—
5. OVERHEATING	Coolant level low	Replenish, and check for leaks	4
	Slipping fan belts	Adjust belt tension	2
	Fouled coolant system	Clean and refill system	2
	Faulty thermostat	Test, and replace if necessary	2
	Choked radiator matrix	Clean matrix	—
	Injection pump timing incorrect	Reset timing	5
	Low oil level	Replenish sump	6
	Turbocharger failure	Inspect turbocharger	7

6. LOW FUEL PRESSURE	Filters choked	Service filters	5
	Faulty relief valve	Change valve	5
	Leak in suction line	Locate and rectify	—
	Faulty feed pump	Change or service pump	5
7. LOSS OF POWER	Low fuel pressure	See Item 6	—
	Injection pump timing incorrect	Reset timing	5
	Faulty injectors	Change injectors	5
	Air cleaner choked	Service air cleaner	7
	Incorrect tappet clearances	Reset clearances	2
	Leaking joints at cylinder head or inlet manifold	Renew joints	—
	Woodward governor linkage incorrectly set	Reset linkage	5
	Turbocharger failure	Inspect turbocharger	7
8. BLACK EXHAUST SMOKE	Overfuelling	Check MAX. FUEL stop seal. If broken, change pump or reset on test rig	5
	Faulty injectors	Change injectors	5
	Injection pump timing incorrect	Reset timing	5
	Air cleaner choked	Service air cleaner	7
	Turbocharger failure	Inspect turbocharger	7

SERVICE INSTRUCTIONS

This Issue, dated February 1984, of T.S.D. 980 contains all relevant information from Service Instructions up to S.I. 129.

Subsequent Service Instructions should be inserted behind this page, reference notes being made at the appropriate places in the Manual.

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